WAR SURGERY

WORKING WITH LIMITED RESOURCES IN ARMED CONFLICT AND OTHER SITUATIONS OF VIOLENCE

VOLUME 1

SECOND EDITION, 2019

C. GIANNOU
M. BALDAN

REFERENCE

ICRC

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PREFACE

Many things change in a decade; many things stay the same. Despite advances in the management of severely injured patients, the challenge of providing timely, adequate and appropriate care for the victims of armed conflict remains.

In the ten years since *War Surgery: Working with Limited Resources in Armed Conflict and Other Situations of Violence* was first published, it has become a basic reference text for surgeons facing the challenge of managing the war wounded – both civilians and combatants – in difficult and austere circumstances. Our surgical colleagues considered it useful to bring certain chapters up to date to reflect new knowledge. In addition to the ICRC-sponsored translations into French, Russian and Spanish, local initiatives now include versions in Arabic, Chinese, Japanese and Turkish, which is a testament to the relevance of ICRC surgical experience.

The challenges are not confined to medical care. In 2019, 70 years after the four Geneva Conventions were signed, disregard for the lives of those providing medical treatment remains all too common. The International Committee of the Red Cross, colleagues from the International Red Cross and Red Crescent Movement and other humanitarian organizations have all made it clear that health care during armed conflict is in danger, despite the requirements of international humanitarian law – the law of war.

The ICRC remains vigilant in guarding against the erosion of international humanitarian law and works with States to correct harmful behaviour. For we know that compliance with international humanitarian law saves lives, keeps hospitals and schools open, maintains electricity and water supplies and allows markets to function. Fewer people are displaced, development efforts are preserved and stability is enhanced. The Conventions remain as relevant and applicable today as they were in 1949, for even in armed conflict, at the worst of times, the core of our common humanity must be preserved.

The care and protection of the sick and wounded during war remains fundamental to the identity of the ICRC and forms the basis of the very first Geneva Convention of 1864. This updated edition of *War Surgery* attempts to share the expertise of ICRC medical professionals in providing a little bit of humanity in situations which, in a better world, would not exist.

Peter Maurer
ICRC President

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INTRODUCTION

> Our common goal is to protect and assist the victims of armed conflict and to preserve their dignity. This book is dedicated to the victims of situations which, in a better world, would not exist.

Facing the challenges

One night while on duty Dr X, an experienced surgeon working in an ICRC field hospital in the midst of a civil war, performed a craniotomy on one patient injured by a bomb, an amputation following an anti-personnel landmine injury on another, and a laparotomy after a gunshot wound on the third; not to mention the emergency Caesarean section that arrived, as always, at the most inopportune time, after midnight. She was the only surgeon available that night. This was common practice at the time, and not very much has changed in the last thirty-odd years.

Standard peacetime health services are already limited or lacking in many low-income countries, and faced with the added burden of weapon-wounded they are quickly overwhelmed. A precarious health-care system is one of the first victims of armed conflict: the disruption of supply lines, the destruction of premises and the flight of medical personnel are all too common.

The lack of adequate resources is not limited to diagnostic and therapeutic technologies. Above all there is a dearth of qualified personnel. Surgeons trained to practise in multidisciplinary teams find themselves alone to face the entire surgical workload and deal with subspecialties with which they have, at best, only a passing acquaintance. Reverting to the philosophy, so common 50 years ago, of the multidisciplinary single surgeon who has to "do it all" is not an easy task.

ICRC teams usually include only one or two surgeons. They are generalists, able to treat all kinds of injuries from simple soft-tissue wounds to penetrating abdominal and head injuries and complicated fractures. They must also provide emergency non-trauma surgical and obstetric care for the civilian population in the area. Ideally, they should be very general surgeons with a broad approach and wide experience.

> The principles of war surgery have been known for centuries but need to be relearned by each new generation of surgeons and in every new war.

This commonly held view remains true to this day. Whether performed by military or by civilian surgeons, war surgery has its particular characteristics that are due to the special nature of the context of armed conflict, its limitations and dangers, and the particular physiopathology of high-energy, penetrating missile and blast wounds. The care of weapon-wounded patients follows accepted surgical standards, but is performed under extreme conditions, which is why the management of a gunshot wound due to criminal violence in a civilian context cannot be easily extrapolated to surgery in a situation of armed conflict.

Where only limited resources are available the surgeon must accept that he cannot fully utilize his capacities and expertise.

Working with limited resources means that the limits of surgery that can be performed are not the expertise of the surgeon, but rather the level of anaesthesia and post-operative nursing care, and the availability of diagnostic and therapeutic equipment.

Limited resources, even in peacetime, may lead to the death of patients who would have survived had more sophisticated means been available. This is often the case in remote, and not so remote, hospitals in low-income countries; a situation exacerbated during armed conflict.

When the principles of triage are applied, saving "life and limb" for the greatest number, with the least possible expenditure of time and resources, often takes precedence.

Indeed, these characteristics mean that war surgery is very different from that practised in peacetime, when most operations are elective and most trauma is blunt, and the surgeon concentrates on doing everything he possibly can – using the full range of resources necessary – for each and every patient.

International humanitarian law – the law of war – complements medical ethics in times of armed conflict or other situations of violence.

Furthermore, the work of medical staff in a situation of armed conflict is governed by a special set of rules, in addition to standard medical ethics: international humanitarian law, or the law of war. This is yet another specificity of this type of surgical care and is important for the security of patients and medical personnel alike living and working under dangerous circumstances.

The ICRC's experience

The ICRC has been providing medical care for the war-wounded ever since its inception, for example during the Franco-Prussian War (1870). The 1970s and 80s, however, saw a tremendous increase in the already considerable humanitarian activities for the victims of war, armed conflict, and other situations of violence. These included relief efforts for refugees, internally displaced persons, and the affected resident population, and medical care for the sick and wounded. In addition, many new organizations were founded and, together with United Nations agencies, they deployed renewed efforts to respond to these humanitarian challenges.

The ICRC embarked on large-scale programmes to provide surgical care for the victims of war. Several independently-run ICRC hospitals were established and surgical staff recruited from various national Red Cross/Red Crescent Societies and Switzerland. A large number of enthusiastic and idealistic surgical staff set off on humanitarian missions. The surgeons were well-trained and experienced, but their training and experience were largely confined to sophisticated hospital facilities in industrialized countries. They faced a steep learning curve.

The ICRC also faced a steep learning curve and has acquired considerable expertise in caring for the victims of conflict in settings where the health-care system is severely disrupted. This know-how derives from three different, but related programmes in various countries afflicted by armed conflict and other situations of violence around the world.

Independent ICRC-run hospitals.

Support to local hospitals through the short-term presence of expatriate surgical teams, with a strong focus on training and capacity building; the provision of supplies and equipment; the renovation of infrastructure and water and sanitation facilities; and financial incentives and salaries for local staff when necessary.

Organization of war surgery seminars, which provide opportunities for colleagues to exchange experiences and expertise.

This three-pronged approach has enabled the ICRC to develop basic clinical protocols and procedures for surgical techniques appropriate to the management of weapon-wounded patients in situations of limited resources and precarious circumstances. In addition, over the last thirty years, the ICRC has trained and maintained a pool of experienced hospital personnel who do not have to re-invent everything with each new conflict.

However, thanks to more widespread educational opportunities in recent years, there has been a sharp increase in the number of surgeons in conflict-afflicted countries. This has allowed the ICRC to switch the emphasis of its programmes from one of substitution – i.e. independent ICRC hospitals – for a poorly-functioning or non-existent hospital system to one that focuses on support and training of medical personnel in the niceties of the management of patients wounded by the weapons of war.

As part of its training programmes, the ICRC has co-organized more than 120 war surgery seminars – over a dozen a year – in the last decade. On these occasions much expertise and many ideas have been exchanged between surgeons from a number of countries – with a varying degree of experience in war trauma – and ICRC surgeons. We have all learned from these discussions, and some of the lessons are reflected in the contents of this new book.

However, in several contexts the ICRC has continued to provide direct surgical services in a neutral and impartial manner. This form of substitution contributes a fundamental element to the protection of the victims and the medical mission in situations where these humanitarian principles have been sorely tried.

While a number of manuals on war surgery have been published, they are mostly produced by and for the armies of industrialized countries. Their operational norms usually require large investments in means and personnel: helicopter evacuation of patients; well-trained field medics and stretcher-bearers; sophisticated technology; multidisciplinary teams of specialist surgeons, anaesthetists, and nurses. ICRC surgical staff refer to these manuals as references but the conditions and means described therein are seldom met in present-day theatres of armed conflict. Many of their "lessons" are inadequate – or even irrelevant – to humanitarian war surgery or the functioning of public hospitals in many countries working with limited resources.

ICRC surgical care aims to be economical, non-specialized, based on solid scientific principles, and offer good returns given the constraints. The clinical protocols and surgical techniques described in this manual are the standard procedures used among the ICRC's pool of experienced surgeons.

Putting pen to paper

To meet the challenge posed by these conditions, our predecessors in the surgical department of the Medical Division of the ICRC edited a basic reference manual for surgeons embarking on their first humanitarian mission: Surgery for Victims of War.

The first three editions of this book have been extensively distributed and received wide acclaim the world over from surgeons who faced the challenge of treating war-wounded patients for the first time. The general surgeon in an isolated rural hospital has perhaps drawn the greatest benefit from it.

Originally intended as a fourth edition of Surgery for Victims of War to address the particular needs and specific requests many of our colleagues raised during ICRC-led seminars, as well as to reflect the developments in ICRC surgical practice, it soon became clear that a new book would better serve this purpose. This book now comprises a significant amount of new material to be presented in two volumes, while maintaining the basic reasoning of the original manual.

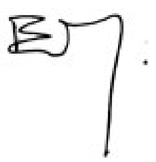
This first volume is devoted to broad topics, with a number of entirely new chapters of a more general character whose contents are relevant not only to surgeons but also to those responsible for the organization and coordination of surgical programmes in times of armed conflict and other situations of violence. It presents the characteristics of surgical care for the victims of war, in particular the epidemiological, organizational and logistic aspects, drawing on the experience of ICRC medical staff and other colleagues. The second volume will deal with weapon-related trauma to specific body systems.

The surgical techniques presented herein share many fundamental ideas with more sophisticated medical services. However, they also derive from tried-and-tested improvisation and the use of very simple methods of treatment aiming to use technological means as appropriate as possible to the prevailing conditions of limited infrastructure, equipment, and personnel.

The explanations of techniques are geared to the level of knowledge and practice of general surgeons in a rural hospital. These surgeons are often the first to see patients wounded in conflict and they know that, under the circumstances, referral to more sophisticated facilities – far away in an inaccessible capital city – is impractical or impossible. This book attempts to provide surgeons who do not have specialized training with basic advice about the treatment of various weapon wounds, describing the types of operations that have proved successful in ICRC and other comparable practice.

Unless stated otherwise masculine nouns and pronouns do not refer exclusively to men, for the manual is gender neutral. Any use of trade or brand names is for illustrative purposes only and does not imply any endorsement by the ICRC.

We hope that civilian and military surgeons, as well as Red Cross/Red Crescent surgeons, facing the challenge of treating the victims of armed conflict and other situations of violence for the first time under precarious and, at times dangerous, circumstances will find this book useful.



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The second edition (1990) was revised by Robin Gray (United Kingdom) and the third (1998) by Åsa Molde (Sweden).

We owe a debt of gratitude to their pioneering work, and their clear and simple approach which has served as a model.

The present publication has benefited from the input of many colleagues with much experience within the ICRC and outside it. Critical comments and valuable advice throughout were provided by:
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The ICRC Master Surgeons Workshop, held in Geneva in March 2002, revised the Red Cross Wound Score, ICRC triage categories, and established the ICRC antibiotic protocol. Participants included: Marco Baldan (Italy), Massey Beveridge (Canada), Christos Giannou (Greece-Canada), François Irmay (Switzerland), Dieter Jacobi, (Germany), Ben Mak (Netherlands), Valery Sasin (Belarus), Jukka Siegberg (Finland), Harald Veen (Netherlands) and Gunter Wimhoefer (Germany).

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Both workshops also helped define the ICRC criteria for the adoption of new technologies, the level of laboratory expertise required, and general strategies for ICRC surgical programmes.

Christiane de Charmant handled the editing of the final text and was responsible for the production while Pierre Gudel provided the graphic design. Their contribution is greatly appreciated.

Note to the Second Edition

A number of advances have been made in the management of war wounded patients since the publication of this volume. We have tried to bring the content up to date, without attempting to offer "cutting-edge" developments that are largely irrelevant to our colleagues working in difficult circumstances with limited resources. Nonetheless, we have attempted to be as professional as possible.

Several colleagues at ICRC headquarters have contributed to this edition. Andreas Wladis (Sweden) was instrumental in launching this revision and contributed to multiple chapters, especially on damage control surgery, as did Slobodan Mirosavliev (Serbia). Sanja Jananin (Serbia) and Dmytro Kuchumov (Ukraine) also contributed to the discussion on damage control and revised the chapter on anaesthesia. Thomas Wilp (Germany) revised the chapter on first aid. Mauro Dalla Torre (Italy), Johnny Nehme (Lebanon-France) and Erik Tollefsen (Norway) contributed to the section on chemical weapons. Ioanna Antzoulatou (Greece) provided new ICRC field statistics. Tom Potokar at the University of Swansea, UK, revised the chapter on burns based on the field experience of the non-governmental organization INTERBURNS. Our colleague and co-author for Volume 2, Åsa Molde, contributed her valuable comments to all updated chapters. The authors wish to extend their gratitude to Steve Rawcliffe for editing parts of the update to this edition.

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Chapter 1

SPECIAL CHARACTERISTICS OF SURGERY IN TIMES OF CONFLICT

1.1 Differences between surgery in times of conflict and civilian practice

The differences between civilian and war trauma are manifold – as are the differences between the experience of the ICRC and those of conventional military medical services.

Most surgeons today, the world over, derive their trauma training from road-traffic accidents and much that applies to the management of casualties in civilian settings will also apply to the situation of armed conflict: war surgery follows classical surgical standards. However, the generation of surgeons who mostly had to deal with accidents among agricultural or industrial workers were well aware of the dangers of gas gangrene and tetanus and the necessity of good wound excision and delayed primary closure. It was relatively easy for the surgeon to shift from this "septic" civilian surgery to war wounds. This is no longer the case for many surgeons trained today; laparoscopy, radioscopic embolization, and unreamed intramedullary nails will not get you very far when facing a landmine injury of the abdomen or a machine-gun wound to the thigh. Early specialist training of surgeons and sophisticated modern technology benefit many patients in a peacetime environment, but can be an obstacle to the practice of surgery during armed conflict.

War wounds are different. The extent of tissue destruction and contamination seen in war injuries is nothing like what is seen in everyday trauma practice. Working conditions during war are radically different from those prevailing in peacetime. Resources are limited and surgeons are often obliged to improvise or make compromises in their management decisions. Their aim should be to bring the best care possible to their patients under the circumstances, not the best care as described in the academic literature.

War surgery is a surgery of mass casualties. The logic of war triage has little to do with the routine emergency department triage of a major civilian trauma centre: war triage has a "leave to die in dignity" category unheard of in everyday civilian practice.

War surgery involves the staged surgical management of the wounded, often at different echelons of care and provided by different surgeons, especially in a military context. Even in a humanitarian context, such as ICRC surgical programmes, several surgeons deployed on short missions may participate in the treatment of a single patient. In everyday civilian practice on the other hand, the same surgeon assumes responsibility for the entire surgical management of his or her patient. While modern civilian practice often involves a "multidisciplinary approach", war surgery often demands a "multi-surgeon" approach.

> "All the circumstances of war surgery thus do violence to civilian concepts of traumatic surgery."
>
> Michael E. DeBakey[1]

These and other challenges mean that practitioners facing surgery for the victims of war for the first time will have to change their mindset, i.e. their "professional mental software".

1 DeBakey M E. Military surgery in World War II – a backward glance and a forward look. *NEJM* 1947; **236**: 341 – 350. Michael E. DeBakey (1908 – 2008), an American surgeon of Lebanese origin, was a pioneer of modern cardio-vascular surgery. His treatise on the management of vascular trauma constitutes a basic reference. He invented the concept of Mobile Army Surgical Hospitals (MASH) for the US armed forces in Korea.

1.2 How war surgery differs

> War surgery is the management of an "epidemic of trauma" in a series of steps: echelons.
>
> N. I. Pirogov[2]

A number of special features characterize the practice of surgery in time of war.[3]

1. Special rules: international humanitarian law (IHL), i.e. the protection of the sick and wounded, and the rights and obligations of medical personnel.
2. Specific epidemiology of war wounds.
3. Predominance of emergency surgery.
4. Surgery in a limited technical environment.
5. Surgery in a hostile, violent environment: constraints of the tactical situation.
6. Mass casualties involving the principles of triage.
7. Triage and surgery in successive echelons of casualty care.
8. Outcome of hospital patient care is a function of the efficiency of pre-hospital echelons.
9. Specific wound pathology: bullets, bombs, blast, non-conventional weapons.
10. Specific techniques appropriate to the context and pathology.
11. Increased prevalence of endemic disease.

1.2.1 IHL: protection of non-combatants and those "*hors de combat*" and the rights and obligations of medical personnel

ICRC

Figure 1.1

Soldiers "*hors de combat*": POWs.

Japanese Red Cross Society

Figure 1.2

Soldiers "*hors de combat*": the wounded.

ICRC

Figure 1.3

Those who care for the sick and wounded.

The Geneva Conventions of 1949 and their Additional Protocols of 1977 define categories of individuals who, by virtue of these treaties, are protected during armed conflict. These include non-combatants, combatants who no longer participate in hostilities – "*hors de combat*" – either through sickness, injury, shipwreck, or by becoming prisoners of war; and those who care for the sick and injured, namely medical and religious personnel. The latter two use the protective emblem of the red cross, red crescent or red crystal to mark the means and facilities that take care of the sick and wounded. According to the law, all these categories of protected individuals are immune from attack, as long as they do not take an active part in hostilities. International humanitarian law – the law of war – offers particular rights to medical personnel, but also ascribes obligations to them.

All health professionals are bound by medical ethics, in times of peace and of war. These are not replaced but are complemented by international humanitarian law. Compliance with these laws may create particular ethical dilemmas and security problems, and the military hierarchy does not always understand the demands of medical ethics. Civilian health staff may face particularly problematic and dangerous situations during a civil war where their own community is involved in the conflict. Chapter 2, Applicable international humanitarian law, explains the main principles and rules governing the rights and obligations of medical staff in times of armed conflict.

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2 Nikolai Ivanovich Pirogov (1810 – 81): Russian anatomist and surgeon, professor at the Academy of Military Medicine, St Petersburg. Founded modern field surgery during the Crimean War (1854); devised the plaster cast and the mass use of anaesthesia on the battlefield and wrote a reference field surgery manual. Representative of the Russian Red Cross sent to inspect the hospitals on both sides during the Franco-Prussian War in 1870.

3 List modified and adapted from bibliographic sources.

1.2.2 Specific epidemiology of war wounds

The nature of warfare – on land, at sea or in the air – will create a particular epidemiology of the wounded. The nature of weapons, protective body armour, and any delay in transport will affect the anatomic distribution of injuries and their severity. The understanding of these epidemiological factors will have important consequences in terms of preparation and allocation of resources: i.e. standardized supplies and specialized personnel (see Chapter 5).

1.2.3 Predominance of emergency surgery

War surgery primarily consists of emergency surgery, especially during early tactical field care. Sophisticated techniques or reconstructive procedures have no place here, except well after combat and in a distant referral hospital (see Chapters 6 and 8).

1.2.4 Surgery in a limited technical environment

The environment in times of war is bleak and harsh. The limits of surgical work are largely determined by the logistic difficulties attending the supply of remote and dangerous areas and the lack of maintenance, repair and spare parts. There is seldom enough technical support staff to ensure that infrastructure functions correctly.

V. Louis / ICRC

Figure 1.4
Surgery in a limited technical environment.

Despite lavish outlays for field hospitals by the armies of modern industrialized countries, equipment limitations in tactical situations are well recognized. The lack of sophisticated diagnostic equipment rather than the surgeon's technical capabilities and expertise is often what determines what can be done. What is essential must be differentiated from what is "nice to have".

1.2.5 Surgery in a hostile, violent environment

The adverse conditions of a tactical situation may put the safety of patients and medical personnel at risk, and thereby create less than optimal working conditions. Dangerous evacuation routes may compromise transport and result in delays. Security must be ensured for patients and staff, by selecting suitable sites for first-aid posts and hospitals. Health facilities and ambulances should be clearly marked with the protective emblem of the red cross, red crescent or red crystal, according to the dictates of international humanitarian law.

Not all combatants are disciplined and well trained. For anyone caught up in armed conflict, there is an all too familiar syndrome seen amongst young fighting men who are under the influence of a "toxic cocktail": testosterone, adrenaline, alcohol and cannabis (and, at times, "other substances" as well).

T. A. Voeten / ICRC

Figure 1.5
Working in a hostile environment.

The setting of surgical work can change rapidly, and surgeons must be prepared to adapt to various difficult and austere environments. With few doctors and limited staff available, and wounded people pouring in, hospital facilities are easily overwhelmed. Doctors and nurses also get tired and sick, and are sometimes frightened. The physical and mental strain of working in new and strange circumstances and at times dangerous conditions means that they may not perform as well as usual.


R. Bigler / ICRC

Figure 1.6
Mass casualties: the principles of triage.

1.2.6 Mass casualties involving the principles of triage

Much has been written about the carnage of the major wars of the twentieth century, and the role of triage in the management of thousands of casualties resulting from a single battle. These lessons are still relevant in contemporary conflicts. The logic followed must be to "do the best for the most" and not "everything for everyone". This involves the most important change in the professional mindset of the surgeon.

Triage decisions are amongst the most difficult in all medical practice, possibly creating ethical dilemmas. There may also be, at times, a conflict between medical criteria and tactical ones of military necessity that require some form of compromise. Persons performing triage must be prepared to accept these necessary compromises while maintaining their professional medical integrity (see Chapter 9).

1.2.7 Triage and surgery in successive echelons

The sick and wounded are evacuated and transferred along a chain of casualty care. The principles of triage are applied at every stage in this chain. The initial surgery must not compromise the performance of later, definitive surgery. The prognosis will be much better if the wounded are evacuated rapidly to a higher echelon hospital structure. A surgeon in the field must understand the system and know what will happen to the patient at the next echelon of care and what is required of him at his echelon (see Chapter 6).

War surgery requires a logic of phased wound management. Treatment takes place in five phases often, although not necessarily, in five different places. This is the classical set-up in military planning. It involves high costs, including the means of transportation and the discipline required of such organization. Modern concepts can be integrated into this approach, such as forward surgical teams performing damage-control surgery. The five phases are as follows.

1. First aid at the point of wounding: self- or "buddy" treatment, or that provided by a field medical officer or first aider.

2. First medical treatment: vital emergency measures including the beginning of resuscitation, generally at the first-aid or dressing post, clearing station or collection point.

3. First surgical treatment: debridement/wound excision, without primary closure, at the first echelon hospital.

4. Definitive treatment: delayed primary closure of wounds and surgical treatment according to traditional principles in a referral hospital. Physiotherapy and convalescence.

5. Reconstructive surgery and rehabilitation: specialized surgery with multiple reconstructive procedures and the fitting of prostheses when required.

The rapid turnover of medical personnel treating numerous patients at different points in a chain of casualty care creates a necessity for standard protocols, which cannot be left to the discretion or whim of the individual surgeon. One cannot individualize treatment for each single patient in a tactical situation; different surgeons will operate on the same patient at the different echelons. In civilian practice, by contrast, the same surgeon manages the surgical care of the individual patient throughout that patient's course of treatment; even in a multidisciplinary approach, the same team is involved.

These five echelons for the management of the war-wounded do not always exist in a civilian or humanitarian context, where all five phases may well occur in the same medical facility – as is in fact common practice for ICRC hospital teams. However, in the humanitarian context, there is also a rapid turnover of personnel. Standardized protocols are the only means to ensure continuity of treatment and to organize surgical and nursing care on a sound footing; the protocols cannot be changed with every change of team surgeon.

Old lessons for new surgeons

Save life and limb, sacrifice limb to save life, prevent infection, and render the casualty transportable to the next echelon.

Heroic surgery will never replace good surgery.

1.2.8 Outcome of hospital patient care depends on the efficiency of pre-hospital echelons

First aid provided at the point of wounding – or at the safest place near the battlefield – and rapid evacuation are of vital importance; mortality and morbidity increase with delay. If first aid is inadequate or unavailable and the evacuation chain is long, then the outcome will be decided by nature. However, hospital mortality decreases as evacuation time increases; with very long delays, the severely injured die long before reaching hospital and surgeons spend most of their time dealing with the septic complications of the survivors (see Chapters 5 and 7).

Old lessons for new surgeons

It is more important to provide proper first aid and render the injured fit for transport, than to give early but inadequate treatment, with insufficient means, and insufficient knowledge.

T. A. Voeten / ICRC

Figure 1.7

Inadequate pre-hospital care.

1.2.9 Specific wound pathology: bullets, bombs, blast, and non-conventional weapons

War wounds are qualitatively different from trauma seen in civilian practice: all are dirty and contaminated. Projectiles may cause massive destruction of soft tissues, bones, and important organs. Infection is the great danger and the rules of septic surgery apply (see Chapters 3 and 13).

Old lessons for new surgeons

War wounds are dirty and contaminated from the moment of injury. The rules of septic surgery apply.

Nothing in routine civilian practice is similar to the polytrauma of multiple shell fragments, traumatic amputation due to an anti-personnel landmine, or the devastating effects of a high-kinetic energy transfer from a military rifle bullet. Again, a change in the professional mindset appropriate to a modern trauma centre is required in order to adjust to the management of wounds in times of armed conflict. Surgeons practising in a low-income country, dealing with much septic pathology, will find this change much easier to handle than those whose usual work involves sophisticated technology with abundant good nursing care in an aseptic environment.

1.2.10 Specific techniques appropriate to the context and pathology

The care of numerous patients, treated in many locations by different surgeons, in austere conditions demands simplicity, security, and speed of surgical procedures. The need for speed in dealing with mass casualties with inadequate numbers of staff should not lead to confusion and disorder. Phased wound care imposes standards and a systematic approach: doing the least amount of surgical work for the greatest results, saving "life and limb", and then sending the patient on to the next stage in the chain of casualty care. The follow-up of surgical procedures by the individual surgeon in the field is difficult if not impossible, and precludes personal and individualistic techniques. Standard protocols, as mentioned, are necessary.

The majority of wounds will be to the extremities, and the objective is to treat them so that they heal as quickly as possible without becoming infected. Sepsis, potentially fatal (tetanus, gas gangrene, haemolytic septicaemia), is the greatest danger for survivors. As aforesaid: the rules of septic surgery apply.

The basic principles of management of war wounds comprise the following steps.

1. Early and thorough wound excision and irrigation.
2. Adequate wound drainage.
3. No unnecessary dressing changes.
4. Delayed primary closure.
5. Antibiotics as an adjuvant.
6. Anti-tetanus vaccine and immunoglobulin if necessary.
7. No internal bone fixation.[4]
8. Early physiotherapy.

4 No internal bone fixation is the rule, at least in the "acute phase". Recent experience has shown the possibility of using internal fixation once the soft tissues have healed in the absence of any infection, but only in skilled hands and with excellent conditions of hygiene and nursing care. This is not, however, standard policy in ICRC practice where no internal fixation whatsoever is used. The risk, and probability, of abuse of internal fixation precludes its availability.

Old lessons for new surgeons

The best antibiotic is good surgery.

Correct surgery gives the patient the best chance of survival with a good quality of life, and shortens the stay in hospital. High-quality physiotherapy is required to ensure early mobilization after surgery and a good functional result. Treatment is not complete, however, until the patient is rehabilitated; prosthetic workshops are needed to fit amputees and provide other suitable devices, such as orthoses, crutches or wheelchairs.

1.2.11 Increased prevalence of endemic disease

Until World War I, more soldiers died of disease than of their wounds. Battle-injury attrition was usually around 20%, and disease four times more common among soldiers. Non-battle injury attrition rates remain very high even today; infectious and communicable diseases differ according to the geography and climate, but psychological disorders and vehicle accidents are universal.

The destruction, disruption and disorganization that accompany armed conflict often cause the public health system to be among the very first to suffer. The humanitarian consequences translate into reduced availability of basic public health requirements such as water, food, shelter, etc., for the civilian population and often overwhelm the capacities of the public health system. This compounds the challenge of caring for the civilian population in a conflict zone: i.e. residents, internally displaced persons, and refugees fleeing to or from neighbouring countries (see Chapter 5).

1.3 "Surgeries" for victims of war

There is more than one type of war surgery. While the needs of the wounded are the same, the means and resources available to meet those needs vary widely from country to country and situation to situation, giving rise to different approaches to war surgery. The management of the war-wounded as performed by the military medical services of an industrialized country is not the same as that of a public rural hospital in a low-income country. Although the principles of wound management are the same in both cases, the diagnostic and therapeutic possibilities are very different. The latter should be *appropriate* to the technological and financial resources at hand, and to the personnel available. Obviously many of these same constraints apply to the practice of civilian, everyday trauma and elective surgery around the world.

At least four major scenarios for the surgical management of victims of war in contemporary armed conflicts can be described.

1. Conventional army of an industrialized society, with a high level of public financing and where the military attempt to provide the same level of surgical care that is practised in civilian life. Rapid evacuation and transfer of patients to specialized facilities is routine. Safe access to adequate medical care for the sick and wounded is perceived as a right; and the duty to provide it incumbent on the armed forces.

2. Developing country with an emergent economy where, at least in the capital and other major cities, a high-level of specialized surgical care including enough trained personnel is available, even if this is not the case in rural areas. Evacuation and transfer of patients to specialized facilities is possible, if sometimes difficult. Safe access to adequate medical care is a goal to be achieved.

3. Poor country, with limited funds and personnel. A few major surgical centres may exist in the capital city but provincial and rural hospitals are largely staffed by young general surgeons or general practitioners with some surgical experience. Supplies, budgets, and personnel are chronically inadequate or even absent. Evacuation and transfer of patients are difficult or impossible. Safe access to adequate medical care is rarely guaranteed.

4. Non-State actors, guerrilla groups, populations without safe access to public structures. Field surgery is practised by a few trained doctors and nurses, because there is no alternative. Safe access to the victims by health professionals, and the victims' access to medical care, is impossible or rare, problematic, and always a challenge.

H. Du Plessis / South African Military Health Service, U. Pretoria

Figure 1.8
Surgery for victims of armed conflict in a modern hospital.

F. McDougall / ICRC

Figure 1.9
Another type of surgery for victims of armed conflict.

1.4 Differences between military and non-military war surgery: the ICRC approach

Non-military war surgery is practised by civilian medical structures (health ministry, missionary and private hospitals) and those of the ICRC or other humanitarian agencies. This section details the ICRC's experience and explains its approach.

The aims of war surgery for the ICRC are to protect the sick and wounded and help maintain their dignity by ensuring access to adequate care; save "life and limb"; minimize residual disability and assist amputees. Besides the direct victims, the ICRC also attempts to support the health system by assisting local medical colleagues to maintain the infrastructure and personnel necessary to resume functioning after the end of the conflict, thus providing the civilian population with at least the basics of healthcare. ICRC assistance to local structures may involve construction and renovation of health facilities, water and sanitation work, food supplements for patients and staff, equipment, supplies and basic salaries. Training programmes for doctors and nurses may be included. In addition, the ICRC may at times set up its own independent hospitals with expatriate staff supplemented by local personnel (see Chapter 6).

1.4.1 Military-civilian cooperation

Armed forces deployed in the field have a specific military mission. Their medical component aims primarily to give support to their soldiers in this mission, i.e. to achieve their tactical and strategic plans. The military may have many of the same "assistance and reconstruction" aims as civilian organizations, but medical criteria in a military context often must take second place to the tactical and strategic demands of military and political necessity.

The ICRC is a neutral, impartial and independent, totally humanitarian, institution. It promotes adherence to international humanitarian law and aims to protect and assist the victims of conflict – all the victims on all sides. Any cooperation with armies in the field of battle that compromises the perception of that neutrality, impartiality or independence can only compromise the humanitarian work of the ICRC, as well as that of other organizations and agencies.

The ICRC insists on maintaining its independence, and the independence of a "humanitarian space" separate from the "assistance and reconstruction" work of armies in the field. Many humanitarian organizations share the same opinion and approach.

1.4.2 Constraints: security

The ICRC often has little or no control over casualty evacuation because of security constraints. In many countries the wounded are transported by private means: taxis, donkeys, oxcarts or on foot. In some contexts, the ICRC has been able to set up first-aid posts, or assist a National Red Cross or Red Crescent Society in doing so. One extraordinary example was a 16-year medical evacuation system by fixed-wing aircraft run by the ICRC and United Nations' Operation Lifeline Sudan to assist victims of the conflict in southern Sudan: it transported over 30,000 sick and wounded patients to an ICRC hospital in northern Kenya. Even with aircraft available, the logistics and distances involved regularly resulted in a one- to three-week delay in evacuation.

While the armed forces deploy the necessary means to protect their health facilities from the "lethal chaos of the battlefield",[5] the ICRC depends on the red cross emblem and negotiations with all belligerent forces for its physical protection. The ICRC has no guns to protect itself and is just as dependent on local authorities and leaders as public hospitals are. The ICRC relies on the limits imposed by international humanitarian law and the discipline of combatants, and its diplomatic negotiating ability. Other humanitarian organizations who work in war zones face similar constraints.

5 Butler F. Tactical Combat Casualty Care: combining good medicine with good tactics. *J Trauma* 2003; **54 (Suppl.)**: S 2 – 3.

1.4.3 Constraints: logistics

A hostile environment presents more than security risks. Remote areas with dangerous routes and extreme climates pose numerous logistic problems for the delivery of supplies and the maintenance of basic infrastructure, for both hospital and living quarters. The military often have lift, delivery and transport capacities that civilian institutions lack. Although the armed forces also have their logistic limits, they are of a different order of magnitude to those of the health ministry, non-governmental organizations, or the ICRC.

V. Mboah / ICRC

Figure 1.10
Challenging environment.

1.4.4 Constraints: hospital equipment

These limitations also affect hospital equipment. The military have lift constraints because they must also transport arms and munitions. For the ICRC, equipment limitations mean resorting to appropriate technology and mastering the tasks of maintenance, repair and availability of spare parts. This is particularly important when working in remote areas in a poor country with training programmes for local colleagues. The aim is to avoid creating a technological dependency that the permanent local staff will not be able to cope with when the conflict is over, and the ICRC leaves the hospital and the country. To this end, the ICRC has developed criteria for the introduction of any new technology into its standard list of medicines and equipment for hospital programmes (see Annexe 1. A: ICRC criteria for introducing a new technology).

K. Barrand / ICRC

Figure 1.11
Limited surgical equipment.

A standard list is a basic, limited set of essential supplies, both medical and non-medical, which corresponds to an appropriate standard of care. All items on a standard list should always be available from a central store or reliable supplier. Standardization provides a simple framework, within which resources can be used to maximum effect, promotes continuity in patient care, helps to simplify staff training, and makes it easier to introduce new and inexperienced staff into the system. The ICRC and the International Federation of Red Cross and Red Crescent Societies have established an Emergency Items Catalogue[6] with predetermined sets and kits that run the gamut of assistance programmes.

ICRC experience shows that it is possible to perform good quality surgery with basic technology such as simple X-ray, and electronic monitoring in the theatre and post-operative ward limited to a pulse oxymeter. An ICRC laboratory set-up is also basic; there is no capacity for bacteriological culture and sensitivity and no blood components.

K. Barrand / ICRC

Figure 1.12

Basic supplies.

1.4.5 Constraints: blood transfusion

Blood for transfusion is often difficult to obtain in some countries because of cultural and religious restrictions and beliefs. With the steady increase in HIV infection around the world, testing must be adequate and indications for transfusion strictly limited. In some areas of the world, giving blood should probably be totally avoided. The use of blood should be restricted to vital needs and to patients with a good chance of survival, following the principles of triage. As in many, if not most, provincial and rural hospitals around the world, ICRC practice uses whole blood for transfusion, as fresh as possible, and usually donated by a relative.

1.4.6 Constraints: geography and climate

The geographic context may be important in terms of disease and the added burden it represents. The wounded may suffer from other illnesses, such as tuberculosis, malaria, typhoid and intestinal worms, as well as from malnutrition. In countries with chronic malaria infestation, there is often a peak of fever post-operatively. The surgeon must therefore try to acquire some basic knowledge of the diseases specific to the area and their treatment. Local health-care workers are usually familiar with these conditions and more expert in their treatment than expatriate staff. These pathologies may also affect and represent a danger for expatriate staff.

1.4.7 Constraints: culture shock

Cultural constraints are another challenge that may add to the frustrations of medical work in a combat zone. In some societies, amputations and laparotomies can only be performed with the consent of the *family* of the patient. After a discussion in which the clear advantages are explained, the final decision must be left to the family. This procedure, which respects local cultural and social behaviour and norms, has to be followed and accepted even though it may be considered as a limitation and constraint by surgical and nursing staff. It is particularly difficult for committed medical personnel to see young people die because permission for necessary surgery has been denied.

In many societies, it is common for a relative to stay with a hospitalized patient, helping with nursing duties related to hygiene and feeding, and providing psychological support. This tradition must be accepted.

> Adaptation to the cultural, social, and geographic context is essential.

6 See Selected bibliography.

1.4.8 Constraints: the human factor

> "War surgery is a surgery of complications, performed by doctors who are often ill-trained or without surgical training. It is surgery replete with adaptations and improvisations to replace that which is missing, a surgery of surprises that new means and methods of combat reveal." [7]

This classic quotation from the Swiss army's war surgery manual describes the situation for the new military surgeon and, as is more and more often the case in contemporary conflicts, for civilian surgeons faced with the victims of armed conflict for the first time. New ICRC surgeons coming from the National Red Cross or Red Crescent Society of a rich industrialized country face the same challenges: a constantly changing field of battle with new limits and constraints that come as a surprise. One must plan for alternatives and always keep an open mind to new options.

If military war surgery is the management of an "epidemic of trauma" in a series of echelons, this is not always the prevailing situation in non-military circumstances. Unlike a military field hospital, an ICRC hospital is responsible for all levels of medical care. It often acts as a first-aid post, field hospital, base hospital, and referral centre all in one. The "multi-surgeon" military approach to treatment in echelons gives way to a more traditional one of attending to the entire surgical history of a patient. However, since deployment of ICRC surgeons is usually for a short period of time (three months on average), a number of surgeons may be involved in caring for a single patient. Continuity of care is essential.

The modern military may "project forward" technical skills by deploying field surgical teams close to the battlefield. The aim is to perform critical surgery, often damage control surgery, as soon as possible after injury in an attempt to save lives, thereby reducing the number killed in action. The ICRC has also deployed field surgical teams – Somalia in 1992, southern Sudan in 2000, and Darfur in 2005 – but with a different aim: the protection of non-combatants and wounded fighters who no longer participate in hostilities and who would otherwise have no access to surgical care. The performance of this medical act and the protection of access to surgical care are based on the essential principles of the ICRC as a neutral and impartial humanitarian actor.

The surgeon must be able to adapt to the conditions of field surgery where "somewhat clean with soap and water" replaces a "sterile" environment and "favourite" surgical instruments are not available on the standard list. Furthermore, living conditions may resemble camping out in the bush and everyone in the team (4 members: surgeon, anaesthetist, theatre nurse and post-operative nurse) participates in the preparation of food and accommodation.

The following qualities are particularly needed by personnel working in ICRC hospitals or field surgical teams:
- professionalism;
- sound judgement and common sense;
- adaptability.

Local skills and material improvisation in some countries may bring to the attention of the surgeon efficient, cheap, and useful ways of treatment: mashed papaya for burns or autoclaved banana leaves as a non-adherent dressing, for instance. Expatriate personnel must show themselves capable of learning "new old tricks" and adapting to the circumstances. War surgery is a challenge and the work trying. Medical staff must be prepared – physically and mentally – for frustrations, fatigue and long hours, and being a witness to the results of "man's inhumanity to man".

> War is deleterious to your health.

7 War Surgery Commission of the Federal Military Department. *Chirurgie de guerre (Aide-mémoire 59.24 f) [War Surgery (a primer)]*. Bern: Swiss Army, 1970 and 1986.

ANNEX 1. A ICRC criteria for introducing a new technology

1. Needs assessment
What is the added value of this new technology? Are requested materials and articles "essential", "important" or "nice to have", or even "superfluous" and a luxury?

2. Maintenance requirements
What are the extra burdens for the daily maintenance of such equipment?

3. Ease of repair
Are specialized technicians necessary, and available?

4. Availability of spare parts
Is there a reliable local supplier?

5. Cost
Expense alone is not a criterion if the equipment is necessary. However, it is taken into account along with the other factors in a total cost/benefit analysis.

6. Competency required to use the technology in question
Is the expertise widely mastered and available or does it correspond to the particular practice of an individual doctor or nurse?

7. Continuity of the competency required
Can successive surgical teams use the equipment or does it depend on the expertise of a limited number of people?

8. Presence of the technology in the country
To all intents and purposes, the ICRC shall not be the first to introduce a new technology to a country; some local practice or competency must already exist.

9. Professionalism and ethical concerns
The supply of equipment and instruments must at all times meet demanding standards of professionalism in surgical care and address possible ethical concerns. (e.g. in Europe, following the outbreak of bovine spongio-encephalopathy – so-called "mad-cow disease" – catgut suture material has been banned by the European Union and Switzerland. It would not be ethical for the ICRC to continue to provide such sutures in its assistance programmes in other parts of the world, thereby creating a lower safety standard than in Europe.) Quality control of medicines and equipment is becoming a major worldwide problem as identified by the World Health Organization.

10. Sustainability
Only if the technologies can be sustained after ICRC withdrawal is it worth considering their utilization.

Chapter 2

APPLICABLE INTERNATIONAL HUMANITARIAN LAW

2.1 Historical introduction

> "You may not be interested in war. War is interested in you."
>
> Leon Trotsky

One of the specificities of the war-wounded and those who care for them is their relationship to international humanitarian law, mainly the Geneva Conventions and their Additional Protocols.

In 19th century Europe, large-scale battles caused real carnage on the battlefields. Soldiers were regarded as cannon fodder and almost no medical services were available. Solferino, a town in northern Italy, was the site of one of these awful battles in 1859: in 16 hours 40,000 people were killed or wounded. Many wounded soldiers were left to die on the battlefield, although many of them could have been saved had relief been available. The medical services of the armies were too limited to respond to such a number of casualties – there were more veterinarians for the horses than doctors for the soldiers! Wounded soldiers lay agonizing for days without help.

Henry Dunant, a Swiss businessman travelling in the area, was struck by this drama. Out of compassion, he spontaneously organized help with the women from the neighbouring villages. Relief was given to all wounded soldiers without discrimination, regardless of their nationality. Others had performed humanitarian deeds on battlefields before; Dunant's genius lies in having taken things a lot further. Back in his hometown, Geneva, still traumatized, he wrote a book, *A Memory of Solferino*, published in 1862, in which he not only related the horrible battle and the suffering of the soldiers, but also launched an appeal around a vision and two key ideas.

Carlo Bossoli, Museo Nazionale del Risorgimento, Turin

Figure 2.1

The battle of Solferino, 1859.

The vision was to provide neutral medical care for wounded soldiers in the field, and the ideas to accomplish this vision were the following.

- On the one hand, to create a relief society in every country which, already in peacetime, would train volunteers who could assist the armed forces' medical services, doctors and nurses ready to care for wounded soldiers in the event of war – this later gave birth to National Red Cross and Red Crescent Societies.
- On the other hand, to negotiate an international agreement that would grant protection and assistance to the sick and wounded and the medical services which cared for them, thus guaranteeing access to the wounded. This idea became the first Geneva Convention, the basis for modern international humanitarian law (IHL). Every human society throughout history has had rules about the conduct of warfare: this was the first concerted attempt to standardize and institutionalize, on an international basis, the law of war. IHL is also referred to as the "law of war" or the "law of armed conflict".

Five citizens of Geneva, including Dunant, members of a charitable association, created the "International Committee for the Relief of Wounded Soldiers" in 1863 in response to Dunant's book. This Geneva Committee persuaded the Swiss government to convene a diplomatic conference in 1864, in order to formalize the protection of medical services on the battlefield through an internationally recognized treaty: twelve governments participated. The result was the Geneva Convention of 22 August, 1864, for the Amelioration of the Condition of the Wounded in Armies in the Field. The Geneva Committee became the International Committee of the Red Cross, and the emblem of the red cross was adopted as a symbol of protection of the medical services that cared for the sick and wounded – the symbols of the red crescent, the red sun and lion, and red crystal were introduced later. Not only was this first Geneva Convention a decisive step towards formalizing the laws of armed conflict, but it also made it the duty of signatory States to create military medical services to care for their own wounded. Soldiers were no longer to be simply regarded as cannon fodder.

2.2 International humanitarian law: basic principles

Throughout history, humanity has known war. All human societies have developed customary rules that regulate how wars are fought. Over 500 cartels, codes of conduct, covenants and other texts designed to regulate hostilities had been recorded before the advent of contemporary humanitarian law. The first laws of war were proclaimed by major civilizations several millennia before our era: "I establish these laws to prevent the strong from oppressing the weak" declared Hammurabi, King of Babylon.

Just as there is no society of any sort that does not have its own set of rules, so there has never been a war that did not have some vague or precise rules covering the outbreak and end of hostilities, as well as how they were to be conducted.

The Geneva Conventions (GCs) as they stand today are the result of a long process. Over the years, the First Geneva Convention has been extended to meet the changing needs of modern warfare. Three other Conventions were adopted, one after the other, covering victims other than wounded soldiers: shipwrecked sailors, prisoners of war, and civilian populations. The four Geneva Conventions of 1949 and their two Additional Protocols of 1977, in particular, as well as other written treaties and customary law, constitute international humanitarian law (IHL): i.e. what is and what is not permitted during international and non-international conflicts. All States in the world have now ratified the Geneva Conventions, which means that they are bound by these legal instruments.

The four Geneva Conventions are mainly designed to regulate the behaviour of combatants and to protect persons who are not (or are no longer) taking part in hostilities in armed conflicts between States (international conflicts).


ICRC

Figure 2.2

I. Amelioration of the condition of the wounded and sick in armed forces in the field.


ICRC

Figure 2.3

II. Amelioration of the condition of wounded, sick and shipwrecked members of armed forces at sea.


ICRC

Figure 2.4

III. Treatment of prisoners of war.


ICRC

Figure 2.5

IV. Protection of civilian persons in time of war.

I. Convention for the amelioration of the condition of the wounded and sick in armed forces in the field (GC I: Revision of the 1864 Convention).

II. Convention for the amelioration of the condition of wounded, sick and shipwrecked members of armed forces at sea (GC II: revision of the 1899 Convention).

III. Convention relative to the treatment of prisoners of war (GC III: revision of the 1929 Convention).

IV. Convention relative to the protection of civilian persons in time of war (GC IV: new Convention adopted in 1949).

Article 3 common to the four Geneva Conventions of 1949 also provides basic rules applicable in armed conflicts "not of an international character occurring in the territory of one of the High Contracting Parties".

In response to new needs in contemporary armed conflicts, the Conventions were developed and supplemented in 1977 by two further agreements: the Additional Protocols I and II relating to the protection, respectively, of victims of international and internal armed conflicts. A third Additional Protocol was adopted in 2005 to introduce a new protective emblem called the red crystal in addition to the red cross and red crescent emblems.

IHL regulates humanitarian issues in times of war; it aims to define the rights and obligations of the parties to a conflict in the conduct of warfare and to protect persons who are not (or are no longer) taking part in hostilities (civilians, wounded or sick soldiers, prisoners of war). These persons must be respected, protected and treated humanely by all parties. All the wounded and sick must also receive the medical care required by their condition. Those who provide such care must be respected and protected, as long as they are involved in their humanitarian tasks.

The various treaties defining IHL have become intricate, but the underlying message is simple. The human dignity of all individuals must be respected at all times without any kind of discrimination. Everything that *can* be done *should* be done to alleviate the suffering of those "*hors de combat*": persons who take no direct part in the conflict or who have been put out of action by sickness, injury, or captivity.

International humanitarian law: main legal sources
- Customary law
- Four Geneva Conventions of 1949 (194 States party to the Conventions)
- Two Additional Protocols of 1977
- Third Additional Protocol of 2005
- The Hague Conventions of 1899 and 1907
- United Nations Convention on Conventional Weapons of 1980
- Mine Ban Convention of 1997
- Cluster Munitions Convention of 2008

2.2.1 Principles underlying IHL: the "law of war"

- The human dignity of all individuals must be respected at all times.
- Persons no longer involved in the fighting (sick, wounded and shipwrecked combatants, and prisoners of war) and those who do not take a direct part in hostilities (civilians) are entitled to respect for their lives and physical and moral integrity. They shall in all circumstances be protected and treated humanely without any adverse distinction.
- The wounded and sick shall be collected and cared for.
- Captured combatants and civilians under the authority of an adverse party are entitled to respect for their lives, dignity, personal rights and convictions. It is forbidden to kill or injure an enemy who surrenders.
- Everyone shall be entitled to benefit from fundamental judicial guarantees. No one shall be held responsible for an act he has not committed. No one shall be subjected to physical or mental torture, corporal punishment or cruel and degrading treatment. Hostage taking is prohibited.
- The choice of methods and means of warfare is not unlimited, and must be proportional to the military goals sought. It is prohibited to use weapons and methods of warfare that cause unnecessary losses, superfluous injury or unnecessary suffering.
- Attacks shall distinguish between the civilian population and combatants and between civilian objects and military objectives. Accordingly, operations shall be directed only against military objectives.
- Medical personnel have rights and obligations in times of armed conflict.

British Museum

Figure 2.6

Soldiers blinded by chemical weapons during World War I: an example of means of warfare that cause superfluous injury and unnecessary suffering.

2.2.2 IHL and human rights law

IHL applies in situations of armed conflict, whereas human rights, or at least some of them, protect the individual at all times, in war and peace alike. Some human rights treaties permit governments to derogate from certain rights in situations of public emergency and if strict conditions are fulfilled. However, certain fundamental human rights must be respected in all circumstances and may never be waived, regardless of the emergency: in particular the right to life, the prohibition of torture and inhuman punishment or treatment, slavery and servitude, and the principle of legality and non-retroactivity of the law. No derogations are permitted under IHL because it was conceived for emergency situations, namely armed conflict.

IHL mainly aims to protect people who do not or are no longer taking part in hostilities. The rules embodied in IHL impose duties on all parties to a conflict, including non-governmental groups. Human rights, being tailored primarily for peacetime, apply to everyone. Their principal goal is to protect individuals from arbitrary behaviour by their own governments. Human rights law does not deal with the conduct of hostilities.

2.3 The distinctive emblems

The distinctive emblems of the red cross, red crescent, and red crystal are meant to mark certain medical and religious personnel and equipment which must be respected and protected during armed conflict (protective use). They also serve to show that persons or objects are linked to the International Red Cross and Red Crescent Movement including in situations other than armed conflict (indicative use). Their use is strictly defined (see Annex 2. A: The distinctive emblems).

Use of the emblems is restricted to the following entities.

1. Medical staff and services of the armed forces are the very first persons authorized to use the distinctive emblem, as a sign of protection.

2. Volunteers of a National Red Cross or Red Crescent Society, when duly authorized by the competent State Authority.

3. Staff of the International Committee of the Red Cross and the International Federation of Red Cross and Red Crescent Societies.

Persons and objects displaying the emblems must not be attacked, but on the contrary must be respected and protected; people bearing the emblem should be encouraged in their work.

V. Louis / ICRC

Figure 2.7

Armed forces' medical services.

B. Fjortoft / ICRC

Figure 2.8

National Society volunteers.

B. Heger / ICRC

Figure 2.9

ICRC, International Federation and National Society staff.

2.4 The International Red Cross and Red Crescent Movement and its Fundamental Principles

The International Committee of the Red Cross and the International Federation of Red Cross and Red Crescent Societies, together with the National Red Cross and Red Crescent Societies, form the International Red Cross and Red Crescent Movement.

Fundamental Principles of the Red Cross and Red Crescent Movement[1]

Humanity

Impartiality

Neutrality

Independence

Voluntary service

Unity

Universality

2

In peacetime, as in time of conflict, it is the duty of the armed forces and the National Society of every country to disseminate the rights and duties enshrined in IHL. This is necessary not only for these rules to become known, understood, accepted and respected by combatants, but also so that the whole population understands and supports its Red Cross or Red Crescent Society for it to become more efficient, for the benefit of all, in times of conflict and in times of peace. Part of this dissemination includes the respect due to the red cross, red crescent and red crystal emblems as a sign of protection.

2.5 Rights and duties of medical personnel according to IHL

IHL provides medical personnel with rights in times of armed conflict, but also assigns duties to them. The duties incumbent on them are directly linked to the rights of the protected persons placed in their care. These provisions are a case-specific refinement of the basic rights and duties defined by medical ethics and the Hippocratic oath. Medical personnel are bound by medical ethics and IHL to treat patients solely on the basis of need and without regard for their nationality, race and class, religious or political beliefs. These rights and duties have been defined to enable medical personnel to perform the humanitarian task entrusted to them, born of the desire to alleviate human suffering by helping and tending the wounded and the sick, which is the very purpose of the medical mission.

The Geneva Conventions define *medical personnel* as:

- persons assigned by a party to the conflict, whether on a permanent or temporary basis, exclusively to medical purposes (search, collection, transportation, diagnosis and treatment of the wounded and sick, and for the prevention of disease) – this includes doctors, nurses, orderlies, first aiders, and stretcher-bearers;
- persons assigned by a party to the conflict, whether on a permanent or temporary basis, exclusively to the administration or operation of medical units or medical transport – this includes administrators, drivers, cooks, mechanics, etc.

The term "medical personnel" is thus not confined to the narrow meaning of the word. All personnel required to ensure the adequate treatment of the wounded and sick are covered by the protection granted to them, as long as they form an integral part of the medical service.

1 See Annex 2. B: The Fundamental Principles of the International Red Cross and Red Crescent Movement.

Medical units, whether military or civilian, include what is set up for medical purposes:
• all buildings or installations (hospitals, clinics, first-aid posts, field hospitals, tents, etc.),
• blood transfusion and preventive medicine centres,
• medical and pharmaceutical depots and stores.

They may be fixed or mobile, permanent or temporary.

Medical equipment includes:
• stretchers,
• medical and surgical appliances and instruments,
• medical supplies, dressings, etc.

Medical transport can be organized by land, water, and air:
• ambulances, lorries or trucks,
• hospital ships, rescue craft,
• medical aircraft, etc.

Medical personnel must not be the object of attack, and must be allowed to care for the sick and wounded unhindered. They should wear the distinctive emblem of the red cross, red crescent or red crystal on a white ground and carry an identity card. Military medics may bear arms only for their own defence and to defend the wounded and sick from pillage. However, they must not use arms to prevent capture of their patients, units or themselves by the enemy; by doing so they lose their protected status.

If medical personnel fall under the control of enemy troops, they shall be allowed to continue their duties towards the wounded and sick. They shall not be compelled to perform acts contrary to medical ethics, or refrain from performing acts required by medical ethics. A patient remains a patient, and medical personnel have a responsibility to provide care according to their training and the means available. If captured medical personnel are not indispensable to the care of other prisoners, they should be repatriated. Those retained shall not be considered prisoners of war and their work shall be facilitated.

In occupied territory, civilian medical personnel should be allowed to continue providing adequate medical services for the civilian population.

The civilian population shall respect the wounded and sick, even if they belong to the enemy, and shall commit no act of violence against them. Civilians are permitted to collect and care for the wounded and sick of whatever nationality, and shall not be penalized for doing so. On the contrary, they must be aided in this work.

Medical units enjoy protected status so long as they are not used to commit acts harmful to the enemy, such as sheltering able-bodied combatants, storing arms or ammunition, or being used as military observation posts. Otherwise, their protection ceases and they become legitimate military targets. This is why strict controls must be established to safeguard the protected status of medical units and transport.

To enhance the protection of medical units and medical transport, they should be clearly marked with the red cross, red crescent or red crystal emblem, of the largest size possible. The emblem is the visible sign of protection conferred by the Geneva Conventions and their Additional Protocols.

2.6 Responsibility of States

As with any international agreement, the governments of States have a distinct responsibility whenever they become party to a treaty.

- The Geneva Conventions and their Additional Protocols are both contracts with other States and commitments towards humankind by which governments have agreed to certain rules that regulate the conduct of armed hostilities and the protection of persons who are not (or are no longer) taking part in hostilities, what is known as "law in war", or *jus in bello*. Its provisions apply to the warring parties regardless of the reasons for the conflict and whether or not the cause upheld by either party is considered to be just, or not.
- On becoming party to the four Geneva Conventions of 1949, States agree to respect and ensure respect for their obligations in all circumstances (common Art. 1).
- Reciprocity is not considered to be a prerequisite to a country adhering to and applying these rules, but it exists in reality and practice. It is in everyone's interest that everyone apply the law of his or her own accord.
- States are responsible for protecting those who do not participate or are no longer participating in hostilities.
- During peacetime, States are to promote IHL and train the members of their armed forces to respect IHL.
- At all times, States must take all measures necessary for the prevention and repression of any misuse or abuse of the distinctive emblems.
- On becoming party to the Geneva Conventions, States undertake to enact any legislation necessary to punish persons guilty of grave breaches of them, and are also bound to prosecute in their own courts any person suspected of having done so, or to hand over that person to another State for judgment. In other words, perpetrators of grave breaches, i.e. war criminals, must be prosecuted at all times and in all places, and States are responsible for ensuring that this is done.
- A number of independent mechanisms have been set up, each within its mandate and competency, to promote better compliance with IHL, including the ICRC, the International Fact-finding Commission, regional and United Nations bodies, and the International Criminal Court (Rome Statute of 1998). Their adequacy and sufficiency in meeting the task remains a challenge to humanity.
- Generally speaking, a State's criminal laws apply only to crimes committed on its territory or by its own nationals. International humanitarian law goes further in

ICRC

Figure 2.10

All too often the red cross emblem is used to indicate any health service without regard to its privileged legal status, which confers protection.

that it requires States to seek out and punish any person who has committed a grave breach, irrespective of his nationality or the place where the offence was committed. This principle of universal jurisdiction is essential to guarantee that grave breaches are effectively repressed. Such prosecutions may be brought either by the national courts of the various States or by an international authority. In this connection, the International Criminal Tribunals for the former Yugoslavia and Rwanda were set up by the United Nations Security Council in 1993 and 1994, respectively, to try those accused of war crimes committed during the conflicts in those countries.

- Lastly, the international community has created a permanent International Criminal Court (Rome Statute of 1998), which is competent to try war crimes, crimes against humanity, and genocide.

- The United Nations Security Council is the main body responsible for the maintenance of international peace and security. To this end, it may decide on measures, including coercive ones, against any State threatening or breaching international peace (Chapters VI and VII of the United Nations Charter). The rules that outlaw war, with some exceptions, are know as "the law on the use of force" or the *jus ad bellum*. This is different from the *jus in bello*, or IHL, which is the law applicable in times of armed conflict.

- "New" or "anarchic" conflicts lead to the partial, and sometimes total, weakening or breakdown of State structures. In such situations, armed groups take advantage of the political vacuum in an attempt to grab power. It is not because a State's structures have been weakened or are non-existent that there is a legal vacuum with regard to international law. The law, and its obligations, remain.

Admittedly, humanitarian rules are harder to apply in these types of conflict. The lack of discipline among belligerents, the arming of the civilian population as weapons flood the territory, and the increasingly blurred distinction between fighters and civilians often cause confrontations to take an extremely brutal turn – in which there is little room for respect for IHL.

As a result, this is the type of situation in which particular efforts are needed to make people aware of humanitarian law. Better knowledge of the rules of law will not solve the underlying problem which led to the conflict, but it is likely to attenuate its deadlier consequences.

Insofar as a "right – or even a duty – to intervene" is tantamount to justifying armed intervention undertaken for humanitarian reasons, this is a matter not for humanitarian law but for the rules on the legality of the use of armed force in international relations, i.e. of *jus ad bellum*, according to the Charter of the United Nations.

R. Sidler / ICRC

Figure 2.11
This ICRC car was targeted by "uncontrolled elements".

2.7 Reality check: some people do not follow the rules

Given what the law dictates, what is the reality on the battlefield? Whether in conflict situations or in peacetime, and whether national or international law is applicable, laws are violated and crimes committed. There are many examples of violations of IHL: surrounding a military objective with medical units so that it will not be targeted; hiding weapons in a hospital; transporting able-bodied combatants in an ambulance; using an aircraft displaying the emblem for reconnaissance missions; not respecting the non-combatant status of sick and wounded soldiers – on the contrary, all too often their survival is seen as an invitation by some to "finish the job", and atrocities are the result. All too often hospitals and medical personnel are the target of attack, or are prevented from doing their duty of caring for the sick and wounded, which is perceived by some as giving "succour and aid to the enemy". All these violations have three things in common: they seriously weaken the system of protection embodied in IHL, they divert people and objects displaying the red cross, red crescent or red crystal from their humanitarian purpose, and they put lives in danger by fostering mistrust.

T. Pizer / ICRC

Figure 2.12

Unfortunately, hospitals are not immune to attack: this photo shows a blatant contravention of IHL.

Red Cross and Red Crescent personnel are not immune to this lack of respect for IHL. Mussolini's air force bombed a Swedish Red Cross field hospital during the invasion of Abyssinia on 30 December 1935, and 28 people were killed and 50 wounded. More recently, masked gunmen entered the residence of the ICRC hospital in the village of Novye Atagi, Chechnya (southern Russia), in December 1996 and assassinated five nurses and the construction engineer in cold blood. The authors of this text have all too often been threatened, prevented from reaching and treating the victims, or seen their hospital attacked or bombed. The world over, colleagues, both civilian and military, are time and again made to suffer "simply" because they want to fulfil their humanitarian, ethical, and legal duty to care for their patients.

Humanitarian action is based on a fundamentally "optimistic philosophy", wrote Jean Pictet.[2] But this optimism in no way detracts from the "philosophy's" realism. It is aware that humanitarian work is difficult. Its greatest enemies may well be neither weapons nor disaster, but selfishness, indifference and discouragement. One should not despair, however. Rather one should see this as an incentive to redouble efforts to educate those involved in armed conflict. Medical ethics go hand in hand with IHL and the Fundamental Principle of impartiality: the sick and wounded are entitled to treatment, whatever their origin or political persuasion.

2 Jean Pictet (1914 – 2002) was Director-General and Honorary Vice-President of the ICRC. He was responsible for the preparatory works that led to the 1949 revision of the Geneva Conventions and the Additional Protocols of 1977, and his writings formed the basis of the Fundamental Charter of the International Red Cross and Red Crescent Movement, adopted in 1965.

All medical personnel should not only comply with medical ethics and IHL but should also disseminate their meaning to military and civilian authorities, ordinary soldiers and citizens.

Medical practitioners have a particularly important part to play: they have responsibilities with regard to individual patients but also towards society at large. They must convince combatants of the need to respect IHL, to refrain from attacking the medical facilities and personnel of the enemy and allow them to perform their humanitarian task. While the underlying philosophy of the Movement is *not* rooted in the principle of reciprocity, in practice medical professionals can only expect to benefit from the "protection" offered by the Geneva Conventions – in a general atmosphere of respect for the Fundamental Principles – if their colleagues practising on the "other" side also benefit from the same protection. They must inform those who bear weapons of their obligations and trust that colleagues in contact with the opposing side are doing the same. This has proved true in the past, and soldiers have often respected the principle of protection afforded to the sick and wounded and medical and religious personnel.

2.8 The neutrality of a National Red Cross/ Red Crescent Society

Another major problem faced during armed conflicts of a non-international character, that is to say internal conflicts, is the question of neutrality, especially of a National Red Cross or Red Crescent Society. The requirement of non-discrimination is of particular concern to Red Cross/Red Crescent Societies, it is in fact a condition for their recognition. They must be open to all those who wish to become members and must permit all social, political and religious groups to be represented; this representativity is the guarantee of the Societies' ability to engage in exclusively humanitarian activities and to resist all partisan considerations.

It is admittedly not always an easy task to apply the principle of neutrality, not least because everyone has personal convictions. When tension mounts and passions are aroused, every member of the Red Cross or Red Crescent must exercise great self-control and refrain from expressing his/her opinions in the discharge of his duties. Volunteers are not asked to be neutral – everyone is entitled to an opinion – but to act neutrally. That is an important distinction. The next difficulty is the fact that the parties to the conflict often take a dim view of neutral behaviour. In countries where an internal conflict is taking place, the armed forces fail to understand why the National Society does not condemn the activities of those they regard as "bandits", much less why it wants to provide assistance to any of their number no longer able to fight. As for the opposition, they are critical of the Society's connections with the authorities.

Anyone trying to work on both sides to help non-combatants is considered at best naïve, at worst a traitor. The extremely polarized nature of many struggles is such that *not taking a stand* is a hostile act in itself. This is why the Red Cross and Red Crescent's neutrality and impartiality must be explained. As one National Society first aider put it: "The best argument I have is to tell one of the parties to the conflict that if I take its side and ignore the victims on the other side, I will never again be able to bring help to its own wounded members".

It would appear, indeed, that the principles of neutrality and impartiality are ideals to be attained, inner qualities that are rarely inborn but that most often require one to overcome one's instincts. They demand from members of the Red Cross and Red Crescent Societies arduous and sustained efforts to overcome their own prejudices and preferences in order to be able to perform the purest act of impartiality, which is to give more help to the adversary who is the victim of great misfortune than to the friend whose suffering is less severe, or to care for the more severely wounded, even if guilty, before assisting the innocent whose injuries are slighter.

2.9 The role and mandate of the ICRC in situations of armed conflict

Established in 1863, the International Committee of the Red Cross (ICRC) is an impartial, neutral, and independent organization whose exclusively humanitarian mission is to protect the lives and dignity of the victims of war and internal violence and to provide them with assistance. The ICRC endeavours to prevent suffering by promoting and strengthening international humanitarian law and universal humanitarian principles.

The ICRC in a nutshell

Neutral, impartial and independent humanitarian organization.

Works in situations of armed conflict.

Entrusted with an international mandate under the Geneva Conventions.

Protects and assists victims of conflict.

Part of the International Red Cross and Red Crescent Movement.

The ICRC has been named the "guardian and promoter" of IHL by the States party to the Geneva Conventions. It works during armed conflict to protect and assist the victims: the wounded and sick, prisoners of war and other detainees, and the civilian population.

The ICRC does not take sides or determine right or wrong in a conflict. The neutrality of the ICRC, however, is not a widely appreciated principle. There are many who express indignation at its neutrality in the mistaken belief that neutrality betokens lack of commitment and courage. The ICRC, for its part, has great difficulty in getting the parties to a conflict to understand that the only thing it must grant equally to each is its willingness to serve, and that in other respects its activities are proportional to the needs, and consequently unequal when distress is greater on one side than on the other.

At the beginning of hostilities, the ICRC:
- reminds the belligerents of their obligations according to IHL;
- offers its services as a neutral intermediary for the accomplishment of humanitarian activities;
- makes an assessment of the needs;
- acts in favour of victims according to the needs.

The protection role the ICRC plays consists in acting in defence of people who are not, or no longer, taking part in combat: the wounded or sick, detainees or prisoners of war, and civilians, including the inhabitants of territories administered or occupied by a hostile power. The ICRC approaches the competent authorities to ensure that these victims receive humane treatment. The ICRC has the right to have access to prisoners of war (Third Geneva Convention), and detained persons covered by the Fourth Geneva Convention, including the right to visit detention camps.

The ICRC has an official policy of discretion. Only when it observes grave and repeated breaches of IHL and when its confidential representations have been in vain and it considers that the only means of helping the victims is to ask for the support of the international community, does it make public representations. This sometimes takes the form of an appeal to the States party to the Geneva Conventions, whose responsibility it is to respect and *ensure* respect for IHL. Such initiatives are nevertheless the exception rather than the rule.

ICRC activities

1. Protection during armed conflict:
   - protection of civilians confronted with the violence of armed conflict;
   - protection and care of the wounded, sick, and shipwrecked;
   - protection of prisoners of war and other detainees (registration and visits);
   - as a neutral intermediary, facilitation and accompaniment of the release of prisoners of war;
   - re-establishment of family links through Red Cross messages;
   - re-establishment of family links through the tracing agency for the missing and dead.

2. Assistance to victims of armed conflict – public health approach (shelter, water, sanitation, food, preventive and curative medical care):
   - economic security;
   - water and habitat;
   - health services (including assistance to the war-wounded and sick).

3. Preventive action:
   - promotion and dissemination of international humanitarian law (IHL);
   - advice and assistance with national measures to implement IHL;
   - mine risk education programmes to raise awareness among people exposed to the dangers posed by mines and unexploded ordnance.

ICRC delegates must be willing to talk to all those who are responsible for violations of IHL and human rights. They cannot pass judgment on them publicly, but must speak to them on behalf of those to whom speech is denied, and who have no one else to turn to. They often do so at considerable risk to their own personal safety and their words may fall on deaf ears, but if this policy of refraining from public denunciation makes it possible to alleviate the suffering of just one man, woman or child, that is ample recompense.

As a neutral and independent institution, the ICRC is authorized by the Geneva Conventions and their Additional Protocols to administer first aid and other care in the field to victims of armed conflict. Military authorities are required to permit the ICRC to collect and care for the wounded or sick of whatever nationality, even in invaded or occupied territories. The ICRC can offer its services to the parties, in particular in the medical realm to establish neutral or hospital zones, set up hospitals for the sick and wounded, assist existing hospitals, and provide rehabilitation for amputees, especially victims of anti-personnel landmines.

The ICRC helps to organize, or provide directly, relief to victims of armed conflict. These relief supplies cover the most essential needs, such as food, clean drinking water, shelter, clothing, and medical care.

Figure 2.13

The assistance pyramid: public health analysis of population needs.

2.9.1 Health services: assistance to the war-wounded and sick

Although proper medical care of sick and wounded soldiers and civilians in times of armed conflict is taken for granted by many governments today, poverty may compromise a government's efforts to provide such care. The ICRC maintains a capacity to aid States whose authorities show a willingness to assume their responsibilities towards their own soldiers and the civilian population.

The ICRC has deployed many assistance and training programmes to this effect. One example of an offer of services by the ICRC to two countries involved in a conflict was the case of the 1998 – 2000 war between Ethiopia and Eritrea. The ICRC provided assistance to help both governments to develop the programmes described below.

ICRC EXPERIENCE

The ICRC carried out the following programmes in Eritrea and Ethiopia from 1998 to 2001.

Ethiopia

- Training in advanced first aid, triage and evacuation for the war-wounded.
- War surgery seminars.
- Specialist surgical training for the war-wounded: thoracovascular, orthopaedic and neurosurgery.
- Maxillo-facial reconstructive surgery training programme.
- Short-term ICRC surgical team presence in an emergency situation.
- Support to the Ethiopian Red Cross Society ambulance service.
- Surgical material and equipment.
- Visits to thousands of POWs and their repatriation after cessation of hostilities.
- Repatriation of thousands of interned enemy aliens.

Eritrea

- Training in advanced trauma nursing care for ambulance staff.
- Emergency Room Trauma Course for the war-wounded.
- War surgery seminar.
- Short-term ICRC surgical team presence in an emergency situation.
- Intensive care nursing training for the war-wounded.
- Development of a physiotherapy training curriculum at the Institute of Nursing Care.
- Support to the Red Cross Society of Eritrea ambulance service.
- Surgical material and equipment.
- Visits to thousands of POWs and their repatriation after cessation of hostilities.
- Repatriation of thousands of interned enemy aliens.
- Assistance to thousands of internally displaced persons (food, shelter, water, sanitation, medical care).

While the ICRC is authorized to care for the wounded and sick during armed conflict, it is also involved in post-conflict reconstruction, indeed in development assistance, and, sometimes, the ICRC achieves the right balance.

ICRC EXPERIENCE

"We want to thank the doctors and nurses of the ICRC. Thank you for coming. And, thank you for leaving."

Rui Paolo [3]

3 Rui Paolo, Director of Hospital Services, Ministry of Public Health, Dili, Timor Leste, June 2001, on the occasion of the handover of the administration of the Dili General Hospital from the ICRC to the Ministry of Public Health.

ANNEX 2. A The distinctive emblems

The distinctive emblems of the red cross, red crescent and red crystal on a white ground are the symbols of impartial humanitarian work and do not represent any particular religious belief. They provide protection for military medical services and relief workers in armed conflicts. Moreover, they are also used for identification purposes by National Societies of the Red Cross and Red Crescent Movement in each country.

In the event of armed conflict, the distinctive emblems are a visible sign of the protection conferred by international humanitarian law upon medical personnel and equipment. The persons and objects displaying them must not be attacked, but on the contrary must be respected and protected.

Their use as a *protective sign* during armed conflict is authorized exclusively for:

- medical units, transport and personnel, as well as religious personnel, of the armed forces;
- civilian medical units, transport, and personnel, as well as civilian religious personnel, that have received special permission by the competent authorities to use the emblem;
- medical units, transport and personnel that a Red Cross or Red Crescent National Society has put at the disposal of the medical services of the armed forces.

Persons and buildings/structures/objects displaying the emblem must not be attacked, damaged or prevented from operating, but, on the contrary, must be respected and protected, even if, for the moment, they are not caring for or housing either wounded or sick people. The perfidious use of the emblems is explicitly prohibited.

In order to ensure effective protection during wartime, the *indicative* use of the emblem must be *strictly controlled* and only used for:

- Red Cross or Red Crescent National Societies, in order to indicate that persons or goods have a connection with the Society in question (it must be small in size to avoid any confusion with the emblem used as a protective symbol);
- exceptionally, ambulances and first-aid stations exclusively assigned to the purpose of giving free treatment to the wounded and sick, with the authorization of a National Society.

The International Committee of the Red Cross and the International Federation of Red Cross and Red Crescent Societies are authorized to use the emblem for all their activities and at all times.

Misuse of the emblem is a serious problem. In peacetime, hospitals, clinics, doctors' offices, pharmacies, non-governmental organizations and commercial companies tend to use the emblem in order to benefit from its reputation, although they are not entitled to do so. This abuse clearly weakens the protective value of the emblem in wartime.

Any case of misuse of the emblem should be reported to the relevant Red Cross or Red Crescent National Society, the ICRC, or the International Federation of Red Cross and Red Crescent Societies.

Parties to the Geneva Conventions shall take the precautions necessary for the prevention or repression of any abuse of the distinctive emblems.

During peacetime staff and volunteers of the International Red Cross and Red Crescent Movement, through their behaviour, activities and awareness-raising efforts, seek to ensure that the protective value of the distinctive emblems is well known to the military and the general public.

Please note:

On 8 December 2005, a Diplomatic Conference adopted Protocol III additional to the Geneva Conventions, which recognizes an additional distinctive emblem. The "Third Protocol emblem", also known as the red crystal, is composed of a red frame in the shape of a square on edge on a white background. According to Protocol III, all distinctive emblems enjoy equal status.[4] The conditions for use of and respect for the Third Protocol emblem are identical to those for the distinctive emblems established by the Geneva Conventions and, where applicable, the 1977 Additional Protocols.

J. Perez / International Federation

4 While no longer in use, the red lion and sun on a white background is still recognized by the Geneva Conventions.

ANNEX 2. B The International Red Cross and Red Crescent Movement

The International Committee of the Red Cross and the International Federation of Red Cross and Red Crescent Societies, together with the National Red Cross and Red Crescent Societies, form the International Red Cross and Red Crescent Movement.

Born of the compassion felt by a Swiss citizen, Henry Dunant, at the sight of the dead and wounded abandoned on the battlefield of Solferino, the International Red Cross and Red Crescent Movement believes that its first duty is to render wars that cannot be avoided less inhuman, and to alleviate the suffering that they cause. Its aim has been to bring a little bit of humanity into the horrors of war. The Movement was founded as a result of a conflict and for conflicts, with the aim of helping people in distress on the battlefield.

The International Red Cross and Red Crescent Movement endeavours, in its international and national capacity, to prevent and alleviate human suffering wherever it may be found. Its purpose is to protect life and health and to ensure respect for human beings. It promotes mutual understanding, friendship, cooperation and lasting peace amongst all peoples.

The humanitarian ideas of the Movement are reflected in the seven Fundamental Principles that guide the activities of all its components at all times: humanity, impartiality, neutrality, independence, voluntary service, unity and universality.

Components of the International Red Cross and Red Crescent Movement

The International Committee of the Red Cross (ICRC)
The International Committee of the Red Cross, created in Geneva, Switzerland in 1863, is the founding body of the Red Cross/Red Crescent Movement. It is an independent humanitarian organization. As a neutral intermediary and on the basis of the Geneva Conventions or the customary law of nations, which grant it the right of initiative, it endeavours to protect and assist the military and civilian victims of international and non-international armed conflict and internal disturbances and tension.

The countries of the world have entrusted to the ICRC the roles of promoter and custodian of international humanitarian law, and the task of working for their development and worldwide dissemination.

The functions of the ICRC are defined in its own statutes, in those of the Red Cross/Red Crescent Movement, and also in the international treaties known as the Geneva Conventions of 1949 and their Additional Protocols of 1977.

The International Federation of Red Cross and Red Crescent Societies
The International Federation is the permanent liaison body between National Red Cross and Red Crescent Societies. It attempts to prevent and alleviate human suffering through the promotion of activities by National Societies and so contribute to peace. The International Federation encourages the creation and assists the development of National Societies in providing services to the community.

The International Federation organizes and coordinates international relief efforts for victims of natural disasters and promotes the adoption of national disaster-preparedness plans. First aid is an important part of both everyday community service and disaster preparedness.

The National Red Cross/Red Crescent Society
There are 186 National Red Cross/Red Crescent Societies around the world, with more currently being created. From the outset, the goal of the Red Cross/Red Crescent Movement has been to create relief societies which, in their capacity of *auxiliaries to their countries' armed forces' medical services*, would be called upon to tend wounded or sick soldiers. The establishment of such Societies was consistent with the aims of the original Geneva Convention of 1864.

The National Societies' activities have developed steadily and diversified over the years. The Societies' concern, at first directed only at members of the armed forces, now extends to protection and assistance of all those, whether military or civilian, who are the victims of conflicts, in close cooperation with the ICRC, and of natural catastrophes, in close cooperation with the International Federation of Red Cross and Red Crescent Societies. National Societies have also developed many activities in peacetime as *auxiliaries to the public authorities* to alleviate suffering, improve health, and prevent disease.

National Society membership is open to everyone and services are provided on the sole criterion of need. National Societies must fulfil stringent conditions to achieve recognition by the ICRC and obtain International Federation membership. Among these conditions: respect for the Fundamental Principles, and recognition by their home government as a voluntary aid society, auxiliary to the public authorities.

Each National Red Cross/Red Crescent Society has its own particular characteristics, and its activities cover a wide range depending on the needs of the country and on the Society's operational capabilities. The one activity that all National Societies share is the provision and teaching of first aid.

The Fundamental Principles of the International Red Cross and Red Crescent Movement

Humanity
The International Red Cross and Red Crescent Movement, born of a desire to bring assistance without discrimination to the wounded on the battlefield, endeavours – in its international and national capacity – to prevent and alleviate human suffering wherever it may be found. Its purpose is to protect life and health and to ensure respect for the human being. It promotes mutual understanding, friendship, cooperation and lasting peace amongst all peoples.

Impartiality
It makes no discrimination as to nationality, race, religious beliefs, class or political opinions. It endeavours to relieve the suffering of individuals, being guided solely by their needs, and to give priority to the most urgent cases of distress.

Neutrality
In order to continue to enjoy the confidence of all, the Movement may not take sides in hostilities or engage at any time in controversies of a political, racial, religious or ideological nature.

Independence
The Movement is independent. The National Societies, while auxiliaries in the humanitarian services of their governments and subject to the laws of their respective countries, must always maintain their autonomy so that they may be able at all times to act in accordance with the principles of the Movement.

Voluntary service
It is a voluntary relief movement, not prompted in any manner by the desire for gain.

Unity
There can be only one Red Cross or one Red Crescent Society in any one country. It must be open to all. It must carry out its humanitarian work throughout its territory.

Universality
The International Red Cross and Red Crescent Movement, in which all Societies have equal status and share equal responsibilities and duties in helping each other, is worldwide.

Humanity and Impartiality express the objectives of the Movement.

Neutrality and Independence ensure access to those in need of help.

Voluntary service, Unity and Universality enable the International Red Cross and Red Crescent Movement to work effectively all over the world.

Chapter 3

MECHANISMS OF INJURY DURING ARMED CONFLICT [1]

1 Acknowledgement: the ballistics portion of this chapter is largely based on the work of Doctor of Forensic Science Beat Kneubuehl, Institute of Forensic Medicine, University of Bern, in collaboration with Armasuisse, Centre for Military and Civilian Systems, Science and Technology, Ballistics Laboratory, Thun, Switzerland. His cooperation and collaboration with ICRC surgeons over the years have permitted a whole generation of war surgeons to gain an important insight into the wounding potential of weapons. We hope that this knowledge has permitted better surgical management of the victims of armed conflict and other situations of violence where the weapons of war are used.

3.1 The various mechanisms of injury

The surgeon caring for the war-wounded will face a wide variety of injuries. During armed conflict, all the usual trauma of peacetime continues unabated and natural catastrophes occur as well. Armed conflict itself provokes blunt injuries and burns, and trauma that are specific to weapons and the circumstances of warfare. More specifically, combat involves penetrating and blast injuries; these will be the major focus of this book.

> Modern armed conflict causes specific penetrating and blast injuries, as well as blunt and burn trauma.

3.1.1 Blunt injury in war

Blunt trauma is common in war. Severe injury due to blunt trauma may be more difficult to detect than in cases of penetrating trauma, and X-ray diagnosis and other more sophisticated technologies are more valuable for patient assessment.

Vehicle accidents
Military vehicles often drive at high speed over difficult terrain where safe roads do not exist. In addition, the environment of any accident may be hostile (presence of enemy forces, minefields, etc.).

Collapsed buildings and falls
The collapse of bombed buildings will cause blunt and crush injuries to anyone inside. People may fall from destroyed buildings or a balcony.

Explosions and anti-tank mines
A bomb or shell explosion can throw people against objects. A car, bus or lorry carrying passengers may drive over an anti-tank mine. The explosion of the mine overturns or destroys the vehicle and people are thrown out and onto the ground, thus suffering blunt injuries.

Beatings
Mistreatment of prisoners, officials, "suspected sympathizers" or other civilians is, alas, all too common.

3.1.2 Penetrating wounds caused by weapons of war

A moving projectile has kinetic energy. When the projectile enters the human body, it releases energy to the tissues, thus causing a wound. There are two types of wounding projectile: bullets and metallic fragments (splinters, shards and shrapnel).[2]

Fragment wounds
Exploding bombs, shells, rockets and grenades, submunitions (cluster bomblets) and some landmines produce metal fragments from the weapon casing (primary projectiles). In the past these fragments were usually irregular in size and shape. In many modern weapons, however, the inner lining of the casing is scored, creating weak points that break off easily on explosion. This generates a controlled fragmentation of large numbers of pre-formed fragments that are regular in size and shape, and usually less than 1 g in weight. In other, usually improvised bombs and explosive devices, nails, bolts, steel pellets or other metallic debris surround the explosive material.

T. A. Voeten / ICRC

Figure 3.1
Different types of shells and explosives

2 The word "shrapnel" is derived from the name of Major-General Henry Shrapnel (1761–1842), an English officer, who designed a new type of artillery shell. The term originally referred only to the metal balls dispersed when a shrapnel shell bursts, but is often used to describe metal fragments intentionally included in explosive devices. For shells, bombs or other munitions, the technical term for these particles is fragments, splinters or shards, fragments being the preferred name in scientific documents and the term that is used in this manual.

Fragments are shot off at a very high speed, which decreases rapidly with the distance travelled because of their non-aerodynamic character. The farther the victim is from the explosion, the more superficial the wounds. At very close range, multiple high-energy fragments combined with the blast effect create mutilating injuries and are often fatal.

Explosions may cause stones or bricks to break up, or shatter glass panes, or the force of the blast wind may transport other debris, also producing penetrating fragments (secondary projectiles), as described in Section 3.1.4.

Fragment wounds are usually multiple and the wound tract is always widest at the entry. There may or may not be an exit wound.

Bullet wounds

Handguns and military assault rifles shoot bullets at high speed. Bullet wounds seen in the injured are usually single with a small entry; multiple bullet injuries are more likely to kill. There may be no exit wound but, if there is, the size is variable. The amount of tissue damage depends on a number of factors.

Under international humanitarian law – both customary and treaty-based – the use of bullets that expand or flatten easily in the human body is prohibited during armed conflict. The bullets used should not cause superfluous injury and unnecessary suffering. This fundamental rule is based on the general principles of international humanitarian law, according to which "… it is sufficient to disable the greatest possible number of men" and "That this object would be exceeded by the employment of arms which uselessly aggravate the suffering of disabled men or render their death inevitable".[3] Because of various ballistic effects, however, some bullets do break up into fragments in the body.

B. Kneubuehl

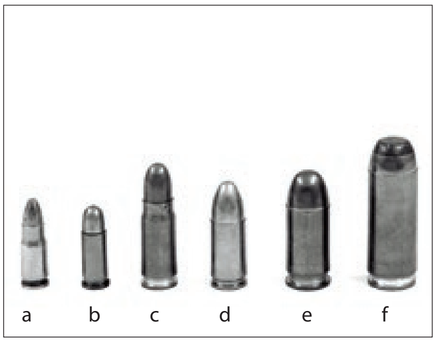

Figure 3.2.1

Examples of pistol ammunition:

a. 5.45 x 19 mm

b. 6.35 mm Browning

c. 7.63 mm Mauser

d. 9 mm Luger

e. 45 calibre automatic

f. 50 calibre AE (Action Express) semi-jacketed bullet

B. Kneubuehl

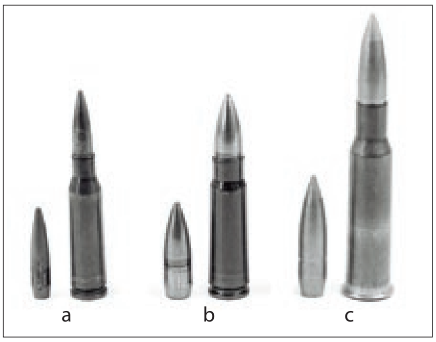

Figure 3.2.2

Examples of military rifle ammunition:

a. 5.45 x 39 mm Kalashnikov

b. 7.62 x 39 mm Kalashnikov

c. 7.62 x 54R Dragunov

B. Kneubuehl

Figure 3.2.3

9 mm Luger semi-automatic pistol (SIG-Sauer P 228).

B. Kneubuehl

Figure 3.2.4

7.62 x 39 mm AK-47 Kalashnikov military assault rifle.

3 Paragraphs from the preamble to the St Petersburg Declaration of 1868 on the prohibition of the use, in wartime, of certain explosive projectiles.

Cut wounds, "arme blanche"

Apart from the modern soldier's bayonet, knives, machetes or pangas[4] may be used by combatants in "traditional" warfare in some societies. These produce incised or puncture wounds.

3.1.3 Anti-personnel landmine wounds

Anti-personnel landmines (APM) come in two basic types: blast mines with a pressure plate, which explode when someone steps on them, and fragmentation mines, which explode when a tripwire is touched. Unexploded ordnance (the lethal remnants of war, consisting of cluster bomblets, bombs and shells that did not explode when fired) is often left on the battlefield and has injuring effects similar to those of fragmentation mines. These weapons continue to kill and injure large numbers of civilians long after the end of hostilities and have widespread humanitarian and economic repercussions.

ICRC

Figure 3.3.1

Blast mine.

ICRC

Figure 3.3.2

Fragmentation mine.

ICRC

Figure 3.3.3

PMF "butterfly mine".

Patterns of injury

Anti-personnel mines cause three distinct patterns of injury according to the blast effect or the production of fragments.

Pattern 1

A person steps on the pressure plate of a blast mine. The explosion and local primary blast effect cause a traumatic amputation or severe injury of the contact foot and leg. There may be wounds to the other leg, genitals, abdomen or pelvis, and the contralateral arm. The severity of the wound depends on the amount of explosive in the mine compared to the body mass (Figure 3.4).

Pattern 2

A person touches the tripwire attached to a fragmentation mine, which provokes its detonation. Fragmentation mines cause the same injuries as other fragmentation devices, such as bombs or grenades, and the severity of the injury depends on the distance of the victim from the explosion.

Pattern 3

A person handles a mine: setting a mine; trying to clear a mine; a child playing with a mine. The explosion causes severe injury to the hand and arm, and frequent injuries to the face and eyes or chest.

For further information on anti-personnel landmine injuries, see Chapter 21 in Volume 2.

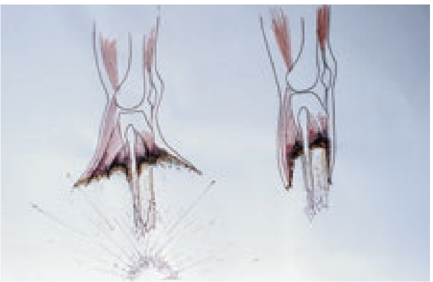

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Figure 3.4

The "umbrella" effect of a blast mine: superficial tissues suffer less damage than deep-tissue planes. The wounds are all severely contaminated by mud, grass and pieces of the shoe driven deep into the tissues at the moment of explosion.

4 In some countries where a "traditional" form of warfare is still practised, a large, heavy knife – the machete or panga – is often used as a weapon. The overhead motion strikes the victim on the head, neck or shoulder.

3.1.4 Explosive blast injuries

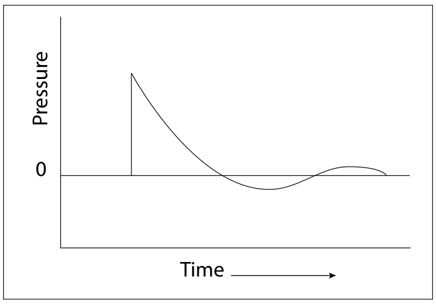


Figure 3.5

Blast wave overpressure followed by negative pressure trough.

The detonation of high-energy explosives creates a travelling pressure blast wave in the air (or in water for underwater explosions). The wave causes rapid and large changes in the outside atmospheric pressure: the positive pressure shock wave is followed by a negative pressure phase (Figure 3.5). Immediately behind the pressure wave is a mass movement of air: the blast wind.

As the blast wave passes any unprotected person it affects all parts of the body, especially those normally containing air. A victim of blast may not have any external injury. A single, large explosion may injure many people at the same time. Explosions in a closed space (building, bus, etc.) are more fatal than those out in the open.

Categorization of blast injuries

Blast injuries are commonly categorized into four types.

Primary

These are direct pressure effects. Rupture of the tympanic membrane is the most common injury. Rupture of the lung alveoli and their capillaries ("blast lung") is the most lethal injury amongst survivors.

Secondary

These injuries include missile wounds. Fragments may arise from the bomb casing or contents (primary missiles). Home-made bombs (improvised explosive devices, known as IEDs) may be packed with nuts, bolts, screws and ball bearings. In addition, the blast wind may mobilize various objects (secondary missiles) that then cause penetrating wounds.

Tertiary

These effects are directly due to the blast wind. It can cause total body disintegration in the immediate vicinity of the explosion or traumatic amputations and evisceration further away. The wind can make buildings collapse or throw people against objects. Trauma may be blunt, crush or penetrating.

Quaternary

Miscellaneous types of harm due to burns, asphyxia from carbon monoxide or toxic gases, or the inhalation of dust, smoke or contaminants.

The various injuries caused by major blasts cover a whole spectrum of trauma and many patients suffer several injuries from a variety of effects: i.e. multiple injuries from one single weapon system.

Other situations of blast injuries

The blast wave travels more rapidly and much further in water than in air. Blast injuries in water occur at greater distances and can be more severe. Moreover, underwater explosions tend to cause pure primary blast injury. A "fuel air explosive" – the liquid explosive material is dispersed in the air like an aerosol and then ignited – also tends to bring about pure primary blast injury and quaternary effects due to the consumption of all oxygen in the nearby air.

The blast effect of a marine mine exploding below an icy surface, or the "deck slap" of a ship hit by a torpedo, produces a shock wave that can severely fracture the bones of anyone on deck or inside the ship. Similarly, some anti-tank mines send a blast wave through the floor of the vehicle causing closed fractures of the foot and leg. The foot appears like a "bag of bones" inside intact skin, which was described in World War I as "*pied de mine*" – a mine foot. Anti-personnel blast mines have a local blast effect, vaporizing the tissues of the contact foot, as described previously.

For further information on blast injuries, see Chapter 19 in Volume 2.

3.1.5 Burns

A large explosion may cause flash burns or the carbonization of tissues. Bombing may start secondary fires in buildings and an anti-tank mine may ignite the fuel tank of a vehicle. Burns are common amongst the crews of tanks, ships and aircraft hit by missiles. Some types of anti-personnel blast mine provoke burning as well as traumatic amputation of the limb.

Certain weapons cause specific burns: napalm and phosphorus bombs, magnesium flares and decoys.

3.1.6 Non-conventional weapons

International humanitarian law prohibits the use of chemical and biological weapons. Despite this absolute prohibition, one cannot entirely exclude the possibility of a State or non-State armed group using them.

A bomb surrounded by radioactive material – a "dirty bomb" – is not a nuclear bomb. The explosion is caused by conventional means but radioactive material may be spread over a wide area, depending on the force of the explosion. The bombing of nuclear medicine and other laboratory facilities, or nuclear power plants, may also release radioactive material into the atmosphere.

The reader should refer to standard military texts and those of the Organization for the Prohibition of Chemical Weapons (OPCW) regarding chemical agents (chemical weapons are discussed in Section 15.10), and documents published by the World Health Organization (WHO) regarding biological agents. We shall not discuss the effects of nuclear weapons here.

3.2 Ballistics

3.2.1 Introduction

Blast and penetrating missile wounds occur in times of armed conflict and whenever the weapons of war are used in peacetime. Weapons cause specific but variable patterns of injury. While standard surgical techniques will suffice to treat simple wounds, the management of war wounds produced by high-energy weapons is based on an understanding of the mechanisms by which projectiles cause injury: wound ballistics. Only by understanding certain physical phenomena can the surgeon appreciate the different varieties of wounds seen in armed conflict and the difference between these wounds and the trauma that is seen in everyday civilian practice.

Although the study of ballistics may be "interesting" in its own right, the clinician does not always know what weapon inflicted the injury and never knows the energy available at point of impact. One can only estimate the transfer of energy in the tissues from the extent of tissue damage.

The study of ballistics gives us an understanding of the basic mechanisms at work during wounding. The importance of this knowledge lies in the fact that projectile injuries should be neither under- nor over-treated. The clinical assessment of the actual wound is the most important factor determining management, and an understanding of ballistics allows the surgeon to better understand the pathology and assess the injuries that he sees, rather than explain every wound and determine specific treatment. "Treat the wound, not the weapon"[5] is not a vain concept.

5 Lindsey D. The idolatry of velocity, or lies, damn lies, and ballistics. *J Trauma*. 1980; **20**: 1068 –1069.

Basic definitions
Ballistics is the part of the science of mechanics that studies the motion and behaviour of a projectile and its effects on a target.

Internal ballistics
Internal ballistics deals with the processes that occur inside a gun barrel when a shot is fired: gas pressures on combustion of the propellant powder, the energy and heat released and the course of the projectile in the barrel are just some of its concerns.

External ballistics
External ballistics describes the trajectory of the projectile once it has left the barrel. The influences affecting the flight include gravity, air resistance and crosswind deflection, stability of the projectile (spin and yaw), together with any contact prior to the projectile reaching the target, known as ricochet.

Terminal ballistics
Terminal ballistics describes what happens when the projectile hits the target, as well as any counter-effects produced by the target on the projectile. If the target is biological tissues, terminal ballistics is called *wound ballistics* and describes the effects on the tissues.

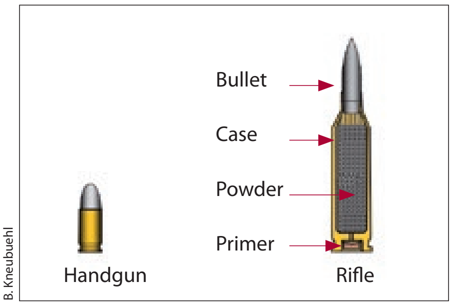


Figure 3.6
Main parts of a bullet cartridge.

3.2.2 Internal ballistics

Bullets: fundamental concepts
Figure 3.6 shows the main components of a bullet cartridge. The primer is struck by a mechanism in the gun to produce a small detonation and flame that sets off the propellant in the case. This causes a very rapid burn with the production of a large volume of rapidly expanding gas, which pushes the bullet out of the barrel of the gun. The velocity with which the bullet leaves the barrel is called the muzzle velocity.

Bullet construction
Bullets are classified according to a number of parameters; one is their manufacture: internal structure and composition (Figure 3.7). They vary in calibre and mass.

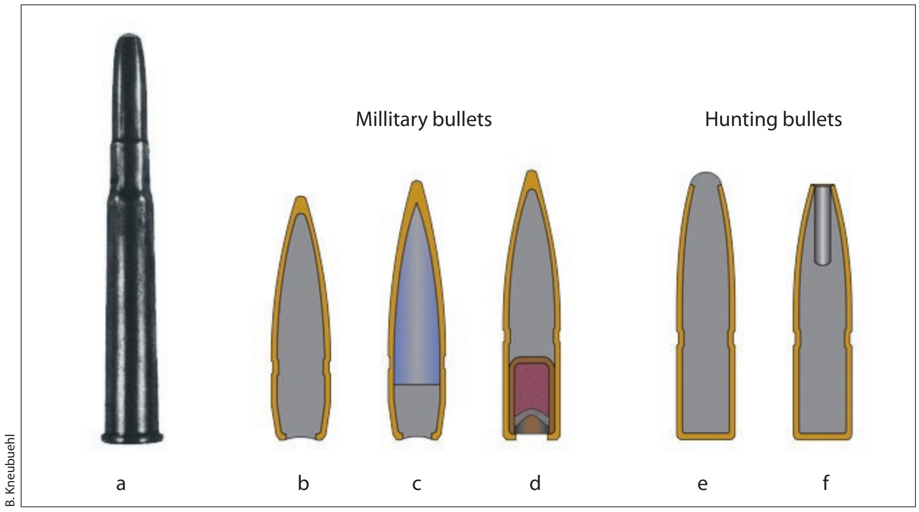


Figure 3.7
Bullets according to construction.

a. .303 British Mark II bullet produced in Dum Dum, India, 1896 (see footnote number 8).

b. Full metal jacket (FMJ) bullet: military-issue bullets have a soft core (lead) with a full metal jacket of copper.

c. Hard core bullet: the lead is replaced by steel or tungsten for better penetrating power.

d. Tracer bullet: contains a pyrotechnical substance at the tail end that burns up in flight and shows the trajectory. Used to identify and pinpoint the target.

e. Semi-jacketed bullet (SJ): part of the point is not jacketed, thus exposing the lead inside. These bullets are supposed to be used only for hunting; their use by combatants during armed conflict is illegal.

f. Semi-jacketed hollow-point bullet (SJ-HP): also a hunting bullet with a hollow-nose tip. Also illegal during armed conflict.

Apart from the hunting bullets mentioned in Figure 3.7, special weapons and their ammunition exist for hunting, such as shotguns, of which the shells discharge multiple lead or steel balls (pellets) available in diameters from 2 to 9 mm (Figure 3.8).

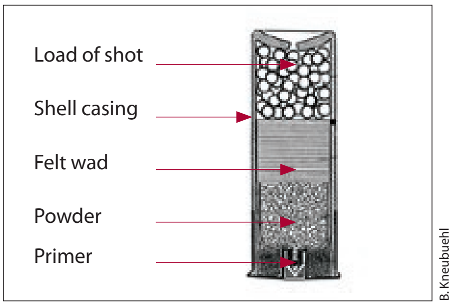


Figure 3.8

Shotgun shell and shot load.

Hunting bullets are not supposed to be used by combatants in armed conflict. These bullets are constructed in such a way as to kill rather than wound. The idea is to be more “humane” when hunting wild animals and to achieve a “rapid and clean kill”. Nonetheless, the surgeon will be faced with wounds caused by such weapons because of accidents or criminal activity, or because combatants have illegally used them during combat.

The international legal limits placed on bullets used by the armed forces do not apply to domestic use during peacetime, and the civilian surgeon may at times face more devastating gunshot wounds than the military surgeon on the battlefield.

Muzzle velocities

Firearms are classically divided into two categories: high-velocity (rifles and machine guns) and low-velocity (handguns and sub-machine guns).The latter fire relatively heavy bullets at low muzzle velocities of 150 – 200 m/s. A typical military assault rifle fires a smaller bullet at 700 – 950 m/s. This, however, says nothing about the actual velocity when the bullet reaches the target.

9 mm Luger pistol	350 m/s
.38 Special handgun	260 m/s
.44 Magnum handgun	440 m/s
5.56 x 45 mm NATO rifle	960 m/s
7.62 x 39 mm AK-47 Kalashnikov rifle	720 m/s
5.45 x 39 mm AK-74 Kalashnikov rifle	900 m/s
12 gauge shotgun	420 m/s

Table 3.1 Some examples of muzzle velocity from different firearms.

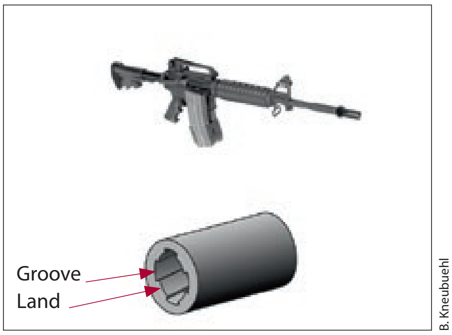


Figure 3.9

Cross section of a rifled gun barrel:
5.56 x 45 mm M-16 A4 military assault rifle.
The grooves and lands (the elevated sections between the grooves) are shown.

The gun barrel

A bullet is a long cylindrical projectile that only flies with stability if a high spin around its longitudinal axis is attained, thus giving it a gyroscopic effect. To achieve this spin, gun barrels are constructed with interior spiral grooves (twists). This is a rifled barrel, used in all handguns and high-velocity rifles (Figure 3.9).

The barrels of shotguns are smooth on the inside; they are not rifled. This limits their accuracy and range (Figure 3.10).

Design of firing

Another classification of firearms is according to their design of firing. A weapon operated with a single hand is a “handgun”. If the barrel and cartridge chamber are in one piece, this is a “pistol”. If several chambers rotate behind the barrel, it is called a “revolver”. If both hands are required to operate the weapon, it is referred to as a “long weapon” (generally a rifle, shotgun or machine gun).

Figure 3.10

Typical hunting shotgun with smooth barrel.

Firing capacity refers to how individual shots are fired. In a single-shot weapon, every shot is loaded individually. A repeating weapon has a magazine that holds a number of cartridges, which are loaded manually one after the other. If the loading movement is repeated automatically after every shot, but every shot is fired individually, this is a semi-automatic weapon. If the automatic loading of cartridges allows several shots to be fired with one pull of the trigger, it is known as an automatic weapon.

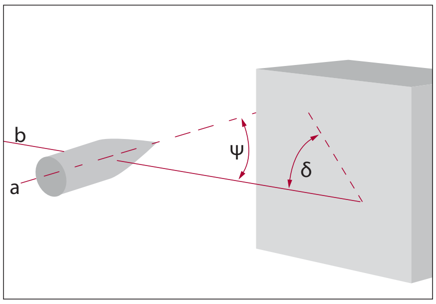
In modern military usage, most weapons are automatic rifles, sub-machine guns, machine guns or semi-automatic pistols.

3.2.3 External ballistics

Flight in air

Once discharged, several variables affecting the projectile in flight tend to influence its stability, accuracy of targeting, or velocity. The most important variables include the following:

- Spin about its own longitudinal axis, giving it gyroscopic stability.
- Distance travelled and the effect of gravity, including the shooting angle – is the bullet fired upwards or is the trajectory flat?
- Air drag: friction is responsible for 10 % of total area drag, while 90 % is due to pressure effects; faster bullets are retarded proportionately more – rifle bullets are aerodynamically shaped to decrease air drag; this is not the case with shotgun cartridges or metal fragments.
- Crosswind deflection.
- Raindrops hitting the bullet.
- Bullet hitting an obstacle before hitting the target.



B. Kneubuehl

Figure 3.11

Angle of incidence and angle of impact:

a. Longitudinal axis of bullet
b. Direction of flight
Ψ. Angle of incidence
δ. Angle of impact

Yaw

A rifle bullet in flight does not travel in a simple straightforward motion. Because it is a spinning gyroscope, the bullet "wobbles" and undergoes some very complicated movements (nutation, precession), the most important being yaw: the nose of the bullet moves up and down, away from the line of flight, and describes an angle with the target surface at impact (Figure 3.11). This influences the wounding potential of the bullet, as a large degree of yaw will destabilize the motion of the bullet inside the target.

Ricochet

A bullet may hit an obstacle during its flight. This may be a branch of a tree, a belt buckle, a concrete wall, the ground or a soldier's helmet or body armour. This causes a ricochet; the bullet is given a small "push" that destabilizes it (Figure 3.12). There is an increase in the deviation of the nose of the bullet (yaw); the bullet may even tumble, rotating about its transverse axis. Such a large yaw angle at point of impact will have important consequences for the wounding potential of the bullet in the target.

In addition, if the "push" is great enough, the bullet may deform or even fragment before hitting the target.

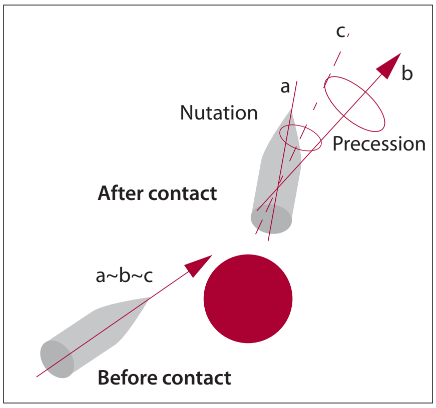


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Figure 3.12

Ricochet: effect on a bullet after contact with an obstacle.

3.2.4 Summary

There are, therefore, quite a number of variables involved in determining the characteristics of a projectile before it hits the target and these will influence its behaviour in the target and its efficiency in creating wounds. They include:

- velocity at moment of impact and any residual velocity if there is an exit;
- mass, shape, internal structure and composition of the projectile;
- type of weapon, handgun or rifle;
- stability of the projectile in flight;
- any yaw at moment of impact.

3.3 Terminal ballistics

3.3.1 Role of kinetic energy

Any moving object has kinetic energy, whether it is a hand-wielded knife or club, a bullet fired from a gun or a fragment given off by the explosion of a shell. This energy is described by the well-known formula:

$$E_K = \frac{1}{2} m v^2$$

This defines the total kinetic energy that the object possesses, but does not define the kinetic energy expended when the projectile passes into and through a target. For a bullet or fragment that does not change its mass, this is calculated from the difference in velocity between entry and exit.

$$E_{K\,EXP} = \frac{m\,(v_1^2 - v_2^2)}{2}$$

If there is no exit, then $v_2 = 0$, and all the kinetic energy has been transferred. If the bullet breaks up into fragments, then the mass (m) also changes, and $E_{K\,EXP}$ is modified.

Total kinetic energy is the potential for causing damage; transferred kinetic energy is the capacity to cause damage. Actual tissue damage, however, depends on the efficiency of this energy transfer, which is determined by many other variables, as will be shown.

3

Weapons according to E_K
Yet another classification of weapons is based on the amount of kinetic energy available for transfer.

- Low energy: knife or hand-energized missiles.
- Medium energy: handguns.
- High energy: military or hunting rifles, with a muzzle velocity above 600 m/s or a large mass of projectile.

For metal fragments given off by an explosion the initial velocity is very high; this decreases rapidly with distance. The wounding potential depends on the mass of the fragment and the distance of the victim from the weapon.

3.3.2 Laboratory experiments

Many researchers have performed different experiments to describe the effect of projectiles on tissues. Targets have included human cadavers, various animals (pigs, dogs, goats) and tissue simulants.

Tissue simulants are specially-prepared blocks of gelatine or glycerine soap, which have a density and/or viscosity close to that of muscle tissue. Soap is plastic and any deformation remains unchanged, representing the maximum effects. Gelatine is elastic and deformations disappear almost entirely; they are studied with high-speed cameras. If the stress on gelatine exceeds the limit of its elasticity then it will crack and tear, showing fracture lines.

Compared to human cadavers and animals, tissue simulants have the advantage of allowing repetitions of the experiment, changing only one variable at a time. These laboratory experiments are all approximations, however, of what happens in a live human being.

Surgeons working for the ICRC have collaborated over many years with the ballistics laboratory of the Swiss Federal Department of Defence.[6] This laboratory uses gelatine and glycerine soap for its ballistics experiments. Its results have been confirmed by comparison with clinical cases treated by ICRC surgeons in various war zones throughout the world.

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6 See footnote 1.

According to these laboratory studies, five categories describe the behaviour of projectiles – non-deforming and deforming bullets – be they from rifles or handguns, and fragments.

3.3.3 Non-deforming rifle bullet: full metal jacket (FMJ) military bullet

When a standard military bullet hits a soft object while in stable flight, it produces a "shooting channel" that presents three distinctive phases: narrow channel; primary temporary cavity and terminal narrow channel (Figure 3.13).

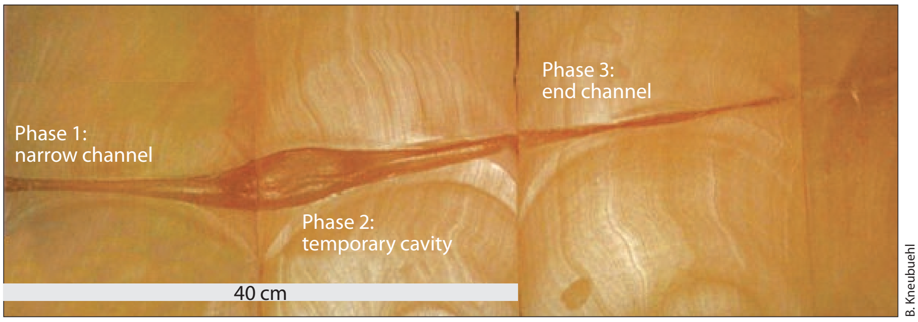

Figure 3.13
Non-deforming rifle bullet (FMJ) in soap.

Phase 1
Straight narrow channel with a diameter about 1.5 times the calibre of the bullet. The greater the velocity, the wider the channel. Different types of bullet have a different length of narrow channel, typically 15 – 25 cm.

Phase 2
The channel opens into the "primary temporary cavity". The reported diameter of this cavity is anywhere between 10 and 15 times the calibre of the bullet.

Figure 3.14 shows the motion of the bullet in a simulant. It starts to yaw, and tumbles, turning a full 270°, and then advances with its tail end forward. The whole lateral surface of the bullet comes into contact with the medium, which greatly decelerates the bullet and subjects it to a high level of stress.

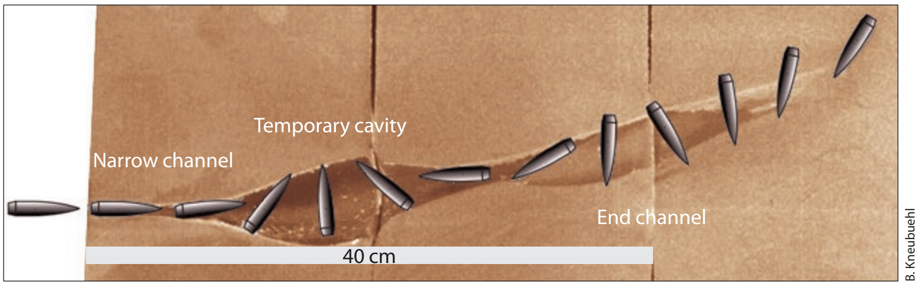

Figure 3.14
The bullet tumbles in the gelatine or soap: it rotates 270° about a transverse axis that is perpendicular to the long axis. (Graphic demonstration of bullet superimposed on soap blocks. The proportions between bullet and trajectory are exaggerated for the sake of clarity.)

The slowing of the bullet involves a release of kinetic energy which, in turn, causes the rapid and massive displacement of gelatine radially outwards, producing a cavity *behind* the projectile; there is a slight delay in the production of the cavity because of the inertia of the gelatine mass. There is a vacuum in this cavity that quickly sucks in air from the entry hole, and from the exit hole if there is one. The cavity collapses after a few milliseconds, only to reform again, with a smaller volume. The temporary cavity effect continues until all the transferred energy is used up: the cavity pulsates! In water or gelatine, there are up to 7 – 8 pulsations, in biological tissue usually 3 – 4.[7]

The diameter of this cavity depends upon the elastic properties of the medium, as well as the amount of kinetic energy transferred. Fissures radiating from the shooting channel indicate that the shearing effect of the cavity has exceeded the elasticity of the gelatine.

7 The formation of a temporary cavity is often described as "cavitation". In terms of physics, this is a misnomer. Cavitation creates bubbles that appear on a body when it travels through a fluid at a velocity so high that the critical pressure drops below the vapour pressure: Bernoulli's principle.

Phase 3
The tumbling slows down and the bullet continues in a sideways position at a considerably reduced speed. In some cases, a narrow straight channel is observed; in others, the tumbling seems to continue but backwards, the bullet again assuming a lateral position, and a second cavity occurs. This does not reach the size of the primary temporary cavity. The bullet then creeps forward and finally stops, always with the tail end facing forwards.

In an elastic medium such as glycerine, what remains in the shooting channel at the end of the process and all temporary effects is called the "permanent channel".

References to these basic definitions of phases of the shooting channel will be made throughout this chapter.

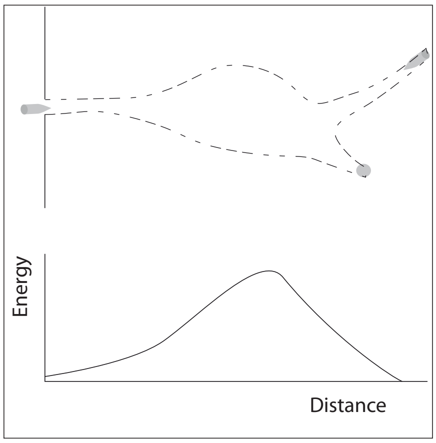

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Figure 3.15

The sketch shows the position of the bullet and the extent of the shooting channel at different phases. The graph represents the transfer of kinetic energy along the bullet track: bullet fragmentation occurs at the peak of energy transfer.

Please note:

These three phases occur with all FMJ rifle bullets, but each bullet has a specific shooting channel. The narrow channel of the 7.62 mm AK-47 is long (15 – 20 cm), while the 5.45 mm AK-74 produces a narrow channel of less than 5 cm before formation of a temporary cavity begins.

Tumbling (yaw) in the target medium
Given a long enough shooting channel, all FMJ rifle bullets tumble. How early the tumbling motion begins determines the length of the narrow channel, and the onset of temporary cavity formation. This depends on the stability of the bullet (yaw) at the point of impact. The less stable the bullet in flight, the greater the yaw, which rapidly brings a larger bullet surface into contact with the medium, leading to early tumbling and a short narrow channel. How early FMJ bullets tumble is also a function of their manufacture design (mass, centre of gravity, etc.) and shooting distance.

Fragmentation of FMJ bullets
It is during Phase 2 – the temporary cavity – that certain bullets deform or even break apart because of the enormous stress exerted on them. This occurs when the bullet-medium interface is at its maximum, the cavity is widest, and the transfer of kinetic energy is highest (Figures 3.15 and 3.16). While the projectile acts on the target medium, this is a good example of the medium acting on the projectile. This fragmentation occurs only at short ranges, up to 30 – 100 m, depending on the bullet's construction and stability.

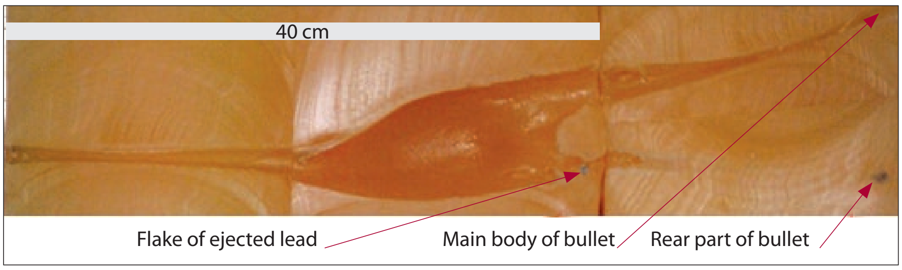

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Figure 3.16

Fragmentation of FMJ bullet during Phase 2, i.e. creation of the temporary cavity.

The bullet flattens on its sides, bends in the middle and, finally, the jacket splits and the lead inside spills out (Figure 3.17). This gives the "shower of lead" picture often seen on X-rays (Figures 3.35, 4.5 and 10.5). If the bullet breaks, the smaller fragment typically deviates downwards. The fragmentation depends on the construction of the bullet and the velocity; at impact velocities below 600 m/s, no FMJ deforms or breaks apart.

If the bullet does fragment then the primary temporary cavity is larger than is the case with an intact bullet. This represents a much larger transfer of kinetic energy and has important clinical repercussions.

ICRC

Figure 3.17

Jacket split apart, exposing the lead within.

3.3.4 Deforming rifle bullets: dum-dum[8]

Some bullets (e.g. hunting bullets) are constructed to always deform, for example by flattening: hollow-nosed, semi-jacketed, soft-pointed, etc. (Figure 3.7 e. and f.). These are usually grouped under the term "dum-dum" bullets and are illegal for military use according to international law.

Deforming bullets are designed to change their shape readily ("mushrooming"), thus increasing their cross-sectional area, but without losing mass – the spent bullet weighs as much as the original. They are used mainly in handguns with a muzzle velocity below 450 m/s, and are available for domestic use (by special police forces and criminals). Fragmenting bullets, on the other hand, break up, lose mass and create a "wall" of particles, thus increasing the total effective cross-sectional area. They are used for hunting.

Figure 3.18 shows a semi-jacketed rifle bullet mushrooming immediately on impact with a soft medium. The increased cross section causes greater bullet-medium interaction; the bullet slows down quickly, releasing kinetic energy very early. The narrow channel almost completely disappears and the temporary cavity occurs right after impact. At first, the cavity is almost cylindrical; it then decreases conically.

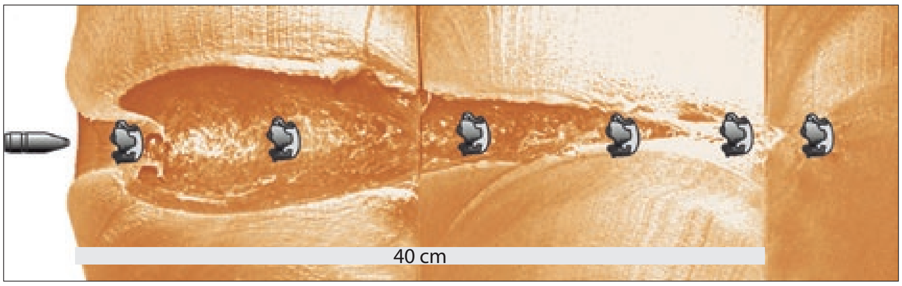


Figure 3.18

Deforming semi-jacketed rifle bullet (SJ) in soap. The bullet "mushrooms" just after impact, then continues in a linear trajectory. (Graphic demonstration of bullet superimposed on soap blocks.)

The principal difference between a full metal jacket and semi-jacketed bullet is the depth of penetration at which maximum energy transfer occurs in the shooting channel. The volume of the cavities is the same in both examples in Figure 3.19, indicating equal transfer of kinetic energy.

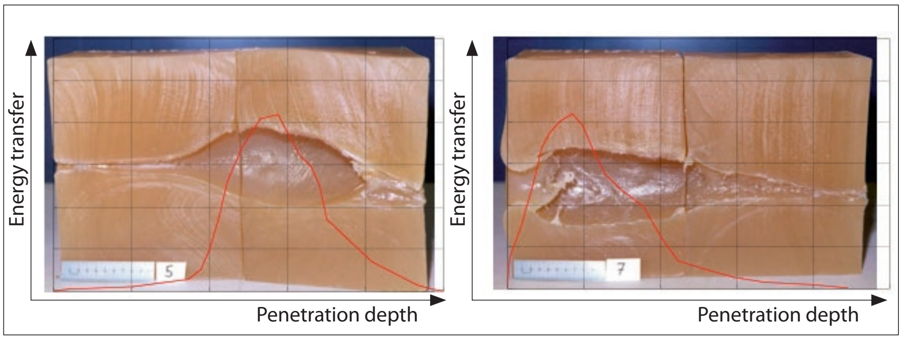


Figure 3.19

Soap blocks showing comparison between ballistic profiles of FMJ and SJ bullets – the transfer of kinetic energy occurs far sooner with the SJ bullet.

8 The Indian Ordnance Department of the British Army developed a bullet for its colonial troops in 1897 at an ammunition factory in the town of Dum Dum, north-east of Calcutta (Kolkata) because the previous bullet was judged to be ineffectual and caused insignificant injuries. The new bullet had a round nose with a full metal jacket of copper-nickel covering a lead core, with the exception of 1 mm at its tip where the lead was bare.

The bullet was used against the Afridi Afghans in 1897 – 98, and again against the Mahdi Army at Omdurman, Sudan, in 1898 with devastating effect. The bullet was judged to be "inhumane" according to the Declaration of St Petersburg of 1868 and was banned by the Hague Convention of 1899. Projectiles causing unnecessary injuries ("maux superflus") were not allowed. As an example, the Conventions mentioned projectiles whose metal jacket did not fully cover the lead core. Since then, all projectiles possessing the same qualities (deformation by expanding or flattening easily) have received the collective name of dum-dum.

The same effect is observed when using a synthetic bone simulant encased in gelatine (Figure 3.20).

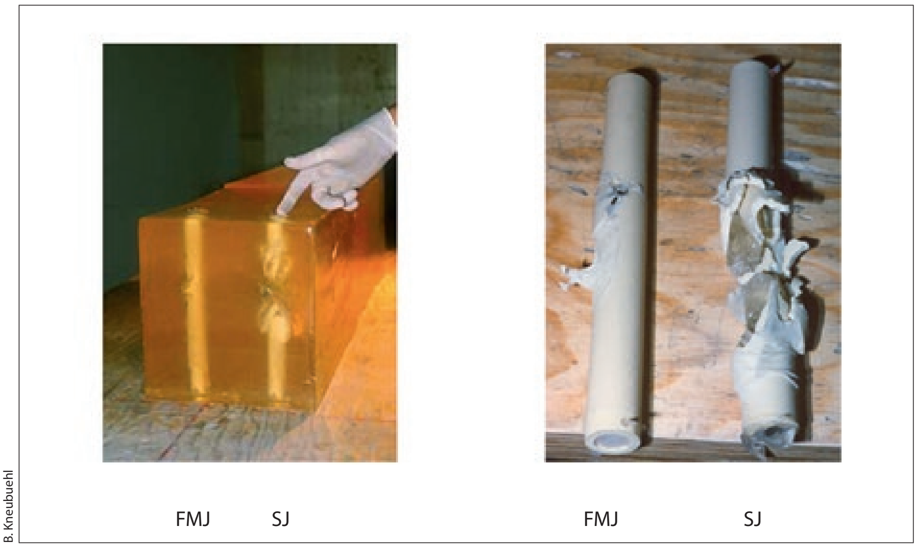


Figure 3.20
Comparison between an FMJ bullet and an SJ bullet: synthetic bone at a shallow depth of gelatine. The FMJ bullet breaks the bone simulant during the narrow channel phase; the shooting channel is practically the same with or without the bone simulant. At the same depth, the SJ bullet shatters the bone simulant completely.

Ricochet effect

When an FMJ bullet strikes an obstacle before hitting the target it is destabilized. After impact, there is almost no narrow channel and the shooting channel resembles what occurs with a deforming or dum-dum bullet (Figure 3.21). This phenomenon has important clinical consequences.

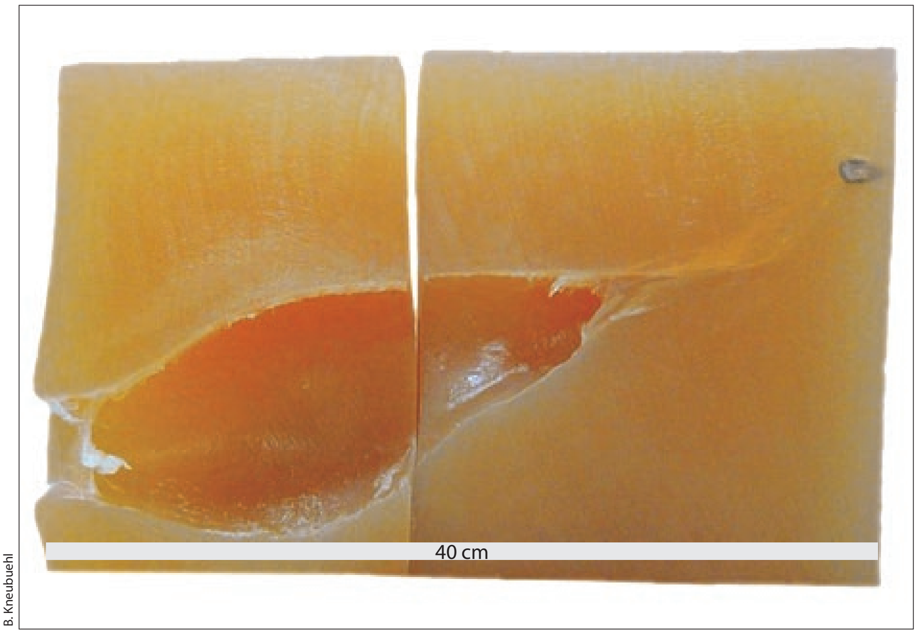


Figure 3.21
FMJ rifle bullet after ricochet effect in soap. The large impact angle after ricochet destabilizes the bullet, which tumbles easily and early in the shooting channel. Note that the temporary cavity starts to form almost immediately on impact, similar to an SJ bullet.

Please note:

Jacket construction is not the only decisive factor in the behaviour of a bullet, be it full or semi-jacketed. It is quite possible to manufacture a bullet that will fragment at high velocities, deform at medium velocities, and retain a stable shape at low velocities.

3.3.5 Handgun bullets

Handgun bullets may be much heavier than rifle bullets.

Non-deforming bullet

The shooting channel of a non-deforming handgun bullet shows little yaw and no tumbling; the tip of the bullet continues to point forward and the bullet penetrates deeply (Figure 3.22). The temporary cavity is long and narrow.

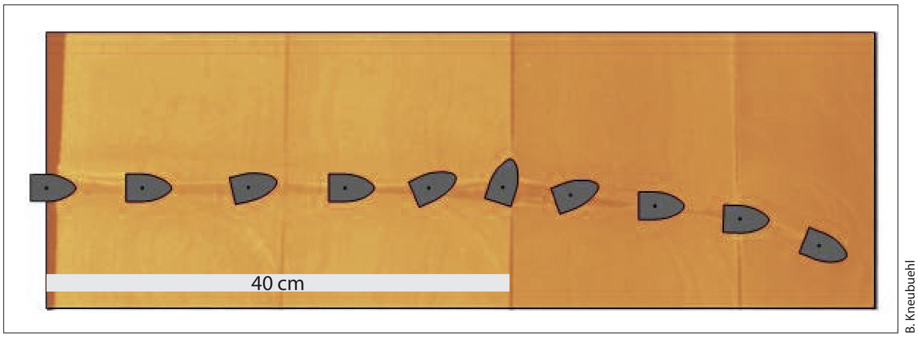


Figure 3.22

Standard military pistol bullet, full metal jacket in soap, no tumbling of the bullet. (Graphic representation of bullet superimposed on soap blocks.)

Deforming bullet

A soft point, deforming handgun bullet – as used by special police forces – mushrooms at entry (Figure 3.23). The large cross section area causes an abrupt reduction in velocity and great transfer of kinetic energy with an immediate, and large, temporary cavity.

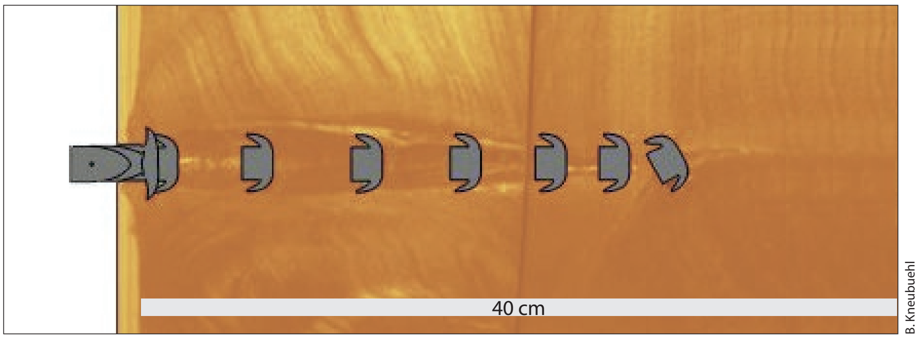
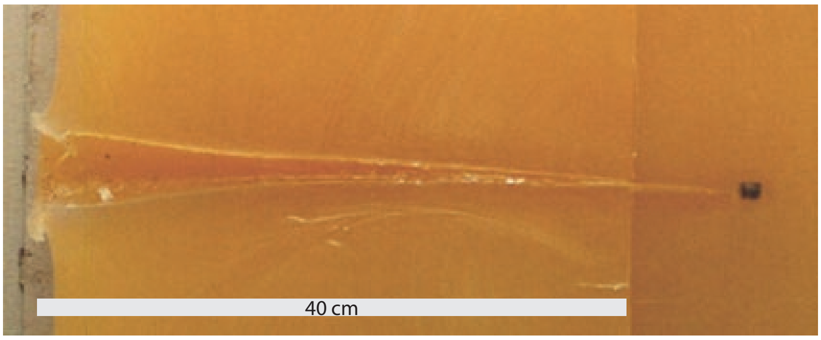


Figure 3.23

Deforming handgun bullet in soap: mushrooming effect. (Graphic representation of bullet superimposed on soap blocks.)

3.3.6 Fragment projectiles

Fragments given off from the explosion of a bomb, rocket or grenade are not aerodynamic; they have an irregular shape. Their velocity decreases rapidly with distance owing to air drag. They have an unstable flight path with an irregular rotation around an indefinite axis. On impact, the biggest cross section comes into contact with the target surface, immediately transferring a maximum of kinetic energy. No yaw or tumbling occurs in the target.



B. Kneubuehl

Figure 3.24

Fragment profile in soap: the widest point is at entry, the cavity is cone shaped.

The shooting channel always has the largest cavity diameter at the entry, and is larger than the diameter of the fragment. The cavity then decreases constantly in a cone-like fashion (Figure 3.24).

The depth of penetration of the fragment will depend on its kinetic energy, but with a particular relationship between velocity and mass. Figure 3.25 shows two fragments with the same kinetic energy; the volumes of the cones are equal.

Thus, a light but rapid fragment tends to transfer most of its energy shortly after impact on the target; a heavy and slow fragment penetrates further and dissipates its energy along the longer shooting channel.

B. Kneubuehl

Figure 3.25

Two fragments with the same kinetic energy – note the difference in energy deposition along the track, demonstrated by the difference in the cavities:

a. Light, fast-moving fragment.

b. Heavy, slow-moving fragment.

3.4 Wound ballistics

Moving projectiles cause wounds by a transfer of kinetic energy to the body that destroys, disrupts, and deforms tissue. One studies wound ballistics in order to understand the mechanisms that produce this injury.

Potential for wounding is one thing; the *actual wound* facing the surgeon is another.

3.4.1 Laboratory studies versus human body

The experiments using tissue simulants as described above help one to understand the processes at work. Laboratory models are, nonetheless, only an approximation and show only the physical part of the process. The tissue structure of the human body is far too complex for a laboratory model to duplicate injuries. Tissue simulants have the disadvantage of being homogeneous media; living tissue is not, as described later. The laboratory results must be compared to clinical cases for confirmation and this has been the procedure adopted by the ICRC and by other wound ballistics experts including the Armasuisse laboratory.

In the real world of clinical practice there are so many variables involved that one cannot be predictive; the surgeon cannot say with certainty that such and such a bullet will always result in a specific wound. One can however be descriptive and, after a good clinical examination, the surgeon can better understand the pathology that he sees, how it was created, and what sort of surgical management is required. The type of wound, its anatomic location, and the amount of actual tissue disruption are the determinant clinical factors.

3.4.2 Projectile–tissue interaction

When a bullet strikes a human body, a projectile–tissue interaction occurs that results in tissue damage, with a reciprocal influence of the tissues on the bullet. This interaction depends on a number of factors, which all result in the transfer of kinetic energy from the projectile to the tissues.

This transfer of kinetic energy either compresses, cuts or shears tissue, causing crush, laceration or stretch. The local energy transfer at a given point along the bullet track is more important in producing tissue damage than the total quantity of energy transferred.

Tissue disruption is due to compression, cutting and shear: crush, laceration and stretch.

A bullet striking a human body goes through the same three phases as in the laboratory simulants – if the bullet track is long enough. In the laboratory experiments with glycerine, the "permanent channel" was defined as what remains of the shooting channel at the end of the process and all temporary effects. In biological tissues, the "permanent wound cavity" of the shooting channel is the definitive tissue damage after all temporary effects have been taken into account. This is the wound channel that the surgeon sees and is the final result of the crush, laceration and stretch of the tissues.[9]

Crush and laceration injury

A projectile causes physical compression and forcing apart of tissues along the shooting channel – crushing and laceration. This is the immediate physical effect of a penetrating foreign body; the bullet damages tissues with which it comes into direct contact, cutting through tissues as would a knife. This tissue damage is permanent and found in the final wound. This is the principal effect caused by low- and medium-energy weapons, such as handgun bullets.

9 Much confusion has been created in surgical literature by authors calling the immediate crush damage of the Phase 1 narrow shooting channel the "permanent cavity", as distinct from the "temporary cavity" where stretch damage occurs. In this manual, in accordance with the Arma-suisse laboratory, the permanent wound cavity is the channel that remains at the end of the wounding process and constitutes the sum of crush, laceration and stretch injury.

At higher energies, when a bullet tumbles or deforms, a larger area of tissue is exposed to its effective cross section and suffers crush. The track left behind by crush is not equal along its length, but increases with bullet yaw in the tissues.

Stretch injury

Tissues have an elastic tensile strength that resists stretching. When a certain limit is reached, capillaries are ruptured and contusion of the tissues occurs. Beyond a critical limit, the tissues themselves are torn, just as laboratory gelatine shows fracture lines. The tissue damage from stretch may be permanent or only temporary.

Tissue stretch occurs during formation of the temporary cavity, which takes place in all projectile wounds, whatever the energy, type or motion of the projectile, and at all points along the entire shooting channel. There is even a minor temporary cavity effect during the Phase 1 narrow channel.

The volume of the cavity is determined by the amount of energy dissipated and the tissue elasticity-resistance. This stretching resulting from the temporary cavity performs work on tissues that have already been injured by crush and laceration, thus adding to the local immediate damage. In wounds from low- or medium-energy projectiles, it is minimal.

When a bullet tumbles (or deforms or fragments), the release of kinetic energy is much greater and is superimposed on greater tissue crush, resulting in a large Phase 2 temporary cavity: a momentary massive displacement of tissue in all directions away from the track of the bullet.

As in gelatine, the cavity pulsates: an elastic acceleration followed by a deceleration of the surrounding tissues: a shearing action. The vacuum in the cavity sucks in air, contaminants, foreign bodies (textile strands from the clothing, dust, etc.) and bacteria through the entry and any exit wound.

In high-energy wounds the volume of the temporary cavity can be up to 25 times that of the permanent cavity left behind, and anywhere between 10 and 15 times the diameter of the bullet. Although this volume is proportional to the kinetic energy dissipated, and will affect the amount of tissue damage, other factors related to the tissues can be even more important in determining the actual extent of injury.

3.4.3 Tissue factors

Resistance to crush, laceration and stretch differs widely among different types of tissue and anatomic structure. Tissue elasticity and heterogeneity are important factors in determining much of the bullet–tissue interaction.

Tissue elasticity

Elastic tissues tolerate stretch well, but may still suffer severe crush. The lung and skin have excellent tolerance, and leave relatively little residual damage after stretch. Skeletal muscle and the bowel wall of empty intestines have good tolerance. The brain, liver, spleen, and kidney are non-elastic, and shatter when stretched. Fluid-filled organs (heart, full bladder, full stomach and intestines) react badly owing to the incompressibility of the fluid contents; they may even "explode".

Nerves and tendons are mobile and blood vessels elastic; they are usually pushed out of the way by the temporary cavity.

Cortical bone is dense and rigid and resists stretch. However, if the temporary cavity accelerates a large enough muscle mass with sufficient energy, the bone is bent beyond its tensile strength and breaks; it may even be shattered violently, especially the diaphysis of a long bone. This phenomenon is an example of a fracture without a direct hit by a bullet. The same mechanism takes place during fracture from a blunt injury, except that the energy transfer bending the bone occurs from the outside.

Tissue heterogeneity

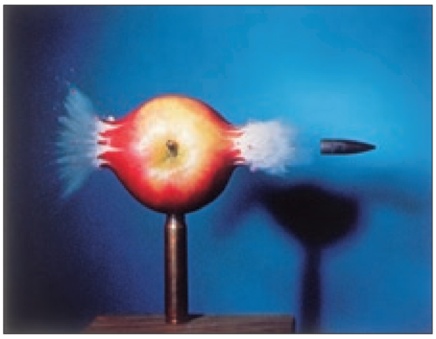
Apart from these considerations of tissue elasticity, there is the particular local anatomy to consider. A block of gelatine approximates skeletal muscle in its elasticity and density, but it is homogeneous. A human limb or the face are a mixture of rigid and elastic tissues comprising fascial compartments enclosing muscles, tendons and ligaments, large blood vessels and nerves, and bones. Not only does each anatomic element have a different elastic tensile strength, but the mixture of elements has its own interactive properties. The various interactions of projectile, soft-tissue organs and bony fragments can become very complicated.

Bound together and boundaries

How tightly tissues are bound together, and to nearby structures such as fascia of varying thickness, also affects the amount of permanent damage a cavity stretch can leave behind. If one side of a structure is fixed and the other side has free movement, a shearing force develops. Fascial planes may also serve as channels for the dissipation of energy – via the path of least resistance – to more remote tissues.

Boundaries limiting the pulsation of a temporary cavity can be very significant. They include not only fascia and aponeuroses, but also hollow, fluid-filled organs: the brain in the rigid cranium, the heart, the full urinary bladder. An empty stomach will be simply transfixed by a stable bullet. The same bullet will cause a full stomach to "explode".

A graphic laboratory example of boundary effect is found in Figures 3.26.1 and 3.26.2. The two pictures show the results with a high-energy bullet cavity. The apple literally explodes after passage of the bullet. Note that the temporary cavity is always created after the passage of the bullet; it is not simultaneous.



Harold & Esther Edgerton Foundation, courtesy of Palm Press, Inc.

Harold & Esther Edgerton Foundation, courtesy of Palm Press, Inc.

Figures 3.26.1 and 3.26.2

Demonstration of boundary effect on the temporary cavity due to a high-energy rifle bullet: the apple literally explodes after the passage of the bullet.

Clinically, these effects can create apparent paradoxes. For example, a heavy and slow bullet can cause a more severe wound in highly elastic tissue, such as lung, than a lighter, faster bullet with more kinetic energy. The heavier, slower bullet produces more crush. The faster, lighter one uses up more energy in creating the temporary cavity, which leaves little residual damage. However, the faster and lighter bullet will create more damage in less elastic tissue (liver, brain), which cannot accommodate stretch as well.

Transfer of kinetic energy does not affect all tissues to the same extent and in the same way.

3.4.4 Pathological description of the permanent wound cavity

The permanent cavity of the final wound that the surgeon sees is the result of a mixture of crushing, laceration and stretching of the tissues. Most of the damage in the majority of ballistic wounds is due to direct crush and laceration.

A number of macroscopic and microscopic changes occur. Severe vasoconstriction blanches the skin around the entry wound for 3 – 4 hours owing to the stretch. This is followed by a hyperaemic reaction that lasts up to 72 hours.[10]

10 Fackler ML, Breteau DVM et al. Open wound drainage versus wound excision in treating the modern assault rifle wound. *Surgery* 1989; **105**: 576 – 584.

In the wound of skeletal muscle itself, three histological zones have been described (Figure 3.27).[11]

1. Crush zone of the wound channel filled with torn and necrotic tissue: 2 – 4 times the diameter of the bullet.
2. Contusion zone of muscle adjacent to the missile tract: the thickness of this zone is variable and averages about 0.5 cm; tissue damage is irregular and uneven.
3. Concussion zone of variable distance with congestion and extravasation of blood: the stretch is not great enough to tear tissues, but sufficient to injure capillaries. The demarcation between the contusion and concussion zones is not always well defined.

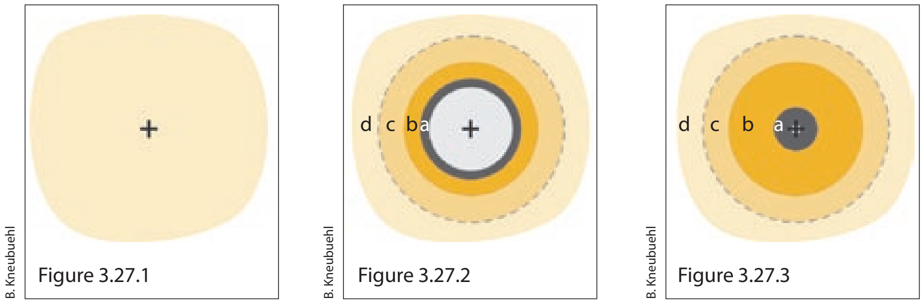


Figure 3.27
Schematic drawing of histopathological changes in the shooting channel:

3.27.1 Geometric shooting channel
3.27.2 Phase of maximum temporary cavity
3.27.3 Final permanent wound channel

a: Zone of destroyed tissues
b: Contusion zone
c: Concussion zone
d: Unaffected tissues

These histological changes are more severe with high kinetic-energy transfer – tumbling or deformation of the bullet – and do not change notably over 72 hours. The tissue damage is irregular along the wound track and how much of the damage is irreversible is not immediately apparent. This has obvious consequences for wound management and the extent of surgery necessary (see Chapter 10).

Bacteria are also seen within the permanent cavity. The sucking action of the vacuum of the temporary cavity aspirates bacterial flora from outside, and projectiles are not sterile; the heat of firing is not intense enough for long enough to sterilize the bullet.

3.4.5 Clinical applications

> The external appearance of a bullet wound can be deceptive. Tiny entrance and exit holes can be associated with extensive internal damage.

The length of the shooting channel in the body, the existence of an exit wound and the characteristics of the particular structures traversed will all greatly affect the final wound caused by a high-energy bullet that the surgeon sees.

The position of the Phase 2 temporary cavity along the wound track is clinically very relevant. Figure 3.28 demonstrates the trajectory of an FMJ rifle bullet in a laboratory soap block with a simple entry wound and three possible exit wounds.

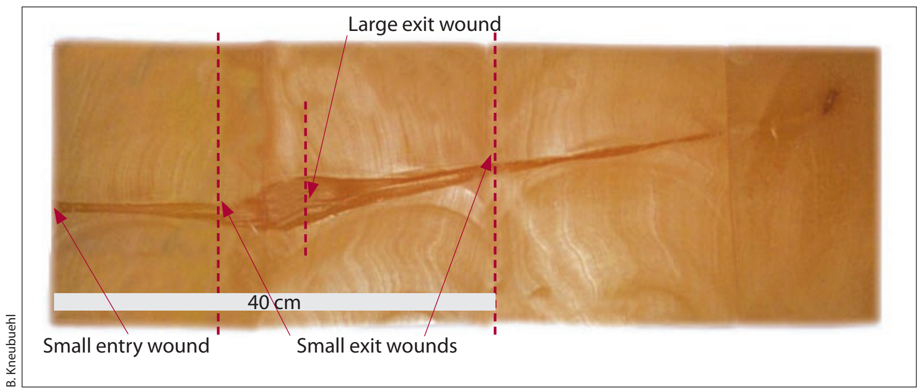
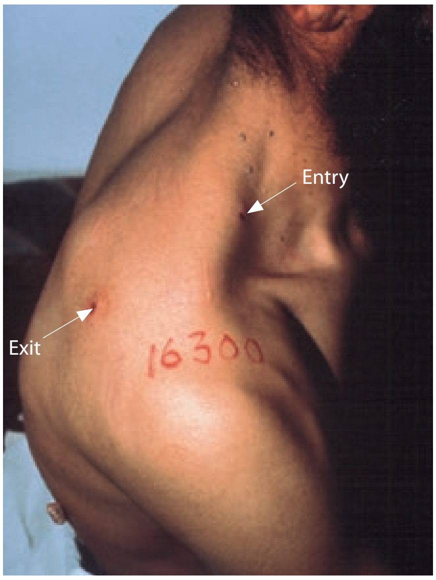


Figure 3.28
Exit wounds may occur before, during or after temporary cavity formation, depending on the length of the shooting channel in the body.

11 Wang Z, Feng JX, Liu YQ. Pathomorphological observation of gunshot wounds. *Acta Chir Scan* 1982; **508**: 185 – 189.

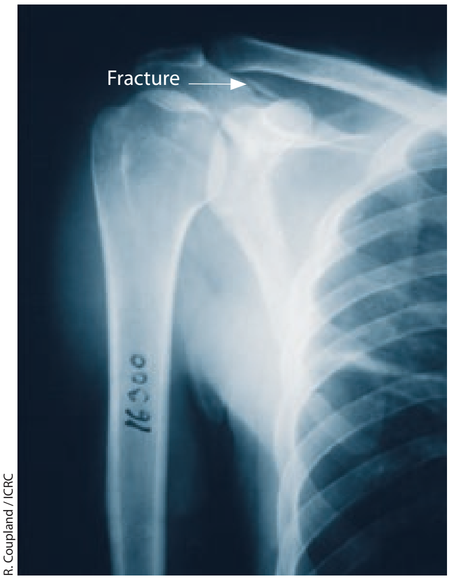
The injured body part may not be long enough for a temporary cavity to occur. Figures 3.29.1 and 3.29.2 show small entry and exit wounds along the narrow channel of Phase 1, with little intervening tissue damage.



R. Coupland / ICRC

Figure 3.29.1

Small entry and exit wounds, through-and-through injury.



R. Coupland / ICRC

Figure 3.29.2

The radiograph shows a small drill-hole fracture of the acromion: Phase 1 narrow-channel injury only.

The exit wound is large when it coincides with the site of the temporary cavity (Figures 3.30.1 – 3.30.3).

R. Coupland / ICRC

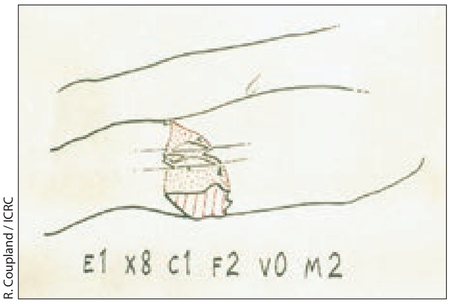
Figure 3.30.1

Gunshot wound to the thigh; the small entry is medial and the large exit on the lateral aspect.

R. Coupland / ICRC

Figure 3.30.2

There is a severe comminuted fracture of the femur and fragmentation of the bullet.

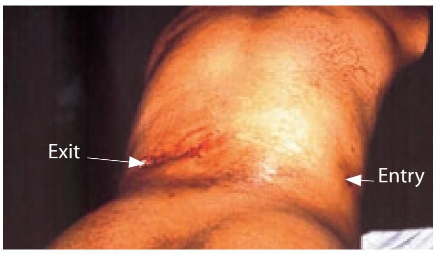


R. Coupland / ICRC

Figure 3.30.3

The exit coincides with the site of the temporary cavity. The fragmentation of the bullet is a tell-tale sign of severe tissue damage. Wound Score: Grade 3, Type F (see Chapter 4).

When a small exit wound occurs *after* the temporary cavity, the *intervening* damage can be severe (Figures 3.31.1 and 3.31.2).



R. Coupland / ICRC

Figure 3.31.1

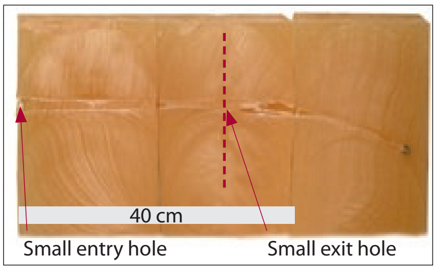
Small entry and exit wounds with severe damage in between.

R. Coupland / ICRC

Figure 3.31.2

The same wound after excision and partial healing.

With a handgun bullet, the temporary cavity effects are minimal and the final wound channel is almost entirely due to crush, whatever the length of the shooting channel (Figures 3.32.1 and 3.32.2).



B. Kneubuehl

Figure 3.32.1

Small entry and exit wounds from an FMJ hand-gun bullet: demonstration in a soap block.

B. Kneubuehl

Figure 3.32.2

Handgun bullet wound to the thigh.

The case of bone

The direct impact of a bullet on bone is different according to where this occurs in the shooting channel. Three clinical situations arise, corresponding to the phases of the shooting channel.

- In the first case, the stable bullet of Phase 1 causes a small "drill-hole" fracture. A small temporary cavity occurs, and the bone then collapses on itself. The final hole is smaller than the calibre of the bullet (Figure 3.29.2).
- In the second case, the bone is broken into multiple fragments owing to a higher release of kinetic energy from the larger cross section of the tumbling bullet during Phase 2 (Figure 3.33). Each bone fragment creates its own local crush and laceration damage; the muscle is cut up in between the fragments. Afterwards, the temporary cavity acts on this shredded muscle, which has lower tensile strength; the cavity is greater and the final remaining wound channel is larger. The bone fragments always remain within the temporary cavity; they do not produce a new second wound outside the cavity. Detached pieces of muscle and the bone fragments are found inside the final wound, which is usually very severe. This is of obvious clinical relevance to the management of these wounds.
- The damage that occurs to bone during the Phase 3 shooting channel depends on how much kinetic energy remains in the bullet. If it is a very small amount, the bone will stop the bullet without fracturing.

ICRC

Figure 3.33

Severely comminuted fracture of the tibia.

Ricochet

As seen in the tissue simulants, a ricochet FMJ bullet creates a wound that resembles that of an SJ dum-dum bullet: early dissipation of energy through crush and stretch (Figure 3.34). This phenomenon can be significant for a soldier wearing body armour. If the armour is pierced by a bullet, the wound may be more severe than if he had not been wearing the protective device.

R. Coupland / ICRC

Figure 3.34

The wound from a ricochet FMJ bullet resembles that of a dum-dum bullet. The head of the humerus has literally exploded.

Please note:

People are not injured in the anatomic position. The situation of a muscle group may alter with the patient's position so that a track is obscured, lengthened or shortened.

3

Disruption of the bullet and secondary fragments

At impact velocities above 700 m/s, standard FMJ bullets tend to fragment in tissues at short shooting distances (30 – 100 m). Some of these fragmented pieces make their own tracks of crushed and lacerated tissue. Tissue disruption from bullet fragmentation is then synergistic: the tissues are multiply perforated by the metallic fragments, thus weakening the tissue's cohesiveness, before being subjected to the stretch caused by the temporary cavity. The injury is severe. The same phenomenon occurs with shotgun pellets; each pellet creates its own crush track.

Clinically, an X-ray showing a "shower of lead" from a fragmented bullet should alert the surgeon to the likelihood of a large transfer of kinetic energy to the tissues and consequent severe damage (Figures 3.35, 4.5 and 10.5).

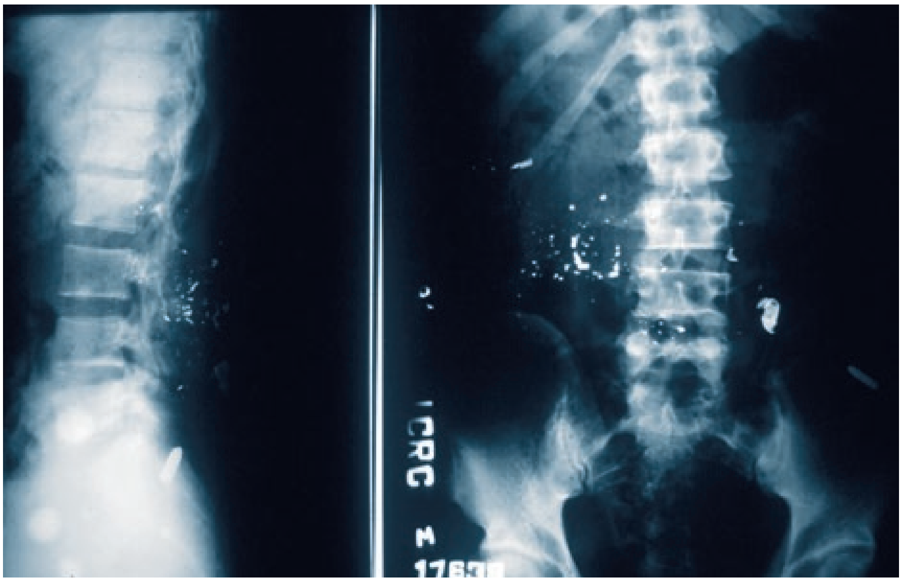


Figure 3.35
Bullet fragmentation: a "shower of lead".

Other secondary missiles are objects to which the bullet imparts sufficient motion through the transfer of kinetic energy. These may include foreign bodies such as a belt buckle, a small stone, the metallic contents of a pocket, or the contents of flak jackets – or autologous bodies including the teeth, dental fillings or dentures, and bone fragments (an ICRC surgeon once found a piece of a shattered mandible embedded in a patient's neck).

3.4.6 Sonic shock wave in tissues

A projectile in flight is accompanied by a series of waves propagated at the speed of sound (330 m/s in air). When the projectile strikes a person, this sonic wave is propagated throughout the body at the speed of sound in tissue (4 times the speed of sound in air).

This sonic shock wave may have high amplitude but is of very short duration, not enough to move or injure tissue. However, researchers have noted microscopic cell changes and stimulation of peripheral nerves, if the pressure generated reaches a certain threshold. The nerve stimulation occurs immediately, while the cell damage is apparent only after 6 hours. Occasional, short-lived neurapraxia appears to be the only clinically relevant damage.

3.4.7 Pressure wave in tissues and blood vessels

The pressure wave is part of the phenomenon of the temporary cavity and should not be confused with the sonic shock wave. The outer boundary of the cavity consists of a "front" of compressed tissues, which creates a pressure wave at the limit of tissue compression. The wave develops fully only after the temporary cavity and decreases with distance. It is measured in milliseconds (i.e. its duration is 1,000 times that of the shock wave). The pressure wave can thus disrupt capillaries or provoke their thrombosis, rupture a full bowel or the liver and cause retinal detachment and fractures at a distance from the cavity.

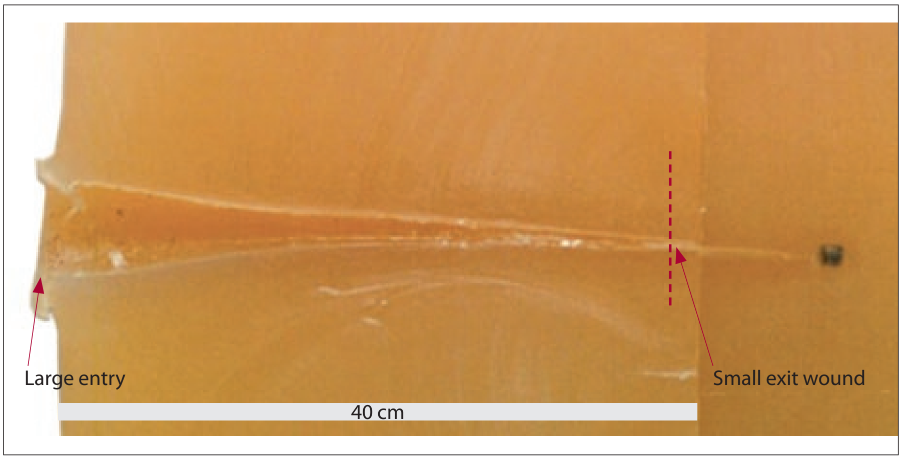
Additionally, blood vessels contained in tissues are squeezed and emptied suddenly with tissue compression. This creates a hydraulic pressure wave in the column of blood that is propagated away from the site of the temporary cavity. The clinical result of this pressure wave along the course of a blood vessel can be thrombosis or dissection of the intima or muscularis.

3.4.8 Fragment wounds

Their non-aerodynamic shape means that fragments rapidly lose speed in air. While initial velocities are reported to be up to 2,000 m/s, the impact velocity in survivors is usually much lower. If the person is very close to the exploding device, the penetration is deep. If very far away, the casualty is only "peppered" superficially with multiple fragments.

Fragments do not tumble in the tissues, as was demonstrated in the tissue simulants. Thus, most tissue damage is due to crush. At the end of the trajectory, the sharp edges of an irregular fragment will cut tissues. By contrast, a bullet tends to push aside tissues at the end of its track. The wound profile resembles a cone of tissue destruction, with the largest diameter at the entry since most energy is dissipated at the surface. The diameter of the entry wound can be anywhere between 2 and 10 times the calibre of the fragment, depending on the impact velocity, mass and shape (Figures 3.36.1 – 3.36.3).

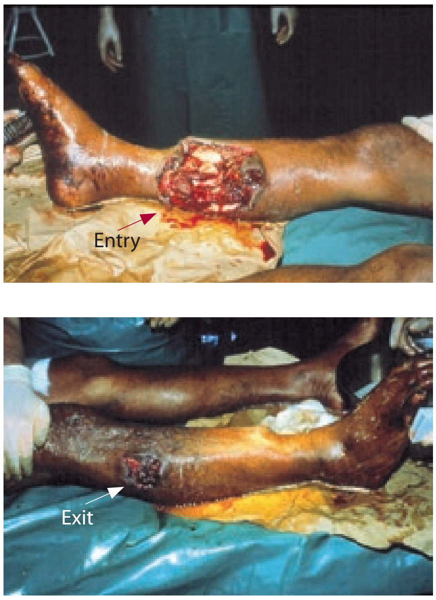
Large, slow fragments penetrate and crush tissues more; small, fast ones result in more stretch. This means that a large and slow fragment tends to cause the same type of wound whatever the tissues, while the wounds of small and fast fragments vary according to tissue elasticity. Nonetheless, in all fragment wounds the extent of tissue damage is always larger than the fragment.



B. Kneubuehl

Figure 3.36.1

Soap block demonstration of fragment injury.



R. Coupland / ICRC

R. Coupland / ICRC

Figures 3.36.2 and 3.36.3

Fragment wound with entry larger than exit.

Wound channel: pathological description

The sharp and irregular surfaces of fragments carry pieces of skin and clothing material into the wounds. As with gunshot wounds, fragment wounds show different zones of tissue injury. The cavity contains necrotic tissues surrounded by a zone of muscle fibre fragmentation with haemorrhage both within and between fibres, further surrounded by a region of acute inflammatory changes and oedema.

The uneven distribution of tissue damage in the concussion and contusion zones has been described as "jumping" or a "mosaic".[12] This is probably because energy has been transferred both along muscle fibres (crush effect) and across them (shear and stretch effect).

12 Wang ZG, Tang CG, Chen XY, Shi TZ. Early pathomorphologic characteristics of the wound track caused by fragments. *J Trauma* 1988; **28 (1suppl.)**: S89 – S95.

3.5 Wound dynamics and the patient

The wound has a life history, from injury to complete healing. As we have seen, tissue damage depends on a number of physical factors. However, the physical effects of energy transfer do not tell us all the pathological and physiological consequences of the act of wounding.

The tissues in and around the wound undergo reversible and irreversible pathological changes, together with inflammatory reactions. It can be extremely difficult to diagnose injured tissue that will heal from that which is nonviable and will not heal (see Chapter 10).

- Total kinetic energy is the potential to cause damage.
- Transferred kinetic energy is the capacity to cause damage.
- Actual tissue damage depends on the efficiency of this energy transfer.

The most valuable information gained from this discussion is that small missiles may cause small and minor wounds, or large and serious wounds, and a small entry wound can be associated with extensive internal damage. Nothing can replace a thorough clinical examination of the patient and the wound. The extent of the crush and stretch is well represented by the grades of the Red Cross Wound Score (see Chapter 4).

The injurious effects on the patient, however, involve more than the local pathology. As with all trauma and many diseases, the physiological and psychological state of the victim must also be taken into consideration. Fit young military personnel, well-trained for their role in warfare and mentally prepared for being wounded, and wounding and killing others, are not the same as civilians. Psychological status cannot be calculated by ballistics. Only these factors can explain the many anecdotes of a person being shot – even several times – and yet continuing to advance or fight in combat.

3

Chapter 4

RED CROSS WOUND SCORE AND CLASSIFICATION SYSTEM

4.1 Applications of the RCWS and classification system

Surgeons from civilian practice usually have no previous experience of managing war wounds. Even experienced surgeons often do not find it possible to tell the true extent of tissue damage. As noted in Chapter 3, ballistics studies show that there is not a uniform pattern or degree of wounding. Preparation for war surgery involves an understanding of the translation of the kinetic energy of a wounding projectile into tissue damage, i.e. the actual wounds that the surgeon must deal with.

The severity of such wounds depends on the degree of tissue damage and the structure(s) that may have been injured: thus, the clinical significance of a wound depends on its size and site. The Red Cross Wound Score (RCWS) and classification system[1] is based on the features of the wound itself, and not on the weaponry or the presumed velocity or kinetic energy of the missile.

Any wound classification system will aid the surgeon if it helps to assess the severity of the injury, influences surgical management, predicts outcome, and provides for an accurate database that can be used in comparative studies. The RCWS goes a fair way to fulfilling these criteria.

4.1.1 Assessment of and communication about war wounds in a standardized scheme

The Wound Score is a useful clinical tool to communicate the severity of the wound to staff and colleagues without having to remove the dressings. It is also an element to take into consideration for the purposes of triage.

4.1.2 Establishing a scientific approach to war surgery

The RCWS permits comparison of treatments and prognoses of similar wounds. An analogy can be made with the TNM (tumour, node, metastasis) staging of different cancers, allowing comparison of treatment regimes for a similar pathology. In the case of a gunshot wound to the thigh, treatment and prognosis will differ according to the amount of tissue damage, degree of bone comminution and whether there is injury to the femoral vessels. Other wound scoring systems are primarily devised for blunt trauma. The presence of a penetrating wound in these systems often indicates a "serious" wound, with little further nuance.

4.1.3 Surgical and hospital audit

Wound Scores can be used to evaluate quality of care when combined with information on length of hospital stay, number of operations performed per patient or units of blood used, morbidity and mortality. An example relating to the adequacy of primary wound surgery is the number and cause of deaths associated with non-vital wounds, or the number of operations performed per patient for each Wound Grade.

4.1.4 Wound information from the field

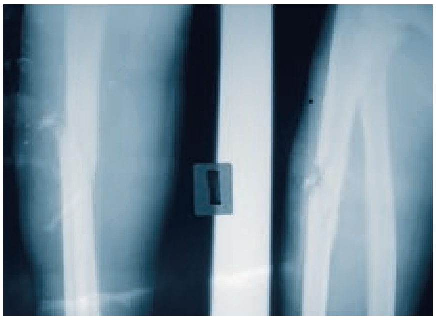
ICRC surgical teams treat thousands of war-wounded every year. Analysis of a larger number of scored wounds will eventually clarify the relationship between experimental laboratory wound ballistics and the clinical management of war wounds. Worthy of note is the fact that information gained in the field served as a scientific basis for the campaign to ban anti-personnel landmines, thus promoting new standards in international humanitarian law.

1 This chapter is largely based on the brochure *The Red Cross Wound Classification, Revised Edition*, by Dr R. M. Coupland. The ICRC Master Surgeons Workshop held in Geneva in 2002 revised the original Wound Score (see Introduction).

R. Coupland / ICRC

Figure 4.1

The width of two fingers is approximately the length of a military rifle bullet.



F. Herkert / ICRC

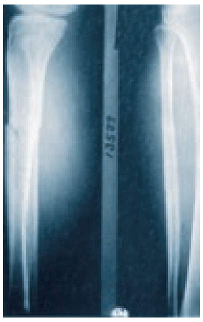
Figure 4.2.1

Gunshot wound: F1 fracture of the ulna.

R. Coupland / ICRC

Figure 4.2.2

Gunshot wound: F2 fracture of the femur.



R. Coupland / ICRC

Figure 4.2.3

Gunshot wound: F 1 fracture (clinically insignificant comminution) of the fibula.

4.2 Principles of the Red Cross Wound Score

Wounds are given a six-figure Score according to several parameters. The Scores can then be translated into a classification system:
- grading of the wound according to the severity of tissue injury and
- typing of the wound according to the tissue structures injured.

The RCWS is intended for quick and easy use in the field, its simplicity especially useful under conditions of stress. It is a simple clinical system that requires no extra equipment or sophisticated procedures. The time required for scoring wounds can be measured in seconds.

E	entry wound in centimetres	
X	exit wound in centimetres (X = 0 if no exit wound)	
C	cavity	Can the cavity of the wound take two fingers before surgical excision?
		C 0 = no
		C 1 = yes
F	fracture	Are any bones fractured?
		F 0 = No fracture
		F 1 = Simple fracture, hole or insignificant comminution
		F 2 = Clinically significant comminution
V	vital structure	Is there penetration of the dura, pleura, peritoneum? Or injury to major peripheral vessels?
		V 0 = no vital structure injured
		V N = (neurological) penetration of the dura of the brain or spinal cord
		V T = (thorax or trachea) penetration of the pleura or of the larynx/ trachea in the neck
		V A = (abdomen) penetration of the peritoneum
		V H = (haemorrhage) injury to a major peripheral blood vessel down to brachial or popliteal arteries, or carotid artery in the neck
M	metallic body	Are bullets or fragments visible on X-ray?
		M 0 = no
		M 1 = yes, one metallic body
		M 2 = yes, multiple metallic bodies

Table 4.1 Parameters of Wound Score.

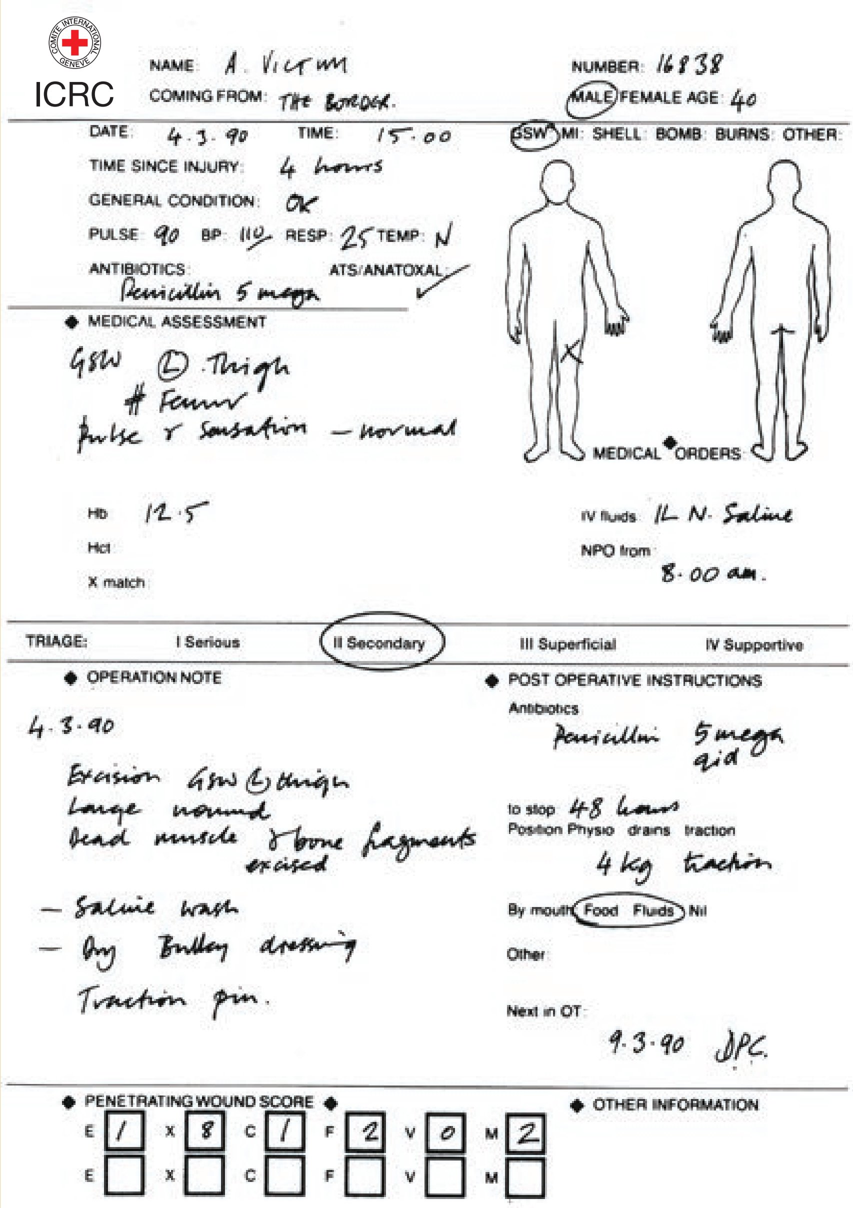
E (entry)	centimetres
X (exit)	centimetres
C (cavity)	C 0, C 1
F (fracture)	F 0, F 1, F 2
V (vital structure)	V 0, VN, VT, VA, VH
M (metallic bodies)	M 0, M 1, M 2

Table 4.2 Total scheme of Wound Score.

Wounds are scored on the patient's admission form after operation or after initial examination if there is no surgery.

ICRC EXPERIENCE

An ICRC admission sheet with Wound Score recorded.


ICRC

NAME: A. Victim NUMBER: 16838

COMING FROM: THE BORDER. MALE FEMALE AGE: 40

DATE: 4.3.90 TIME: 15.00 GSW MI: SHELL: BOMB: BURNS: OTHER:

TIME SINCE INJURY: 4 hours

GENERAL CONDITION: OK

PULSE: 90 BP: 110 RESP: 25 TEMP: N

ANTIBIOTICS: Penicillin 5 mega ATS/ANATOXAL: ✓

◆ MEDICAL ASSESSMENT

GSW Ⓛ Thigh
Femur
Pulse & sensation – normal

◆ MEDICAL ORDERS

Hb 12.5

Hct

X match

IV fluids 1L N. Saline

NPO from 8.00 am.

TRIAGE: I Serious II Secondary III Superficial IV Supportive

◆ OPERATION NOTE

4.3.90

Excision GSW Ⓛ thigh
Large wound
Dead muscle & bone fragments excised
– Saline wash
– Dry Bulky dressing
Traction pin.

◆ POST OPERATIVE INSTRUCTIONS

Antibiotics: Penicillin 5 mega qid

to stop: 48 hours

Position Physio drains traction: 4 kg traction

By mouth: Food Fluids Nil

Other:

Next in OT: 9.3.90 JPC.

◆ PENETRATING WOUND SCORE ◆

E	X	C	F	V	M
1	8	1	2	0	2

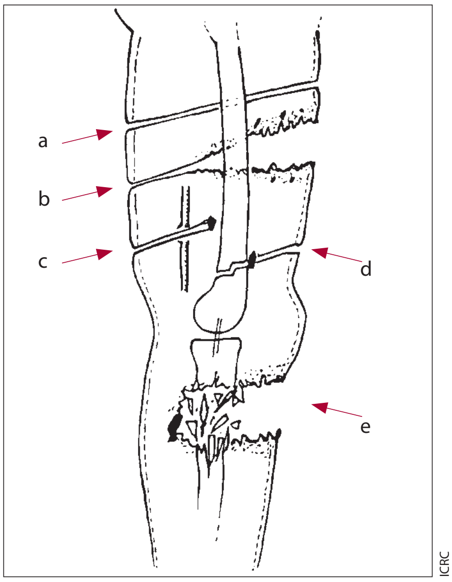
◆ OTHER INFORMATION

4.2.1 Examples

The following two sketches (Figures 4.3 and 4.4) present various wounds due to projectiles, and their assessment according to the ICRC's wound scoring system.

Figure 4.3

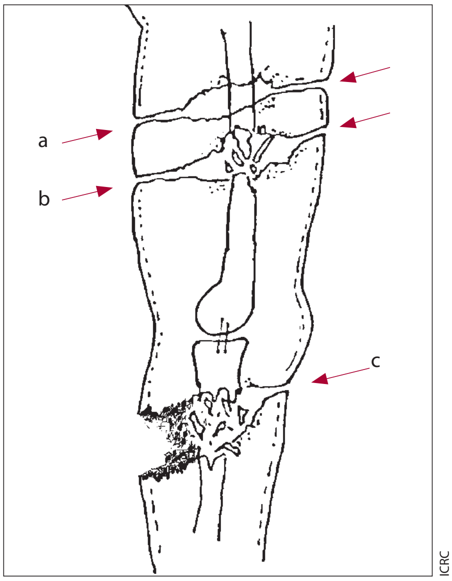
Examples of Wound Scores.
a. Simple bullet track.
b. Track produced by bullet when the exit coincides with cavity formation.
c. Simple track with involvement of a vital structure (artery).
d. Low-energy transfer wound with simple fracture.
e. High-energy transfer wound by fragment with comminuted fracture.



	E	X	C	F	V	M
Wound (a)	1 ?	2	0	0	0	0
Wound (b)	1	4	1	0	0	0
Wound (c)	1	0	0	0	H	1
Wound (d)	1	0	0	1	0	1
Wound (e)	6	0	1	2	0	1

Figure 4.4

Further examples of Wound Scores.
a. Through-and-through bullet wound of soft tissue with central cavity formation.
b. Through-and-through bullet wound with central cavity formation and comminuted fracture.
c. High-energy transfer bullet wound with cavity formation and comminuted fracture.



	E	X	C	F	V	M
Wound (a)	1 ?	1	1	0	0	0
Wound (b)	1 ?	1	1	2	0	0
Wound (c)	1	6	1	2	0	2

4.2.2 Notes on wound scoring

1. When it is impossible to differentiate between the entry and the exit wounds, put a (?) between the E and X Scores.
2. With multiple wounds, only the two most serious are scored.
3. If a wound cannot be scored (unclassifiable), U/C is written on the Score. This applies to a minority of wounds.
4. When one missile causes two separate wounds (e.g. through the arm and into the chest), the 2 separate Scores are joined by a bracket.
5. Include penetrating wounds only, not superficial tangential skin wounds; e.g. skin wound 20 cm long and 1 cm wide but without penetration deep to the fascia.
6. Estimation of the cavity: the width of two fingers is approximately the length of a bullet from a military assault rifle (Figure 4.1). If the permanent cavity of a wound admits two fingers before surgical excision, then something other than crush by a bullet travelling sidelong must have taken place, i.e. stretch and laceration by cavity formation. A C1 wound is likely to present significant tissue damage whatever the cause.
7. Fracture severity: it is inevitable that some wounds fall between F1 and F2, but for simplicity this is not accurately defined here. A further refinement is given in Section 22.3.4 in Volume 2. An example of a clinically insignificant comminution (F1) is a wound with a comminuted fibula but with an intact tibia (Figure 4.2.3).
8. A vital injury implies a more dangerous wound involving a surgical task in addition to simple wound management (e.g. craniotomy, pleural drainage or thoracotomy, laparotomy). VH includes the popliteal and brachial vessels but not those more distal. The outcome of injuries to the head, thorax or abdomen, or causing massive peripheral haemorrhage, is only partly determined by the clinical size of the wounds as determined by the RCWS (see below).
9. Metallic fragments: note the difference between an intact bullet (M1) and a fragmented bullet (M2), as shown in Figure 4.5. If the full metal jacket of a bullet has been disrupted and the lead interior has leaked out as fragments, this indicates a severe stress on the bullet and a large transfer of kinetic energy to the tissues (Figures 3.35 and 10.5).

   Note also the difference between multiple metallic fragments from a grenade or shell (Figure 4.6) – which are common and do not necessarily represent a large transfer of kinetic energy – and a disrupted and fragmented bullet, which does. If there are numerous metallic fragments, do not count them; only mark M = 2.
10. If X-rays are not available the RCWS is still valid. The F Score is judged clinically and the M parameter omitted, or included if fragments are found during surgical excision. X-rays should not be performed just to fill in the M and F Scores.
11. Traumatic amputation of limb (Figure 4.7): this injury is often seen with anti-personnel blast mines. The open end of the amputated limb equals a combined entry-exit, whose diameter represents the sum of E+X. It is equivalent to a cavity (C = 1), while the vaporized missing part of the limb qualifies as a severe fracture (F = 2). The level of traumatic amputation (above or below the knee or elbow) will determine if the Vital structure Score is 0 or H.

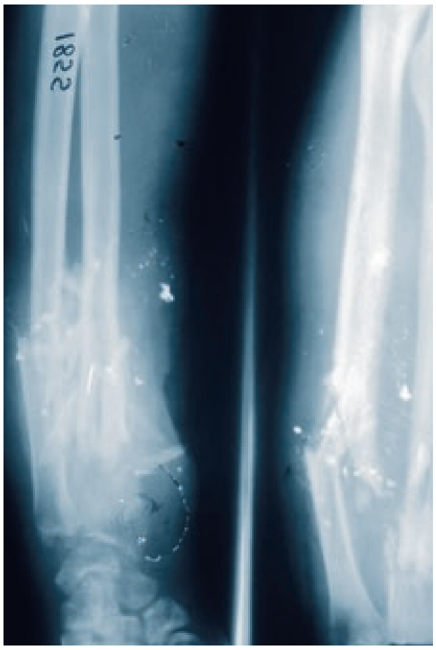

ICRC

Figure 4.5

Disrupted and fragmented bullet: M2.

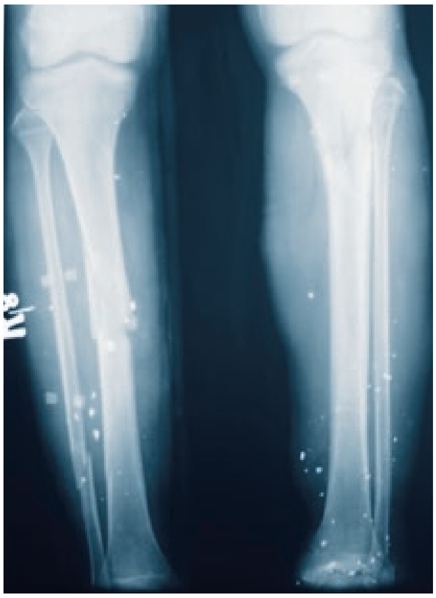

ICRC

Figure 4.6

Multiple shell fragments: M2.


K. Barrand / ICRC

Figure 4.7

Traumatic amputation of the forearm.

E	X	C	F	V	M
20	?	1	2	0	0

4.3 Grading and typing of wounds

Once scored, the wound can be *graded* according to severity (E, X, C and F), and *typed* according to tissue type (F and V).

4.3.1 Wound Grade according to amount of tissue damage

The wound should be *graded* according to severity.

Grade 1
E + X is less than 10 cm with Scores C 0 and F 0 or F 1.
(Low energy transfer.)

Grade 2
E + X is less than 10 cm with Scores C 1 or F 2.
(High energy transfer.)

Grade 3

E + X is 10 cm or more, with Scores C 1 or F 2.
(Massive energy transfer.)

These Grades represent the outcome of a simple clinical assessment that corresponds to the effective transfer of kinetic energy of projectiles to body tissues. Large wounds are more serious and require greater resources; this is particularly true of wounds to the limbs.

4.3.2 Typing wounds according to the injured tissues

Once *scored*, the wound can be *typed* according to tissue structures.

Type ST
Soft-tissue wounds: F 0 and V 0.

Type F
Wounds with fractures: F1 or F 2, and V 0.

Type V
Vital wounds putting the patient's life at risk: F 0 and V = N, T, A or H.

Type VF
Wounds with fractures and involving vital structures putting life or limb at risk: F 1 or F 2 and V = N, T, A or H.

4.4 Wound classification

Combining Grades and Types gives rise to a classification system divided into 12 categories.

	Grade 1	Grade 2	Grade 3
Type ST	1 ST Small, simple wound	2 ST Medium soft-tissue wound	3 ST Large soft-tissue wound
Type F	1 F Simple fracture	2 F Important fracture	3 F Massive comminution threatening limb
Type V	1 V Small wound threatening life	2 V Medium wound threatening life	3 V Large wound threatening life
Type VF	1 VF Small wound threatening limb and/or life	2 VF Important wound threatening life and/or limb	3 VF Large wound threatening life and/or limb

Table 4.3 Grade and tissue Type categories.

These categories help determine surgical management for a number of wounds, though by no means all (see Chapters 10 and 12).

Further refinement of the fracture type is possible, especially for assessing the extent of bone defect. This can be useful in a specialized study of war wounds with fractures (see Section 22.3.4 in Volume 2).

4.5 Clinical examples

Epidemiological studies from the ICRC surgical database of over 32,000 patients have shown that the Red Cross Wound Score gives excellent prognostic results for surgical workload and morbidity due to war wounds. As demonstrated in the statistical analysis in Chapter 5, the Wound Grade is highly relevant to the number of operations per patient. This is particularly the case for wounds to the extremities. Vital Wound Scores to the extremities (V = H) also give good measures for mortality and the amputation rate.

One of the avowed weaknesses of the Classification concerns the prognostic mortality of vital central wounds. It is in the anatomic nature of the brain, heart and great vessels that even a very small wound from a projectile with low kinetic energy can be lethal if a vital centre is injured. The RCWS does classify such wounds as "potentially" lethal; that is why, by definition, they are categorized as "vital" injuries. However, a Grade 1 wound can be just as lethal as a Grade 3 wound depending on what particular structure is hit: medulla oblongata rather than temporal cortex; ascending aorta rather than lung parenchyma.

What is certain is that for most Grade 3 wounds to the head, thorax and abdomen, pre-hospital mortality is bound to be high. Without autopsies of those killed in action (KIA), analysis can only be made of the relatively few "survivors" who reach hospital; for them, wound Grade is not significant with respect to mortality (Tables 4.4 – 4.6).

Thus, the outcome of injuries to the head, thorax and abdomen are not only, nor even mainly, determined by the clinical size of the wound as defined by the RCWS. The various factors affecting the mortality from vital wounds; e.g. for the abdomen, number of organs injured, degree of faecal contamination, intraoperative blood loss, delay in operative treatment, etc., will be discussed in Volume 2.

	Number	Deaths	% mortality
Grade 1	75	14	18.7
Grade 2	70	15	21.4
Grade 3	9	3	33.3

Table 4.4 Mortality from head and neck injuries (VN): N = 154 (ICRC Kabul, 1990-92).

	Number	Deaths	% mortality
Grade 1	82	4	4.9
Grade 2	41	2	4.9
Grade 3	3	0	0

Table 4.5 Mortality from chest injuries (VT): N = 126 (ICRC Kabul, 1990-92).

	Number	Deaths	% mortality
Grade 1	120	9	7.5
Grade 2	70	11	15.7
Grade 3	5	0	0

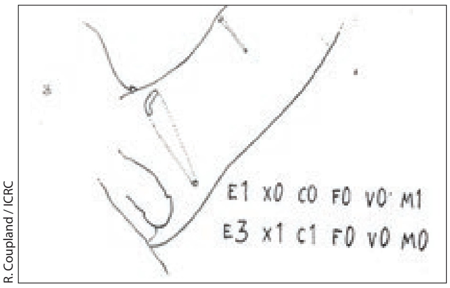
Table 4.6 Mortality from abdominal injuries (VA): N = 195 (ICRC Kabul, 1990-92).

Nonetheless, as explained in Chapter 5, a distinction should be made in patient databases between superficial and penetrating wounds to the head, thorax and abdomen to allow for a better analysis of results of treatment. Using the RCWS enables this.


R. Coupland / ICRC

Figure 4.8.1

Two fragment wounds to the thigh. The surgeon is assessing the larger wound cavity.



R. Coupland / ICRC

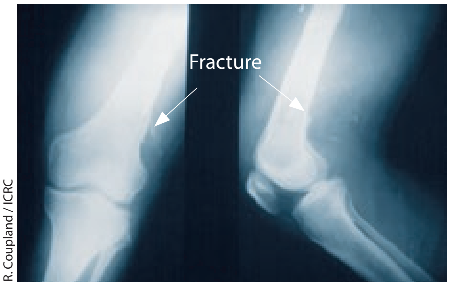
Figure 4.8.2

Both wounds are Type ST. The smaller wound is Grade 1, and the larger Grade 2.


R. Coupland / ICRC

Figure 4.9.1

Through-and-through gunshot wound to the knee.



R. Coupland / ICRC

Figure 4.9.2

There is a small fracture above the lateral condyle.


R. Coupland / ICRC

Figure 4.9.3

The popliteal artery has been injured.

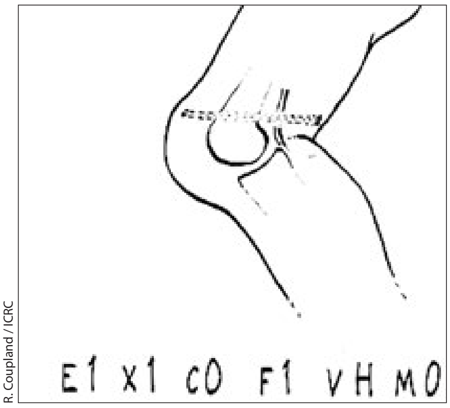


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Figure 4.9.4

The wound is Type V(H)F, Grade 1.


R. Coupland / ICRC

Figure 4.10.1

Gunshot wound to the abdomen.

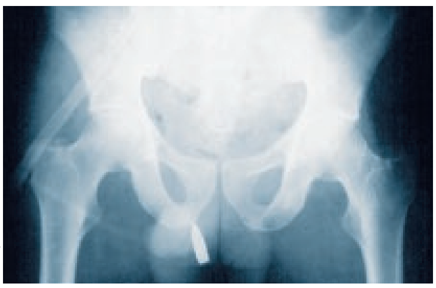
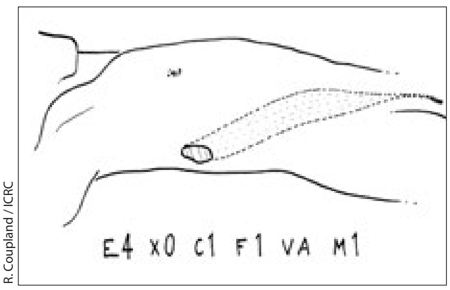

R. Coupland / ICRC

Figure 4.10.2

The bullet is lodged in the scrotum. There is a small fracture of the right pubic bone.



R. Coupland / ICRC

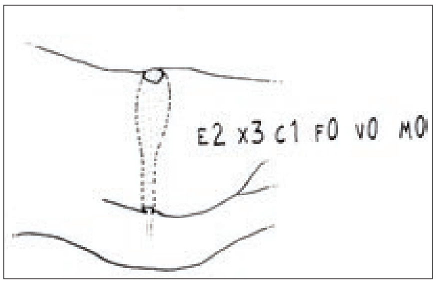
Figure 4.10.3

This is a Grade 2 wound, Type V(A)F.

R. Coupland / ICRC

Figure 4.11.1

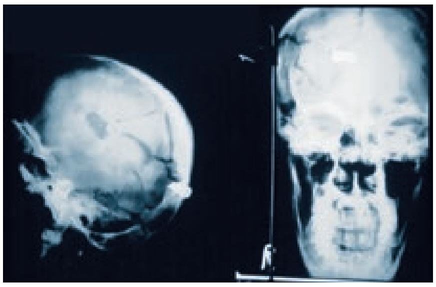
A bullet has grazed the left buttock and then entered the right buttock at the anal cleft. The exit is located laterally.



R. Coupland / ICRC

Figure 4.11.2

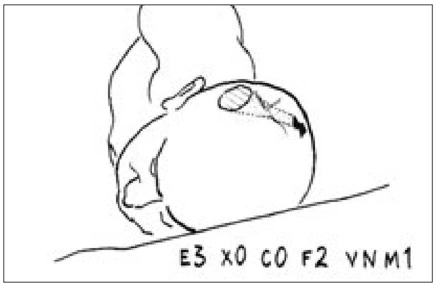
This is a Grade 2, Type ST wound.



R. Coupland / ICRC

Figure 4.12.1

Fragment wound to the head with entry right parietal. Note the severe linear fractures.



R. Coupland / ICRC

Figure 4.12.2

The cone of tissue destruction extends to the occipital lobe. Grade 2, Type V(N)F.

4.6 Conclusions

The Red Cross Wound Score enables medical staff to translate war wounds into surgical lesions rather than weaponry phenomena. It refines the heterogeneity of wounds and helps define them according to their clinical significance, and it is a good indicator of tissue damage due to the transfer of kinetic energy in penetrating wounds.

The limitations of the scoring system are recognized; complete accuracy cannot be obtained. It should be emphasized that the RCWS is for rapid use under adverse conditions, including extreme stress, and uses no additional equipment or sophisticated technology. The simplicity and advantages of the RCWS outweigh any disadvantages that may occasionally be introduced by observer error. As with any classification system, the more experience gained in using the RCWS, the more accurate the results and the fewer the observer errors.

Chapter 5

THE EPIDEMIOLOGY OF THE VICTIMS OF WAR

5.1 Introduction: purpose and objectives

Epidemiological studies are standard practice in medicine. Doctors need to understand the characteristics of their patient population and the relationships between particular circumstances and the outcome of treatment. These elements help to establish the high-risk factors.

As regards the victims of war, the total effects of conflict must be analysed: the impact on civilian populations as well as on the armed forces, the direct effects of war trauma and the indirect public health consequences. These help the ICRC and other organizations determine their response in terms of assistance (see Chapter 2).

5.1.1 The reader and this manual

Most readers of this manual will be civilian surgeons who are unacquainted with the practice of war surgery and its literature. Even among military surgeons many may have only a superficial acquaintance with these topics. This chapter on the epidemiology of victims of war presents a certain approach to the understanding of the many factors involved in patient care and outcome.

First the public health repercussions of armed conflict will be dealt with briefly, then the purely surgical aspects will be addressed in more detail. Questions of general methodology and definitions will begin the surgical study, and will be followed by a presentation of historical and ICRC experience and results. Relevant clinical conclusions will be emphasized throughout, as will recurring problems of methodology.

For the purposes of this discussion, the authors make direct reference only to the ICRC's experience in armed conflict and to the importance of epidemiological studies in guiding ICRC surgical activities. In addition, we shall refer to the statistics in standard and well-accepted scientific works and journal articles concerning historical results that have come to influence clinical practice (see Selected bibliography).

5.2 Public health effects of armed conflict

5.2.1 Historical perspective

It is commonly said that contemporary warfare causes more civilian victims than military, and that the public health effects are greater than those caused by trauma. In all major conflicts over the last one hundred years, with few exceptions (World War I), civilians have become a direct target and accounted for one-half to two-thirds of the casualties.

> "Throughout history there have been many small local wars, often involving wholesale starvation and occasionally the elimination of whole populations or tribes."[1]
>
> G.W. Odling-Smee

The heavy civilian toll in contemporary conflicts is therefore not new. Nevertheless, in certain recent conflicts – whether revolutionary wars of national liberation, civil wars, territorial and border disputes, or peasant uprisings – the destabilization of political, social, and economic infrastructure, the destruction of cultural symbols and institutions and the psychological terrorizing of civilians have become explicit political and military goals. A number of reports have indicated that the indirect effects of social disruption have caused two to fifteen times more civilian deaths than war wounds have, and, in some cases, civilians may account for up to 90 % of the victims.

1 Odling-Smee GW. Ibo civilian casualties in the Nigerian civil war. *BMJ* 1970; **2**: 592 – 596.

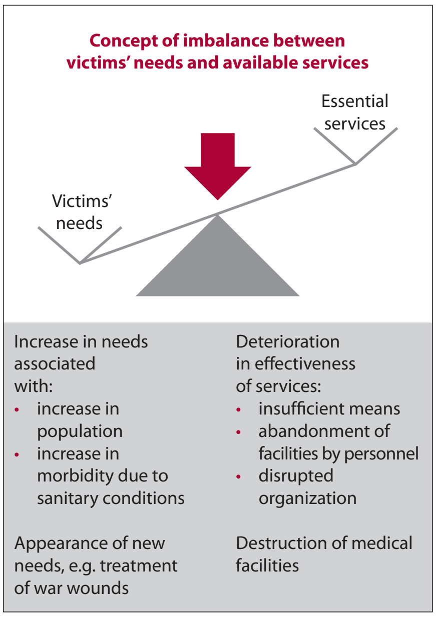
> "Today's armed conflicts are essentially wars on public health."
>
> Rémi Russbach, former Chief Medical Officer at the ICRC

5.2.2 The public health effects of social disruption

Social disruption includes population displacement – either internal or refugee – pauperization, the breakdown of nutrition and sanitary conditions, the lack of safe drinking water and the disruption of medical systems (Table 5.1).

Direct effects	Indirect effects
Death	Economic pressure and disruption
Disability	Reduced food production and distribution
	Family disruption (orphans, abandoned children)
Destruction of health services	Refugees
	Psychological stress
Disruption of health programmes	Effects on housing, water supply and sewage disposal
Psychological stress	Economic pressure on those caring for the war-disabled
Illness	Environmental (landmines, deforestation)

Table 5.1 Effects of political violence on health and health systems. [2]



P. Perrin / ICRC

Figure 5.1

Victims' needs and available services during armed conflict.[3]

Pathologies and the pathology of the health system

Complex emergencies during armed conflict in poor countries tend to cause death by endemic communicable disease and malnutrition. In more developed countries, increased mortality rates due to trauma and chronic disease dominate. The lack of access to care, either because of poverty, the disruption of the medical system, or for reasons of security, aggravates the problems.

To pre-conflict poverty and fragile health services are added the problems of the collapse of medical supply and distribution, the targeting of hospitals and clinics in violation of medical neutrality and the neglect or abandonment of preventive health programmes. In addition, health professionals are often amongst the first people to flee a conflict zone. Having to provide for war trauma also means a greater investment in curative services to the disadvantage of the preventive. The entire health system becomes organized around the conflict and there is an imbalance between the needs of victims and the available public health services (Figure 5.1).

Moreover, all too often, increased military spending in a country at war is to the detriment of social and health investments. Another recent development is the creation of a war economy controlled by criminalized military networks. The extraction of diamonds and other precious stones, oil, timber, and various minerals, the trafficking of narcotics, and sheer banditry, take a further and severe social toll.

A public health approach shows the full range of the humanitarian consequences of the use of anti-personnel landmines, especially during the post-conflict period. In addition to death and disability, there are the long-term socio-economic effects of disrupted economic activity through the loss of farmland, livestock, water resources, and industrial capacity because of the presence of landmines.

Landmines and other UXO (unexploded ordnance) are not the only weapons left over after war. Demobilized combatants with guns are not often successfully reintegrated into social and economic life: criminal violence replaces political violence; peace combined with high criminality offers little respite from war. And the social and economic costs continue to cast a shadow over everyday life.

2 Zwi A, Ugalde A. Towards an epidemiology of political violence in the third world. *Soc Sci Med* 1989: **28**: 633 – 642. Cited in Lautze S, et al., 2004.

3 From Perrin P. *War and Public Health: A Handbook*. Geneva: ICRC; 1996.

In addition, one must count the social costs of deliberate physical, psychological, and sexual abuse as methods of warfare. Torture and rape have profound and long-term consequences.

Public health effects on the armed forces

Even among the conventional armies of industrialized countries, disease caused more deaths than combat until World War II. Mortality does not tell the whole story, however. Serious disease continues to affect modern armies, still accounting for high rates of non-availability of personnel for military duty. Of course, certain natural environments (jungle, high mountains) increase the incidence of non-battle pathology.

5.2.3 The burden of war-wounded civilians

Although trauma may account for only a small number of all war-related deaths in a given civilian population, the relative proportions of mortality and morbidity due to disease and trauma vary over time and between different war zones; refugee camps are different again.

In some conflicts, the burden of war trauma is greater than the public health consequences. This was the case in the wars in the former Yugoslavia (1991 – 99) in Lebanon (1975 – 90) and in Rwanda (1994), among others. One must also take into consideration the relatively small population of certain countries; a limited number of deaths may represent a proportionately high death toll.

In some conflicts, the burden of the war-wounded is greater than the consequences for public health.

The type of combat may place civilians at greater risk and war casualties may overwhelm civilian medical services, even in situations where the public health effects are greater than the direct effects of trauma (Biafra 1967 – 70, Uganda 1987, Democratic Republic of the Congo from 1997 to the time of writing).

Mortality data, however, do not reflect the extent and severity of war injuries. Morbidity and disability rates due to injuries are testimony to the long-term socio-economic burdens.

Demographics of the victims

Historically, military casualty statistics concern young, fit and healthy men. In the past, women were not close to combat in most conventional armies, although this is now changing, and certain revolutionary guerrilla groups have long had female combatants.

When a civilian population finds itself in the midst of war, the demographic profile of casualties is closer to its population pyramid. This has clinical consequences for the treatment of endemic diseases and chronic pathologies among the wounded.

J-P. Di Silvestro / ICRC

Figure 5.2

The number of wounded and dead by direct trauma may at times far exceed the effects on public health.

5

5.2.4 Methodology

Public health monitoring and data collection are notoriously difficult during the chaotic and overwhelming conditions of complex emergencies. Missing and displaced persons, constraints of time, lack of access to populations and dangerous security situations all create formidable problems for a limited number of qualified personnel to conduct proper studies. Furthermore, the distinction between civilians and military personnel during a civil war is not always obvious.

The ratio of military to civilian wounded and sick may be very sensitive political and military information, easily exploited for propaganda purposes by the various antagonists. In an attempt to prevent this, should ICRC delegates determine that civilians are being expressly targeted by combatants, the organization makes approaches (*démarches*) regarding the conduct of hostilities to the authorities concerned in accordance with its traditional confidential procedures.

Many authors have recently written about the public health effects of armed conflict and complex emergencies. The ICRC first published its standard *War and Public Health* in 1996 and, together with the World Health Organization and a number of universities around the world, it organizes a dozen H.E.L.P.[4] courses on the management of humanitarian aid every year.

5.3 Epidemiology for the war surgeon

What should one look for in a study of epidemiology? What information will help the individual surgeon managing war wounds for the first time? What needs to be taken into consideration to set up an efficient system for the care of the war-wounded? Is it possible to determine the "normal" levels of morbidity and mortality during armed conflict?

To respond adequately to the challenge requires preparation, on the part of the individual surgeon and of the institution, and a system for monitoring the results of patient management.

5.3.1 Preparation of the surgeon

The surgeon facing war-wounded casualties for the first time will ask a number of questions: "What wounds should I expect? Which injuries kill? What will the surgical workload be like? What are the gaps in my training?"

In many conflicts, civilian surgeons without previous military experience become heavily involved in the management of the war-wounded. Yet epidemiological studies clearly show that combat injuries differ from those in civilian practice: different aetiology and pathology; multiple-cause injuries; delayed access to care and austere working conditions requiring different philosophies of treatment.

> Epidemiological studies show that the management of the war-wounded is different from the management of civilian trauma. The war surgeon must develop a new clinical mindset.

Various indices have been devised to define injury patterns, which differ according to the type of conflict and the nature of the weapons used: the lethality of wounding agents; the anatomic distribution of wounds; delay to treatment and pre-hospital and post-operative mortality are among the most important. Knowledge of these helps determine the high-risk factors affecting the outcome of surgical treatment and the set of specialist skills needed: orthopaedic surgery, vascular, visceral, etc. In addition, the surgeon must understand that there are medical and non-medical factors at play.

4 H.E.L.P.: Health Emergencies in Large Populations. The reader is directed to the publications in the Selected bibliography for further study.

These patterns also have an impact on hospital activities and surgical workload and influence the standardization of protocols for patient management.

5.3.2 Preparation of the institution

The institution involved – military medical services, public health ministry, the ICRC or any other humanitarian agency – must also be prepared.

The standardization of protocols and knowledge of the workload permits the establishment of ready-made kits of equipment, medicines and supplies that are easily deployed in an emergency situation as a rapid response to well-known needs. This facilitates the setting up of a surgical hospital to treat the victims of war.[5]

Non-medical factors must be taken into account in estimating the potential workload: tactical situation; mechanisms of injury; wearing of protective gear; environment, topography and climate, plus transport infrastructure. In addition, and of particular importance to civilian and humanitarian organizations, the manner in which war is waged often determines the direct effects on a civilian population: shelling of residential areas, guerrilla tactics in rural surroundings or suicide bombers in market places.

Preparation also implies choosing the correct profile of surgeon and training him or her to understand the context, the pathology, and the functioning of the institution in which they will be working, together with the prevailing clinical protocols (see Section 6.3).

Knowing what kind of patient comes through the hospital door helps in planning a response: allocation of medical resources and personnel and the training of surgeons.

5.3.3 Surgical audit: monitoring

Monitoring of the outcome of patient management in a context of armed conflict involves a surgical audit using an epidemiological approach: demographics, types of wounds, anatomic distribution, mechanism of injury, time since injury, post-operative mortality, number of operations and blood transfusions per patient, morbidity, etc. There are several reasons for this.

- The adequacy of surgical expertise is important: the "fog of war" and the confusion and stress of a situation of armed conflict are no excuse for bad surgery. Professional standards must be maintained, even when resources are limited.
- The adequacy of the clinical protocols in use must be verified: changes must be made in response to poor or unexpected outcomes. Many surgeons will be seeing war pathology for the first time, under conditions that do not resemble their routine work circumstances. At times, a strict and rigid application of protocols is required; on other occasions, there will be a need for improvisation and adaptation.
- The adequacy of the chain of casualty care must also be tested: hospital and pre-hospital data help to assess the efficiency of first-aid measures in the field and of the evacuation system. Surgeons – civilian or military – may be involved in training or helping set up pre-hospital programmes so that the injured reach them in better condition and in a timely fashion, which makes their surgery easier and ensures a better outcome for the patient.
- The role of surgeons in the development and application of international humanitarian law.

5 The Emergency Items Catalogue of the International Movement of the Red Cross and Red Crescent (available at https://itemscatalogue.redcross.int/index.aspx) has a listing of such kits for the establishment of a surgical field hospital and for the treatment of 100 war-wounded hospitalized and operated on.

5.3.4 The surgeon and IHL

Surgeons working for the ICRC believe that health professionals have a duty to gather data "to prevent and not just to treat" with regard to the law and norms of behaviour in the conduct of hostilities. They are not alone in this belief.

Health professionals were instrumental in gathering the epidemiological data from clinical studies to make the humanitarian argument for the banning of blinding laser weapons, anti-personnel landmines and cluster munitions.[6]

In the field, ICRC delegations in areas of armed conflict monitor the compliance of belligerents with IHL. Epidemiological studies, in both hospital and pre-hospital settings, can help detect certain breaches of IHL. For example, mortality statistics can help reveal that executions of prisoners of war are being passed off as killed in combat. The ICRC then undertakes a series of confidential representations (*démarches*) to the offending party, in order to promote observance of humanitarian norms.

Other organizations may do likewise, in compliance with their humanitarian responsibilities.[7] However, the ICRC warns against the possibility of exploitation and manipulation of statistical epidemiological studies for political purposes.

5.3.5 The surgeon and the specialized literature

"Statistics can be made to say whatever you want them to say" is a well-worn cliché. It is therefore important for the surgeon reading the vast literature on war surgery to understand what is being said, what the shortcomings are, and what some of the traps and pitfalls are.

Most of the war surgery literature consists of large retrospective studies written by military surgeons of industrialized countries; some of the exceptions are included in the Selected bibliography at the end of this volume. Most surgeons are not well trained in epidemiology or statistical methods, and civilian surgeons are usually not knowledgeable about military terminology. Thus, the surgeon facing the new experience of dealing with the war-wounded who wishes to read up on the topic will often find a bewildering vocabulary and methodology.

Differences

In addition to the differences between war and civilian trauma there are disparities between the experience of the ICRC, other humanitarian agencies and public health facilities on the one hand, and the experience of conventional military medical services on the other. The rest of this chapter deals with some of these differences and disparities.

5.4 General questions of methodology

There are a number of problems and difficulties relating to how epidemiological studies have been conducted. The surgeon reading the literature should be aware of them.

5.4.1 Large and small numbers

First it must be clear which phenomenon is being studied. Comparisons of data between a single battle and longer wars may not be valid; a small cohort may not be representative. Most clinical protocols take as a basis large numbers in big wars. On the other hard, the individual surgeon will face individual casualties from particular battles. Thus, the experience with small cohorts may help prepare the surgeon to face a novel situation or specific injuries.

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6 The Protocol on Blinding Laser Weapons 1995 (*Protocol IV to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects*, 1980), the *Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction*, 1997, and the *Convention on Cluster Munitions*, 2008.

7 Burnham G, Lafta R, Doocy S, Roberts L. Mortality after the 2003 invasion of Iraq: a cross-sectional cluster sample survey. *Lancet* 2006; **368**: 1421 – 1429. Dudley HAF, Knight RJ, McNeur JC, Rosengarten DS. Civilian battle casualties in South Vietnam. *Br J Surg* 1968; **55**: 332 – 340.

5.4.2 Problems of data collection

Trauma registries are notoriously difficult to maintain during war. Fatigue and lack of time, a shortage of trained staff and the personal danger that medical staff must often confront complicate the keeping of statistics. The administrative personnel and time and effort required to keep up full documentation and archives can appear to be a luxury when one is faced with the stress of caring for battle casualties. A telling comment about the American experience in Viet Nam:

> "Many of the physicians who filled out these forms recognized that they were frequently completed under stress, by command, and without enthusiasm, by physicians who considered it another thankless task, and therefore the ac-curacy of some of the data may be questionable…"[8]
>
> R. M. Hardaway III

In an attempt to correct this situation, the USA and UK armed forces introduced a Joint Theatre Trauma System and Registry in Afghanistan and Iraq, involving large numbers of administrative personnel and substantial IT resources for data collection and entry. Nonetheless, "the accuracy of medical records to abstract data for analysis… falls on the conscientiousness of the individual surgeons. Data reporting practices vary by physician and can depend on the situation (i.e., during mass casualty events, surgeons may forget to properly report or document their work)."[9]

Besides the problems of data collection mentioned with respect to public health statistics and the displacement of populations, other discrepancies and difficulties arise when one is dealing with a retrospective analysis of hospital-based data, especially when they have been collected in civilian hospitals with limited administrative support.

- The quantity and quality of data from different hospitals are irregular. Hospital records are often incomplete, or contain clerical errors.
- Initial admission data, operating theatre observations and ward medical records for individual patients do not always match.
- There is often observer bias: many experiences with low patient numbers are simply not published and therefore the published literature is not a comprehensive representation. Or there may be survivor bias: patients arriving at hospital alive are taken to be representative of all patients.
- The management of casualties at different points in a chain of evacuation compounds reporting problems, particularly with respect to patient outcome.
- Medical care for the wounded – especially during a civil war or guerrilla warfare – is not always available or must be provided in secret.
- Patients may disappear from the hospital before completing their treatment because of personal security concerns.
- Families do not always bring their dead for registration.

As mentioned before, one must also always consider the political and military sensitivity of trauma information; ICRC health personnel have on occasion been accused of being spies because they were asking a hospital director for admission statistics.

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8 Hardaway RM III. Viet Nam Wound Analysis. *J Trauma* 1978; **18**: 635 – 643.

9 Turner CA, Stockinger ZT, Gurney JM. Combat surgical workload in Operation Iraqi Freedom and Operation Enduring Freedom: the definitive analysis. *J Trauma Acute Care Surg* 2017; **83**: 77 – 83.

5.4.3 Important first questions: who is counting whom?

Foremost is the very important problem of different definitions of epidemiological categories. Some military definitions have changed over the last century or been replaced by other terms. Civilian authors have often invented their own epidemiological categories and definitions in articles on the subject. Who exactly composes the target population under study is different from one article to the next, although all deal with the "wounded" and during the same war. Large retrospective studies are fraught with such traps.

There are important first questions the reader must ask of all war surgery studies: who is counting whom and where? When is a wounded person counted as a wounded person? Which patients are included in the nominator and denominator in any formula or equation?

Important first questions:

Who is counting whom?
When is a wound a wound?
Who are the nominator and denominator?

Who is counting?
Different hospitals – military, public, and other (mission hospitals, non-governmental organizations, the ICRC, etc.) – all have their own objectives, mandates and routines. They all collect statistics, but often for very different reasons, and they collect very different statistics (see ANNEX 5. A: ICRC Surgical Database).

A well-organized conventional army can state how many of its soldiers were killed or disabled; pensions and allowances must be paid and the necessary administrative systems to do so exist. Guerrilla forces and civilian medical facilities are incapable of fully recording such statistics, with rare exceptions.

Who is being counted and where?
Are casualties calculated at the point of wounding, at first-aid posts, first echelon or referral hospitals? The total number of wounded will depend on which level of the evacuation chain is counting, and what happens to them after injury.

The wounded who arrive at hospitals – where most studies are made – are only a sample of the casualties; they do not represent the total reality of war.

When is a wounded person a wounded person?
Many studies in the military literature, even when dealing with the same war, define the wounded differently. One example: for World War II, the United States Surgeon General's Statistical Health Report indicated 724,000 wounded and 228,000 battle-related deaths among American troops; a fatality rate of 23.9%. The Adjutant General's Report gave the figure of 593,000 battle injuries and 235,000 deaths; a rate of 28.4%. The latter report excluded the lightly wounded.[10] Retrospective analyses do not always indicate which figure is being used.

Studies do not always make clear if all superficial and light injuries are excluded or not from the calculations. To state the obvious: a scalp laceration is not the same as an open wound to the brain. The reader should note that non-penetrating head, chest, and abdominal injuries are not always clearly differentiated from penetrating ones. The use of the Red Cross Wound Score permits this distinction (see Chapter 4).

Similarly, studies of the anatomic distribution of wounds, the wounding agent and delay in evacuation do not always state specifically whether the authors are dealing with the survivors only, or with total combat casualties comprising the dead as well as the wounded survivors.

10 Carey ME. Learning from traditional combat mortality and morbidity data used in the evaluation of combat medical care. *Mil Med* 1987; **152**: 6 –12.

5.4.4 Some definitions: the wounded and the dead

Table 5.2 includes some basic epidemiological definitions intended to standardize reporting by the armed forces of the United States of America.

Killed in action (KIA)	Died from battle injuries before reaching a medical facility (MF). Comparable to civilian dead on arrival (DOA).	$\%KIA = \frac{\text{Died before reaching MF}}{\text{KIA} + (\text{WIA - RTD})} \times 100$
Wounded in action (WIA)	Wounded who survive to reach a medical facility staffed by a physician capable of trauma life support, whether pre-hospital or hospital.	$\text{WIA} = \text{Total wounded - RTD}$
Died of wounds (DOW)	WIA but later died from wounds.	$\%DOW = \frac{\text{Died after reaching MF}}{(\text{WIA - RTD})} \times 100$
Returned to duty (RTD) or Carded for Record Only (CRO)	Wounded but not hospitalized, and returned to active duty within 72 hours. May include patients who are registered in a pre-hospital setting: carded for record only but not evacuated.	
Case Fatality Rate (CFR)	Overall lethality among all wounded: all deaths compared with all wounded including DOW.	$\text{CFR} = \frac{\text{KIA} + \text{DOW}}{\text{KIA} + \text{WIA}} \times 100$
Hospital mortality	Died intra- or post-operatively in a surgical facility.	$\% \frac{\text{Dead}}{\text{Admitted (WIA)}} \times 100$

Table 5.2 Standardized epidemiological definitions as used by the USA armed forces.[11]

ICRC EXPERIENCE

Major fighting broke out in June 2000 in Kisangani, a city of 600,000 inhabitants in the remote east of the Democratic Republic of the Congo. Hostilities lasted seven days. One week later, visiting ICRC delegates recorded that 4 hospitals and 62 clinics had registered 1,691 wounded; 369 were still hospitalized (over 90 % civilians, as most military casualties had been evacuated). The remaining casualties were under ambulatory care. It was impossible to determine the number killed. Almost a month later, a total of 2,393 casualties had been registered and 248 were still hospitalized. The vast majority of these patients suffered such superficial wounds that, had they been living in a rural environment far from a health facility, they would never have presented. These are the civilian equivalent of RTD and CRO.

In nine and a half months in Beirut, in 1976, an ICRC field hospital treated 1,289 war-wounded on an outpatient basis and another 696 in hospital. Similarly, an ICRC surgical team triaged 2,588 patients over three months of urban warfare in Monrovia, Liberia in 2003, but only 1,015 were admitted to hospital.

These examples tell us a great deal about the sociology of medical care during armed conflict and the effects on statistical results. In urban warfare, all civilian city-dwellers who are injured, even with very minor wounds, will seek medical treatment and be registered as war-wounded. Everybody goes to the hospital! Their reasons for presenting at a hospital or clinic are many: the medical sophistication of an urban population used to seeking curative care; the need for reassurance and a "safe" haven (the hospital as "hotel"), hopes of financial compensation for those injured and the search for simple psychological support for a traumatized civilian population.

11 Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF. Understanding combat casualty care statistics. *J Trauma* 2006; **60**: 397 – 401. Nessen SC, Gurney J, Rasmussen TE et al. Unrealized potential of the US military battlefield trauma system: DOW rate is higher in Iraq and Afghanistan than in Vietnam, but CFR and KIA rate are lower. *J Trauma Acute Care Surg* 2018; **85**: S4-S12.

5

Although the presence in hospitals and clinics of so many superficially wounded patients may not represent the true extent of the surgical workload, the burden on the emergency department (triage and first aid), nursing care (wound dressings), and non-clinical work (administration, registration, laundry and kitchen) can be overwhelming. Statistical analysis is both difficult and tedious under such circumstances (e.g. Monrovia) or almost impossible (e.g. Kisangani).

5.4.5 Clinical and operational consequences and IHL

A number of clinical and operational elements are significant as regards IHL.

1. For armies, the total number of casualties – soldiers removed from active participation in combat or support – and the overall lethality of the battlefield as represented by the case fatality rate (CFR) are important in terms of medical planning and allocation of fighting resources.

   For civilian health facilities, the total number of casualties is only one measure of the social and economic burden of war and the human consequences of the disintegration of society.

2. The killed in action (KIA) figure is an indicator for the lethality of weapons and the type of combat. IHL concerns itself with the lethality of weapon systems and the conduct of hostilities.

3. KIA and died of wounds (DOW) are indicators for the efficiency of the evacuation chain, which depends on access to the wounded, appropriate pre-hospital care (field triage and initial treatment) and transport logistics (evacuation time and access to a hospital for the wounded). Access of health personnel to the wounded and access of the latter to medical facilities are supposed to be guaranteed, in accordance with the protection conferred upon these persons by IHL.

4. The adequacy of medical treatment depends on the efficiency of the evacuation system, the wounding mechanism and pathology (burns, blast, penetrating wounds, anti-personnel mines, etc.), and hospital competency. DOW and hospital mortality are the main indicators. Again, the medical consequences of weapon systems are relevant to IHL.

5. These indices of mortality are important. However, they say nothing about the severity of injury in survivors – morbidity and disability – or surgical workload, and these factors may have a greater long-term effect on civilian populations and health facilities. The number of operations per patient, infection rates, amputation rates and length of hospitalization are better indicators for the severity of injury and the burden of war-wounded casualties on a hospital. The human consequences of such effects are of direct relevance to IHL.

5.5 Aetiology of injury

5.5.1 Warfare scenarios

The type of warfare greatly influences the kinds of wound the surgeon sees and the anatomic distribution of injuries, which obviously affects hospital workload. The widespread use of anti-personnel blast mines in guerrilla and counter-insurgency warfare results in many traumatic amputations of the legs. Close combat with assault rifles causes many gunshot wounds with severe single injuries; shelling and bombing from a distance produce multiple fragment wounds, many of which are superficial. Major contemporary wars have seen a shift from gunshot wounds to fragment injuries in the majority of casualties.

In intercommunal strife, combatants in some societies engage in "traditional" warfare using machetes and pangas; slash wounds to the head, neck and shoulders predominate and, secondarily, injuries to the forearms when the victim attempts to protect him or herself. Elsewhere, the ready availability of small arms means that "traditional" combat and cattle raiding are now undertaken using AK-47 Kalashnikov rifles.

Weapon systems available to belligerents vary. The conventional armies of industrialized countries use air bombardment as well as artillery and armour, and their infantry is often fitted out with personal protective equipment. The conventional armies of low-income countries tend to rely on infantry and artillery. Rural guerrilla formations depend on ambush with personal firearms and landmines; urban guerrilla warfare is largely street fighting with rifles, rocket-propelled grenades and, sometimes, short-range mortars. The weapon systems available to combatants can also change during the course of a war.

The intensity of fighting, being on the offensive or defensive, losing or winning a given battle, the size of the unit actually engaged, and the percentage of soldiers really exposed to combat, all affect various combat casualty statistics.

Relevant clinical consequences
The numbers and relative proportions of civilian and military wounded and dead depend to a large extent on combat strategy and operational tactics, geographical site of fighting, access to medical care and who is winning or losing.

5.5.2 Definitions of weapon systems: methodology

Some confusion arises in surgical literature because of differing categories and definitions for wounding agents and mechanisms of injury: there is no universally accepted standard and the distinction between agent and mechanism is not always made clear.

"Landmines" include both anti-tank mines (ATM) and anti-personnel mines (APM); the two are not usually differentiated. ATM may be the agent of wounding, but the mechanism of injury can be blast, blunt, burn, or penetrating fragment. APM may be either a blast or a fragmentation device. The severity of the injury differs with the mechanism and aetiology, but this cannot always be determined from the categories in a study.

The category of "fragment wounds" often groups together injuries from shells, bombs, and grenades, together with APM. The differences are important in terms of surgical management, however. Small, superficial wounds from preformed grenade fragments often require no surgery, whereas this is never the case for APM fragments (see Chapter 10). Table 5.3 gives an indication of the distribution of wounds according to projectile, from a number of conflicts.

	Bullets %	Blast & fragments %	Other %
World War I (Western Allies)	39	61	
World War II (Western Allies)	10	85	5
Korea (USA)	7	92	1
Indochina (France)	62	38	
Algeria (France)	71	23	
Borneo (UK)	90	9	1
Lebanon: Beirut 1975 – 86	49	36	14
Northern Ireland	55	22	20
Falkland Islands / Malvinas (UK)	32	56	12
Thailand 1981	38	20	42 (APM)
Lebanon 1982 (Israel)	12	53	35
Lebanon: Bourj el-Barajneh refugee camp 1986 – 87	20	60	20
Eritrea 1988 – 91	33	63	2.2 (APM)
Bosnia-Herzegovina: Sarajevo 1992 – 96 (France)	59	37	4 (APM)
Bosnia-Herzegovina 1993 (Bosnia-Herzegovina)	49	46	5
Croatia 1991 – 93 (Croatia)	25	70	6 (APM)
Yugoslavia 1991 – 92 (Yugoslavia)	41	2	52 (APM)
Afghanistan 2008 – 2014 (USA)	28.5	58.5	6
Mosul offensive 2016 – 17 (Iraqi Kurdistan)	18	68	14 (IED)

Table 5.3 Aetiological distribution of the war-wounded: generally accepted historical examples. Anti-personnel landmines included in some. The country name in brackets indicates the source of information; see Selected bibliography.

5.5.3 ICRC statistics

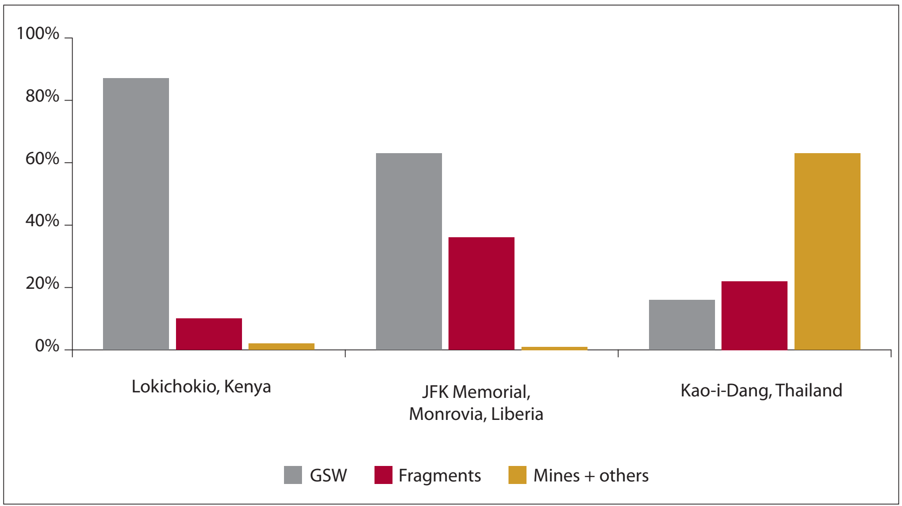
ICRC surgical teams have worked in many different wars and combat scenarios. Table 5.4 shows the mechanism of injury in different types of warfare.

Hospital	N =	Fragments %	Bullets %	Mines %
Butare	40	8	92	–
Kabul	6,244	52	29	19
Kao-i-Dang	1,067	22	16	63
Kandahar	1,159	24	50	26
Novye Atagi	186	44	35	22
Peshawar	4,340	42	23	35
Quetta	6,570	33	39	28
Lokichokio	12,196	10	87	2
Monrovia (JFK Memorial)	867	38	62	–
Peshawar 2	2,964	56	37	6

Table 5.4 Aetiology of war-wounded in a number of ICRC hospitals.

Extremes of the distribution of wounding mechanisms are to be found in these very different conflicts, and reflected in the statistics held in the various hospitals (Figure 5.3). Southern Sudan was the scene of a rural guerrilla war in semi-desert sahelian landscapes and reed swamps (Lokichokio hospital in northern Kenya) where most injuries were gunshot wounds (GSW). Fighting in Monrovia, Liberia, was irregular urban warfare (JFK Memorial Hospital). Patients coming to Kao-i-Dang hospital (Thailand) had been injured in rural guerrilla warfare waged in the forests and jungles of Cambodia with widespread use of anti-personnel landmines. Needless to say, the types of pathology encountered in these three hospitals differed widely.

Figure 5.3
Different combat tactics produce very different distributions of wounding agents.



5.6 Anatomic distribution of wounds

The aetiology of wounds and their anatomic distribution change constantly depending on the development of new weapon systems, personal protective material (body armour), and the nature of combat. One constant, however, is the preponderance of wounds to the limbs amongst survivors. This distribution is important in determining surgical workload.

5.6.1 Body exposure

Body exposure to injury differs according to the type of weapon:

- anti-personnel blast mines strike the legs (Pattern 1 APM injury);
- manipulation of mines injures the upper limbs, face and chest (Pattern 3 APM injury) as described in Chapter 3;
- fragmentation devices spray the whole body with multiple hits in a random fashion.

Body exposure also varies according to the type of combat and military activity:
- aimed sniper fire targets the head or chest;
- trench warfare particularly exposes the head, resulting in the many mutilating facial wounds of World War I, the victims being known as "*gueules cassées*" – literally, "broken faces";
- deliberate observation and lookout activities on the part of a soldier also increase the risk to the head and neck.

On the other hand, improved helmets and body armour, covering the chest and upper abdomen, effectively modify the relative exposure of anatomic regions, with remarkable results among coalition forces in Afghanistan and Iraq. Improved vehicle armour also skews the results.

Apart from aimed sniper fire, projectiles cause injuries in a random manner. Traditionally, combat exposure to injury has been estimated using as a basis the percentages of body surface area applied to assess burns, but taking into account operational necessities for soldiers and the consequent body position at time of wounding: lying down facing the enemy, standing, running, etc. (Table 5.5). It should be noted that combat exposure of the head and limbs is over-represented when compared to burns.

	Head	Neck	Thorax	Abdomen	Limbs
Body exposure in combat %	12		16	11	61
Surface area (burns) %	9	1	18	18	54

Table 5.5 Percentage of body surface area versus surface area exposed in combat.[12]

5.6.2 Definitions and methodology

The anatomic distribution of wounds has been remarkably consistent over the last century. Reporting, however, has been remarkably inconsistent. Some studies cite only the primary site of injury if there is more than one; others include the category "multiple". Some count the "wounds" and not the "wounded", so that sites of injury exceed the number of patients. Many studies do not clearly define the counting method; in some reports only survivors are counted, while for others total combat casualties – KIA and WIA – are included. Again, the methodology is not always specified.

Anatomic regions are not standardized either. Different studies use different definitions for anatomic regions; there is again no universal standard. Some report only the "torso"; "pelvis and buttocks" are under a separate category from "abdomen" in some, and included in others. To be truly accurate, head, face, and neck categories should be clearly separated, which they rarely are. These latter wounds represent very different clinical problems – traumatic brain injury, asphyxia, haemorrhage – and degrees of lethality.

Anatomic distribution furthermore only indicates a potential threat; crude statistics often include superficial wounds, which is not a true indication of hospital workload and threat to life and limb. As has been mentioned above, it would be preferable to separate out penetrating from non-penetrating wounds of vital regions: head, thorax, and abdomen. The Red Cross Wound Score and Classification System attempts to address some of these problems in a simplified manner.

12 Carey ME, 1987.

5.6.3 Historical results

The reader going through the literature will find very different figures for the same war, depending on the source and the methodology. This can make for frustrating reading. Table 5.6 below nonetheless presents a number of historical approximations. Wounds to the limbs predominate, ranging from 50% to 79%.

Conflict	Head & neck %	Thorax %	Abdomen %	Limbs %	Other & multiple %
World War I (Western Allies)	17	4	2	70	7
World War II (Western Allies)	4	8	4	79	9
World War II (USSR)	19	9	5	67	–
Korea (USA)	17	7	7	67	2
Viet Nam (USA)	14	7	5	74	–
Borneo (UK)	12	12	20	56	–
Northern Ireland	20	15	15	50	–
Arab-Israeli War 1973 (Israel)	13	5	7	40	31
Thailand 1981	10	12	4	66	8
Falkland Islands / Malvinas (UK)	16	15	10	59	–
Lebanon 1982 (Israel)	14	5	5	41	34
Lebanon: Bourj el-Barajneh refugee camp 1986 – 87	12	16	18	54	–
Gulf War 1991 (UK)	6	12	11	71	(32)*
Gulf War 1991 (USA)	11	8	7	56	(18)**
Afghanistan (USSR)	16	12	11	61	–
Chechnya 1995 (Russia)	24	9	4	63	–
Croatia 1991 – 93 (Croatia)	15	11	4	69	1
Yugoslavia 1991 – 92 (Yugoslavia)	21	9	8	62	(23)**
Croatia 1991 (Yugoslavia)	12	15	8	65	–
Bosnia-Herzegovina 1992 (Yugoslavia)	14	15	9	62	–
Bosnia-Herzegovina 1993 (BH)	19	16	11	53	–
Bosnia-Herzegovina: Sarajevo 1992 – 96 (France)	11	11	14	61	3
Bosnia-Herzegovina: Sarajevo market bombing 1995	13	13	12	62	–
Eritrea 1988 – 91	20	9	6	63	2
Afghanistan / Iraq 2005 – 09 (USA)	28	10	10	52	
Mosul offensive 2016 – 17 (Iraqi Kurdistan)	18.5	6	10	59	6.5
ICRC surgical database	12.5	7.2	7.8	65.5	7
Overall average	~15	~10	~7	~65	

* Buttock and back wounds – all of which were multiple-fragment injuries – as a separate figure.

** Multiple wounds.

Table 5.6 Anatomic distribution of major wounds; some statistics include both dead and survivors, others include minor injuries. The country name in brackets indicates the source of information, see Selected bibliography.

5.6.4 ICRC results

The experience of ICRC surgical teams in various conflicts closely mirrors that of surgeons in other wars, particularly in relation to the type of conflict (Table 5.7). Many patients have multiple wounds; the distribution is given for injuries and not for patients, hence more wounds than patients. Only one wound is counted per anatomic region, however.

Pelvis and buttocks, back and soft tissue are given separately. Head, face and neck are not differentiated further.

Hospital	Number	Head & neck %	Thorax %	Abdomen %	Pelvis & buttocks %	Back & soft tissue %	Upper limb %	Lower limb %	Limbs combined %
Kabul	8,804	15	9	10	4	3	24	35	59
Kao-i-Dang	1,660	15	8	7	4	3	24	39	63
Peshawar	6,840	18	8	6	5	3	25	35	60
Kandahar	1,396	11	9	11	3	2	24	40	64
Quetta	9,373	15	9	8	5	3	24	36	60
Butare	45	16	7	2	–	2	31	42	73
Novye Atagi	210	10	3	7	2	3	26	50	76
Lokichokio	14,203	7	8	3	7	3	29	44	73
Monrovia	904	14	13	4	4	–	21	43	64

Table 5.7 Anatomic distribution of wounds in various ICRC hospitals serving victims of differing types of combat.

5.6.5 Primary tissue injury

The anatomic distribution of wounds and the analysis of primary tissue injury permit the assessment of the surgical workload. In both, wounds to the limbs predominate. The WDMET[13] statistics from Viet Nam are eloquent (Table 5.8), as are the figures from a French military field hospital in Sarajevo, 1992 – 1996, (Table 5.9). The widespread use of improved body armour by American troops in Afghanistan and Iraq has changed certain percentages: note the great decrease in chest wounds (Table 5.10). These analyses take into account non-penetrating wounds to vital regions.

Soft tissue (especially of limbs)	47 %
Extremities (long bone fractures)	26 %
Abdomen	8 %
Chest	4 %
Neck	2 %
Face	6 %
Head	2 %
Multiple	5 %

Table 5.8 Distribution of wounds according to primary tissue injury (USA in Viet Nam).[14]

Soft tissue (especially of limbs)	56 %
Extremities (long bone fractures)	22 %
Abdomen	14.5 %
Chest	11 %
Face & neck	6 %
Head	6 %
Peripheral vessels	6 %
Multiple	6 %

Table 5.9 Distribution of wounds according to primary tissue injury (French military field hospital in Sarajevo).[15]

Soft tissue (especially of limbs)	37.5 %
Extremities (long bone fractures)	13.8 %
Abdomen	13 %
Chest	0.9 %
Face & neck	6.9 %
Head	3 %
Peripheral vessels	6.5 %
Amputation	4.6 %

Table 5.10 Distribution of wounds according to surgical procedure (USA in Afghanistan and Iraq).[16]

ICRC results

In the hospitals included in the ICRC database, where evacuation was difficult for numerous patients and many with minor soft-tissue wounds did not bother to come to hospital, soft-tissue injuries still represented 36 % of wounds, fractures of the extremities 46 % and vital central wounds 20 %.

13 In the military literature, the Wound Data and Munitions Effectiveness Team (WDMET) of the United States set a gold standard for data collection. A large number of administrative staff meticulously and systematically collected information on 7,989 patients during the war in Viet Nam from 1967 to 1969. Bellamy RF. Combat trauma overview. In: Sajtchuk R, Grande CM, eds. *Textbook of Military Medicine, Anesthesia and Perioperative Care of the Combat Casualty*. Falls Church, VA: Office of the Surgeon General, United States Army; 1995: 1 – 42. This report is often cited in review articles.

More recently, the US Joint Theater Trauma Registry (JTTR) and System (JTTS), and similar UK and NATO registries, have attempted to overcome shortfalls in battlefield data collection, which is an onerous task in terms of administrative staff and IT resources.

14 Champion HR, Bellamy RF, Roberts P, and Leppäniemi A. A profile of combat injury. *J Trauma* 2003; **54 (suppl.)**: S13 – S19.

15 Versier G, Le Marec C, Rouffi J. Quatre ans de chirurgie de guerre au GMC de Sarajevo (juillet 1992 à août 1996). *Médecine et armées* 1998; **26**: 213 – 218.

16 Turner CA, Stockinger ZT, Gurney JM. Combat surgical workload in Operation Iraqi Freedom and Operation Enduring Freedom: the definitive analysis. *J Trauma Acute Care Surg* 2017; **83**: 77 – 83.

Various other ICRC reports confirm these findings (Tables 5.11 and 5.12).

Soft tissue	33 %
Bones and joints	33 %
Vascular	11 %
Peripheral nerves	11 %
Abdomen – hollow organs	17 %
Abdomen – solid organs	9 %

Urogenital	5 %
Chest	9 %
Brain and spinal cord	3 %
Maxillo-facial	3 %
Eye, internal ear	2 %
Other	1 %

Table 5.11 Distribution of wounds according to tissue injury, hospitalized patients in the ICRC field hospital, Beirut 1976 (N = 696).[17]

Parts injured	Total % (N = 1,033)	Bullet wounds % (n = 231)	Shell fragment wounds % (n = 508)	Mine injuries % (n = 294)
Soft tissue	73	67	75	70
Bone	39	52	20	63
Thorax	7	7.5	9	4
Abdomen	11	10.5	14	7.5
Brain	2.5	–	5	1
Other	4	2.5	4	4

Table 5.12 Tissue injuries according to wounding weapon, Kao-i-Dang ICRC hospital, 1984 – 85.[18]

The clinically important point for the surgeon is the very large hospital workload represented by soft-tissue and orthopaedic injuries.

5.7 Fatal injuries

5.7.1 Site

It is not a simple matter to determine cause of death and site of lethal injury. Multiple injuries tend to have a synergetic effect and it can be impossible to define which of several wounds was the direct cause of death. Furthermore, many fatal war injuries involve total body disruption or severe mutilation.

A formal complete autopsy for every combat death is onerous even for the armed forces of a wealthy industrialized country, and this has rarely been common practice. Three examples of the anatomic distribution of fatal wounds are given in Table 5.12.

<table>
<tr><th></th><th>US dead in World War II[19]</th><th colspan="2">US dead in Viet Nam (WDMET)[20]</th><th colspan="2">Israeli dead in Lebanon 1992[21]</th><th>US pre-hospital dead in Afghanistan/Iraq[22]</th></tr>
<tr><td>Head</td><td rowspan="3">42 %</td><td>37 %</td><td rowspan="3">46 %</td><td>9 %</td><td rowspan="3">34 %</td><td rowspan="3">34 %</td></tr>
<tr><td>Neck</td><td>6 %</td><td>3 %</td></tr>
<tr><td>Face</td><td>3 %</td><td>22 %</td></tr>
<tr><td>Chest</td><td>30 %</td><td colspan="2">24 %</td><td colspan="2" rowspan="2">45 %</td><td>23 %</td></tr>
<tr><td>Abdomen</td><td>12 %</td><td colspan="2">9 %</td><td>2 %</td></tr>
<tr><td>Multiple</td><td>–</td><td colspan="2">17 %</td><td colspan="2">–</td><td>13 %</td></tr>
<tr><td>Limbs</td><td>13 %</td><td colspan="2">3 %</td><td colspan="2">21 %</td><td>4 %</td></tr>
<tr><td>Soft tissue</td><td>–</td><td colspan="2">1 %</td><td colspan="2">–</td><td>(High spinal) 3 %</td></tr>
</table>

Table 5.13 Anatomic distribution of fatal wounds.

17 Translated from: Kjaergaard J. Les blessés de guerre de l'hôpital de campagne du CICR à Beyrouth en 1976. *Schweiz Z Milit Med* 1978; **55**: 1 – 23.

18 Trouwborst A, Weber BK, Dufour D. Medical statistics of battlefield casualties. *Injury* 1987; **18**: 96 – 99.

19 Garfield RM, Neugut AI. Epidemiologic analysis of warfare. *JAMA* 1991; **266**: 688 – 692.

20 Champion HR, et al., 2003.

21 Gofrit ON, Kovalski N, Leibovici D, Shemer J, O'Hana A, Shapira SC. Accurate anatomical location of war injuries: analysis of the Lebanon war fatal casualties and the proposition of new principles for the design of military personal armour system. *Injury* 1996; **27**: 577 – 581.

22 Nessen SC, et al., 2018.

Central wounds predominate, as would be expected, particularly to the head, face, neck and thorax.

The great majority of war wounds are to the limbs.
The most lethal wounds are to the head and chest.

5.7.2 Trimodal distribution of trauma mortality

Mortality in civilian trauma was classically described by D. Trunkey in 1983[23] as falling into three categories: immediate death (50 %), early death (30 %), and late death (20 %), see Figure 5.4.

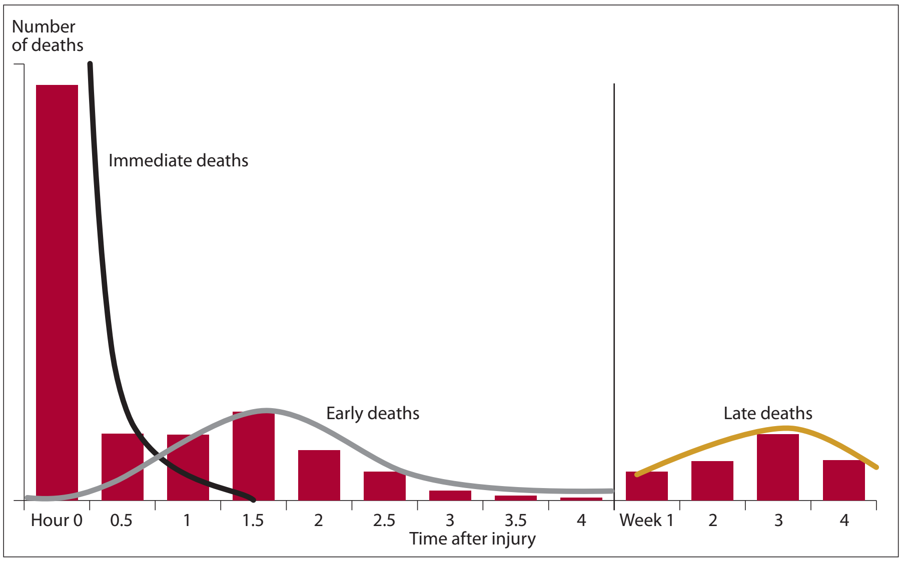


Figure 5.4
Trimodal distribution of trauma deaths.

Peak 1: Immediate deaths
Most deaths occur at the moment of injury or within minutes. These are due to overwhelming trauma incompatible with life (severe brain injury, massive haemorrhage).

In war, in addition to severe injuries to the head and torso (heart, liver, and major blood vessels), some casualties suffer total body disruption or incineration through burns. It is estimated that 70 % of deaths occur within five minutes, and little to nothing can be done for these patients, who represent about 17 – 20 % of the severely wounded.

Peak 2: Early deaths
These occur between the first minutes and the first few hours after injury. This peak gave rise to the idea of the "golden hour"; if certain measures are implemented rapidly, the patient can be saved.

In war trauma, there are three major causes of early death:
- continuing exsanguinating haemorrhage;
- inadequate/impaired airway due to survivable penetrating head injury;
- compromised breathing due to tension pneumothorax.

Many of these early deaths are avoidable within this "golden hour" if adequate first-aid measures in the field are implemented in time.

Peak 3: Late deaths
These occur a few days to weeks after injury and are the result of subsequent complications of infection, multiple organ failure and coagulopathy, and uncontrollable increased intra-cranial pressure due to post-injury cerebral oedema (closed injury).

23 Trunkey DD. Trauma. *Sci Am* 1983; **249**: 220 – 227.

Good and early first-aid measures can decrease infectious and other complications in the setting of armed conflict where wounds are dirty and contaminated from the very beginning. Inadequate early care affects morbidity (sepsis, disability) as well as mortality.

Understanding this trimodal distribution of deaths stimulated an improvement in emergency medical services and patient transport in civilian settings. Rapid evacuation times and early advanced life support in many industrialized countries, in a bid to reach the injured during the "golden hour", have reduced these three peaks to a bimodal profile: immediate deaths and late.

Applicability to the military war-wounded

The armed forces have found that the trimodal distribution is relevant to armed conflict. They have tended to underline three categories of patients corresponding to what can be done under various operational scenarios in the field. This has an important influence on field triage categories.

1. Unsalvageable injuries: i.e. KIA for whom nothing can be done (10 – 20 % depending on use of improved body armour).
2. Severe but potentially survivable injury (10 – 15 %).
3. Moderate to minor injuries (65 – 70 %).

One result of improved pre-hospital care and evacuation is that some casualties become DOW (early deaths) instead of being KIA (immediate deaths) while a few others are saved. The most important field measures undertaken include stopping haemorrhage from controllable peripheral bleeding and maintaining a patent airway and breathing by simple procedures.

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Not all penetrating head injuries are so severe as to be incompatible with life. However, precarious pre-hospital care and long and difficult evacuation routes can result in large numbers of survivors of head injuries (WIA) succumbing later (DOW) because of inadequate control of the airway, resulting in asphyxia or vomiting and aspiration.

This was the case during one recent war in Africa involving a "conventional" army. Large numbers of patients with salvageable head injuries were dying during a three-day evacuation in the backs of lorries travelling over dirt roads in the bush. There was no possibility of monitoring endotracheal intubation.

An ICRC surgeon advised performing a tracheotomy in a front-line field hospital before evacuation, the only way to ensure an adequate airway under the circumstances in these comatose patients. This simple procedure halved the mortality rate for these cases.

Applicability to civilian war-wounded

During the shelling of the Markale market place in Sarajevo on 28 August 1995, only minutes away from two referral hospitals, 104 persons were injured of whom 42 ultimately died; a fatality rate of 40.8 %.[24]

Twenty-three died instantly and another ten were dead on arrival at hospital (79 % of deaths were first peak). Five patients succumbed during surgery (second peak 12 %) and another four a week later (third peak 10 %), as shown in Figure 5.5. The trimodal distribution of deaths appears to have been preserved.

24 Suljevic I, Surkovic I. Medical aspects of the mass-scale civilian casualties at Sarajevo Markale Market on August 28, 1995: triage, resuscitation, and treatment. *Croat Med J* 2002; **43**: 209 – 212.

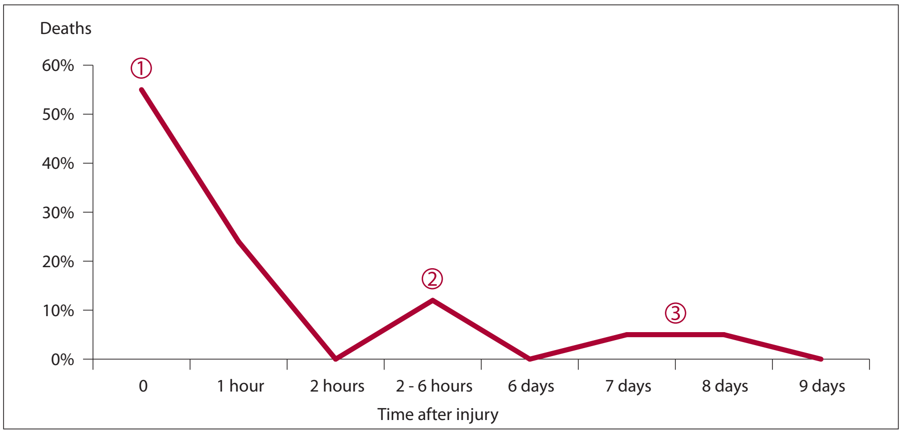


Figure 5.5

Trimodal distribution of deaths after shelling of Markale Market, Sarajevo.

Furthermore, in remote rural areas with difficult evacuation routes, both armies and civilian populations will probably experience the trimodal distribution of deaths, as originally described. Trauma survival under such circumstances is geography-specific.

5.7.3 Ratio of dead to survivors

Many authors have noted that the ratio of dead to survivors in modern conflicts tends to be about 1:4 over the long term. This corresponds to our threshold fatality rate of about 20 – 25 %.

$$\frac{\text{Dead} = \text{KIA} + \text{DOW}}{\text{Survivors} = \text{WIA} - \text{DOW}} = 1{:}4$$

Many factors can distort the specific results under given circumstances, including:
- the inclusion of minor wounds in the calculations – the famous methodological problem;
- the tactical situation (note the 40 % fatality rate of the Markale market place bombing mentioned above; burn injuries in tank crews or on ships; a successful surprise ambush, etc.);
- the lethality of particular weapon systems (anti-personnel landmines, napalm, etc.);
- any delay in medical evacuation;
- the execution of wounded prisoners in contravention of the laws of war.

Improvements in personal protective equipment (body armour), better pre-hospital care and the early availability of more aggressive surgery and enhanced intensive care facilities have changed the ratio in recent conflicts. For US armed forces in Iraq and Afghanistan, the dead to survivor ratio has become 1:7.[25] Effective body armour has decreased fatal wounds to the chest and abdomen, but increased wounds to the head and neck in survivors. No other armed forces use such improved body armour as extensively, and the US experience is not easily translated to other armies and groups, but it does set a standard.

5.7.4 Lethality of weapons

If KIA equals about 20 % and DOW 5 %, this approximates the total lethality of weapons during combat on land (CFR). Sea and air warfare are different.

It has long been recognized that different weapon systems have different lethality. In general, and over a large number of casualties, the percentages are as follows:
- Military rifle bullets: 30 – 40 % lethality; or one death in every 3 – 4 wounded.
- Randomly-formed fragments: 20 % for shells and 10 % for grenades.
- Preformed fragments: 15 % for shells and 5 % for grenades.
- Blast injury has a fatality of about 22 %.

Tactical considerations for individual battles can change these figures. A well-laid ambush in which small arms are used can easily result in an entire small patrol being killed.

25 Nessen SC, et al., 2018.

The particular case of anti-personnel landmines

All studies indicate the heavy surgical and nursing burden of injuries due to anti-personnel landmines, especially blast mines. Specific types of APM – bounding mines that jump up one metre in the air before exploding – invariably kill their victim: lethality lies close to 100 %.

Public health studies and ICRC surveys in poor countries where APM have been widely used in rural areas with little or no organized evacuation system and limited surgical facilities (Mozambique, Somalia, Cambodia, Afghanistan and Angola) indicate a case fatality rate of well over 50 % for traumatic amputations due to APM.

It is difficult to exclude the non-weapon factors in these studies and mortality statistics. Suffice it to say that the lethality of weapons includes their actual use in field conditions, and their total socio-economic and humanitarian effects. This is important in terms of IHL and was one of the significant factors in convincing countries to negotiate the 1997 Ottawa Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-personnel Mines and on their Destruction.

5.7.5 Conclusions of clinical relevance

From this analysis and further extrapolations a number of conclusions can be drawn.

1. Wounds to the head and torso are the most lethal; they represent most of the mortality. The great majority of survivors have injuries to the limbs; they represent the majority of surgical workload and morbidity.

2. Despite the fact that the head represents only 9 % of exposed body surface area, it accounts for a disproportionate number (25 %) of all battle casualties. The lethality of penetrating head wounds is approximately 75 % and they account for slightly less than 50 % of combat deaths (KIA + DOW), and about 8 % of survivors.

3. Head wounds kill either through devastating brain injury or through asphyxiation of the comatose patient who would otherwise survive the injury.

4. Death through closed head injury is relatively more frequent in the civilian setting than during armed conflict.

5. Uncontrolled exsanguinating haemorrhage accounts for another 50 % or so of deaths. Most of these (80 %) present central injuries to the thorax and/or abdomen, which require surgical facilities for control. The lethality of chest wounds is about 70 %.

6. The other 20 % of haemorrhage deaths are due to bleeding from peripheral, compressible blood vessels. Half of these wounds are to the neck and half to the limbs. About 10 % of all deaths are therefore due to haemorrhage from the limbs.

7. Death rates through haemorrhagic shock are higher in armed conflict than in the civilian trauma setting and haemorrhage accounts for 90 % of pre-hospital and 80 % of in-hospital deaths from potentially survivable injuries.

8. Little can be done medically for most immediate deaths and there is a threshold percentage of killed-in-action no matter how sophisticated the medical services are.

Conclusions for improvement of patient outcome

1. Some immediate and early deaths can be prevented by personal protective armour covering the torso.

2. Many early deaths can be prevented by simple measures to:
   - control limb haemorrhage;
   - relieve airway obstruction, especially in comatose patients after head injury;
   - relieve tension pneumothorax.

3. Some early deaths due to haemorrhage, particularly of the abdomen, can be prevented by rapid evacuation to a surgical facility.

5.8 The lethality of context: delay to treatment

5.8.1 Historical developments

Possibly one of the most important developments in combat casualty care over the last half-century has been improved pre-hospital care and the timely evacuation of the wounded to a surgical facility. Lasting days during much of World War I, evacuations took an average of 10.5 hours during World War II; the use of helicopters by American troops lowered this to 6.3 hours in Korea and to an average of 2.8 hours in Viet Nam. Transfer of Israeli wounded during the 1982 war in Lebanon took an average of 2.3 hours. The use of helicopters has radically changed evacuation and pre-hospital care for the armies of industrialized countries, but requires air superiority to be truly effective. It has also revolutionized equivalent civilian trauma systems. This resource is seldom available in a low-income country.

5.8.2 Forward projection of resources

Delayed evacuation may still result from operational contingencies, tactical situations, and difficult geography. Consequently, many armies have projected their surgical capacities forward, close to zones of actual combat, in an attempt to reach wounded soldiers earlier and avoid the mortality and morbidity related to any delay. The aim is primarily to reduce the number of "early" deaths.

Soviet deployment of "Special Surgical Teams" in forward locations in Afghanistan shortened time to reach surgery: 31 % of wounded were in surgery within 1 hour and another 39 % within 2 hours. Cumulatively, 92 % were in surgery within 6 hours with this system. This compares with an overall average during the war of 88 % operated within 12 hours, before and after the establishment of the forward teams.

During fighting in Croatia in 1991, a Yugoslav mobile field hospital was located 5 – 10 km from the front: 61 % of wounded were evacuated within 30 minutes and another 22 % between 30 and 60 minutes of being injured.

US and UK troops in Afghanistan and Iraq have also seconded Forward Surgical Teams (FST) to the field that focus on damage control and resuscitative surgical techniques before transferring patients to referral theatre hospitals. Early reports gave a mean time of one and a half hours for evacuation of USA military wounded in Iraq to a forward surgical facility, which was further reduced to 43 minutes by the deployment of extra helicopters and FSTs.

5.8.3 Urban warfare: hospitals on front lines

During urban warfare, fighting can take place literally in front of surgical facilities; more than once has a patient been wounded at the front door of a hospital. This was the case during much of the fighting in Beirut in the Lebanese civil war, often with evacuation times of only minutes. A French medical team in Sarajevo in 1992 – 96 (UNPROFOR – IFOR), serving military and civilian casualties, had evacuation times of 15 – 45 minutes.

Comparable times were encountered by ICRC hospital teams in Kabul in 1992 and Monrovia, Liberia, in 2003. ICRC and Somali Red Crescent surgical teams working in the Keysaney Hospital in North Mogadishu have witnessed similar short evacuation times from 1992 up until the time of writing.

Although the vast majority of wounded patients arrive at the hospital within minutes under these circumstances, a few suffer considerable delay. Without an organized pre-hospital system and given an absolute absence of ambulances, civilians are often cut off from care facilities during street fighting and have to wait hours or even days for evacuation.

5.8.4 The paradox of early treatment: changing mortality ratios and rates

There is an apparent paradox as regards early evacuation and treatment: an increase in the absolute numbers who survive, but also an increase in the DOW and hospital mortality rates. Medics reach more injured patients in time who would have been KIA a few years ago, and a larger number of severely injured casualties enter the evacuation chain. However, this means that the natural automatic triage that weeded out the more severely injured does not come into play, so a higher percentage of injured now die of their wounds after they have received care.

Of US armed forces personnel who died in World War II and Viet Nam, 88 % were KIA and 12 % DOW. In the conflicts in Iraq and in Afghanistan, the figures are 76 % and 24 %.[26]

The KIA percentage in Viet Nam was 20.5 %, excluding RDT, while DOW was 3.3 %. In the Afghan and Iraqi conflicts, KIA decreased to 14.1 %, but DOW increased to 5.3 %; both changes are statistically significant.

This effect has also been observed in hospital mortality rates at ICRC facilities (Tables 5.14 and 5.15).

Time until arrival in hospital	Patients (n =)	Died	Mortality
< 6 hours	3,114	172	5.5 %
6 – 24 hours	3,588	141	3.9 %
24 – 72 hours	1,668	46	2.8 %
> 72 hours	2,430	55	2.3 %

Table 5.14 Mortality according to evacuation time to ICRC hospitals: January 1991 to July 1993.

Longer evacuation times allow for "natural triage" to come into play. The more seriously wounded die before they reach hospital when evacuation is delayed.

Time until arrival in hospital	Patients (n =)	Died	Mortality
< 6 hours	79	5	6.3 %
6 – 24 hours	704	21	3.0 %
24 – 72 hours	210	5	2.4 %
> 72 hours	134	2	1.5 %

Table 5.15 Mortality according to evacuation time: patients transferred from ICRC first-aid posts to Peshawar ICRC hospital, 1990 – 91.[27]

A new ratio: critical area to extremity wounds

A statistical method has been used to try to overcome this "bias" of logistical progress, in order to better evaluate the effect of "natural triage" due to a lack of appropriate surgical care and evacuation facilities in low-income countries. In such conditions pre-hospital mortality cannot be properly determined either. The ratio of wounds in critical areas (trunk, head and neck) to wounds of the extremities is calculated among survivors: CA: EXT:

$$\frac{\textbf{Critical areas (head, face, neck, thorax, abdomen, pelvis)}}{\textbf{Non-critical areas (limbs, back, soft tissue injuries of trunk)}} = \textbf{CA: EXT}$$

CA = critical area, EXT = extremities and other non-critical areas.

Obviously, the wearing of body armour and the inclusion in statistics of minor or superficial, non-penetrating wounds to the head or trunk will distort the anatomic distribution of wounds and the ratio.

26 Holcomb JB, et al., 2006. Nessen SC, et al., 2018.

27 Korver AJH. Outcome of war-injured patients treated at first aid posts of the International Committee of the Red Cross. *Injury* 1994; **25**: 25 – 30.

In most wars, with evacuation counted in hours, the ratio is approximately 0.5. In urban areas and other situations of rapid evacuation, it tends towards 1. With increasing delay of evacuation to over 24 hours, and even days and weeks, the ratio falls.

Thus, studies of guerrilla and counter-insurgency warfare in difficult geographical terrain give much lower ratios, indicating that the most seriously injured patients (critical area wounds) died before treatment (Table 5.16).

Conflict	Ratio
Thailand counter-insurgency	0.39
Eritrean war of independence	0.26
Ugandan guerrilla war	0.21
Afghan mujahideen	0.07
Southern Sudan guerrilla war (ICRC Lokichokio hospital)	0.33

Table 5.16 Ratio of critical area to limb wounds in various insurgency conflicts.[28]

5.9 Hospital mortality

5.9.1 Historical considerations

As mentioned, rates of killed in action for armies have remained relatively stable over the last half-century at about 20 %. Hospital mortality, however, has diminished greatly with medical progress (safe anaesthesia, blood transfusion, better understanding of the physiology of shock, antibiotics and more aggressive surgical techniques) as shown in Table 5.17.

Conflict	Hospital mortality rate %
Crimean War 1854 – 55 (UK casualties)	16.7
American Civil War 1861 – 65 (Union casualties)	14.1
Boer War 1899 – 1901 (UK casualties)	8.6
World War I 1917 – 18 (USA casualties)	7.6
World War II (USA casualties)	4.5
American – Viet Nam War (USA casualties)	2.5

Table 5.17 Hospital mortality: examples from the past.

Hospital mortality has come to be an indicator of the efficiency of the management system, bearing in mind what has already been said about the paradox of early evacuation of the very severely injured. In calculating these figures, however, one must take into account the percentage of truly "vital" injuries and exclude or specify the superficial ones.

5.9.2 Hospital mortality versus post-operative mortality

A number of considerations must be taken into account if one wishes to use hospital mortality as an indication of the efficiency of patient management systems. In armed conflict, surgeons often face mass casualties. Some patients will be triaged into Category IV, and given supportive treatment only, to die without pain and with dignity (see Chapter 9). These patients are recorded as DOW and are often included in hospital mortality figures.

Other patients die shortly after arrival, or "on-table", in an extreme attempt to save life. With a slightly longer evacuation time, many such patients would be KIA, dying before reaching hospital, as mentioned previously. Nonetheless, they are registered as DOW and are again included in hospital mortality figures.

Then there are the truly post-operative deaths; some from irreversible shock, others from irretrievable brain injury and others still from surgical complications, mostly sepsis, and additional medical pathologies.

28 Adapted from Bhatnagar MK, Smith GS. Trauma in the Afghan guerrilla war: effects of lack of access to care. *Surgery* 1989; **105**: 699 – 705.

Gross statistics of hospital mortality do not always take into consideration these very different categories of patients.

5.9.3 ICRC hospital mortality

Austere working conditions, often a limited number of professional staff and at times a perilous security situation, all mean that work in ICRC hospitals resembles that commonly seen in public hospitals in a poor country. Military medical services from industrialized countries may also face these constraints, but they tend to be of a different order of magnitude.

Post-operative mortality in ICRC hospitals varies from 2.2% in Quetta and 3.1% in Peshawar to 4.2% in Kao-i-Dang, 4.8% in Kabul, and 6.1% in the Monrovia battle, where evacuation times were extremely short.

5.10 ICRC statistical analysis of hospital workload

5.10.1 Surgical audit: methodology

Without control over the pre-hospital phase and the known inadequacies of data collection, the mortality rate is not a credible statistic in ICRC surgical programmes and hospitals. The same is true of most public civilian facilities. Far more substantial is the workload and morbidity, as represented by the number of operations and blood transfusions per patient and the duration of hospitalization.

For statistical purposes, most patients, if well managed, undergo two operations: wound excision and delayed primary closure. There are a number of factors that explain this:

- The ICRC does not have a series of operative echelons of treatment as do the armed forces; all operations are performed in the same hospital (see Chapters 1 and 6).
- Rarely do ICRC surgeons perform planned serial debridements of war wounds, requiring more operations (see Chapter 10).
- Some patients require a third operation for skin grafting to close the wound, or even more if a burn complicates a penetrating wound (see Chapter 11).
- Others call for a single operation (craniotomy, chest tube drainage or laparotomy).
- Some patients call for no operation, if they have been admitted solely for observation – expectant triage category, paraplegic, etc. (see Chapter 9).
- Small superficial wounds are often treated conservatively with dressings and antibiotics, with the exception of those caused by anti-personnel landmines (see Chapter 10).

These "normal" single and multiple operations tend to balance each other out. (Pure burn injuries are not included in this discussion.)

> Most patients require two operations: debridement and delayed primary closure. More than two usually denotes a complication, typically infection.

Performing more than two operations per patient usually denotes a complication, typically infection, and is a good indication of morbidity. Thus, as an appropriate approximation of workload and correct surgical management, the ICRC uses the average of two operations per patient in large studies. These premises form the basis for the following discussion.

5.10.2 Number of operations per patient: all patients

The number of operations per patient for all patients with the relevant information in the ICRC database is given in Table 5.18.

None	9 %
1 operation	16 %
2 operations	41 %
< 2 operations	66 %
3 operations	14 %
> 4 operations	20 %

Table 5.18 Number of operations per patient (N = 16,172).

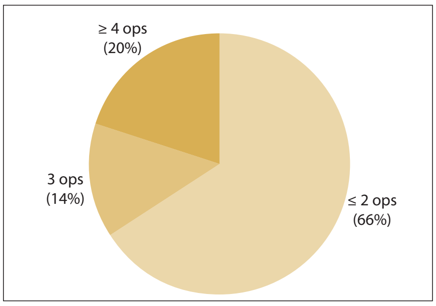


Figure 5.6
Number of operations per patient, simplified (N = 16,172).

To simplify, the number of operations is described as two or less, three, or four and more (Figure 5.6).

Fully two-thirds of all patients in the database had two operations or less, indicating a minimum of morbidity and good surgical management. There are a number of factors that influence this surgical workload: delay in evacuation, severity of the wound, type of wound, and wounding mechanism. A brief analysis of some of these factors is given in the following sections.

5.10.3 Number of operations according to delay in evacuation

Table 5.19 shows the results for the number of operations per patient according to evacuation time to the ICRC hospital in Kabul during a period of major urban combat.

Evacuation time	N = 6,140	None	1 op	2 ops	≤ 2 ops	3 ops	≥ 4 ops
< 6 hrs	3,214	7 %	30 %	47 %	84 %	7 %	8 %
6 – 24 hrs	1,606	7 %	23 %	51 %	81 %	9 %	11 %
24 – 72 hrs	605	6 %	24 %	50 %	80 %	7 %	12 %
> 72 hrs	715	9 %	26 %	42 %	77 %	9 %	14 %

Table 5.19 Number of operations per patient according to time of evacuation to ICRC Kabul hospital 1990 – 92.

These figures are confirmed if one examines the entire database (Table 5.20).

Evacuation time	N = 16,172	≤ 2 ops	3 ops	≥ 4 ops
< 6 hrs	2,409	81 %	9 %	10 %
6 – 24 hrs	3,727	70 %	13 %	17 %
24 – 72 hrs	2,785	69 %	13 %	17 %
> 72 hrs	7,251	71 %	12 %	17 %

Table 5.20 Number of operations per patient according to time of evacuation to ICRC hospitals, 1990 – 99.

While hospital mortality is influenced by delay in evacuation, morbidity as determined by number of operations per patient apparently is not. The critical limit would appear to be 6 hours delay – the category "6 – 12 hours since injury" does not exist in the ICRC database, and this is a field for future study. However, before rushing to such a conclusion, another factor must be analysed: wound severity.

5.10.4 Number of operations according to the Red Cross Wound Grade

War wounds are categorized into one of three Grades of increasing severity according to the Red Cross Wound Score and classification system (see Chapter 4). The distribution in the ICRC surgical database is as follows.

- Grade 1: 42 %.
- Grade 2: 37 %.
- Grade 3: 21 %.

If one looks at the number of operations according to Wound Grade, an important difference appears (Table 5.21 and Figures 5.7.1 – 5.7.3).

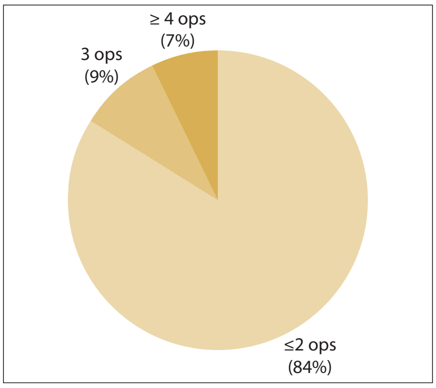


Figure 5.7.1
Number of operations per patient for Grade 1 wounds (N = 6,729).

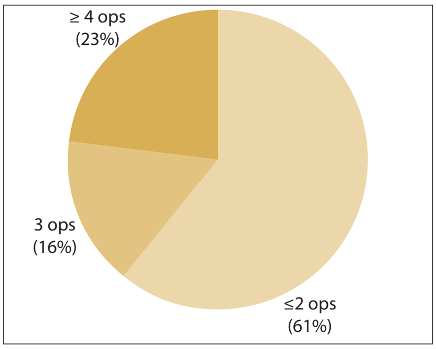


Figure 5.7.2
Number of operations per patient for Grade 2 wounds (N = 5,974).

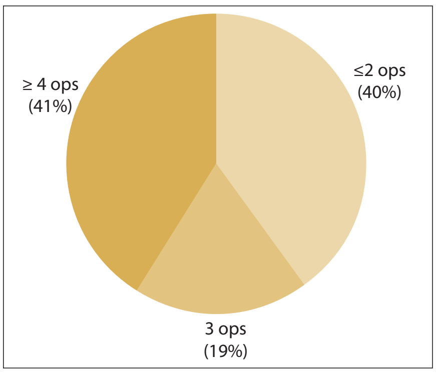


Figure 5.7.3
Number of operations per patient for Grade 3 wounds (N = 3,469).

Severity of wound		Number of operations per patient					
	Patients (N = 16,172)	None %	1 op %	2 ops %	≤ 2 ops %	3 ops %	≥ 4 ops %
Grade 1	n = 6,729	16	23	45	84	9	7
Grade 2	n = 5,974	4	12	44	61	16	23
Grade 3	n = 3,469	3	7	30	40	19	41

Table 5.21 Number of operations per patient according to Red Cross Wound Grade.

The number of operations required differs substantially according to RCWS grade. Surgical workload is definitely influenced by the severity of injury, as would be expected, and the RCWS is capable of predicting this.

5.10.5 Number of operations according to Wound Grade and delay in evacuation

If one now analyses the number of operations by combining the RCWS Wound Grade and the delay in evacuation, the results are telling (Table 5.22).

Grade and evacuation time	Number of patients	≤ 2 operations	3 operations	≥ 4 operations
Grade 1	N = 6,729			
< 6 hrs	1,124	93 %	5 %	3 %
6 – 24 hrs	1,694	84 %	9 %	7 %
24 – 72 hrs	1,182	82 %	11 %	7 %
> 72 hrs	2,729	82 %	10 %	9 %
Grade 2	N = 5,974			
< 6 hrs	788	77 %	11 %	12 %
6 – 24 hrs	1,186	62 %	16 %	22 %
24 – 72 hrs	1,110	58 %	17 %	25 %
> 72 hrs	2,890	56 %	18 %	26 %
Grade 3	N = 3,469			
< 6 hrs	497	47 %	17 %	35 %
6 – 24 hrs	847	37 %	19 %	44 %
24 – 72 hrs	493	39 %	19 %	42 %
> 72 hrs	1,632	40 %	20 %	40 %

Table 5.22 Number of operations per patient according to Red Cross Wound Grade and time since injury.

It would thus appear that the Red Cross Wound Score better represents morbidity and surgical workload than the delay in evacuation to hospital alone, but a combination of the two is more noteworthy. Grade 3 wounds tend to be very severe and delay does not appear to make a difference. Many such patients will simply not survive to reach hospital.

5.10.6 Number of operations according to weapon

The results of an analysis of ICRC hospitals treating a variety of weapon-induced injuries (Kabul, Kandahar, Kao-i-Dang, Novye Atagi, Peshawar, and Quetta), are presented in Table 5.23.

No distinction is made in the ICRC database between anti-personnel and anti-tank mines, or unexploded ordnance. Furthermore, some wounds classified as being caused by fragments may well have been from fragmentation anti-personnel mines. Hospital staff have only the account of the patient to go by and, naturally, many patients are ignorant of weapon systems; they only know of "bombs" or "guns".

Weapon	None	1 op	2 ops	≤ 2 ops	3 ops	≥ 4 ops
Mine N = 5,236	9 %	15 %	38 %	62 %	14 %	24 %
GSW N = 5,984	9 %	22 %	44 %	75 %	12 %	13 %
Fragment N = 7,674	11 %	24 %	44 %	80 %	9 %	11 %

Table 5.23 Number of operations per patient according to weapon.

It is obvious that mines imply a much greater workload and morbidity than gunshot (GSW) or fragment wounds (Table 5.22 and Figure 5.8).

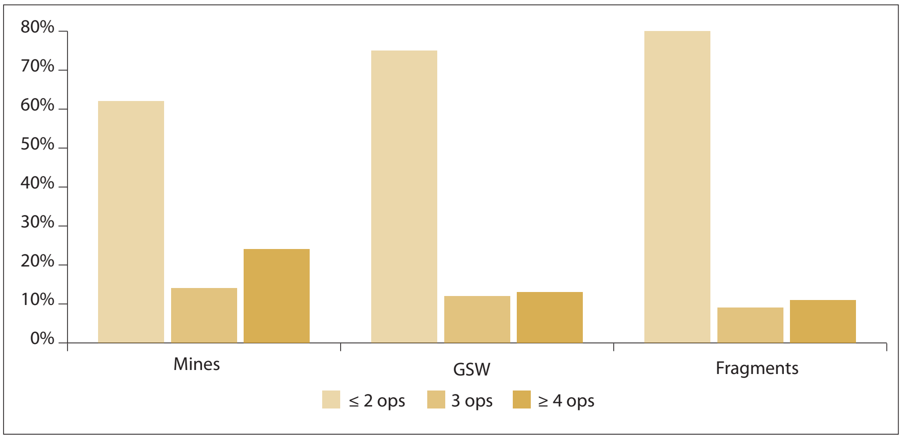


Figure 5.8
Number of operations per patient according to weapon, simplified.

Although the lethality of weapons is important, the total effects of surgical workload, morbidity and suffering and the socio-economic consequences must also be taken into account. It is not for nothing that poison gas, bacteriological weapons, blinding laser weapons, anti-personnel mines and cluster submunitions have been proscribed and banned by international treaty.

5.11 Conclusions: lessons to be gained from a study of epidemiology

From this brief overview of the epidemiology of the victims of war, a few conclusions affecting clinical work and humanitarian action may be drawn.

1. For a civilian population in a poor country, the public health effects of war are usually greater than the effects of direct trauma. In some conflicts, war injuries carry a greater burden and post-traumatic morbidity may have more profound long-term effects than mortality. This is especially the case in a post-conflict situation with widespread contamination by anti-personnel mines, of which the socio-economic repercussions are long-lasting.
2. The outcome of war surgery in a civilian context is influenced by:
   - the type of injury according to wounding agent;
   - the severity of the injury;
   - the general condition of the patient (malnutrition, chronic disease, concomitant endemic disease such as malaria, etc.);
   - early and appropriate first aid;
   - the time needed for transport to the hospital;
   - the quality of hospital treatment (resuscitation, surgery, post-operative care, physiotherapy and rehabilitation);
   - the possibility of evacuation to a better-equipped hospital with more experienced staff.
3. In a civilian context, and especially in a poor country, pre-hospital care is the phase most open to improvement. Much can be done to prevent death and morbidity with early and efficient first aid and life support.

4. An efficient first-aid and evacuation system can prevent deaths from controllable haemorrhage and compromised airway. As pre-hospital care improves, the "killed in action" or "dead on arrival" may diminish slightly, only to see the "died of wounds" and hospital mortality rise; more casualties are saved, but the rates become distorted. This bias should be taken into account when judging the adequacy of care.
5. Long and difficult evacuation of the wounded results in an automatic "natural triage" of the most severely injured. Hospital mortality rates decrease as a result.
6. Up to 40 – 50 % of the civilians wounded during urban fighting do not need hospitalization. First-aid measures – plus a simple oral antibiotic and analgesic – are all that are required. Their presence constitutes a supplementary burden on hospital management. However, discharging them from hospital can prove problematic because of security concerns, socio-economic factors and patients' fears.
7. Wounds to the head and torso are the most lethal. Injuries to the soft tissues and the limbs constitute the majority of surgical workload.
8. Gunshot wounds carry a heavier burden than injuries due to fragments, but burns and anti-personnel landmine injuries represent the heaviest hospital workload and morbidity.
9. The Red Cross Wound Score allows a good appreciation of the severity of war wounds, and the surgical workload that they represent.

5.11.1 Setting up a surgical database for the war-wounded

Various military medical services have their own categories and charts for data collection. The ICRC offers civilian health facilities an example of categories that could be placed in a simple spreadsheet to allow the collection of data for further study (see ANNEX 5. B: Setting up a surgical database for the war-wounded).

ANNEX 5. A ICRC surgical database

The ICRC set up a centralized wound database and trauma registry in 1990, originally designed to give the organization an indication of the surgical workload of its independent hospitals (i.e. hospitals that were established and run under ICRC administration). All war-wounded patients admitted to ICRC hospitals have routinely had a data form filled out on their death or discharge. Patients are not asked whether they are combatants or civilians.

Age and sex, the cause and anatomic site of injury and the time elapsed between injury and admission are recorded for each patient. Projectile injuries are scored according to the Red Cross Wound Classification System described in Chapter 4. The emphasis is on surgical workload as described by severity of injuries, number of operations per patient, number of blood transfusions required and length of hospitalization.

These independent ICRC hospitals have served the victims of a number of armed conflicts involving very different types of combat. The database contains the records of more than 56,000 war-wounded patients. Not all records are complete, however.

Hospital	Period of activity	Nature of combat
Kao-i-Dang Hospital, Thailand	1979 – 92	Jungle guerrilla warfare in Cambodia
Peshawar Hospital, Pakistan	1981 – 93	Mountain guerrilla warfare in Afghanistan
Quetta Hospital, Pakistan	1983 – 96	Mountain guerrilla warfare in Afghanistan
Karteh-Seh Hospital, Kabul, Afghanistan	1988 – 92	Irregular warfare, mostly urban
Mirweis Hospital, Kandahar, Afghanistan	1996 – 2001	Irregular warfare, mostly urban
Butare Hospital, Rwanda	1995	Irregular guerrilla warfare, mostly rural
Novye Atagi Hospital, Chechnya, Russian Federation	1996	Irregular guerrilla warfare, rural and urban
Lopiding Hospital, Lokichokio, Kenya	1987 – 2006	Rural guerrilla war in semi-desert, sahel and reed swamps in southern Sudan
Peshawar Hospital 2, Pakistan	2009 – 2012	Mountain guerrilla warfare

The above-mentioned conflicts were different in nature. Time to treatment often included extremes – minutes to weeks. Logistic difficulties over great distances meant that the ICRC could rarely organize efficient and timely evacuation of the victims. Notable exceptions were the first-aid posts set up near the Afghan border with Pakistan and close to Kabul. The air medical evacuation programme for southern Sudan, coordinated with the United Nations Operation Lifeline Sudan, saw over 20,000 patients transferred to the ICRC hospital in Lokichokio, northern Kenya. However, the distances, and delays in notification of patients, meant that timely evacuation was rarely possible.

The ICRC has also set up other hospitals, and its surgical teams have worked in local public hospitals, but their patients are not included in the database. In addition to the surgical database, other major sources of data include the Somali Red Crescent-run Keysaney Hospital in Mogadishu (1992 – present), and the JFK Memorial Hospital, Monrovia, Liberia (2001 – 2004), operated jointly by the ICRC and the hospital's Board of Governors.

When studying ICRC statistics from the database, the limits of a retrospective analysis of prospectively collected data taken exclusively from hospital admissions must be recognized.

The usual problems have been observed:

- clerical errors;
- missing patient files;
- incomplete patient files (not all categories were filled in for all patients);
- confusion as to the definition of classification categories;
- lack of continuity due to the constant turnover of hospital personnel;
- lack of properly trained administrative support staff to maintain a database.

Nonetheless, ICRC statistics are offered throughout this manual as an example of non-military experience in different combat zones as an approximation of the reality of the battlefield, especially for non-combatant populations.

ANNEX 5. B Setting up a surgical database for the war-wounded

The following categories can be recorded using database software or a spreadsheet. If a spreadsheet is used, the categories should be entered across the columns of the top row, with the patients recorded in the rows.

Lessons have been learnt from shortcomings in the ICRC surgical database: this version has been modified accordingly.

Administrative data

- hospital (if the database contains patients from more than one hospital)
- patient hospital number
- database number
- date of admission
- date of discharge
- number of days hospitalized
- re-admission of patient for the same injury?
- age
- sex

Time since injury

- hours (or < 6 ; 6 – 12 ; 12 – 24)
- days (or 24 – 72 hrs ; >72 hrs)
- weeks

Weapon causing injury

- firearm (rifle, pistol, machine gun, shotgun)
- bomb, shell, mortar, grenade
- anti-personnel mine (APM)
- anti-tank mine (ATM)
- unexploded ordnance (UXO), including cluster bombs
- “arme blanche”: bayonet, machete, panga

Mechanism of injury

- gunshot (GSW)
- fragment
- blast
- blunt
- burn

<u>Please note:</u>

A bomb, artillery shell or anti-tank mine may give off penetrating fragments, cause blast or burn injury and, by destroying a vehicle or building, also cause blunt injury. One weapon is recorded, but several mechanisms of injury are recorded. The same can be said of anti-personnel mines.

Clinical data

- blood pressure on admission
- number of operations
- number of anaesthesias
- number of units of blood transfused
- outcome: healed, complications, death (including cause)

Anatomic data

Site of injury: if more than one, each injury is given a number and the appropriate number put in the column for the anatomic region. Only one injury per anatomic region is noted.

- head
- face
- neck
- thorax
- abdomen
- pelvis, buttocks
- back and soft tissue of torso
- upper limb left
- upper limb right
- lower limb left
- lower limb right

Red Cross Wound Score

This should be entered for the two most important wounds, more if so desired. Wound 1 should correspond to Anatomic Region 1; Wound 2 should correspond to Anatomic Region 2.

- Wound 1: Entry
- Wound 1: Exit
- Wound 1: Cavity
- Wound 1: Fracture
- Wound 1: Vital injury
- Wound 1: Metallic fragment
- Wound 1: Grade
- Wound 1: Type
- Wound 2: Entry
- Wound 2: Exit
- Wound 2: Cavity
- Wound 2: Fracture
- Wound 2: Vital injury
- Wound 2: Metallic fragment
- Wound 2: Grade
- Wound 2: Type

Major operation

- craniotomy
- thoracotomy
- chest tube
- laparotomy
- peripheral vascular repair
- amputation above-elbow left
- amputation above-elbow right
- amputation below-elbow left
- amputation below-elbow right
- amputation above-knee left
- amputation above-knee right
- amputation below-knee left
- amputation below-knee right

Comments

Chapter 6

THE CHAIN OF CASUALTY CARE

6.1 The links: what kind of care, and where?

Modern armed conflict embraces conventional war between conventional armies, urban combat between militias, and isolated and sporadic but fierce guerrilla attacks in remote rural areas. It may involve mass conflict or chronic irregular, low-intensity combat, or individual terrorist attacks. Civilians often represent the majority of victims (see Chapter 5). Field situations vary considerably, but basic medical problems for the wounded are universal. A system must be developed and adapted to deliver the best possible care in a timely manner, under all circumstances.

> Modern armed conflict takes place in rural areas and cities.
>
> Civilian populations are increasingly at risk.
>
> Landmines and unexploded cluster munitions continue to cause victims after the conflict has ended.
>
> Field situations vary; medical needs are universal.

The system of evacuation and treatment of the sick and wounded – the chain of casualty care – like any chain, is as strong as its weakest link. It is measured not in kilometres but in hours and days. The setting up of such a system requires planning ahead of time: an assessment of the tactical circumstances must be made, an analysis of the physical limitations and appropriate personnel carried out and the resulting plan implemented.

Wounded patients are transferred along a chain of medical care, beginning with simple "life- and limb-saving" procedures and continuing to ever-greater levels of sophistication. The principle of echelons of care in a military system has been described in Chapter 1. In civilian practice, patients also tend to follow a chain of evacuation and treatment although, in many countries, this is not very efficient.

6

6.1.1 Protection: IHL

Protection and prevention from further injury come first and foremost in patient care.

> Article 3 common to the four Geneva Conventions and article 7 of Additional Protocol II:
>
> "The wounded and sick shall be collected and cared for."

The wounded and sick have the *right* to be cared for and to have access to appropriate medical care. The red cross, red crescent and red crystal emblems symbolize the legal protection afforded the casualty and the medical personnel, who have the right and the obligation to care for the wounded and sick. The protective quality of these emblems is a function of the training and degree of discipline of the combatant forces, and their adherence to internationally accepted norms of behaviour on the battlefield: the Geneva Conventions and their Additional Protocols. This protection begins with the first-aider in the field and continues through all the levels of treatment.

Special measures must be taken to prevent further injury to any casualties and to protect them from the elements (see Chapter 7).

6.1.2 Levels and locations of medical care

The following list defines the generic places where the wounded receive different levels of medical care in the multiple-phase treatment of war wounds.

1. On the spot: first aid.
2. Collection point: first aid with/without resuscitation.
3. Intermediate stage: resuscitation with/without emergency surgery.
4. Surgical hospital: primary surgical treatment.
5. Specialized centre: definitive surgical treatment including reconstructive procedures, physiotherapy and rehabilitation, both physical and psychological.
6. Transport system for transfer from one echelon to another.

Treatment on the spot may be self- or "buddy"-treatment, or practised by a military medic or first-aider. First aid starts at the point of wounding, but can be given anywhere and everywhere along the evacuation line to the place of definitive treatment. First aid is the only possible treatment on the battlefield.

The setting up of a collection point or clearing station may be a spontaneous response. Alternatively, an established first-aid post (FAP), dispensary, or primary health centre might serve this purpose. Some FAPs will be staffed by military stretcher-bearers and medics, others by Red Cross/Red Crescent volunteers, or other civilian personnel. The closer to the battlefield, the more prominent will be the role of military medical services. In purely civilian rural settings, village health workers, nurses or medical assistants are often the only health professionals available. Collecting the wounded at one specific location allows for the proper organization of field triage and their efficient evacuation. Besides basic first aid and trauma life support, resuscitative measures may be begun here.

A health centre or rural hospital might represent the intermediate stage, where more sophisticated resuscitation and emergency surgery are available. The armed forces might establish a forward surgical unit.

B. Fjortoft / ICRC

Figure 6.1
National Society first-aiders in the field.

J-P. Kolly / ICRC

Figure 6.2
First-aid post on the Afghan-Pakistani border.

J-J. Kurz / ICRC

Figure 6.3
Transfer of patients to the ICRC hospital in Peshawar, Pakistan.

6.2 Surgical hospital treating the war-wounded

The level of sophistication of hospital care will depend on the degree of socio-economic development within the country before conflict breaks out. War will then usually degrade the functioning of any pre-existing hospital. Efficient evacuation of the wounded to deficient surgical facilities is not an effective chain of casualty care.

Levels of hospital competency differ from country to country and between geographic regions. Three basic levels can be described.

M. Bleich / ICRC

Figure 6.4

ICRC field hospital, Lokichokio, Kenya.

6.2.1 Hospital A: rural hospital = basic trauma services

A district hospital (Africa) or primary health centre (South Asia) without full-time specialist doctors, especially without a fully-trained general surgeon, is a typical example. These hospitals are usually staffed by general practitioners or medical assistants with some surgical training and equipped with a minimum of proper surgical facilities. Front-line hospitals with "field surgeons"[1] exist in some military medical services and are the equivalent. Basic resuscitation and some simple but critical operations are usually performed here.

6.2.2 Hospital B: provincial hospital = advanced trauma services

A regional hospital (Africa), district hospital (South Asia), or general hospital (Latin America) has a full-time general surgeon and proper operating theatre and sterilization facilities. Most life-threatening conditions can be dealt with adequately. The military equivalent is usually a forward field hospital specializing in damage control and resuscitative surgery.

6.2.3 Hospital C: major city hospital = comprehensive trauma services

This is a referral facility offering a broad range of specializations and sub-specializations and usually represents the highest level of care in the country or administrative region. It is often a teaching or university hospital. In military terms, this is a referral facility far from the front lines.

6.2.4 Hospital assessment

ICRC programmes aim to maintain, and upgrade if possible, the competencies of these different levels of hospital care when necessary. The ICRC has developed an analytical tool for assessing the quality of hospital management and surgical work prior to providing assistance. This tool comprises a number of factors to be considered. There are factors external to the hospital, involving an analysis of the national and provincial health systems, and internal factors: hospital infrastructure, administration and functional organization, departments, available resources, medical personnel (number and expertise), non-medical support services, finances, etc. (see ANNEX 6. A: Initial assessment of a surgical hospital treating the war-wounded.)

1 A field surgeon is a general practitioner or an experienced nurse who has acquired a wide on-the-job experience of surgery; present mostly in Africa or in the ranks of revolutionary movements where academic training is not available.

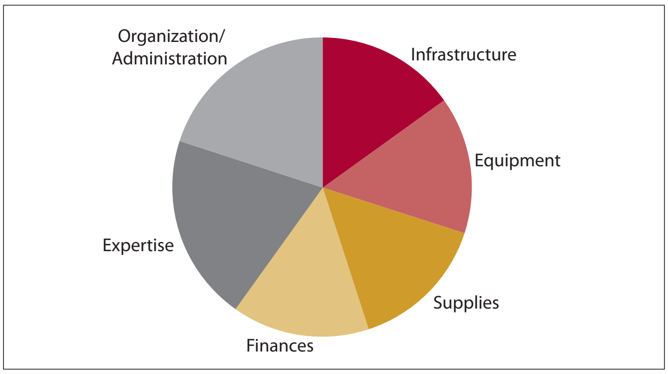


Figure 6.5

Assessment of a surgical hospital caring for the war-wounded.

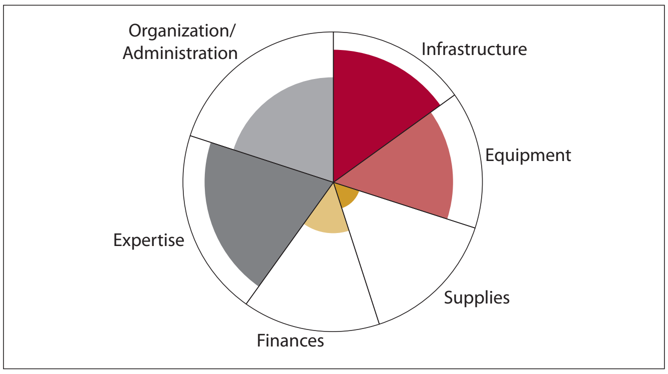


Figure 6.6

Assessment results of a typical hospital in a low-income country disrupted by war, causing disorganization in the hospital.

T. Gassmann / ICRC

Figure 6.7.1

National Society volunteers transporting patients by boat.

L. Petridis / ICRC

Figure 6.7.2

Medical evacuation by plane from southern Sudan to the ICRC hospital in Lokichokio, Kenya.

T. Gassmann / ICRC

Figure 6.7.3

National Society "Zero Mobile" horse-drawn carriage ambulance.

The pie-charts above show the various factors that affect the functioning of a hospital dealing with the added burden of war-wounded patients, compounded by the constraints of a weakened health system, and help identify dysfunctional areas. An additional factor is the emotionally stressful presence of casualties who are related to, or friends of, the medical staff.

6.3 Transport

Transport of some sort provides the connection between the different echelons of the chain of casualty care. Moving a patient has a price: transportation is a trauma in itself. It uses up additional resources and involves security risks ("mortality of the ambulance ride"), and perhaps even exposure to military activity. These extra costs must be weighed up against the likely benefits of moving the wounded. In many contexts, the availability of transport for the sick and wounded is almost a "luxury".

Moving wounded people is difficult, always takes longer than expected, adds to the trauma, and is often dangerous.

6.3.1 Command, control and communications: coordination

A chain of command is necessary to make the various echelons function correctly. A central command or dispatch centre will assume overall coordination (e.g. decisions about transfer/evacuation destinations, engagement of resources, etc.), and be responsible for contacts with related command levels of various authorities (e.g. armed forces, police, headquarters of the National Red Cross/Red Crescent Society, civil defence and national rescue service, etc.).

Circulation of information between the different levels is assured by some means of telecommunication – radio and mobile phones – if possible, or by other means (e.g. foot messengers) if not. Mobile telephone systems have a tendency to stop functioning – be turned off – during crises and armed conflict. The efficiency of the command and communication systems depends on strict observance of established procedures.

6.4 Forward projection of resources

Bringing more than basic first aid closer to the collection point is called "forward projection of resources". The availability of advanced procedures closer to the battlefield has many advantages. It allows quicker access to "life- and limb-saving" emergency measures, thus decreasing both mortality and morbidity. The need for potentially dangerous transport is reduced. The projection of resources applies particularly to treatment at the intermediate stage, but can be applied to any echelon in the chain.

> Forward projection of resources allows quicker access to life- and limb-saving measures.
>
> However, certain conditions must be met.

A number of factors limit the possibility to project resources.

1. Security (essential).
2. Personnel and expertise (essential).
3. Equipment (appropriate technology).
4. Supplies (appropriate).
5. Infrastructure (minimum requirements).
6. Possibility of onward evacuation.

When a front-line hospital is coming under bombardment, putting both patients and personnel at risk, there is little point in attempting more than first aid if evacuation to another facility is possible. On the other hand, a forward collection point may provide advanced treatment. Only a minimum of equipment is necessary for well-trained medics to perform endotracheal intubation or place a chest tube, and then quickly evacuate the patient. A secure building with adequate resources may be used as an intermediate stage where a forward surgical team may perform damage control and resuscitative surgical procedures.

All of these possibilities will depend on meeting the criteria defined above; but especially on security and human expertise. Infrastructure, equipment and supplies must all meet minimum requirements, and be appropriate to the task under the prevailing conditions.

> The most important factors determining the forward projection of medical care for the war-wounded are security and human expertise.

The appropriate choice of procedures to undertake for the injured outside a formal hospital setting will depend on the factors mentioned above, and will vary from country to country, and even from region to region within the same country.

The organization of any chain of casualty care for the war-wounded – military or civilian – should rely on a large dose of common sense to determine what is practical and what can realistically be accomplished to assure the best results for the greatest number, while at the same time guaranteeing the safety of the injured and the health workers. What exactly can be done for the injured outside a formal hospital setting will depend on the particular circumstances and means available. There is no dogma to be followed blindly; situations are different and improvisation and adaptation the key to success.

	On the spot	Collection point	Intermediate stage
Who?	Family, friends, the community[2] Community health workers First-aiders (Red Cross or Red Crescent, military stretcher-bearers and medics, combatants, etc.) Health professionals	Health professionals First-aiders (Red Cross or Red Crescent, military stretcher-bearers and medics, combatants, etc.)	General practitioners, emergency room staff, other medical and surgical professionals Field surgical team
Where?	In a combat zone, at the front lines	Spontaneously chosen (e.g. the shade of a tree) First-aid post Dispensary, primary health-care centre	First-aid post, dispensary, primary health-care centre, outpatient clinic Rural hospital Forward surgical hospital
What?	Life-saving first-aid measures *The only appropriate care on the spot*	Collection of casualties Evaluation of their condition Advanced emergency care and/or stabilization Evacuation planning Routine care (fever, diarrhoea, scabies, etc.) and ambulatory care (pneumonia, non-combat trauma, etc.)	Advanced emergency care Forward life-saving surgery Occasional hospital care, if uncomplicated and requiring few days of observation Routine care (fever, diarrhoea, scabies, etc.) and ambulatory care (pneumonia, non-combat trauma, etc.)

Table 6.1 What can be done at which level?

6.5 The reality: common war scenarios

As mentioned in Chapter 1, there is more than one "surgery" for the care of the war-wounded. The exact number of levels of care and the path followed by casualties are determined on a case-by-case basis according to the sophistication of care and logistics available. In some armies or countries, the organization may be so efficient that a wounded soldier may expect to receive treatment virtually as sophisticated as the care available to him in peacetime.

In developing countries, however, the health-care system might already be weak before the conflict and may almost cease to function because of it. Water and electricity supplies can be unreliable, trained staff often flee the area, drugs and disposable equipment cannot be replaced, budgets are not covered, salaries are not paid and buildings are destroyed. The quality of hospital care is badly affected.

Every combination of levels of care is possible:

- The wounded from a modern industrialized army are transferred by helicopter from the scene of injury directly to a surgical hospital.
- Patients in low-income countries reach health facilities on foot or by oxcart, donkey, private motor vehicle, taxi or lorry.
- During urban warfare, family and neighbours transport a casualty directly to the emergency room of a surgical hospital, which then serves as a collection point.
- In the rural areas of a low-income country, the hospital is the only health facility functioning and serves as all levels in one – forward referral of patients to a more sophisticated level of care is not available.
- Rural health centres may flourish while surgical hospitals may exist only in large cities.
- A collection point or intermediate stage in a secure building is upgraded with the necessary equipment and personnel to serve as a forward surgical hospital, with or without the possibility of forward referral.

2 In armed conflicts, international humanitarian law permits civilians to collect and care for the wounded and sick of whatever nationality, and stipulates that they must not be penalized for doing so. On the contrary, they must be aided in this work. Furthermore, IHL requires that the civilian population respect the sick and wounded, even if they belong to the enemy, and shall commit no act of violence against them.

In some contexts, the ICRC has resorted to deploying a Field Surgical Team that is not hospital-based. This mobile team goes to the wounded rather than having the wounded come to a hospital; the chain of casualty care is turned upside-down. This has been necessary where casualties have not had access to medical care for reasons of personal security (Figures 1.4 and 6.8).

Techniques will also differ according to context. For the armed forces, there is a balance between the needs of the wounded soldier and the necessities of combat. Some armed forces may teach the use of the self-applied tourniquet, which purportedly allows a wounded soldier to continue shooting. This logic does not apply to civilian institutions, and the ICRC's first-aid manual[3] defines the criteria for the use of a tourniquet in the field.


V. Louis / ICRC

Figure 6.8

The ICRC Field Surgical Team in Darfur.

6.6 Conflict preparedness and implementation

Every country should have a disaster plan. Part of emergency preparedness is the capacity to respond to armed conflict, internal disturbances or natural disasters. This is normal procedure for most armed forces. Ministries of public health and National Red Cross/Red Crescent Societies usually also have a disaster plan, which should be integrated into the national emergency preparedness programme.

The objective of planning is to ensure that wounded people get the right care, at the right place, and at the right time.

Those who have to face the challenges of armed conflict should understand how to proceed in setting up a chain of casualty care. The best possible outcome for wounded people can only be achieved with proper planning and training. Plans must be realistic, flexible and reviewed regularly. Should a country be caught unawares at the outbreak of hostilities without having a pre-prepared plan, then the planning process must be accelerated and the necessary analysis take place immediately.

All plans begin with a strategic assessment of the possible conflict scenarios. What may happen and where? What needs are foreseen? What resources exist? (see ANNEX 6. B: Strategic assessment of a conflict scenario).

An analysis of the assessment will then answer the questions of what should be done, where and by whom, to improve care for the wounded.

The reality check asks a few basic questions. Are the recommendations compatible with the context? Are they relevant? Practical? Reality checks are important; they influence planning, care, and training, and make certain that academic theory does not override simple pragmatism.

The organization of a chain of casualty care and in particular the assignment of resources to the different echelons must take into consideration a number of factors:

- the nature of the conflict, the tactical and geographic circumstances and security concerns;
- the size of the casualty load;
- the nature of the casualty load, i.e. the types of injury;
- the absolute number of staff and the ratio of staff to workload (surgical capacity depends on the number of teams working and the rate of arrival of casualties);
- the expertise of the personnel;
- logistics and supplies;
- the infrastructure.

3 Giannou C, Bernes E. *First Aid in Armed Conflicts and Other Situations of Violence*. ICRC: Geneva; 2006.

Some typical situations of armed conflict and internal violence can be described. Model scenarios are then based on a consideration of the above-mentioned factors and the analytical tool of strategic assessment (see ANNEX 6. C: Humanitarian intervention for the wounded and sick: typical settings).

The medical response of humanitarian organizations to major disasters has all too often been inadequate. Lack of training, preparation and logistic capacity have been important factors. In an attempt to remedy this, the World Health Organization (WHO) has initiated a programme for the pre-registration of organizations wishing to deploy medical teams abroad: Emergency Medical Teams (EMT). The criteria include training health personnel to work in difficult conditions with limited technological resources, and on the specifics of the pathologies they are likely to encounter. To make this work, recipient countries will have to demand pre-registration before accepting the deployment of foreign medical teams to their territories. Although initially intended for response to natural disasters, the criteria are also compatible with dispatch to a zone of armed conflict, the main difference being compliance with the rights and obligations of medical personnel as defined by the Geneva Conventions.

6.7 The pyramid of ICRC surgical programmes

ICRC delegates are often called upon to help organize a chain of casualty care. At times this will be in support of existing governmental or non-governmental facilities. On occasion, the ICRC is required or asked to establish its own independently-run hospitals. The main reasons for doing so are either a question of protection – of the patients or medical services – or because of a dire shortage of local personnel.

Unlike a military field hospital, an independent ICRC hospital is often responsible for all levels of medical care. It acts as a first-aid post, field hospital, base hospital, and referral centre. In this sense, an ICRC hospital resembles many provincial hospitals in non-industrialized countries. Only general surgeons are present, and no further referral of patients to a specialized centre is possible.

An independent ICRC hospital comprises all echelons in one facility.

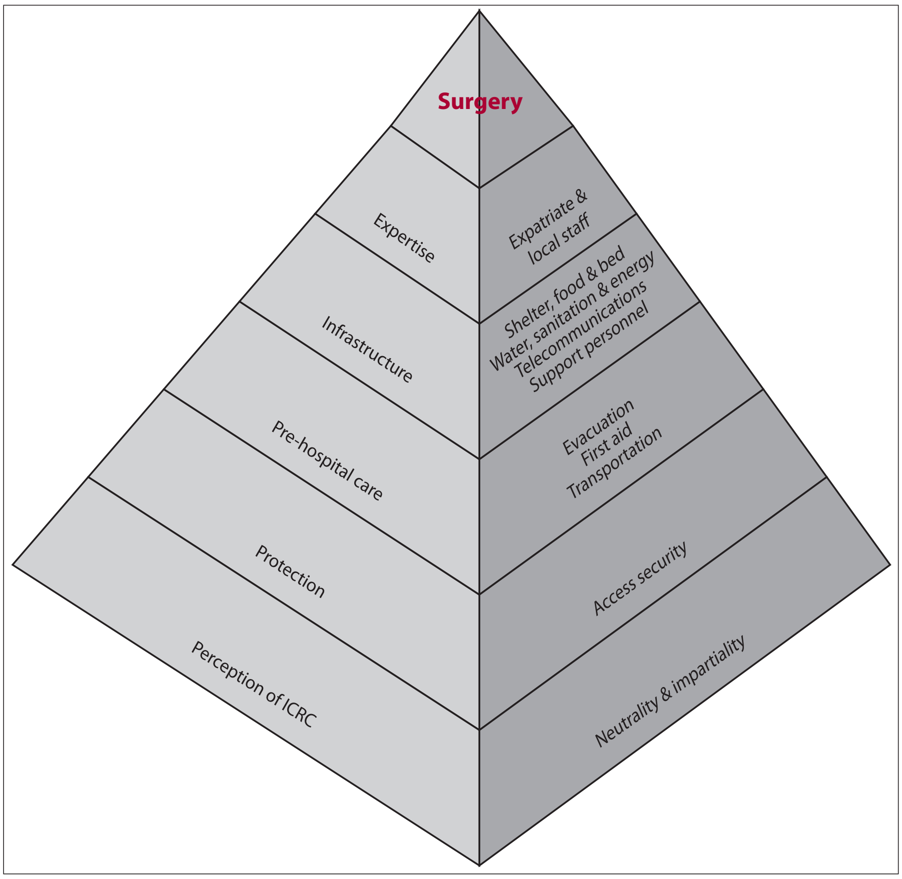


Figure 6.9

The ICRC surgical pyramid. A number of factors are taken into consideration to ensure the neutrality and independence of ICRC activities on the one hand, and the quality and professionalism of care on the other. The same logic applies to other humanitarian agencies. These factors are summarized in this pyramid and the checklist in Section 6.7.1 .

6.7.1 Checklist

Political and operational considerations

- Perception of neutrality and impartiality, i.e. ICRC image.
- Acceptability of the ICRC by political factions, the armed forces and the population.
- Possibility for negotiations: availability of and access to interlocutors (ministries of health, defence, foreign affairs and interior, faction chiefs); contacts with owners of facilities to be rented.
- Role of the hospital in the protection of hospitalized patients.
- Role of the hospital in protecting medical services by providing access to neutral medical care, across enemy lines if necessary.
- Any possible competition with other health facilities, private or public, i.e. the "medical market".

Security

- Hospital and staff security concerns owing to the conflict or possible developments in the fighting:
  - location and environment, i.e. distance from hostilities or military targets;
  - type of building, i.e. number of storeys, ground floor, underground cellar or bomb shelter, tents.
- Incidence of banditry, hostage-taking, etc.
- Patients' safety, inside the hospital and upon discharge.

Access

- Distance and evacuation time.
- Availability of means of transportation: roads, vehicles, air evacuation.
- Safety of roads and checkpoints: military activity, political affiliation, banditry.
- Possibility of setting up a system of first-aid posts.
- Logistics: medical supply, fuel, food (local, regional, from ICRC headquarters).

Infrastructure

- Pre-existing hospital structure.
- Building capable of being transformed into a hospital (school, factory); structural integrity, possibility of expansion.
- Use of tents, prefabricated and/or temporary structures.
- Water and sanitation, electricity.
- Facilities: kitchen, laundry, residence for personnel.
- Warehouse.

Local and expatriate personnel

- Availability and number of local and expatriate Red Cross/Red Crescent medical personnel.
- Recruitment of new national staff and the question of neutrality.
- Professional competence and level of education.
- Language problems: need for translators/interpreters.
- Availability of support personnel: ICRC delegates, medical and general administration, water and sanitation engineers, builders, mechanics, electricians, etc.

ANNEX 6. A Initial assessment of a surgical hospital treating the war-wounded

This form should be regarded as a guide, a kind of checklist, to help the health professional responsible for the assessment of the hospital remember certain key points.

Its purpose is to give a quick overview and understanding of the functioning of the hospital; to identify its capacity, limits and insufficiencies. It should allow for rapid and adequate decisions about the kind of support the hospital might need.

The form can be used *in toto* or in part according to the objectives of the assessment. It consists of questions deliberately left open to allow the health professional in charge to decide to enquire further or not according to the results expected. It is more important to get a correct understanding of how the hospital is working rather than to have exact figures.

The assessment is divided into six sections

General

Management and administration (including non-medical support services)

Medical support services

Clinical services *(only the surgical component is dealt with in this annex)*

Further comments

Conclusion

General

Name of the hospital: Town: Country:

Assessment done by:

Date:

Interlocutors:

1. Type (MoPH, private, military, missionary, NGO, other):
2. Catchment population:
3. Assistance from entities other than the authority in charge:
4. Level of reference (rural, district, regional):
5. If rural or district hospital, number of primary facilities served (first-aid posts, dispensaries, health centres):
6. Possibilities for further referral:
7. Transport system for patients (in and out):
8. Reputation of the hospital (indicate source of information):
9. Bed capacity, effective number of beds (breakdown by department):
10. Present bed occupancy:
11. Activities including specialities (surgery, medicine, paediatric, obstetric, specialized services, etc.):
12. Security (Is the area safe? Is the hospital secured? i.e. clearly marked, fenced, watchmen present, absence of arms inside the hospital compound?):
13. Endemic diseases and epidemic risk in the region:

Management & administration

I General management

1. Set-up (management team/board):
2. How are decisions taken and implemented?

II Personnel management

1. Who is in charge?
2. Do the staff receive salary/incentives?
3. Total number of personnel/breakdown by function (MD, medical assistants, nurses, students, etc.):
4. Is there a roster system in place in the hospital?

III Financial management

1. Management of finance (Is there a budget? How is the hospital financed?):
2. Is there any cost participation, "cost-recovery system"? Do the destitute have access to care?

IV Statistics

1. Management of statistics and reporting:
2. Are statistics available?
3. Is there an annual report?
4. Are there people specifically in charge of collecting data?

V Infrastructure & utilities (general condition of):

1. Walls and roof:
2. Water (running water, wells, safety of water supply, etc.):
3. Sanitation (type of toilets, etc.):
4. Electricity and/or generator (number of hours per day, fuel supply, etc.):
5. Heating/ventilation/air-conditioning:
6. Maintenance team (number, composition, etc.). Is there a maintenance schedule?
7. Is there a functioning workshop?

VI Waste disposal

1. Waste management systems (including toxics such as X-ray developer/fixator, etc.):
2. Incinerator (type, condition, etc.):

VII Non-medical support services

1. Kitchen (staff, nutritionist, origin of food, number of meals served per day, special diets, etc.):
2. Laundry (staff, washing by hand, machine, supplies, etc.):
3. Tailor (staff, supplies, etc.):
4. Cleaning and hygiene (system, staff, supplies, etc.):
5. Morgue (infrastructure, management, etc.):

Medical support services

I Pharmacy

1. Pharmacy staff and management:
2. Is there a standard list of medicines?
3. Are stock cards used?
4. Where do the drugs and medical equipment come from (regular supplier, local market, donations, etc.)?
5. Is there a reliable system of communication between the pharmacy and the wards (request forms, delivery forms, etc.)?
6. Did the pharmacy run out of basic drugs last month (penicillin, anti-malaria, paracetamol, ORS)?
7. What are the storage conditions (air-conditioning, refrigerator, etc.)?
8. Is medical equipment regularly maintained and serviced?

II Laboratory

1. Laboratory staff and management:
2. Tests available (haematology, chemistry, parasitology, bacteriology, serology, etc.):
3. Source of supplies:
4. Is there a reliable system of communication between the laboratory and the wards (request and results forms)?
5. Quality of the working relationship between the clinical and laboratory staff:

III Blood transfusion

1. Staff and management:
2. Policy of blood sampling and transfusion: HIV/AIDS policy?
3. Indications for blood transfusion/average number of requests:
4. How are the blood units kept? Is there a functioning refrigerator to store the blood?
5. Testing process and quality control:

IV Imaging (X-ray & ultrasound)

1. Staff and management:
2. Average number of X-rays per day:
3. Type and quality of machine(s):
4. Are there guidelines for the prescription of X-rays?
5. Is more sophisticated imaging equipment available?

V Other diagnostic services

1. ECG, EEG, etc.:

Clinical services

I Outpatient department (OPD)

1. Role of the OPD (consultation, follow-up of patients, admission, emergency):
2. Are there specialized OPDs?
3. Are there criteria for admitting the patient to the OPD?
4. Is there a register with data about all patients seen every day?
5. Average number of cases seen every day (medical, paediatric, surgery, obstetric, etc.):
6. Personnel in charge (MD, medical assistants, nurses):
7. Is there a clear roster?
8. Opening days and hours:
9. Main pathologies:
10. Access to laboratory and imaging:

II Admission/emergency department

1. Number of beds:
2. Is there a team on duty 24 hours a day; composition of the team?
3. Is there an on-call system in place?
4. Is there an admission book or regular procedure for admitting and registering patients?
5. Is there a regular procedure for sending patients to the appropriate wards or to the OT?
6. Number and type of emergencies per day:
7. Are basic supplies and equipment available?

III Operating theatre (OT)

1. Staff and roster:
2. Hygiene of the OT:
3. Is there an accurate operation book? If yes, number of surgical operations in the last month:
4. What kind of surgery is performed?
5. What kind of instruments and sets are available (laparotomy, caesarean section, debridement, skeletal traction sets, etc.)?
6. Number of operating rooms, tables:
7. Surgical linen (availability and source of provision):
8. Functioning surgical equipment (lamps, suction, diathermy, oxygen, etc.):
9. Source of materials and consumables:

IV Sterilization

1. Staff and roster:
2. Equipment (autoclaves, dry ovens):
3. Protocols in place?

V Anaesthesia

1. Staff and roster (MD and/or anaesthetist nurses):
2. Is a laparotomy performed safely with full muscle relaxation (including endotracheal intubation) by a trained anaesthetist?
3. Common anaesthesia (gas, ketamine, spinal, local):
4. Types of anaesthesia machine:
5. Availability of other equipment (pulse oxymeters, oxygen supply, etc.):

VI Nursing care

1. Is there 24-hour nursing supervision in the wards?
2. Are the patient records complete?
3. Is the nursing handover book used properly?
4. Are drugs administered on time?
5. Is a laparotomy performed safely with the patient supervised (vital signs) for 24 hours post-operatively in a room with light, and where he or she receives intravenous fluids and antibiotics?
6. What do dressings look like (clean, smelly, etc.)?
7. Are bedsores a problem?
8. Are relatives involved in patient care?

VII Frequently asked questions

1. Availability of mosquito nets for all beds:
2. Is there an admission book or regular procedure for admitting and registering patients in the ward? If yes, number of admissions to the ward in the last month?
3. Is there a person in the admissions/ER and wards who controls a system whereby the patients are assessed and then go to the OT or receive treatment?
4. Are new admissions systematically seen by a senior surgeon/MD and within what timeframe?
5. Are there regular rounds in the wards and/or regular meetings to discuss the cases?
6. Are the diagnosis and treatment clearly formulated in the patients' files and the treatment copied onto the patients' charts?

VIII Surgical care

1. Main pathologies present in the wards (fractures, burns, chest, abdomen, etc.):
2. Management of the ward/hygiene:
3. Personnel (number, composition, roster):
4. Infrastructure and beds:
5. Is a laparotomy performed safely – patients seen a few days after operation with healing wound and eating normally?
6. Can five or more laparotomies be performed in 24 hours under good conditions including anaesthesia? If not, why?
7. What type of orthopaedic treatment is present in the surgical wards (POP, skeletal traction, external or internal fixation)?
8. What do the wounds present in the ward look like (clean, dirty, smelly, pus)?

IX Physiotherapy unit

1. Are patients walking on crutches in the wards? If not, why?
2. Management of physiotherapy department:
3. Personnel:

Further comments

1. Particularities of the context:
2. Do you have any requests for the ICRC (logic and rationale of the request)?

Conclusion

1. First general impression (cleanliness and hygiene, staff present, presence of patients):
2. Main positive findings:
3. Main negative findings:
4. Capacity to cope with mass influx of wounded:
5. Emergency/contingency plan:
6. Proposals:
7. Next step:

ANNEX 6. B Strategic assessment of a conflict scenario

The main appraisals in a strategic assessment of a conflict situation aimed at identifying some of the factors influencing the chain of casualty care are as follows:

1. Geography:
   a. Topography of the conflict area
   b. Routes of communication and transportation
   c. Distribution of medical facilities available and their safety
2. Where is the fighting taking place? Safe areas, dangerous areas?
3. Where do patients come from?
4. How many wounded are there?
5. Who are the wounded?
   a. Trained soldiers in a regular army
   b. Guerrilla fighters, militiamen
   c. Civilians
6. Who performs first aid, if anyone?
   a. National Red Cross/Red Crescent Society volunteers
   b. Military services
   c. Trained civilians (RC/RC community-based first aid, MoPH)
   d. Untrained civilians
   e. Non-governmental organizations
7. Assessment of efficiency of first-aid system
8. How are the wounded transported from point of wounding to hospital?
   a. Private means
   b. Public transportation
   c. Ambulance service
   d. Military services: air, land, etc.
9. Assessment of efficiency of evacuation system
10. Which hospitals receive the wounded ?
11. Assessment of work performed in hospitals and their capacity to receive and treat patients (see ANNEX 6. A: Initial assessment of a surgical hospital treating the war-wounded).
12. Which other entities are present in the area?
   a. National Red Cross/Red Crescent Society
   b. Ministry of public health
   c. Military medical services
   d. National non-governmental organizations

  e. Missionary clinics or hospitals

  f. Foreign non-governmental organizations

On the basis of the above assessment, the military or civilian health services or National Red Cross/Red Crescent Society should take action to fill in any gaps by creating the following:

1. System of first-aid posts.

2. Transport system.

3. Reliable surgical units: central, regional, zonal, local; alternative sites for hospitals; convalescent homes.

These can take various types of action to set up an efficient chain of casualty care.

1. Negotiate with the belligerents to make sure international humanitarian law is respected, in order to ensure that:

   a. Medical personnel have access to the sick and wounded.

   b. The sick and wounded can reach medical care.

   c. First-aid and health personnel and facilities are safe.

2. Support existing health facilities; this may take the form of infrastructure renovation, equipment, medical supplies, or making additional personnel available.

3. Mobilize local infrastructure and personnel to improve the chain of casualty care or project medical care for the wounded forward.

4. Mobilize international agencies to supplement national efforts.

ANNEX 6. C Humanitarian action for the sick and wounded: typical settings

Many factors affect the deployment of humanitarian medical teams: this ANNEX helps to analyse a number of them. The terms used are operational descriptions and have no legal significance.

Possible scenarios

1. Military activity, natural disaster or major accident? (Is health infrastructure intact?)
2. Military context: conventional front lines, guerrilla war, internal troubles, post-conflict (particularly the presence of landmines, cluster bombs and other unexploded ordnance)
3. Urban or rural setting?
4. Industrially-developed or low-income country: funds available?
5. Personnel: are there sufficient, few or very few trained doctors, nurses, and first-aiders?

There are three typical general settings for a humanitarian operation.

1. **Optimal situation:**
   Adequate access to medical care in spite of the violence and conflict.
2. **Austere situation:**
   Poverty before the conflict has already jeopardized access to care.
3. **Dire situation:**
   Very poor access to care because of the violence and conflict, sometimes compounded with pre-existing poverty.

	OPTIMAL	AUSTERE	DIRE
Location	Urban in a developed country	Poor rural area	Developing country Major destruction
Duration of trouble	Single, isolated event (e.g. act of terrorism)	Ongoing low-intensity fighting (e.g. guerrilla warfare)	Continuous heavy fighting and/or bombardment
Casualty flow	Small irregular numbers (compared to the population of the city)	Discontinuous/ intermittent flow, including massive influx	Continuous but unpredictable flow, including massive influx
Infrastructure (roads, ambulance service, health facilities)	Intact and functioning	Poor or irregular (e.g. few good roads, limited number of ambulances, etc.)	Severely damaged or dysfunctional (roads damaged, debris in streets, hospitals looted, etc.)
Communications	Good	Poor to moderate Irregular	None or poor
Personnel	Adequate (in number and skills)	Variable	Minimum number or none at all
Materials and supplies	Adequate (in quantity and quality)	Irregular and inadequate	Irregular supply or non-existent
Environment	Good (daytime, good weather)	Harsh	Bleak (night, cold, heat, etc.)
Evacuation	Safe and short	Predictable but long and arduous	Uncertain or unknown
Destination of transfers	Known and available	Known but variable	Unknown or absent

6

Types of situations of armed conflict and violence and their effects on humanitarian medical work[4]

Example	International armed conflict	Internal armed conflict/guerrilla warfare	Civil disturbance/revolt	Widespread banditry and other crime
Description	A straightforward war between country X, and its allies, and country Y, and its allies	Intense fighting within one country	Unpredictable; hit and run skirmishes, often with a vested interest in the continuation of anarchy	May coincide with any of the other situations
Combatants/ Fighters	Easily visible, and wearing distinctive uniforms	Not all wear uniforms Government forces opposing well-organized military groups	Armed individuals, gangs, bandits, and militia groups	Purely self-interested individuals or groups
Front lines	Well known	May not exist, or may change very quickly	Linked to constantly shifting alliances among or between forces	At the fringes of the conflict, ready to take advantage of circumstances
Chain of command	Structured and with available points of contact	Tenuous points of contact on the opposing sides	Not clear, and variable from one faction to another (often based on an individual leader surrounded by a small group and supported by part of the population)	Traditional and local leader, personalized (e.g. street gangs)
Compliance with IHL	Parties aware of their obligations and try to meet them	A certain degree of compliance	Very little, with a complete breakdown of law and order	IHL unknown or no regard for it
Humanitarian tasks	Classic	Classic	Extremely difficult	?
Risk level	Low	Growing and less predictable	Very high, perhaps bordering on the unacceptable	Very real and very dangerous threat
Obstacles to medical work	Few, if any	More restrictions, negotiations, controls and delays, etc.	Severely restricted ability to act – vehicles, radios, goods, etc. are extremely attractive to the warring parties	Numerous: greatest caution required

Model scenarios

In contemporary armed conflict, health staff and facilities are called upon to function in various scenarios: typical situations include the following.

1. Safe urban setting

- Urban, developed environment
- Single, isolated event
- Casualty numbers relatively small compared to population of city
- Infrastructure intact: roads, emergency vehicles
- Health infrastructure intact, sophisticated hospitals
- Short evacuation time: route is secure
- Good communications
- Personnel: adequate number and quality of trained health staff
- Materials adequate
- Environment good: weather, daytime
- Final destination of the wounded is known

4 The terms used are purely descriptive and have no legal significance.

2. Unsafe urban setting

- Low-income country: under-developed or destroyed urban setting
- Continuing danger: street fighting and bombardment in city
- Continuing and unpredictable casualty flow including massive influx of wounded
- Poor infrastructure: potholed roads, debris in streets
- Disrupted health infrastructure: hospitals damaged or looted
- Availability and length of evacuation uncertain or unknown
- No or poor communications
- Minimum health personnel available
- Material re-supply uncertain, irregular, or non-existent
- Environment poor: cold, wet, dark
- Final destination of the wounded not always obvious

3. Unsafe rural setting

- Low-income country: under-developed rural area neglected in peacetime
- Constant danger: ongoing combat, landmines
- Continuing and unpredictable casualty flow
- Poor infrastructure: badly maintained or no roads
- Poor health infrastructure: few health posts, even fewer district hospitals
- Availability and length of evacuation uncertain, long and arduous
- No or poor communications
- Minimum health personnel available
- Material re-supply uncertain, irregular, or non-existent
- Environment poor: extreme cold or heat, rainy season and dry season
- Final destination of the wounded not always obvious

4. Safe but austere setting

- Low-income country
- Continuing danger: ongoing low-intensity warfare
- Discontinuous casualty flow; includes irregular mass evacuations
- Poor infrastructure: few good roads and few vehicles
- Minimum of health infrastructure: some rural clinics or health centres, fewer district hospitals
- Evacuation predictable but long and arduous
- Poor to moderate communications
- Minimum to moderate number of health personnel available
- Minimum material re-supply
- Environment harsh
- Final destination of the wounded: distant, but known

Chapter 7

FIRST AID IN ARMED CONFLICT

7

7.1 First aid: its crucial importance

Optimal management of the injured involves a continuum of care from the point of wounding to the surgical hospital: the chain of casualty care. The surgeon wishes to receive patients who arrive in good condition and well-stabilized, in a timely manner, and according to priority for treatment. To understand how this is achieved, or not, there are a number of things that need to be known about first aid. In addition, the surgeon working in a conflict area may well be called upon to participate in the training of first-aiders to achieve a more efficient chain of casualty care.

First aid is the initial assistance given to an injured or sick person until the condition of the person is stabilized or remedied, a higher level can be reached or professional medical help is made available. How first aid is applied varies according to the security environment, the number and condition of the wounded in a particular location, the resources that can be mobilized for care, transport capacity or availability of emergency medical services (EMS), and access to surgical hospitals and the latter's capacity to receive and treat patients.

Since its foundation, the International Red Cross and Red Crescent Movement has been predominantly associated with the provision of first aid. It pioneered the concept of immediate response by first-aiders and local communities to the consequences of war, disasters and epidemics.

The goals of a first-aider in action are:
- to intervene securely and safely;
- to preserve life by supporting vital functions;
- to limit the effect of injury and to prevent further injury;
- to prevent complications and disability;
- to alleviate suffering and to provide psychosocial/moral support;
- to promote recovery;
- to ensure proper handover of the injured and sick to the next higher level of care or health-care professionals when needed.

First-aiders can also help mobilize their community to prepare for and respond to emergencies that happen in everyday life and during crises such as armed conflict.

Experience has shown that one of the most important factors determining the outcome of the management of the war-wounded is the pre-hospital phase. It is a fact that first aid saves lives and decreases morbidity. It also results in easier surgery, thus decreasing the hospital surgical burden. Furthermore, up to 40 – 60 % of the civilians and soldiers wounded during armed conflict do not require hospitalization. First-aid measures – plus a simple oral antibiotic and analgesic – constitute all the treatment they need. Military terminology calls them "returned to duty" (see Chapter 5).

First aid, begun early, saves lives and can prevent many complications and much disability.

The provision of first aid is one of the fundamental responsibilities of military medical services, National Red Cross and Red Crescent Societies and, increasingly in contemporary armed conflict, of medical staff in both urban and rural public hospitals. The essential role of local communities in providing assistance on the spot should not be forgotten, as Henry Dunant, founder of the Red Cross and inspiration behind the Geneva Conventions, witnessed after the battle of Solferino on 24 June 1859.[1]

1 See Henry Dunant. *A Memory of Solferino*. ICRC: Geneva; 1986.

7

Consequently, basic first-aid training – both initial and refresher – should be supported among:

- the general population;
- soldiers and members of security forces;
- non-State armed groups and opposition groups;
- community health-care workers;
- military and other medical staff (paramedics, nurses, doctors and other health-care professionals).

Commanders do not appreciate seeing their troop levels decrease when healthy uninjured soldiers are involved in transferring their own wounded because first-aid services are inadequate in the field. Fighting capacity is then doubly reduced.

Advanced competencies can be added to the training curriculum of those specially dedicated to providing first-aid services in the field, such as military medics and the first-aid teams of the National Red Cross and Red Crescent Societies, as a forward projection of resources.

7.2 First aid in the chain of casualty care

First aid starts at the point of wounding, but can be given anywhere and everywhere along the chain of casualty care to the place of definitive treatment.

Point of wounding
On-the-spot first aid, often performed on the actual battlefield, may be self- or buddy-first-aid if combatants and other weapon bearers have received the proper training prior to deployment. Otherwise, it is practised by a military medic, civilian or Red Cross/Red Crescent first-aider.

Collection point
It is common practice and convenient to bring all the wounded to one spot, depending on the tactical situation, to evaluate their condition, start first aid if it has not yet been given and stabilize those for whom lifesaving measures have already been undertaken, and then to decide who needs to be evacuated for further treatment according to triage priorities. This is best served by a first-aid post (FAP).

Evacuation
The decision to transport a casualty should be assessed carefully considering the dangers and difficulties inherent in situations of armed conflict. Whatever method of transport is used along the chain of casualty care, first-aid measures should be maintained throughout.

Hospital emergency room
In the rural areas of a poor country and during urban warfare, the first site where any care is available is often the emergency reception of an established hospital. Even if there is an efficient emergency transport service, family and neighbours often do not wait for it and prefer to transport the wounded directly to the hospital, whose emergency room (ER) then serves as a first-aid post.

The degree of development and sophistication of the emergency transport and EMS in a given country will determine what level of first aid and triage are performed "in the field" and what occurs only in a health-care facility.

First aid can be performed everywhere and anywhere along the chain of casualty care.

Even in armed conflicts, ordinary life goes on. There is no let-up in vehicle accidents, other accidents or diseases among the local population and weapon bearers. The efficient work of first-aiders is as necessary as usual.

7.3 First-aiders: an important human resource

Usually, first-aiders are organized into teams with proper supervision and equipment, such as those of the Red Cross or Red Crescent or of the armed forces. Civilian and Red Cross/Red Crescent first-aiders are an essential part of the health-care team, as they are members of the local community, reflect its characteristics, and are well accepted by society. They take on many roles from the front lines to the health-care facility, and their availability and versatility are respected.

Therefore, it is important to respect their knowledge, and appreciate their courage and dedication. They have important rights and duties according to international humanitarian law, and should be trained accordingly. They should also be trained in the methods and practice of triage. It is important not only to welcome them when they bring in a casualty but also to give them feedback on the measures they have taken and on the evolution of the casualties they have already brought in, to ensure a proper handover of the patient and prepare for future work. The surgeon plays a vital role in this communication with first-aiders.

> First-aiders are often volunteers and an essential part of the health-care team, and should be appreciated accordingly.

The presence of first-aiders before, during and after emergencies helps rekindle the humanitarian spirit of individuals and communities, inspiring tolerance and ultimately building healthier and safer living environments.

7.4 Essential elements of the first-aid approach and techniques

7.4.1 Security first and always

One of the specific characteristics of armed conflict, as mentioned, is the particularly hazardous situations encountered, more dangerous than during natural catastrophes or industrial accidents. The situation is made even worse because of the will of weapon bearers to continue fighting and inflict harm after the initial damage has been done, and the increasing unwillingness of many fighters to recognize and obey the rules of armed conflict.

First-aiders are exposed and at great risk, or are at times even targeted in an ambush or a gun battle. All too often, when a bomb explodes or is dropped there is a rush of first-aid rescuers to the site; a second bomb goes off a short time later, causing far more casualties than the first: the so-called "second hit". Furthermore, the work space may be limited by an excited and angry crowd of bystanders and the casualties' friends, relatives and comrades, who may threaten first-aiders.

> The point of wounding is, by definition, a very dangerous and chaotic place.

This entails practical consequences for the first-aider and imposes necessary constraints for the safety of patient and first-aider alike. A wounded first-aider needs help and cannot help others. The question of first-aid care under fire – for military personnel – will depend on the doctrine and training of each army.

As previously stated, the sick and wounded benefit from legal protection and the first-aider has rights and responsibilities under international humanitarian law. An opportunity to provide care more safely may be created by negotiations or a ceasefire. The armed forces may choose to remove the threat or provide security by armed force. This does not mean first-aiders need not take security measures prior to engagement in the field. Circumstances determine how and when care can be provided with acceptable risk.

The benefits of caring for the wounded must always be weighed against the risk of first-aiders themselves being wounded.

An absence or limitation of transportation and the impossibility of deploying personnel in the field to perform first aid because of political or security constraints – all too often the case in the circumstances where the ICRC works – will cause some patients who might otherwise have survived to die, and surviving patients to have established infections and other complications which lower their subsequent chances of quality survival. The challenge is how to deploy and organize the necessary first-aid personnel, material, and equipment in the field. For the armed forces, this is also a challenge but has a different connotation. Tactical considerations may mean that soldiers must win the firefight before treating or evacuating the wounded.

7.4.2 Basic actions

The basics of a routine first-aid deployment apply, while at the same time safety and security must be ensured.

Preventing further injury: removing casualties from danger
A wounded person is more likely to be injured again or even killed, especially if the person cannot take measures of self-protection, such as seeking cover from shooting or bombing. The prevention of further injury thus involves removing casualties from the point of wounding, and putting patients and medical personnel in as safe a place as circumstances allow. Furthermore, conscious and walking wounded must be separated from the others as a matter of scene security management, as well as triage.

Preventing aggravation of the injury: sheltering the casualties
Shelter offers some protection from further injury in a combat environment, and also provides a shield from the elements. Exposure to the sun and heat, or cold and rain, are deleterious to the wellbeing and stabilization of the injured. It is also easier and more efficient to deliver medical care when working under more comfortable physical conditions.

7.4.3 Standard sequence of basic life support: ABCDE or C-ABCDE?

"C" = Catastrophic peripheral haemorrhage
A = Airway
B = Breathing
C = Circulation
D = Disability (neurological status)
E = Environment and Exposure

ABCDE has become established as the ubiquitous first-aid paradigm. Although some injuries are inevitably un-survivable, there are many cases where death can be prevented by rapid and decisive first-aid care following this approach at the point of injury. However, ballistic and blast injuries are different from civilian blunt trauma.

Massive bleeding from limb wounds accounts for most preventable deaths in combat (see Chapter 5). Far more soldiers die from catastrophic peripheral haemorrhage than from airway obstruction or respiratory inadequacy. Indeed, emergency medical practitioners working in armed conflict or in contexts of violence are often intuitively uncomfortable with the ABCDE approach due to their similar experience. It therefore makes sense to put "C" for Catastrophic peripheral bleeding first, simply because it is more common, and a more frequent cause of death, giving us C-ABCDE.

Research demonstrates that a high number of deaths from catastrophic peripheral bleeding could be prevented by using a tourniquet (see below). The ICRC's experience reaffirms the pivotal role of the tourniquet in managing life-threatening peripheral haemorrhage.

> Protection of the casualty, prevention of further injury, and life-saving and stabilization measures are the fundamental responsibilities of the first-aider in the field.

Once control of catastrophic haemorrhage has been achieved, ABCDE is followed, as part of the standard sequence of basic life support:

1. ABCDE algorithm leading to additional life-saving measures related to airway and breathing and first-aid techniques that are applicable to the great majority of casualties: those who suffer fractures and soft-tissue injuries, which may cause disability.
2. Complete examination leading to stabilization measures. The patient must be exposed in order to perform a correct and complete examination. Cultural and religious constraints, and the tactical situation, may impose limits on how much a casualty may be undressed in the field.
3. Additional measures:
   - Keeping the casualty warm: when an individual experiences massive haemorrhage the body loses heat, even in warm climates. Casualties should be covered with a sheet or blanket to prevent hypothermia, which can be very detrimental in terms of coagulopathy (see Chapters 8 and 18). It is important to also put something under the patient, as their body heat can also dissipate into the ground.
   - National and institutional guidelines will establish the protocols for the level of treatment that is implemented in any first-aid programme, such as oral or i.v. fluids, antibiotics, analgesia, tranexamic acid, endotracheal intubation etc.).
   - Psychological support.
4. Monitoring of the casualty's condition and the effectiveness of the measures taken.

> Control of catastrophic peripheral haemorrhage and other simple life-saving measures take precedence over more complex techniques and are based on the priorities of the C-ABCDE system.

7.5 Setting up a first-aid post

The establishment and organization of a first-aid post (FAP) should rely on a large dose of common sense to determine what is practical and realistic in a given situation, and will depend on how long it will operate (from a few minutes to a few days or weeks).

7.5.1 Location

Choosing a site for an FAP should follow certain rules. It should be placed in a secure position, far enough from the fighting not to be in danger, yet near enough to enable the rapid transfer of casualties to the post. For operational and security reasons, its location should be indicated as soon as possible to the dispatch or command centre of the chain of casualty care. Its presence should be made known to the local population and combatants and other weapon bearers, who are the potential beneficiaries of its services. A prominently-displayed distinctive emblem (a red cross, red crescent or red crystal), large enough to be seen from all directions and from as far as possible, helps to identify the FAP and provide protection under IHL.

> The security and protection of casualties and first-aiders are the primary considerations for setting up a first-aid post.

ICRC

Figure 7.1.1

First-aid post: formal.

T. Gassmann / ICRC

Figure 7.1.2

First-aid post: ad hoc.

7.5.2 Infrastructure

An FAP is a functional unit: it can therefore be set up in a makeshift fashion in a tent, a school or any available building; or in an already existing dispensary or primary health-care centre. Certain minimum requirements should be fulfilled: appropriate shelter against the elements; adequate size to accommodate casualties on stretchers; easy access for the "walking wounded" (e.g. avoid long stairways); adequate in-and-out access for ambulances and ample parking space.

7.5.3 Staffing, equipment and supplies

The level of technical expertise of the personnel in an FAP will depend on the circumstances and standards of the country. Anyone from a first-aider to a nurse, general practitioner or even a surgeon may be found working in an FAP. This allows for the "forward projection" of care for casualties (see Chapter 6). Equipment and supplies must meet minimum standards and be adequate for basic trauma care, and adapted to the personnel's skills and local standards. Telecommunication equipment, if any, should be properly installed and placed in a reserved area.

Please note:

The Emergency Items Catalogue of the International Red Cross and Red Crescent Movement contains the description of a standard first-aid and triage post, equipped for experienced nursing staff and/or a general practitioner (see Selected bibliography).

7.5.4 Organization

The premises of the FAP should be organized – and the staff prepared – for dealing with a mass influx of casualties. The principles and practice of triage should be well understood by all present through simulation exercises (see Chapter 9).

If the FAP stays open for a certain length of time, and the facilities allow for it, the following areas should be pre-arranged:

- Admission area at the entrance to register and triage casualties.
- Holding area to care for and monitor casualties awaiting evacuation.
- Waiting area for relatives, friends and comrades.
- Temporary mortuary.
- Storage area for equipment and supplies.
- Storage area for weapons removed from the wounded.
- Rest area for personnel, and personal hygiene facilities.

ICRC EXPERIENCE

Occasionally, the ICRC has had to set up an ad hoc FAP where access to surgical facilities was insecure. During the long-running civil war in Sierra Leone, fighting broke out several times in the capital city, Freetown. During one such episode in 1998, the ICRC delegation was turned into a first-aid post: the car park became the reception and triage department and the various offices became wards and intensive care areas. Over a period of 10 days, 6 nurses and 3 Red Cross volunteers treated 244 war casualties and 228 sick patients, while a surgical team from Médecins sans Frontières (MSF) operated in the general hospital.

Urban fighting often made it dangerous for patients to reach the hospital and they regularly stayed in the improvised FAP for 2 or 3 days prior to evacuation.

In addition to basic first-aid treatment, intravenous fluid resuscitation, tetanus immunoglobulin, penicillin and analgesia were given. Many patients survived 2 - 4 days, before being transferred to the hospital, and surgery. The MSF surgical team appreciated receiving patients who had dressed wounds and were well hydrated, ready for surgery.

Security, however, was a major concern. Looting of the ICRC delegation by armed men occurred twice and several of the 4,500 civilians who had taken refuge in the delegation premises, effectively turning it into a displaced persons camp, were injured or killed by stray bullets. The emblem of the red cross offers only limited protection under such circumstances.

7.6 ICRC involvement in first-aid programmes

The ICRC supports first-aid programmes and activities in contexts of armed conflict and other situations of violence. These programmes include:

- deployment of medical staff to operate first-aid posts;
- education and training where no other organization has access (e.g. for irregular guerrilla groups);
- helping to adapt routine first-aid programmes of National Red Cross and Red Crescent Societies and other organizations to the context of conflict preparedness and response;
- development of the strategic, management and planning capacities of national and local institutions and team leaders;
- provision of materials and equipment;
- assistance in the organization, development and implementation of pre-hospital emergency care systems;
- production of standards and reference documents (see Selected bibliography).

7.7 Debates, controversies and misunderstandings

Detailed first-aid techniques are described in the manuals listed in the Selected bibliography. The rest of this chapter deals only with a few topics that may give rise to controversy or misunderstanding or are specific to the scenario of armed conflict.

7.7.1 "Scoop-and-run" versus "stay-and-treat"

Like the rest of the chain of casualty care, the organization of first aid requires planning and training. A strategy for the efficient care and evacuation of the wounded must be established. Two well-known strategies are described by the expressions "scoop-and-run" and "stay-and-treat". These derive largely from the civilian practice of emergency medical services in industrialized countries and may not be particularly relevant in a context of armed conflict.

In a peacetime environment, there is no impediment to patient transfer other than infrastructure and geography. The efficiency of evacuation is determined by the availability and coordination of transport, either by air (fixed wing with airports, or helicopters and helipads), or by land (proper roads, necessary vehicles, etc.); and the distances involved. The context of armed conflict is not as simple.

Scoop-and-run implies basic life-saving first-aid measures, then taking the patient immediately to a surgical hospital. This is appropriate if the distances are short, reliable transport is available, and the nearby hospital is adequately supplied and staffed. Keeping patients on the spot until patient stabilization prior to evacuation – stay and treat – is correct if distances are great, infrastructure and transport are less than adequate, and proper surgical facilities are more difficult to access. The common-sense approach is to stabilize the patient as much as needed and get to hospital as soon as possible, according to circumstances.

In a military context, the factors of ongoing combat and enemy activity must be added to those present during peacetime. Here, scoop-and-run implies air superiority if helicopters are used, safe and controlled roads for transport over land, and, in both situations, surgical facilities at a reasonable distance. These conditions are fulfilled for only a few armies in the world and, even then, only under certain tactical situations; this approach is not feasible in mass-casualty situations, for example. More common is the establishment of a collection point or clearing station, i.e. the "stay-and-treat" approach. How much "treatment" occurs depends on the forward projection of resources. Indeed, the US armed forces now call this "prolonged field care".[2] The performance of more advanced techniques in the field has been discussed in Chapter 6.

7.7.2 Mechanism of injury and the problem of the cervical spine

The first-aider, or other medical personnel, must immediately determine whether the casualty has suffered blunt or penetrating trauma. Blunt trauma above the level of the clavicles or causing unconsciousness requires immediate observation and immobilization of the cervical spine, while still giving priority to the airway. A penetrating wound to the brain causing unconsciousness requires no special care of the cervical spine.

In the case of a penetrating missile wound to the neck hitting the cervical vertebrae, any damage to the spinal cord has already been done. Unstable cervical spine injury from a projectile results in permanent cord injury. The reported mortality is over 95 %. The first-aider should be careful while handling the casualty, but cannot prevent damage that is already irreversible. A combination of blunt and penetrating neck injuries should be managed in the same way as blunt ones.

M. Dalla Torre / ICRC

Figure 7.2

Gunshot wound to the mandible: no danger to the cervical spine.

ICRC EXPERIENCE

Here are two practical examples taken from ICRC experience to demonstrate the difference between blunt and penetrating trauma:

A person injured in a vehicle accident, with a fractured mandible and bleeding from the mouth that obstructs the airway also requires care of the cervical spine in case there is hidden injury. A bullet wound to the mandible – with bone fragments, haematoma, drooling saliva, and damaged soft tissue of the floor of the mouth – does not. If the patient is conscious, he will maintain a particular position – head thrust forward and looking down, blood and saliva flowing out – in order to maintain as patent an airway as possible. There is no use in placing a protective cervical collar on this patient and, if the first-aider attempts to place the casualty in a reclining position, the wounded person will resist.

A fall may result in both loss of consciousness and injury to the cervical spine. Loss of consciousness due to a bullet wound to the head, however, does not require any specific precautions regarding the cervical spine.

2 Rasmussen TE, Baer DG, Remick KN, Ludwig GV. Combat casualty care research for the multidomain battlefield. *J Trauma Acute Care Surg* 2017; **83 (1Suppl.)**: S1 – S3).

7.7.3 The tourniquet: when and how?

Limb injuries with massive external bleeding from a severed artery are the most common cause of preventable death during armed conflict: bright red blood spurts from the wound and the patient can die within two to three minutes. Application of a tourniquet appears obvious. Yet no subject has caused so much debate in first aid as the use of tourniquets. In addition, a distinction is to be made between commercial manufactured tourniquets and improvised ones.

E. Winiger / ICRC

Figure 7.3.1

Improvised tourniquet: how harmful? Here a tourniquet was applied for more than six hours, resulting in a very high above the knee amputation.

R. Coupland / ICRC

Figure 7.3.2

Improvised tourniquet: how effective?

Whilst it is widely accepted that tourniquets have saved countless lives in a military setting, their use among civilians is often misunderstood and bad practices are frequently still taught. The most important factor is the indication for tourniquet use: not every bleeding limb has arterial haemorrhage, and much can be done before a tourniquet is considered.

By far the simplest and most common techniques with which a first-aider can control peripheral haemorrhage are direct pressure, or proximal digital pressure and packing, and a compressive bandage. A tourniquet can be applied to temporarily control bleeding while either packing the wound and applying a compressive bandage, or caring for other severely injured patients. Indeed, tourniquets may be considered when victims with severe injuries outnumber first-aiders on scene. An improvised tourniquet should only be used as an absolute last resort, when all else has failed, and the victim's life is at risk.

Although a tourniquet can save lives, it endangers limbs. By using a tourniquet, the first-aider is making a conscious decision to risk the limb in order to save the victim's life. However, it is difficult to apply correctly and to maintain and supervise, and open to many complications. A tourniquet cuts off all collateral circulation and its prolonged application – longer than 2 hours – can result in permanent nerve, muscle and vascular injury, skin necrosis and infection. Muscle necrosis is almost certain by 6 hours and compartment syndrome can result not only in loss of the limb but put the patient's life in danger (see Figure 7.3.1 above and Section B.10 in Volume 2), as can an incorrectly placed tourniquet, by stopping venous return but not occluding the arterial flow: the person bleeds out because of the tourniquet. Improvised tourniquets are often not even effective (Figure 7.3.2). On the other hand, catastrophic uncontrolled bleeding is a life-or-death situation. In armed conflict and/or mass casualty situations survival often outweighs the risk of limb loss.

Training to apply, maintain and supervise a tourniquet correctly is essential. A properly applied tourniquet is painful, so significant pain relief may be required if it is to be applied with the appropriate pressure. A tourniquet should also be placed as distally as possible on the limb and it should be released and then re-applied at regular 20-30-minute intervals; this will, theoretically, avoid or at least limit any complications. In addition, after a period of time of reduced arterial flow, clotting may have occurred sufficiently to allow simpler methods of haemorrhage control, known as "tourniquet conversion".

Generally, a purpose-made tourniquet is recommended. In life-threatening situations, improvisation may be required, but knowledge is required for proper improvisation: the tourniquet should be at least as wide as a wide belt. Improvising a tourniquet is not as simple as it sounds; one must know what one is doing in order for it to be truly effective.

It is justifiable to apply a tourniquet in the case of crush injuries (e.g. when a casualty is trapped under the rubble of a building that has collapsed due to an earthquake or bombardment), but precautions should be taken to ensure rehydration/resuscitation and thereby avoid the complications of myoglobinaemia, which is otherwise inevitable. For further information on crush injury, see section B9 and ANNEX B. 2 in Volume 2.

The use of tourniquets by the armed forces is determined by various tactical considerations that do not apply to civilian health services. The ICRC declines to pronounce on these considerations, but warns against the abuse of the tourniquet that has occurred in many conflicts.

Simple measures can control most cases of peripheral haemorrhage. A tourniquet is a life-saving measure that may be taken when simpler measures fail. Complications related to tourniquet use occur due to inappropriate, incorrect, or prolonged application.

7.7.4 Adjuvants in haemorrhage management

Some armies are currently testing new locally-active haemostatic powders, sponges and compresses to promote clotting in traumatic wounds. However, direct pressure must still be applied. The ICRC has no experience with these and, like most others, awaits the definitive results of the field trials. Cost and availability will be factors when considering their use worldwide.

Early in-hospital administration of tranexamic acid (TXA) has proven to reduce mortality from severe haemorrhage (see Chapter 8). Military and civilian trauma systems worldwide have been examining whether to implement pre-hospital TXA protocols. At present the ICRC does not have the necessary experience, nor is there any definitive evidence, to confirm the efficacy of pre-hospital TXA in armed conflict settings.

7.7.5 Resuscitation or rehydration?

The first-aider can only implement simple procedures in the field. The administration of intravenous fluids requires a certain degree of medical knowledge and specific equipment that are beyond the normal scope and competencies of a first-aider. He can be involved in the monitoring of a perfusion, however.

The subject of pre-hospital i.v. fluids has given rise to considerable controversy. Maintaining adequate tissue perfusion and oxygenation is balanced off against the dilution of clotting factors and the dislodging of existing clots when the blood pressure goes up ("popping the clot"). The currently recommended "hypotensive resuscitation" involves giving fluids to a just palpable radial pulse – equivalent to a systolic blood pressure of 90 mm Hg – and no more (see Chapter 8).

A great deal of this controversy concerns efficient civilian trauma systems where evacuation times are short, less than 2 hours. It is probable that only the war-wounded showing obvious clinical signs of shock require pre-hospital i.v. fluids. In addition, in many contemporary conflicts transfer to a hospital takes much longer – days or even weeks – where "popping the clot" is not really relevant. Rehydration – as part of resuscitation – may be a more appropriate term under these circumstances.

If the wounded patient is conscious and not suffering from head trauma, the first-aider can rehydrate with oral fluids (e.g. oral rehydration salts), especially if evacuation is delayed and transport long. This procedure is probably not employed nearly enough. Oral rehydration can probably be given with no detriment to the patient even in cases of abdominal trauma, and especially for severe burns.

7.7.6 Supplemental oxygen in the field?

Warning!

Oxygen cylinders are the equivalent of a bomb if hit by a bullet or piece of shrapnel. In addition to the danger they represent, the cylinders are heavy and must be replaced, lasting only a short time at high flows. Furthermore, their replenishment is complex and requires special factory capacity.

Oxygen cylinders must be ruled out in the event of any deployment to a dangerous area. This is now standard ICRC policy.

Palestine Red Crescent Society

Palestine Red Crescent Society

Figures 7.4.1 and 7.4.2

Ambulance destroyed by the detonation of an oxygen cylinder, which has gone through the roof like a rocket. The photos show the ambulance and the cylinder on the ground.

Depending on security conditions, the collection point or intermediate station may have oxygen available. An oxygen concentrator (requiring an electrical supply) is preferable to compressed oxygen cylinders.

7.8 Disability: the AVPU system

Disability in this context refers to the neurological status of the casualty: the state of consciousness and any paralysis due to injury to the spinal cord.

The Glasgow Coma Scale is the hospital standard (see Section 8.8). However, the AVPU system is a simpler means of assessing consciousness and it may be easier for first-aiders to use in the field. It easily translates into the Glasgow system when the patient arrives at the hospital and gives the surgeon a good appreciation of the evolution of the patient's condition.

Alert	The casualty is awake, lucid, speaks normally and is responsive to the environment (e.g. eyes open spontaneously as you approach).
Voice responsive	The casualty is able to respond in a meaningful way when spoken to.
Pain responsive	The casualty does not respond to questions but moves or cries out in response to a painful stimulus (pinching the neck muscles, earlobe or nipple; rubbing the supra-orbital margin, or the angle of the mandible).
Unresponsive	The casualty does not respond to any stimuli.

Other conditions may influence the level of consciousness: hypoxia, shock, medication, and narcotics and alcohol (the latter all too often consumed to excess during times of armed conflict).

7

In the field, securing the airway is the first step to take when dealing with a casualty whose consciousness is compromised.

Examination of the spinal cord and vertebral column
This involves two phases: determining the movement of the limbs – comparing the two sides – and palpation of the bony prominences of the spine. Palpation of every vertebra – like "fingers playing on piano keys" – aims to identify any induration or deformity. If there is any danger to the spinal cord, then the four-person log-roll technique should be used to move the patient onto a stretcher. The cervical spine can be immobilized initially by manually controlling the head before a neck collar is placed – preferably a soft type, rather than rigid. Immobilization of the cervical spine must not increase the risk of airway obstruction, however.

The importance of the mechanism of injury – blunt or penetrating – has already been mentioned. In all cases of suspected injury to the vertebral column, proper handling of the patient and immobilization techniques are of the utmost importance; the injury may already be there, but the first-aider should act in such a way as not to worsen the condition.

7.9 Evacuation: a risk to take

Transportation of the wounded is always difficult, always takes longer than expected, adds to the trauma and can be dangerous to the patient and those transporting the casualty: the famous "mortality of the ambulance ride". In situations of armed conflict, the danger of the ambulance ride is complicated by the risks of ongoing combat.

Figures 7.5.1 and 7.5.2
Different means of patient evacuation: modern and traditional.


L. Berlemont / ICRC


Y. Muller / ICRC

Speed is less important than safety of transport: ambulance crashes are notorious. All these parameters, aggravation of the patient's condition, use of resources and security must be weighed against the likely benefits of moving the wounded.

In an urban environment, it should be standard procedure for a first-aider to bypass the neighbourhood clinic if the injury is serious, and to evacuate to a clinic for a minor wound in order not to overburden the hospitals. Unfortunately, city-dwellers (and too many first-aiders) often spontaneously rush patients to hospital no matter how slight the injury. Evacuation and transport may be difficult and dangerous during urban fighting even if distances are very short, and transfer may be delayed while waiting for a calm period or ceasefire.

There is also the confusion that reigns during street fighting and the highly-charged emotional atmosphere to contend with. An absence of the discipline needed to perform good pre-hospital triage – and pressure from bystanders – can result in chaos in the receiving hospital. The first wave of ambulances transports the dead and badly mutilated. The second wave of ambulances carries people who are shouting, hysterical, and frightened: the lucid and superficially injured. The third wave evacuates the seriously wounded who truly require emergency treatment; these patients lie still – they are usually haemorrhaging – without shouting to bring attention to themselves.

In remote rural areas, if transportation takes many hours or even days, it is logical to project competency forward by training local providers in more advanced skills. The principles of triage apply to the choice of which patients to evacuate first (see Chapter 9). Note that there is an important difference in the priority to treat and the priority to evacuate, especially if evacuation is prolonged. The recognition of injuries that are not survivable helps to spare the victim and would-be rescuers the agony and frustration of unsuccessful efforts to reach a higher level of care, and to provide better care for those who can survive.

Delay in evacuation will contribute to an increase in pre-hospital mortality; the more severely injured suffer "nature's triage". As was seen in Chapter 5, longer and more difficult evacuation sorts out central injuries, with a consequent decline in hospital mortality: only those patients with a good chance of survival reach the hospital. This remains a major problem in the care of the war-wounded.

Chapter 8

HOSPITAL EMERGENCY ROOM CARE

8.1 C-ABCDE priorities

The framework for casualty management in a hospital emergency room (ER) is a continuation of the basic life-support procedures of first aid. The logic is the same; the diagnostic and treatment means available are simply more advanced. The "golden hour" begins at the site of trauma, not on arrival at the emergency room.

If pre-hospital services were efficient, one would never see catastrophic haemorrhage from a limb wound in the ER. Unfortunately, such services are all too often unavailable in precarious and dangerous situations. Especially during urban warfare, it is often bystanders, friends or family who ensure evacuation of the wounded, and it is under these conditions that the patient with an exsanguinating limb wound may present in the ER.

Whether or not the casualty arriving at a hospital has received first aid, they should undergo the full C-ABCDE examination. The patient's condition may have changed during transport or important wounds may have been missed because of the difficult working conditions in the field, including the inability to fully undress the patient. Nonetheless, apart from stopping obvious massive peripheral haemorrhage, the standard ABCDE algorithm should be followed.

> Priorities: the C-**ABCDE** scheme of thinking.
>
> Catastrophic external haemorrhage before Airway, before Breathing, before Circulation.

1. Assess
Initial examination:
Catastrophic external haemorrhage
Airway
Breathing
Circulation
Disability
Environment and **E**xposure.

Triage in a mass casualty situation: see Chapter 9.

2. Act
Emergency resuscitation: act on life-threatening conditions.

3. Assess
Complete examination: head-to-toe palpation, front and back and sides.

4. Act
Definitive treatment, surgical or not: stabilization; damage control approach or not.

5. Assess and Act
Treatment *in situ* or evacuation of the casualty, according to triage priority, to a higher-echelon hospital for specialized care if necessary.

Please note:

In certain countries, emergency examination and treatment of male and female patients must take place in separate areas. This can be problematic in a mass casualty situation, but the emergency department must be organized accordingly.

8.2 Initial examination

The initial examination and emergency resuscitation are carried out simultaneously. The receiving ER doctor must automatically ask a series of questions.

1. Is the patient dead or alive?
2. Is the patient conscious or not?
3. What is the mechanism of injury: penetrating or blunt?
4. What are the life-threatening conditions, if any, according to the C-ABCDE algorithm?

The natural reflex when faced with a wounded person is to look at the bleeding first, even minor bleeding. Except in the case of obvious massive peripheral haemorrhage, the greatest immediate threat to life is an inadequate intake of air. Airway takes precedence over both breathing and circulation.

The ER doctor must learn to use the ABCDE scheme of thinking in a circular fashion. Determining whether the patient is dead or alive already involves a rapid ABCDE examination. The dead have no air intake (A), no ventilation of the lungs (B), and no pulse (C); the pupils are dilated and do not react to light and there is no reaction to painful stimulus (D); there is no movement of the limbs and the body feels cold (E).

Most casualties are conscious, anxious or frightened, and in pain, and will tell you what happened and where "it hurts": they are alive, lucid, and the act of speaking shows that the airway is free. These signs of life may seem obvious. Nonetheless, one should make a mental checklist and practice the routine of asking the series of initial questions in order to establish an organized and coherent method of examination.

As mentioned in the previous chapter on first aid, blunt trauma above the level of the clavicles requires adequate care of the cervical spine, but not at the expense of a life-threatening airway problem. Simple measures include: manual stabilization in a neutral position with the head maintained in the axial line; semi-rigid collar; sandbags; taping; specialized backboard.

The initial examination should include the diagnosis of any life-threatening A, B or C problems and the number, location and extent of obvious wounds. These two elements together are important for establishing triage priorities (see Chapter 9). A more complete examination to locate all wounds should follow the initial ABCDE examination.

It is important to determine the time since injury and estimate blood loss since injury. Past or pre-existing diseases and medications for chronic conditions should be taken into account, as should allergies. Young, healthy combatants do not usually present such medical problems.

In a hospital environment, the casualty should be completely undressed to allow for a correct examination – again, certain cultural or religious constraints may apply. Vital signs should be taken, i.v. lines placed and blood samples withdrawn simultaneously for blood grouping and cross-matching, and a haematocrit or haemoglobin estimation to determine a baseline for future comparison. Other tests, such as electrolytes, blood gases, glucose, etc. may be performed depending on local standards and laboratory capacity.

8.3 Catastrophic haemorrhage

Types of haemorrhage

Haemorrhage may be arterial, venous or capillary and blood loss may be:

- peripheral and obvious (a blood clot the size of a fist or an open wound the size of a hand represents 500 ml);
- peripheral and hidden:
  - closed fractures of long bones (tibia = 500 ml, femur = 1.5 litres);
  - open wound with small entry that is blocked by a piece of torn muscle;
- central (chest, abdomen, pelvis and retroperitoneum): a massive haemothorax can represent 2 – 3 litres of blood; a severe fracture of the pelvis 3 litres.

Obvious massive peripheral haemorrhage should be dealt with immediately. If a bleeding blood vessel can be seen in the depths of a wound, and *only if* it is clearly visible, direct control may be obtained with haemostatic artery forceps.

Blind clamping must never be attempted

A pneumatic tourniquet, if available, is the best method of temporarily controlling severe arterial haemorrhage from the limb. Otherwise, one should resort to packing the wound. Digital pressure is applied to the artery proximal to the wound (pressure point), while the wound is carefully packed with gauze compress first, followed by a bulkier dressing, and finally a firm compressive elastic bandage in order to apply even pressure and thereby achieve haemostasis.

Once bleeding has been arrested, the tourniquet or dressing should not be removed until the patient is in the operating theatre. The surgeon should be ready to rapidly obtain vascular access and control of the major blood vessels.

Bullets, fragments and other foreign bodies embedded in the wound should only be removed in theatre, as part of the operative procedure.

Penetrating trauma causing catastrophic central bleeding into a body cavity requires urgent operation as part of the resuscitation process. Such patients have a high priority for surgery and a damage control approach should be considered (see below).

Beware of removing packs from missile wounds, as the resultant bleeding can be torrential and difficult to control.

8.4 Airway

Airway obstruction is an emergency that requires an urgent response. Some injuries cause an immediate problem; others may result in delayed impairment of the airway.

Common conditions that can compromise the airway include:

Head injury with decreased consciousness
Apart from the danger of aspiration of vomitus, the tongue and epiglottis may fall back and block the airway.

Maxillo-facial injuries
Blood, broken teeth, bone fragments or foreign bodies can impede air entry, Even if the patient can breathe adequately in the beginning, the development of oedema of the tongue, floor of the mouth and pharynx may obstruct air intake after several hours.

Penetrating wounds to the larynx or upper trachea
If large enough, they will create a "traumatic tracheotomy".

Blunt injury to the larynx (e.g. from a rifle butt)
This may crush the cartilage, resulting in collapse of the airway.

Compressive haematoma in the neck
This may accumulate quickly or slowly, compressing the hypopharynx or larynx from the outside.

Burns to the face and neck or inhalation burns of the larynx and trachea
Whether due to flame and smoke or irritating chemical agents, these require close observation for delayed obstruction or respiratory failure due to oedema.

Please note:

Inhalation of chemical agents requires special precautions for decontamination of the patient and of any equipment coming into contact with him. Not only is this an essential part of the treatment, but it is also necessary for the protection of the hospital staff and other patients.[1]

The conditions causing delayed airway obstruction may develop slowly and there is a danger that they will not be recognized in time, especially during triage of mass casualties with inadequate supervision.

8.4.1 Opening the airway

As in first aid, the standard treatment for an actual or potential obstruction applies.

Basic steps for securing the airway
Open the mouth.
Displace the tongue forward.
Remove any blood or debris from the mouth and oropharynx.
Maintain the airway patent.

To open and clean the mouth the standard manoeuvres are jaw thrust or chin lift: displace the tongue forward, and then finger-sweep the mouth while protecting the finger, aided by a suction apparatus if available. These techniques will cause some movement in the cervical spine, it is particularly important to minimize such movement in case of blunt trauma. Manual in-line axial stabilization of the head during the manoeuvres will reduce such movement. Patency of the airway nonetheless takes precedence.

A number of devices can be used to maintain the airway patent:
- oropharyngeal airway (Guedel tube);
- nasopharyngeal airway;
- laryngeal mask airway;
- combitube (double lumen tube inserted blindly into the trachea and oesophagus).

All of these methods keep the airway open but cannot ensure protection against vomiting and aspiration of gastric contents.

During the reception of mass casualties, overwhelmed ER personnel may have to revert to a simpler method as a temporary procedure. Under these conditions, the lateral security or semi-prone position will afford relative protection against vomiting and aspiration and is the position of choice for most patients with an airway at risk until more secure procedures can be carried out.

Many conscious patients with maxillo-facial injuries spontaneously sit up with the head tilted forward to allow any blood and saliva to come out by gravity and thus keep the airway open. If an attempt is made to lie these patients on their back, they refuse and fight to avoid it (see Chapter 7).

8.4.2 Definitive patent airway: indications

The following conditions require a definitively secured airway:
- apnoea or cardiac arrest, whatever the cause (with assisted ventilation);
- severe haemorrhagic shock (Class IV, see below);
- Glasgow Coma Scale score of less than or equal to 8, which is equal to being unresponsive to pain;
- continued seizures and convulsions (with assisted ventilation);
- unstable fractures of maxilla or mandible (usually bilateral fractures of the mandible, or instability of the whole mid-face at the level of the glabella and zygomata);

1 See Larsson F. *Guidelines in Pre-clinical Management of Chemical Agent Contaminated Victims in Contexts of Armed Conflicts and Other Situations of Violence*, ICRC, Geneva, 2019.

- large flail chest segment (with assisted ventilation);
- respiratory failure (with assisted ventilation);
- moderate to severe facial or oropharyngeal burn.

8.4.3 Definitive patent airway: endotracheal intubation

The simplest technique to maintain a patent airway with protection from aspiration is endotracheal intubation, through either a nasal or oral approach. Deeply unconscious patients can usually be intubated easily. Others may be restless, irritable, and uncooperative. Intubation under these circumstances requires sedation. Various agents (diazepam, pentothal, propofol or ketamine) given intravenously will allow rapid intubation without aggravating the patient's hypoxic condition. The alternative to endotracheal intubation is a surgical airway.

8.4.4 Definitive patent airway: surgical airway

The need for a surgical airway should be identified early and it should be performed quickly. This may be the primary effort (maxillo-facial injuries, wounds to the neck involving the larynx or pharynx or haematoma accumulation, etc.) or following failure of endotracheal intubation. A surgical airway is also beneficial where there are no facilities for mechanical ventilation.

> Cricothyroidotomy is preferable to tracheostomy, which can be a difficult procedure under emergency conditions and may be associated with profuse haemorrhage.

Cricothyroidotomy

This is a quick, safe, and relatively bloodless procedure (Figures 8.1.1 – 8.1.4). A vertical incision is made in the skin followed by a horizontal incision through the cricothyroid membrane. The handle of the scalpel is inserted and turned 90° to hold the membrane open until a small tracheostomy tube can be inserted. In extremis, a wide-bore needle can be inserted instead; this needle cricothyroidotomy is particularly useful in children.

Figures 8.1.1 – 8.1.4

Cricothyroidotomy.

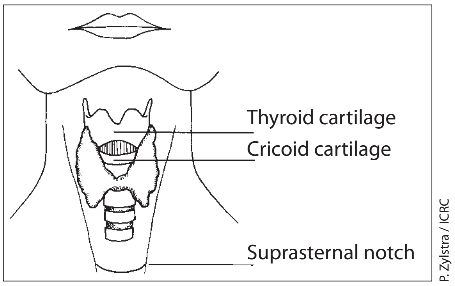


Figure 8.1.1

Surgical landmarks: the patient's neck should be placed in extension with a pad beneath the shoulders. The thyroid and cricoid cartilages are identified by finger palpation, the cricothyroid membrane is then identified as the depression in between them.

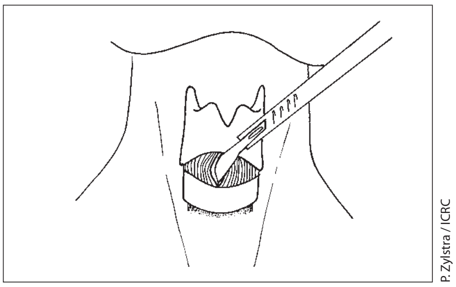


Figure 8.1.2

A horizontal skin incision is made over the cricothyroid membrane. The wound is spread apart using the thumb and index finger. The incision is carried down through the membrane and widened by insertion of the scalpel handle, which is then rotated through 90°.

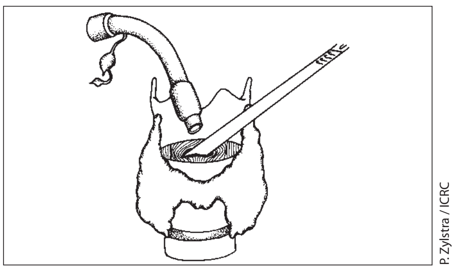


Figure 8.1.3

A tracheostomy tube is placed through the opening and secured.

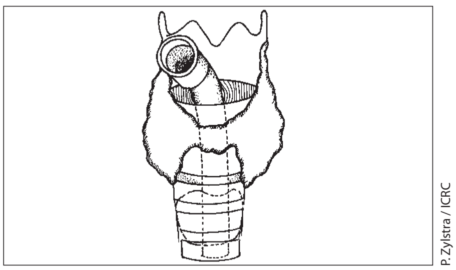


Figure 8.1.4

The entire procedure should take no more than 30 seconds.

Tracheostomy

Tracheostomy should be an elective procedure. The only specific indication for an emergency tracheostomy in missile wounds is direct laryngeal injury. The urgency of the problem and the experience of the surgeon will determine which technique is the safest and most appropriate for ensuring a secure airway.

8.5 Breathing and ventilation

The cause of respiratory distress must be found and treated. Patients with head injuries often require intubation and ventilation to support respiration, as is the case for tetraplegia, blast lung, chemical injuries and inhalation of smoke fumes. Previous disease may also impair ventilation in an injured patient.

Clinical examination may reveal a chest injury that decreases respiration, including:
- flail segment of the chest;
- open pneumothorax or sucking wound to the chest;
- tension pneumothorax and haemopneumothorax.

Flail segment of the chest

This condition should be treated initially by good analgesia, physiotherapy and positioning of the patient. More severe and complicated cases may require a chest tube and intubation with mechanical ventilation. It is usually the underlying lung contusion that causes the greatest difficulty in treatment.

For further details on flail segment of the chest, see Section 31.10.2 in Volume 2.

Sucking wound or open pneumothorax

A sucking wound requires a three-sided occlusive dressing in the ER. The patient then goes to theatre for placement of an intercostal drain and debridement and closure of the wound of the chest wall

Please note:

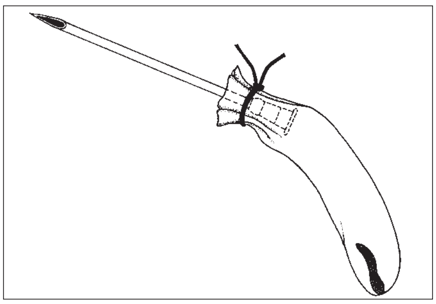
There is a risk of transforming an open wound into a closed tension pneumothorax if all four sides of a dressing are firmly closed.

Tension pneumothorax

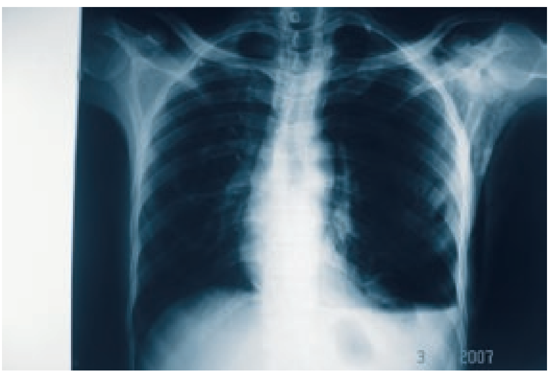
This condition is rare in projectile injuries, more common in primary blast injuries and even more common after blunt trauma. The diagnosis of a tension pneumothorax with obvious respiratory distress is a purely clinical one (Table 8.1); no time should be wasted taking an X-ray (Figure 8.2). The condition requires an immediate wide-bore i.v. cannula to be inserted into the second or third intercostal space in the midclavicular line (needle thoracocentesis) attached to an improvised Heimlich one-way flutter valve as a temporary measure (Figure 8.3). A positive finding is indicated by the sudden rush of air as the needle enters the pleural cavity. The cannula should be long enough (8 cm) to fully penetrate the muscles of the chest wall (average thickness 4 – 6 cm). An intercostal chest tube in the 5th intercostal space at the midaxillary line should replace the needle thoracocentesis as soon as possible.

Figure 8.3

Improvised Heimlich flutter valve: a wide bore cannula is inserted at the upper edge of a rib. A finger from a surgical glove, with a 1 cm-long incision in the end, is tied around the cannula.



P. Zylstra / ICRC



H. Nasreddine / ICRC

Figure 8.2

Tension pneumothorax with respiratory distress: the only thing wrong with the X-ray film is that it was taken. The diagnosis should have been a clinical one.

Needle thoracocentesis may fail, however. A negative trial does not necessarily rule out the presence of a tension pneumothorax. A simple finger thoracostomy in the 5th intercostal space at the midaxillary line is a good alternative. Again, a positive result is indicated by the hiss of air rushing out, in which case a chest tube is placed immediately.

Haemothorax

A haemothorax should be drained using a wide-bore chest tube. When clinical signs of haemothorax exist, an intercostal tube should be inserted *before X-rays are taken*. Chest tubes are usually placed under local anaesthesia. If there is a wound to excise, ketamine anaesthesia would be more appropriate.

For information on insertion of chest tube – thoracostomy – see Section 31.6 and ANNEX 31. B in Volume 2.

8.5.1 Assisted ventilation

After intubation, assistance with respiration may be required. Common pathologies requiring such assistance include:

- head injury;
- large flail segment;
- blast injury of lungs;
- inhalation of toxic gases or smoke, or flash burn to the tracheo-bronchial tree;
- aspiration pneumonitis;
- other medical causes of respiratory insufficiency.

Assisted ventilation may be manual:

- mouth-to-mouth or -nose for infants (use a compress barrier);
- mouth-to-mask;
- bag-valve-mask;
- bag-valve-endotracheal tube or surgical airway;

or mechanical, provided by a ventilator.

In a hospital, it is possible to administer supplemental oxygen from a central supply, cylinders or an oxygen extractor/concentrator.

The ICRC usually operates in situations of limited resources, and mechanical ventilators are not standard equipment. Few patients can be maintained for any length of time using manual ventilation by nurses and doctors; the recruitment of "volunteers" from family and friends can be considered in certain circumstances. In a mass casualty situation the principles of triage will apply and most patients requiring assisted ventilation will be Category IV; it will therefore not be performed (see Chapter 9). In the absence of mechanical ventilation, a tracheostomy has been found to be a useful adjunct to other measures in many conditions to ensure good oxygenation and blowing off of carbon dioxide.

8.6 Circulation

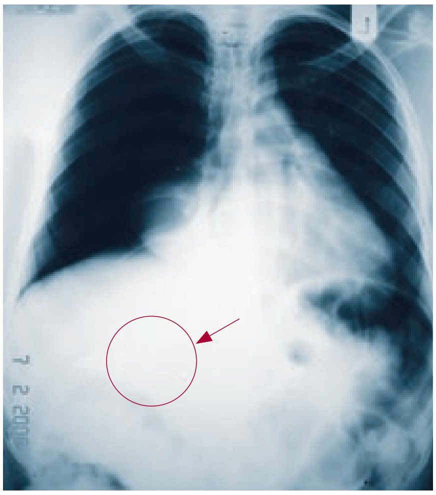
The main circulatory problem encountered in the war-wounded is hypovolaemic shock, usually due to haemorrhage or burns. In addition to any blood loss they cause, large soft-tissue wounds sequestrate large quantities of tissue fluids, with further loss of plasma and circulating volume. Dehydration complicates any previous fluid loss if evacuation is long and delayed.

Neurogenic, anaphylactic and cardiogenic shock may also occur; septic shock is a late complication. Injury to the spinal cord causing tetra- or paraplegia will result in neurogenic shock due to a disproportion between blood volume and dilated vascular bed. Allergy to antibiotics must always be kept in mind. Traumatic cardiogenic shock is due to direct injury to the heart that is not immediately lethal (e.g. small shrapnel

H. Nasreddine / ICRC

Figure 8.4.1

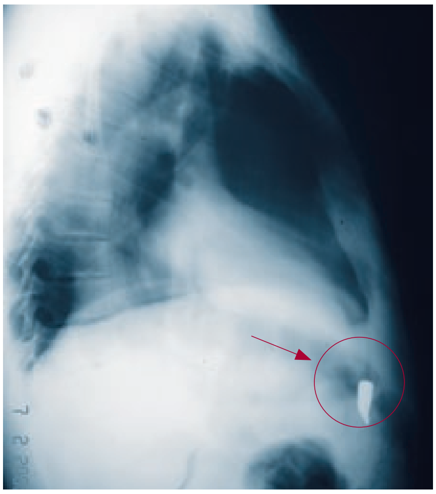
Simple, but massive, pneumothorax. Patient lying comfortably and breathing without effort. X-ray films are justified.



H. Nasreddine / ICRC

Figure 8.4.2

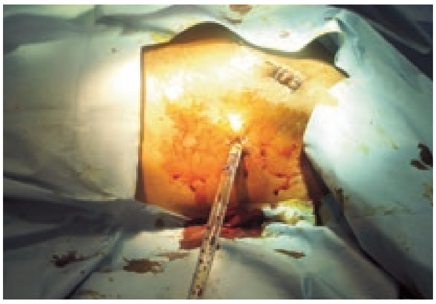
Antero-posterior radiograph showing large right-sided pneumothorax. The arrow marks the bullet.



H. Nasreddine / ICRC

Figure 8.4.3

Lateral film.



H. Nasreddine / ICRC

Figure 8.5

Intercostal tube.

8

wound causing traumatic myocardial infarction and/or pericardial tamponade). Furthermore, cardiogenic shock may be caused by primary blast effect either directly on the myocardium or mediated through an exaggerated vagal response due to a dysfunction of the autonomic nervous system. (See Section 19.4.1 in Volume 2).

8.6.1 Pericardial tamponade and pericardiocentesis

In the rare instance of constrictive haemopericardium with cardiac tamponade due to a penetrating missile wound to the heart, pericardiocentesis may be required if there is acute decompensation, but only to *gain time* until emergency thoracotomy can be performed.

The procedure for pericardiocentesis is as follows.

1. A 20 ml syringe is attached to a long over-the-needle cannula (or alternatively a spinal anaesthesia needle).
2. The skin is punctured 1 – 2 cm to the left of the xiphisternal junction, at a 45° angle to the skin, and the needle advanced through fascia and muscle.
3. (The inner trocar is now removed if using a spinal needle – but not if using the needle of the cannula).
4. The needle is gently advanced while aiming at the tip of the left scapula and applying continuous suction on the syringe.
5. When the needle tip enters the pericardial sac, blood will immediately appear in the syringe. The needle is withdrawn if using a cannula, which is then advanced into the sac.
6. As much blood as possible is aspirated. If the tamponade has been relieved, the patient's condition improves immediately; if the right ventricle has been entered, there is no change.
7. At the end of aspiration, the synthetic over-the-needle cannula can be left in place with a 3-way stopcock valve. (The spinal needle is gently withdrawn, millimetre-by-millimetre, if this technique is being used).
8. Should the tamponade return quickly, the stopcock can be re-opened and aspiration repeated (or the spinal needle tap is repeated).
9. The patient is taken to theatre *immediately*!

An alternative to pericardiocentesis is a subxyphoid pericardial window (see Section 31.11 in Volume 2). An emergency room thoracotomy should not be performed when the operating theatre is just down the corridor: it is as pointless as it is dangerous in most hospitals around the world, especially in conditions of limited resources.

8.6.2 Haemorrhagic shock

A pneumatic tourniquet is only necessary in case of catastrophic arterial haemorrhage from a limb. Wound packing is an excellent alternative and especially useful in a very large soft tissue wound. Otherwise, direct pressure and elevation of the limb will stop most cases of peripheral venous and capillary haemorrhage. Fractures should be splinted. Central bleeding into a body cavity requires a surgical intervention.

The body's response and classes of shock

Immediately after haemorrhage, the body initiates a number of homeostatic circulatory changes that aim to stop the bleeding and to compensate and preserve perfusion of the vital organs. The circulating blood volume represents 7 – 8 % of body weight in the adult (5 – 5.6 litres in the 70-kg male or 70 ml/kg body weight) and 9 % in children (80 ml/kg body weight).

Haemorrhage and the shock response are traditionally graded into 4 classes according to the volume of acute blood loss.

Class I

Up to 15 % blood volume lost (750 ml or less). Mild tachycardia is the only clinical sign since the body's normal homeostatic mechanisms are capable of fully compensating the loss.

Class II

15 – 30 % blood volume lost (750 – 1,500 ml). Definite tachycardia, slight decrease in systolic blood pressure with rise of diastolic pressure (decreased pulse pressure), refilling of blanched capillary bed of fingers delayed, restlessness or anxiety.

Class III

30 – 40 % blood volume lost (1,500 – 2,000 ml). Marked tachycardia, tachypnoea, hypotension, low urine volume, classic picture of shock. Compensatory mechanisms start to fail.

Class IV

> 40 % blood volume lost (> 2,000 ml). Full classic symptoms of shock are present: cold, clammy and pale skin, irritability, aggressiveness and confusion followed by loss of consciousness if the patient loses more than 50 % circulating volume.

Class	I Up to 750 ml (<15 % loss)	II 750 – 1,500 ml (15 – 30 % loss)	III 1,500 – 2,000 ml (30 – 40 % loss)	IV >2,000 ml (>40 % loss)
Pulse	<100/min Full and bounding	100 – 120/min Full	120 –140/min Weak	>140/min Thready
Systolic blood pressure	120 Normal	90 – 120 Radial felt	< 90 Radial not felt	< 60 Carotid not felt
Pulse pressure	Normal	Narrowed	Greatly decreased	Absent
Capillary refill	Normal	Delayed	Delayed	Absent
Respiratory rate	14 – 20/min Normal	20 – 30/min Mild tachypnoea	>30/min Marked tachypnoea	>35/min Marked tachypnoea
Urine output	>30 ml/hr	20 – 30 ml/hr	5 – 20 ml/hr	Negligible
Mental function	Lucid/thirsty/ slightly anxious	Anxious/ frightened/ irritable	Hostile/irritable/ confused	Confused/lethargic/ unresponsive
Physiological status	Fully compensated	Peripheral vasoconstriction	Compensation fails, classic clinical picture	Immediately life-threatening

Table 8.2 Signs and symptoms of haemorrhagic shock according to class of blood loss.

8.6.3 Fluid replacement

The important point is to maintain adequate tissue perfusion until the haemorrhage is brought under control. Sufficient blood pressure to maintain this tissue perfusion is judged to be a systolic pressure of 90 mm Hg, equivalent to a palpable radial pulse.

The great majority of war-wounded patients are relatively healthy young adults who suffer injuries to the extremities, and in whom the amount of blood loss is not lethal. They are haemodynamically stable (Class I blood loss) and the usefulness of oral fluids for their resuscitation – in the field and in hospital – is probably underestimated. Head, thoracic and abdominal injuries, however, even with Class I blood loss, should always have an intravenous line placed.

In massive injury, with obviously gross blood loss, several wide-bore intravenous lines should be established, where central i.v. lines are not available. A venous cut-down may be required if shock is profound. Available sites include: median basilic or cephalic in the arm, greater saphenous in the groin, and the distal saphenous vein at the medial malleolus. A venous cut-down should be used for less than 24 hours, and replaced as soon as possible. If available, devices for interosseous fluid administration can be useful. The site of the wounds will influence where i.v. lines are placed. Fluid replacement should begin with an isotonic crystalloid solution.[2]

2 Ringer's lactate is the preferred resuscitation flued in ICRC practice.

8

Monitoring of clinical response

The estimation of blood loss is a very approximate measure. Rather than relying on this to guide resuscitation efforts, the doctor should observe the signs and symptoms of the *clinical response* to determine continuing fluid requirements. These include:

- pulse;
- systolic blood pressure;
- pulse pressure difference between systolic and diastolic;
- capillary refill;
- urine output;
- mental status.

The most important simple measure of the adequacy of fluid replacement is *urine output*. Once a catheter is placed and the bladder emptied, a urine flow of 0.5 ml/kg body weight/hour in adults (1 ml in children and 2 ml in neonates) – and even higher in case of crush syndrome – should be aimed for.

Rapid and stable response

The great majority of war-wounded patients suffer from limb injuries, with Class I or II shock. Simple crystalloids are sufficient for their resuscitation and the quantity (usually around 2 – 3 l) is determined by the clinical picture. The pulse falls below 100, the systolic blood pressure is above 100, and the pulse pressure widens. Urine output is good. These measurements remain stable. No further fluid resuscitation is required, but the i.v. line is maintained open.

Transient unstable response

An initial positive response to crystalloid fluid resuscitation of the pulse, blood pressure, and pulse pressure is followed by a return to subnormal values. Urine output remains low. Further administration of crystalloids, or a plasma expander such as dextran, should be limited. Continuing subnormal shock values indicate continuing blood loss; the patient should be prepared for emergency surgery. This situation occurs in some patients who have suffered internal injuries with Class II shock, and in those with Class III shock.

Please note:

Not more than two units of dextran should be given in any 24-hour period and it should be avoided completely if at all possible. Colloids are less effective than Ringer's lactate in diffusing into the interstitial space and can help provoke coagulation defects and interfere with cross-matching; they should not be used for resuscitation. Fresh frozen plasma or lyophilized (freeze-dried) plasma, if available, are excellent alternatives, even to Ringer's lactate.

No response

The patient remains in shock, indicating Class IV blood loss of more than 40 % blood volume, and requires emergency surgery – surgery as part of resuscitation – or is triaged to Category IV in a mass casualty situation (see Chapter 9);

or

other, less common pathologies that become manifest with time have been overlooked. The airway and breathing should be re-assessed to diagnose a possible cardiac tamponade, tension pneumothorax or myocardial injury. Neurogenic shock and acute gastric dilatation should not be overlooked.

Time since injury should also be taken into account to evaluate the evolution of the shock state. If Class IV shock is present less than 1 hour after injury, emergency operation is needed for resuscitation. If Class IV shock has developed in 4 hours or more, some degree of resuscitation is required before operation because blood loss has probably been compounded by a degree of dehydration and third-space fluid sequestration.

8.6.4 Hypotensive resuscitation and damage control approach

Unstable responders and non-responders represent 5% to 15% of war-wounded patients, depending on evacuation time; the longer the delay, the more natural and automatic triage comes into play (see Chapter 5). These patients have continuing haemorrhage; it has been demonstrated that simple fluid replacement only compounds the problem.

Giving all severely shocked patients a standard crystalloid fluid challenge of 2 litres or more in order to push the systolic pressure up to a "normal" figure of 120 mm Hg is no longer considered good practice for a number of reasons: rapid return to normal blood pressure *before* bleeding is controlled can be associated with hydraulic disruption of an effective blood clot ("popping the clot"), the clotting factors are diluted and lowering of blood viscosity decreases resistance to flow around an incomplete clot. All of these factors may cause bleeding that has temporarily stopped to start again, especially if it is a non-compressible central haemorrhage.

In addition, better understanding of the pathophysiology of traumatic shock, in particular the "fatal triad" of hypothermia, acidosis, and coagulopathy, has led to a "damage control" approach for these very severely injured patients. Post-traumatic coagulopathy and "shock lung" (acute respiratory distress syndrome) are now well-recognized dangers in patients who receive massive crystalloid infusions (see Chapter 18).

Moderate resuscitation is therefore to be preferred, limiting the use of crystalloids so as to raise the systolic blood pressure to only 90 mm Hg, until the radial pulse is felt, rather than to over 100. This is known as "hypotensive resuscitation" or "permissive hypotension" and should be considered in Class III and IV blood loss.

<u>Please note:</u>

Hypotensive resuscitation should not be used for patients who have sustained head trauma, where any hypotension and hypoxia are deleterious. However, such a consideration is of more significance with the polytrauma of severe blunt injury, such as occurs after a car crash: cerebral concussion, internal haemorrhage and several fractured bones. It is rare to encounter such varied polytrauma with projectile wounds. Only severe blast injury may create a similar polytrauma clinical picture. Likewise, hypotensive resuscitation should not be used for very young or old patients, or for pregnant women.

8

Hypotensive resuscitation and the limited administration of crystalloids are today part of a strategy of damage control resuscitation (DCR), of which the aims are to reduce the mechanical dislodging of formed and effective blood clot and prevent the lethal triad of hypothermia, acidosis and coagulopathy. The DCR protocol promotes the early use of blood for resuscitation, administration of tranexamic acid (see below) and measures to overcome hypothermia, before a shortened surgical operation of which the aims are to stop bleeding and contamination by the simplest and quickest methods possible. This is damage control surgery (see Chapter 18).

Using blood or blood components for resuscitation in the DCR approach, rather than crystalloids, can be very problematic in conditions of limited resources where blood is in short supply. It is here that hypotensive resuscitation is of greatest value. The surgeon must balance the infusion of crystalloids to maintain a systolic pressure of 80 – 90 mm Hg until such time as bleeding is brought under control, and only then administer what blood is available. This balancing act can prove very delicate. It is here that plasma, in some form, can be most beneficial.

Hypotensive resuscitation is widely used by ICRC surgeons today for patients who arrive quickly at a hospital. However, if evacuation is delayed (more than 6 – 12 hours), rebleeding is less likely. In addition, delayed evacuation will result in more profound shock because of plasma loss due to post-traumatic tissue oedema and general dehydration rather than pure blood loss. Excessive sweating, vomiting or diarrhoea, rough handling of the casualty during transport and not splinting fractured limbs will aggravate the total fluid and electrolyte loss. More aggressive resuscitation is allowed under these circumstances and the patient should be fully hydrated prior to surgery.

8.6.5 Adjuvant therapy

Never give cold fluids by rapid intravenous infusion.

No effort should be spared to prevent hypothermia in the shocked patient. Intravenous fluids should be warmed (see Section 8.9 and Chapter 18).

Oxygen and small doses of i.v. analgesia are equally important. The best is morphine (5 mg i.v., repeated every 10 minutes as necessary). Morphine should not be given if there is any question of head injury or respiratory depression. A good alternative in this case would be tramadol. Analgesia in shock should be given intravenously only.

Tranexamic acid (TXA), an inexpensive antifibrinolytic medication used in patients with haemophilia or in elective surgery to decrease blood loss, has proven to be useful in traumatic and post-partum haemorrhage. TXA prevents blood loss by stabilizing clots and preventing their early dissolution in the severely injured, who often demonstrate a state of hyperfibrinolysis. It decreases mortality in haemorrhaging patients, but only if given within the first three hours of onset of bleeding; the earlier, the better. Indeed, it may well increase mortality if administered after three hours. The loading dose is 1 g in 100 ml normal saline i.v. over ten minutes and then infusion of 1 g over eight hours.

A naso-gastric tube to empty the stomach and prevent gastric dilatation is essential, as is a catheter to monitor urine flow.

Steroids should *not* be administered in cases of haemorrhagic shock.

Some clinical experiments have taken place using hypertonic saline for resuscitation. ICRC surgical teams have no experience with this and cannot comment.

8.7 Blood transfusion where supplies are limited

Where blood supplies are scarce, what should the role of blood transfusion be? This scenario is a far cry from optimal conditions, in which there are relatively few limits to blood or component administration, but it is common.

The aim of blood transfusion is to save life or to prevent significant morbidity, and not to restore a normal haemoglobin level. Blood is a rare and expensive commodity with serious risks attached to its administration and should therefore be used with caution. The decision to give blood to a particular patient should be based primarily on the clinical state correlated with the laboratory findings, balanced against the risks and the shortage of supply. A better understanding of the physiology of oxygen transport, the shortage of donors and the increased risk of viral infections has led to a policy of accepting lower levels of haemoglobin than before, without overly detrimental effects to the patient. One should avoid a transfusion for reasons such as “accelerating the patient’s recovery”, increasing patient comfort, or providing a supplement to correct anaemia. (Certain medical conditions, such as small children with severe malaria are an exception to this last rule.)

ICRC policy is to screen donated blood for hepatitis B and C, HIV, syphilis, and – in non-endemic areas – malaria. In countries where malaria is endemic, it is not uncommon for trauma patients to have a malarial attack 2 to 3 days post-operatively even without a blood transfusion; this is treated when it occurs. Where donors are scarce, they are not excluded because of malaria. A blood transfusion can never be 100 % safe.

The ICRC seeks blood donors in the community. Family, friends and clan members are usually the source. In certain countries, the National Red Cross/Red Crescent Society plays an important role in the collection of blood.

Culture and tradition in some societies may render blood collection extremely difficult; consequently, blood for transfusion is often in very short supply. Accordingly, and in keeping with the principles of triage, ICRC practice is to limit the maximum number of units of blood per intervention. Historically, in certain contexts, this was 4 units per patient, and this figure was only exceeded in cases of anti-personnel landmine injury with traumatic amputation and severe burn patients undergoing skin grafting. (Early tangential debridement with immediate skin grafting is not practised by ICRC teams, partly because of the risk of major blood loss.) Any limitation in the number of units transfused must be context-specific and will depend on the cultural factors that determine the willingness of donors to donate.

ICRC practice has been to transfuse whole blood, as fresh as possible. Otherwise, whole blood is stored with CPD-A anticoagulant (citrate – phosphate – dextrose – adenine). Blood components are not available in ICRC surgical programmes or in many rural public hospitals. In practice, this has not been considered a handicap.

8.7.1 Clinical use of blood in ICRC practice

If blood is in very short supply, it should not be administered until bleeding has been controlled; one must rely on hypotensive resuscitation.

On table, if the patient remains haemodynamically unstable and the haemoglobin is less than 6 g/dl, blood is administered, while the surgeon performs damage control techniques (see Chapter 18). Haemoglobin less than 6 but in a stable patient is not an indication for transfusion. (However, there is a threshold haematocrit value of 5 – 10 %, below which continued crystalloids can provoke cardiac arrest by "washout anaemia".[3])

In the non-resuscitation scenario (preparing the patient for a second operation), pre-operative transfusions are not administered where blood supplies are low, unless the patient is anaemic *and* symptomatic.

The blood supply and stocks determine whether a particular patient will receive blood: the principles of triage apply.

Consider autotransfusion where appropriate (see Section 8.7.4 and Chapter 34 in Volume 2).

If massive transfusion of stored blood is necessary, every second unit should be supplemented with one ampoule of sodium bicarbonate (44.3 mEq) and calcium (10 to 20 ml of 10 % calcium gluconate or 2.5 ml of 10 % calcium chloride) by a separate i.v. line. As with crystalloid fluids, blood should be warmed to body temperature to avoid increasing hypothermia.

8.7.2 Two unit rule

It has been traditional practice to administer not less than 2 units of blood to any patient who requires transfusion. In the ICRC context, this rule is not always appropriate since extreme shortage of blood is so common. It is sometimes more appropriate to prescribe just one unit to certain symptomatic patients as this may improve their condition sufficiently, thus allowing supplies of this scarce resource to be kept for other patients in need. This is particularly true for patients in danger of "washout anaemia". World Health Organization (WHO) guidelines also accept one unit of blood in case of symptomatic anaemia.

3 Takaori M, Safar P. Treatment of massive hemorrhage with colloid and crystalloid solutions. *JAMA* 1967; **199**: 297 – 302. Cited in Barkana Y, Stein M, et al. Prehospital blood transfusion in prolonged evacuation. *J Trauma* 1999; **46**: 176 – 180 and Shoemaker WC, Peitzman AB, Bel-lamy R, et al. Resuscitation for severe hemorrhage. *Crit Care Med* 1996; **24 (2Suppl.)**: S12 – S23.

8.7.3 Fresh whole blood

This is best when screened and given within one hour of collection. Fresh whole blood is especially reserved for:
- massive haemorrhage;
- coagulopathy;
- septic shock;
- non-trauma pathologies:
- snake bite with haemolysis;
- amniotic fluid embolism.

8.7.4 Autotransfusion

When faced with inadequate blood supplies and patients suffering massive haemorrhage, ICRC surgical teams have practised recuperation of shed blood and autotransfusion. Haemothorax and haemoperitoneum from the spleen, liver or ruptured ectopic pregnancy are the most common indications.

For further information on autotransfusion in acute haemorrhage, see Chapter 34 in Volume 2.

8.7.5 Total blood requirements: the ICRC's experience[4]

ICRC colleagues studied total blood requirements for 4,770 patients in two hospitals treating the wounded from the war in Afghanistan during a six-month period in 1990–91. No differentiation was made for blood transfusion given pre-operatively, peri-operatively or immediately post-operatively: all were considered part of patient resuscitation given the difficulties and delay in obtaining blood. Guidelines at the time allocated a maximum of 6 units per patient (although this was exceeded in some cases) and a limiting haemoglobin level of 8 g/dl. Autotransfusion was not used in this series.

A comparison was made of the number of units transfused according to time since injury for all wounded patients and separately for those with central injuries (head, neck, chest, and abdomen), and according to the cause of injury.

Need for transfusion was greatest for patients arriving less than six hours after injury, steadily decreasing to those arriving after 72 hours. This was true for all patients. Surprisingly, patients with central injuries required less blood, on average, than those with peripheral wounds.

The most remarkable results were associated with the cause of injury. Blood requirement for anti-personnel landmine injuries far exceeded that for bullets or fragments, (Table 8.3) and was the main reason for the high blood use in peripheral injuries

	Mine	Fragment	Gunshot	Burn
Patients	787	2,577	1,016	111
Percentage transfused	27.9 %	13.1 %	15.0 %	18.0 %
Average transfusion units/ patient transfused	3.7	2.6	2.7	4.1
Average units/100 patients	103.2	34.1	40.5	73.8

Table 8.3 Blood given to patients related to cause of injury: 279 patients were categorized under "other" injuries.

Consequently, ICRC recommendations for a hospital undertaking total surgical care of the wounded from conventional warfare were amended as follows:
- For every 100 war-wounded patients, the blood bank should expect to provide 45 units as a baseline.
- Baseline should be increased to 60 units if the majority of patients are admitted within 6 hours of injury.

4 Eshaya-Chauvin B, Coupland RM. Transfusion requirements for the management of war injured: the experience of the International Committee of the Red Cross. *Br J Anaesth* 1992; **68**: 221 – 223.

- Baseline should be increased to 100 units if anti-personnel landmines are widely used in combat.
- Burn patients require greater transfusion capacity, even in the absence of early tangential excision with immediate grafting (not practised in ICRC hospitals).
- Long evacuation lines with much delay and no use of anti-personnel landmines in combat may negate the need for a blood bank, and blood for transfusion should be collected on an individual patient basis.

These recommendations may have little relevance to a modern industrialized army with very early evacuation and resuscitation but may be quite relevant in conditions of limited resources.

8.8 Disability

Any neurological deficit must be determined, whether central or peripheral. As mentioned previously, if the mechanism of injury is blunt trauma above the level of the clavicles then the cervical spine must be cared for in the usual manner.

According to the nursing expertise available, the AVPU system may be used or one may proceed immediately to the Glasgow Coma Scale (GCS) to determine the level of consciousness and identify any traumatic brain injury (Table 8.4). Although the GCS was originally intended for closed trauma to the head, and there are certain shortcomings when dealing with penetrating head trauma, it has been ICRC practice to use it.

	Criterion	Response	Score
Eye opening	Open before stimulus	Spontaneous	4
	After spoken request	To verbal command	3
	After fingertip stimulus	To pain	2
	No opening at any time	No response	1
	Closed by local factor	Non testable	NT
Verbal response	Correctly gives name, place, date	Orientated and conversing	5
	Not orientated but coherent	Disorientated	4
	Intelligible single words	Inappropriate words	3
	Only moans / groans	Incomprehensible sounds	2
	No audible response	No response	1
	Factor interfering with communication	Non testable	NT
Motor response	Obeys 2-part request	Obeys verbal command	6
	Brings hand above clavicle to stimulus on head	Localizes pain	5
	Bends arm at elbow rapidly and normally	Flexion-withdrawal	4
	Bends arm at elbow but abnormally	Flexion-abnormal	3
	Extends arm at elbow	Extension	2
	No movements	No response	1
	Paralysed or other limiting factor	Non testable	NT

Table 8.4 Glasgow Coma Scale: the best response for each variable is scored. Maximum score is 15, minimum is 3.[5]

A GCS < 8 indicates severe head injury and airway protection is mandatory, by intubation or cricothyroidotomy/tracheostomy.

Disability examination includes the entire vertebral column/spinal cord: presence of paraplegia, level, etc. Palpation of the vertebrae, one by one, for tenderness, induration and crepitus is more important than identifying deformity, which may be masked by haematoma. A rectal examination to determine sphincter tonus is important for prognosis!

5 For the latest version of the Glasgow Coma Scale guidelines, please see https://www.glasgowcomascale.org/

Proper stabilization measures should be undertaken and a urinary catheter placed. Neurogenic shock is common in patients with spinal cord injuries above T7: fluid resuscitation and an i.v. vasopressor are often required.

For the management of paraplegic patients, see Chapter 36 in Volume 2.

8.9 Environment/exposure

Hypothermia must be avoided at all costs – the patient should be examined rapidly but thoroughly – and treated aggressively. With a core body temperature of 37° C, an ambient temperature of 32 – 34° C is considered neutral. Less than this and the body loses heat to the environment. After examination, the patient should be kept covered, even in a tropical climate. Hypothermia (core temperature less than 35° C) is probably the most potent factor in causing the vicious cycle of the fatal triad syndrome: hypothermia, acidosis and coagulopathy (see Chapter 18).

Every effort should be made to preserve heat in an injured patient, since rewarming consumes far more energy than maintaining normothermia. Warm inhaled O2, warm i.v. fluids (achieved through the use of locally-made water baths or the body heat of staff members), and external rewarming to a maximum of 40 – 42° C should be the first step. More aggressive "central reheating" measures such as rectal enema and gastric, bladder and peritoneal lavage (at 37° C) can be used.

Fractures should be immobilized if this has not already been done in the field.

8.10 Complete examination

At this stage it is even more important than in the pre-hospital setting to undress the patient and perform a thorough examination, from head to toe, front and back and sides. In some societies, this may contravene certain cultural and religious traditions (male doctor examining a female patient). Compromises must be found.

In the more accommodating atmosphere of a hospital emergency room, a systematic approach should be used to thoroughly examine the scalp and head (mouth, nose, and ears), neck, thorax, abdomen, perineum (scrotum, urethra, rectum and vagina), the back of the trunk and buttocks, and the extremities. The peripheral pulses, temperature and capillary refill are compared on both sides. Motor function of the main peripheral nerves is tested. The aim is to have a complete assessment of all injuries and a more accurate assessment of the organ-specific damage.

The complete examination is best described as a thorough palpation. The entry wound may be exceedingly small and not seen. This is especially the case with fragment wounds to the head, axilla or perineum where body hair matted with blood can easily hide the wound (Figure 8.6). The entry wound must be identified by close palpation; it is better felt than seen. Remember also that contusion/erythema can be better felt than seen in dark-skinned people.

M. Baldan / ICRC

Figure 8.6

Small temporo-zygomatic entry wound hidden by hair.

One should attempt to identify the likely path of the projectile through the body. This may involve any structure between the entry and exit wounds. Every attempt should be made to establish the position of the projectile on an X-ray if no exit exists. Remember that wounds to the chest, buttock, thigh or perineum may involve the abdominal cavity (Figures 8.7.1 – 8.7.3). X-rays should include, at the least, one body region above and below the entry wound.

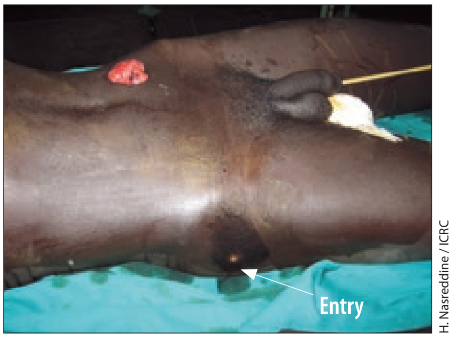


Figure 8.7.1

Bullet wound to the pelvis: the entry is located on the right side. A defunctioning colostomy has been performed.

Figure 8.7.2

Exit wound in the left buttock.

Figure 8.7.3

Any structure between entry and exit should be identified: here blood is seen in the rectum.

A simple outline drawing of the body on the admission chart (homunculus), front and back, is useful for recording all injuries.

Dressings on the limbs should not be removed if the casualty is haemodynamically unstable. Only once resuscitation has begun and the patient's condition is under control is it safe to examine wounds to the extremities, preferably in the operating theatre.

The ABCDE paradigm should be monitored for any change in the patient's condition. Resuscitation and stabilization are continued while complementary examinations are performed. The extent of the latter will depend on the level of sophistication and competency of the particular hospital.

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A basic complement is a plain X-ray, one body cavity above and below any entry or exit wound. If no exit wound exists and no projectile is evident, further radiographs should be taken to locate its position. It may be difficult to differentiate a radio-opaque bullet from a normal anatomic radio-opacity such as the heart shadow (see Chapter 10 and Figures 8.4.2 and 14.9.1).

The complete and definitive examination will cover each specialized body system. The signs, symptoms, and treatment will be described in the relevant chapters of Volume 2.

8.10.1 Complementary diagnostic examinations and monitoring

Electrocardiogram (ECG) monitoring is not routinely available in ICRC surgical hospitals, neither are computerized tomography (CT) scans, angiography, sonography, Doppler blood flow or arterial blood gases. The use of central venous pressure lines carries too high a risk of septicaemia in most circumstances where the ICRC works. Diagnostic peritoneal lavage for abdominal injury is not practised routinely – in any case, it is unnecessary in projectile injuries.

The minimum ICRC standards for emergency war surgery under precarious circumstances in hospital settings with limited resources include:

- plain X-ray;
- pulse oxymeter;
- haemoglobin;
- haematocrit;
- total and differential white blood cell count;

- platelet count;
- coagulation time;
- bleeding time;
- fasting blood sugar;
- blood smear for malaria (and for other blood parasites where applicable);
- sickle-cell test (where applicable);
- urine analysis: dipsticks, pregnancy tests;
- blood grouping, testing and cross-matching.

If more general surgery, internal medicine and paediatrics are widely practised in the ICRC hospital, more elaborate laboratory analyses are added. In more precarious situations, as experienced by field surgical teams, it is rare for any of the above to be available.

8

Chapter 9

HOSPITAL TRIAGE OF MASS CASUALTIES

9.1 Introduction

9.1.1 The logic of triage

In daily, routine practice surgeons face patients one by one. They use all of the means, equipment, and supplies at hand to do the most they can for every patient; they try to do everything they possibly can for every single individual. The priority is high-intensity care for the sickest.

In a single multiple-casualty incident means may be stretched to the limit, but one can still manage to do the best possible for all patients. With a massive influx of wounded, however, the hospital is overwhelmed; resources cannot meet the needs of all the casualties. This is when the logic of mass casualty triage comes into play. It is no longer possible to do everything for everyone. Medics must try to do what they can: the greatest good – but not necessarily everything – for the greatest number. This is another example of the change in professional "software" – the mindset – that is called for in surgery for the victims of war.

A change of mindset: from "everything for everyone" to "best for most".

The French term *triage*, which means to sort into groups according to quality, has been applied to the sorting of battle casualties since the time of Napoleon's surgeon of the Imperial Guard, Baron Dominique-Jean Larrey (circa 1812), who recognized the need to categorize wounded soldiers during an actual battle according to their priority for treatment.

The experience of two world wars during the twentieth century, when tens of thousands were wounded during a single battle, demonstrated the importance of sorting casualties and determining priorities for evacuation and treatment. This concept of triage has now been extended to natural disasters and single mass-casualty incidents (terrorist bombings, industrial accidents, fires in social institutions, etc.) with considerable benefit, and its use is now generally accepted worldwide.

Natural disaster triage, however, is not the same as war triage. An important natural disaster is a single mass-casualty event that overwhelms hospital services; the wounded suffer injuries at one time, but there is then a respite. The same can be said for other mass-casualty accidents. Armed conflict on the other hand can involve a continuing mass arrival of freshly wounded victims that may go on for weeks or months on end; there may be no respite until the end of hostilities. Nonetheless, many of the fundamental concepts underlying war triage apply to the disaster scenario.

Establishing priorities for treatment amongst many casualties is the most difficult decision to be taken in all of medical practice. Patients with very severe wounds whose management consumes many resources and much time, and who have little chance of survival despite treatment, may have to wait or may only receive minimal care in the interest of being able to intervene effectively for the others. One must often choose to treat first the patients for whom the smallest surgery gives the biggest results; i.e. the wounded who, though seriously injured, stand a fair chance of "good survival".

The aim in a mass casualty situation is to do the "best for most".

Some armies have practised "inverted" or "reverse" triage: the least injured were treated first so as to make them able to return more quickly to the battlefield! It should be noted that this practice contradicts the principles of international humanitarian law.

The practice of triage is not dogmatic. It is not a series of rules, but a logical approach and philosophy that must be adapted to each and every particular situation.

9.1.2 Where to perform triage

As mentioned in Chapter 1, one of the special characteristics of surgery in times of war is the staged management of patients in a chain of casualty care. The principles of triage are applied at every stage.

Triage takes place at every echelon of the chain of casualty care, including during evacuation.

The organization of a casualty collection point and effective triage permits the orderly evacuation of the wounded, the most efficient use of stretchers, ambulances or other transport, and the optimal use of the personnel available. With the necessary training, rapid assessment of casualties can be carried out not only by doctors, but also by nurses, paramedical staff and first-aid workers. It should be possible to implement triage at *any point* along the chain of casualty care, in order to set *priorities* for first aid and evacuation of the wounded to the next echelon of treatment.

More efficient lines of evacuation and shorter duration of transport, coupled with better pre-hospital care, ensure that a greater number of the severely injured will survive to reach a surgical hospital. The number of KIA decreases; however, the DOW rate often increases (see Chapter 5).

In many low-income countries, however, civilian casualties often arrive at the hospital without having received first aid and without the help of an ambulance service. In this case the less seriously injured usually arrive first. The hospital then becomes the first triage station.

Whatever the prior treatment or sorting, however, triage must be carried out again when casualties reach the hospital; the condition of patients changes and the priorities in the hospital may be different from those in the field. All patients arriving at the hospital during an influx of casualties go through the triage process.[1]

9.1.3 A delicate balance

To set priorities for patient management a number of factors must be taken into consideration to define the needs on the one hand, and the resources available on the other. The practice of triage is a fine balance between these two.

Triage is a dynamic equilibrium between needs and resources:

- needs = number of wounded and types of wounds;
- resources = facilities at hand and number of competent personnel available.

Needs

- How many patients are arriving? 10, 50 or 100?
- Are they all suffering from penetrating injuries? Or are there many burn cases amongst them?

The number of wounded and the different pathologies should be taken into account in the total workload. Penetrating wounds will require a great deal of surgery. Burn patients require relatively little immediate surgery, but a great deal of nursing care.

1 For field triage, see Giannou C, Bernes E. *First Aid in Armed Conflicts and Other Situations of Violence*. Geneva: ICRC; 2006.

Resources

- How many surgeons and anaesthetists?
- How many operating tables?
- How many instrument boxes, and what is the efficiency of the sterilization system?
- How many beds? etc.

A hospital may have three fully-equipped operating theatres, but if there is only one surgeon then only one patient can be operated at a time. If there are three surgeons and three anaesthetists, but only one theatre, then the team must improvise extra operating facilities, if there are sufficient boxes of surgical instruments.

ICRC EXPERIENCE

During fighting in Kabul in 1992 with an influx of mass casualties, four surgical teams worked in the ICRC hospital, supplemented by Afghan general practitioners with some surgical experience. There were two operating theatres in different buildings with 4 tables that could function at the same time. One team operated in one building and one in the other; the third team performed triage; and the fourth was resting!

All these factors – needs and resources – must be balanced out. No two triage situations are the same. It is this constantly changing equilibrium between needs and resources that will determine the priority for treatment among all the patients who reach the hospital. One cannot be dogmatic about which patient to operate first, since no two situations are the same. Only a full understanding of the logic and philosophy of triage will help to establish efficient priorities that will result in the best treatment possible for the greatest number of victims.

9.2 Setting priorities: the ICRC triage system

There are a number of triage category systems used throughout the world today. Some are more sophisticated than others and depend on injury severity scores and physiological parameters. There are two important factors to keep in mind when deciding upon a system to use in a hospital.

1. It should be kept as simple as possible – a mass influx of wounded always creates confusion, tension and anxiety.
2. All members of the hospital team should understand the system being used.

The ICRC uses a triage category system based upon several factors.

- Physiological appreciation of life-threatening conditions according to the ABCDE protocol – in practice, severe haemorrhage will constitute the great majority of life-threatening injuries during armed conflict (see Chapters 5 and 8).
- Anatomic factors, including the Red Cross Wound Score for penetrating injuries – in general, vital injuries (head, neck, thorax, abdomen and major peripheral vessels) will have priority, but the grade of injury must also be taken into consideration (see Chapter 4).
- Mechanism of injury – especially anti-personnel landmine injuries and burns (see Chapter 3).
- Time since injury – important for determining degree of shock and response to resuscitation as well as limb ischaemia (see Chapter 5).
- Epidemiology of the war-wounded – knowledge of the relative numbers of severe and superficial wounds (see Chapter 5).

9.2.1 The ICRC triage categories[2]

Category I: Serious wounds – resuscitation and immediate surgery

Patients who need lifesaving surgery and have a good chance of recovery. Some examples include:

- airway – injuries or burns to the face and neck requiring tracheostomy;
- breathing – tension pneumothorax, major haemothorax;
- circulation – internal haemorrhage, wounds to major peripheral blood vessels, traumatic amputation.

Category II: Second priority wounds – can wait for surgery

Patients who require surgery but not on an urgent basis. In practice this applies to many casualties, including:

- penetrating abdominal injury in haemodynamically stable patient, most probably injury to hollow organs only;
- penetrating head injuries with GCS > 8, providing definitive airway control can be maintained – if a surgical airway is necessary, then Category I for tracheostomy only;[3]
- most compound fractures: in practice, a large number of the wounded;
- major soft-tissue wounds: in practice, a large number of the wounded.

Category III: Superficial wounds – ambulatory management

Patients who do not require hospitalization and/or surgery because their wounds are so minor that they can be managed on an ambulatory basis.

They are often called the "walking-wounded". In practice, this is a very large group including those presenting superficial wounds managed under local anaesthesia in the emergency room or with simple first-aid measures.

Category IV: Severe wounds – supportive treatment

Patients with injuries so severe that they are unlikely to survive or would have a very poor quality of survival. These include the moribund, or patients with multiple major injuries whose management could be considered wasteful of scarce resources in a mass casualty situation in terms of operative time and blood. Examples include:

- penetrating head wound with GCS < 8;
- quadriplegia;
- burns > 50 % body surface area;
- major blood loss and no blood available.

2 The system of triage categories employed by the ICRC was revised by the Master Surgeons Workshop held in Geneva in 2002 (see Introduction).

3 Please note: ICRC hospitals are *not* equipped with ventilators and close monitoring of intubated patients is not always possible. A surgical airway avoids many problems, and should replace an endotracheal tube if the patient remains intubated for several days in any case.

9.2.2 Notes on triage categories

The number of casualties who require urgent treatment may exceed the surgical capacity available. A second triage within Category I is then necessary (see Section 9.3.2). On the other hand, when evacuation time to the hospital is longer than 12 hours, few patients may fall into Category I.

Many surgeons believe that all penetrating brain wounds are a Category I emergency; others believe that they are all hopeless Category IV. The use of the GCS helps to differentiate those patients who will probably survive, even with some delay in operation (Category II in the experience of ICRC surgical teams) from those whose condition is definitely a Category IV. This, evidently, provided the airway is patent.

The Category III superficially wounded may be so numerous, frightened, in pain and excited, that their uncontrolled presence in the emergency room/triage area creates great confusion. In urban contexts, they tend to be the very first evacuated to hospital, to the detriment of the more seriously wounded.

The categories are not rigid; patients waiting for surgery may change category and a single patient may fall into two categories, such as one with severe maxillo-facial injury who requires an immediate tracheostomy and basic haemostasis (Category I), while the debridement and primary reconstruction of the patient's face, which may take many hours, can wait (Category II).

Please note:

There is one exception to these categories: when an excited, and often drunk, combatant holds a gun to your head and demands that you treat his wounded comrade first. This patient immediately becomes top priority.

ICRC EXPERIENCE

Two examples of the epidemiology of triage patients recorded in recent years.

Fighting in Kisangani, Democratic Republic of the Congo, June 2000

Four hospitals and 62 clinics registered a total of 2,393 wounded. Only 25 % required hospital care, and even less a surgical operation. The vast majority were Category III and could have been treated as ambulatory cases; many were hospitalized for several days nonetheless.

Combat in Monrovia, Liberia, June – August 2003

2,567 patients were triaged in the JFK Memorial Hospital, but only 1,015 were deemed to require hospital admission (40 %), only 718 of whom (71 %) underwent operation. Of those admitted, some did not require any operation (paraplegia), while for many others there was simply not enough time or personnel available. Many patients who were originally placed in Category II – and given antibiotics, dressings and analgesia – eventually became Category III, with and without sequelae.

The equilibrium – between needs and resources – is a dynamic one; change is constant, no two triage situations are the same.

9.3 How to perform triage

Triage is a dynamic process: it requires a continuous reassessment of patients.

Patients may change triage category: their condition may deteriorate, or improve over time and with pre-operative resuscitation. As a result, a continuous reassessment of patients is absolutely necessary.

Triage is a multiple-step process: "sift and sort", then re-examine, re-examine, re-examine. "Sift" involves placing the patient in a general Category; "sort" then decides priority within that Category.

9.3.1 "Sift"

On reception of the casualties in the hospital, the triage officer must perform a rapid examination of each patient – a maximum of 30 seconds – checking the whole body, including the back. Field dressings should be changed by the nursing team as part of the examination; except for obviously large and severe wounds whose dressings are removed only in theatre. Severity of injury and probability of survival are the keys to decision-making. Clinical experience with the war-wounded – not training or reading books – is the most important preparation for this task.

To sift, the triage officer first looks for life-threatening conditions based on:
- airway, breathing, circulation;
- important physiological clues (mental status, character and rate of pulse, ease of respiration);
- anatomic site of wounds (head, chest, abdomen);
- severity of obvious wounds according to the RCWS (amputation of limb, etc.).

Based on clinical judgement alone, a first decision is made, to "sift" the casualty into a Category. The Category does *not* depend on how many patients arrive with serious wounds.

Every wounded patient must be examined *and* categorized *immediately*.

The idea is to quickly recognize the two extremes of injury, which, together, comprise a very large number of casualties: the very minor (Category III) and the very serious (Category IV); and to identify and separate out the dead. As little time as possible is spent on these Category III and IV patients and they must quickly be removed from the triage area to specially designated areas.

The triage officer concentrates on the critically and seriously injured (Categories I and II):
- patients who require resuscitation and immediate surgery as part of the resuscitation process;
- those who need continuing resuscitation; and
- patients who will tolerate some delay before receiving surgical attention.


Å. Molde / ICRC

Figure 9.1
Triage officer assisted by an administrative clerk.

The triage officer should not perform *treatment*, with one exception: if the patient is not breathing, the mouth should be opened and cleaned and the person put in the lateral recovery position, before the next patient is dealt with.

An "administrative team" consisting of a nurse and a clerk supports the triage officer for purposes of documentation, including all personal details of each patient, the securing of their identity papers and valuables, and the signing of any necessary consent forms. Other supporting personnel present at the entrance or in the triage area include those responsible for hospital security and crowd control.

Initial treatment is started by a dedicated team, and patients should be transferred as quickly as possible out of the triage area to theatre or the ward designated for their triage Category in order to make room for new arrivals. Resuscitation, as necessary, is continued in these assigned areas.

The use of X-rays should be *limited*; it is seldom essential under these circumstances and the triage officer should not wait for an X-ray to decide on the triage Category.

An identifying tabard or armband stating "triage officer" is useful; if, inevitably, the triage officer must move away from the triage area this can be handed over to the deputy/replacement.

9.3.2 "Sort"

After "sifting" casualties into the general Categories, a second examination is performed: "sorting". No two triage situations are equal and, therefore, according to the number of competent personnel available, the triage officer or a second physician-in-charge continues the reassessment of patients within the Category I cohort. "Sorting" decides which of the Category I patients to send to theatre first: *priority amongst the priorities*. The others, while waiting, remain under close observation and continued resuscitation.

This re-examination may reveal patients with an "emergent" condition who should receive priority over the stable: e.g. one of two Category I patients with penetrating abdominal wounds becomes haemodynamically unstable because of continuing internal haemorrhage, while the other has a stable pulse and blood pressure because bleeding has stopped.

The surgical teams should begin operating on Category I patients immediately. Since the number of casualties cannot be foreseen, it is not possible to wait for all patients to arrive and be triaged before deciding which should be taken to the operating theatre first.

> When in doubt about priority amongst Category I patients, put in chest tubes and send in a laparotomy; get going!

The triage officer must keep in close contact with the operating theatre, to reassess continuously the priorities of the operating list.

The time that patients are waiting for surgery can be profitably used for completing X-rays and laboratory analyses, if necessary, but should not interfere with resuscitation efforts.

The same logic applies to the patients in the other Categories. Either the triage officer or the person in charge of the department re-examines the patients in Category II. Priorities are set for the operating list among the Category II patients.

Reassessments may result in changing a patient's Category. The condition of a patient originally triaged into Category III because he had no *obviously* serious wound may suddenly deteriorate and become Category I or II. If a second-in-charge is continuing the reassessments, a system must be available to transfer patients from one Category area to another. Referring back to the triage officer for every decision will only result in overburdening him.

Usually the hardest part of triage is having to accept that some patients may only receive analgesics and be removed to a quiet place where they can die in comfort and with dignity. After treatment of priority patients has been completed, a repeat examination of Category IV patients, if still alive, may allow the triage officer to contemplate surgery for them at this stage.

9.3.3 Avoid undertriage and overtriage

In undertriage the assessment underestimates the severity of injury and the patient is not given sufficient priority. Overtriage overestimates the injury, and a patient is assigned to a higher Category than necessary. This will divert resources from the truly seriously injured and overburden the critical care services. Repeated re-examinations will correct these errors.

It may be necessary to transfer minimal care patients to other sites for convalescence, even outside the surgical hospital. If this is done, care should be taken to identify patients for follow-up treatment and administration of medication, and to exercise some control over their whereabouts. Documentation is important: patients can easily get lost.

9.3.4 Avoid confusion and disagreements within the team

Triage decisions must be respected.

There is no time or place for disagreements during a triage of mass casualties. The decisions of the triage officer must be "dictatorial". The post-triage evaluation session is the place for "democratic" discussion and constructive criticism.

In spite of training, practising and planning, the unexpected will happen. The hospital team – led by the team leader, triage officer, head nurse – will at times have to improvise and invent new protocols and procedures to meet new circumstances. One should not be dogmatic, but rather understand the philosophy and logic of the triage process, and adapt to new situations in accordance with that logic.

9.4 Triage documentation

Good records are essential and no effort should be spared to record important aspects of the wounds, treatment, and the patient's triage category.

Each casualty should be appropriately identified, numbered, and assigned a medical chart. Large plastic bags, labelled with the patient's number, are used for clothing; smaller labelled plastic bags are used to collect patients' valuables. They are stored separately and the valuables put in a safe place.

Some system must be devised for indicating the patient's triage Category. This could be colour-coded tags tied around a hand or foot, or hung around the neck. These are easily removed and changed should the patient's triage Category change. Writing an "indelible" number on the forehead or chest only creates confusion with a change in Category.

The patient's medical chart should include basic information and be in telegraphic style: clear, concise, yet complete. It should include *at least* the following information:
- name, age, sex, time of injury, cause of injury, any first aid given;
- time of admission to hospital;
- vital signs: BP, pulse, respiration rate, neurological status;
- diagnosis: using a diagram (homunculus) is very useful;
- triage Category;
- complete pre-operative orders.

See Annex 9. A: Sample triage card.

This basic information is particularly important if patients are being transferred to another facility. A list of admitted or treated patients is necessary so that people who come looking for their relatives or friends may be informed. The local authorities may require information about the number of admissions and deaths. The media must be dealt with. These issues are addressed by the triage team leader, or replacement.

ICRC EXPERIENCE

During the post-triage evaluation, it was decided to use a plastic sleeve to hold the triage cards in order to protect them from various body fluids.

ICRC

Figure 9.2
State of the admission card after triage.

9.5 Emergency plan for mass casualties: disaster triage plan

Any hospital treating the war-wounded must be prepared to receive large numbers of casualties. Preparation means planning and training.

9.5.1 Planning

The triage tent in Figure 9.3 shows a number of key points:
- there is enough space to move around;
- the small lightweight beds/stretchers that are easily moved and inexpensive;
- small carts for emergency medical supplies;
- i.v. fluids hanging on a rope strung across the room, for flexibility of patient placement;
- a patient carried on a stretcher by dedicated bearers;
- relatively few staff members present, getting on with their allotted tasks in what appears to be a calm atmosphere.

ICRC

Figure 9.3
Inside a triage tent.

This scene illustrates proper organization, which requires planning of the space, infrastructure, equipment, supplies and personnel.

Figure 9.4 shows the premises surrounding a triage tent:
- the site is temporary;
- space is available to receive ambulances or to expand the facilities;
- the structure is lightweight and easy to set up or take down;
- the structure is inexpensive;
- there is a water tower nearby;
- there is a rubbish bin outside.

ICRC

Figure 9.4
Outside a triage tent.

This scene illustrates proper organization, which involves planning of the space and infrastructure.

A triage system cannot be organized ad hoc: it requires planning and training.

The hospital team must be prepared for any kind of crisis: every hospital should have a disaster/triage plan (see Annex 9. B: Hospital emergency plan for mass influx of wounded). The aim of the plan is to organize:
- personnel;
- space;
- equipment;
- supplies (medical and non-medical);
- infrastructure (water, fuel for electricity generators, etc.);

- services (laundry, kitchen and cafeteria, etc.);
- training of the hospital team;
- communications;
- security.

9.5.2 The team

The hospital team should hold a series of meetings, to discuss the organization of the disaster/triage plan. Everyone working in the hospital should be aware of the plan and their respective role during a crisis. The plan should be posted so that everyone is well acquainted with it.

The plan should be put into operation as soon as notice is given of the expected arrival of mass casualties. It should include the mechanism for deciding who declares the emergency and under what conditions to implement the plan. The ordinary operating list and other routine activities should be suspended until the situation is resolved. This kind of organization does not require money or special technology; only time, effort, discipline and motivation. Any disaster plan should be an extension of the normal hospital routines, and the roles allocated to individual staff remain as close as possible to their familiar daily work. The plan should not be a complete change in the system. Introducing many new procedures will only add to the confusion.

A simple emergency plan: personnel, space, infrastructure, equipment, supplies = system.

9.6 Personnel

There are three key leadership functions in a disaster triage scenario: triage team leader, triage officer, head nurse.

9.6.1 Triage team leader

The triage team leader is the coordinator. He is usually designated to announce the onset of the hospital triage plan; he then coordinates the work of the different units and services, and makes sure that all departments are informed. The triage team leader maintains an overview of the situation, including a constant reassessment to determine the need for additional staff, supplies, and ward areas. In addition, he must be aware of events outside the hospital, maintaining contact with relevant authorities in order to anticipate any new arrival of casualties due to continuing combat.

9.6.2 Triage officer

The triage officer performs the actual clinical triage, assigning a category to each and every patient on entry. There has been much discussion about who should perform triage: surgeon or anaesthetist? Again, there is no strict rule. Each hospital team must decide according to its circumstances.

The logic of triage demands that the most experienced and respected person willing and able to take on the responsibility should do so. This person must know how to organize the emergency room/triage area and have a good understanding of the functioning and capacity of the hospital.

Even more importantly, the hospital team must be able to live with the decisions taken by the triage officer. Staff members, relatives, and military commanders might try to influence the triage decisions; nevertheless, these should be made on purely medical grounds. This can be especially difficult in a public hospital where friends and family members of the hospital staff may be among the victims. Deciding priority of treatment solely on the basis of medical need and resources available when the injured include close relatives of the personnel may be a heart-wrenching decision.

The hospital staff must be able to continue their work and live with the triage decisions for the rest of their lives. As a consequence, the experience of the triage officer and the respect with which the personnel hold the triage officer must be beyond reproach.

Triage Officer

No task in medicine requires greater understanding, skill, and judgement than the categorization of casualties and the establishment of priorities for treatment.

9.6.3 Head nurse

The head nurse organizes the nursing and paramedical personnel (laboratory, pharmacy, etc.) and non-medical support staff (trolley orderlies/stretcher-bearers, kitchen, laundry, cleaning, etc.). This is largely a coordination function. Any clinical role or supervision by the head nurse will depend on the particular circumstances of the hospital involved.

9.6.4 The team

Whether one person fills more than one leadership function will depend on the availability of competent personnel. The triage team leader may be the same as the triage officer in a small hospital; in a larger facility, this coordination function is probably best assigned to someone else, for instance an administrative officer or the head nurse. In a very large hospital, three different people should assume the three functions.

ICRC EXPERIENCE

What is the reality in the field?

In many small rural hospitals, the only surgeon is also the director. This one person often becomes the triage team leader and triage officer. After performing triage, the surgeon and the only anaesthesia nurse go to the operating theatre. A new influx of casualties arrives. Who then performs triage? Who continues the necessary coordination tasks? Either a general practitioner or the head nurse. This should be decided upon beforehand and be part of the hospital's disaster plan.

The ICRC supports the Somali Red Crescent Society in running the Keysaney Hospital in north Mogadishu, where triage has been routinely practised from 1992 until the time of writing. The triage officer in the emergency room is an experienced female nurse, "because she is the only one who can organize things".

9.6.5 Triage groups/nursing teams

Such teams should be formed for the triage area, with responsibility for the following tasks.

1. Setting up intravenous lines and taking blood for grouping and cross-matching.
2. Administration of tetanus prophylaxis, antibiotics, analgesics and other medication as prescribed.
3. Dressing wounds and splinting fractures.
4. Bladder catheterization, if indicated.
5. Arranging for an orderly flow of categorized casualties to the operating theatre or to designated areas for continuing resuscitation, delayed, or minimal treatment.

The disaster plan may be nominative, designating by name the triage officer and triage groups: who is in charge of setting up i.v. lines, dressing wounds, giving analgesics and antibiotics, etc. (Figure 9.5); *or* it may designate the function (ER doctor 1, ER nurse 3) regardless of who is on the roster that day. This depends on the staffing system, and availability of personnel, of the particular hospital.

9


GENERAL DISASTER PLAN OF ADI-UGRI HOSPITAL

ORGANISATION OF DISASTER TEAMS

I. TRIAGE (screening) TEAM:

III. CONTROL (COORDINATING) TEAM:

M. Ghebrehiwet / MoPH Eritrea

Figure 9.5

Example of a nominative disaster/triage plan in a small rural hospital.

9.6.6 Surgeons and theatre personnel

These members of staff should have prepared the operating theatre and be ready and waiting for the casualties. The surgeon in theatre will see patients he or she has not previously examined and who may not have a known name or signed consent form. Outside the mass casualty situation this would be regarded as negligent practice, and so another "mental adjustment" is required.

9.6.7 Rest and relief

Early consideration should be given to the *rest and relief* of staff. Triage is not an everyday routine activity. The shift system may need to be changed in order to deal with the increased workload: 2 twelve-hour shifts instead of 3 eight-hour ones, for example.

During a crisis the hospital team will be under severe emotional and physical stress. All staff members will need to pace themselves in order to perform efficiently and maintain a professional attitude. As mentioned before, during armed conflict there may be a mass arrival of new casualties every day for weeks on end. It is not possible to foresee how long the influx will last.

ICRC EXPERIENCE

At the beginning of the fighting in Monrovia in 2003, the surgical team worked 48 hours non-stop, without sleep: they were not able to continue operating. Subsequently, a strict 18-hour operating schedule was instituted: the team was able to maintain this schedule for three months.

A triage situation is tiring for everyone. Some, out of a misplaced sense of professional duty, find it difficult to accept that they *need* to rest; rest must be insisted upon. Working for extended periods without sleep only results in hospital staff no longer being able to adequately treat the new patients who continue to arrive.

9.7 Space

During an influx of mass casualties the various hospital departments must be re-arranged according to the pre-decided plan. Besides the original hospital site, any alternative sites (building, underground shelter, etc.) must be included in the plan, should the hospital require evacuation for reasons of security. The equivalent in cases of natural disaster is the destruction of the hospital premises and/or its access routes (earthquake, landslide, tsunami, etc.).

R. Aburabi / ICRC

Figure 9.6.1
Alternative triage department in an unused building: empty.

R. Aburabi / ICRC

Figure 9.6.2
The same premises: full.

The usual emergency reception/admissions room may not be large enough to accommodate a large influx of wounded. A large and extendable area capable of serving as a triage department should be pre-selected. The area should be cleared of all inpatients, and be large enough to permit easy movement of casualties and medical personnel.

In certain contexts, for religious and cultural reasons, it may be necessary to have separate male and female areas for incoming mass casualties. This must be taken into account during planning.

Once triaged, patients should be transferred out of the triage department to the operating theatre or designated wards.

Different units or wards should be identified for the different triage categories. Category I patients, requiring resuscitation and immediate surgery, might be put in a pre-operative intensive care unit near the operating theatre while waiting for an operating table to free up. Resuscitation with i.v. fluids can continue here under close supervision. The Category II cohort of patients who require surgery but not on an urgent basis can be grouped in a special ward where they can receive treatment (antibiotics, analgesics, i.v. fluids, dressings) under observation while awaiting surgery.

Category III patients suffering superficial wounds could be sent to the outpatient department or an area for convalescence outside the surgical hospital. This group is composed of many patients who are lucid, frightened (because of the shooting and shelling), panicky, and often in pain. Organization and basic staffing of this space are important in order to identify and isolate such patients, give them rapid treatment, and then discharge them.

Finally, a quiet, secluded room should be made available for Category IV patients with very severe wounds who should be left to die peacefully with dignity. An i.v. line should be put up and analgesics given if appropriate.

Some provisions should be made for the well-regulated visit of friends and relatives to all seriously-injured patients. This comes under the necessary security measures to be implemented (see Section 9.13).

9.8 Equipment and supplies

A large number of stretchers or trolleys are needed at the hospital entrance during triage, to accommodate the casualties left by incoming ambulances. Blankets and sheets are required in the triage area, as are lines on which to hang infusions. Complete sets of supplies for triage should be prepared and stored in boxes or trunks which can easily be carried to the triage area from an accessible storage space.

Triage boxes should include:
- disposable latex or plastic gloves;
- venepuncture equipment;
- i.v. fluids;
- dressings, bandages, scissors;
- catheters, naso-gastric tubes, etc.;
- drugs which are likely to be needed.

Needless to say, these triage boxes should be inspected regularly for the expiration date of their components. The drugs will probably need to be stored separately. Stocks should include the appropriate antibiotics and analgesics, as well as tetanus toxoid and anti-tetanus serum.

A reasonable stock of items that will be required for the management of extra cases in the wards should be maintained. There should be adequate numbers of bed blocks for elevation of the foot of the bed, supplies of i.v. bottle holders, and supplies of dressings, plaster of Paris, splints and traction apparatus.

Again, depending on the particular circumstances of the hospital, the pharmacy may hold designated emergency triage stocks or not. The re-supply of the hospital may be disrupted because combat has interrupted the ordinary lines of supply.

Standard documentation charts and patient folders, *each with a unique number*, should be prepared and maintained in readiness. Each folder should include a triage/admission form, a fluid balance chart, and laboratory and X-ray request forms.

9.9 Infrastructure

Plans must be made to ensure adequate supplies of water, sufficient electricity, proper sanitation, and the disposal of waste. This may include special reserves of fuel for electric generators. Spare parts are also important to keep in stock; things tend to break down in the middle of an emergency situation.

The designation of roles, responsibilities and tasks is not limited to the medical personnel. Technicians and maintenance workers to run the generators and ensure the water supply must be put on a special shift system so as to be available at all times.

9.10 Services

Hospital personnel, patients and their relatives, and volunteers must all eat. Hospital linen must be washed and theatre linen re-sterilized. The kitchen, cafeteria and laundry staff and facilities must all be included in the disaster plan. Relatives are a great nuisance in the triage area but their energies can be harnessed for the general good. They may be directed to give blood and engaged as volunteer stretcher-bearers, carriers of water, cleaners and kitchen staff, etc.

9.11 Training

The hospital team should regularly practise different triage scenarios, on its own and as part of any national disaster or conflict-preparedness plan. Volunteers from the National Red Cross or Red Crescent Society, and their first aiders, may be mobilized to work in the hospital and/or play the role of the injured.

Clinical protocols and guidelines for triage and patient management must be standardized and understood by all doctors and nurses. This helps to avoid confusion and disagreements under tense and tiring circumstances.

After every triage incident and when feasible, a general meeting of the staff should be held to discuss what went well and what went wrong. This evaluation permits the fine-tuning of the triage plan, to improve it for the next mass influx.

Some individuals or even the whole team may have found the experience very stressful. An open, frank discussion about what happened and why certain decisions were made can be very beneficial, and even therapeutic.

9.12 Communication

If the hospital is part of an integrated health system, then a means of coordination and communication with other health facilities may make it possible to transfer the wounded from the overwhelmed hospital to another which has received comparatively few patients. Alternatively, other health facilities may be able to provide help in the form of additional personnel.

The plan should include the means to contact staff who are off duty, bearing in mind that if combat is occurring in the area, hospital personnel may have difficulty in getting to work. Mobile telephone systems tend to stop functioning (or are stopped by certain authorities) during urban fighting or troubles.

In an age of immediate mass communication contact with the media is inevitable, and what is happening in the hospital can be easily exploited for political purposes. The patients, hospital and staff are all protected under IHL. Obviously, military and governmental civilian hospitals are not "politically" neutral and cannot be expected to be. However, hospital personnel must act and speak publicly in accordance with their "medical" neutrality and impartiality. An "official spokesperson" for the hospital should be duly selected.

9.13 Security

Last, but certainly not least, is the safety and security of the hospital premises, patients and staff. When armed conflict results in mass casualties every wounded person transported to the hospital is accompanied, as a general rule, by two to four friends, relatives, comrades-in-arms, or bystanders who have helped in the evacuation or transport. Curious onlookers may try to enter the hospital as well. The civilian population may be in a state of panic and consider the hospital a safe place. This well-known phenomenon is called the "convergence reaction". People's fear and excitement add to the confusion and danger, especially if many in the crowd happen to be armed. Limiting the number of people entering the hospital reduces the confusion considerably.

One major factor that creates the convergence reaction and confusion is the lack of proper pre-hospital triage, as is often seen in an urban context. A paradoxical sequence of admissions often occurs as the first large group of patients reaching the nearest hospital is the lightly injured, who are lucid and afraid, see blood on their body, and are in pain. They shout to call attention to themselves and the nearest available vehicle – private car or taxi – is commandeered to take them to the closest hospital. They may represent up to 75 % of the casualty volume and, if not identified and diverted to an area of the hospital other than the ER, they will inundate it, preventing more seriously injured patients from getting priority care.

The ambulance services often take some time to reach the scene. The most seriously injured require time to be extracted and evacuated and, since they are too weak to call out, do not always receive priority attention; they arrive at hospital as a second wave. Curiously, dead and badly mutilated bodies are often evacuated before patients who are seriously injured but salvageable.

Security must be ensured by having guards posted at the gate of the hospital. Only wounded persons, possibly accompanied by a close relative according to local cultural traditions, should be allowed to enter. All weapons must be left outside the gate.

Access to the triage area should be blocked off, and a guard posted here as well to keep other patients and onlookers from mingling with new casualties.

The large numbers of relatives and friends who inevitably rush to the hospital must be prevented from crowding the premises and impeding the work of the medical staff. A system for well-regulated visits by patients' friends and relatives must be set up to reduce the possibility of "friction" occurring. Under certain circumstances, board and lodging close to the hospital compound must also be organized and provided.

Whether the guards are armed or not will depend on the circumstances of the country concerned. IHL does not prohibit armed guards if their purpose is to maintain order and protect patients and personnel.

In extreme circumstances, the hospital can organize a "security lock"[4] at the hospital or triage area entrance. This forced channel allows for better crowd control, especially of armed men.

R. Aburabi / ICRC

Figure 9.7.1

Monrovia "triage tent" in front of the hospital.

R. Aburabi / ICRC

Figure 9.7.2

"Triage tent" seen from the outside.

R. Aburabi / ICRC

Figure 9.7.3

Volunteers inside "triage tent" before the action.

R. Aburabi / ICRC

Figure 9.7.4

Volunteers after the action.

4 A lock is a short section of a canal with gates at each end which can be opened or closed to change the water level, used for raising and lowering boats going through the canal. This permits control of the movement between areas at different water levels. By analogy, a security lock permits the control of people's movements between different hospital areas.

ICRC EXPERIENCE

The ICRC hospital in Kabul, Afghanistan, used commercial, steel containers with doors cut into the ends at the hospital entrance in 1992 to create a "tunnel" that allowed the filtering of all who entered. The width of the door was calculated to allow for the passage of a carried stretcher only.

The ICRC – Somali Red Crescent Hospital in Mogadishu, Somalia, in 1992 was located in a converted prison. A first set of guarded gates led to a triage area with a large tent. A second set of gates separated the triage tent from the hospital compound itself, permitting controlled entry to the hospital.

The ICRC hospital team working in the JFK Memorial Hospital in Monrovia, Liberia, in 2003 set up a so-called "triage tent" just outside the fence and gate entrance to the hospital. No medical triage was actually performed there, it was more of a "disarmament tent". The tent provided a space for disarming any combatants, stripping the wounded of their soiled clothing, weapons and ammunition, and performing basic first aid. The wounded were then carried into the triage department – unarmed – on stretchers where the clinical triage was performed.

9.14 Summary of triage theory and philosophy: sorting by priority

The triage process has three components.

1. Clinical assessment to determine which patients take priority for the limited surgical time and resources available.
2. The organization and management involved in admitting large numbers of wounded to the hospital.
3. Re-assessment of the functioning of triage and its adaptation to the number of incoming wounded.

9.14.1 Triage system: a simple emergency plan organizing the personnel, space, infrastructure, equipment, and supplies

The sudden arrival of large numbers of casualties may occur at any time. Prior planning and training prevents poor performance. Unless a plan exists for the reception and triage of mass casualties, chaos will result. Hospital staff should be prepared, however, to improvise when faced with a new evolving situation.

Evaluation of hospital capacity is essential in emergency planning.

An emergency plan does not cost money; organization does not cost money. They cost time, effort, discipline and motivation.

9.14.2 Emergency hospital disaster triage plans differ and no two triage scenarios are the same

Hospital teams must regularly practise receiving a mass influx of wounded, resulting from armed conflict or natural disaster. Simulation exercises should be organized covering a variety of scenarios, and adapted to the particular circumstances of the hospital involved.

9.14.3 "Best for most" policy

Priority patients are those with a fair chance of "good survival" with the least amount of surgical work.

> Triage is essential to put some order into a chaotic situation.

However good the disaster plan and extensive the training, a mass influx of casualties is *always* stressful and attended by confusion. Flexibility and adaptability of the hospital team are important. Triage is not a series of rules. It has a logic and philosophy that must be adapted to each particular situation. Triage is not a simple science; it is an art.

<u>Please note</u>:

Further practical information on the organization of hospital management in a triage situation is available in the ICRC manual *Hospitals for War-Wounded: A Practical Guide for Setting up and Running a Surgical Hospital in an Area of Armed Conflict* (see Selected bibliography).

In a military context, all standard war surgery manuals written by and for armed forces deal with the organization and implementation of triage under military constraints.

9

ANNEX 9. A Sample triage card

Triage Card No: ______________

Name: ____

Coming from: ______________________________________ Male / Female / Age ______________________________________

Date: ____ Time: ____

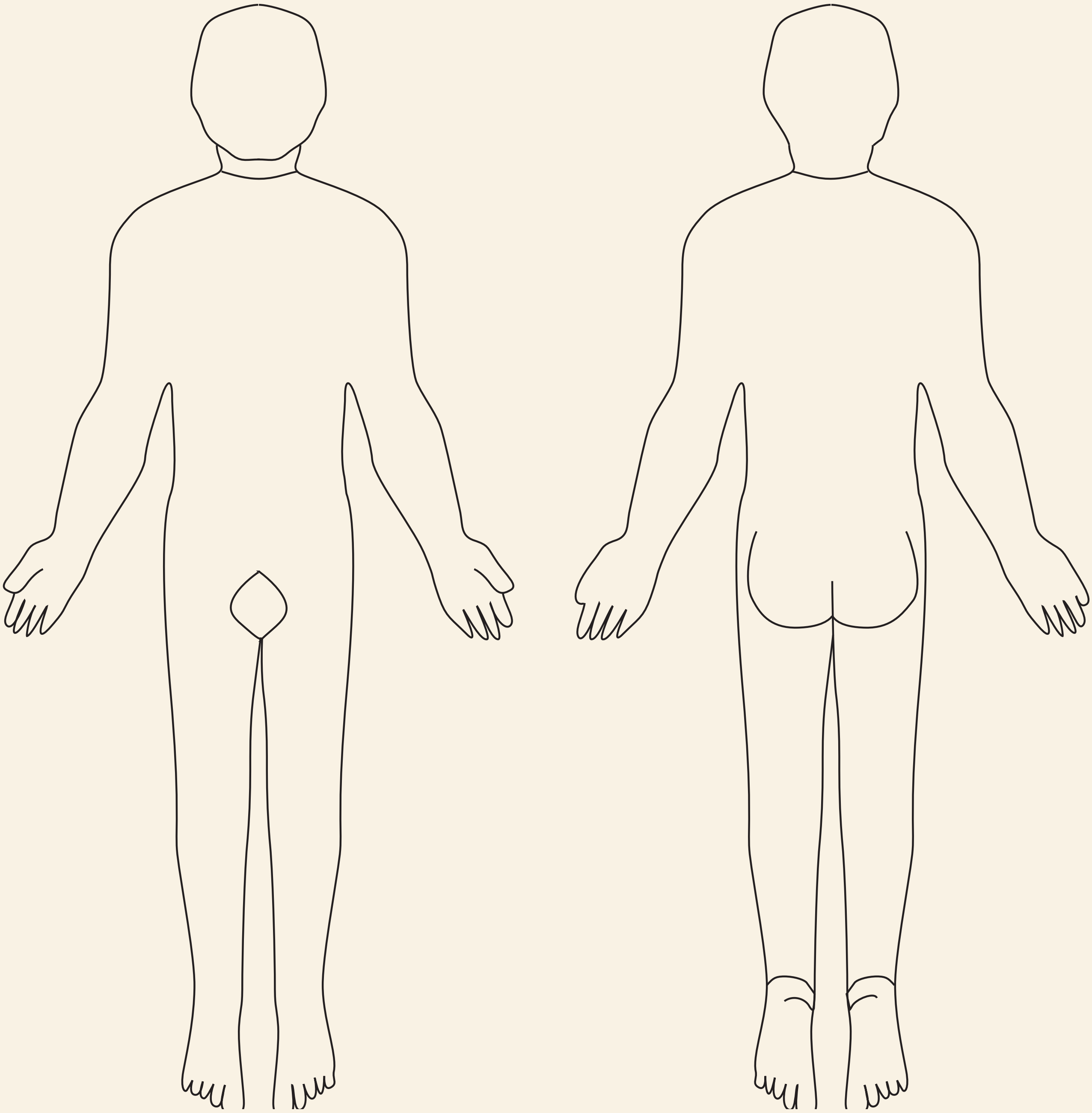
GSW: ☐ Mine: ☐ Fragment: ☐ Blast: ☐ Burn: ☐ Other: ______________________________

Time since injury: __________________________________

General condition:

Pulse: __________________ BP: ________________________ Resp. rate: ___________ Consciousness: _________________

Wound assessment:



Triage Category:

I	II	III	IV

ANNEX 9. B Hospital emergency plan for a mass influx of wounded

HOSPITAL EMERGENCY PLAN FOR A MASS INFLUX OF WOUNDED										
PHASE	Influx of wounded (number of patients)	Secrity + Porters/ stretcher - bearers	TTL / TO / HN	Triage Area (ER + OPD + Physio room)	OT	Wards	Administration	Laboratory X-ray	Kitchen Laundry Tailor	Transport
1	**1 – 10**	Routine	HN informed OT informed	Routine	Stop routine Inform wards	Routine No more elective patients sent to OT	Routine	Routine	Routine	Routine
2	**11 – 20**	Extra guards at patients' entrance	TTL informed TO: INITIATE TRIAGE HN: Inform wards, OT, administration	Request triage material and staff	Keep staff on duty Check supplies	Update bed situation Inform HN/TTL	"	"	"	Standby ambulance
3	**21 – 30**	Visitors leave Visiting hours suspended	Call in on-call nurses Ensure that all staff have breaks	Call in extra staff Physio staff on standby to help in triage or in wards	Extra surgical team and staff standby	"	Keep pharmacy staff on duty	"	Prepare food and drinks for OT staff if needed	"
4	**31 – 40**	"	HN: Reassess bed situation TTL/:Monitor OT situation	"	"	Assess need for additional staff Inform HN	Keep purchaser and storekeeper on duty	Call in extra staff if needed	Laundry: prior-ity is OT linen	Standby bus for staff transport
5	**41 – 50**	Call in extra porters/ stretcher-bearers	TTL/HN: REASSESS Define needs for staff, beds, supplies	"	Check supplies Open reserve linen stocks	"	Monitor needs for staff	"	Open emergency food stocks	"
6	**> 50**	"	REVIEW AGAIN	"	"	"	Provide resting area and sleep accommoda-tion for staff on duty	"	Provide food and drinks for all staff on request if needed	"

ER: emergency reception room

HN: Head Nurse

OPD: outpatient department

OT: operating theatre + sterilization

TO: Triage officer

TTL: Triage Team Leader

Chapter 10

SURGICAL MANAGEMENT OF WAR WOUNDS

10.1 Introduction

There are many factors that determine the final outcome of the management of war-wounded patients:
- the actual injury – the clinical significance of the wound is a function of the severity of tissue damage and the anatomic structures involved i.e. size and site;
- the general condition of the patient – nutritional status, dehydration, concomitant diseases, host resistance, etc. ;
- pre-hospital care: protection, shelter, first aid, triage, evacuation time;
- resuscitation, especially in the presence of haemorrhagic shock;
- hospital triage;
- surgery;
- post-operative nursing care;
- physiotherapy and rehabilitation.

However, the single most important act that the surgeon performs for the great majority of casualties is wound excision or debridement.[1]

The basic principles of trauma wound management have been known for a considerable period of time. Ibn Sinna commented on this (Figure 10.1), as did Alexander Fleming one thousand years later.

Å. Molde / ICRC

Figure 10.1
"Damaged tissues must be removed in time."
Ibn Sinna, *Qanun fi al-Tib*.[2]

> "The severity of these [war] wound infections is merely the result of the very extensive destruction of the tissues by the projectile, thus furnishing an admirable culture medium for the bacteria out of reach of the natural protective forces of the body, and if it were possible for the surgeon to remove completely this dead tissue I am quite sure the infections would sink into insignificance."
>
> Alexander Fleming[3]

K. Barrand / ICRC

Figure 10.2.1
Wound sutured primarily to "close the hole", without debridement.

K. Barrand / ICRC

Figure 10.2.2
Sutures removed: pus pours out.

Often, ICRC health personnel have witnessed inexperienced medical staff in a low-income country dealing with severely war-wounded patients for the first time. Their initial reaction is to try to stop the bleeding by "closing the holes". If suture material is available, they stitch the wounds shut without excising dead tissue; if not, they plug the wounds with gauze compresses. Soon, infection develops. This is treated by a frequent change of dressing and antibiotic anarchy, wasting already insufficient hospital supplies. The end of the story may be a slow recovery with a major disability, or, more frequently, major complications often leading to the death of the patient accompanied by a deep sense of frustration among the medical staff.

The basic management of war wounds is an art based on sound scientific principles. A good knowledge of wound ballistics helps the surgeon assess more accurately the extent of tissue damage and of the necessary surgery; it will not explain every wound or prescribe specific treatment for every patient. In only a few cases will knowledge of the specific causative weapon be of any clinical use.

Wound ballistics teaches us that the formation of a cavity by a projectile conveys pathogenic organisms, pieces of dirty skin and clothing and dust into the depths of the wound. Anti-personnel blast mines drive pieces of the shoe or bones of the foot,

1 "*Débridement*" is a French term originally used to mean the removal of a constriction, or to unbridle, and thus to promote drainage and relieve tension by incision. The English word "excision" means to cut away or cut out. A confusion of terminology occurred at the Inter-Allied Surgical Conference for the Study of War Wounds held in Paris in 1917, and the historic French expression came to mean a wound excision – the removal of dead tissue – for English-speaking surgeons.
A further misunderstanding may be caused by the fact that excision, when used with reference to cancer surgery, tends to mean "*excision en bloc*" with a wide margin of healthy, surrounding tissue. In this book, the expressions "excision" and "debridement" are used interchangeably and are understood to mean the cutting away of dead or devitalized tissue.

2 Ibn Sinna – Avicenna (980 – 1036 CE), Persian physician and philosopher, author of *Qanun fi al-Tib* (The Laws of Medicine).

3 Alexander Fleming (1881 – 1955), British physician, discoverer of penicillin.
Fleming A. On the bacteriology of septic wounds. *Lancet* 1915; **186**: 638 – 643.

gravel, soil, leaves and grass, and pieces of the weapon into the proximal tissues. Although the wounds are contaminated, infection does not set in for the first 6 – 8 hours. Ideally, therefore, war wounds should be debrided within six hours; this is not often the case.


ICRC

Figure 10.3

Anti-personnel landmine injury: war wounds are dirty and contaminated.

Old lessons for new surgeons

War wounds are dirty and contaminated, from the moment of injury.

Whatever the weapon, a thorough examination of the patient and the wound(s) is essential.

Examine the patient:
- initial examination and resuscitation;
- complete examination to identify all open wounds and any closed injuries.

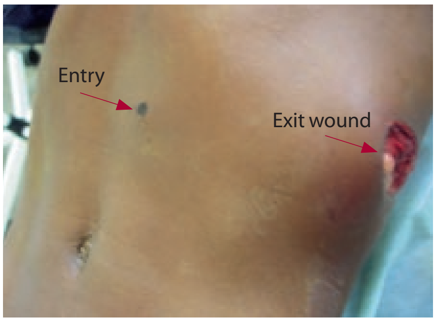
Examine the wounds and damaged organs:
- to operate or not to operate;
- to establish priorities if more than one surgical procedure is required;
- to plan the operation.

Please note:

The treatment of mismanaged and neglected wounds is dealt with in Chapter 12.

10.2 Complete examination

All wounds involve soft tissues, and many of them will be complicated by damage to other structures. *War wounds are often multiple* and the *pathology often multiple*: a bomb explosion can simultaneously cause primary blast injury, penetrating metallic fragments, blunt trauma and burns. Close and complete examination of the patient is important to determine the site and size of *all* wounds present, in order to determine which wounds require surgery and to best plan the sequence of operations.



H. Nasreddine / ICRC

Figure 10.4

Entry and exit thoraco-abdominal wounds: think anatomy!

As mentioned in Chapter 8 the surgeon should try to identify the path of any projectile. The wound may perforate the body part through-and-through, or the projectile may be retained without an exit. Entry and exit wounds may be at the same or different levels. The surgeon should visualize the anatomic structures that lie along the probable projectile trajectory, which may include a vital cavity: brain, thorax, or abdomen. The surgeon must think "anatomy".

The examination may reveal a tense, tender swelling in a through-and-through wound to the calf, which indicates haematoma and severe muscle damage; by contrast, the same exit and entry wounds with soft and relaxed tissues signify minimum injury. The surgeon must think "pathology".

Fractures and peripheral vascular and nerve damage should be identified. If there has been delay in evacuation, a *bruit* or vascular murmur may be heard and a "thrill" felt, signifying a pseudoaneurysm or arteriovenous fistula. Peripheral motor function and sensation are tested. Neurapraxia is more common than a severed nerve.

Most wounds involving vital organs should already have been identified during the initial examination for airway, breathing and circulation. Nonetheless, the full-body palpation of a complete examination may reveal the small entry wound of a tiny fragment that has penetrated the meninges, pleura or peritoneum without immediately affecting the vital functions.

A full assessment may require X-rays as well – with the exception of through-and-through soft-tissue wounds, which do not require them. One body region above and below any entry or exit wound should be filmed. Deformation or fragmentation of a bullet, showing the characteristic "shower of lead particles", is a good indication of severe tissue damage. (Figures 10.5, 3.35 and 4.5). Many foreign materials, it should be noted, are *not* radio-opaque: pieces of shoe or clothing, mud, leaves and grass, plastic fragments from some landmines, for instance. On the other hand, it may be difficult to differenciate a projectile from the normal radio-opacity of some anatomic features (Figures 8.4.2 and 14.9.1). Major bone comminution also implies severe soft-tissue damage. Having radiography helps, but is not an absolute necessity for diagnosing fractures.[4]

Note that the presence of air in tissues on X-ray does not necessarily mean the gas of clostridial myositis. The temporary cavity associated with high velocity missiles often leaves behind palpable and radiographic intrafascial and intramuscular air in healthy tissue some distance from the wound. This usually indicates severe tissue damage. The diagnosis of gas gangrene is a clinical one and the radiograph is not pathognomonic: *vide* Figures 10.6 and 13.2.

More sophisticated diagnostic means can be used, of course, depending on the equipment and professional expertise of the hospital in question.

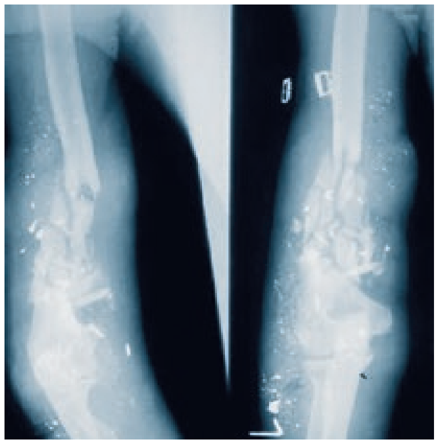


Figure 10.5

Massive comminution of humerus showing characteristic "shower of lead particles" after bullet fragmentation.

10.3 Preparation of the patient

Not only are war wounds dirty and contaminated but battlefields are dirty places as well. The wounded do not have access to basic sanitary facilities and every precaution should be taken to meet fundamental hygiene standards. The majority of casualties have wounds to the limbs and are haemodynamically stable. All stable patients should be put through a warm shower upon admission; dressings are changed as necessary for examination and triage. Only critical cases go straight to the operating theatre.

In the operating theatre, the surgeon should prepare the patient's position – in coordination with the anaesthetist and nursing staff – for the sequence of the operation before starting. A pneumatic tourniquet is very useful for limb wounds, especially before removal of a field dressing on an obviously serious injury.

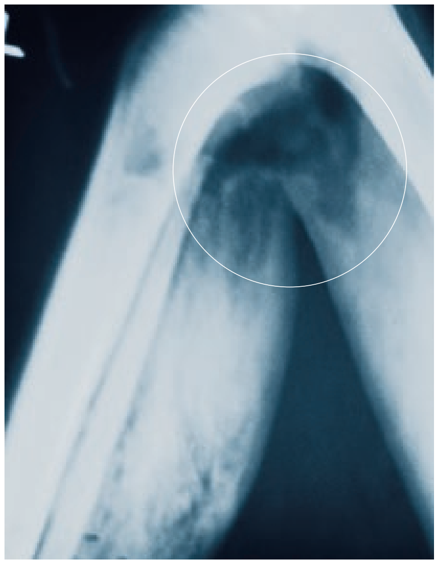


Figure 10.6

X-ray showing air in tissues in a patient not suffering from gas gangrene.

In the case of multiple soft-tissue wounds, those on the posterior aspect of the trunk and limbs should be dealt with *before* those on the anterior aspect, unless there is clinical evidence of a vascular injury. Many wounds to the back have been *"forgotten"* after much work on anteriorly situated wounds, and it is easier for the anaesthetist to finish off the operation with the patient supine.

Under anaesthesia, dressings and splints are carefully removed. The skin over a large surrounding area, including the whole circumference of the limb or torso, is cleansed with soap and water and a brush, shaved, dried, and then painted with povidone iodine. The wound is irrigated copiously.

Sterile sheets are put in place. Drapes with holes should only be used for the smallest and most superficial wounds. Most wounds will have to be extended and the operative field enlarged as a result.

The wound is then thoroughly irrigated again to remove surface dirt and debris. Under optimal conditions, sterile normal saline should be used. Under conditions of limited resources, potable water from the tap can be resorted to: "If you can drink it, you can put it into a dirty wound". Groundwater may be treated with sodium hypochlorite to reach a concentration of 0.025 % (5 ml of bleach in one litre water) if necessary.

Figure 10.7

Washing an anti-personnel landmine injury prior to surgery.

Only in extreme cases of impending asphyxia or exsanguinating haemorrhage should the basic rules of hygiene and sterile technique be broken.

4 Many ICRC surgical teams have had to operate in emergency situations with *no* X-ray equipment.

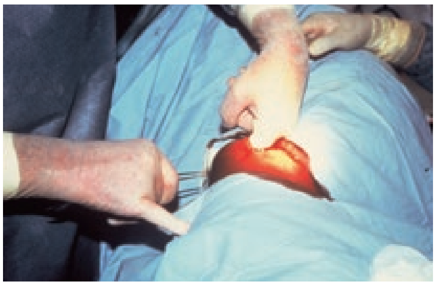


Figure 10.8
Finger exploration of the wound.

10.4 Examination of the wound

Following the initial careful examination of the patient, full assessment of the wound(s) may require finger exploration in theatre under anaesthesia. In this era of HIV and Hepatitis B and C, the surgeon should take great care not to suffer injury from sharp bony edges.

> **Old lessons for new surgeons**
>
> The best instrument for wound exploration is the surgeon's (protected) finger.

The surgical work required to treat a wound depends on its site and size: i.e. the location and amount of tissue damage. Knowledge of ballistics allows only for an understanding of wounding possibilities, but knowing that certain weapons have greater wounding potential does not help the surgeon in this assessment. With the exception of anti-personnel blast mines, even knowing which weapon was used is often of no practical use. Many wounds are the result of full metal jacket bullets that ricochet, creating large injuries similar to a dum-dum bullet (see Chapter 3).

The most significant component of tissue damage is the permanent wound cavity, yet energy loss by the projectile and tissue disruption along the track is not uniform, resulting in a "mosaic of tissue damage". Injury can also occur well beyond this, owing to stretch and shear during the formation of the temporary cavity: late ischaemic necrosis in the wall of hollow organs; or intimal detachment and vascular thrombosis of vessels that still look intact from the outside. The time between injury and treatment and the possible beginning of sepsis, must also be taken into account.

> War wounds are never identical, even if caused by the same weapon.

There is an art to the assessment of tissue damage that is learnt largely through experience. It is important neither to under-treat – causing sepsis and even death – nor to over-treat – resulting in excess loss of normal tissue and increased disability.

This art does have a scientific basis, nonetheless. The Red Cross Wound Score classifies penetrating weapon wounds into different categories according to the degree of tissue damage (Grade) and the structures injured (Type). This Score helps determine the extent of surgery necessary. Careful examination is important because not all wounds require surgical excision.

10.5 Surgical treatment

> **The surgical treatment of a major wound is performed in two stages:**
>
> - *wound debridement*, leaving the lesion wide open, without any suturing of skin or deep structures;
> - *delayed primary closure* 4 – 5 days later.

The surgical treatment of most war wounds is a staged process involving two main procedures, the first being wound debridement or excision. The resulting wound is left unsutured. The open wound then undergoes delayed primary closure (DPC) after 4 – 7 days, once the exudative phase of trauma inflammation has subsided and the proliferative phase begun. In practice, DPC is usually performed after 4 – 5 days. Closure may be by simple direct suture or require sophisticated techniques of grafting and reconstruction (see Chapter 11).

10.5.1 Technique of wound debridement

Basic principles of wound debridement

1. Stop haemorrhage.
2. Make adequate skin incisions and fasciotomies.
3. Remove dead and severely contaminated tissues to prevent/control infection.
4. Leave the wound open – unsutured.
5. Re-establish physiological function.
6. Handle gently and treat the tissues with respect, as always.

Control of haemorrhage is the first priority. In a large wound with heavy bleeding, blind clamping in the depths of a blood-filled cavity is mentioned only to be condemned. Direct local pressure should be exerted while proximal and distal control of the vessels by standard surgical exposure is performed.

For management of vascular injuries, see Chapter 24 in Volume 2.

After haemorrhage, the greatest danger to the patient is sepsis. Surgical infection requires a culture medium, which in the case of weapon wounds is a mixture of dead muscle, haematoma, bone fragments, dirty skin, foreign material (pieces of cloth or shoe, mud, gravel, leaves, dust, the missile, etc.), and, at times, extrinsic bone (bone fragments which come from the wound in another part of the body or another person and whose penetration, as secondary missiles, then creates a new wound). Injury caused by extrinsic bone fragments is seen with bomb explosions and APM.

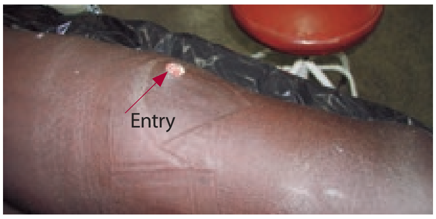
Wound debridement is the process whereby this dead and damaged tissue, grossly contaminated with bacteria and debris, is completely cut away. This leaves an area of healthy tissue with a good blood supply and capable of combating residual surface contamination, provided the wound is not closed. Excess excision of healthy tissue, however, will increase the potential for deformity and disability.

Good vascularisation and oxygenation of the wound requires relief of tension within the wound and good drainage of the inflammatory exudate. This is provided by adequate incision of the skin and fascia, and leaving the wound unsutured.

Wound debridement involves incision and excision.

A basic instrument set is all that is needed in the vast majority of cases: scalpel, Metzenbaum (tissue) and Mayo (suture) scissors, toothed dissection forceps, non-toothed anatomic forceps, bone curette, six haemostats, and retractors. Diathermy is not necessary; absorbable ligature material is preferable.

For the young surgeon, or one without experience of war wounds, it is best to excise the wound layer-by-anatomic-layer, proceeding from superficial tissues to deeper ones in order to best visualize the anatomy and pathology. At all times the surgeon should anticipate the anatomic structures present. Tissue damage, haematoma, and oedema can easily *alter the visible anatomy*, and camouflage important structures.



F. Jamet / ICRC

Figure 10.9.1

Patient X: entry wound on anterior aspect of thigh.

F. Jamet / ICRC

Figure 10.9.2

Patient X: longitudinal extension of the skin incision.

F. Jamet / ICRC

Figure 10.9.3

Patient X: opening of the fascia throughout the length of the skin incision. Note the contused and necrotic muscles.

10.5.2 Skin

Skin is elastic, with a good blood supply, very resistant to damage and remarkably viable. It should be treated conservatively. Only skin that is grossly pulped should be cut away. Usually no more than 2 – 3 mm of the skin edge need be removed at both entry and exit sites.

This is followed by as generous an incision as necessary of healthy skin in order to gain access to the depths of the wound (Figure 10.9.2). Small entry and exit wounds may hide considerable internal injury. The most common error is to attempt to make a wound excision through a small entry or exit wound. In limbs, the incision should be made in the longitudinal axis, but not over subcutaneous bone, and at flexion creases it should curve in the usual way.

The commonest mistake is to attempt a wound excision through small entry or exit holes or to make incisions too short.

This extension of the skin wound not only permits better visualization, but also allows for the proper decompression of deeper tissues and their subsequent drainage.

10.5.3 Subcutaneous fat

Subcutaneous fat has a poor blood supply and is sticky, easily holding heavy contamination. This layer should be excised generously, 2 – 3 cm all the way around the original traumatic wound.

10.5.4 Fascia and aponeurosis

Shredded fascia should also be trimmed. Large amounts of damaged muscle may lie underneath a small hole in the fascia; therefore, the muscular compartment should be opened up by a large incision of the deep fascia parallel to the muscle fibres along the entire length of the skin incision (Figure 10.9.3). This essential step allows wide and deep retraction to expose the depths of the wound. It may be necessary to add transverse cuts to the deep fascia to improve access.

Post-traumatic oedema of the wound can easily cause compartment syndrome, compromising the local circulation with resultant necrosis of the muscles. The fascial incision is left open to allow oedematous and congested muscle to swell without tension, so as to avoid interference with the blood supply and to promote drainage of the inflammatory exudate and haematoma.

After haemorrhage control, the relief of tissue tension is the most important step in wound debridement.

Deep to the fascia, the gloved finger is the best and gentlest probe to follow the track and estimate the extent of damage. Again, particular attention should be paid to the sharp edges of any fractured bone.

Fasciotomy

Compartment syndrome can occur in any fascial space, but is seen most commonly in the lower leg. Great care should be taken when dealing with any penetrating wound below the knee, with or without tibial fracture.

If there is any suspicion of compartment syndrome, decompression must be performed without delay.

For information on the technique of fasciotomy, see Section B10 in Volume 2.

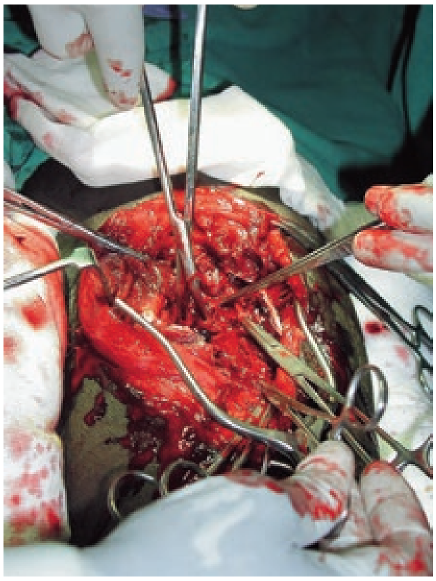
10.5.5 Muscle

Dead muscle is the *ideal medium* for the development of *clostridial* infection leading to gas gangrene or tetanus as well as for the growth of many other bacteria. The track of the missile through the muscles must be opened up, layer by layer, to be properly visualized. It is vital that all grossly contaminated, obviously necrotic and detached muscle lining the track be excised.

All dead or heavily contaminated muscle must be removed.

Warning!

Muscles that are completely transected contract *away* from the wound cavity. The retracted muscle bellies must be found for inspection and excision. During wound exploration, division of uninjured muscle in a transverse direction should be avoided.



F. Jamet / ICRC

Figure 10.9.4

Patient X: wound cavity completely opened and excised.

However, not all injured muscle will undergo necrosis. How to differentiate between muscle that is injured but will heal from that which is not viable? Classically, reference is made to the four Cs of muscle viability:

- colour,
- consistency,
- contractility, and
- capillary bleeding.

All muscle that is not healthy and red, that does not contract when pinched or bleed when cut, must be excised until healthy, contractile, bleeding muscle is found.

However, confusion may arise because of certain pathological changes described below.

- As mentioned in Chapter 3, wound ballistics studies have shown that there is an intense but transient vasoconstriction lasting several hours, followed by the reactive local hyperaemia of the inflammatory response. Consequently, it is not always necessary to "cut until it bleeds". The surgeon must therefore take into account the time since wounding.
- However, minimal excision is often followed by necrosis of the muscle when the wound is looked at several days later. What is irreversible is not always immediately apparent. The wound evolves and these changes demonstrate the different stages in the "life-history" of the wound[5] and should be well understood by the surgeon.
- The surgeon should also understand that shock or the use of a tourniquet can change the colour or the capacity of muscle to bleed and that contractility is affected by hypothermia and paralysing anaesthetic agents.

The criteria of the 4 Cs are very subjective and a function of the surgeon's experience, but are nonetheless the best clinical measure available. The colour and consistency – texture – of the muscle should be noted. To test for contractility, 2 cm^3 lumps of muscle should be picked up and pinched with a forceps and, if they do not contract, excised using scissors or knife. Note if the cut edge of the muscle lump bleeds. Cutting away lumps larger than 2 cm^3 may result in the inadvertent removal of healthy tissue. Meticulous technique is the key.

Intermuscular fascia should be excised if blood-stained and contaminated.

5 Pearson W. Important principles in the drainage and treatment of wounds. *Lancet* 1917; **189**: 445 – 450.

10

10.5.6 Haematoma

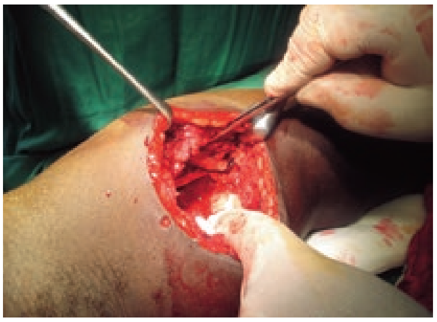
The presence of a large haematoma generally implies that a major vessel has been damaged. Dislodging the haematoma can result in sudden heavy blood loss. It is wise to be prepared for vascular control before a haematoma is evacuated. If working under a pneumatic tourniquet, the anatomical structures must be clearly identified.

10.5.7 Bone and periosteum

The Haversian vascular system of bone is a fragile one. Fragments of bone with no attachment to periosteum or muscle are already sequestrated and should be discarded, but any bone still attached should be retained. Exposed medullary bone should be curetted back to firm marrow. Any bone left *in situ* must be cleaned of dead muscle and foreign material, dirty bone ends are trimmed by a bone-nibbling forceps (*rongeur*). *Bone defect* is not important at this stage, the *wound* is of paramount importance, and every attempt should be made to avoid infection, whose development will only lead to greater bone loss. The danger of non-union from the removal of multiple bone fragments is overrated.

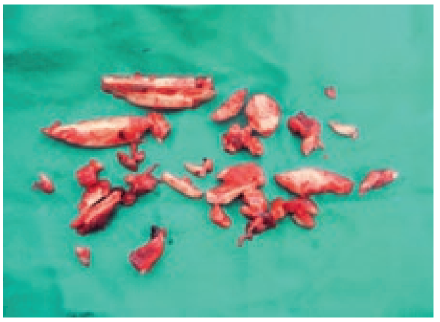
H. Nasreddine / ICRC

Figure 10.10.1
Patient Y: gunshot wound to arm and chest.



H. Nasreddine / ICRC

Figure 10.10.2
Patient Y: wound track opened up.



H. Nasreddine / ICRC

Figure 10.10.3
Patient Y: detached bone fragments removed.

Periosteum, on the other hand, is resilient and has a rich blood supply: it plays the predominant role in new bone formation. Its debridement should be conservative and restricted to obviously dirtied and contaminated edges.

ICRC practice is to use the simplest form of bone immobilization at the first debridement; this is usually a plaster of Paris (POP) posterior slab or some form of skeletal traction. Seldom is external fixation required at this stage and internal fixation is proscribed in ICRC practice. More definitive bone immobilization is decided during delayed primary closure of the wound.

For information on indications for different techniques of fracture immobilization and repair of bone defect, see Chapter 22 in Volume 2.

10.5.8 Arteries, nerves and tendons

As aforesaid, bleeding should be controlled if a major artery to the limb is damaged and either immediately repaired or replaced by a saphenous vein graft or temporary stent if a limb is to survive. The surgeon should pay particular attention to the possibility of a vascular injury near severely comminuted fractures with multiple fragments.

All nerves must be preserved as far as possible. Large nerves are resistant to section, although they may suffer neurapraxia. They are often the only structure left traversing a wound cavity. If they are found to be damaged, the site and degree of damage should be recorded. A non-absorbable suture may be placed in the proximal and distal ends and pulled together to facilitate their identification at a future operation. Exploration of the implicated nerve should be attempted during wound debridement *only* if it does not involve opening up healthy tissue planes.

Tendons should be trimmed and only grossly destroyed fibres removed. Severed tendons, if important and requiring later repair, should be marked with a non-absorbable suture as with nerves.

No attempt should be made at primary tendon or nerve repair, as success is unlikely in these grossly contaminated wounds. The failure of immediate repair will only make subsequent efforts that much more difficult. Also, repairs take time and energy at the "wrong time of the day"; they are best dealt with as planned elective procedures. Nerves and tendons should nonetheless be protected from extended exposure, by covering them with muscle or skin flaps or wet dressings.

For techniques on artery, nerve, and tendon repair, see Chapters 24 and 25 in Volume 2.

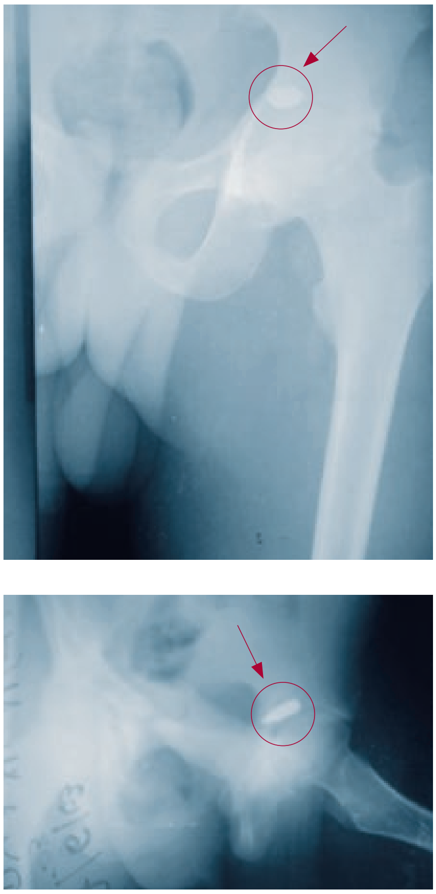
10.6 Retained bullets and fragments

Obviously, if the surgeon comes across a projectile during wound debridement then it should be removed, but healthy tissue should not be dissected in an attempt to find one. Otherwise, there are two conditions that require *immediate removal* of bullets and fragments, and these are related to specific proven risks and complications.

1. Projectile situated in a synovial joint – the piece of metal will cause pain, disability and progressive destruction of the joint cartilage though a mechanical action, and possible toxicity if made of lead: it should be removed as part of the wound debridement of the acute injury (Figures 10.11.1 and 10.11.2).

2. Risk that the projectile may cause erosion of an important structure (usually a major blood vessel) with the possibility of major haemorrhage or embolization (Figures 10.12.1 and 10.12.2). Should the surgeon suspect a pseudoaneurysm or an arterio-venous fistula then an operation to treat these pathologies involves the removal of the foreign body.

   Whether this removal is performed as an acute or planned elective procedure will depend on the exact anatomic location and endangered structure, the haemodynamic stability of the patient, the availability of diagnostic and operative equipment, and especially the *expertise of the surgeon*. The risks of a major procedure (removal of a bullet in the mediastinum, brain, etc.) whose morbidity may be quite high (especially in inexperienced hands) must be weighed against the benefits where the overall incidence of complications is low: for further indications and details, see Chapter 14.



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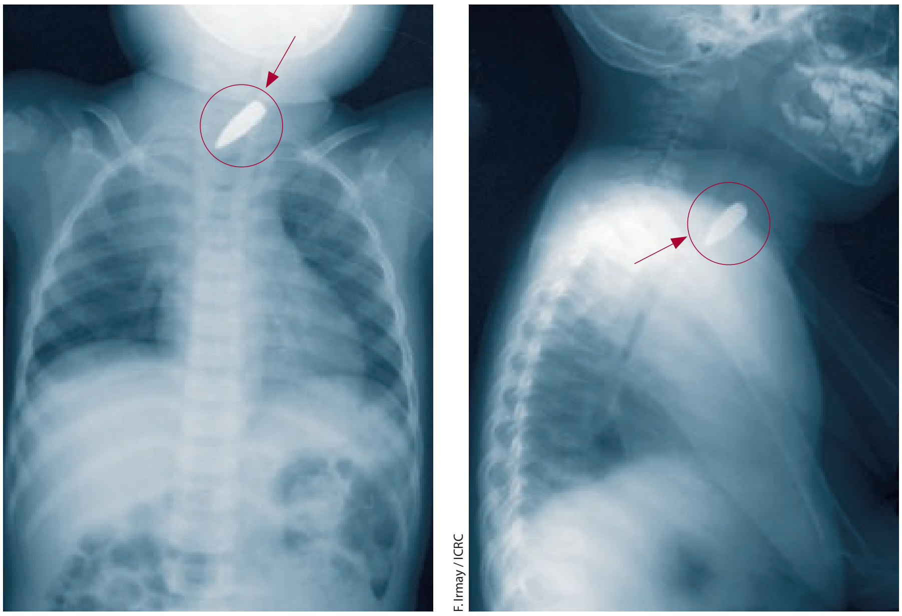
Figures 10.11.1 and 10.11.2

Retained bullet in the hip joint.



F. Irmay / ICRC

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Figures 10.12.1 and 10.12.2

Retained bullet in the upper mediastinum.

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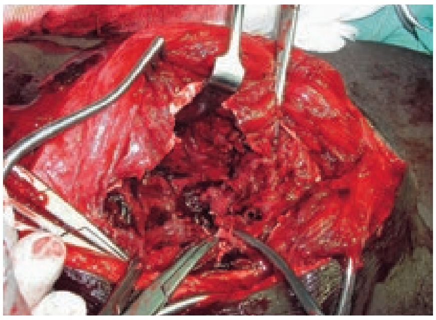
10.7 Final look and haemostasis



F. Jamet / ICRC

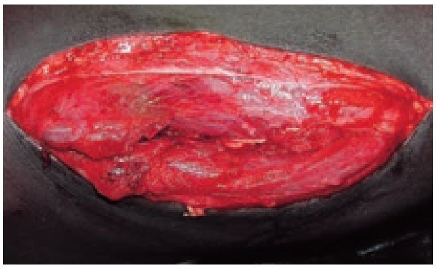
Figure 10.13

Patient X: final appearance of the wound cavity.

The edges of the wound should be retracted, and gentle and copious irrigation under low pressure will wash out any residual debris and clot and dilute any bacterial load. Normal saline is preferable, but any potable water can be safely used. A plastic bottle with holes cut into the top squeezed manually with both hands provides sufficient pressure; depending on the size of the wound cavity, one to three litres of saline is used. Very large and complicated fractures may require up to ten litres until the wound "looks" clean.

All the structures in the wound cavity should now be visualized and identified (Figure 10.13). The surgeon should carefully explore the wound with the finger to identify any foreign bodies or unexpected extensions of the wound.

- *Do not* open fresh planes in healthy tissue.
- *Do not* explore unnecessarily for metallic fragments.
- Remove fragments of clothing, in-driven dirt and vegetation.



F. Jamet / ICRC

Figure 10.14

Patient X: wound is left open.

After removal of the pneumatic tourniquet, bleeding should be controlled by pressure with gauze and by fine absorbable ligatures. Electric cautery (diathermy) is best avoided as it leaves dead burnt tissue behind, which is more harmful than the foreign body of an absorbable knot.

The wound should be left wide open (Figure 10.14). There is no use in "putting in a few sutures" to partially close the wound, "just to bring the edges together a bit". This will defeat the purpose of allowing for extensive wound decompression and drainage and, after the development of reactive oedema, a loose stitch becomes tight. In addition, although the wound may look clean, it is not sterile. Bacteria and microscopic debris still exist in the wound and will only be expelled with the post-traumatic inflammatory exudate if drainage is adequate.

Should a drain be put in place? If the wound is relatively shallow and left wide open, there is no need for a drain. If there are deep pockets in the wound, which cannot be fully opened up because of anatomical constraints, then a soft penrose or corrugated rubber drain may be required. Counter-drainage through a stab wound in a dependent part might be more useful.

These procedures are *not new*. They are the rules of all septic surgery to be found in all standard surgical reference texts. "Never close infected wounds. Do not close contaminated wounds or clean wounds that are more than 6 hours old. Systematically perform wound toilet and debridement and saline irrigation until the wound is completely clean. Perform delayed primary closure as a second procedure."

Old rules for new surgeons

In war wounds, the rules of septic surgery apply.

10.8 Wound excision: the exceptions

10.8.1 Management of minor Grade 1 wounds

Many Grade 1 soft-tissue wounds, according to the Red Cross Wound Score, can be treated conservatively. Examples include:

- perforating bullet wound with small entry and exit (narrow channel wound) without swelling of intervening tissues (haematoma/oedema) or other signs of injury to important structures (Figure 3.29.1);
- multiple superficial wounds due to "peppering" with tiny fragments of obviously low velocity and low kinetic energy (e.g. hand grenade) as shown in Figure 10.15.1.

Some superficial Grade 1 soft-tissue wounds will require only simple local wound toilet. This will suffice with many low-energy small fragment wounds where the potential culture medium is so small that the body's normal defence mechanisms can deal with it. They can be cleansed with soap, water, and a disinfectant and a simple dry dressing applied; the small wound is left open to heal by secondary intention. This is especially the case if antibiotics can be administered early (see Chapter 13). This ICRC experience has been confirmed by others.[6]

Excision of entry and exit wounds under local anaesthesia may be necessary to promote free drainage in other superficial Grade 1 wounds. This may be accompanied by syringe injection of normal saline for irrigation of the wound track with/without a drain. Some such wounds, however, will require a full surgical exploration and excision, particularly in the one well-known instance where the type of weapon is of utmost importance: anti-personnel blast mines. Even small puncture wounds from landmines can be loaded with mud and grass or the mine casing, all of which must be removed (Figure 10.16).

Heterogeneity of war wounds: there is no single treatment that applies to all wounds. Wounds must be considered by Grade and Type.


R. Coupland / ICRC

Figure 10.15.1
Superficial "peppering" by grenade fragments.

R. Coupland / ICRC

Figure 10.15.2
There is no penetration of the joint and no vascular injury – the wounds require simple wound toilet.


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Figure 10.16
All APM fragment wounds – large and small – require debridement.

10.8.2 Serial debridement

For some large wounds the line of demarcation between dead tissue and damaged, but viable, tissue is not clear. The life-history of a wound is such that apparently clean and living tissue may become necrotic after a few days, especially if there has been a delay between injury and debridement; and if the surgeon is not experienced in this type of surgery. The idea here is to debride obviously dead tissue; otherwise excise conservatively, and then re-examine the wound in theatre after 48 hours.

This method is called a "serial debridement", i.e. a wound excision over several sessions, and it should be *planned* as such. The surgeon should make a conscious decision that, "in this patient, because I am not certain of the viability of the remaining tissues and excessive excision of normal tissue would cause deformity or compromise function, I shall perform a second debridement later" (Figure 10.17).

In armies with very efficient means of evacuation and sufficient personnel, serial debridement may be the preferred method of treatment and takes place at different hospitals with different operating surgeons along the chain of casualty care.

Serial debridement cannot be considered a standard method of treatment in a situation of mass casualties and poor or no evacuation capacity. It requires sufficient personnel and resources to handle the number of wounded and to allow for a second look and follow-up. More often, the surgical workload is so great, or the tactical situation such, that serial debridement is not possible. The surgeon must treat each wound excision as a definitive one. In this instance, if in doubt about tissue viability, it is wiser to excise.

6 Bowyer GW, Cooper GJ, Rice P. Small fragment wounds: biophysics and pathophysiology. *J Trauma* 1996; **40 (Suppl.)**: S159 – S164.

ICRC

Figure 10.17

Serial debridement of a large wound: the line of demarcation of necrotic tissue has now become apparent.

M. Baldan / ICRC

Figure 10.18

Panga wound to the head.

The practice of serial debridement should not be confused with an incomplete or failed wound excision. In the latter case, the patient returns to theatre for delayed primary closure after five days and the wound is found to be infected with remaining necrotic tissue. It is not ready for suture and requires re-debridement.

10.9 Leaving the wound open: the exceptions

As is usually the case in surgery, there are exceptions where wounds may, or even should, be closed.

10.9.1 Head, neck, scalp and genitals

The excellent blood supply and minimal soft tissue of these structures usually allows for immediate primary closure after wound excision. Only in the presence of severe contamination, or if in doubt, might it be wiser to leave these wounds open.

In maxillo-facial wounds, the oral mucosa is an exception in all respects and every attempt should be made to close it primarily.

Machete or *panga* wounds, especially to the face or scalp, are *not* incised wounds, but rather a mixture of crush and laceration. Dirty connecting tissue is found to underlie an overhanging edge of skin and galea aponeurotica. If less than 6 hours since wounding, immediate primary closure, after full debridement, with a subcutaneous drain is permissible. If more than 6 hours old, it is better to leave the wound open for delayed primary closure after 2 – 4 days.

In penetrating brain injury, it is best to close the dura. This can rarely be sutured directly, but the problem can easily be overcome with a patch of pericranium or aponeurosis. After debridement of the scalp wound, the skin should be closed either directly or with a rotation flap.

10.9.2 Soft tissues of the chest (sucking chest wound)

These wounds must be debrided, but healthy muscle and pleura should be closed to preserve a functional serous cavity. The skin and subcutaneous tissue should be left open and a chest tube inserted.

10.9.3 Soft tissues of the abdominal wall

As with the chest, the wound should be excised and every effort made to secure peritoneal closure. Furthermore, if the development of abdominal compartment syndrome is suspected, temporary abdominal closure is preferable (Bogotá bag, etc).

For further details on abdominal compartment syndrome see Annex 32. A in Volume 2.

10.9.4 Hand

Excision should be very conservative and all viable tissue preserved to simplify reconstruction and improve the functional result. These wounds should be left open for DPC after 2 – 4 days; however, tendons and nerves should be covered by healthy tissue, through rotation flaps if necessary. Small wounds may be closed primarily.

10.9.5 Joints

Synovial membranes should be closed; if this is not possible the capsule alone should be sutured. Little harm seems to be done if the synovium cannot be closed securely. The skin and muscle should be left open.

10.9.6 Blood vessels

Blood vessels that have been repaired primarily or by vein graft should be covered by viable muscle if possible. The skin should be left open.

For specifics of each anatomic region, see Volume 2.

10.10 Dressings

Once the wound has been adequately excised, it should be covered with a bulky absorbent dressing made of dry fluffed-up gauze re-enforced with a layer of absorbent cotton wool. This is held in place with a *loose* crepe bandage or non circumferential adhesive tape. A tight bandage wrapped around the limb and soaked with exudate that dries will have a tourniquet effect. The gauze compresses should *not* be packed tightly in the wound; this will only impede drainage. The aim is to draw inflammatory exudate out of the wound and into the dressing. Exposed tendons and joint capsules may be covered with saline-soaked compresses.

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Figures 10.19.1 – 10.19.4

Big bulky dressing of fluffed gauze covered by an elastic bandage.

Vaseline gauze should not be used, and the wound should not be "packed" in any way with gauze that will form a plug and prevent the free outflow of fluid.

The dressing should not be removed until taken down in the operating theatre under anaesthesia at the time of delayed primary closure. Ward dressings are an invitation to nosocomial infection. The surgeon should resist the temptation to change the wound dressing to "have a look at how it is doing". Each dressing change constitutes trauma to the healing granulation tissue and exposes it to cross-infection. A good look at the patient instead will suffice: the wound is doing quite well if the patient is smiling, eating, and sitting comfortably in bed.

If the dressing and bandage have become soaked with exudate, either over-dress with absorbent cotton, or take down the bandage and wet cotton and replace without disturbing the gauze compress that is in direct contact with the wound. The state of the dressing is not an indication of the state of the wound.

Wounds awaiting DPC should not have dressings changed until formal closure.

10.10.1 The exceptions

- Continuing *haemorrhage* requires immediate re-exploration; as do vascular changes indicating ischaemia.
- Obvious *signs and symptoms of infection:* fever, toxicity, excessive pain and tenderness, warmth, redness or shiny surface in dark-skinned people, oedema and induration, or a moist wound dressing with an offensive smell. These indicate the need for further surgical excision, which should be attended to in the operating theatre, not by changing the dressing in the ward.

All wounds awaiting DPC develop a "sour" odour after several days: the "good-bad smell" of ammoniacal products from the breakdown of serum proteins. The infected wound has a characteristic offensive odour: the "bad-bad smell".

10.11 Anti-tetanus, antibiotics, and analgesia

All patients should receive prophylaxis against tetanus (see Chapter 13).

For proper rest of the injured part, and to make the patient ready for physiotherapy, good analgesia should be given (see Annex 17. E: ICRC pain management protocols).

10.12 Post-operative care

It goes without saying that proper post-operative nursing is crucial. ICRC experience has shown that the most important factor limiting the sophistication of surgical procedures performed in an ICRC hospital is not the technical expertise of the surgeon, but rather the level of post-operative nursing care. This should not be underestimated in the context of a poor, war-ravaged country.

In all cases where there is an *extensive* soft-tissue wound, even in the absence of a fracture, the entire limb should be immobilized to provide rest. This can be achieved by a plaster of Paris (POP) back slab.

The normal catabolic response to trauma must be overcome and patients offered a good nutritious diet. In a poor country, many wounded patients will arrive at hospital suffering from malnutrition. This will only compromise the body's ability to heal and resist infection.

The functional result of ultimate wound healing depends to a great extent on proper physiotherapy to retain muscle mass and joint mobility, and should be instituted early as part of the healing process.

The principles of good wound management

1. Adequate wound excision: removal of necrotic tissue, contaminated debris, organic foreign material, and blood clots.
2. Adequate wound drainage: fascial decompression, wound left open without any suturing, large bulky absorbent dressing.
3. Haemostasis.
4. Limb immobilization until healing of soft tissues.
5. Tetanus prophylaxis, antibiotics, and analgesia.
6. Nutrition.
7. Nursing and physiotherapy: mobilization of the patient.
8. No unnecessary dressing changes.
9. Delayed primary closure (4 – 5 days).

Chapter 11

DELAYED PRIMARY CLOSURE AND SKIN GRAFTING

11.1 Delayed primary closure

Delayed primary closure (DPC) is wound closure performed *four to seven days after debridement*, which corresponds to the fibroblastic phase of wound healing. In the practice of ICRC surgical teams, the standard has been 4 – 5 days. The timing of wound closure is important; this is still defined as healing by *primary intention*.

Attempts to close wounds before they are clean must be avoided; but DPC is seldom possible later than 8 days after wound excision because of fibrosis. At this stage, healing by *secondary intention* will set in.

No wound should be closed if there is persistent contamination or infection.

For DPC, the patient is taken to theatre and the wound opened and inspected under anaesthesia. The dressing over a clean wound is dry and greenish-black in colour, and has the ammoniacal odour ("good-bad smell") of degraded serum proteins. The muscle is adherent to the gauze and, as the dressing is gently peeled away, the muscle contracts and bleeds slightly. The surface is a bright red and oozes blood. This wound is ready for DPC. Figures 11.1.1 – 11.1.5 show an example of the full sequence of wound managment with closure by skin graft.

R. Coupland / ICRC

Figure 11.1.1
Very dirty wound.

R. Coupland / ICRC

Figure 11.1.2
After debridement.

R. Coupland / ICRC

Figure 11.1.3
Five days later, removal of dressing – note the dried haemoserous discharge. As the dressing comes off, the muscle contracts and bleeds.

R. Coupland / ICRC

Figure 11.1.4
Clean wound ready for DPC; in this case by split-skin grafting owing to the large area of skin loss.

R. Coupland / ICRC

Figure 11.1.5
Wound covered by early split-skin graft.

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If the wound is infected, the dressing slides off with no resistance whatsoever because there is a film of pus between it and the wound surface, which may contain areas of necrotic tissue as well as pus. The surface is a dull- or greyish-red and does not bleed. The dressing gives off the "bad-bad smell" of wound infection.

Such an infected wound, or one containing residual contamination or devitalized tissue, requires further surgical excision – redebridement – and is then left open again. Closure is postponed. This failed attempt at DPC is not to be confused with "serial debridement" (see Chapter 10).

H. Nasreddine / ICRC

Figure 11.2
Direct suture as DPC.

11.1.1 Methods of delayed primary closure

This is usually accomplished by direct suture: simple approximation of the deep structures and skin with minimal mobilization of the skin edges, and *without tension* (Figure 11.2). If there is tension in the suture line, the skin edges will become necrotic and the wound will break down. Small wounds may be closed using adhesive tape to approximate the edges.

The wound should not be closed under tension.

Significant tissue loss prevents approximation of the deep structures and skin. Rotation skin flaps might be useful in some anatomic locations. If bone is exposed, a musculocutaneous flap may be necessary. Larger areas require skin grafting (Figure 11.1.5).

Adequate primary surgical excision is vital for uncomplicated wound closure by DPC.

11.1.2 Dead space

As with all wounds, the obliteration of dead space is an accepted principle of DPC management. This may be technically difficult when there has been extensive loss of deep tissue. Absorbable sutures are used to approximate deep structures, but, here again, undue tension should be avoided as it will only result in local tissue ischaemia that decreases local resistance to the development of infection and impedes healing. It is not necessary to suture fascia or subcutaneous tissues.

Drains should be *avoided* whenever possible in DPC. Drains may act as retrograde conduits for skin bacterial flora and contaminants to gain entrance into the wound, and they impair the resistance of tissue to infection; a drain constitutes an additional foreign body in the wound.

Drains should never be placed in wounds without dead space; they should only be used for those with significant dead space and where there is associated oozing of blood. Within 24 hours, the oozing has usually stopped and the drain should be removed. If used, a drain should be placed dependently and, if possible, be of the suction catheter variety. Otherwise, a simple soft penrose drain will suffice.

Avoid drains whenever possible in DPC. If used, remove within 24 hours.

11.1.3 Wound care

After DPC, the wound should be covered with some layers of dry gauze which can be left until the time of suture removal. If signs of infection develop after closure, the patient is taken back to theatre where the wound is inspected, sutures removed, and the wound re-opened for drainage and redebridement if necessary. Avoid performing this procedure in the ward, where proper inspection and drainage are difficult, as it only favours the development of cross-infection.

11.2 Skin grafting

If the wound cannot be closed by direct suture or rotational flaps because of skin loss, a skin graft can be applied, sometimes combined with partial direct suture.

11.2.1 Types of autologous skin grafts

Free skin grafts may be partial-thickness (epidermis and part of the dermis) or full-thickness (including all the dermis). Partial-thickness grafts, also called split-skin grafts (SSG), vary in thickness depending upon how much of the dermis is incorporated. The thicker the graft, the less it will contract and the more it will resemble normal skin in colour and texture; but the risk of the graft failing is greater. Conversely, thinner grafts are hardy and take more readily, but contract and distort more than thick ones and have a poorer functional and aesthetic result.

Thin partial-thickness grafts
These are used for large areas and when the development of a contracture or quality of skin cover is not important.

Thick partial-thickness grafts
These are used when skin quality is important, such as over flexion creases where contractures should be avoided. However, the recipient area must be very healthy with good vascularity.

Full-thickness grafts
These are best for a good cosmetic result in the face, or to cover a sensitive functional area on the hands or fingers.

11.2.2 Requisites for skin grafting

Skin grafts can cover any wound with enough vascularity to produce granulation tissue. This does not imply that fully mature granulation tissue must be present prior to skin grafting, and early grafting for DPC, when the wound is first opened on the fifth day post-debridement, is often used (Figure 11.1.5). Early SSG has advantages and disadvantages: the wound is closed preventing any infection from developing, which is particularly important in large wounds; but the quality of resultant skin is less and there is greater tissue fibrosis and contraction. Most full-thickness grafts are also performed early.

On the other hand, a deep wound, or one over a flexion crease, may be dressed while waiting for more granulation-tissue to grow in, and then grafted at a later date. However, excessive granulation tissue should be scraped clear prior to graft application. A limb with a wound over a flexion crease should be splinted in the extension position with a plaster back slab to avoid contracture while waiting for closure.

Tissues which cannot take skin grafts include avascular areas, such as hyaline cartilage, exposed tendon without paratenon, and exposed bone cortex without periosteum. These cases will require some form of skin or musculocutaneous flap for closure. In the case of exposed bone cortex, an alternative may be the drilling of multiple small holes in the cortex to let granulation tissue grow through from the inner cancellous bone.

11.2.3 Partial thickness grafts

Split-skin grafts (thin and thick) are taken from an area which can produce a broad area of skin. The common donor sites are the thighs, back, and arms and forearms (Figure 11.3).

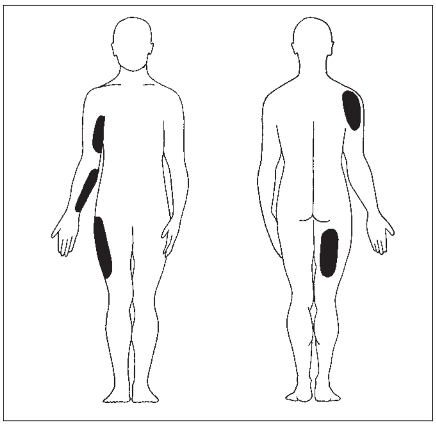

P. Zylstra / ICRC

Figure 11.3
Donor sites for partial-thickness grafts.

P. Zylstra / ICRC

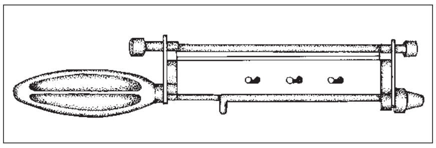


Figure 11.4

A dermatome: various models, with disposable blades, are available – the thickness of the split skin graft harvested is controlled by the screw at the right end of the instrument; the setting is then locked using the screw at the left end.

Split-skin grafts should be taken using a dermatome, such as a Humby knife (Figure 11.4). A free hand knife, such as a De Silva knife which incorporates a razor blade, or scalpel, can be used if a dermatome is not available or if the area to be harvested is small.

The principles for the use of all hand knives are the same. The blades are disposable and are fitted into the knife. A calibration control is adjusted to set the depth of split skin required. Once this has been adjusted, a locking nut is tightened at the opposite end of the knife. It is important to check the gap between the blade and the knife before use, by holding the instrument to the light and visually checking the gap. The gap should be even throughout its length. Electric and pneumatic knives are also available but are not standard in ICRC practice.

The gap between the knife and the blade must be visually checked before use.

Harvesting the SSG

The area of skin to be removed is washed with soap and water and shaved if necessary; povidone iodine is applied. Intradermal saline or, better still, dilute adrenaline solution (1:500,000), is injected into the donor area prior to cutting, to facilitate harvesting and diminish local blood loss. The donor site, the cutting edge of the knife, and the edge of a skin board are greased with vaseline-gauze.

An assistant applies an ungreased skin board to the distal end of the donor site and pulls in such a fashion as to tense the skin tight. The assistant's other hand grasps the underside of the donor site (thigh or arm) to flatten the area from which the graft is being taken (Figure 11.5.1).

P. Zylstra / ICRC

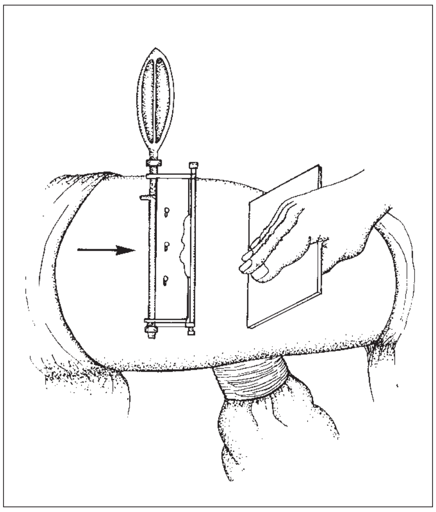


Figure 11.5.1

Harvesting a split skin graft from the medial side of the thigh – note the assistant's left hand flattening the donor site by exerting upward pressure on the undersurface of the thigh.

E. Winiger / ICRC

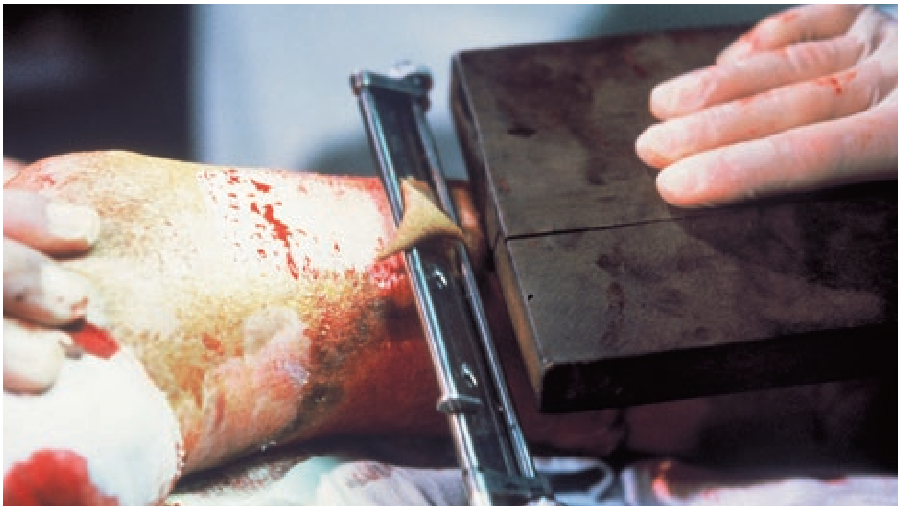


Figure 11.5.2

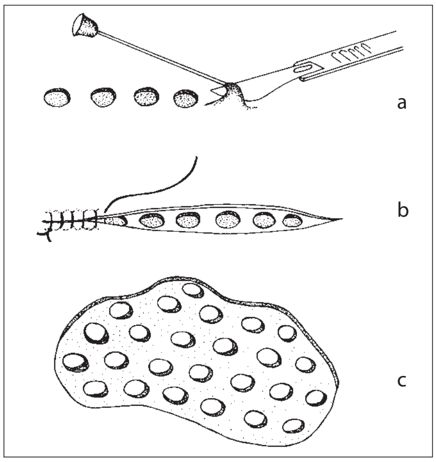
Surgeon's wooden board applying counter-traction.

The surgeon places the greased board about 4 – 5 cm in front of the ungreased board, and exerts counter traction to increase the skin tension (Figure 11.5.2). The knife goes into the gap between the two boards at an angle of 30° and even, gentle, side-to-side cutting movements of about 2 cm are made. Continuous movement of the knife is essential. The surgeon advances the greased board proximally while exerting *minimal effort* to advance the knife. The tendency is to cut too quickly, or exert too much pressure at too high an angle; the blade will not shave the skin off but cut deeply into the subcutaneous tissue. When the desired amount of skin has been raised, the wrist is supinated and the knife cuts through. The harvested skin is now placed on a saline-soaked gauze swab, undersurface upwards, and stored until applied to the recipient area.

11.2.4 Reverdin pinch grafts

These can be used to cover large areas of defect and where the recipient area is unfavourable, such as muscles moving in different planes. A full take is not expected and the gaps between the grafts will fill in as the skin spreads outwards and coalesces. The cosmetic result is poor.

As with SSG, an intradermal infiltration of local anaesthetic with adrenaline is injected into the donor area. This helps to avoid cutting the grafts too deeply and is often all the anaesthesia required. The grafts are cut using a scalpel blade and can vary in size up to about 2 cm^2 (Figure 11.6). The harvested skin is handled as described previously until it is applied to the recipient area.



P. Zylstra / ICRC

Figure 11.6

Reverdin pinch grafts:

a. The skin is picked up with a needle and round patches of thick SSG, 1 – 2 cm in diameter, are cut with a scalpel.

b. If the patches are taken in a line, the area can be excised and the wound closed by primary suture.

c. The patches are spread over the receptor site with gaps of a few millimetres between each piece.

11.2.5 Application of grafts and graft meshing

The recipient bed is prepared by washing with saline and scraping clean any exuberant granulation tissue.

V. Sasin / ICRC

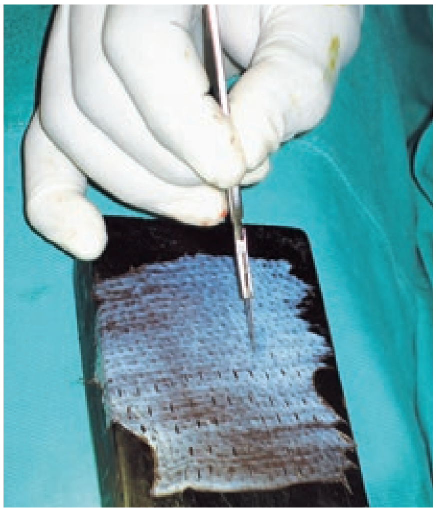
Figure 11.7

Recipient site prepared to receive SSG.

The harvested partial-thickness skin is laid across the recipient bed and cut so that it is slightly larger than the site. This allows for the cut undersurface to be in complete contact with the recipient bed and for later graft contraction. Often a graft is placed on a wound that is deeper than the thickness of the graft. In these cases the edge of the graft at the base of the wound must be carefully approximated to include the entire height of the defect.

The graft should be meshed to allow for drainage of serum and blood; this is important to avoid the graft "floating" and provide for close contact between it and the recipient bed. Meshing is accomplished by placing the harvested skin on a surface, preferably the wooden board, undersurface facing upwards, and making numerous parallel incisions through the graft with a No. 15 scalpel blade. Optimally, the ratio of gaps to skin should be 3:1 thus allowing the SSG to cover an area three times its original size (Figure 11.8). Over a period of 10 – 14 days, the skin grows across the interstices and complete healing is obtained.

Graft meshing is particularly useful in cases where there is insufficient autograft to completely cover raw areas, such as large wounds or burns (see Figure 11.1 for a clinical example). Mechanical meshing machines are available – and expensive – but are not standard ICRC equipment except in hospitals with a large number of patients suffering from burns. A good improvisation is a sharp circular pizza cutter, modified with notches ground into its circumference, and used to mesh skin against the wooden board.



H. Nasreddine / ICRC

Figure 11.8

Meshing of a skin graft.

Grafts can often be kept in place by a suitable dressing and elastic bandaging. If graft stability cannot be ensured by the covering dressing, it should be sutured in place (Figure 11.9). One technique is a continuous 3/0 non-absorbable suture run around the edge of the graft to provide adequate contact. Another is to use several anchor sutures about the circumference, left long and used as tie-overs across the dressing; especially useful for small grafts on hollow areas (Figure 11.11). The excess skin of the graft can either be trimmed once the graft has been sutured in place, or cut 10 – 14 days later.

Figure 11.9
SSG sutured in place.

V. Sasin / ICRC

Once the graft has been sutured or placed on the recipient bed, it should be covered with a sheet of vaseline-gauze followed by a gauze compress or cotton-wool pledgets soaked with saline. These dressings should be pressed into the concavities of the defect to ensure that there is complete apposition between the graft and the bed. The dressing should then be covered with a thick layer of cotton wool held in place by a crepe bandage.

In case of consistent oozing from the recipient bed, consider delaying the application of the graft for 24 – 48 hours. The harvested skin can be stored for up to three weeks in an ordinary domestic refrigerator at 4° C without compromising the success rate. It is placed on a moist piece of gauze with the undersurface facing upwards and then put in a sterile jar containing normal saline. Jars should be stored with an airtight lid and *carefully labelled* with the patient's identification and the date of harvesting.

Delayed application of split skin grafts is often the preferred method.

11.2.6 Graft take

Grafts adhere initially by a thin layer of fibrin and are fed by "plasmatic imbibition" from the recipient bed granulation tissue until in-growth of capillaries occurs by about the fourth post-operative day. The new capillaries link with the graft and the fibrin clot is transformed into fibrous tissue. For these reasons, there are three major factors determining the success rate of split-skin grafts.

1. A vascular recipient bed which is *free of pathogenic bacteria*. Normal bacterial flora will not necessarily interfere with graft survival. The most common pathogen causing graft failure is beta-haemolytic *Streptococcus pyogenes*, probably through its fibrinolytic enzymes. ICRC protocol suggests prophylaxis with penicillin for five days, to which this bacterium remains sensitive.

2. The *vascularity* of the graft itself. Thin split-skin grafts have a higher concentration of capillaries on their undersurface than thick grafts. For this reason, a thin split-graft has a higher chance of survival than a thick one.

3. The maintenance of *close contact* between the graft and the recipient bed. If the graft is under tension, if blood or serum collects between the surfaces, or if there is movement of the graft on its bed, satisfactory contact cannot be maintained. Thus, meshing of the graft and tight contact between the graft and recipient site are important; grafts spanning joints should be splinted to prevent graft loss from shearing forces.

Grafts should be harvested under sterile conditions and placed on a clean, well-vascularized recipient bed. It is imperative that there be tight contact between the graft and its bed.

11.2.7 Graft care

Grafts must be cared for by experienced personnel. A graft may be *saved* if a collection of serum or haematoma is evacuated early. Great care must be taken not to *lose* a good graft through clumsy or careless removal of the dressing.

Grafts require careful nursing care.

In ICRC practice, the graft is first inspected after 48 – 72 hours; the dressing is carefully removed using two pairs of tissue forceps: one holding the graft and keeping it applied to its bed, the other removing the dressing. Care must be taken not to tear away the graft. If the graft is healthy and adherent to the recipient base, another vaseline-gauze and compress are bandaged in place and no further dressing is necessary for another 10 days, until the time of stitch removal.

If a haematoma or seroma is found, the fluid should be expressed through the meshed gaps using gentle pressure applied through the forceps and a pledget of soaked cotton-wool. Another firm dressing of vaseline-gauze is applied. These grafts are then inspected on a daily basis until firmly adherent to the recipient base.

Any small pus collections should be debrided with scissors to prevent spread of infection. Intra-epidermolysis is a phenomenon where the outer layer of the graft is lost while viable epithelial cells remain at the base. Dark blisters can be seen and may be debrided but great care should be taken not to disturb underlying graft that may still be viable.

On the other hand, any graft which is dead or floating on a "sea of pus" should be removed and the wound cleaned with normal saline. (If Pseudomonas is the culprit – presence of bluish-green pus – a dilute vinegar solution is useful.) If the raw area of the wound is more than 2 x 2 square cm, it should be re-grafted when clean. If smaller, it can be left to heal by secondary intention.

At ten days, a healthy graft should be firmly adherent and can be left exposed and submitted to a simple daily inspection.

11.2.8 Dressing of donor sites

Split-thickness donor sites can bleed briskly, and in children can result in significant blood loss. As mentioned above, the donor site should be infiltrated intradermally with a 1:500,000 solution of adrenaline or a local anaesthetic with adrenaline to decrease bleeding. They can also be extremely painful, especially when dressings become firmly adherent.

The following regimen minimizes discomfort and complications.

1. After harvesting the SSG, a dry dressing should be applied immediately, kept in place if necessary with an elastic bandage, and left alone while the graft is being applied; by which time haemostasis has usually been achieved.
2. The dressing should then be removed. If there is persistent bleeding, a compress wetted with the dilute adrenalin solution should be applied and direct pressure exerted for a few minutes.
3. Next, the donor site should be covered with a firm pressure dressing of vaseline-gauze, dry compresses and elastic bandage; it should be kept from falling down the limb by adhesive strapping. The dressings should be left *in situ* for 10 –14 days, unless there are signs of underlying infection.
4. A membrane dressing, such as Opsite ®, can be used if available. If fluid accumulates beneath the membrane, it can be evacuated by pricking with a needle and pressing. The perforation site should be covered with a smaller piece of membrane. If the dressing falls off it can be reapplied. Generally, this stays in place for the desired period of about ten days.

11.3 Full-thickness grafts

Full-thickness skin grafts consist of the epidermis and entire dermis. These grafts are used principally for the *head and neck* and *hands and feet* to provide thicker, better-quality cover.

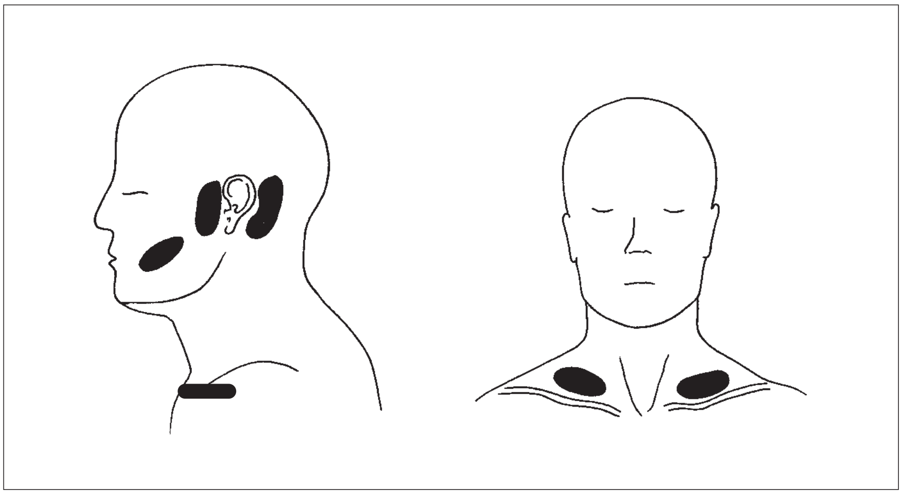
Full-thickness grafts have a number of advantages apart from better texture and colour. They allow for the transfer of hair-bearing skin, as all the dermal adnexal structures are intact, and they contract less than split-skin grafts. The main disadvantages are a lower survival rate and their limited size.

The recipient bed must be in optimal condition to take a full-thickness graft; haemostasis, in particular, must be perfect. There should be meticulous suturing and approximation between the graft and the recipient edge. Generally, a full-thickness graft is small because the plasma exudate of the recipient bed is barely sufficient to feed and oxygenate the graft, and capillaries from the recipient bed and edge and graft undersurface must grow in quickly to assure survival.

11.3.1 Donor sites

The best and most readily available donor sites are the supraclavicular fossa, in front of and behind the ear, and the flexor surface of the forearm or the groin creases. In older persons, the cheek or the neck in the line of a skin crease may also be used. The donor site is sutured primarily following harvesting of the graft.

Figure 11.10
Donor sites for full-thickness skin grafts.



P. Zylstra / ICRC

11.3.2 Technique

The graft can be taken under local anaesthesia. The donor and recipient areas are cleansed in a sterile fashion and a template of cut gauze compress made to fit the defect exactly. The template is placed on the donor site and an outline drawn around its circumference. The donor area should be injected with local anaesthetic *with* adrenaline and the edge of the recipient area with local anaesthetic *without* adrenaline; both are left for five minutes before incision. The full-thickness skin should then be excised exactly.

The graft must be *thoroughly defatted* before application. This is best achieved by placing the moist graft, epidermis-side down, on the finger tip and scrupulously excising the fat using fine scissors. The graft is left unmeshed.

The graft is then sutured in place immediately and meticulously. Several interrupted nylon sutures are inserted close to the edge and left long for tie-overs (Figure 11.11). Small interrupted or continuous fine nylon sutures (5/0 if available) are placed around the circumference.

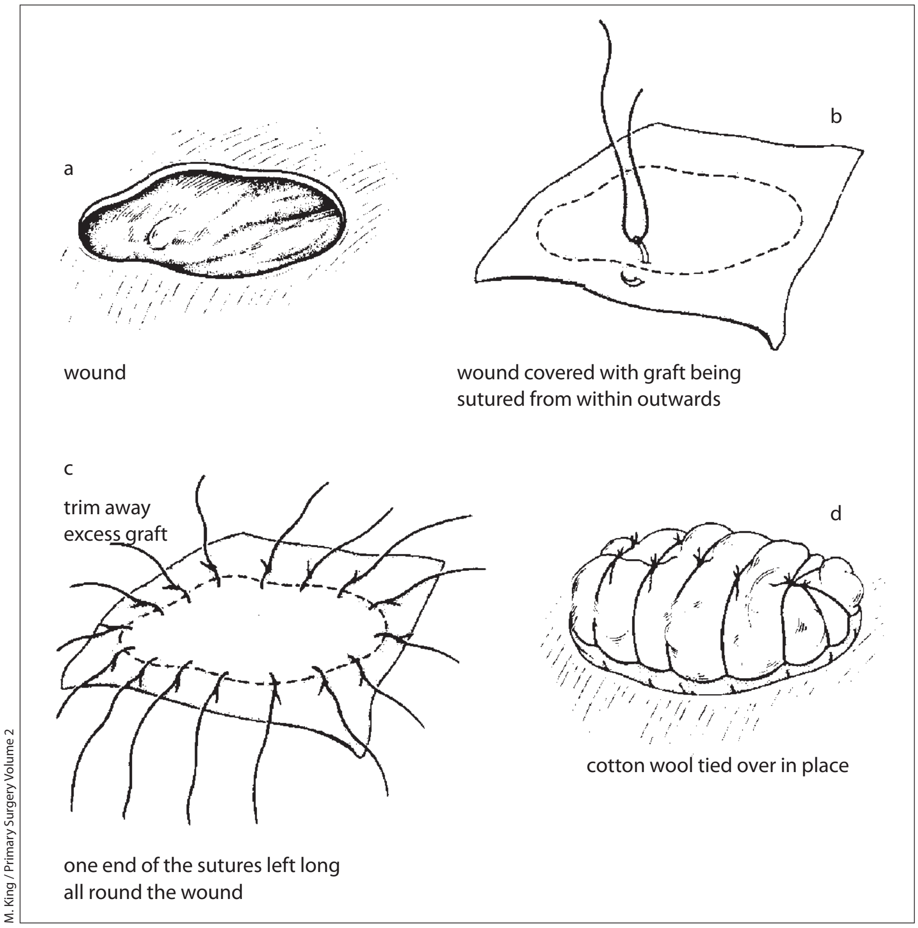


Figure 11.11

Tie-over method of securing skin grafts.

Face grafts may be left open and covered with antibiotic ointment. They may be gently rolled with gauze or poked with a needle in the first 48 hours to express small serum collections.

On the hands or over a flexion crease, once the graft has been sutured in position a bolus of dressing is fashioned with vaseline-gauze and moist cotton-wool pledgets to hold the graft closely in contact with the recipient bed. The tie-over sutures are brought together over the dressing, which should be snug, but not so tight as to strangle the graft.

The dressing should be left in place for 7 – 10 days and then removed. At this point, in both light- or dark-skinned people, the graft may be any colour from pinkish or pinkish-white to bronze to black. Even a graft that has a blackish appearance on inspection can survive. No judgement on graft survival should be passed until a month from the time of application.

11.4 Healing by secondary intention

Some small wounds are difficult to suture without tension, or without very wide mobilization of skin flaps, because their surrounding edges are fibrotic. There is little benefit in another surgical operation, even skin-grafting. These wounds are best left to granulate and heal by secondary intention (Figure 12.10).

A change of dressing and gentle washing with normal saline every 4 – 5 days is usually sufficient: every dressing is a trauma to a healing wound. Daily dressings are not necessary if the wound is dry. Some traditional local dressings (sugar, honey, etc.) have an antibacterial effect and promote the formation of granulation tissue and are useful if the wound is deep. They have been used successfully by ICRC surgical teams.

Chapter 12

NEGLECTED OR MISMANAGED WOUNDS

12.1 General considerations

As described in Chapter 10, in many war zones today, characterized by irregular bush warfare, rebellions and insurrections, neglected and mismanaged wounds are amongst the commonest injuries that the surgeon sees. First aid is not available, doctors and nurses are scarce, and health services have been disrupted by poverty and conflict. Distances are long and the terrain difficult with little in the way of organized transport. Many patients reaching hospital have wounds which were inflicted more than 24 hours earlier, and some have wounds that are many days, or even weeks, old. Even if injured patients reach hospital fairly quickly, the sheer number of casualties often exceeds the surgical capacity or expertise available. The result is an inordinate delay in their treatment or frank mismanagement.

ICRC EXPERIENCE

In the ICRC hospital of Lokichokio in northern Kenya serving the victims of the conflict in southern Sudan, 12,264 war-wounded patients were registered between 1991 and 2006 in the ICRC surgical database. Evacuation was by ICRC and United Nations airplanes and few, if any, received pre-hospital treatment of any sort. Of these patients, 84 % reached the hospital more than 72 hours after injury. ICRC staff have seen similar conditions of delay in evacuation to a surgical facility in Somalia, the Democratic Republic of the Congo, Nepal and elsewhere, and have seen the same phenomenon with crush wounds after earthquakes in low-income countries.

H. Nasreddine / ICRC

Figure 12.1.1

Patient A: The gunshot wound to the left iliac region was sutured 5 days previously. The wound to the right thigh underwent insufficient wound debridement.

Before reaching a proper surgical hospital, some patients receive no treatment at all; others a cursory dressing, while yet others have undergone an inadequate wound excision. Some wounds will have been sutured, generally without any form of excision.

All sutured wounds, no matter how clean they appear, must have their sutures removed and opened up for drainage. As mentioned previously, the simple rules of septic surgery apply. Never close infected or contaminated wounds primarily.

Remove all sutures from previously sutured wounds.

After delay, some Grade 1 minor soft-tissue wounds are found to be healing spontaneously. Most wounds, however, will be inflamed or frankly infected with a degree of chronic infection, and some will be grossly putrefying. This is often seen in mismanaged wounds. Tetanus, gas gangrene, and invasive haemolytic streptococcal infection are ever present dangers (see Chapter 13). These wounds require aggressive excision.

12

H. Nasreddine / ICRC

Figure 12.1.2

The sutured wound is infected; a pearl of pus is evident at the lateral edge.

H. Nasreddine / ICRC

Figure 12.1.3

Sutures have been removed revealing abundant pus.

ICRC

Figure 12.2.1

Patient B: primary suture was performed – note the tension in the wound due to tissue oedema and infection. Some sutures have been removed.

ICRC

Figure 12.2.2

All stitches have been removed – the skin edges are ischaemic and necrotic and the subcutaneous tissues oedematous.

ICRC

Figure 12.2.3

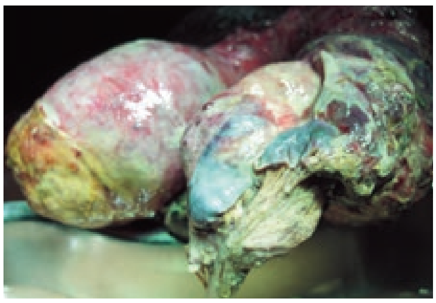
After redebridement – the wound is now larger than the original injury.

H. Nasreddine / ICRC

Figure 12.3

Neglected gunshot wound to the knee with frank infection.

H. Nasreddine / ICRC



H. Nasreddine / ICRC

Figures 12.4.1 and 12.4.2

Neglected wound to the scrotum with gangrenous tissue.

Figure 12.5

Maggot infestation of a wound. (The colouring is due to gentian violet.)

Please note:

Many neglected wounds are infested with maggots. There is a long historical literature about "maggot debridement therapy", especially for chronic wounds, and a number of surgeons around the world practise it today. Suffice it to say that, for cultural and psychological reasons, most patients do not accept such a method. ICRC experience in this domain, although often positive, can only be described as anecdotal.

Please note:

There is much clinical and experimental evidence to back the claim that the early administration of antibiotics, penicillin in particular, can delay the advent of serious infection in war wounds. It is ICRC practice in first-aid posts to begin penicillin as soon as possible. However, adequate first-aid measures, as described in Chapter 7, are seldom available in many contemporary theatres of war and it is to this context that the present chapter is devoted.

12.2 Chronic infection: the role of biofilm

The chronic pyogenic infection of a neglected wound has its own particular pathology and bacteriology, and life history. Bacteria exist in discrete colonies only in a laboratory. The natural state of bacteria through natural selection is to become attached to surfaces, especially to inorganic or dead matter, such as sequestrated bone and cartilage. In chronic infection, bacteria secrete a glycopolysaccharide biofilm; this is the "slime" one feels on the rocks in a river. This biofilm protects the bacteria and prevents not only antibiotics, but macrophages, leukocytes and antibodies from attacking them. It must be actively broken up in order to eradicate the infection.

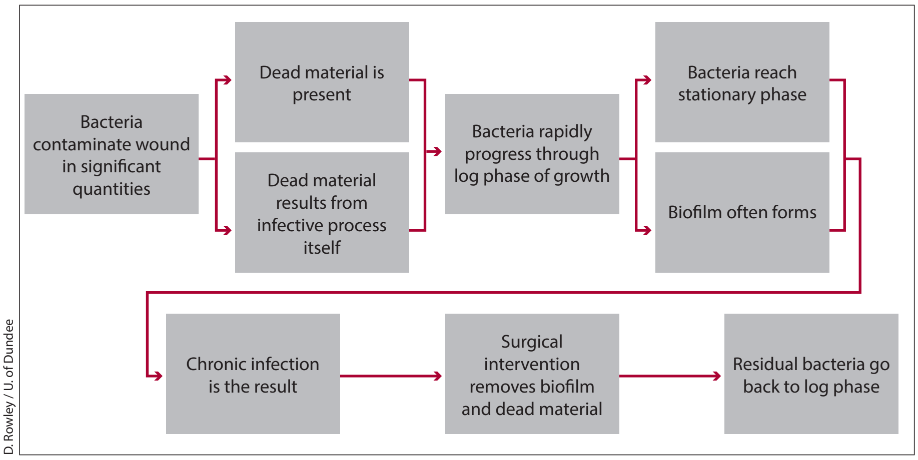
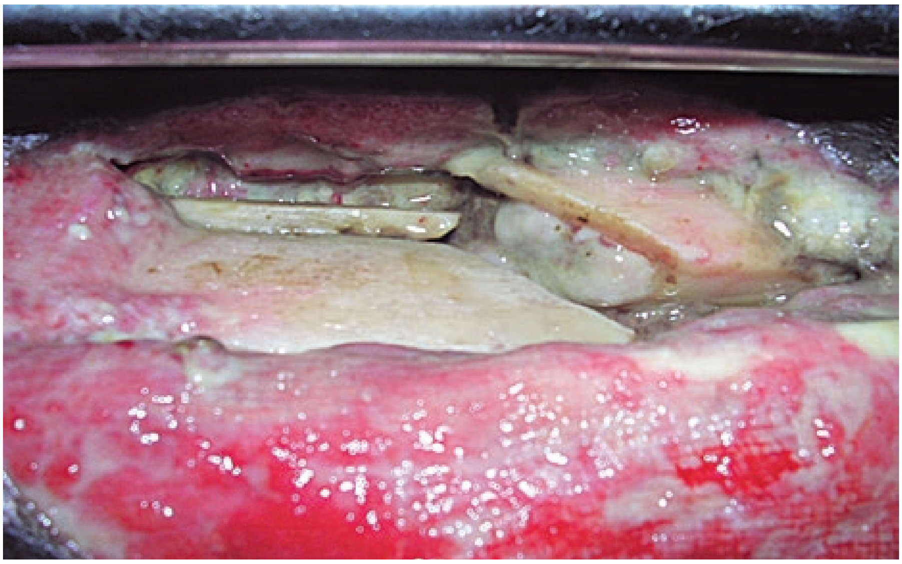


Figure 12.6

Schema of the chronic infective process.[1]

The biofilm is secreted during the stationary phase of bacterial life. Physical disruption of this biofilm and surgical removal of the dead tissues are required to push the bacteria back into the rapid multiplication of the log phase when they are most susceptible to antibiotics and the body's natural defence mechanisms.

1 Rowley D.I., University of Dundee, Course on chronic bone infection, Seminar on the Management of War Wounds; ICRC: March 18, 2005; Geneva.



E. Dykes / ICRC

Figure 12.7.1

Neglected infected wound showing a layer of biofilm pus.

M. Dalla Torre / ICRC

Figure 12.7.2

Neglected wound of a traumatic amputation stump, without biofilm layer.

R. Coupland / ICRC

Figure 12.7.3

Neglected wound to the arm with necrotic tissue, but dry.

12.3 Surgical excision

Surgical excision is a more difficult procedure in these neglected and mismanaged wounds. The line of demarcation between viable and non-viable tissue, especially in oedematous muscle and fascia, is less obvious, and the zone of post-traumatic inflammatory hyperaemia is compounded by that of infective inflammation and the presence of the biofilm. The extent of adequate excision is more difficult to assess since there is not only a "mosaic" of ballistic tissue damage in the permanent cavity itself but also that due to the septic process. Festering wounds that are days old have regions of infection mixed with regions of fibrous tissue healing.

The wound often resembles a cavity filled with detached soft tissue, bone fragments or the ends of fractured long bones, foreign debris, and fibrous tissue, covered with a coat of pus (Figures 12.7.1 and 12.8.2). Access may be difficult because of areas of wound contracture due to the tough fibrous tissue.

The principles of surgery remain the same, however. The skin and deep fascia must be widely re-incised and the wound cavity laid open for proper visualization and drainage (drainage following the same principle as for a simple abscess). The excision is directed towards the *removal* of all non-viable and heavily contaminated tissue and foreign debris, and the *physical disruption* of the biofilm.

Because surgical excision is more difficult in these wounds, there is a higher incidence of persistent infection. In such circumstances, several redebridements may become necessary. Depending on the experience of the surgeon, these are the patients who might most benefit from staged serial debridements.

12.3.1 Soft tissues

If present, all sutures must be removed and debridement performed as if no previous wound toilet had been done.

All macroscopic contamination should be excised. Skin and subcutaneous fat must be cut back until they ooze blood. Grossly infected fascia is usually shredded and dull grey, while healthy fascia is a glistening white. The muscle compartments are in even greater need of decompression than those of a fresh wound.

Contractility is the best indication of muscle viability. On the other hand, the surgeon must learn to distinguish between bleeding from small vessels in partially necrotic tissue, and capillary oozing from healthy but inflamed tissue. Experience brings an increase in the amount of tissue excised. Vessels and nerves should be left intact on the other hand, because they rarely turn septic.

Operative blood loss is usually considerable because of the inflammatory oedema and hyperaemia.

It is even more important *not* to open up healthy tissue planes in an attempt to remove any projectile. This will only help to spread the infection.

12.3.2 Bone

If there is an underlying fracture in these infected wounds, it usually contains *detached and necrotic* bone fragments that provide the perfect "surface" for bacterial adhesion. It is vital that these be found and removed. A plain X-ray will assist in their identification (Figure 12.9.2).

F. Jamet / ICRC

Figure 12.8.1

Gunshot wound 7 days after inadequate debridement.

F. Jamet / ICRC

Figure 12.8.2

Obvious sequestra presenting at the wound surface – note the presence of a pus-filled biofilm covering bone and soft tissue.

F. Jamet / ICRC

Figure 12.8.3

Wound 7 weeks after debridement.

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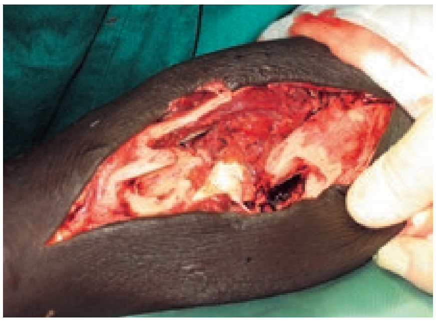
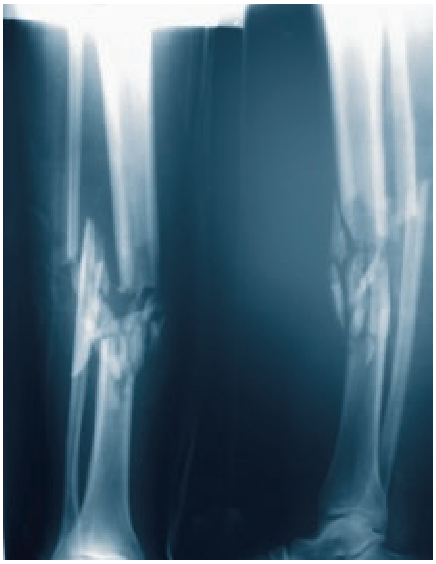
Totally detached bone fragments are often trapped inside fibrous tissue and their localization and identification can be extremely difficult and frustrating.

- A dead bone fragment is pearly white; living bone is dull greyish-white with red capillary specks.
- If scratched with a bone curette, dead bone will give off a high and hollow resonance; living bone sounds low and dull.
- Another telltale sign can be observed when the bone fragment is grasped with forceps and a motion of pronation and supination imparted. If muscle or periosteum is holding the fragment in place, these structures will move with the pronation and supination. If the fragment is detached and held by fibrous tissue only, the movement will break the fibrous adhesion and the bone fragment will come free.



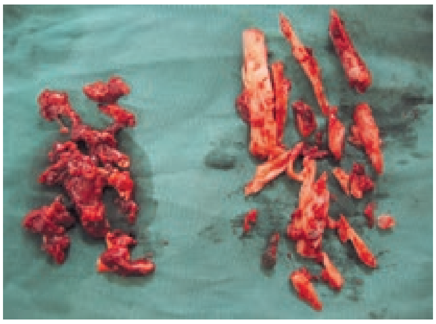
H. Nasreddine / ICRC



H. Nasreddine / ICRC

Figures 12.9.1 and 12.9.2

All loose bone fragments must be removed.



H. Nasreddine / ICRC

Figure 12.9.3

Bone fragments on the right, excised fibrous tissue on the left.

Once all loose bone fragments have been removed, the wound cavity is then curetted and a careful finger exploration performed to confirm a smooth surface: sharp bone edges may injure the exploring finger! All detached and dead bone fragments must be removed; they are already sequestra. Sometimes, several attempts may be necessary to eliminate them all, i.e. several redebridements.

All detached bone fragments are sequestra.

12.3.3 Irrigation

The wound is now copiously irrigated and dressed as for routine surgical excision. The ICRC has tested irrigation with a high-pressure pulsatile lavage and daily showering of the open cavity in these neglected infected wounds. Although both techniques appeared to clear up the biofilm and afford a better assessment of tissue viability, the results were inconclusive. Both involve a great deal of time, effort, and nursing care, and are difficult to maintain if a large number of patients are under treatment with no possibility of transfer to other less overstretched facilities.

12.4 Antibiotics

Penicillin and metronidazole are given, according to the antibiotic protocol (see Chapter 13); and gentamycin is added if there are signs of active spreading inflammation. No topical antibiotics or antiseptics are used in ICRC practice.

Bacterial culture should be done, if available. Good bacterial culture and sensitivity in a forward hospital is far more diffucult to accomplish than is usually realized. Note that clinical response does not always follow laboratory sensitivities, or lack thereof. Not only do "wild" bacteria not live in colonies, but *in vitro* sensitivity does not always reflect *in vivo* response, and the surface or discharge flora does not always represent the bacteria present *inside* the tissues.

Nonetheless, the basic rules of septic surgery still apply. Infection requires good drainage – as with an abscess – and the elimination of the bacterial culture medium, i.e. the dead tissue. Antibiotics will only be effective once the biofilm has been disrupted and the bacteria made susceptible to their action.

Persistent or recurrent wound infection requires re-excision, not ward dressings.

12.5 To close or not to close?

The primary phase of wound healing begins at the moment of wounding. It is well established by the time of presentation if the wound is a few days old. Thus, several days after surgical excision, many wounds are past the time of healing by primary intention. There is already much fibrous tissue present (Figure 12.9.3) and even more by the time the wound is clean and ready for closure. If secondary suture is attempted there is usually considerable tension on the wound edges with a high incidence of necrosis and breakdown.

The majority of these wounds are unsuitable for delayed suture and require skin grafting or rotation skin flaps for closure; or, if small, should be left to granulate and heal by secondary intention (Figure 12.10).

Most delayed or neglected wounds will be unsuitable for delayed primary closure.

It is in healing by secondary intention that several traditional local wound treatments may be of value, as mentioned in Chapter 11. ICRC surgeons and nursing staff have used dressings of honey or sugar, or hypertonic saline (add salt to normal saline until it no longer dissolves), which promote granulation tissue formation and have antibacterial properties. It must be emphasized that these topical treatments are an *adjunct to*, and *not a replacement for*, adequate surgery.

F. Jamet / ICRC

Figure 12.10
Healing by secondary intention.

Many patients with severe wound infection or frank putrefaction are malnourished, anaemic and dehydrated. As a result wound healing is poor and special measures should be taken to address these concerns.

For a discussion of post-traumatic osteomyelitis, see Section 22.9 in Volume 2.

Chapter 13

INFECTIONS IN WAR WOUNDS

13.1 Contamination and infection

All war wounds are grossly contaminated by bacteria. Bullets and fragments are not sterilized on discharge and, at the entry site, bacteria are carried into the tract by the contaminated projectile itself. Furthermore, the negative pressure of the temporary cavity at both entrance and exit wounds also sucks in bacteria.

War wounds are dirty and contaminated from the moment of injury.

Other contaminants found in war wounds include clothing fragments, dust, miscellaneous organic matter (mud, grass, leaves, etc.), and wood and glass splinters from bombed buildings. Studies in Korea and Viet Nam showed that different varieties of soil are associated with different organisms – which also vary according to weather and season – with varying likelihood of producing severe infection (mud and agricultural soil contaminated with animal or human excrement are apparently the worst). In addition, the chemical composition of some soils can inactivate antibodies and impair leukocyte phagocytosis. Various home-made landmines have contained animal manure contaminant.

It is important, however, to distinguish between:
- simple contamination of a wound;
- local infection;
- invasive infection.

In a contaminated wound, bacteria proliferate in dead tissues but no invasion of viable tissue takes place until the number of bacteria reaches a threshold of 10^6/gram of tissue. The presence of crushed tissues, dirt, and other foreign materials lowers the threshold of infection and invasion, by providing an environment where bacteria can grow and replicate without the patient's immune system being able to eliminate them. There are a number of microbe-related risk factors involved: virulence, production of enzymes and toxins, etc.

The body attempts to wall off the mass of necrotic muscle and bacteria with a fibrin barrier. Without adequate drainage, this will form an abscess; with proper drainage the necrotic mass will be expelled after 10 days.[1] In both cases, the body's natural defence mechanisms come into play to isolate the contaminants and the dead tissues.

When the local defence mechanisms can no longer cope, invasive deep tissue and systemic infection occurs. Patient immunity and resistance can also be weakened by malnutrition and chronic disease, especially HIV/AIDS. The local defence mechanisms and general resistance constitute the host-related risk factors.

Six hours appears to be the critical period after contamination. The efficacy of surgery and antibiotics in preventing infection decreases with time from injury, while the bacterial load increases exponentially. As with the differential grading of wounds according to the Red Cross Wound Score described in Chapter 4, a good understanding of the pathology involved is important in determining the proper and adequate procedure to follow, and the usefulness of antibiotics to supplement excision, drainage, and the body's natural resistance to infection. Uncomplicated soft-tissue Grade 1 wounds, as already explained in Section 10.8.1, can be treated with simple wound toilet; an antibiotic treatment helps if begun within 6 hours. Early administration of antibiotics in more severe wounds seems to inhibit bacterial growth and limit local invasion, at least temporarily. Any delay beyond six hours, however, greatly increases the risk of infection.

1 Fackler ML, Breteau JPL, Courbil LJ, Taxit R, Glas J, Fievet JP. Open wound drainage versus wound excision in treating the modern assault rifle wound. *Surgery* 1989; **105**: 576 – 584.

13.2 Major bacterial contaminants in war wounds

The relative preponderance of various bacterial species differs according to geography, topology of the terrain, and climate: agricultural land, urban environment, jungle, or desert; summer or winter. The presence of community-acquired resistance in "normal" body flora also differs from region to region, and with the passing of time.

Nonetheless, certain constants remain, and the following list gives a general indication of the common pathogens involved in infections of war wounds.

Gram-positive cocci
Staphylococcus aureus and β-haemolytic streptococcus. These are a normal part of the skin flora. In recent years, community-acquired methicillin-resistant *Staphylococcus aureus* (MRSA) has become more of a problem in certain countries.

Gram-negative bacilli
Escherichia, Proteus, Klebsiella, Pseudomonas, and Bacterioides are found in the gastro-intestinal tract. Acinetobacter *baumannii* is to be found in the soil and on the skin and has recently become important in causing nosocomial infections.

Gram-positive bacilli
The Clostridia species are spore-bearing obligatory anaerobes. They are widely distributed in the environment, especially in agriculturally fertile soils, and are carried in the faeces. They are the cause of gas gangrene and tetanus.

Wounds to the upper thigh and perineum are particularly at risk from contamination by faecal organisms (Clostridia and Gram-negative bacilli), even without bowel perforation. Bowel injury demonstrably increases the risk of infection.

> War wounds have a "bacteriological life history": contaminating bacteria change with time.
>
> Different infections occur early or later in the wound's history.

The important point to note about this varied bacterial flora is that wound contamination is not static. That war wounds have an evolving "bacteriological life history" from the time of injury has been known since World War I and the studies made by Alexander Fleming.[2]

Many studies since have demonstrated that wound contamination – and any resulting infection – evolves with time. At the instant of wounding, there is polymicrobial contamination with particular risk from Clostridia and β-haemolytic streptococcus. Afterwards, self-contamination from skin and gastro-intestinal flora occurs; finally, hospital-acquired nosocomial bacteria may step in. In addition, many studies have shown that initial wound cultures are useless at best, and misleading at worst, with little relevance to any ultimate infection.

This concept is essential to understanding the roles of hygiene and environmental control measures, adequate surgery, and the use of antibiotics: i.e. the operation-related risk factors.[3] The widespread availability of antibiotics – and their misuse – during the last fifty years has further complicated the bacteriology of wounds because of the hospital selection of resistant strains. Whether infection follows contamination, and what type of infection develops, depends on a number of factors.

> The major threats faced by the war-wounded are the development of gas gangrene, tetanus, and invasive streptococcal bacteraemia, which can all be fatal.

2 Fleming A. On the bacteriology of septic wounds. *Lancet* 1915; **186**: 638 – 643.

3 Rubin RH. Surgical wound infection: Epidemiology, pathogenesis, diagnosis and management. *BMC Infect Dis* 2006; **6**: 171. Available at: http://www.biomedcentral.com/1471–2334/6/171.

13.3 Major clinical infections of war wounds

The polymicrobial nature of wound contamination can result in a variety of infections. Several specific lethal infections are notorious in war wounds, especially in neglected or mismanaged wounds, and particularly if they have been stitched closed without proper excision. Common pyogenic wound infection runs through a spectrum of disease from the minor (superficial surgical site infection) to the severe (organ or space surgical site infection) and systemic (septicaemia).

13.3.1 Definitions

Simple contamination
The surgical literature classifies wounds as clean, clean-contaminated, contaminated, and infected or dirty. War wounds are considered contaminated and dirty.

Cellulitis/local abscess formation
Bacteria begin to spread to tissues that are contiguous to the wound, in the zone of contusion (see Chapter 3). Little systemic toxicity exists. Superficial erythema and seropurulent discharge occur; some necrotic tissue is evident, but this is related to the original injury and not to the infection. Eventually a mass of necrotic tissue and bacteria forms; if drainage is inadequate (small skin wounds), an abscess develops. In a large wound, the mass will be walled off and then expelled.

Myositis/deep tissue infection
Bacteria spread into muscles and tissues further than the permanent cavity and the zone of contusion and invade the zone of concussion and beyond. Systemic symptoms become more pronounced and, with certain infections, come to dominate the clinical picture. Overwhelming infections usually present with the classic signs of sepsis (fever, tachycardia, etc.); but they may also present without these signs, particularly in immune-compromised patients (HIV/AIDS, chronic disease, malnutrition).

In the past, deep-tissue infections were usually caused by Clostridia and invasive β-haemolytic streptococcus and accounted for the greatest amount of tissue damage, and the most severe systemic signs and symptoms. The availability of penicillin has radically changed this clinical picture.[4]

Different types of invasive tissue infection have been described:
- Pyogenic deep tissue infection – this is usually a mixed infection, Gram-positive and -negative organisms, often including non-clostridial anaerobes.
- Gas gangrene: this infection is still seen in neglected and mismanaged wounds.
- Tetanus: poverty and the disorganizing effects of war disrupt immunization programmes in many countries – this infection is still, all too often, a major killer.
- Invasive streptococcal infection – also still seen in neglected and mismanaged wounds.
- Bone infection: when deep-tissue infection extends to sequestrated bone fragments, chronic infection tends to develop with the production of a "biofilm" – this is often seen in neglected and mismanaged wounds (see Chapter 12).
- Necrotizing fasciitis, synergistic gangrene and anaerobic cellulitis.

4 Polhemus ME, Kester KE. Infections. In: Tsokos GC, Atkins JL, eds. *Combat Medicine: Basic and Clinical Research in Military, Trauma, and Emergency Medicine*. Totowa, New Jersey: Humana Press; 2003: 149 – 173.

13.3.2 Gas gangrene

Gas gangrene as a particular complication of wounds has been known since the time of Hippocrates. Its occurrence in war wounds throughout history as well as in other trauma has been widely described mainly because of its dramatic manifestations and very high associated mortality. Delay to surgery, as may occur during war or after a natural disaster with mass casualties, greatly increases the risk of gas gangrene.

Gas gangrene is a rapidly-spreading oedematous myonecrosis occurring characteristically in severe wounds in muscles contaminated with pathogenic obligatory anaerobes, particularly *Clostridium perfringens*. Almost every case presents a mixed bacterial flora; aerobes use up available oxygen and promote the anaerobic environment required by Clostridia.

In large muscle wounds there will always be areas of ischaemia and the potential for gas gangrene. But gas gangrene can also develop even when the trauma is not very severe. If the wound is deep, contains necrotic tissue, and is isolated from the surface, an anaerobic environment is formed and it is possible for a clostridial infection to become established. This deep anaerobic environment is seen particularly in wounds sutured closed without debridement. The presence of foreign material in wounds, especially soil, will increase the risk of developing gas gangrene. The prolonged application of tourniquets or tight plasters and fascial compartment syndrome also present high risks. The infection is more common in wounds to the lower limb and perineum than to the upper limb.

The features of the disease result, first, from the local action of the organisms on muscle glucose, producing acid and gas, and on muscle protein, causing digestion. Second, the organisms produce soluble, very potent toxins, which diffuse into the tissues causing further tissue destruction and profound toxaemia. The muscle breakdown products are very toxic in their own right. The combination of breakdown products and specific toxins causes the relentless and profound toxaemia which, if untreated, will inevitably lead to death.

Early and adequate surgery will prevent gas gangrene in war wounds.

The incubation period of gas gangrene is usually short, almost always less than three days, and in the majority of cases less than 24 hours long; it may even be as short as 6 hours. Incubation periods of up to six weeks have occasionally occurred.

Typically, gas gangrene manifests itself with the sudden appearance of increasing pain in the region of the wound. The sudden onset of pain, sometimes so sudden as to suggest a vascular catastrophe, always suggests the possibility of gas gangrene in a wounded person. Soon afterwards the limb becomes oedematous and is associated with drainage of thin serous or serosanguinous exudate, which may become gelatinous. The pulse rate rises markedly but the patient's temperature is rarely higher than 38° C. As classically described, clinical deterioration takes place quickly and within several hours the patient becomes anxious and frightened, or may even be euphoric, and exhibits all the signs of severe sepsis.

The skin is tense, pale, often marbled with blue, and rather colder than normal. In untreated cases, local bronzing of the skin becomes more diffuse, greenish yellow areas appear in which blebs may form and become filled with dark red fluid, and patches of cutaneous gangrene may occur. The skin may, however, appear normal, even when lying over massive gangrene.

R. Coupland / ICRC

Figure 13.1.1

Gas gangrene of the leg following the application of a tourniquet.

J. Goosen / South African Military Health Service, U. Witwatersrand

Figure 13.1.2

Gas gangrene of the arm.

Rapidly, swelling oedema and toxaemia increase, the serous discharge becomes more profuse and a peculiar sweetish smell may be present. The smell is variable and not pathognomonic.

Gas is usually produced at this stage and is partly responsible for the swelling of the affected part (Figure 13.2). It is produced in and between the muscle fibres, follows the fascial planes, and eventually escapes into the subcutaneous tissues under pressure through holes in the fascia, spreading rapidly beyond the confines of the infected area. Crepitus may be felt under the skin if the part is palpated. The extent of the spread of gas is not equivalent to the extent of muscle necrosis.

Infection spreads up and down the muscle from the site of the wound but has little tendency to spread to other healthy muscles; the bacteria is a strict anaerobe. Even in well-established gas gangrene, the bloodstream is rarely invaded by Clostridia until immediately before death.

The muscle changes are usually only seen at operation. In the early stages, they consist of little more than swelling and pallor. Later, the colour alters to a lustreless pinkish-grey, then to brick red, and finally to a dark green-purple colour.

E. Dykes / ICRC

Figure 13.2

X-ray showing gas collections between muscle groups.

Management

All patients with missile wounds should receive prophylactic antibiotics that are effective against Clostridia, such as penicillin, metronidazole, first generation cephalosporin, or erythromycin. But the antibiotics can only reach tissues with a blood supply and good tissue perfusion. Antibiotic concentrations in the dead muscle in the depths of an anaerobic environment are ineffective. Surgery as early as possible is the goal to be attained.

The basis of management of established gas gangrene is thorough excision of dead tissue, which might necessitate urgent amputation. The limit of excision is necrotic muscle, not the extent of tissues containing gas. Tissues must be cut away until healthy red, bleeding, and contracting aerobic muscle is reached.

> Immediate surgical intervention is essential in the management of gas gangrene.

Because of the severe toxaemia, supportive measures including oxygen, fluids and fresh whole blood should be instituted. Appropriate antibiotics should be continued.

13.3.3 Tetanus

Tetanus is always a risk with any penetrating wound. The risk is greater for severely contaminated wounds, especially small, deep, punctate-type ones. Pyogenic infection in the depth of a narrow track can create the necessary anaerobic environment. The incubation period is 3 to 21 days, but can be as short as 1 day to as long as several months.

E. Dykes / ICRC

Figure 13.3
Badly infected wound giving rise to tetanus.

Virtually total protection can be obtained by active immunization with a full course of tetanus toxoid injections.

Å. Molde / ICRC

Figure 13.4
Risus sardonicus in a patient suffering from tetanus.

Clostridium tetani is a strict anaerobe. The organism produces an extremely potent toxin called tetanospasmin that spreads along peripheral nerves to the spinal cord and brainstem. The toxin affects the motor end-plate by inhibiting cholinesterase, resulting in a build-up of acetylcholine and tonic muscle spam. There is, in addition, hyperexcitability of lower motor-neurones causing muscular rigidity and dysfunction of activity in antagonistic muscles that cause unopposed reflex activity, giving rise to the typical spastic phenomena of tetanus. Early signs are neck rigidity and *trismus* (stiffness of the jaw) with difficulty in swallowing, followed by *risus sardonicus* (grimacing smile). Profound autonomic nervous system dysfunction is also present in severe cases with unstable pulse rate, blood pressure and temperature, which are difficult to treat. Once the toxin is fixed to the nerves, anti-tetanus immunoglobulin can no longer neutralize it.

The infection may affect a single muscle group or be more generalized. Three clinical degrees are described:
- mild = no generalized spasms;
- moderate = generalized spasms on provocation;
- severe = spontaneous generalized spasms with opisthotonos.

The muscular spasms are quite painful, and can last a short time or go on for several weeks. The greatest danger is asphyxiation due to laryngeal spasm or aspiration. Frequently, there is a high temperature with profuse sweating that requires careful fluid replacement. The patient remains conscious throughout.

Prophylaxis

The best precaution against tetanus is active immunization. However, many patients in developing countries where conflict has further disrupted public health programmes are not immunized and therefore the risk of tetanus in war wounds is great. In some countries, ICRC practice is to proceed with active and passive immunization for all patients.

Early and adequate excision of dead tissue, and leaving wounds open, is vital to prevent its development. This is particularly important in small, deep, punctate-like wounds. Penicillin and metronidazole are the drugs of choice.

Tetanus prophylaxis for war wounds

All patients whatever their immunization status:

1. Tetanus toxoid vaccine 0.5 ml i.m. (5 LF units) – this is a booster dose in a previ-ously vaccinated patient.
2. Penicillin in large doses.
3. Thorough excision of the wound.

Non-immunized patients or those whose immunization status is in doubt, addition of:

4. Human tetanus immunoglobulin – also known as human anti-tetanus serum: 500 IU i.m. (adults) or 250 IU (children under 15 years of age).
5. Tetanus toxoid 0.5 ml i.m. to be repeated at four weeks and again at six months.

Please note:

Vaccine and immunoglobulin should be administered through separate syringes and at separate sites.

Treatment of established tetanus
Treatment of established tetanus should follow the steps listed below.

1. Extensive debridement of the wound. Ketamine anaesthesia should be avoided if possible as patients waking from this form of anaesthesia are often restless and have hallucinations and this may stimulate spasms. Spinal anaesthesia or a regional nerve block are excellent methods.
2. Antibiotics: crystalline penicillin G (5 MIU. i.v. QID) and/or metronidazole (500 mg i.v. TID). Erythromycin, tetracycline and chloramphenicol are also active against Clostridia, in case of allergy to penicillin.
3. Anti-tetanus human immunoglobulin (3,000 – 10,000 IU): a single large dose is given intravenously and as soon as possible. The actual dose ordered is dependent on the severity of the disease and the age of the patient. It is diluted in 20 ml of normal saline and given slowly over a period of 15 minutes. This can be given intramuscularly (undiluted) in the proximal part of the wounded limb if the type of immunoglobulin is not recommended for intravenous use. An intrathecal injection of 250 IU can be given, e.g. with spinal anaesthesia for debridement of the lower part of the body.

In some regions, human immunoglobulin is in short supply or not available at all. In these circumstances, one must rely on equine anti-tetanus serum. A test dose must be administered before giving the full dose (20,000 IU).

4. Control of the spasms: the patient should be nursed in an environment as devoid of stimulation as possible in a dark, quiet room. For severe cases, and in the best of circumstances, the patient should be in an intensive care unit, anaesthetized and paralysed, with mechanical ventilation. Many hospitals lack these facilities; control is based on sedation.

Intravenous diazepam, either intermittently or continuously, is used with doses of up to 20 mg or more per hour depending on the duration and intensity of the spasms. If diazepam alone does not control the spasms, chlorpromazine may be added, or thiopental (pentothal) may be required. This latter is given preferably by continuous infusion, which has been found to control the spasms more effectively with lower total dosages than if given intermittently.

Warning!

Oversedation can be as fatal as the disease.

For several years now, ICRC teams have used magnesium sulphate in high doses (40 mg/kg over 30 minutes, followed by i.v. infusion of 1 – 3 g/hour) with encouraging results. This regime allows lower doses of diazepam and thiopental to be used, thus avoiding oversedation: this line of treatment is still under investigation.[5]

5. Airway management is of the utmost importance to prevent aspiration. If laryngospasms persist, tracheostomy may be needed, and the decision to perform one should be taken early. Care of the tracheostomy tube is instituted with particular attention to how much this stimulates spasms, and adapting the sedation accordingly. Chest physiotherapy is required to prevent respiratory complications.
6. Fluid replacement: there may be excessive fluid loss due to sweating – this needs to be carefully monitored along with urinary output. A Foley urinary catheter should be placed.
7. Nutrition: if the spasms continue for some days, a feeding gastrostomy or jejunostomy may be required as a nasogastric tube may provoke spasms and become obstructed. Again, it is important to decide to perform this procedure early. These patients require a high calorie diet.
8. Excellent nursing care is fundamental. The patient's position must be changed four-hourly. Extra sedation may be required prior to this, as movement can provoke spasms. Patient hygiene – skin, oral and bowels – is essential.

Please note:

Clinical tetanus does not confer normal immunity. The patient therefore needs to complete immunization after recovering from the disease.

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Figure 13.5

Invasive β-haemolytic streptococcus infection of the abdominal wall.

13.3.4 Invasive streptococcal infection

Beta-haemolytic streptococcus produces powerful toxins that trigger a rapid progression of disease from local to systemic infection. It begins with a local cellulitis with severe pain out of proportion with physical findings, and advances rapidly to fever, tachycardia, disorientation and delirium. The wound is malodorous with large quantities of thin, blood-stained seropurulent discharge. The muscles suffer from a moist oedema, and turn from pale, to bright red, then dark purple-brown. Progression can occur in a matter of hours. It is still seen in mismanaged wounds, and especially if there is a delay in treatment.

Wound debridement, drainage, and massive doses of penicillin are the basis of management, along with supportive measures. Blood transfusion is usually necessary.

13.3.5 Necrotizing soft-tissue infections

Various non-clostridial spreading gangrenous infections have been described in the surgical literature: necrotizing fasciitis, synergistic gangrene, anaerobic cellulitis, etc. There is necrosis of the skin, subcutaneous tissues and fascia, but not of the muscles. It can rapidly progress to systemic toxicity and even death. Spreading gangrene can follow trauma or thoracic and abdominal surgery (postoperative synergistic gangrene), and affect persons suffering from a general disease, such as diabetes, or malnutrition; alcoholics are particularly at risk. Infection usually affects the torso, perineum or extremities. The bacterial flora is mixed, causing synergy amongst various organisms, anaerobic and aerobic, particularly microaerophilic nonhaemolytic streptococci in association with haemolytic staphylococci.

5 Thwaites CL, Yen LM, Loan HT, Thuy TTD, Thwaites GE, Stepniewska K, Soni N, White NJ, Farrar JJ. Magnesium sulphate for treatment of severe tetanus: a randomised controlled trial. *Lancet* 2006; **368**: 1436 – 1443.

In no case are healthy muscles involved, and the clinical picture is less dramatic than in gas gangrene. Nonetheless, the systemic toxicity is life-threatening. There is severe pain disproportionate to local findings, crepitus can often be felt and soft-tissue air is present on plain X-rays. The skin is discoloured (blue, purple or black) with blistering leading to haemorrhagic bullae and induration. The necrosis can spread widely causing a large soft tissue defect. The diagnosis is primarily a clinical one, and the earlier treatment is instituted the better the result.

Management includes:

- aggressive excision of necrotic tissue and the relief of tension, which may require serial debridements – amputation may be necessary in cases of necrotizing infections of the limbs – and defunctioning colostomy in cases of infection of the perineum with faecal contamination;
- leaving the wound open for drainage;
- triple intravenous antibiotics: penicillin, gentamycin and metronidazole;
- fluid resuscitation, blood transfusion and other supportive treatment.

Reconstructive surgery to cover the defect should only be considered once the patient's condition has stabilized and the infection is fully eradicated.

H. Nasreddine / ICRC

H. Nasreddine / ICRC

Figure 13.6.1 and 13.6.2

Necrotizing fasciitis with large skin loss and tissue defect.

13.4 Antibiotics

It is important to distinguish between the prophylactic use of antibiotics and their role in the therapy of established infection. The surgeon must also remember the life history of wounds and their changing bacterial flora.

Prophylaxis is aimed at preventing a specific infection. It is impossible to find any reasonable cocktail of antibiotics that would be effective against the entire "polymicrobial cesspool" that can contaminate a war wound. Nor is it desirable to do so. Such a practice would constitute a simple misuse of antibiotics and contribute to the development of bacterial resistance.

Old lessons for new surgeons

The best antibiotic is good surgery, good nursing care and good hygiene.

The surgeon must realize that trust in the efficiency of antibiotics will never replace good surgery, proper nursing techniques and good patient and hospital hygiene. Good surgery involves good diagnosis, good clinical decision-making, and good holistic management of the patient. Sometimes "good surgery" means knowing when not to operate. As we have seen, uncomplicated Grade 1 wounds and many civilian gunshot wounds can be treated conservatively and expectantly.

War wounds, however, are usually understood to be different from civilian weapon trauma; not always because of the weapon, but because of the environment. The battlefield is a dirty and contaminated place and the danger of invasive infection is always present, even in minor wounds; mass casualties cannot always be followed up correctly, there is often a long delay between injury and treatment, proper hygiene and nutrition cannot always be maintained and immunization is not always universal.

Under such circumstances, the basis of prevention of primary infection remains complete wound excision and good drainage, respect in the handling of the tissues and leaving the wound open for delayed primary closure. Antibiotics are only an adjunct to good surgical practice, and cannot compensate for poor surgery.

A case can be made for prophylaxis against the second series of infections – those acquired from the flora of the patient (skin, respiratory and gastrointestinal tracts) – if the occurrence of such infections becomes an important clinical problem in the functioning of a given hospital, and is proven by proper bacteriological studies.

Infections caused by bacteria with multiple antibiotic resistance and by opportunistic organisms, such as *Pseudomonas aeruginosa*, have become more prevalent with the uncontrolled use of wide-spectrum antibiotics. Again, good surgery and proper hygiene measures and environmental control cannot be replaced by antibiotics, and their use should be regarded as an adjunct only.

The prevention of nosocomial infection is another story. Proper clinical protocols and hygiene are the correct means of prevention: frequent hand washing; no unnecessary change of dressings on the ward; isolation of infected patients; adequate sterilization; good patient hygiene and proper cleaning of the hospital premises, etc. These alone can and will stop nosocomial infection. The use of antibiotics to supplement such measures will depend on the virulence of the particular bacteria involved.

A well-functioning bacteriology laboratory is important if antibiotic use is to be anything more than a "shotgun" approach or an "educated guess". Wound cultures are notorious for not predicting subsequent infections or infecting pathogens. In the absence of correct collection of specimens, aerobic and anaerobic, and proper bacterial culture and sensitivity techniques, an educated guess is the best that can be hoped for in most cases. Accurate bacteriological capability is a far more difficult endeavour in a forward hospital than most people realize.

13.4.1 Antibiotic prophylaxis in the primary treatment of war wounds

Antibiotics do not reach the source of infection in a missile wound – i.e. the culture medium of dead tissue, debris and foreign material – they only affect the contusion and concussion zones around the wound. However, early administration of antibiotics seems to inhibit bacterial growth and delay invasive infection. Antibiotics especially help prevent spread to the blood stream. The efficacy of antibiotics in preventing invasive infections in wounds that received no other treatment for hours to days after injury has been demonstrated,[6] and ICRC clinical experience confirms this. The ICRC recommends that the administration of antibiotics commence in the pre-hospital setting if at all possible.

As mentioned, historically the biggest killers of surviving war-wounded casualties have been primary infection by β-haemolytic streptococcus and Clostridia. This is a relatively narrow spectrum of bacteria, for which penicillin remains the best antibiotic. Alternatives include first-generation cephalosporin, tetracycline, metronidazole and erythromycin. It is often necessary to use these antibiotics because of a shortage of penicillin in many countries.

Prophylaxis for war wounds can only be assured for Clostridia and β-haemolytic streptococcus: penicillin is the drug of choice.

Single-dose or the administration of prophylactic antibiotics limited to 24 hours are indicated under optimal conditions of rapid evacuation, early pre-hospital first aid, and adequate infrastructural hygiene. In the ICRC context of limited resources, often less than ideal environmental control, and delayed evacuation, antibiotics are usually given for 5 days, until delayed primary closure.

Topical antibiotics and the washing of wounds with antibiotic solutions are not recommended.

6 Mellor SG, Cooper GJ, Bowyer GW. Efficacy of delayed administration of benzylpenicillin in the control of infection in penetrating soft-tissue injuries in war. *J Trauma* 1996; **40 (3 suppl.)**: S128 – S134.

ANNEX 13. A ICRC antibiotic protocol

For many years, the ICRC antibiotic protocol attempted to address two problems: prophylaxis and therapy. The prophylaxis part was simple and straightforward, as mentioned in this chapter. Prevention was aimed at specific bacteria that cause the traditional lethal infections of warfare: tetanus, gas gangrene and invasive haemorrhagic infection: *Clostridium tetani* and *perfringens*, and β-haemolytic streptococcus. The best antibiotic to cover these, and to which no resistant strain has been found to date, is penicillin.

No attempt was made to prevent the multiple possibilities of pyogenic infection of soft tissue and bone injury through antibiotics, as any such cocktail of antibiotics would be ineffective at best and a misuse at worst. Instead, the ICRC has always promoted the idea that the best antibiotic is good surgery: the surgical removal of all necrotic, non-viable, and contaminated tissues, and especially any organic foreign bodies. If the "food" of bacteria is removed, then the body's natural defence mechanisms should be able to address any bacterial burden. Good nursing practice and patient and hospital hygiene are also essential aspects of the prevention of wound infection.

Cranio-cerebral injuries were addressed as one would bacterial meningitis, while abdominal wounds received standard antibiotics given for non-trauma abdominal pathologies.

The therapy aspect was the more problematic. The great majority of patients arriving at ICRC hospitals were, and are, evacuated more than six hours after injury due to limitations in first-aid services, security concerns, and a simple lack of transport. In many instances, patients arrived days after injury. It was presumed that an infective process had already begun. The ICRC therefore prescribed the same regime of antibiotics, for a duration of five days. For prophylaxis this was probably excessive, but it did cover the period between initial wound debridement and delayed primary closure.

In order to facilitate good nursing care in situations where many personnel were national staff under training, it was decided to standardize the antibiotic protocol for all patients, whether the goal was prophylaxis or therapy.

For many reasons, but particularly the appearance of significant numbers of different multiple resistant bacteria around the world's combat zones, the ICRC has undertaken a geography-specific bacteriological study to better address this problem and adapt its antibiotic protocol accordingly. This study is on-going at the time of this revision of Volume 1.

Chapter 14

RETAINED BULLETS AND FRAGMENTS

14.1 The surgeon and the foreign body

There are hundreds of thousands of perfectly healthy people walking around the present and past war zones of the world who have retained projectiles in their body. These metallic foreign bodies often catch the attention of patients and relatives, who impute to them any pains and disabilities they suffer from and insist upon their removal, even after the wound has completely healed.

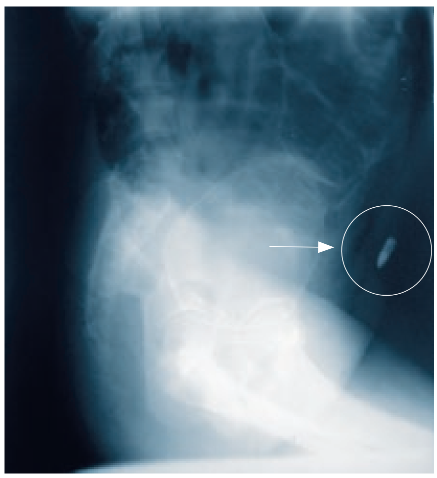
It can be very difficult, and frustrating, for the surgeon to point out to an insistent patient that a projectile is dangerous when moving but is no longer so when it has come to a stop. The incidence of late infection is low (2 – 3 %)[1] and vascular embolization rare and more common with fragments than bullets. The risk of embolization – "migrating bullet" – is more common in published clinical cases in the specialized surgical literature than it is in real life. One American study from Viet Nam reported a rate of 0.3 % in 7,500 cases with arterial injuries; and rarer still in the overall wound population.[2]

The frustration is directly related to the number of patients presenting with such requests, who can at times be counted literally in the hundreds. The problem tends to be psychological and cultural rather than surgical. How can one convince a young combatant that the operation to remove a bullet may cause more damage than the bullet has accomplished? Such a foreign body in the midst of a muscle mass, where there are no pain receptors, is not painful and the surgeon must find a way to overcome the patient's subjective fixation; perhaps by making the bullet's presence a matter of "pride".

The experience of the ICRC shows that many of these operations to remove a projectile are risky, useless, consume time and materials, and result in new surgical trauma with its possible complications, often without identification and removal of the foreign body. There are few surgical endeavours more frustrating for an unprepared young surgeon than to spend two hours searching ever more frantically for an "easy" fragment or bullet, and finally not finding it.

Figures 14.1.1 and 14.1.2

Bullet lodged in full-term pregnant uterus.



14.2 Early indications for removal

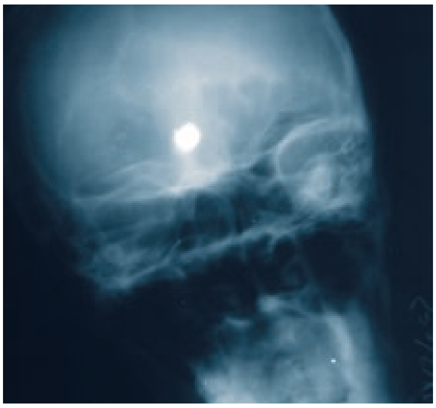
However, as stated previously, there are indications for removal of bullets and fragments, which may be divided into early and late. The most important early indications have been dealt with in Chapter 10: as an integral part of the primary operation or to address the possibility of erosion of an important structure (Figures 10.11, 10.12 and 14.1).

As mentioned in the latter case, whether the removal is an immediate or planned procedure will depend on a number of factors, especially the experience of the surgeon and the possible morbidity and lethality of the operation itself compared to the relatively low incidence of serious complications arising from leaving the projectile in place. The decision is not always a simple one and the reader may consider what should be done in the following examples (Figures 14.2 – 14.8).

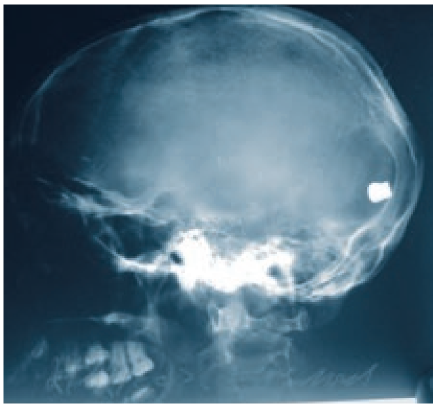
1 Rhee JM, Marin R. The management of retained bullets in the limbs. *Injury* 1997; **28**: 23 – 38.

2 Rich NM, Collins GJ, Andersen CA, McDonald PT, Kozloff L, Ricotta JJ. Missile emboli. *J Trauma* 1978: **18**: 236 – 239.

M. Baldan / ICRC



M. Baldan / ICRC



Figures 14.2.1 and 14.2.2

A fragment entered the forehead and is retained in the occipital region.

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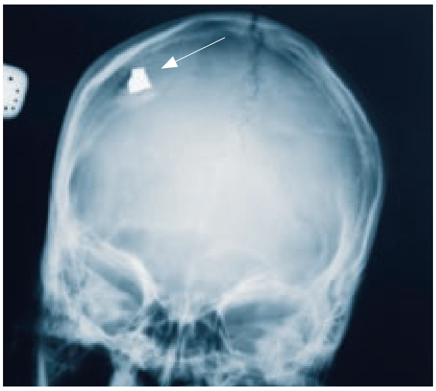

ICRC

Figures 14.3.1 – 14.3.3

A fragment has entered the parieto-occipital area.

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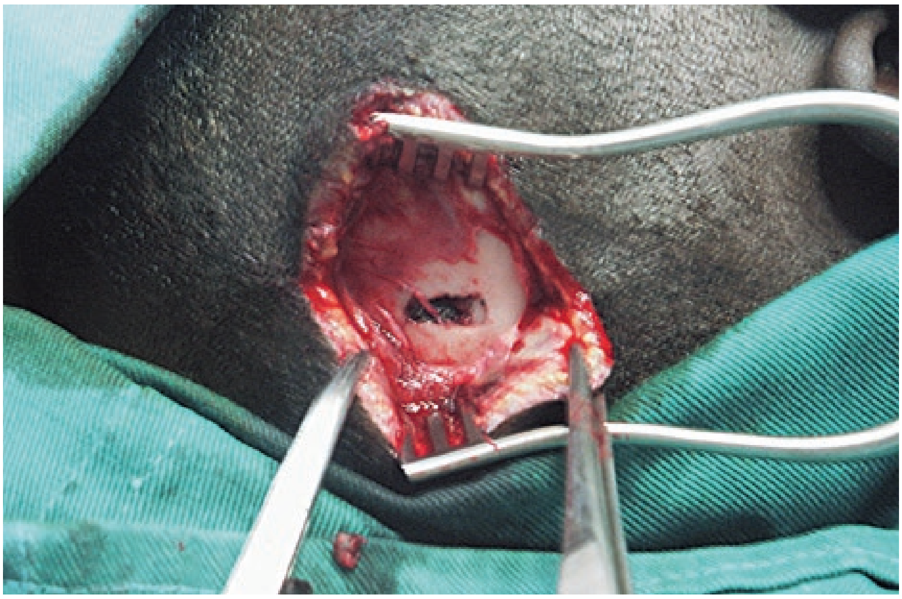


Figures 14.3.4

The fragment is evident under the bone.

R. Coupland / ICRC

Figure 14.4.1

Nurse pointing out site of fragment entry.

R. Coupland / ICRC

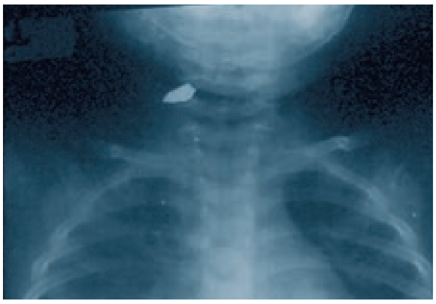


Figure 14.4.2

Radiograph showing a fragment retained in the neck.

M. Baldan / ICRC

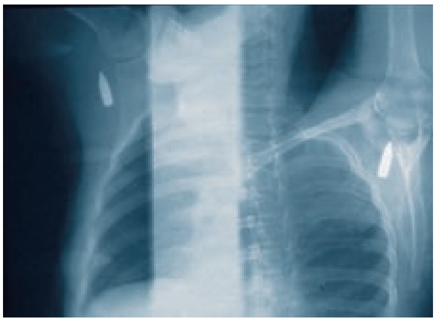


Figure 14.5

Bullet in the axilla: the vessels and nerves are intact.

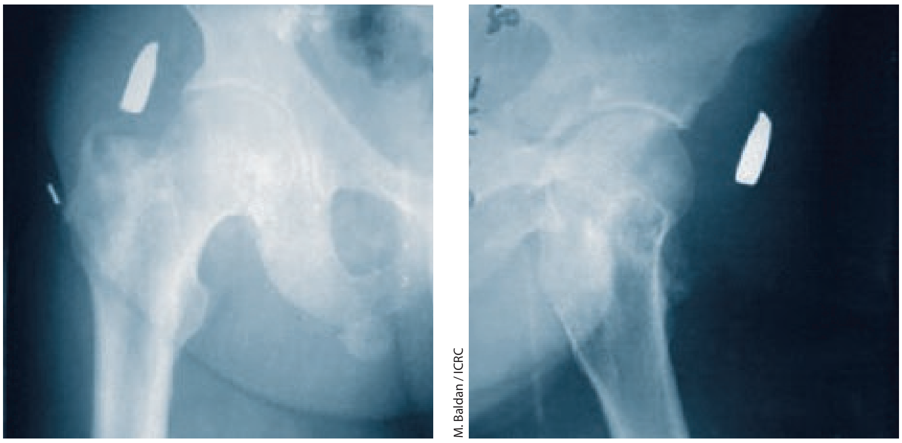
M. Baldan / ICRC

Figure 14.6

Fractured humerus with bullet retained in the subscapular muscles.

M. Baldan / ICRC

M. Baldan / ICRC



Figures 14.7.1 and 14.7.2

Extra-synovial bullet near the hip.

F. Herkert / ICRC

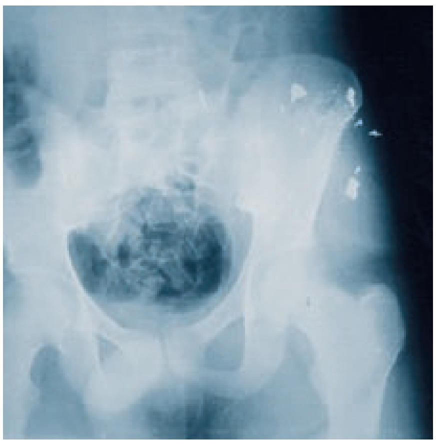
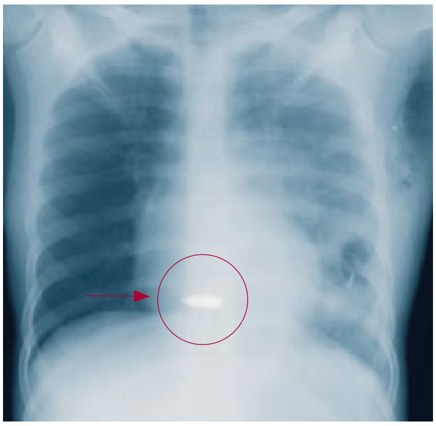
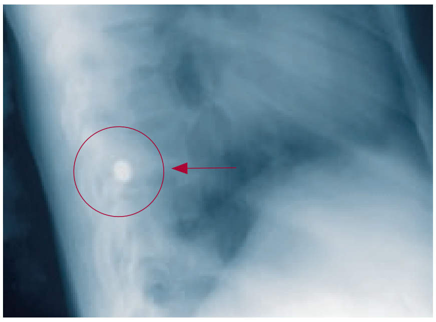


Figure 14.8

Fragmented bullet in extraperitoneal muscle mass.



F. Irmay / ICRC



F. Irmay / ICRC

Figures 14.9.1 and 14.9.2

Bullet retained in vertebral column, the patient is paraplegic.

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Figure 14.10

Metallic fragment located in a pressure point: sole of the foot.

The following scenarios should be added to the early indications already mentioned.

- A small fragment in a heart chamber – the concomitant pericardial tamponade is an urgent condition, the removal of a retained fragment is not – or a fragment obviously within the lumen of an important vessel. The possibility, and danger, of embolization is high in these particular instances. Operation should *only* be undertaken, however, if the surgeon *and* anaesthetist are experienced and the necessary diagnostic and operative equipment are available.
- A projectile located in the spinal cord: emergency laminectomy and removal should be considered *only* if there is clear progressive neurological deficit and radiological evidence of spinal cord compression by the foreign body *and* the surgeon is experienced in this field. A definitive diagnosis of paraplegia, indicating that the spinal cord is irrecoverably sectioned, means that it is already too late.
- Small metallic fragment penetrating the eye: removal is indicated if located in the anterior chamber, again, *only* if the surgeon is experienced, *and* magnification, proper instruments and suture material are available.

14.3 Late indications

Late indications are largely the result of the complications listed below.

Infection

If the projectile, along with surrounding contaminants, is acting as a nidus for infection: an abscess or sinus. The removal is performed as a planned operation after the necessary diagnostic procedures (X-ray, sinugram, etc.).

Pain

If located superficially, especially if over a pressure point (palm of hands, sole of foot, elbow, etc.), the projectile will cause true pain. The removal may be performed as an elective procedure after healing from the acute trauma.

Pain

If the foreign body is impinging on a nerve and causing radicular pain or paraesthesia. As above, the removal is performed as a planned operation.

ICRC

Figure 14.11.1

Bullet in antero-lateral compartment of the leg pressing on common peroneal nerve.

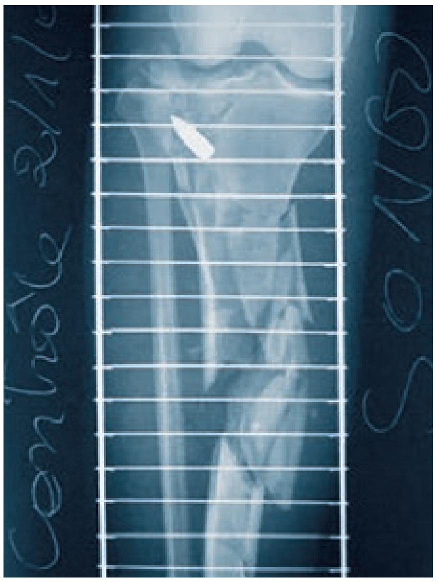

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Figure 14.11.2

Bullet not pressing on a nerve.

Lead toxicity

This is extremely rare, usually involves a synovial joint or intervertebral disc, and surgery should be contemplated only if there is documented elevation of serum lead level (above 5 micrograms/dl in children and 10 micrograms/dl in adults). The response to an EDTA (ethylene diamine tetra-acetic acid) challenge is a useful diagnostic test. Standard chelation therapy is instituted (EDTA, dimecaprol, d-penicillamine, succimer) and the surgical removal of the metal should not be performed before serum lead levels have been reduced to avoid acute lead poisoning.[3] This complication does not arise with an intact, full metal jacket bullet where no lead filling has spilled out.

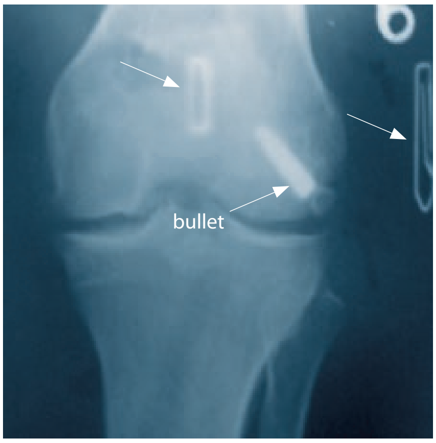
We shall not deal with wounds not related to armed conflict where the bullet may be required as part of a legal and forensic investigation. National law of the country concerned determines what exactly can be done while not subjecting the patient to unnecessary harm and suffering.

14.4 Technique for the removal of a projectile

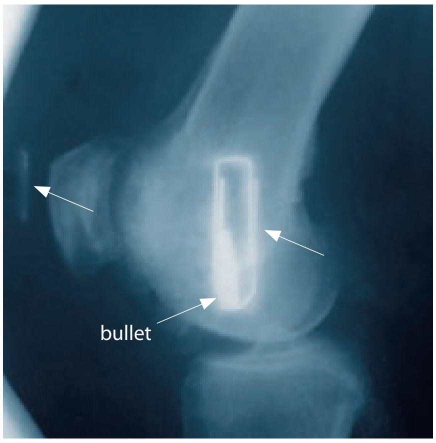
For those patients requiring removal of a deeply-seated metallic fragment or bullet, proper localization prior to surgery is of the utmost importance. Most rural or provincial hospitals do not have fluoroscopy or an image-intensifier in the operating theatre enabling the surgeon to operate under direct vision.

A simple stereotactic technique to assist localization involves taping a series of radio-opaque objects (paper clips, injection needles, Kirschner wires) to the body part, both anterior and lateral surfaces, to act as guides. Plain X-rays with antero-posterior and lateral views are taken. The radio-opaque objects are then removed and their position on the skin marked with a felt pen.

By looking at the two X-ray views, the surgeon can estimate the relative distance of the bullet from the radio-opaque objects in the axes both across and in the depth of the body part – e.g. half-way between the second and third paper clips in the A-P view and one-third of the way between the first and second paper clips in the lateral view. The idea is to use two-dimensional X-rays to extrapolate into three dimensions. The films should be taken on the morning of the operation and the patient should be undressed (combatants often carry bullets in their pockets).



K. Barrand / ICRC



K. Barrand / ICRC

Figure 14.12.1 and 14.12.2

Stereotactic localization of metallic foreign body. Safety-pin is anterior and paper clip lateral.

In due course, the body will form tough avascular scar tissue around the metallic fragment: a foreign body granuloma. This includes other foreign matter and dirt, and should be excised together with the projectile.

3 Linden MA, Manton WI, Stewart RM, Thal ER, Feit H. Lead poisoning from retained bullets: Pathogenesis, diagnosis, and management. *Ann Surgery* 1982; **195**: 305 – 313.

Chapter 15

BURN INJURIES

15.1 Introduction

Burns are a common event in a war environment. Flame weapons, explosive blast and ignition of combustible materials all create burn hazards. In addition, overcrowding, interrupted power supplies and use of kerosene for cooking often increase everyday burns. The causal agent may be thermal, chemical, electrical, or linked to radiation. Each cause has specific consequences that may require specific assistance.

A serious burn injury is a painful and life-threatening event requiring an inordinate amount of hospital resources and nursing care. The most immediate threat to life is an impaired airway due to inhalation of hot air and smoke with consequent oedema; the most important subsequent threats to life are from hypovolaemic shock and infection, followed by the complex pathophysiological effects which continue after injury. It is associated with many complications, prolonged morbidity, multiple operations and great demands on equipment, materials, medical and nursing time. The long-term sequelae, physical, cosmetic and psychological, deeply affect the morale of both patients and staff. Modern burn centres have made great progress in the successful treatment of major burns, but such facilities are never available in situations of limited resources.

Nevertheless, the principles of treatment are the same, and the aim is to do the best one possibly can under the austere circumstances, where stark reality imposes its frustrating limitations. Surgery will have the greatest impact on young people with small but potentially crippling injuries such as bilateral hand burns. In environments where options for treatment are limited, it is likely that patients with severe burns over 40 – 50 % of the total body surface area will not survive and therefore palliative care should be considered, including adequate analgesia and sufficient fluids to relieve thirst, etc. In a mass-casualty triage situation they are considered Category IV, i.e. given supportive treatment only.

15.2 Pathology

15.2.1 Burn depth

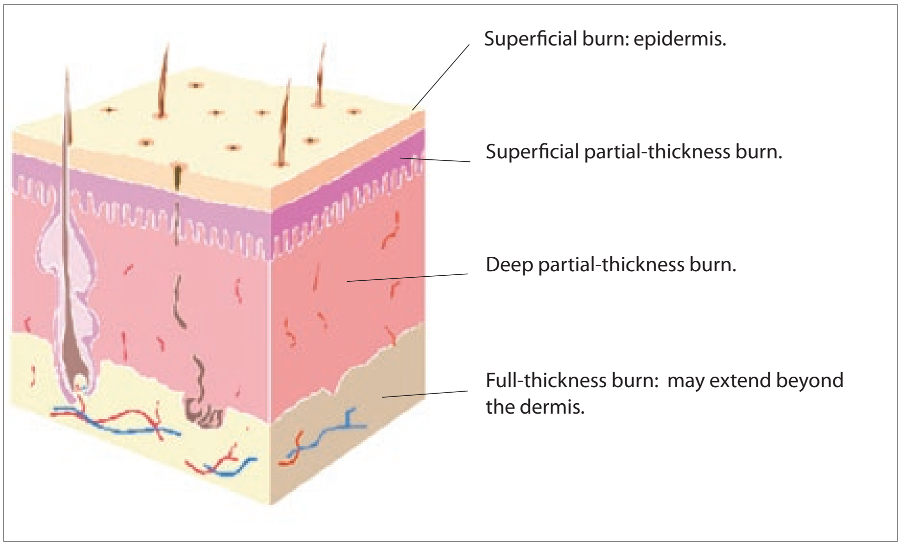
Burns involve varying amounts of injury to the skin, partial or full thickness, and varying degrees of severity (Figure 15.1).

Superficial burns (formerly First degree)
These burns are painful, red, and have no blisters. They will heal on their own.

Superficial partial-thickness burns (formerly Second degree)
These are invariably blistered. The blister floor is usually pink or mottled red in appearance with a moist surface. The burn blanches with pressure. They are painful and have some sensation to pinprick. Hairs are difficult to pluck out since the base of the follicle is alive. Most should heal within 2 – 3 weeks by re-epithelialization.

Deep partial-thickness burns (formerly Second degree)
Blisters are not present, and the burn does not blanch with pressure. They may or may not be painful and sensation to pinprick is reduced or absent. Hairs are easier to pluck out. Most will eventually heal by a combination of re-epithelialization and wound contraction but take longer than 2 – 3 weeks, and seriously disabling scar contracture often occurs. In general, they will benefit from appropriate skin grafting.

Full-thickness burns (formerly Third and Fourth degree)
Destruction of the full thickness of the skin gives a charred, leathery or waxy appearance. Any surviving hairs pull out easily. The burns are usually dry and have no sensation. Injury may extend to the muscles and deeper tissues. They are normally caused by flames, immersion in very hot liquids, electric current or chemicals. Smaller full-thickness burns will eventually heal by contraction but this inevitably causes severe deformity and loss of function. They are best treated by skin grafting.



ICRC

Figure 15.1

Histology of the skin and degree of burn depth.

E. Dykes / ICRC

Figure 15.2

Different regions of a burn wound have different depths of damage: central eschar of full-thickness burn surrounded by areas of partial-thickness burn.

Different regions of a burn wound have different depths of damage. A burn is basically an ischaemic three-dimensional wound with:

- a zone *of coagulation – a central area of irreversible skin death that creates the eschar;*
- *a zone of stasis – a middle layer of damaged but viable tissue with a significant inflammatory reaction, but an early stasis of local blood flow;*
- *a zone* of hyperaemia – a deep and peripheral area that looks like cellulitis, but is only hyperaemic.

Appropriate fluid resuscitation preserves cells in the zone of stasis, but subsequent infection or drying of the wound can rapidly enlarge the injury, both peripherally and in depth.

Superficial burn wounds are painful; deep burns are anaesthetic.

15.2.2 Pathophysiological changes

The most important pathophysiological change from thermal injury is increase in capillary permeability, which, if resuscitation is successful, returns to normal within 24 – 48 hours. Plasma water and proteins up to a molecular weight of 350,000 are freely exchanged between the intra- and extravas-cular compartments of the extracellular space. A strongly negative interstitial fluid pressure develops that creates a strong “suction” in the burnt tissue. If the affected area is very large, these changes become widespread with the loss of important amounts of fluid from the vascular com-partment.

This loss is most marked in the region of the burn wound and accounts for the local oedema, which peaks at 6 – 12 hours post-burn. However, with aggressive crystalloid resuscitation in large wounds (>25 – 30 % of the total body surface area or TBSA), the hypoproteinaemia causes a sys-temic disorder resulting in generalized oedema of non-injured skin and internal tissues, above all swelling of the larynx, and resultant obstruction to the airway, pulmonary oedema and abdominal compartment syndrome.

For further details on abdominal compartment syndrome, see ANNEX 32. A in Volume 2.

There is an associated rapid rise in the haematocrit which, together with polymerization of some plasma proteins, causes a marked increase in blood viscosity. The immediate danger linked to the sequestration of fluids in the extravascular space is hypovolaemic shock and, with haemoconcentration, acute tubular necrosis and renal failure. The loss of skin cover, and its function as a regulator of temperature, means that hypothermia, with its complication of coagulopathy, is an ever-present danger (see Chapter 18). Loss of skin cover also implies loss of the bacteriological barrier and hence an increased risk of infection.

15.2.3 Types of burns

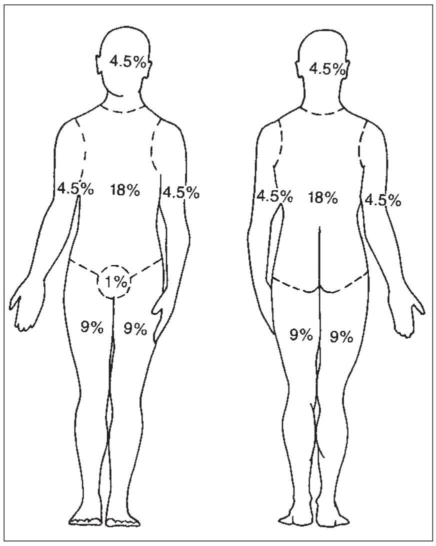
Flame and scald burns are by far the most common. Flame burns are usually deep and appear so at presentation, whereas scald burns may appear much less severe at first; experienced burn surgeons usually withhold prognostication until they have inspected them on the third day. Contact flame burns are typically very deep at the centre, which should be taken into consideration if they are to be operated on.

Electrical burns fall into two distinct categories. Flash burns occur when a person causes a short circuit and resulting electrical flash, but no current travels through the body. These may be treated as regular thermal injuries. High voltage (>1,000 volts) electrical conduction injuries – the current travels through the body and is characterized by the "can't let go" phenomenon – are "iceberg injuries" as they usually present with small cutaneous wounds and severe deep-tissue damage with extensive muscle necrosis and risk of compartment syndrome.

Chemical burns are caused by particular agents: acids, alkalis, and specific compounds (napalm, phosphorus, vesicants, etc.), with their individual characteristics.

15.2.4 Extent of burns

The sequestration of large amounts of fluid and plasma proteins in the extravascular space is a function primarily of the extent of burnt tissues. It is thus important to estimate the total body surface area that has been burnt. The depth of the burn must also be taken into account; only partial and full thickness are included in the estimation of TBSA, not superficial epidermal burns.



P. Zylstra / ICRC

Figure 15.3

Homunculus diagram showing the "Rule of Nines" to assess burnt surface area in an adult.

The simplest calculation is best done using the "Rule of Nines" (Figure 15.3). The size of the *patient's* hand (including palm and fingers, with fingers adducted) is about 1 % of TBSA.

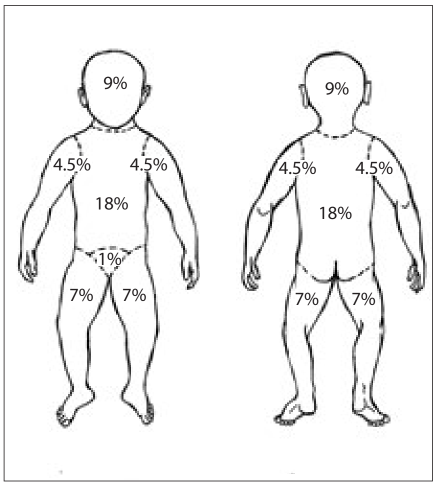
In children, the proportions are different: the head and neck of a child under one year of age represent about 18 % and the lower extremity 14 % of TBSA (Figure 15.4). With age, these figures gradually change to adult proportions.

It is difficult to grade the severity of burn wounds. However, in terms of TBSA, the following criteria provide a rule of thumb, although clearly the part of the body involved and associated injuries such as inhalation also play a significant part:

Minor
- Partial thickness, less than 15 % TBSA.
- Full thickness, less than 3 % TBSA.

Moderate
- Partial thickness, 15 – 25 % TBSA.
- Full thickness, less than 10 % TBSA.

Major
- Partial thickness, more than 25 % TBSA.
- Full thickness, more than 10 % TBSA.



N. Papas / ICRC

Figure 15.4

Assessment of burnt surface area in a child homunculus.

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15.3 Burn management

The management of burns consists of a series of standard measures, as with any wound or trauma.

1. First aid.
2. Resuscitation:
   - airway;
   - breathing;
   - circulation / fluid replacement therapy.
3. Analgesia.
4. Tetanus prophylaxis.
5. Nutrition.
6. Prevention/treatment of hypothermia.
7. Wound management.
8. Rehabilitation

15.3.1 First aid

Rescuers should first ensure that the scene is safe and take suitable precautions if un-ignited fuel, explosives, electricity, or chemical agents are present. The patient should be removed to safety and clean fresh air, and the vital signs assessed. If available, oxygen should be provided if there is any indication of smoke inhalation.

The burn should then be cooled with water or wet towels (for 20 minutes), and covered with clear plastic if available to reduce pain. The patient should not, however, be left wrapped in cold wet material so long as to provoke hypothermia. After cooling the burn, keep the patient warm.

If evacuation to the hospital is delayed and the airway is not at risk, the patient should be encouraged to drink plenty of small quantities of fluids often and regularly, and the colour and volume of the urine monitored.

15.3.2 Resuscitation

The following elements should be determined:
- nature of the causal agent – flame, scald, contact, electrical conduction, electrical flash, chemical;
- possible aggravating factors – additional trauma, smoke inhalation (fire in an enclosed space equals smoke inhalation);
- time since injury – fluid resuscitation is calculated from the time of burn, not the time the patient arrives at hospital.

As with all injured persons, examination begins with the ABCDE sequence. Deep burns to the face, neck or anterior chest can cause laryngeal oedema, which increases dramatically with fluid resuscitation. Inhalation of smoke, hot gases or chemical products contributes to this swelling. However, critical laryngeal oedema can occur in any deep burn to this important area. The patient should be checked for burnt hair in the nostrils or soot in the nose, mouth or sputum, a hoarse voice, excessive coughing and/or a history of decreased level of consciousness.

The airway must be secured and kept open, either by intubation or by tracheostomy. This should be performed before the airway is compromised since it will be very difficult once oedema has closed the airway and cutting through oedematous tissues can be bloody and complicated.

Please note*:*

Because of this oedema, even the tracheostomy hole will disappear in the depths of the tissues. Rather than an ordinary tracheostomy tube, an endotracheal tube should be inserted in the tracheal opening.

True smoke inhalation induces carbon monoxide poisoning and a chemical pneumonitis related to the inhalation of hot toxic gasses. Carbon monoxide poisoning should be assumed in any person found unconscious at the scene of a fire, and is treated by administering as high a concentration of oxygen as possible for 6 hours.

Increased fluid requirements early in resuscitation may be due to severe inhalation injury, which may not appear on a chest X-ray until the second or third day. Inhalation injuries increase the 24-hour fluid requirements by 1 – 2 ml per kg of body weight per percent of TBSA (1 – 2 ml/kg/ %), which is an increase of about 50 %. However, there is also increased risk of pulmonary oedema, and tolerating a lower urine output to avoid overloading the patient and risking pulmonary complications is acceptable. Hypoxia and hypercapnoea despite maximal oxygen supplementation or ventilation are ominous signs. Serious cases of smoke inhalation will not usually survive without mechanical ventilation. This can be difficult to organize in a setting offering limited resources.

The sequestration of large amounts of fluid and plasma proteins in the extravascular space produces hypovolaemic shock.

Please note*:*

Only partial- and full-thickness burns should be included in the estimation of the percentage of TBSA. The patient must therefore be completely exposed and the extent and depth of the burn carefully estimated using the "Rule of Nines". The patient should be weighed and the homunculus diagram used to assess and mark the extent of the injury. Particular attention should be paid to circumferential burns which may require escharotomy.

The natural tendency is to overestimate the extent of the burn. In controlled series this has been shown to be up to 25 %. A good idea is to first calculate the burnt area and then the area which is not burnt; the total should add up to 100 %. Another natural tendency is to underestimate the depth of the burn; periodic re-examination will help to determine this better.

Patients with burns of moderate and major severity should get a Foley catheter placed in the bladder to monitor the hourly urine volume, which is the most important single measurement of adequacy of resuscitation. A nasogastric tube should also be passed and, if there is no acute gastric dilatation, enteral feeds can be started within the first 24 hours. Early feeding through the nasogastric tube and appropriate acid suppression (antacids, H2 blockers) prevent acute haemorrhagic gastritis, which is usually fatal. Where maintaining an i.v. line is difficult, fluid resuscitation may be administered via the nasogastric tube or even orally in smaller burns. This may be particularly useful in small children.

Adequate analgesia (intravenous narcotic) is necessary at all stages of burn management. Any infection is treated ad hoc. Tetanus prophylaxis must be instituted as required. Applying a topical antimicrobial, removing lines and catheters as soon as possible, etc. are more important than antibiotic prophylaxis. Other associated injuries (penetrating wounds, fractures, etc.) must be diagnosed and treated in parallel with the burn wound.

15.3.3 Initial fluid replacement therapy

Given adequate initial resuscitation with crystalloids, capillary integrity is mostly restored within 18 – 24 hours following the burn. At this point, colloid can be given and will stay within the vascular compartment, increasing the plasma volume. Cardiac output will respond to fluid replacement long before blood and plasma volumes return to normal and a first, mild diuresis begins at about 12 hours after fluid therapy. Red cell life is reduced and although replacement of red cell mass is not necessary for the first 48 hours, for major burns blood transfusion will probably be necessary after this time.

Most minor burns presenting less than 15 % TBSA partial-thickness damage do not require formal i.v. fluid resuscitation and can be treated with oral fluids, and patients can be managed on an outpatient basis. (Some surgeons prefer to hospitalize even a 3 % full-thickness burn, especially to the face, hands or feet.) Moderate and major burns require hospitalization and intravenous fluids. The ICRC uses the modified Brooke/Parkland formula[1] for fluid resuscitation.

There are three phases in resuscitation therapy.

1. First 24 hours following the infliction of the burn wound (not from the start of treatment).
2. Second 24 hours.
3. After 48 hours.

The first 24 hours
Ringer's lactate is the fluid of choice. Administration should be divided into two periods.

Ringer's lactate solution 2 – 4 ml/kg/% burn = total volume for first 24 hours:

- first eight hours: one half the volume;
- next sixteen hours: one half the volume.

Urine output should be 0.5 ml/kg/hour.

Fluid creep (giving too much fluid) is a significant risk and has significant complications. Administration should therefore start at the low end of the formula (2 ml/kg/ %) and the hourly urine output monitored. There is a non-linear relationship in burn patients between the infusion rate and the urine flow. Normal urine flow is described as 0.5 – 1.5 ml/kg/hour. The lower limit should be aimed for, and any increase above this calls for a lowering of the infusion rate to avoid over-resuscitation.

If the urinary output is low and does not respond to increased infusion in the second eight-hour period, the third eight-hour-period Ringer's lactate can be replaced with colloid, plasma or 5 % albumin if available. If the vascular compartment is well-filled, however, but the patient is not making urine, the kidneys are likely to be failing and may respond to furosemide or mannitol.

Other clinical vital signs must be closely watched, particularly the peripheral circulation, the patient's general condition, such as consciousness, restlessness, nausea or vomiting, and the haematocrit.

Constant monitoring is required and, after 12 hours, the patient's condition and fluid requirements should be reviewed and recalculated.

1 Brooke formula: 2 ml/kg/% TBSA for first 24 hours; Parkland formula: 4 ml/kg/% TBSA for first 24 hours.

Please note:

Not only is there a natural tendency to overestimate the TBSA but, in much contemporary clinical practice, it has been discovered that over-resuscitation has become more common and more of a problem than under-resuscitation. The traditional fear of renal failure has led many clinicians to administer an excess of fluids. This has been called "fluid creep"[2] or "resuscitation morbidity" and manifests itself most commonly as pulmonary oedema and, later, abdominal compartment syndrome, delayed wound healing, increased susceptibility to infection and multiple organ failure. It should be remembered that the fluid resuscitation formula is only a guideline. It is appropriate when beginning resuscitation, but actual amounts of i.v. fluids should be adapted according to the clinical response.

After 24 hours

During this phase, expansion of plasma volume can be achieved.

Plasma should be administered: 0.3 – 0.5 ml/kg/%/day.

If plasma is safe and available, theoretically it is best given at this stage. Albumin 5% is an expensive alternative, but the evidence to support either strategy is slim. Otherwise, and in ICRC practice, it is best to keep things simple and Ringer's lactate should continue to be given at the rate of one-quarter of the first day's volume; intravenous fluid should be adjusted to urine output and enteral feeding increased as tolerated. This will provide not only essential nutrition but free water to cover evaporative losses from the burn wound.

15.3.4 Monitoring resuscitation

Clinical evaluation is particularly important in the absence of sophisticated means and laboratory measures. A clear sensorium, good tissue perfusion, good pulse, and an adequate urinary output are all signs of good progress. Less and less fluid is needed at the end of resuscitation in order to maintain urine volume. A flow sheet should be used to monitor vital signs and fluid input/output. The patient should be serially weighed if possible.

15.3.5 After 48 hours

Mobilization of burn wound oedema causes an expansion of the blood volume and results in massive diuresis, high cardiac output, tachycardia and anaemia. The better the fluid management in the first period – avoiding over-resuscitation – the less pronounced these clinical signs and the more stable the patient will be.

Blood should be given to maintain haemoglobin greater than 70 g/l. Deep burns cause greater anaemia. Fresh whole blood is best. Potassium, calcium, magnesium and phosphate are generally excreted in large amounts at this time, and should be supplemented where possible.

15.4 Burns presenting late

Often, patients with severe burns present late. Those presenting after a delay, but within the first 24 hours, should receive fluid resuscitation approaching the calculated volume; however, large amounts of fluid given rapidly may precipitate airway problems. Caution is required, and the patient must be monitored very carefully.

2 Pruit BA Jr. Fluid and electrolyte replacement in the burned patient. *Surg Clin N Am* 1978; **48**: 1291 – 1312.

E. Dykes / ICRC

Figure 15.5
Old flame burn to the leg.

Patients presenting after 24 hours will probably need some fluid but the amount should be guided primarily by clinical assessment of hydration and renal function. Patients who have survived the first 72 hours without renal failure have compensated the losses themselves (usually with oral fluids); they may require some rehydration but infection of the burn wound is the main concern. For those presenting weeks after the burn, infection is compounded by poor nutritional status, anaemia, and hypoproteinaemia. In these cases steps should be taken to control infection (debride grossly infected necrotic tissue) and to improve nutrition, before any definitive surgery is undertaken. Early creation of a feeding gastrostomy should be considered.

15.5 Nutrition

Catabolism is particularly elevated in burn patients, especially those losing large amounts of protein through open wounds, and healing will require a large increase in caloric and protein intake for a lengthy period. Early enteral feeding is very important in maintaining gut function (reducing gastroparesis), and preventing complications. Major burn patients may require more than twice their normal protein and calorie intake until their wounds have closed. Nutritional requirements may be easily calculated for the individual patient (see ANNEX 15. A: Nutrition in major burns).

Blenderized enteral feeding solutions can readily be made from commonly available local foods and can be delivered by naso-gastric tube, gastrostomy or jejeunostomy. Especially when dealing with burn wounds that are weeks to months old, the patient's nutritional status should be evaluated and improved before any attempt is made at skin grafting or both the graft and the donor site risk delayed or failed healing.

15.6 Care of the burn wound

After successful resuscitation of the patient has been achieved, the next greatest threats to life that must be addressed are the burn wound itself and the complications of infection and sepsis.

The aim of treatment is to achieve healing of the burn by the following measures:

1. Control of bacterial colonization by removal of all dead tissue.
2. Prevention of accumulation of purulent fluid and debris.
3. Prevention of secondary bacterial contamination.
4. Maintenance of an environment that promotes wound healing.
5. Avoidance of techniques or treatment that will damage the healing burn wound.

Most of the morbidity and mortality associated with major burns are the result of infection. All the methods for cleaning the wound, excising dead tissue and treating the burn are directed towards the control of "burn wound sepsis".

Untreated, eschar desiccates and sloughs off by means of bacterial enzymatic invasion of the plane between viable and non-viable tissue. Full-thickness burns will require skin grafting to heal properly; otherwise, healing will be by fibrous tissue contraction alone with chronic open wounds and disabling scar contracture.

In partial-thickness burns, viable areas of dermis underlie the necrotic tissue and if sufficient epidermal cells remain at the base of skin appendages, such as sweat glands and hair follicles, re-epithelialization will gradually take place if given the right conditions.

Infection will transform a partial-thickness burn into a complete-thickness one. Because of the complete or partial ischaemia associated with burn wounds, systemic antibiotics may not reach the site of bacterial colonization. Local treatment, both mechanical and antimicrobial, is the basic element of wound care.

15.6.1 Initial wound management

Initial wound toilet should be undertaken after resuscitation has begun and proceed in parallel. Once the patient's condition has stabilized, attention can be turned to more definitive measures.

Any constricting agents (rings, wrist-watch, jewellery, etc.) should have been removed on admission. The patient should be sedated and the burn wound gently washed with soap and water. Freely running, clean water, without excess pressure but a regular flow and at a temperature comfortable for the patient, is best. This will cool the burn, decrease pain, and remove superficial debris and adherent clothing.

Small intact blisters may be left undisturbed but large, bloody, or pus-filled blisters, and those that interfere with joint movement, should be unroofed and debrided, which also assists in determining the depth of the burn. Large burn wounds may be more easily cleaned by placing the patient in a shower. Baths should be avoided because of the attendant logistical difficulties and the danger of cross-infection under field conditions. The routine daily immersion of burn patients in filthy tubs of cold water is to be condemned.

Particular attention should be paid to circumferential deep burns. During the first 48 hours the increasing oedema of the tissues and the thick unyielding burn eschar may result in a tourniquet effect. Circumferential burns of the chest will restrict breathing and those of the limbs will cause peripheral ischaemia, which can lead to amputation. This disaster is easily averted.

> Escharotomy is the process of incising the eschar down to the subcutaneous fat to allow relief of the constriction.

Escharotomy should be performed with a sharp knife or electric diathermy through the burnt skin into the subcutaneous fat. Even with immediate haemostasis, venous bleeding often starts after 30 minutes; the surgeon must re-examine the patient appropriately.

Escharotomy incisions are placed in the mid-lateral and mid-medial lines of the affected extremity and should extend up to, but never include, unburnt skin. A "T-cut" at each end of the escharotomy allows tissue to expand without causing an acute constriction at the end of the incision. On the hands, the mid-lateral incisions coming down each side of the forearm should be swung onto the dorsum, and branched to make a single escharotomy incision down the mid-lateral line of each finger on its less-used side. (i.e. ulnar side of thumb, index and ring finger; radial side of middle and little finger).

A thoracic escharotomy begins at the midclavicular lines, continues along the anterior axillary folds down to the costal margin, and across the epigastrium to the xyphoid process.

<u>Please note:</u>

Few patients who truly need a thoracic escharotomy will survive without mechanical ventilation.

Though full-thickness burns are usually anaesthetic, the escharotomy should be done with some form of anaesthesia as the edges can be very painful and the cut goes into the subcutaneous fat. Ketamine is ideal.

Particular attention should be paid to burns with underlying fractures, or burns extending deep into the fascia; these can create a compartment syndrome. Formal fasciotomy, with excision of the aponeurosis, may be necessary in addition to escharotomy. Fasciotomy will almost always be required in high-voltage electrical injuries. Closure of the escharotomy incisions should take place at the same time as the skin grafting of the burn wound itself.

Severe perineal burns may necessitate faecal diversion.

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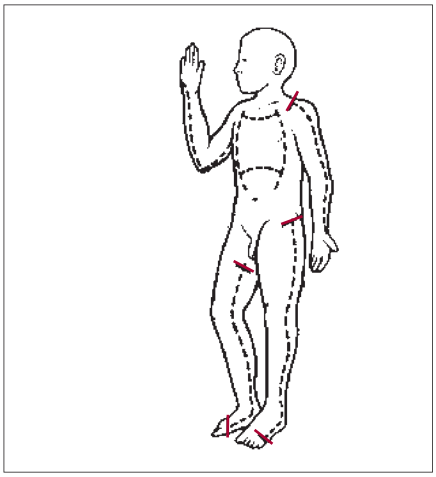
Figure 15.6

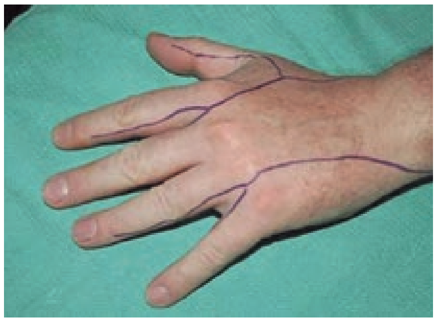
Burn to the face with intact blisters.



M. King / Primary Surgery Volume 2

Figure 15.7.1

Sites for escharotomy incisions.



M. Beveridge / ICRC

Figure 15.7.2

Placing for escharotomy incisions on the hand.

M. Baldan / ICRC

Figure 15.7.3

Escharotomy incision of the arm.

15.6.2 Local care

Care of burn wounds involves an extraordinary amount of nursing care. The method used depends on the depth, extent, and location of the burn. ICRC surgical teams use occlusive dressings – and their plastic bag modification – and open therapy, both with a topical antibacterial agent.

Many antibacterial compounds can be used. Silver sulphadiazine (Flamazine®) and silver nitrate solution are unique in that they can penetrate the wound surface and reach the bacteria beneath it; they are therefore the best options for infected full-thickness burns. Antibiotic ointment (polymyxin/bacitracin or similar) and paraffin gauze is another excellent dressing, particularly for partial-thickness burns with no eschar. Honey and ghee dressings can be used where expensive compounds such as silver sulfadiazine are scarce. Equal parts of honey and either ghee (clarified butter), or oil, are mixed together and poured over open sheets of gauze in a pan. The honey provides a hyperosmotic environment that discourages bacterial growth and the ghee or oil keeps the gauze from adhering. Silver nitrate solution (0.5 %) is effective but oxidizes easily, staining everything it contacts black. Other agents used around the world include gentian violet, which desiccates the burn; tea, which tans the burn like leather; papaya and banana leaf; boiled potato skins; fermented fish sauce and Amazonian frog skin. In some instances local methods may be preferable to imported products.

K. Yagi / U. of Khartoum

Figure 15.8

Paraffin gauze and occlusive dressings.

K. Yagi / U. of Khartoum

Figure 15.9

Plastic bag modification of occlusive dressing.

Occlusive dressings

Bulky sterile dressings relieve pain and are comfortable for the patient, and protect the burn wound from infection. They absorb serum and exudate and foster a moist healing environment by keeping the injured part immobile and warm; they contain antibiotics able to penetrate the dead eschar (i.e. silver sulphadiazine ointment).

The dressings have three components: an inner layer of a liberal application of silver sulphadiazine covered by fine-mesh gauze or paraffin gauze; a middle layer of large gauze-wrapped absorbent cotton pads, which absorb the exudate and protect the wound, and an outer layer of bandages that secures the dressing.

If the dressing becomes soaked through, the outer layers should be changed or bacterial contamination will occur by capillarity. Dressings should be changed every day or two under adequate analgesia, and the old silver sulphadiazine washed off in the shower. The wounds should be inspected and gently cleaned at dressing time, and morsels of dead eschar removed with scissors and forceps.

Occlusive dressings are best for small burn areas, especially on the limbs, or when hygienic conditions are less than optimal.

The plastic bag or surgical glove method

This method is used for burns to the hands and feet. After cleaning the burn and applying silver sulphadiazine, a plastic bag is used as a glove or a sock, tied around the wrist or ankle. It must not be too tight. The limb should be kept elevated to reduce swelling. The burnt area will be kept moist and movement of the joints, both passive and active, is encouraged. A surgical glove may also be used instead of a plastic bag. As an extension of this, a cellophane wrap of the type used for food can also be used around the limbs as an inexpensive occlusive method. This should be changed every six hours (it becomes very moist and mucky) and attention paid to any tourniquet effect.

Open therapy

Hospitals may have to resort to the less than optimal "open" technique where, for logistic and financial reasons, resources are scarce. However, this method is the standard for treating burns of the face and perineum. It requires clean and isolated surroundings, and the ambient temperature must be warm; hypothermia is to be avoided at all costs.

The patient is placed on clean sheets and the burnt area left completely exposed. Silver sulphadiazine ointment is applied to the burn wound liberally with a sterile gloved hand and repeated twice daily or as required. If the room is cold, the patient may be covered with a clean sheet and blanket draped over a frame to prevent contact with the wound. The entire bed should be kept under overhanging mosquito netting.

The *advantages* of this method of treatment include simplicity of examination of the burn wound and ease of nursing care. It also allows early mobilization by physiotherapy.

The *disadvantages* are pain, odour, desiccation of the wound, delayed eschar separation, hypothermia and decreased movement with a tendency for the patient to remain in bed for prolonged periods, leading to stiffened joints, contractures and muscle wastage. Frequent showering is required to wash away exudate and fragments of softened eschar. The bed linen must be changed regularly; it is readily dirtied by the burn exudate. Local customs and religious practice may limit the use of this "open" method.

Facial burns are best treated open with frequent gentle cleansing and application of moist warm saline gauze soaks, interspersed with application of topical antibiotic ointment (e.g. polymyxin/bacitracin). Beards and facial hair growing through the burn should be shaved at least every two days to prevent accumulation of exudate which may harbour infection. Antibiotic eye ointment should be applied frequently to the conjunctiva if the lids are burnt and retracted, to prevent keratitis and corneal ulceration. The lids should only very rarely be sutured together (blepharoplasty) as the sutures almost inevitably pull out causing yet more damage to both lid and globe.

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Figure 15.10

Open burn therapy with frame.

15.7 Closure of the burn wound

The preparation of the burn wound and its subsequent closure are the two main steps in the surgical management of burns. The type of surgery required depends upon the skill and training of the surgeon, the specific burn injury, and the facilities available to support the treatment, especially the availability of blood for transfusion. Like all other injuries treated under difficult circumstances, great judgement is required to select the technical procedure that is appropriate.

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Figure 15.11

Healing burn to the face.

Partial-thickness burns will generate new epithelium on their own if infection is prevented. The wounds should be inspected carefully as they progress. In superficial partial-thickness burns (and donor skin graft sites) epithelial cells grow out from around tiny skin appendages giving a typical "leopard spot" appearance in those with pigmented skin and, on close inspection, a slightly dull, silvery coat of epithelial cells may be seen growing atop the dermis (Figure 15.12.1). Tiny white pearls of epidermis herald re-growth and healing; areas of raspberry-red granulating dermis or fat do not have sufficient epidermal cells to heal (Figure 15.12.2). A "nicely granulating" burn wound is not a good thing unless there is a plan to graft the wound.

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Figure 15.12.1

Partial-thickness burn well on the way to healing.

E. Dykes / ICRC

Figure 15.12.2

Granulating burn: no healing. The pale colour of the granulations indicates that the patient is anaemic.

For full-thickness burns, the eschar may be removed completely in a single procedure or in a number of stages. The aim of treatment is to prepare the wound for eventual closure and to prevent colonization by bacteria and fungi.

15.7.1 Mechanical cleansing and debridement

Thorough cleaning and removal of debris and fragments of eschar are performed at each dressing session. Gentle washing and sharp debridement of dead skin fragments should be combined with thorough irrigation with water. The surface can then be cleansed with a mild disinfectant (dilute hypochlorite solution, detergent soap) and thoroughly washed again with water. Silver sulphadiazine is reapplied. Where resources are scarce, the cycle of dressing and plucking can be continued until the wound is completely free of eschar. This gives partial-thickness burns the optimum chance to re-epithelialize and minimizes the area that will require grafting. Such patients need large amounts of nursing time and dressing material, and will probably require blood transfusion even without surgery.

15.7.2 Surgery

The most difficult decisions in burn care involve the timing and extent of surgery. Judicious staging of burn surgery is highly important; factors to consider include co-morbidities, age, and occupation or livelihood, as these will all have an impact on decision making. Donor and graft areas should be matched in advance and the process broken down into manageable parts. Attention should be paid to how the body parts will be positioned for the operation: if the plan is to graft the arm, it should be seen to before the hand as the latter will be needed to hold up the arm for surgery.

The hands, feet, and joint surfaces are considered priority areas in order to re-establish function; early grafting of these parts must be balanced against the metabolic advantages of closing larger areas on the limbs and torso. At least two weeks should pass before grafting of facial burns is considered, as even quite deep burns may go on to heal on their own. Eyelids are the first priority here.

Tangential excision
The removal of the full thickness of the burn wound is performed in a single session. Early tangential excision and immediate grafting of burns reduces mortality, morbidity, suffering and hospital stay while improving functional and cosmetic results, but it requires considerable resources and is impracticable for areas larger than 10–20 % TBSA, as a staged procedure, outside specialized burns centres. It is bloody surgery.

Most field surgeons should be conservative with regard to this technique. It is, however, recommended in ICRC practice for small burnt areas, especially on the face, hands and feet, and over joint surfaces.

In tangential excision of the eschar, the superficial layers of the burnt tissue are progressively shaved away by knife, dermatome or cutting diathermy until viable tissue is reached. Traditionally, this is determined by the appearance of copious punctuate bleeding. It is accompanied by significant blood loss and is the most important limiting factor of this technique.

Blood loss can be reduced by Esmarch bandage exsanguination of the limb and a tourniquet, and subcutaneous infiltration of a dilute adrenaline solution (1:500,000); in the face, lidocaine with adrenaline can be used. The subcutaneous infiltration of some type of fluid (saline, dilute adrenaline solution or local anaesthetic), causes a local tumescence that facilitates the excision. With adrenaline solution, as dead burn eschar is sliced away, the surgeon should look for a level with visible pearly white dermis, or glistening yellow fat, and no capillary thrombosis. After excision, larger bleeders should be cauterized and the wound wrapped for ten minutes with gauze soaked in adrenaline solution. The wrapping should be removed, and the process repeated until there is no active bleeding, before the skin graft is applied.

When tangential excision is successful, only dead tissue is removed. It can be difficult to judge how much to take away in order to leave a viable layer that will take an immediate skin graft.

Face

The skin of the face, particularly the beard areas on males, is very thick and well populated with deep epidermal cells that will provide for re-epithelialization if given time. If there is any doubt about the depth of burn on the face it is best to wait two weeks before tangential excision.

As mentioned, face burns are treated by the open technique with warm wet gauze soaks, followed by gentle cleaning and the application of a local antibiotic ointment, with shaving every second day. Severe face burns will require scraping and cleaning under general anaesthesia to properly evaluate which areas are healing and which will eventually need grafting. Gauze soaked in an adrenaline-saline solution (1:33,000) should be used and pressure applied to control bleeding. When clean, a thin coat of antibiotic ointment should be applied and the previous dressing routine resumed while waiting to decide whether to excise and graft.

Excision of a small deep burn to the face can be performed under local lidocaine with adrenaline anaesthesia; larger areas require general anaesthesia, but simultaneous subcutaneous infiltration with a dilute adrenaline solution will render the excision easier and less bloody.

Hands, feet, and joint surfaces

Tangential excision of the hands, feet and joint surfaces can be performed at three days onwards, once the patient is well resuscitated.

Many severe hand burns will benefit from early escharotomy since deep partial-thickness or full-thickness burns heal with extremely disabling contractures; operating these early should be considered and good, thick skin for the grafts saved. Typically people clench their fists when they sustain a burn so the palmar skin extending up to the mid-lateral lines of the fingers is usually preserved, or burnt much less deeply than the dorsum, and rarely needs grafting. Most burnt hands and fingers will therefore only require grafting of the dorsum. If the escharotomy was performed accurately along the edges of the full-thickness burns along the mid-lateral lines of the fingers, this will mark the extent of excision necessary.

Proper preparation is the key to good excision. The areas to be excised should be carefully marked with ink or gentian violet. The hand and forearm should be exsanguinated by five-minute elevation and application of a rubber Esmarch bandage, beginning with the hand and progressing proximally; a pneumatic tourniquet is then applied. (Correct use of a tourniquet is painful; the operation should be performed under general anaesthesia.) Normal saline or a weak adrenaline solution should be infiltrated subcutaneously over the dorsum of the hand. The edges of the areas to be excised should be scored with a #15 blade.

Tangential excision should be performed using a small dermatome, scalpel, or Watson knife if available, preserving viable dermis where possible and being very careful not to damage tendon sheaths. The hand should be wrapped in adrenaline-soaked gauze and the tourniquet briefly released. The tourniquet should then be re-inflated for ten minutes to allow natural haemostasis, then removed. The hand should be unwrapped and diathermy used to cauterize remaining bleeders. Wrapping in adrenaline gauze and cauterizing of bleeders may need to be repeated several times to ensure perfect haemostasis prior to application of the skin grafts. Sheets of relatively thick split-thickness skin should be used. Grafts should be carefully tailored over the dorsum of the hand and fingers, and sutured in place. Each finger should be covered in paraffin gauze dressing, then wrapped independently in gauze, taking care to leave the tips of the fingers exposed in order to assess perfusion.

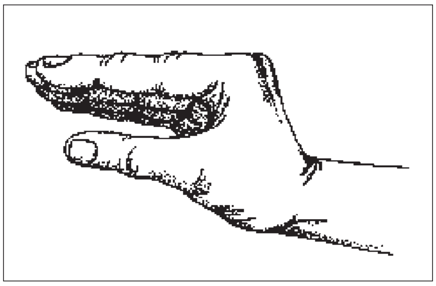
M. Beveridge

Figure 15.13
The "safe position" for splinting a hand.


E. Winiger / ICRC

Figure 15.14.1
Meshed skin graft: recipient site.

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E. Winiger / ICRC

Figure 15.14.2
SSG after grafting.

Finally, the hand should be splinted in the "safe position" (Figure 15.13) with the wrist dorsiflexed 30°, the metacarpal-phalangeal joint flexed as close to 90° as possible, the fingers splayed apart and the inter-phalangeal joints straight. The initial dressing should be left for 5 – 7 days and then unwrapped carefully. The graft should then be re-dressed daily with paraffin gauze and the hand re-splinted. Physiotherapy and mobilization should begin as soon as the grafts are solid. A hand should never be immobilized longer than ten days. K-wires placed through the fingers may help in bad cases. The same general principles apply to the feet and over joint surfaces.

Early tangential excision gives the speediest recovery and best functional and cosmetic results when it is practicable, but should never be undertaken for large areas unless the resulting blood loss can be properly managed.

Skin grafting

The hands, feet, and joint surfaces are priority areas for skin grafting, with or without tangential excision. The anterior chest and neck take priority over the belly and buttocks. The back has very thick skin, and so burns to it may be observed for some time while waiting to see if they will heal on their own.

Allowing burns to granulate and demarcate under dressings (2 – 6 weeks) is prudent practice where resources are scarce. This means accepting inevitable protein loss from open wounds, possible infection, delayed healing, and chronic anaemia; supplementary measures must therefore be taken to reduce these effects.

To prepare for grafting, the jelly-like granulation tissue must be scraped away with the back of a scalpel handle before the skin graft is carefully secured and dressed. The advantage of delayed grafting is that often a much smaller area need eventually be grafted.

Grafting on burns is time-consuming and adequate time should be allocated for these operations. The staging of the surgery should be carefully planned and just one limb or body area operated at a time. In general, the thinner the graft, the better its chances of "take", and the thicker the graft, the better the functional and cosmetic result (see Chapter 11 for details on skin grafting). A limb or digit that has to be amputated should be regarded as a prime source of donor skin. Harvesting of grafts in children whose skin may be extremely thin should be performed with great care. If there is no solid layer of dermis left behind, the donor site will not heal. Except on the face, hands and feet, skin grafts should be meshed to allow serum to drain through rather than lift the graft off the bed of the recipient site.

Old wounds or sites where previous grafts have failed are notorious for difficulty in achieving an adequate graft take. Good nutrition and meticulous preparation of the surface are the keys to success. Early excision of grossly dead and infected tissue, topical and systemic antimicrobial therapy and aggressive nutritional supplementation should precede any attempt at skin grafting. The best course may be to graft critical areas while leaving some of the larger, less functional areas to granulate.

The surface of the debrided burn wound often has a superficial slime of exudate and bacterial contamination. Dressings with a supersaturated saline solution (add salt to normal saline until it no longer dissolves), changed frequently for a couple of days, will produce a clean, bright red granulating surface ready for grafting.

The occlusive dressing which is applied after skin grafting plays a great part in the survival of the graft. It must be put on with great care. The dressing must hold the graft closely applied to the recipient site for the first few days for capillaries to grow in. Any blood or serum that floats the graft away from its bed will cause it to fail.

The life of a patient with a severe burn is in danger until the dead tissue has been excised and the defect closed with a healthy skin graft.

15.8 Scar management and rehabilitation

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Figures 15.15.1 and 15.15.2

Post-burn scar contractures.

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Burns frequently result in scars, especially when appropriate and effective treatment is delayed or unavailable. The longer a burn takes to heal, the greater the scarring and the higher the risk of contracture formation. Scar contractures can be devastating, leading to significant deformity, disfigurement and functional impairment. All efforts should be made to prevent significant scarring, and this starts with initial local care of the burn wound. Avoiding delayed wound healing and providing adequate analgesia to allow early active and passive mobilization and function are key. Proper positioning and rigorous splinting, using plaster of Paris slabs, with the limb actively or passively mobilized and stretched against the force of contracture, should be implemented to prevent contracture of major joints. If a joint is equally burnt on both sides, it should be splinted in extension. Airplane-strut type splints should be used for burns to the axilla in 90 degrees abduction.

The functional benefit of skin grafting depends on good graft take followed by diligent splinting, mobilization and stretching of the tissues afterwards to prevent contraction. With growing children there is increased risk of contracture formation, which can be very severe. Even after successful reconstructive surgery there may be recurrence of contractures, especially if tissues are not managed properly over the succeeding 6 – 12 months.

All skin grafts crossing joints should be splinted at operation with plaster slabs. Later, when the grafts have taken (usually after 5 – 7 days), a plaster slab covered in tube bandage and fitted correctly makes an excellent, reusable splint that can be worn at night and removed for therapy during the day. Dedicated staff and adequate analgesia are essential to active and passive stretching of burn scars and mobilization of the joints; if this hurts too much the patient will simply not comply. An active environment should be created where the patient is encouraged to be as independent as possible with functional tasks and to mobilize around the ward. Burns crossing joints should be splinted and stretched even if they have not been grafted, as this will reduce the degree of contraction as the scar heals.

After discharge from hospital, regular follow-up is vital, as contractures develop over the first nine months; treatment and assessment must be continued. Adequate moisturization of scars and healed skin grafts is important to help prevent dry skin, ulceration and breakdown. Pressure garments are important to optimum scar management and their use can result in softer and more pliable scars. Where they are not available, elastic bandages and a variety of tight-fitting stretchy commercial clothing may help. New scars should be protected from the sun to prevent permanent discolouration of skin. Antihistamines can help treat itch, and keeping finger nails short can help prevent skin breakdown with scratching.

15.9 Electrical burns

As mentioned, there are two distinct categories. With flash burns, the patient typically presents with fairly deep burns to the face and one or both hands and forearms. Treatment is as with regular thermal injuries.

High voltage (>1,000 volts) electrical conduction injuries have small cutaneous entry and exit wounds, which extend deep into the muscles causing myonecrosis. The rhabdomyolysis has a systemic effect (with myoglobinaemia and myoglobinuria leading to acute tubular necrosis) and a local effect, i.e. compartment syndrome.

The patient should receive Ringer's lactate, with 50 mEq sodium bicarbonate per litre, in sufficient volume to maintain urine output at 0.5 ml/kg. If the urine is dark or bloody, or urine output ceases, the vascular space should be well filled and a bolus of 20 % mannitol given (1 g/kg); furosemide may be added as well.

Any suspicious compartments should be released promptly by generous full-length fasciotomy, including carpal tunnel release in the forearm. Dead muscle should be debrided conservatively, and numerous returns to the operating theatre may be needed (serial debridement).

Numerous complications attend electrical conduction injury including arrhythmias (ECG monitoring is strongly recommended), cervical fractures associated with the jolt of electricity, intestinal perforation and a variety of unusual neurological sequelae.

15.10 Chemical burns

A number of chemical substances cause specific burns. The presence of any of them on an injured person poses a danger to first-aiders, hospital staff and other patients. Careful removal of contaminated clothing and proper decontamination measures – covering the patient and any equipment used – must be undertaken, and specific protocols followed to protect the medical personnel treating the patient. See footnote 5.

The wounding chemical agent constitutes a danger to first-aiders, hospital staff, and other patients. Specific actions and proper protective measures must be taken.

15.10.1 Acid and alkali burns

In general, acids cause coagulative necrosis of the skin, while strong alkalis cause liquefactive necrosis and burrowing of the chemical deep into the tissues. "Acid violence" involving the throwing of concentrated sulphuric acid into the face is an increasingly common phenomenon and the chemical is readily available wherever there is a motor vehicle garage. The acid burn should be washed with very large volumes of water and the eyes thoroughly irrigated. Strong alkalis may come in dry form (NaOH crystals); any remaining material must be brushed off the patient before washing with water.

After this decontamination, the treatment of chemical burns follows the same sequence as the treatment of thermal burns. Acid attacks usually involve the face and typically cause extremely disfiguring injuries which are very difficult to reconstruct.

15.10.2 Phosphorus burns

Some modern weapons contain white phosphorus. This element *ignites on contact with oxygen*, and fragments of phosphorus will be scattered throughout any wounds; it is lipid soluble and sticks to the subcutaneous fat. The burn is deep and painful and the phosphorus continues to burn as long as it is in contact with oxygen or until all the phosphorus is consumed. The white phosphorus fragment can dig a cavity all the way down to the bone. Local treatment is more urgent than with conventional burns because of the aggressive nature of phosphorus. Much of the injury, however, results from the ignition of clothing, which causes a conventional burn.

Contaminated clothing must be removed immediately, care being taken not to contaminate the staff attending to the casualty. Visible, smoking particles can be removed with a spatula or knife, and should be placed in a basin of water to exclude them from the air. Phosphorus burn wounds must then be isolated from oxygen by being kept wet through liberal soaking with water, by covering with wet dressings, or by placing the injured part in a basin of water. On no account must they be allowed to dry out.

When surgical treatment is available, the idea is to identify and remove the remaining phosphorus particles. The wet wound can be irrigated with a neutralizing agent. A freshly prepared solution of 1% copper sulphate combines with the phosphorus to form black copper sulphide, which impedes violent oxidation and identifies the particles. The black particles can then be carefully removed with forceps and placed in a basin of water. The solution must not exceed 1%, the palest blue colour, since its absorption can cause haemolysis and acute renal failure. If used, the copper sulphate solution must be washed away immediately. Or, if copper sulphate solution is not available, the operating theatre lights may be put out; any remaining particles will glow with phosphorescence in the dark and can be carefully picked out with forceps and placed in a basin of water.

Care must be taken not to allow the wound and the phosphorus to dry out and re-ignite in theatre; appropriate, non-flammable anaesthetic agents should be used. In all cases, the wound should then be excised and dressed as usual.

Phosphorus may provoke hypocalcaemia, by combining with endogenous calcium, and hyperphosphataemia; intravenous calcium should be given. Absorbed phosphorus can be toxic to many organs:

- central nervous system – delirium, psychosis, convulsions, coma;
- gastro-intestinal tract – abdominal colic, melaena;
- liver – hepatomegaly, jaundice;
- kidneys – proteinuria, acute tubular necrosis;
- blood – thrombocytopenia, hypoprothrombinaemia;
- myocardium – ventricular arrhythmia, myocarditis.

15.10.3 Napalm injuries

Napalm is jellied petrol, an intensely flammable agent that clings to the clothing and skin while still burning and causes serious, deep and extensive burns. Its incomplete combustion of the oxygen in the air around the victim provokes an acute rise in carbon monoxide that can lead to a loss of consciousness and even death. The intense heat and benzene fumes easily cause inhalation burns.

Napalm burns are invariably full thickness, with coagulation of muscles and other deep tissues. Nephrotoxicity is a serious complication of the rhabdomyolysis, and mortality may be high in proportion to total body surface area involved. A full-thickness burn of only 10% of the body surface area may result in renal failure. The patient should be kept well hydrated and in alkalosis; mannitol may be necessary to protect renal function.

First-aid treatment includes extinguishing the burning napalm by smothering it, i.e. excluding the oxygen. Unlike phosphorus, napalm does not then reignite in contact with the air. Surgical treatment involves removal of the napalm with a stick, spatula or knife. The wound is then excised deep to any remaining contaminant, care being taken to avoid contact ("no-touch" technique), and dressed as usual.

15.10.4 Magnesium

Flares released from aircraft to avoid heat-seeking missiles use magnesium, which gives off great heat when lighted. These may reach the ground and cause fires and injuries. The intense heat causes a full-thickness burn. The wound should be excised deep to the contaminant using the "no-touch" technique. Some reports from ICRC surgical teams (Kabul, Afghanistan) have mentioned toxic side effects due to absorption of magnesium, similar to phosphorus; this has not been confirmed.

15.10.5 Chemical weapons

Unlike other agents causing specific burns, chemical weapons have been banned by international treaties.[3] However, some States retain stockpiles, which may either be used militarily or released into the air if the storage facilities are bombed. Certain chemicals have a potential dual function: they can be used in weapons and are widely employed for civilian purposes (the disinfection of public water supplies in the case of chlorine).

Traditional chemical weapons are classified as:[4]

- choking agents (chlorine, phosgene);
- neurotoxic agents (sarin, tabun, VX);
- blood agents (cyanides);
- vesicant (blistering) agents (mustard gas, lewisite, phosgene oxime): these cause burns to the skin, similar to flame burns, and inhalation injury.

The patient's clothing must be removed and properly destroyed. The patient is then decontaminated with abundant soap and water. Care must be taken not to contaminate hospital personnel, equipment, and other patients with the chemical agent. Correct decontamination protocols include the use of protective clothing and equipment (mask, gloves, boots, etc.) by first-aiders or hospital staff.[5]

Once decontamination has been performed, the wounds are dealt with in the traditional manner; however, a "no-touch" technique should be used during wound debridement and removed tissues disposed of with care. The patient's respiratory function must be closely monitored. Inhalation of chemical fumes will burn the respiratory mucosa with the development of acute respiratory distress syndrome (ARDS). Assisted ventilation may be required. Oxygen should be delivered at 15 l/min and the medical personnel must take suitable precautions, as toxic vapours remain in the patient's lungs even after decontamination.

3 1925 Geneva Protocol for the Prohibition of the Use of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare and the 1993 Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction.

4 See OPCW, *What is a Chemical Weapon?*: https://www.opcw.org/our-work/what-chemical-weapon

5 See Larsson F. *Guidelines in Pre-clinical Management of Chemical Agent Contaminated Victims in Contexts of Armed Conflicts and Other Situations of Violence*, ICRC, Geneva, 2019.

ANNEX 15. A Nutrition in major burns: calculating nutritional requirements

Calorie requirements = Basal energy expenditure x stress factor x activity factor

The basal energy expenditure is calculated as follows:

[66 + (14 x weight in kg) + (5 x height in cm) – (6.8 x age in years)]

Stress factors:
- minor procedures: 1.3
- skeletal trauma: 1.35
- major sepsis: 1.6
- major burns: 2.1.

The activity factor is 1.2 for those in bed and 1.3 for those who are mobilizing. Women require about 4% less than men for equal body size and age.

Example
For a 25-year-old male weighing 60 kg and 170 cm tall, in bed with a major burn, the calorie requirements are:

[66 + (14 x 60) + (5 x 170) – (6.8 x 25)] x 2.1 x 1.2 = 3,997 kcal/day

Protein, glucose and fat requirements
Daily *protein* requirement for acute burns is 2 g/kg in adults and 3 g/kg in children. Protein provides about 4 kcal/g (120 g and 480 kcal in the example given above).

Daily *glucose* requirement is about 6 g/kg/day in burns.
Glucose provides 4 kcal/g (360 g and 1,440 kcal in the example).

The difference between the calculated energy requirement (3,997 kcal) and that provided by protein and glucose should be made up with fat.

Daily *fat* requirement = 3,997 kcal – 480 – 1,440 = 2,077 kcal.
Each gram of fat provides 9 kcal, therefore, 2,077 ÷ 9 = 231 g of fat.

The larger the volume and the higher the fat concentration the more likely the patient is to develop diarrhoea. In an adult with a major burn, 3 litres of feeds per day is a reasonable target; therefore for the patient in the example, a "cocktail" containing 40 g of protein, 120 g of glucose and 80 g of fat per litre should be prepared.

Making a high-energy enteral feeding solution for burn patients

Ingredients	Glucose	Protein	Fat	kcal
Skimmed milk powder 110 g (244 ml)	44 g	40 g		385
Edible oil 80 g (80 ml)			80 g	720
Sugar 50 g (50 ml)	50 g			200
1 Banana (15 mEq potassium)	25 g			110
Add: Salt: 3 g Calcium-containing antacid: 3 tablets Multivitamin tablet: 1 daily Ferrous sulphate + folic acid tablets Codeine: 30 – 60 mg per litre provides analgesia and reduces diarrhoea Boiled and filtered water to make 1,000 ml of solution				Total 1,415 kcal per litre
N.B. Eggs contain 15 g of protein each: supplement tube feeds with cooked eggs fed by mouth when possible – beware of salmonellosis from raw eggs!				

Make a paste of milk powder with a little water; add sugar, salt, crushed tablets and oil. Slowly add more water while mixing well. Add mashed banana and mix thoroughly (using a blender if possible). Filter the mix through a gauze compress and refrigerate. Irrigate the feeding tube regularly with water to keep it from blocking. Use within 24 hours.

15

Chapter 16

LOCAL COLD INJURIES

16.1 Physiology of thermal regulation

The significance of prevention and treatment of local cold injuries during armed conflict cannot be overemphasized. Although most commonly seen in arctic and subarctic climates, cold injuries can occur whenever the combination of cold, wet, and immobility exists. High altitudes, even in tropical or temperate regions, can experience cold weather. Wind is an aggravating factor in all circumstances.

Normal body temperature is maintained through a balance between heat production and heat loss, and is regulated by a hypothalamic "thermostat". At least 95 % of the heat produced by the metabolism of viscera and muscles is normally lost to the environment by conduction, convection, radiation, and evaporation, largely through the skin and lungs; the head and neck account for 20 – 30 %. The skin primarily dissipates heat by regulating its blood flow, which may vary from 50 ml/min to 7,000 ml/min.

In a cold environment, the *core temperature* (that is, the temperature of the vitally important visceral organs) is conserved by decreasing heat loss through peripheral vasoconstriction, and by increasing the production of heat by involuntary muscle contractions (shivering). If the heat loss exceeds the heat-producing resources of the body, the core temperature begins to fall and *hypothermia* develops. Wetness and wind increase the effect of cold in inducing loss of body heat.

In peripheral tissues subjected to low temperatures, wetness, wind, and contact with a cold surface (metal), local cold injury may result from vasomotor and/or cellular effects, including intracellular ice crystal formation.

O. Litvin / ICRC

Figure 16.1
Patient with "trench foot" affecting both feet.

16.2 Types of local cold injuries

Local cold injuries can occur at temperatures above or below freezing point and are classified as non-freezing or freezing injuries.

16.2.1 Non-freezing injury

This is also known as "immersion foot" or "trench foot", and is seen in prolonged exposure to cold ambient temperatures above freezing, with high humidity and immobilization, as often witnessed during the trench warfare of World War I, hence the name. Prolonged wetness and cooling of the feet, as can occur in a jungle or rice paddy, can also provoke an "immersion foot" injury. Such injuries are diagnosed and treated like other cold injuries, except that the feet should not be immersed in warm or hot water.

16.2.2 Freezing injury

This type of injury may be superficial (chilblain), in which only skin and subcutaneous fat are involved, or deep (frostbite), reaching structures such as muscle.

Frostbite occurs in the extremities and exposed body parts: nose, ears, etc. In the early stages of injury, it is not easy to differentiate between superficial and deep wounds.

16.2.3 Local signs and symptoms

These include:
- paraesthesia;
- numbness and insensitivity to pin prick;
- pallor (wax-white or mottled blue discoloration);
- impaired movement leading to paralysis;
- firmness of the body part;
- oedematous swelling (particularly in non-freezing injuries) followed by blister formation after 24 – 36 hours.

16.3 Management

16.3.1 First aid and transport

When a body part is frozen solid for hours it runs a lesser risk of tissue loss than when it is exposed to a cycle of thawing, refreezing, and thawing. A person can continue to walk on a frozen foot while it remains frozen; but will be unable to walk after thawing because of the pain and swelling. This should be kept in mind *before* pre-hospital treatment is attempted; it might be preferable to transfer the patient to adequate shelter and facilities rather than begin treatment with inadequate means.

The patient should be moved to a sheltered place as soon as possible. Boots and socks should be removed, avoiding trauma to the skin. As with burns, constricting agents such as rings should also be removed.

As some degree of central hypothermia generally coexists with local cold injury, the general body temperature should be raised by hot drinks, blankets, or skin-to-skin contact. The frozen extremity should be *prevented* from thawing before normal core temperature is reached.

Once hypothermia has been corrected, any available form of heat transfer (skin-to-skin contact, foot-in-axilla, hand-to-nose) should be utilized to warm the body part. Rapid rewarming in warm water (40 – 42°C, or just tolerable to elbow immersion) should only be used when it is certain that refreezing can be avoided.

Analgesia is essential, as thawing of frostbite is extremely painful.

Do not:

- rub or massage injured tissue;
- apply ointments or other topical medication;
- break blisters;
- rewarm by exposure to fire, radiant heat or excessively hot water.

16.3.2 Hospital treatment

Central hypothermia should be dealt with *first* through external rewarming by blankets and warm water bath. In severe cases (core body temperature below 30° C) combined or not with frostbite, central warming has a priority over peripheral warming because of the risk of "after-drop". This represents a situation where the core temperature tends to decrease during peripheral heating of the body. Rewarming of the limbs causes a local vasodilatation with shunting of cold stagnated blood towards the central part of the body; arrhythmias and cardiac arrest may result. Central core warming measures include warm i.v. fluids, rectal enema, and bladder, gastric and peritoneal lavage at 37° C. A low-reading thermometer is necessary to satisfactorily monitor core temperature (see Chapter 18).

Hypothermia takes precedence over local cold injury.

General rewarming should precede local rewarming.

Once hypothermia has been sufficiently corrected, attention may be given to the local cold injury. Superficial injuries may be rewarmed rapidly in 40 – 42° C water. For deep injuries, if the limbs are still frozen or cold and vasoconstricted, they should be rewarmed with dry heat at 37 – 39° C. Even if only one limb is affected, both should be rewarmed together until the nail beds become pink. The patient should receive 100% oxygen, warmed and humidified, during the warming process.

If the patient is comatose, it should be borne in mind that the patient is not dead until he is *warm* (33° C core temperature) and dead!

Aspirin still appears to be a most useful drug for pain relief and possibly for preventing tissue loss. Pethidine may be added as necessary. Amitriptyline is the preferred analgesic for immersion injury. Tetanus prophylaxis and penicillin should be given. Smoking is contraindicated.

Heparin, anticoagulants, corticosteroids, antihistamines and intravenous dextran have all been shown to be of little benefit. Disagreement exists on the effect of sympathectomy.

16.3.3 After care

Once rewarming is complete, little more can be done to alter the course of events.

> The basic treatement is conservative wound care.

Good nursing care and physiotherapy is the essence of conservative treatment. The extremities should be kept on sterile sheets under cradles. Sterile cotton pledgets are placed between toes or fingers. Warm povidone iodine soaks twice daily help prevent superficial infection. As blebs appear, precautions are taken to avoid their rupture: they should not be allowed to dry up. The limb should be placed so as to avoid pressure on the injured part as much as possible. A good functional result will be helped by maintaining active exercises and elevating the affected limb.

It is difficult to predict the extent of eventual tissue loss from frostbite during the first weeks after injury. Tissue loss, however, is generally smaller than expected. It is therefore important to wait until the damaged tissue becomes necrotic and mummified, with a clear line of demarcation and spontaneous amputation of fingers or toes. As with burns, escharotomy of circumferential injuries, and even fasciotomy, might be necessary.

> Wait until a clear line of demarcation appears between necrotic and viable tissue.

The *surgical treatment* of local cold injury is to avoid excision of tissues unless secondary infection intervenes. The natural process is allowed to happen: “frozen in January, amputation in July”.

Chapter 17

ANAESTHESIA AND ANALGESIA IN WAR SURGERY [1]

1 Much of this chapter is based on the report of the Senior Anaesthetists Workshop held in Geneva, November, 2002 (see Introduction).

17.1 Introduction

Standard anaesthetic practices, as utilized in trauma care, should be followed. However, providing safe and effective anaesthesia with limited resources is probably the most challenging task of hospital work. Many limitations must be accepted owing to security concerns, lack of infrastructure and difficult logistics.

> A reminder to surgeons: operations are "large" or "small".
> All anaesthesia is potentially fatal.

This chapter is not intended for anaesthetists, but rather presents the most important challenges and tactics in anaesthesia that surgeons should consider when working under precarious circumstances. There are several reasons for this.

1. Surgeons perform "large" and "small" operations. There is no such thing as a "small" anaesthesia. Every anaesthesia is potentially fatal. The limits of operational activity in the theatre are not those of the surgeon's expertise. They are determined far more by the level of competency and sophistication of the anaesthesia department. The anaesthetist will tell the surgeon what can be done; not the other way around. The surgeon must understand and accept this limit. There is only one other limiting factor that is as important as anaesthesia, if not more so, in determining the level of sophistication of surgery to be performed: postoperative nursing care.
2. In wartime, a surgeon may sometimes find himself without an anaesthetist. In this case, the war surgeon must know how to administer safe and adequate anaesthesia in order to perform the most important and basic of lifesaving procedures. There is much that a surgeon alone can do in terms of anaesthesia. Good knowledge of local anaesthesia techniques – practical, cheap and safe – can be very helpful when resources are limited.
3. Moreover, in many countries practising surgeons far outnumber anaesthetists, and this is likely to remain the case in the foreseeable future. Anaesthesia in low-income countries is often administered by a nurse or technician under the "guidance" – and medical responsibility – of the surgeon, who must understand the important indications and contraindications of the various anaesthetic techniques. Needless to say, the surgeon must know about the possible complications of the anaesthesia used and how to counter them.

It would be presumptuous to try to explain the safe administration of anaesthesia in a half-dozen pages. This account comprises the basic precepts that a surgeon should be familiar with. For a full description of appropriate anaesthetic techniques under circumstances of limited resources, the reader is referred to the excellent texts listed in the Selected bibliography.

Figures 17.1.1 – 17.1.4

Standard ICRC equipment for anaesthesia.

H. Hay / ICRC

Figure 17.1.1
Typical operating theatre. Note the inhalation anaesthesia machine and oxygen concentrator.

M. Baldan / ICRC

Figure 17.1.2

Pulse oxymeter for monitoring; laryngoscope and endotracheal tube, bag for manual ventilation.

C. Gerber / ICRC

Figure 17.1.3

Foot-driven suction pump.

M. Baldan / ICRC

Figure 17.1.4

Electric suction pump.

ICRC EXPERIENCE

ICRC anaesthetists have found the points listed below to be particularly important and they may be useful to other humanitarian organizations or foreign staff operating in a war environment in a new and strange context.

- The presence of a good interpreter, preferably with a medical background, is essential for communication with patients.
- Unfamiliarity with anaesthetic equipment and local conditions increases the likelihood of complications. The presence of an assistant knowledgeable about local standards and available resources is essential.
- The assistance of a second person – doctor, nurse – preferably with experience in anaesthesia, is mandatory for all anaesthetic procedures.
- Assessing the time the patient last ate is difficult, especially with breastfed babies.
- Many of the wounded, especially in hot climates, are severely dehydrated. It is important to correct any hypovolaemia before surgery.
- The patient should be discharged to the ward only when fully awake, properly resuscitated and comfortable.
- Routine premedication is not necessary; premedication should be administered only when specifically indicated.
- Arrangements for blood transfusion may be complicated (involving negotiations with family or clan members) and require local blood-collecting procedures to be activated. Likely blood requirements should be ordered early.

17.2 Anaesthesia methods

There are many different levels of sophistication for the provision of anaesthesia. Even when working in an austere environment, minimum mandatory standards should be followed to ensure safe anaesthesia. These include WHO safety checklists, World Federation of Societies of Anaesthesiologists standards and fasting rules for non-emergency surgery including DPC (ANNEX 17. A).

Local and regional anaesthesia techniques are excellent and can be used in many patients, al-though they tend to be underestimated and, therefore, underused: a below-knee amputation or Caesarean section can be performed under local anaesthesia, for example. They are safe in avoiding vomiting and aspiration, especially when the time of the last meal cannot be determined accurately.

Oxygen, nitrous oxide and other volatile anaesthetics may be in short supply. In the context of actual combat, oxygen cylinders are to be banned. Not only are the logistics for refilling cylinders and transporting them difficult and dangerous and there is no standard shape, size and colour, and pressure gauges and regulators may be absent or malfunction, but an oxygen cylinder is the equivalent of a bomb. Oxygen concentrators – with a pulse oxymeter for control – are standard ICRC equipment for these circumstances, but they do require an electrical supply.

Ketamine is the anaesthetic of choice in ICRC practice for major surgery and is considered a "safe drug". Equipment for the use of ketamine is minimal – not even an oxygen concentrator is necessary – and muscle relaxants can be added to provide full general anaesthesia. The further the hospital from the actual conflict zone, the more sophisticated the equipment and supplies that may be provided, and therefore the techniques employed.

Standard ICRC anaesthesia equipment is listed in ANNEX 17. B.

The following anaesthetic agents and their characteristics should be well known to surgeons. For anaesthesia techniques recommended for different operations see ANNEX 17. C.

17.3 Local and regional anaesthesia

The clinically significant point in all forms of local and regional anaesthesia is to allow sufficient time for the anaesthetic to work. The most common mistake is to make a local anaesthetic infiltration, and then incise immediately.

Technique	Use	Drug of choice	Recommended volume*	Remarks
Topical anaesthesia	Ophthalmic	0.4 % oxybuprocaine or 0.5 % proxymetacaine (Alcaine)		If not available, 2 % or 4 % lidocaine drops
	Mucosa	4 – 5 % lidocaine		Nebulizer spray of lidocaine
Local infiltration (field block) anaesthesia	In general	1 % lidocaine with adrenaline or 0.25 % bupivacaine** with adrenaline	40 ml 60 ml	If a volume greater than 40 ml is required, dilute with an equal volume of isotonic saline
	Fingers, toes, ears or penis	1 % lidocaine without adrenaline	20 ml	Danger of ischaemic gangrene if adrenaline is used
Peripheral nerve block	Digital block	2 % lidocaine without adrenaline or 0.5 % plain bupivacaine	2 – 4 ml per digit	
	Axilla: brachial plexus block	2 % lidocaine with adrenaline or 0.5 % bupivacaine with adrenaline	30 – 40 ml	Where early movement is desired
	Wrist / ankle block		20 ml 30 ml	
	Intercostal block (flail chest)	0.5 % bupivacaine with adrenaline	2 ml for each nerve	Prolonged analgesia required
Intravenous regional anaesthesia	Limbs	0.5 % lidocaine without adrenaline	40 – 50 ml	Not first choice in ICRC settings
Neuraxial anaesthesia	Subarachnoid block	0.5 % bupivacaine in 5 % dextrose		Hyperbaric, single dose ampoule
	Epidural block	0.5 % bupivacaine	1 – 2 ml/ segment to be blocked	Requires appropriate conditions of hygiene Not to be used routinely, limited to specialized surgery
	Caudal block	0.25 – 0.5 % bupivacaine	1 ml/kg < 7 yrs	Useful for children

Table 17.1 Anaesthetic agents of choice for local and regional anaesthesia.

* Doses above are for adults. As a rule of thumb, the maximum dose of lidocaine without adrenaline is 3 mg/kg (200 mg for an adult); and double with adrenaline: 6 mg/kg.

** Bupivacaine (L-bupivacaine): 2 – 3 mg/kg (max dose 150 mg), provides prolonged sensory analgesia

17.4 Dissociative anaesthesia with ketamine

The main components of safe and adequate general anaesthesia are:
- unconsciousness (hypnosis);
- analgesia;
- amnesia;
- immobility/muscle relaxation.

Ketamine is the anaesthetic of choice for major war surgery in conditions of limited resources.

17.4.1 General considerations

Ketamine is very safe for both adults and children, and can be given intramuscularly or as an intravenous bolus or perfusion.


M. Baldan / ICRC

Figure 17.2
Drugs for general ketamine anaesthesia.

It causes amnesia, analgesia, and a state of dissociation. The patient feels detached from the environment, but the reflexes are intact, particularly the laryngo-pharyngeal reflexes that protect the airway. Opening of the eyes, shouting, and limb movements are frequent and normal; the patient is nevertheless anaesthetized. It may cause hallucinations and should be combined with a sedative such as a benzodiazepine (diazepam is inexpensive but burns on injection; midazolam is not irritant but is costly).

Ketamine increases the cardiac output and the arterial blood pressure and, therefore, is particularly useful in patients with haemorrhagic shock. Ketamine dilates the bronchi, but also increases bronchial secretions and saliva. Atropine can be administered first to control saliva and bronchial secretions. There are important contraindications to the use of atropine: marked tachycardia, hypertension, valvular stenosis, hyperthyroidism or fever. Ketamine also increases the muscular tone, which is why it makes a laparotomy, and especially the closure of the abdomen, more difficult if used without myorelaxants.

There is no absolute contraindication for ketamine anaesthesia. Relative contraindications include:
- psychiatric disease;
- mitral or aortic stenosis;
- untreated hyperthyroidism;
- eclampsia;
- epilepsy;
- operation on the eye – this is due to nystagmus, which causes the globe to move and makes operating difficult.

The question of the use of ketamine in patients with a head injury or increased intracranial pressure has been controversial, although that controversy is based on very few and very early reports in the 1970s. There is no longer any contraindication for its use in these patients consistent with evidence-based medicine, and ICRC standard practice includes craniotomy performed under ketamine anaesthesia (see Selected bibliography).

The advantages of ketamine are the following:
- easy and rapid to administer with quick onset of action;
- safe;
- provides amnesia and strong analgesia;
- cardiovascular stimulation;
- maintains spontaneous respiration (very slow intravenous injection);
- protective airway reflexes remain intact in the majority of patients; vomiting may however occur: staff should be ready to suck the mouth clean and secure the airway;
- maintains cerebral blood flow;
- particularly suitable for infants.

17.4.2 Ketamine i.m. and i.v. bolus

Both the intramuscular and the bolus intravenous routes are simple forms of ketamine administration. Table 17.2 compares the two.

	Ketamine i.m.	Ketamine i.v. bolus
Indications	Short operation (10 – 20 minutes) Anaesthesia in children (injected while the mother is holding the infant) Repeated injections for change of dressings in burn patients with poor i.v. access	Short operation (10 – 20 minutes) Induction of anaesthesia
Premedication	Preferable if time allows In children diazepam may be given orally or rectally	Preferable if time allows
Technique	Ketamine and atropine can be mixed in the same syringe Diazepam should be given in a separate syringe	Place an intravenous line and inject atropine Inject diluted diazepam solution very slowly over 3 minutes, until the patient becomes drowsy Inject ketamine very slowly over one minute (rapid injection can provoke respiratory arrest)
Latent period	5 – 10 minutes	Painful stimuli (skin incision) can be tolerated after one minute
Continuing anaesthesia: second dose	Second injection can be given if necessary before the effect of the first wears off	After 10 – 15 minutes, the patient begins to feel pain and reacts to stimuli with movements and speech – not to be confused with normal movements under ketamine Administer another i.v. bolus: one-third to one-half the initial dose

Table 17.2 Comparison of ketamine anaesthesia administered intramuscularly versus intravenous bolus.

In special circumstances (repeated ketamine anaesthesias with “ketamine resistance” and/or disturbing limb movements), one or more of the following may be added according to the reaction of the individual patient:

- 50 – 100 mg tramadol or 5 –10 mg morphine
- 3 – 5 mg midazolam
- 50 – 100 mg thiopental
- 50 – 100 mg propofol

17.4.3 Ketamine infusion anaesthesia

This is the preferred technique in ICRC practice. It is not only more economical of ketamine, but allows for a longer operation without re-injections. It can be used either after i.v. bolus induction of anaesthesia or as an induction method on its own.

A solution is made of ketamine in normal saline and placed in a different vein from that used for fluid replacement. The rate of infusion is titrated against the patient’s response, both for induction and as maintenance of anaesthesia.

Ketamine infusion anaesthesia can be combined with muscle relaxants and endotracheal intubation. This is standard ICRC procedure where muscle relaxation is necessary (abdominal or thoracic surgery). As mentioned previously, the absence of mechanical ventilators means that the paralysed patient must be bagged manually.

M. Kruck / ICRC

Figure 17.3
Ketamine infusion.

17

> **ICRC EXPERIENCE**
>
> Most anaesthesia machines are fragile and require complex maintenance. The ICRC deploys small, portable, gas-driven ventilators to free the hands of the anaesthetist. These ventilators are specifically designed for an austere environment and are able to function using only an oxygen concentrator (there must be a regular supply of electricity) rather than with compressed air or oxygen. They provide safe and reliable anaesthesia through a draw-over vapourizer.

Like any drug, ketamine has adverse effects, most of which are dose-dependent. Side effects include excessive salivation, which is particularly problematic in children and can lead to transient laryngospasm. This can be offset by premedication with atropine, or by gentle suction at the corner of the mouth. Vomiting can occur after emergence. Purposeless movements or muscle hypertonicity can interfere with surgical procedures.

Over time, tolerance to ketamine develops, requiring higher doses. Psychiatric events may include euphoria, frightening depersonalization, illusions, delirium and hallucinations, and once encountered are likely to be repeated on other occasions. The frequency of hallucinations tends to differ with different population groups, and strong post-ketamine emergence reactions may occur in heavy users of alcohol or other drugs. Sometimes these patients are very loud, they shout or sing, and move a great deal. This is normal and is not dangerous for them.

These reactions can be prevented or terminated by sedatives. In addition, patients should be in a calm and quiet recovery environment without excessive tactile, verbal or visual stimulation, although continuous monitoring is mandatory. On awakening, they respond to orders – "show your tongue" or "raise your head" – and can be safely discharged to the ward.

Different examples of ketamine regimes are described in ANNEX 17. D.

17.4.4 Ketamine analgesia

The analgesic effect of ketamine can be profitably used for a number of conditions. One noteworthy example is for repeated change of dressings in burn patients. For analgesia, a lower dose than that given for intramuscular anaesthesia is administered to those whose venous access is compromised, as is often the case with major burns (see ANNEXes 17. D and E).

17.5 Post-operative pain management

Good post-traumatic or post-operative pain relief not only helps to alleviate suffering, but also allows for rapid mobilization of the patient and early physiotherapy, which help attain as good a functional result as possible. (See ANNEX 17. E)

17.5.1 General guidelines

1. Pain is managed by the three Ps: psychology (humanitarian), physical methods (surgical fixation, physiotherapy etc.), and pharmacology (drugs).
2. Analgesia should be given before the pain starts and on an around-the-clock basis, at regularly scheduled intervals.
3. Combination therapy is recommended. Analgesic drugs have a better effect in combination than alone, e.g. paracetamol and an NSAID have additive pain-relieving activity because of their different sites of action, thereby leading to dose-sparing and, later, opioid-sparing effects.

4. Local anaesthetic infiltration or blocks are used whenever appropriate, in conjunction with other forms of analgesia.
5. Injectable analgesics act more quickly and are more effective if administered as an i.v. bolus, titrated until the desired effect has been achieved. This is especially true in case of hypovolaemia and shock where the peripheral circulation is decreased and, therefore, the intramuscular or subcutaneous routes are unreliable.
6. The choice of drugs is made with the staff and facilities in mind; e.g. opioids may be undesirable if proper monitoring is unavailable.
7. It is advisable to institute a system of pain scoring, especially for post-operative pain relief.

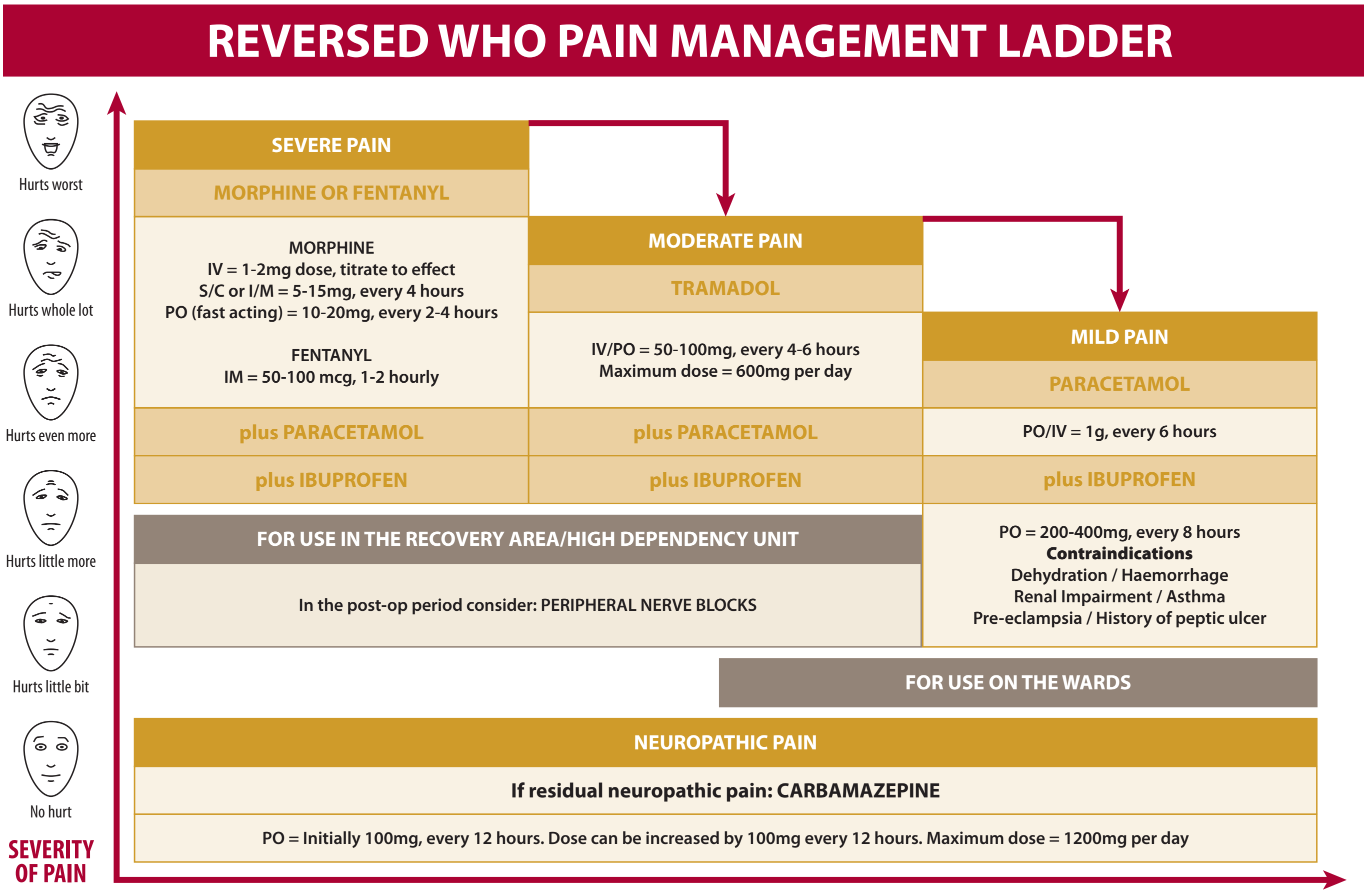

Figure 17.4 Adapted from Reversed WHO Pain Management Ladder

The ICRC follows the WHO reversed pain ladder in the management of acute pain:

17.5.2 Pain scoring systems

Pain intensity can be measured in various ways and the use of a system of measurement is recommended. The choice of scoring system depends on a number of factors, including cultural issues and the level of literacy and numeracy of patients and the nursing staff. In all of them it is the patient who assesses the intensity of pain.

Common scoring systems include the following.

Verbal score
The pain intensity is measured using words:
- None
- Mild
- Moderate
- Severe
- Extreme

Number scale

Numbers from 0 to 10 should be used:
0 means no pain and 10 the worst pain imaginable.

Visual analogue score

This is analogous to the number scale. The pain intensity is measured on a 10 cm line. The left end indicates "no pain" and the right-hand side means "the worst pain imaginable". The distance in cm from the left edge to the point the patient indicates is the pain score.

The availability of particular drugs for pain relief in a given country is often subject to importation and distribution restrictions. The widespread abuse of opioids in particular has created many problems in the proper management of patients. ANNEX 17. C includes various alternatives that may be used according to the availability of various medications. These must of course be adapted to specific situations.

ANNEX 17. A Fasting rules for non-emergency surgeries, including delayed primary closure

Fasting rules for non-emergency surgeries – adults	
Night before surgery	Carbohydrate (CHO)* preloading up to 800 ml
Up to 6 hours before anaesthesia induction	Food (solids, milk, milk-containing drinks)
Up to 2 hours before anaesthesia induction	Clear fluids**
* CHO – 10 % sugary water (10 g sugar/100 ml water)	
** Clear fluids – fruit juices without pulp, lemonade, soft drinks, tea and coffee without milk.	

Fasting rules for non-emergency surgeries – children (1 – 16 years)	
Night before surgery	Free feeding
Up to 6 hours before anaesthesia induction	Food (solids, milk formula, milk-containing drinks)
Up to 4 hours before induction	Breastfeeding
Up to 1 hour before anesthesia induction	Sugary water up to 3 ml/kg: 1 – 5 years: up to 55 ml 6 – 12 years: up to 140 ml ≥ 12 years: up to 250 ml Other clear fluids if tolerated.
* CHO – 10 % sugary water (10 g sugar/100 ml water, lemonade, soft drinks, tea)	

If patients are malnourished and there is a long operating list, the strict NPO rule should be modified.

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ANNEX 17. B Standard ICRC anaesthetic equipment

Pre-op – all	General anaesthesia
• Oxygen (concentrator ± cylinder) • Saturation monitoring • ECG • End-tidal CO2 monitoring • BP monitoring • Suction • Anaesthetic machine • Self-inflating bag (Ambu bag) • Stethoscope • Sterile and non-sterile gloves • Tape/marker pen for labelling syringes	• Laryngoscope handles • Laryngoscope blades 1 to 4 ± straight blades • Endotracheal tubes 3.0 – 8 mm • Guedel airways • IV cannulae 24 g to 16 g • Tape / Elastoplast / Ties • Bougies • Magill forceps, large and small • Syringes 2 ml – 20 ml ± 50 ml • Drawing-up needles • Face masks, neonate to adult • Adult and paediatric oxygen masks/nasal specs • IV-giving sets • 3-way taps • Yankaeur suckers + ET suction catheters • HME filters
Extras for regional / spinal anaesthesia	**Drugs**
• US machine • Regional needles • Spinal needles • Syringes for spinal needles • Skin prep	The ICRC constantly reviews the drugs available to ICRC field projects. An up-to-date drug list can be made available on request.
Other kit to consider	
• Nasogastric tubes • Urinary catheters and bags • Chest drain • Pressure bag • IO access • Rescue sheet • Fluid warmer • Peripheral nerve stimulator • Defibrillator • Ayre's T-piece (for paediatrics) • LMAs 2–5	

ANNEX 17. C ICRC recommendations for choice of anaesthetic techniques

	General anaesthesia with spontaneous ventilation (ketamine) *	General anaesthesia with intubation (ketamine ± halothane) **	Spinal ***	Peripheral nerve blocks (ultrasound guided)	Local anaesthesia/ sedation	Caudal anaesthesia. Paediatric cases (up to 7 years old)
Upper extremities	+++	±	-	+++	+	-
Lower extremities	++	±	+++	+	+	+++
Lower abdominal surgery	+	++	+++	-	-	++
Upper abdominal surgery	±	+++	±	-	-	-
Neurotrauma	+	+++	-	-	±	-
Maxillofacial trauma	±	+++	-	+	-	-
Eye surgery for traumatic injuries	++	+	-	+++	-	-
Thoracic surgery	±	+++	-	-	-	-
Caesarean section	±	++	+++	-	±	-
Minor procedures	0	0	0	0	+++	0

– Not applicable
0 Not necessary
± Indicated if no alternatives available
+ Suitable technique
++ Second choice technique
+++ Technique of choice in ICRC/field anaesthesia

* Length of anaesthesia less than 60 min: ketamine is the first choice
** Plus adjuvant (opioids, thiopental, propofol): sevoflurane can be an option.
*** Except for unstable patients (major haemorrhage, coagulopathy, sepsis, etc.) or in case of patient refusal

ANNEX 17. D Ketamine delivery regimes

<table>
<tr><th>Delivery (based on required duration)</th><th>Examples of different ketamine regimes</th></tr>
<tr><td>Induction and bolus maintenance for short procedures</td><td>Ketamine – either i.m. or i.v. – is the anaesthesia of choice for short procedures

Intravenous ketamine recipes
• Ketamine 1 – 2 mg/kg i.v.: produces dissociative anaesthesia; patient maintains own airway.
• Midazolam 5 mg or diazepam 2 – 5 mg i.v. with a small dose of morphine i.v., followed by ketamine 80 – 100 mg i.v. (1 – 2 mg/kg) as a slow i.v. bolus over at least 20 sec.
- Intermittent boluses of ketamine i.v., one-quarter of the induction dose, every 15 minutes.
- Doses of benzodiazepines or opioids added as necessary in response to increasing vocalization or purposeful movements with surgical stimuli.
• Midazolam 0.07 mg/kg i.v. followed 2 minutes later by ketamine 1 mg/kg i.v..

Intramuscular ketamine recipes
• Bolus dose of ketamine 4 – 6 mg/kg i.m., depending on depth of anaesthesia required. This may be very useful in mass casualty scenario.
• Ketamine 10 mg/kg i.m. with anaesthesia given over 5 – 10 minutes for surgery lasting 12 – 25 minutes

Intravenous ketamine recipe for sedation in short procedures
• For very short procedures such as changing burn dressings or splinting trapped limbs using 10 mg/ml i.v. boluses of 10 – 20 mg (1 – 2 ml) ketamine.</td></tr>
<tr><td>Intravenous infusion</td><td>• "The ICRC way": ketamine infusion (0.5 mg/ml ketamine in 1 litre of normal saline) titrated to effect or following i.v. ketamine bolus induction.
• Ketamine infusion (500 mg of ketamine in bag of 500 ml of dextrose or normal saline).

The drip is initiated (via a 15 drop/ml non-micro chamber i.v.-giving set) at a rate of 2 drops/kg/min until an adequate level of anaesthesia is attained (usually takes 2 minutes).

Drip rate is then reduced to 1 drop/kg/min to maintain anaesthesia. The patient will awaken 10 min after the drip is stopped.</td></tr>
<tr><td>Analgesia</td><td>• Ketamine doses of less than 1 mg/kg i.v.
• Ketamine as an i.v. infusion at 60 – 180 mcg/kg/hr. (Adults: put 50 mg in a 500 ml bag and give at 40 – 80 ml/hr).
• Ketamine 2 – 3 mg/kg i.m.</td></tr>
</table>

ANNEX 17. E ICRC pain management protocols

Analgesic drugs

Opioids

1. When Level 3 analgesics (opioids) are used in a hospital, naloxone must also be immediately available.
2. Morphine remains the gold standard for pain relief, intra-operatively as well as pre- and post-operatively.
3. The use of opioids – morphine, fentanyl, pethidine and tramadol – should be restricted to trained health-care professionals because of the risk of respiratory depression.

ICRC surgical teams use opioids only if nursing staff are sufficient in number and trained in patient monitoring, as well as in the recognition and treatment of respiratory depression. In practice this will usually mean that post-operative opioids are only used in the recovery ward or intensive care or high-dependency units (ICU/HDU).

4. Do not mix opioids (e.g. tramadol and morphine) until an appropriate time has lapsed.
5. In the emergency room, operating theatre and recovery area/ICU, the preferred route for opioid administration is intravenous. If they are used in the ward, the oral or subcutaneous routes are preferred.
6. The fear of addiction when using opioids for pain relief, although widespread, is exaggerated; if a patient is in pain and needs an opioid, the development of addiction is extremely rare. The fear of addiction must not stop good pain control.
7. Sedation score: when using Level 3 opioids the level of sedation should be monitored.
   0 = none: patient awake and alert
   1 = mild: occasionally drowsy, but easy to rouse
   2 = moderate: frequently drowsy, but easy to rouse
   3 = severe: drowsy and difficult to rouse
   S = sleep: normal sleep and easy to rouse

Monitoring, diagnosis, and treatment of respiratory depression
When using Level 3 opioids the patient must be monitored regularly for:
- blood pressure;
- pulse;
- temperature;
- respiratory rate;
- sedation score;
- pain score.

All findings must be documented.

Respiratory depression
1. Recognition
   Respiratory depression is diagnosed by:
   - sedation score of 3: this is the earliest and most reliable sign;
   - respiratory rate 8 or less: this comes later than sedation;
   - decreasing pO_2, as shown by pulse oximetry: this is a late sign, especially if the patient is also being given oxygen.

2. Treatment:
   - oxygen;
   - respiratory assistance with bag and mask if necessary;
   - naloxone i.v. in 50 mcg increments until clinical signs improve.

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Remember that the duration of action of naloxone is shorter than morphine and it may therefore need to be repeated; alternatively, use a continuous infusion of 1 – 5 mcg/kg/hr.

A patient must never be discharged to the ward with a sedation level of 3 or more, or a respiratory rate of 8 or less, or if respiratory depression has occurred.

Ketamine

A low dose of ketamine is a good alternative analgesic where opioids are not available or for high-risk patients. Give repeated doses of 0.1 – 0.3 mg/kg i.v., titrated until the desired analgesia is achieved; or an i.m. bolus of 2 – 3 mg/kg. Ketamine in a low dose does not require routine atropine and diazepam as adjuvant therapy.

Pre-hospital care

For pre-hospital first aid, often through National Red Cross/Red Crescent Societies, the ICRC distributes only:

- paracetamol tablets/syrup;
- tramadol injections (rarely causes respiratory depression).

Emergency room

The following are available in the emergency room:

- paracetamol;
- diclofenac injection;
- tramadol injection.

In a hospital with adequate nursing care, the following are also provided:

- morphine injection;
  - adult: 1 – 3 mg i.v. titrated
  - child: 0.05 mg/kg i.v. titrated
- low-dose ketamine (see above).

Operating theatre

All analgesic drugs are available and their intra-operative use is greatly encouraged. The choice of drug depends to a large extent on the quality of post-operative monitoring.

1. Opioids
   Note the level of post-operative monitoring.

2. NSAID
   It is advisable to administer an NSAID before the end of surgery.

3. Ketamine
   0.1 – 0.3 mg/kg boluses can be used as analgesia if opioids are unavailable.

4. Local and regional anaesthesia
   The use of local anaesthetic infiltration or local and regional blocks is greatly encouraged.

Post-operative pain control

The level of pain control needed depends on the psychology of the patient, the type of surgery and the time since surgery. The basic principles of post-operative analgesia are the following.

1. Give analgesia regularly and not on an as-necessary basis (PRN).
2. Do not wait for the pain to be felt, but start immediately once the patient has regained consciousness. This also means that analgesia should be started before spinal anaesthesia has worn off.
3. Start with combination treatment and decrease doses in subsequent days.
4. Review post-operative analgesia regularly.
5. Use local anaesthetic infiltration or blocks as much as possible.

MILD PAIN

Paracetamol
+
Local infiltration or block

MODERATE PAIN

Paracetamol
+
NSAID
+
Local infiltration or block

SEVERE PAIN

Paracetamol
+
NSAID
+
Opioid
+
Local infiltration or block

Analgesic doses

ADULT			
Paracetamol	Oral	1 g QID Max. 4 g/day	
Ibuprofen	Oral	400 mg TID/QID Max. 2.4 g/day	Caution in cases of asthma and renal impairment Contraindicated in pregnancy Max. 72 hours
Diclofenac	i.v./i.m.	75 mg BID Max. 150 mg/day	Caution in cases of asthma and renal impairment Contraindicated in pregnancy Max. 72 hours
Tramadol	Oral/i.v.	50 – 100 mg 4-hourly Max. 600 mg/day	
Pethidine	i.m.	50 – 150 mg 3-hourly	
	i.v.	10 mg increments	Titrate to effect
Morphine	Subcutaneous / i.m.	5 –15 mg 4-hourly	
	i.v.	2 mg increments	Titrate to effect
Naloxone	i.v.	50 mcg increments	Repeat until clinical signs improve

PAEDIATRIC			
Paracetamol	INFANTS (0 – 12 months)		
	Oral / suppository if available	Loading dose: 15 mg/kg Maintenance: 10 – 15 mg/kg QID Max. dose: 60 mg/kg/day	
	CHILDREN		
	Oral / suppository if available	Loading dose: 20 – 30 mg/kg Maintenance: 20 mg /kg QID Max dose: 80 mg/kg/day	
Ibuprofen	Oral	20 mg/kg/day in 3 – 4 divided doses Max. single dose: 200 mg Max. daily dose: 800 mg	Not under 6 months (immature kidneys) Caution in cases of asthma and renal impairment Max. 72 hours
Diclofenac	i.m.	1 mg/kg TID Max. single dose: 50 mg Max. daily dose: 150 mg	Not under 6 months (immature kidneys) Caution in cases of asthma and renal impairment Max. 72 hours
Tramadol	Not recommended, but commonly used in some European countries for children under 1 year		
Pethidine	i.m.	1 mg/kg 4-hourly	
	i.v.	0.25 – 0.5 mg/kg increments	Titrate to effect
Morphine	Subcutaneous / i.m.	0.05 – 0.1 mg/kg 4-hourly	
	i.v.	0.05 mg/kg increments	Titrate to effect
Naloxone	i.v.	4 mcg/kg	Repeat until clinical signs improve

BID: *bis in die* (twice a day)

QID: *quater in die* (four times a day)

TID: *ter in die* (three times a day)

Chapter 18

DAMAGE CONTROL SURGERY AND HYPOTHERMIA, ACIDOSIS AND COAGULOPATHY

18.1 Introduction to damage control

ICRC EXPERIENCE

Afghan colleagues working with ICRC surgical teams in the Jalalabad Teaching Hospital in 1993 developed a system for dealing with patients severely injured by anti-personnel landmines. Many patients had suffered a traumatic amputation of one leg and severe injuries to the other and succumbed, exsanguinated, by the time the debridement of the second leg had been performed.

Our Afghan colleagues decided to divide the surgery into two parts: the first operation was on the traumatic amputation, the other leg was simply washed and dressed, and the operation ended. Fresh whole blood was sought from family members and the patient fully resuscitated and given penicillin. Forty-eight hours later, another operation to debride the second leg was performed. This was Afghan "life-saving resuscitative surgery", locally invented, to face the situation of a lack of blood for transfusion.

Shortly after a war surgery seminar in Kinshasa, two young Congolese doctors with limited surgical expertise working with the military medical services, told the ICRC surgeon of one of their experiences and asked a simple question. While in a field hospital in the bush, they received a comrade with a bullet injury to the abdomen. Evacuation to another hospital was impossible. They operated and found a severe wound to the liver and had no blood for transfusion.

"We couldn't stop the bleeding, and not knowing what to do, we packed the liver and stopped the operation", they recounted. They then managed to persuade some other soldiers to donate several units of blood, and re-operated the patient after 48 hours; the patient survived. "Did we do the right thing?" they asked.

One of the basic principles of what is today known as damage control surgery (DCS)[1] – temporarily stopping severe bleeding – has long been practised and re-invented by many surgeons beginning with Pringle in 1908 and Halstead in 1913. This approach is especially relevant in critical situations where blood for transfusion is in short supply.

A better understanding of the pathophysiology of severe trauma has made it clear that fixing the tissues and organs and stopping the bleeding during a long operation – a purely anatomic approach – is not sufficient if certain physiological limits are thereby exceeded. There exists a "lethal triad" of hypothermia, acidosis and coagulopathy whereby, even after haemostasis and haemostability, the patient still succumbs. There are a number of iatrogenic factors that increase the risk of the triad and, in addition, there is now known to exist a phenomenon of "acute traumatic coagulopathy", not directly related to the triad.

This recognition of the importance of the pathophysiology has proven itself in improved clinical results through the multiple-stage protocol of damage control surgery, which has recently been expanded to include the pre-operative phase: damage control resuscitation (DCR) (see Chapter 8).

A five-stage protocol for damage control has therefore been formulated, to preclude the risk of pushing the patient beyond those physiological limits into the lethal triad. At all stages, it is essential that there be good communication among the team – surgeon, anaesthetist and nursing staff: the decision to go to a damage control approach must be recognized by all, so that all appropriate means and measures are deployed.

1 "Damage control" is originally a United States Navy term denoting "the capacity of a ship to absorb damage and maintain mission integrity". In surgery, we mean the procedures necessary to maintain the physiological capacity to maintain life's vital functions.

Five-stage damage control protocol

- First stage: patient selection and damage control resuscitation
- Second stage: life-saving resuscitative surgery
- Third stage: restoration of physiology
- Fourth stage: definitive surgery
- Fifth stage: reconstructive surgery

The success of this formalized protocol depends almost entirely on both of the following:

- early recognition that the injury is so severe as to require curtailment of the initial operation – that operation should aim only at stopping bleeding and limiting contamination (specific techniques for different organs and body regions are covered in Volume 2);
- the capacity to correct the physiological parameters at the third stage.

In the two examples cited above, the time between operations – used to obtain fresh whole blood from family and friends and "stabilize" the patient – helped to fight hypothermia, acidosis, and coagulopathy without the surgeons being aware of what they were actually doing. Attention was paid only to the haemodynamics and the comfort of a shivering patient (keeping him warm), but this was sufficient to overcome the triad. What started as "life-saving resuscitative surgery" unintentionally became "damage control".

ICRC

Figure 18.1

Typical patient who would benefit from a damage control approach: eventration and a shattered liver.

R. Gray / ICRC

Figure 18.2

Another candidate for damage control surgery: anti-personnel mine injury with penetrating wounds to the abdomen, thorax, left thigh, left hand and face.

ICRC

Figure 18.3

Patient with anti-personnel mine blast injury: traumatic amputation of the left foot; penetrating injuries and burns to both legs, the perineum and genitalia, with penetration of the abdomen.

18.2 Hypothermia, acidosis and coagulopathy

The effects of hypothermia in trauma patients have long been underestimated. It afflicts the injured even in tropical climates. While metabolic acidosis due to shock and coagulopathy are better known, the combined triad is far more prevalent than is often realized and its effects easily fatal. These three elements compound and reinforce each other, leading to a self-sustaining vicious circle.

Early recognition of the risk is essential and simple preventive measures should be initiated during first aid and evacuation and continued in the hospital. Even if the context does not allow for a full-blown damage control approach, a great deal can be done with appropriate means to prevent or fight off the effects of the triad.

18.2.1 Hypothermia

Physiology

The body's temperature is kept in a homeostatic balance between heat production and heat loss. Hypothermia is determined by central body – core – temperature, taken *per rectum*. A normal medical thermometer is useless; a special extended-range one beginning at 30° C is necessary. Classically, a core temperature below 35° C denotes hypothermia and medical classifications include profound states of 25° C or less (immersion in a cold lake, hypothalamic disorders, drug abuse, etc.). Cold injuries were discussed in Chapter 16. In trauma patients, haemorrhagic shock decreases tissue perfusion and metabolism and thus heat production. This is often compounded by exposure of the casualty to the elements, particularly in the context of armed conflict.

> It should be taken as a general rule that every injured person will lose body heat, even in a tropical climate.

Some patients suffering from severe non-traumatic hypothermia do survive (see Chapter 16). There are also reported beneficial effects of controlled therapeutic hypothermia in certain critical pathologies, but this topic will not be considered here.

Pathology

> "It has been said that any wounded man in a state of stupor whose temperature sinks below 36° C will die."
>
> E. Delorme, 1888[2]

This observation is not new, although the threshold has changed. It is very rare for patients suffering trauma *and* uncontrolled hypothermia lower than 32° C to survive; this temperature is recognized today as the crucial cut-off point. All enzyme systems in the body are temperature-dependent and therefore all organ systems will tend to fail at this low core temperature if stress is accentuated by trauma and shock.

Non-surgical systems for classifying hypothermia are not suitable for the trauma patient. A more appropriate classification system has been proposed (Table 18.1). In the trauma patient, any temperature below 36° C should be considered hypothermic.

General medical classification		Trauma classification	
Mild	35° – 32° C	I	36° – 35° C
		II	34° – 32° C
Moderate	32° – 28° C	III	32° – 28° C
Severe	28° – 20° C	IV	< 28° C
Profound	< 20° C		

Table 18.1 Hypothermia classification systems. [3]

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2 Delorme E. *Traité de Chirurgie de Guerre*. Paris: Félix Alcan; 1888. English translation by Méric H. War Surgery. London: H.K. Lewis; 1915. [WWW Virtual Library, The Medical Front WWI website] Available at: http://www.vlib.us/medical/delorme/delorme.htm.

3 Adapted from Kirkpatrick AW, Chun R, Brown R, Simons RK. Hypothermia and the trauma patient. *Can J Surg* 1999; **42**: 333 – 343.

The clinical effects of hypothermia are multiple and mimic intense sympathetic stimulation:

- shivering – the patient attempts to produce body heat by muscular contractions, but this leads to increased oxygen consumption and tissue hypoxia;
- hypoventilation – leads to hypoxaemia, with further tissue hypoxia;
- peripheral vasoconstriction – to shunt blood to the central organs, with tissue hypoxia;
- decreased oxygen liberation in the tissues (O2 dissociation curve shifted to the left);
- decreased metabolism.

Clinical picture

Early signs include shivering and tremors, tachycardia and tachypnoea (with hypoventilation). Making the diagnosis is a challenge because most of the early signs are the normal sympathetic response to the stress of trauma and haemorrhage; the surgeon should be particularly attentive to the presence of shivering and tremors. It is also difficult to judge clinically when the patient passes from Stage I (36° – 35° C) to II (34° – 32° C) without close monitoring of the rectal temperature.

As the patient goes into Stage III (32° – 28° C), there is a general slowing down of all the vital functions: loss of shivering and hyporeflexia with prolonged action of neuromuscular blockers; respiratory and circulatory depression with decreased urine output; stupor; and, with myocardial ischaemia, the onset of arrhythmias, including atrial and ventricular fibrillation, which begin at 30° C. Clotting time is prolonged, which leads into the self-reinforcing lethal triad.

With even greater hypothermia the patient becomes unconscious and ventricular fibrillation resistant to defibrillation occurs. The patient may appear dead: no heart beat and dilated pupils. Re-warming should continue until a core temperature of at least 33° C before pronouncing death.

High-risk cases

Patients who have the following *extrinsic factors* are at high risk of developing post-traumatic hypothermia:

- severely injured and subjected to a long delay in evacuation to hospital;
- remained trapped under rubble and thus exposed to the environment.

Iatrogenic *extrinsic* factors include:

- haemorrhagic shock treated with large quantities of room temperature intravenous fluids or cold transfusions – banked blood is stored at 4° C and its administration acts as a heat sink that withdraws large amounts of body heat;
- long, extensive laparotomy or thoracotomy in air-conditioned operating theatres – the surgeon and anaesthetist are comfortable, but the patient is dying.

Factors *intrinsic* to the patient include:

- severe liver or brain injury;
- major burns;
- chronic illnesses involving metabolism, alcoholism or drug abuse;
- the very young and very old, in general.

Management

Management begins with active measures of prevention during first aid and evacuation: the casualty must be kept warm! The patient must be sheltered from cold and wind, relieved of wet clothing, and covered with a dry blanket or sheet, even in a tropical climate.

In hospital, active preventive measures must continue: the emergency room should be kept thermo-neutral (28° C for an adult) and, after the patient has been undressed, examined, and resuscitative measures begun, they must be covered with a blanket.

For the severely injured, further environmental measures should continue. In the operating theatre, air-conditioning should be turned off (the OT should be heated if necessary), and prolonged contact with wet drapes avoided: the patient starts off dry and warm and ends up wet and hypothermic.

A patient shivering on the operating table is a clear warning sign!

Under general anaesthesia with muscle relaxation, a patient can no longer shiver. Since 20 – 30% of body heat is lost through the head and neck, keeping these body parts warm is a priority (e.g. wrapping the head in a towel and plastic bag intra-operatively). The rest of the body, apart from the operative site, can equally be wrapped in dry towels secured with plastic bags. Warm saline should be used for peritoneal or pleural lavage.

Administered oxygen should be humidified – a heat and moisture exchange filter (HME) should be used, if available. Intravenous fluids and blood transfusions should be warmed by being placed in a tub of hot water, comfortable to an elbow touch.

All of these simple measures, which do not require sophisticated equipment, should be standard procedure for all surgical patients, especially those suffering from severe trauma.

Not only will these simple measures prevent hypothermia, but their early implementation will help treat the condition.

Postoperatively, third-stage resuscitation should include active internal "central heating" of the patient if necessary by:

- gastric, colonic and bladder lavage with warm water (37° – 39° C);
- continued perfusion of similarly warm i.v. fluids.

More sophisticated technologies exist – including extracorporeal circulation, pleural and peritoneal lavage in the ICU – but the vast majority of patients will be well served by these simple and inexpensive preventive and active measures.

Type of measure	Procedures	Applicability
Standard measures	Passive external warming (warm environment, blankets and covers) + warmed intravenous fluids + warmed and humidified oxygen	Standard measures are applicable at all stages and at all times
Active external warming	Electric blankets Environmental heater	Particularly suitable for ICU/emergency room
Active internal warming intraoperatively	Irrigation of pleural/peritoneal cavity with warm saline during surgery	Should be routine surgical procedure
Active internal warming postoperatively	Warm gastric, colonic, and bladder lavage Warm pleural/peritoneal lavage if feasible	Particularly suitable for ICU

Table 18.2 Management of hypothermia in the trauma patient.

18.2.2 Acidosis

Hypotension will lead to tissue hypoperfusion and hypoxia with a subsequent rise in anaerobic metabolism. Oxygen delivery to the tissues is also impaired by the anaemia and peripheral vasoconstriction due to acute blood loss, compounded by hypothermia. In addition, resuscitation with large amounts of unbalanced crystalloids (normal saline, Ringer's lactate) pushes the patient toward acidosis. The resultant anaerobic metabolism shows a raised level of serum lactate, a by-product of glycolysis, which accumulates until metabolized by the liver (normal 0.5 – 2.2 mmol/L for venous blood).

This metabolic acidosis is further compounded by the respiratory acidosis of hypoventilation, whether caused by shock, central respiratory depression, decreased ventilation (flail chest), or pre-existing chronic obstructive lung disease. Increased serum lactate is accompanied by base deficit (less than –2 mEq/L), which differentiates metabolic from respiratory acidosis.

Normal serum pH is 7.35 – 7.40 and once it reaches 7.2 profound changes result:
- decreased enzymatic activity and impaired clot formation and stability, leading to the self-reinforcing lethal triad;
- decreased cardiac output and response to catecholamines;
- ventricular tachycardia and arrhythmias;
- impairment of the respiratory system;
- impaired mental status.

Often, the changes in the vital signs due to acidosis are overshadowed by those due to shock and hypothermia. In the absence of laboratory capacity to determine the serum lactate and base deficit, it is best to monitor the clinical picture closely.

Full resuscitation in a warm patient, assuring good tissue perfusion, is the best antidote. Intravenous sodium bicarbonate is risky and requires sophisticated monitoring.

18.2.3 Coagulopathy associated with trauma

Thromboelastography, a technology that allows the study in real time of clot formation, strength, and dissolution (fibrinolysis), has proved important for a better understanding of the coagulopathy associated with trauma. This coagulopathy is of several types and involves various intrinsic and extrinsic factors, some of which are iatrogenic. The most obvious type is that which is provoked by the disruption of enzymatic and platelet activity due to hypothermia and acidosis, as discussed, and leads to the lethal triad. Another is the acute coagulopathy of trauma.

Acute post-traumatic coagulopathy is more common than realized (affecting up to 25 % of the severely injured) and results from a combination of factors, independently of hypothermia and acidosis. The most important intrinsic factors include:
- extensive tissue injury, which releases tissue factors, resulting in consumption coagulopathy (with reduced platelet count) and excessive fibrinolysis;
- activation of the C-reactive protein inflammatory cascade, which results in the abnormal activation of the clotting cascade;
- haemodilution resulting from the mobilization of extravascular fluids as a homeostatic response to shock;
- decrease in the total and ionized calcium concentrations.

These events all result in excess clot formation, with subsequent dissolution, that is out of proportion to the injury and consumes the remaining clotting factors. The subsequent increased bleeding leads to progressive hypothermia and acidosis, which, in a vicious circle, cause even more compromised enzyme and platelet function with impaired clot formation and propagation. The severity of this acute coagulopathy of trauma appears to parallel the severity of injury and shock.

Please note:

Prolonged PT and PTT may be overlooked because the testing is performed at 37° C rather than at the patient’s actual temperature.

Important factors resulting in post-traumatic coagulopathy:
- Tissue damage.
- Shock: hypoperfusion and homeostatic haemodilution.
- Hypothermia.
- Acidosis.
- Inflammation.
- Therapeutic haemodilution with i.v. fluid resuscitation.

This intrinsic coagulopathy is often exacerbated by clinical practice in a "bloody vicious cycle".[4] In an attempt to maintain blood pressure, haemorrhagic shock is aggressively treated with large volumes of intravenous fluids (not warmed) – which leads to further haemodilution – plus massive transfusion of stored blood or packed RBCs (also not warmed). These measures adversely affect the coagulation cascade and only produce more bleeding. If the patient remains hypothermic, bleeding and coagulation times remain prolonged despite adequate replacement of blood, plasma and platelets.

It must also be remembered that the anticoagulant preservative solution and the refrigeration of stored blood or its components have profound effects on the physiological properties of transfused blood with time. The most important of these are greatly reduced oxygen availability to the tissues through decreased 2,3-diphosphoglycerate (2,3-DPG) and loss of red cell viability because of decreased adenosine triphosphate (ATP). Despite the increase in haemoglobin, these effects compromise the attempt to overcome early tissue hypoxia through transfusion. In addition, the glucose in stored blood is slowly metabolized, with production of lactate and a fall in pH, exacerbating the acidosis.

Some patients have comorbidities that further complicate the picture: those who are on anticoagulant therapy or who have chronic liver or renal failure.

Warm whole blood, as fresh as possible (best given within 1 hour of collection), is probably the best treatment and, as often repeated in this manual, in conditions of limited resources is often all that is available. Tranexamic acid given within three hours of injury is a good adjunct (see Chapter 8).

Intravenous calcium should be administered, separately: 10 to 20 ml of 10 % calcium gluconate or 2.5 ml of 10 % calcium chloride for each 500 ml of blood transfused.

18.3 Damage control protocol

Damage control surgery is restricted to the very severely injured – a small minority. It is a highly individualized form of management, requiring the mobilization of considerable resources if applied on a regular basis. Indeed, a patient who would qualify for DCS in a context with a small number of casualties will in many cases be triaged into Category IV during a mass influx of wounded.

In much of the world, the sophisticated ICUs and large quantities of blood required for a full-scale damage control approach are simply not available. However, basic principles apply everywhere, and simple measures can and must be implemented to prevent and correct the syndrome of the lethal triad.

It is only possible to implement damage control protocols if certain criteria are fulfilled and if personnel, equipment and supplies are all adequately prepared. Good communication among all members of the surgical team is essential at all stages.

4 Kashuk J, Moore EE, Milikan JS, Moore JB. Major abdominal vascular trauma – a unified approach. *J Trauma* 1982; **22**: 672 – 679.

A DCS approach can be implemented in almost any body region, but in its most elaborated form it applies especially to abdominal trauma.

First stage: patient selection and damage control resuscitation

"The treatment of bleeding is to stop the bleeding."[5] Resuscitation does not stop bleeding. The first step is to determine which patients would benefit from a staged damage control approach rather than a single definitive procedure. That decision may be taken in the ER or in the OT.

The clinical picture is indicative of an unstable physiology:

- A systolic blood pressure lower than 90 mm Hg.
- A core temperature lower than 35° C.
- Acidosis, with a pH of less than 7.2 and serum lactate > 5 mmol/L (measurement of which is not usually available, unfortunately).
- An estimated need for large quantities of blood.

Damage control resuscitation includes:

- hypotensive resuscitation (90 mm Hg) (see Chapter 8);
- limited use of crystalloids;
- early use of blood for resuscitation;
- administration of tranexamic acid if within three hours of injury;
- measures to overcome hypothermia.

DCR calls for early use of blood rather than crystalloids. However, as mentioned in Chapter 8, there may be insufficient blood available in an austere environment with limited resources and this would further justify the use of permissive hypotension. Colloids have a negative effect on coagulation and renal function and should not be used.

Second stage: life-saving resuscitative surgery

An initial operation should be performed to control haemorrhage and limit contamination from hollow organs. This operation should be as short as possible and should involve doing only what is strictly necessary to overcome life-threatening conditions. Priority is given to physiological recovery over anatomic repair.

A patient in Stage I hypothermia (36° C – 35° C) may have definitive surgery completed, depending on the severity of injury. The strategic change occurs at Stage II (34° C – 32° C): damage control surgery only. If Stage III or IV has been reached, surgery may be briefly postponed, even in the OT, in order to warm the patient somewhat before opening the peritoneum or pleura, but this will depend on the severity of the haemorrhage. Again: rare is the bleeding trauma patient with a core temperature below 32° C who survives, however good the surgery.

Further criteria for the implementation of DCS not related to the lethal triad include:

- injuries difficult of access (retrohepatic vena cava, deep venous plexus in the pelvis, etc.);
- inability of the surgeon to perform certain procedures on the spot (e.g. vascular anastomosis);
- estimated operating time of more than 60 minutes due to complicated procedures;
- need for re-evaluation of abdominal organs due to uncertain viability;
- inability to close the laparotomy incision because of bowel oedema;
- the polytrauma patient with several severe injuries to different body parts.

The surgical procedures usually involve temporary measures, such as the packing of bleeding sites, stenting of blood vessels, or tying off of injured gut (no anastomoses or stoma formation), and temporary closure of the laparotomy incision (see Section 32.9.1 in Volume 2).

5 Definitive Surgical Trauma Care Course, International Association of Trauma and Surgical Intensive Care.

Action is undertaken intraoperatively to overcome hypothermia. Operating time should be kept as short as possible; an open abdomen or thorax inevitably entails loss of body heat, which is just as critical at this stage as blood loss.

Summary of damage-control procedures

1. Stop haemorrhage:
   - Clamp and ligature.
   - Place temporary vascular shunt.
   - Perform Foley balloon catheter tamponade.
   - Pack bleeding sites.
2. Stop contamination:
   - Clamp, suture or tie shut injured bowel: no anastomoses or formal stomas.
   - Drain noxious secretions.
   - Wash and dress wounds, delay debridement.

Separate chapters of Volume 2 present descriptions of damage control techniques for different organs and anatomic regions.

Third stage: restoration of physiology

The aim is to achieve as complete a physiological resuscitation as possible, to stabilize the patient by correction of shock, hypothermia, acidosis, and coagulopathy. This is performed in the critical care area of the hospital and usually takes 24 to 48 hours.

In many ways this stage may be the most challenging to organize under austere working conditions. Part 3F in Volume 2 describes the organization of a critical care area in the hospital. Centralization of competent staff and the necessary equipment is essential. The availability of sufficient quantities of blood for transfusion is often the most significant limiting factor and will depend on the cultural norms of the local society.

Nonetheless, much can be done with simple methods. The patient should be warmed to over 35° C, the haemodynamics normalized, supplemental oxygen provided, and the coagulation profile brought to within 20% of normal. If laboratory facilities are available, the serum lactate should be less than 2.5 mmol/L, the base deficit corrected, and the pH more than 7.3.

Fluid resuscitation should aim for a urine output of 0.5 ml/kg per hour in the adult and 1 ml/kg/hr in the child. A tendency to "over fill" with crystalloids is to be avoided since it often leads to abdominal compartment syndrome with oedematous bowel (see ANNEX 32. A).

When to conclude stage three and return the patient to theatre depends upon:
- the initial indication for choosing the damage control approach;
- the physiological response of the patient;
- the need for removal of packs (left too long, they invite infection);
- the pattern of injury;
- the presence or absence of abdominal compartment syndrome.

Fourth stage: definitive surgery

As mentioned on numerous occasions in Volume 2, certain procedures require specialized surgical training, which is not always available. It is here that the possibility of transferring a patient for a second operation is of the utmost importance. An appropriate operating team must be mobilized, equipment and supplies prepared, and good communication among team members maintained.

The second operation includes a search for any missed injuries and aims to achieve definitive anatomic repair: liver suture, intestinal anastomosis or a stoma, vascular repair, etc., plus definitive fascial closure of the laparotomy incision if possible.

Abdominal compartment syndrome must be avoided and temporary closure methods with a planned incisional hernia may be implemented.

Fifth stage: reconstructive surgery

More complicated reconstructive procedures are undertaken, especially reconstruction of the abdominal wall months later in those patients who were left with a large planned incisional hernia.

ACRONYMS

ABCDE	Airway, Breathing, Circulation, Disability, Environment/Exposure
APM	Anti-personnel mine
ARDS	Acute respiratory distress syndrome
ATM	Anti-tank mine
ATP	Adenosine triphosphate
AVPU	Alert, Voice responsive, Pain responsive, Unresponsive
BID	*Bis in die* (twice a day)
CFR	Case fatality rate
CPD-A	Citrate – phosphate – dextrose – adenine
CRO	Carded for record only
CT	Computerized tomography
DOA	Dead on arrival
DOW	Died of wounds
DPC	Delayed primary closure
2,3-DPG	2,3-diphosphoglycerate
E_K	Kinetic energy
$E_{K\ EXP}$	Kinetic energy actually expended, transferred or dissipated
ECG	Electrocardiogram
EDTA	Ethylene diamine tetra-acetic acid
EEG	Electroencephalogram
ER	Emergency (reception) room
FAP	First-aid post
FMJ	Full metal jacket
FST	Field surgical team
GC	Geneva Convention
GCS	Glasgow coma scale
GSW	Gunshot wound

H.E.L.P.	Health emergencies in large populations
HIV/AIDS	Human immunodeficiency virus / Acquired immunodeficiency syndrome
HME	Heat and moisture exchange (filter)
HN	Head nurse
ICRC	International Committee of the Red Cross
ICU	Intensive care unit
IED	Improvised explosive device
IHL	International humanitarian law
i.m.	Intramuscular
i.v.	Intravenous
IU	International unit
KIA	Killed in action
LF	Low frequency
mEq	Milliequivalents
MIU	Million international units
MoPH	Ministry of Public Health
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSF	Médecins sans frontières (Doctors Without Borders)
NATO	North Atlantic Treaty Organization
NGO	Non-governmental organization
NSAID	Non-steroidal anti-inflammatory drug
OPCW	Organization for the Prohibition of Chemical Weapons
OPD	Outpatient department
ORS	Oral rehydration salts
OT	Operating theatre
POP	Plaster of Paris
POW	Prisoner of war
PRN	*Pro re nata* (whenever necessary)
PT	Prothrombin time
PTT	Partial thromboplastin time
QID	*Quater in die* (4 times per day)
RBC	Red blood cell
RC/RC	Red Cross/ Red Crescent
RCWS	Red Cross Wound Score
RTD	Returned to duty
SJ	Semi-jacketed
SSG	Split-skin grafts
TBSA	Total body surface area

TID	*Ter in die* (3 times per day)
TNM	Tumour, node, metastasis
TO	Triage officer
TTL	Triage team leader
UN	United Nations
UNPROFOR – IFOR	United Nations Protection Force – (NATO) Implementation Force
UXO	Unexploded ordnance
WDMET	Wound Data and Munitions Effectiveness Team
WHO	World Health Organization
WIA	Wounded in action

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Please note:

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