Preface to the Second Edition: Why This Book, Why Now?

In 1997, Professor J.M. Ryan and others produced the reference work *Ballistic Trauma: Clinical Relevance in Peace and War* (Arnold, 1997). Much of this is still valid, but a number of concepts in care of the ballistic casualty have changed. These include developing ideas on fluid resuscitation and refinement of field protocols based on operational experience.

Authors, editors, and colleagues expressed the view that there was a need for a practical guide encompassing these developments, along the lines of *Conflict and Catastrophe Medicine* (Springer, 2002). The aim was to distill real-life practice and try to capture that which often is lost or diluted in traditional texts.

With 9/11, the world changed. Since then, major conflicts have occurred in Afghanistan and Iraq, and operations are still ongoing. Many of the authors and editors deployed to these conflicts with nongovernmental organizations, Aid Agencies, and the military. Others are working with these injuries on a day-to-day basis at one of the USA's busiest trauma centers.

This has delayed the production of *Ballistic Trauma: A Practical Guide*, but means that people are writing with recent experience of managing ballistic injury. Colleagues returning from deployment have emphasized the need for clear guidance on managing ballistic injury, especially as more and more military reservists are being deployed and their day-to-day work may not include managing these types of injury.

Authors have been given a relatively free hand in structuring their chapters so they would be unconstrained by the book's style and be able to pass on their lessons unhindered.

Finally, our request is that this book be a "living" document. Give us feedback. Record what treatment works and what treatment does not. Use this knowledge to improve the care of the ballistic casualty.

Peter F. Mahoney
James M. Ryan
Adam J. Brooks
C. William Schwab

Preface to the First Edition, *Ballistic Trauma: Clinical Relevance in Peace and War*

This book aims to bring together the science behind and the management of ballistic trauma. It is directed at the surgeon, though perhaps not an expert, who might find him or herself having to deal with patients suffering from penetrating trauma in environments as diffuse as a late twentieth-century hospital or the arduous conditions of a battlefield.

The book also brings together the views of UK and US experts from military and civilian backgrounds. This composite view was deliberate, as it was recognized that these potentially diverse views reflected the complexity of an international problem that increasingly impinges on the practice of surgery in today's world.

The UK editors were the joint professors of military surgery to the three armed services and the Royal College of Surgeons of England, along with a medical scientist with an international reputation in the field of ballistic science. The US editor is Professor and Chairman of the Department of Surgery at the Uniformed Services University of the Health Sciences and has extensive experience in the management of ballistic trauma.

Though the book is influenced heavily by the military background of many of the authors, it is directed at a much wider audience, particularly those who may have to deal unexpectedly with the consequences of the trauma seen in an urban environment. It compares and contrasts the differing civil and military management viewpoints and goes on, where relevant, to debate the areas of controversy in the specialized fields of the relevant authors.

The subject of ballistic trauma is controversial in part because its management depends so much upon the situation in which it occurs. Thus, there often is confusion and a misunderstanding that emanates from the failure to recognize that the location of surgical facilities, the number of injured, and whether the injuries are sustained during peace or war may have a profound effect on the way patients are treated. The lesson of history is that you cannot take the experience of an urban hospital onto the battlefield. It also can be said that you cannot do the reverse, and nowadays there is further confusion from the deployment of troops to *peace-keeping* duties

performed under the scrutiny of the media. The latter is not the same as war.

The book has four sections. The first section is on the science behind understanding ballistic trauma; it also adds to its declared remit by including a chapter on blast injury. The second section is on general principles of assessment and initial management. The third section deals with management from a regional perspective, and the fourth section is on more specific but general problems. The intention is to provide surgeons with an understanding of the fundamentals of ballistic trauma, the mechanisms and some insight into the significance of new weapons, as well as the variations on the principles of management.

The book acknowledges that no single viewpoint can address the management of patients sustaining ballistic injuries and does not fall into the trap of recommending rigid and single guides unless there is a convergence of opinion. Its approach has been to provide a greater understanding so that the clinician facing the clinical problem feels sufficiently informed as to make coherent choices appropriate to the circumstances.

J.M. Ryan
N.M. Rich
R.F. Dale
B.T. Morgans
G.J. Cooper
1997

28
Managing Ballistic Injury in the NGO Environment

Ari K. Leppäniemi

Introduction

There are tens of thousands of nongovernmental organizations (NGOs) operating today in most countries, with their scope varying from large, Northern-based charities to community-based self-help groups in the South. The World Bank defines NGOs as "private organizations that pursue activities to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services or undertake community development." With increasing globalization, NGOs have become more influential in world affairs, and it has been estimated that over 15% of total overseas development aid are channeled through NGOs. These organizations are not directly affiliated with any national government, but often have a significant impact on the social, economic, and political activity of the country or region involved.

The most prevalent form of conflict in the post-cold war era is the occurrence of local or regional low-intensity conflicts, such as civil wars, guerrilla warfare, terrorism and counter-insurgency operations. In the 12-year post-cold war period 1990–2001, there were 57 different major armed conflicts in 45 different locations. All but three of the major conflicts were internal—the issue concerned control over the government or territory of one state. Other states contributed regular troops to one side or the other in 15 of the internal conflicts. As the historian Samuel Huntington has pointed out, communal conflicts between states or groups from different civilizations, or fault line conflicts, are likely to increase in the future. They tend to be protracted by nature, and when they are intrastate, they tend to last on average six times longer than interstate wars. Because of their protracted character, the fault line wars tend to produce a large number of casualties and refugees (see Table 28-1 for casualty figures).

With increasing erosion of nation-states, especially among the developing countries, many states are sliding into anarchy and ungovernability caused by scarcity of resources, overpopulation, refugee migration, tribal-

TABLE 28-1. Casualty figures from fault-line wars in the early 1990s

50000 in the Philippines,
50000–100000 in Sri Lanka,
20000 in Kashmir,
0.5–1.5 million in Sudan,
100000 in Tajikistan,
50000 in Croatia,
50–200000 in Bosnia,
30000–50000 in Chechnya,
100000 in Tibet,
200000 in East Timor,
The number of injured victims being multiple times higher than those killed.

ism, disease, environmental degradation, uncontrolled crime, and the empowerment of private armies, security firms, and international drug cartels.

Future wars will be associated with a large number of factors that have a major impact on the conditions of the affected people living in the conflict areas, and include population expansion, poverty, the AIDS epidemic, shortage of water and agricultural land, post-cold war availability of arms, megacities, drug trafficking (de facto governments), violent transnational groups and countries protecting them, rapid communications and travel, and recruitment of child-soldiers.

With increasing frequency of less-defined states between peace and war and risk of collapsing infrastructure, including medical facilities in the affected countries, the type of medical challenges to the local and international community is likely to involve more frequently humanitarian and peace-keeping type of missions, as well as providing surgical care for the war wounded under less-than-optimal conditions. It can be even more difficult when an internal war is combined with a total collapse of the country's infrastructure (failed states) and mass movements of people, as witnessed recently in western and central Africa. The care of the wounded under these extreme conditions has to be limited to the very basic with maximal use of the limited resources (see Triage, Chapter 26).

A major conventional war could require mobilization of surgical teams with relatively little experience in managing mass casualties (see Training, Chapter 24). This creates an enormous challenge to peacetime training of the medical personnel. In spite of recent progress of minimally invasive surgical techniques, a surgeon in a twenty-first century conflict must have the capability to adequately assess the wounded patient and perform major

conventional surgery under adverse conditions with very limited resources using different techniques and approaches depending on the available resources and overall situation.

There are several organizations directly participating in the patient care of wounded civilians and soldiers in conflicts around the world, especially in developing countries. One of the best-known delivering medical care to victims of war on a large scale and with established and published management guidelines is the International Committee of the Red Cross (ICRC). Based on the mandate of the ICRC to bring protection and assistance to the victims of international and non-international armed conflicts and internal disturbances and tensions, it deploys surgical teams for the treatment of victims of armed conflicts. Surgical care is promoted by placing teams in preexisting hospitals or establishing independent ICRC surgical hospitals. First aid posts near the conflict areas usually serve these hospitals.

This review is based on published reports of surgical care from ICRC and other NGO hospitals and the personal experience of the author while working as field surgeon in an ICRC hospitals in Khao-I-Dang on the Thai–Cambodian border, in Lokichokio in northern Kenya–South Sudan and in Peshawar, Pakistan.

NGO Hospital Environment and Facilities

A health care system is one of the earliest casualties of the social and economic disruption of a country in conflict. Hospital doctors and nurses may not be able to perform their normal duties, they may not be paid or able to reach the hospital, or they might be discriminated against for working. Medical teams from humanitarian agencies who step in trying to work in these conflicts may do so in danger. There is little or no discipline among those who have the weapons, and one side of the conflict may target the agencies because they are perceived as aiding the other. With the prolongation of the conflict, the local health care facilities have little chance of reestablishing themselves, and there will be increasing demands on the NGO hospital to take care of the non-combat-related medical problems of the affected population. Occasionally, the organized management of patients is made more difficult by accompanying relatives and friends who may be armed and try to hasten treatment with threats.

The majority of NGO field hospitals can be compared with civilian hospitals, which are isolated in an area of conflict. They differ from typical military hospitals because they are not a part of echeloned care, but work, at the same time, as hospitals of first contact and referral hospitals, implying that both primary surgery, secondary surgery, and basic reconstructive

FIGURE 28-1. Operation room in the ICRC hospital in Peshawar, Pakistan, with two teams working parallel performing acute and planned surgery, respectively.

surgery are conducted in the same hospital (Figure 28-1). This poses great challenges to personnel working under these conditions because they must have broad knowledge and experience in all areas of surgical care, including wound surgery, amputations, fracture management, craniotomies, thoracotomies, vascular procedures, laparotomies, management of burns, and basic plastic surgical techniques.

Although there is great variation in the level of equipment, most NGO-run hospitals have limited availability of blood, no ventilatory equipment, minimal laboratory services, and only plain radiography. Because of the limitations and special conditions in these field hospitals, the planning of surgery is of utmost importance, and the restrictions encourage the use of simple methods of treatment and improvisation to provide adequate care. In addition, the geographical, climatic, cultural, and social environment imposes limitations and constraints, making adaptation to the environment essential. Local skills and materials should be used as much as possible. Sanitation and nutrition should be adapted to local needs and customs. The effects of endemic diseases such as malaria should be taken into account, especially in the early postoperative phase in a febrile patient. And finally, the surgical treatment should be conducted with the aim of minimizing blood loss and the need for blood transfusions, as well as optimizing the chances of postoperative recovery without the facilities for intensive

care, total parenteral nutrition, and use of sophisticated and expensive medication.[1,2]

Patient Characteristics in an NGO Hospital

A large number of wounded patients brought to an NGO field hospital are civilians, defined as women and girls, boys (under 16 years of age), and men of 50 or more. Of the 18877 patients injured by bullets, bombs, shells, mortars, or mines and admitted to ICRC hospitals in 1991 through 1998, about 28% were civilians. The proportion of civilians injured by fragments and mines is larger than those injured by bullets, most probably because weapons that fragment can easily injure more than one person, and because mines remain after the conflict, both increasing the likelihood of civilian injuries. Overall, in most published reports from ICRC hospitals, fragments account for the majority of wounds, followed by bullets and mines.

Many of the wounded civilians, especially in developing countries, may not be optimal candidates for surgery because of preexisting malnutrition, chronic infections, and parasites.

The vast majority of wounded patients treated in NGO hospitals suffer from extremity injuries, with lower extremities being injured more often than upper extremities. The proportion of potentially life-threatening injuries of the head, neck, and torso is about 10 to 30%, but can be as low as five percent if there is lack of appropriate surgical attention and evacuation facilities in the field *because many of these patients die before receiving care.*

Prehospital Care

Under conditions where most NGO hospitals work, the prehospital care is poorly organized if at all. The often-chaotic conditions, collapse of infrastructure, and mass movements of population prevent or pose enormous challenges in creating a functional and adequate prehospital care system. Sometimes, when an ICRC hospital has been located inside a border of a neighboring country not participating in the conflict, first aid posts in or near the conflict areas have served the hospitals.

In most cases, patients are brought to the hospital by relatives and friends using all available means of transport. The delay from the moment of wounding can be anything from a few minutes to several days. Because it has an effect of the method of treatment, it is important to try to find out the time of injury in spite of occasional difficulties of gaining adequate information due to language problems or because the information might be politically or militarily sensitive.

Triage

In most mass casualty situations encountered in NGO hospitals, the conventional military type of triage process of categorizing patients according to the urgency of treatment can be applied.

Sometimes, however, the extent of work requires modification of the conventional approach, as described by Robin Coupland while working in ICRC hospital in Kabul, Afghanistan in 1992.[3]*

> I was a team surgeon in one of four teams when we received roughly 600 new casualties over a period of six days. Most were civilians from the vicinity of the hospital. About 250 with small soft tissue wounds were sent home with antibiotic tablets after having received tetanus prophylaxis. They had instructions to return if they developed problems; few did. This was in keeping with a non-operative policy for small soft tissue wounds, but the extreme circumstances did not allow the patients to remain in hospital for observation. We were able to admit all patients with larger wounds to dress the wound and give fluids intravenously, benzylpenicillin, tetanus prophylaxis, and analgesia. Owing to fatigue and the proximity of the battle we were able to operate only for some hours each day and those with abdominal wounds had priority. The perioperative mortality was high. Those who were rushed into the operating theatre because of the severity of their wounds usually died during or soon after surgery because the admission procedure had become so disrupted that many arrived on the operating table having received insufficient intravenous fluid replacement. After surgery more died through lack of postoperative supervision. Much valuable surgical time and energy was wasted. The patients with abdominal wounds who survived were those who required laparotomy for perforation and not for bleeding. The few patients admitted with thoracic wounds whose condition was not stabilised by fluid resuscitation and chest drainage died before they could reach the operating theatre. Most patients with severe wounds of the limbs that required amputation or wound excision had to wait three or four days for their surgery; only those with massive multiple wounds died in the meantime.

Based on this experience in Kabul, three lessons were learned:[3]*

1. Intravenous fluids and antibiotics buy time for most patients.
2. Patients with severe life threatening injuries die despite treatment unless resources, the number of nursing staff, and the organization of the hospital infrastructure are adequate.
3. When the hospital infrastructure is disrupted, surgical resources are easily wasted by operating on patients whose prognosis is hopeless—underlining the importance of realistic triage for treatment—and the death rate is unacceptably high among those who should survive.

Thus, under extreme conditions, the traditional approach to triage and major surgical intervention can be challenged by an epidemiological

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* From reference 3, page 1693, with permission.

approach, where less emphasis is placed on the more spectacular aspects of surgical care that benefit only a few, in favor of some effective care reaching many more with emphasis on adequate first aid and delayed surgery directed at casualties who would die of infective complications if surgery was not performed.

Airway protection, fluid resuscitation, arrest of accessible hemorrhage, and tube thoracostomy could prevent early deaths. Later deaths could be avoided by prevention of infective complications with antibiotics, wound excision, correct amputation, and laparotomy for perforation alone.

Surgery in an NGO Hospital

General Comments

The majority of surgical procedures carried out for wounded patients in NGO hospitals include wound surgery in different stages, amputations, and treatment of open fractures and abdominal surgery. Table 28-2 lists surgical procedures performed in one ICRC hospital.

In most cases, a NGO hospital is the sole provider of surgical care in the conflict area with no possibility of transferring patients to better-equipped hospitals for secondary surgical procedures, such as reconstructive plastic surgical procedures or correction of badly healed fractures. In addition, the local conditions to which patients return after being discharged may be challenging in terms of access to rehabilitation, prosthetic equipment, and disposable items, such as urine bags, colostomy equipment, and even gauze material. Finally, the social security network and means of surviving economically after a bilateral lower extremity amputation, for example, can in some societies and under times of conflict be almost non existent. All these

TABLE 28-2. Surgical procedures performed by a New Zealand Red Cross surgical team in the ICRC hospital in Kabul during a six month period in 1990 (n = 1017)

Debridement	240
Wound revision	364
Delayed primary closure	145
Split skin graft, flaps	30
Amputation	37
External fixation	31
Steinman pins	16
Laparotomy	70
Closure of colostomy	10
Hemothorax	26
Craniotomy	24
Maxillofacial, eyes	14
Vascular	8
Laminectomy	2

factors have to be considered when surgical intervention is performed for victims of armed conflicts in a NGO environment, and the surgical procedure chosen must be the most appropriate for that patient under those circumstances.

Damage Control

Successful damage control surgical approach requires access to adequate postoperative care facilities with expertise and equipment for invasive and aggressive hemodynamic monitoring, ventilatory management, correction of coagulation factors, and other procedures usually performed in a well-equipped intensive care unit (ICU). On most occasions, the NGO environment does not have the resources to establish an effective ICU, which would make a traditional damage control approach for patients with severe physiological derangement undergoing just the necessary procedure to stop hemorrhage and control contamination inappropriate. As discussed above in the triage section, most of the severely ill patients treated under extreme conditions die anyway, stressing the importance of adequate triage, concentrating the use of scarce resources to patients with a reasonable chance of survival under those conditions.

Diagnostic Equipment

Under the most primitive conditions, physical examination is the only available method of assessing the patient after appropriate history from the patient or accompanying persons. In most NGO hospitals, however, basic laboratory and radiological equipment for plain X-rays are available, although the reading of the X-ray results has to be carried out by the clinician without the support of a trained radiologist. Occasionally, simple surgical procedures, such as diagnostic peritoneal lavage with macroscopic assessment of the lavage fluid, can be performed to aid decision making.

Antibiotics

All war wounds are contaminated with bacteria and eventually will become infected. Although non-surgical treatment might be appropriate in some cases, antibiotics are not an alternative to proper wound surgery in grossly contaminated or old wounds in the presence of dead tissue because gas gangrene and tetanus are real threats in patients with inadequately managed wounds. Nevertheless, antibiotic prophylaxis with penicillin and adequate measures for tetanus prophylaxis should always accompany the surgical management of war wounds.

In patients with head wounds, penicillin should be combined with another antibiotic that, in resource-limited situations, could be chlorampenicol or trimethoprim-sulphametoxazole.

Bowel injuries are very common in penetrating abdominal war wounds, and a sufficiently broad-spectrum antibiotic with activity against anaerobic bacteria or an additional antibiotic with such activity should be given as early as possible to all abdominal casualties. A cephalosporin–metronidazole combination would probably be most effective, but with limited financial and logistical resources, other cheaper antibiotics such as crystalline penicillin or chloramphenicol could be well justified.

Anesthesia

A range of anesthetic methods can be used for surgery of war wounds, and the method of choice depends on many variables, including the available expertise, equipment and drugs, circumstances, urgency, and postoperative monitoring capabilities. A trained anesthesiologist is an integral part of most NGO hospital teams, but occasionally the surgeon has to be his own anesthetist, using methods that are familiar, safe, and applicable in conditions where the surgeon is operating and can not dedicate his full time to monitor the anesthesia.

Anesthetic methods that can be administered with relative safety by doctors not formally trained in anesthesia, but with some previous practical experience, include topical anesthesia (eyes, mucosal surfaces), local infiltration anesthesia, digital and axillary nerve blocks, spinal or epidural anesthesia, and ketamine anesthesia with spontaneous ventilation.

Blood Transfusions

Frequently, during war, the requirement to produce large quantities of blood often exceeds the ability to collect, prepare, and distribute sufficient quantities of donated blood. This is even truer in the NGO environment, where blood products are seldom available in large quantities. In a study of the use of blood products in ICRC hospitals, the average units per patient transfused were 2.9. The quantity of blood required for every 100 patients was 44.9 units. The low consumption of blood is probably related to long evacuation times, the availability of blood, and the strict ICRC criteria for transfusion.

Until oxygen-carrying blood substitutes are added to the everyday use in civilian hospitals and would be logistically and economically manageable under field conditions, there will be a constant shortage of blood products available to surgeons working in field hospitals. With appropriately measured surgical interventions, strict indications for blood transfusions, and meticulous attention to surgical technique to reduce blood loss, the blood transfusion requirements can be kept as low as possible and save the available blood for those benefiting most from it.

Surgical Management

The principles of management of war wounds in NGO hospitals differ little from the general guidelines followed in regular military hospitals and will not be reviewed here in detail. The basic principles of wound excision, delayed primary closure, external fixation of fractures, etc. apply to most NGO conditions as well. There are, however, some adjustments required in managing ballistic trauma in a typical NGO hospital and environment; these will be emphasized below.

In addition to the previously mentioned lack of echeloned care and possibility of transferring patients to receive secondary surgical treatment in better-resourced facilities, the most typical feature is the common encounter of old (days, or even weeks) or neglected wounds. Their surgical management must be flexible to take into account the wound changes this delay produces. The wound may require more aggressive surgery because of putrefaction or gangrene. Alternatively, the wound assessment may reveal that the wound has started to heal and so a less-aggressive surgical approach may be taken. Intraoperative blood loss when excising an old wound may be great because the surgeon is working through edematous and inflamed tissue, and it can be difficult to identify viable muscle and vital anatomic structures under these circumstances.[4]

Under some conditions, another characteristic of an NGO hospital environment is the admission of patients who have had a front-line treatment by local providers, including suturing of wounds, splinting of fractures, or even a front-line laparotomy. These patients sometimes arrive with pus, feces, urine, or bile leaking from wounds, incisions, or drain sites. After rehydration, antibiotics, and correction of anemia, a second operation might reveal grossly infected tissues, and in case of a relaparotomy, missed perforations, leaking anastomoses or repairs, and retained surgical compresses.

Wound Surgery

The majority of wound surgery is performed on limbs, and the application of a pneumatic tourniquet before the removal of field dressing can be helpful in initial surgery of the distal limb wounds to minimize blood loss and create a bloodless operative field, especially in patients with traumatic amputations.

Longitudinal skin incisions are usually most appropriate in extremity wounds and the surgical wound should always be larger than the initial wound, although as little skin as possible is removed. After managing the skin lesion, the wound is thoroughly exposed and debrided layer by layer by dissecting individual muscles and tendons bluntly and excising their damaged parts until healthy tissue is encountered. When a muscle group is injured, only those individual muscles that are partially divided are visible

in the wound. Those muscles, completely transected, contract away from the wound. Their devitalized ends must be exposed by adequate skin incisions and dissection to achieve complete removal of dead muscle tissue. With through-and-through wounds, the skin incisions and dissection are based on both entry and exit wounds and, if possible, should meet.

Those foreign materials that could cause severe infection, such as mud, pieces of shoe, or cloth, must be meticulously removed. When the wound includes a fracture, that part of the bone must be exposed. Small and unattached bone fragments are removed and curettage is performed to remove exposed medullary bone back to firm marrow.

The fascial compartments, especially below the knee, are prone to the compartment syndrome (Figure 28-2), and the surgeon should be prepared to perform an open fasciotomy at the time of wound excision, if needed.

After securing hemostasis with sutures and other surgical means, the wound is liberally washed with saline and then left open by packing it not too tightly with dry gauze in sufficient quantities so that blood and serum will be taken up. Gauze moistened with normal saline can be applied over exposed joints and tendons.

Exceptions to the delayed primary closure method include wounds of the face, scalp, dura, joint capsules, and serous cavities, which are closed at initial wound surgery.

After wound excision the operative dressing is left for 4 or 5 days and removed in the operating theater with the patient under general anesthesia. The state of the dressings is no indicator of the state of the wound, especially in a field hospital in a hot country. If the muscle adheres to the adjacent gauze and contracts away as the dressing is gently peeled off—

FIGURE 28-2. Compartment syndrome following a gunshot wound of the leg with necrotic muscle being excised from all compartments (ICRC hospital in Khao-I-Dang, Thailand).

sometimes with the help of saline irrigation—and the wound is clean with a reddish healthy surface, the wound excision has been adequate and it can be closed without tension using appropriately placed interrupted sutures (Figure 28-3). A large wound may require split skin grafting, which usually requires a longer period before the graft will be accepted.

If the patient's general condition is not improving after initial surgery, if there is temperature, excessive pain, and purulent discharge to the dressings, the wound requires reassessment in the theater and removal of remaining dead tissue, followed by open treatment with gauze dressings.

If the wound fails to heal after several days or even weeks, or if there is visible bone, more soft tissue usually has to be removed. A degree of healing will have occurred around the wound, which remains a cavity containing nonviable tissue, bone fragments, or protruding ends of fractured long bones. The treatment includes reincising of the skin, curettage of the cavity, and excision of the dead bone ends. When reexcision is complete, digital examination confirms a smooth cavity free of bone ends and fragments, and it will slowly heal by secondary intention, and ultimately callus will form across it.[4]

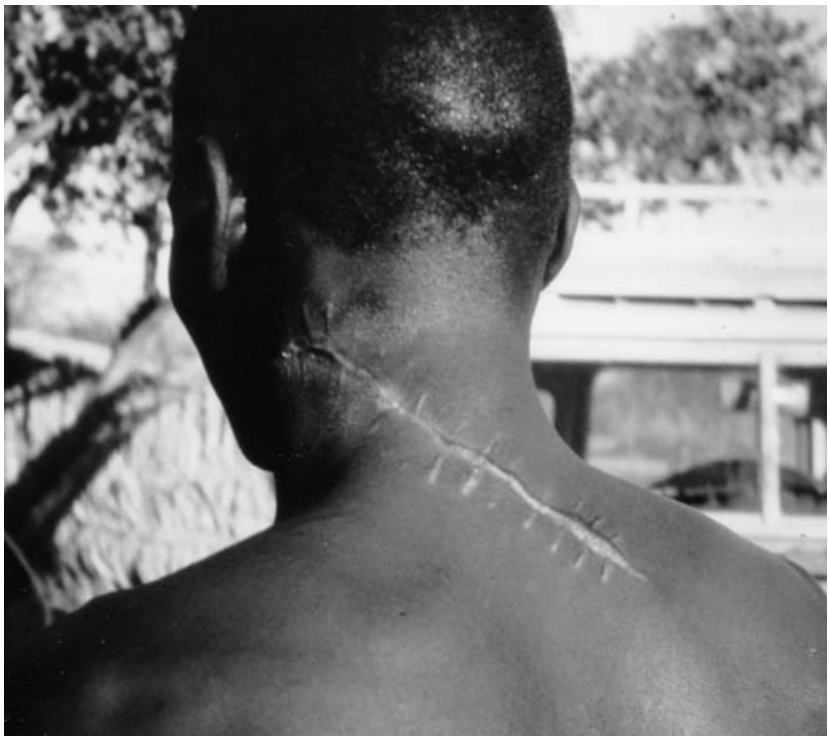
Amputations

Irreparable damage to the soft tissues or arteries of the extremities and significant bone loss are usually best treated with amputation with the primary intention of saving life by preventing infection and gas gangrene. Antipersonnel mines are, by design, intended to disable rather than kill, and the victim receives a typical pattern of injuries in which the foot, which triggers the weapon, is blown off, mud or earth, fragments of mine, shoe, or foot are blown up into genitals, buttocks, the contralateral arm and leg. When the lower tibia is shattered by explosive injury, there is considerable proximal soft tissue damage, with the muscles of the anterior, lateral, and deep anterior fascial compartments being severely contused and contaminated.

Preservation of a functional knee joint is of paramount importance for the rehabilitation of lower limb amputees, even more so in developing countries where resources are limited for the manufacturing and maintenance of prosthesis. The level of amputation is determined by the extent of the original injury, but if a below-knee amputation stump becomes severely infected postoperatively, the consequence will often be an above-knee amputation, which is much more devastating.

Depending on the level of traumatic amputation and the degree of the soft tissue damage, the surgical amputation may resemble a thorough excision of the original wound or a formal amputation with planned skin and muscle flaps. Guillotine amputations should be avoided. With the help of a pneumatic tourniquet in the proximal limb, only damaged skin is removed and devitalized and contaminated muscle is excised. The optimal lengths of amputations are:[1]

a



b

FIGURE 28-3. High-energy gunshot wound through the neck treated with wound excision, followed by delayed primary closure five days later (a) and seen at two months (b) (Lokichokio, Kenya).

– tibia: 12 to 14 centimeters from the tibial tuberosity (minimum five centimeters);
– femur: 25 to 28 centimeters from the top of the great trochanter (minimum 10 centimeters);
– arm: six to eight centimeters above the elbow (minimum 2.5 centimeters of ulna beyond the anterior axillary fold);
– forearm: six to eight centimeters above the wrist (minimum 2.5 centimeters of ulna beyond the prominence of the biceps tendon when the elbow is flexed).

It is rare to be able to perform a below-knee amputation with a long posterior myocutaneous flap, and equal skin flaps are usually the sole option. After transfixing the principal vessels with sutures, hemostasis must be secured after release of the tourniquet.

The amputation stump is left open and delayed closure is performed after four to six days. Because of the retraction of the skin and swelling of the muscle, the stump might need trimming before closure can be achieved. A suction drain can be placed under the skin flaps during delayed closure.

In an analysis of 111 below-knee amputations performed mostly for mine injuries in the ICRC hospital in Peshawar, Pakistan in 1989, the closure was performed after an average of 6.4 days, with re-amputation above the knee being required in only one case due to wound sepsis. The best results were obtained when the stump closure was performed within one week after the amputation. Overall, 84% of the stumps healed without problems, and there were no patients with gas gangrene or tetanus.

Fractures and Vascular Injuries of the Extremities

A wound with bone injury is treated with the same principles as any other ballistic wound, with careful removal of devitalized tissues including bone fragments. Fractures can be stabilized with skeletal traction, plasters, or external fixation, and the wounds are left open for delayed primary closure.

The optimal method of fracture stabilization depends on the circumstances, available equipment, surgical expertise, type and location of the fracture, degree of soft tissue injuries, and the presence of associated injuries. In general, external fixation is preferred in long bone fractures with large soft tissue injuries in adults, traction can be used with children, and plaster in cases with less degree of soft tissue injury.

In analysis of more than 200 high-velocity missile injuries treated in ICRC hospitals in Afghanistan and northern Kenya, the conclusion was that in an environment where facilities are limited and surgeons have only general experience, very careful initial wound excision is the most important factor determining outcome. Femoral fractures were treated either by traction or external fixation with identical positional outcome in both groups, but the patients treated with external fixation remained in the hospital longer than those treated with traction. In tibial fractures, the exter-

nal fixator was only of extra benefit in those of the lower third when compared with simple plaster slabs, unless more-complex procedures such as flaps or vascular repair were to be performed. In complex humeral fractures, external fixation resulted in long stays in the hospital and a large number of interventions when compared with simple treatment in a sling.[5]

Because of the limited diagnostic equipment in most NGO hospitals, the diagnosis of extremity vascular injuries is based on a high index of suspicion, location of the missile track, local signs of major hemorrhage, and careful assessment of the circulatory status of the injured limb. If distal pulses remain absent after adequate fluid resuscitation, or if other signs indicating major vessel damage are present, rapid surgical exploration at the injury site for possible vascular injury is warranted. In addition to arterial transection or laceration, a possible arterial contusion has to be recognized and repaired early. Occasionally, a major vascular injury is presented as a false aneurysm or arterio-venous fistula.

The repair of vascular injuries is performed according to the established principles described elsewhere. In general, direct repair is preferred in small lacerations, but narrowing has to be avoided or prevented by using a vein patch. End-to-end anastomoses should be reconstructed without tension. Large segment damage of a major artery requires repair with a saphenous vein graft. Before completing any arterial repair, free forward bleeding and adequate back flow from the distal segment has to be established, and, if needed, distal embolectomy performed with a Fogarty balloon catheter. A repaired artery should be flushed with heparinized saline (5000 international units per 100 milliliters of saline) injected into the distal arterial tree, but no heparin should be given after operation. Injuries to major concomitant veins should be repaired if possible. All vascular repairs should be covered with viable muscle, although the wound itself is left open. Stabilization of associated fractures should not create tension to a vascular anastomosis.

Under circumstances with long evacuation times, vascular repair is not always possible and appropriate, and an amputation to save life over limb can be a better option. Among 23 consecutive patients with combat wounds from the Afghan conflict treated at the ICRC hospital in Peshawar, the mean delay from injury to treatment was 34 hours. The overall amputation rate was 65%, but only 22% for patients revascularized within 12 hours from injury in contrast to the 93% amputation rate in patients undergoing surgery more than 12 hours after injury.

Abdominal Injuries

The proportion of external war wounds located in the anterior abdomen, flanks, and back is 10 to 20%, and the proportion of casualties with abdominal injuries is 11 to 14%. Small bowel, colon, and the liver are the most commonly injured organs. The ICRC wound database carries basic infor-

mation of more than 25 000 war-wounded persons admitted to ICRC hospitals in different locations. Of the 7479 patients with sufficient data, 15% had abdominal wounds, and eight percent had wounds of the buttocks or pelvis. Of these, 335 had only abdominal wounds and 195 had only pelvic wounds. Of these 530 wounds, 257 (49%) did not penetrate the peritoneum or cause abdominal organ injury.

In the NGO environment, a substantial number of patients with abdominal injuries may arrive relatively late, even days after the injury. Among the 70 patients undergoing laparotomy for abdominal trauma in the ICRC hospital in Kabul from 1989 to 1990, 48 patients arrived within 12 hours from injury, and the remaining 22 arrived one to four days later.

The value of mandatory laparotomy for all abdominal casualties can be questioned when some of the patients arrive several days after injury, resulting in natural triage with the more severely injured unlikely to reach the hospital alive. Among 17 patients with abdominal injuries treated at the ICRC hospital in Quetta in 1985, 12 were managed operatively, most of them suffering from intestinal perforations and operated on within 48 hours from the injury. In five patients (29%), penetrating foreign bodies could be demonstrated radiologically to be intraperitoneal. As these injuries were several days old and the patients had no clinical signs of continuous bleeding or infection, they were managed nonoperatively with good results.

Experience from another ICRC hospital at the Thai–Cambodian border showed that when the influx of wounded overwhelms the capacity for timely surgical management of all patients, those with severe injuries and little chance of survival, such as severe thoracoabdominal injuries requiring thoracolaparotomy (Figure 28-4) should not have priority unless several surgical teams are available and one team can be sequestered for several hours in an attempt to save some of these patients.

It is of note, however, that even under the most primitive circumstances such as described by De Wind from an Ugandan mission hospital, good results can be achieved with determined efforts. Out of 19 patients with penetrating abdominal and/or thoracic injuries, only two patients (11%) died; one from irreversible shock due to extensive blood loss and the other from multiple intestinal perforations and extensive contamination leading to death on the operating table.

In summarizing his extensive experience from treating abdominal war wounds in ten ICRC hospitals, Robin Coupland concluded:

(a) assuming competent surgical care, energy transfer from the missile to tissue is the most important factor determining the mortality associated with abdominal war wounds,

(b) outside a conventional military context, the focus of surgical resource and competence should always be on the majority with intestinal perforation only, who need surgery to save life but not necessarily on an urgent basis and who have a good chance of survival,

FIGURE 28-4. A soldier with multiple intrathoracic and intra-abdominal organ injuries (after detonating a mine with a jeep), exsanguinating on the operating table (Khao-I-Dang, Thailand).

(c) in modern wars, civilian casualties predominate and military forces are likely to be used in a United Nations context, and the wounded cannot travel along a conventional chain of evacuation, and

(d) a surgeon receiving wounded who have had a front-line laparotomy where the level of surgical competence or ethics is in doubt, should consider a routine second-look laparotomy to prevent death for those who have been subjected to an incompetent laparotomy and who have not yet become seriously ill through prolonged sepsis.[6]

A midline laparotomy incision is widely used due to its speed, wide exposure, and flexibility. The general conduct of trauma laparotomy depends on the surgeon's experience and preferences and should always be conducted with the time factor and overall triage situation in mind. Upon entry into the abdomen, all four quadrants should be rapidly packed to control bleeding. The importance of reducing blood loss and the need of blood transfusions while working under austere conditions can not be overemphasized. After packing, all four quadrants should be rapidly inspected for ongoing major hemorrhage. Once all major sites of hemorrhage have been identified, they should be controlled. Bleeding from venous injuries, which can

initially be overlooked, can usually be controlled by packing, allowing time for volume restoration. This is also true of many arterial injuries and injuries of the liver.

After controlling major hemorrhage, gross contamination from hollow viscus injury is prevented by closing bowel injuries temporarily with clamps or sutures. Careful inspection of the small bowel and the colon, including mobilization of the retroperitoneal portions of the colon, should be performed.

After major bleeding and gross contamination have been taken care of, the abdomen can be examined in greater detail one quadrant at a time, not forgetting the lesser sac and rectum. All injured organs are repaired and the abdominal cavity is irrigated with warm saline and closed with a single-layer mass closure. Skin is closed separately; grossly contaminated skin incision wounds should be left open (see Chapter 10 and Chapter 14).

The techniques of individual organ repair are summarized below. Under field conditions, simple, quick, reliable, and established war surgical methods of organ repair should be applied. The majority of patients have multiple gastrointestinal tract perforations and relatively minor (non-bleeding) liver injuries. Among 70 patients undergoing laparotomy for abdominal trauma in the ICRC hospital in Kabul from 1989 to 1990, the most commonly injured organs were the colon and rectum (35 patients), the small bowel in 33 patients, the liver in 17 patients, and the stomach in 10 patients. There were no major vascular or pancreatic injuries.

A short list of the main principles in managing individual abdominal organ injuries in the NGO environment is presented below. Obviously, the circumstances, the skill and experience of the surgeon, and the condition of the patient have to be taken into consideration during the intraoperative decision-making process.

- liver: non-bleeding injuries need no sutures; save blood, avoid extensive procedures; careful debridement of devitalized tissue and selective hemostatic suturing or ligation of bleeders; use perihepatic tamponade for severe bleeding from multiple lacerations; use intrahepatic balloon tamponade (not suturing entry and exit holes) for bleeding through-and-through injuries; anticipate bile leak by inserting a perihepatic drain;
- extrahepatic bile ducts: cholecystectomy for gallbladder injuries; suture repair and/or T tube drainage for partial common bile duct injuries without tissue loss; in extensive common bile duct injuries Roux-en-Y hepaticojejunostomy or with less experience, a Roux-en-Y cholecystojejunostomy or ligation of the distal common bile duct and temporary external biliary drainage with subsequent reconstruction at a later stage;
- spleen: non-bleeding injuries need no sutures; splenectomy for severe injuries; drain the splenic bed;
- stomach: two-layer suture closure; explore posterior wall; decompress with a nasogastric tube;

- duodenum: Kocher mobilization, two-layer suture closure, decompress with a nasogastro-duodenal tube with extra side holes, always insert external, periduodenal drainage; for injuries with tissue loss, Roux-en-Y duodenojejunostomy; repair of extensive injuries secured with pyloric exclusion;
- pancreas: enter lesser sac if pancreatic injury suspected, Kocher mobilization of the duodenum and head of pancreas; distal pancreatectomy with splenectomy for distal main duct injury; other injuries treated with hemostatic sutures and external drainage only;
- small bowel: suture repair in two layers; resection and primary end-to-end anastomosis in extensive injuries with multiple closely located perforations or devascularizing injury;
- intraperitoneal colon: excision of devitalized tissue and primary repair if colon wall looks healthy; otherwise colostomy, aim for colostomy closure within two to four weeks;
- rectum: suture repair (if visible without extensive mobilization) and mandatory proximal colostomy;
- kidney: hemostatic sutures; severe injuries require nephrectomy (confirm existence of contralateral normal-sized kidney);
- ureter: primary repair over stent; ureteroneocystostomy for distal injuries; nephrectomy (confirm existence of contralateral normal-sized kidney) for severe renal pelvic or proximal ureteric injuries;
- urinary bladder: two-layer suture closure with bladder decompression (transurethral or suprapubic catheter); perivesical drainage;
- urethra: primary repair if possible; otherwise suprapubic cystostomy;
- retroperitoneal hematoma and abdominal vascular injuries: explore a hematoma if expanding or large following penetrating injury; secure proximal and distal control of potentially injured vessels; repair vessel if possible, consider temporary shunting and planned re-operation or packing if impossible; second-look laparotomy if intestinal ischemia risk after repair;
- diaphragm: closure in two layers with nonabsorbable sutures; treat pneumothorax.

In order to outline the most common procedures and the every day conditions in managing abdominal injuries in the NGO environment, some published reports from ICRC hospitals are summarized herein:

Of 17 patients with liver injuries treated in the ICRC hospital in Kabul, five required no surgical intervention, seven were managed with debridement and suture, and three by debridement and omental pack. Two patients exsanguinated during operation from extensive parenchymal disruption. Morris and Sugrue managed 33 small bowel and mesenteric injuries in the ICRC hospital in Kabul with suture repair, resection of the involved segment, and primary anastomosis, or combination of these two procedures without any complications.

Of 29 patients with colon injuries treated in the ICRC hospital in Kabul from 1989 to 1990, primary suture repair or resection and primary anastomosis was performed in 16 cases, including four transverse and five left-sided colon injuries, with no mortality, no abscesses, and no fistulas. A series from the ICRC hospital in Kabul during 1990 through 1992 reported 73 patients with colon injuries, of which all underwent primary repair (resection and anastomosis in 52 and suture repair in 21) with an overall mortality rate of six percent. One patient had a fecal fistula treated conservatively and one colostomy was performed as a precaution in a patient undergoing relaparotomy for intra-abdominal abscess.

Of five patients with renal injuries treated at the ICRC hospital in Kabul from 1989 to 90, four were managed conservatively and one with a lower pole partial nephrectomy. In the ICRC hospital in Kabul, one patient with a posterior urethral injury was treated with railroading catheters, leaving urethral and suprapubic catheters in place, suturing down the prostate to the perineum, and paravesical drainage.

In the ICRC hospital in Kabul, Morris and Sugrue successfully managed three patients with injuries to the inferior mesenteric vessels by ligation, whereas two patients with injuries of the portal vein and iliac artery and vein, respectively, died.

Thoracic Injuries

More than 90% of all chest injuries can be managed initially by conservative measures, including chest tubes, without thoracotomy. A properly placed chest tube is life saving and should be inserted as soon as possible. Indications for thoracotomy include massive bleeding, persistent bleeding or air leak, mediastinal injury, and major defect in the chest wall.

Entrance and exit wounds of the chest wall are excised, intercostal vascular bleeding is treated with suture ligation, and the pleura and deep muscle layer are closed to ensure an airtight seal, leaving the outer layers open for delayed primary closure.

In thoracoabdominal injuries, separate incisions should be used when possible. A chest tube should be inserted routinely in all thoracoabdominal wounds, especially those requiring laparotomy.[1]

Head and Neck Injuries

A large part of penetrating ballistic head injuries are fatal, but at times low-energy bullets or fragments, especially if tangential or in the frontal lobe of the brain, can cause injuries that are not immediately fatal. The aims of surgical treatment in these injuries include evacuation of intracranial hematomas, debridement of dead brain tissue, and closure of the wounds to prevent infection.

A burr hole is placed close to the bone defect and the craniectomy is performed by enlarging the hole towards the area of damage with bone nib-

blers until healthy dura around the damaged part is encountered. If not opened by the missile, the dura is opened in a stellate manner; all bone fragments, accessible foreign bodies, and dead brain tissue is debrided with careful use of forceps, low-pressure suction, and irrigation. Hemostasis is secured with accurate use of cautery and other topical hemostatic measures. Watertight closure of the dura is important. If not possible, the dural defect can be closed with a fascial graft from the temporalis muscle or fascia lata. It is important to elevate the dura with sutures to the skull to prevent the formation of hematomas compressing the brain. Large depressed bone fragments should be elevated, or if removed during craniectomy, replaced in situ. The bone should be covered with skin using rotation flaps if needed. Chloramphenicol should be added to the antibiotic treatment.

A penetrating ocular injury should be suspected in every wound around the eye and upper part of the face. Unless it is obvious that disruption of the globe is total, the possibility of salvaging the eye should be considered, and every effort should be made to get the patient to an ophthalmologist, even after delay. Although rare, the development of sympathetic ophthalmia (angry red eye or the quiet iridocyclitis) after a penetrating eye injury is a real threat under difficult circumstances and requires prompt treatment. Extensive corneoscleral lacerations with either prolapse or loss of the intraocular contents require early excision of the eye by complete evisceration of the contents of the eye (Figure 28-5).

In patients with facial wounds, establishing and securing the airway is most important, followed by control of hemorrhage (Figure 28-6). Soft tissue injuries are carefully debrided and can usually be closed primarily including approximation of the subcutaneous tissue. Fixation of fractures with wiring requires some experience, but those of the mandibula with associated soft tissue injuries are usually stabilized with external fixation.

Any penetrating neck wound deeper than the platysma requires surgical exploration, which usually is performed through an incision along the anterior border of the sternocleidomastoid muscle. Small pharyngeal or esophageal lacerations are debrided and sutured; larger injuries may require a cervical esophagostomy and closure at a later time. Small tracheal injuries can often be suture repaired, more severe injuries require a tracheostomy. In most cases, injuries to the carotid arteries require vascular repair. One-sided injuries of the internal jugular vein can be ligated.

Burns

Burns are not uncommonly encountered during conflicts. They require prompt correction of the hypovolemia, adequate pain control, and accurate estimation of the depth and extent of burn injury as a percentage of the total body surface. Subsequent fluid-replacement therapy calculations are based on the burn area. Under a typical NGO environment, closed treatment of the burn injury with a two-component dressing (inner dressing

FIGURE 28-5. Penetrating eye injury leading to excision of the eye (Lokichokio, Kenya).

FIGURE 28-6. Mine blast injury of the face with posterior nasal hemorrhage controlled with Foley catheters and traction (Peshawar, Pakistan).

applying an antibacterial agent to the wound and an outer dressing absorbing the exudate and protecting the wound) is appropriate, although open treatment with topical antibacterial agents can also be used. One percent of silver sulphadiazine in a water-soluble cream base should be applied liberally to the wound and repeated twice daily. The definitive treatment includes excision of the dead tissue or eschar, followed by skin grafting.

Postoperative Care and Casualty Transfer

Ideally, most war-wounded patients treated in the NGO hospital should undergo two operations: wound excision and other early surgery on admission and delayed primary closure about five days later. Unless contraindicated, patients should have normal oral intake of food started as soon as possible after the first operation. Even in patients with maxillofacial, cervical, or abdominal injuries, oral intake of liquids and subsequently food should be started as soon as possible. In unconscious patients, establishing a route for gastric or enteral feeding should be anticipated early if the patient has a favorable prognosis within a reasonable time and the hospital has other facilities to treat unconscious patients. One of the most important things in postoperative care is to avoid a vicious circle of repeated surgical interventions with the patient being nil-by-mouth every other day and rapidly getting malnourished, accompanied by poor wound healing and infectious complications, which emphasizes the importance of adequate wound surgery at the initial operation and adherence to the established principles of war surgery, especially to delayed primary closure of excised wounds and amputation stumps.

In patients with fractures treated with external fixation, the fixator can be replaced with plasters as soon as the wounds are healing, enabling the patients to be more easily discharged for further follow up. Sometimes there is no possibility to organize the follow up by local providers, and the recovery and rehabilitation phases have to be completed in the NGO system. In most cases, there are NGOs specialized in rehabilitation working in the same conflict area, and close cooperation between different agencies and organizations is of utmost importance in order to provide the patient with a best possible follow-up care available.

Although occasionally (and often with the help of the media), selected patients will be provided the opportunity for advanced reconstructive procedures abroad, most other patients with persisting postoperative problems have no place to go for more advanced treatment. Therefore, at every stage beginning with the triage and admission phases, the overall perspective has to be kept in mind and the patient's treatment planned and calibrated in a way to achieve the best possible long-term outcome in those particular circumstances. In some cases, this might require unconventional solutions and even unpleasant decisions made by the surgeon in charge of the patient's overall care, but profound understanding of surgical principles, good com-

munication with the patient, relatives, and the hospital staff, familiarity with the available resources, measured optimism, determination, and common sense are the guidelines by which everybody working in the NGO environment can do the most good to most injured people who often have nowhere else to go.

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