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War Injuries, Trauma, and Disaster Relief

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Summary: Some volunteer surgeons may be interested in providing care for civilian victims of war in developing countries. More commonly, volunteers will be increasingly confronted with nonintentional acute and chronic trauma cases, mostly from road traffic accidents. On rare occasions, they might even participate in the relief and reconstruction efforts after natural disasters. There are significant differences between the type and management of cases seen overseas versus those seen at home. **Key Words:** Injuries—Trauma—War—Volunteer.

WAR INJURIES

History

War has plagued humanity since the dawn of time. Paradoxically, armed conflicts have benefited not only the military–industrial complex, but the discipline of surgery.[17] Celsus already addressed the management of battlefield casualties in the first century AD.[6] At the time, it was estimated that three of four injured did not survive their injury, a trend that has persisted well into the 19th century.[28] The introduction of gunpowder in the 14th century dramatically changed the nature of battlefield injuries. By necessity, advances in surgical management of war wounds followed advances in weapon technology. In 1536, Ambroise Pare, a barber–surgeon, ran out of boiling oil, which was then systematically used to cauterize wounds and used a makeshift dressing that included egg yolks, oils, and turpentine. The next day, the wounds apparently faired much better, and he abandoned the practice of cauterization. He was also the first to recognize that wound healing was related to the nutritional status of the patient. Amputations for war injuries had been performed for nearly 2 millennia when a significant technical improvement was provided by the introduction of Jean-Louis Petit's "tourniquet." In the mid-1700s, John Hunter, a Scottish surgeon, emphasized the benefits of delayed closure of war wounds. Dominic Jean Larrey, a Napoleonic war surgeon and prolific amputationist, is also credited with revolutionizing transport of war wounded from the battlefield with the introduction of his "ambulances volantes" (flying ambulances).[69] In 1867, Joseph Lister reported a significant improvement in wound care for compound fractures with the use of carbolic acid.[41] The Russian surgeon Carl Reyher promoted a more aggressive wound exploration, with an extensive mechanical cleansing, which he termed "debridement." In World War I, this technique eventually replaced amputation for the prevention of infection, gangrene, and death.[68] It is also during World War I that a basic understanding of shock was achieved, and the importance of blood transfusions was recognized.[26] Norman Bethune, a surgeon from Montreal, established the first blood bank in war during the Spanish Civil War. Unfortunately, this lesson had to be relearned at great cost during World War II, when initially, the American army did not have any blood banks.[18,26] The use of penicillin, the first antibiotic accidentally discovered by Alexander Fleming, was introduced at the end of the war, which also saw advances in the knowledge and management of shock, in anesthesiologic pharmacology and techniques, in the concept of phased wound management. The Korean War saw the pioneering work of Michael DeBakey on vascular injuries during World War II come to fruition and improve significantly the outcomes of such injuries.[19] Aminoglycosides were extensively used, and the concepts of disseminated intravascular coagulation and multiple organ failure were introduced. They were later studied in more depth during the Vietnam War, which also saw the first description of shock lung or Da Nang lung, later called adult respiratory

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distress syndrome (ARDS). The Vietnam War was also the first time that the importance of hypothermia, acidosis, and coagulopathy in shock was appreciated. The concept of "damage control surgery" was popularized, the external fixator was widely used, and significant improvements in rapid evacuation of casualties were achieved.[29,43] The more recent conflicts have contributed to technologic improvements such as the use of portable field imaging techniques, antibiotic-delivery systems such as beads or pouches, and in the field of orthotics/prosthetics.

It should also be noted that until World War II, more soldiers died of diseases than from injuries.[17] This was the impetus behind the medical research done to prevent or treat some tropical diseases such as yellow fever or malaria.

Epidemiology of Conflicts

Academic institutions, private think tanks, and independent watchdog organizations such as Project Ploughshares have agreed to define an armed conflict as a "political conflict in which armed combat involves the armed forces of at least one state, and in which at least 1000 people have been killed by the fighting during the course of the conflict."[62] In 2003, there were 36 armed conflicts in 28 countries around the world. Of those, 23 had been fought for more than 10 years and eight for more than 25 years. The Iraq invasion was the only international war in 2003. War and conflicts are directly related to the level of economic and human development. Almost half (47%) of the countries in the bottom third of the human development index (HDI) ranking in 2003 were at war in the past 10 years. Only 5% of states in the top third were at war in the same period.[62,73]

The nature and character of warfare have changed. The social chaos seen in failed states results in armed violence that is often not guided by a political program or a set of clearly defined military objectives. The distinction between military activity and criminal activity is sometimes blurred. Whatever the motivation is (ethnic supremacy, control of natural resources, and so on), the objective is often to destabilize the opponent's political, psychosocial, and cultural fabric and infrastructure. This is now commonly achieved by targeting the civilian population, which is the case in the vast majority of the ongoing conflicts. Civilian mortality was less than 20% of war-related deaths in World War I but is now well over 80%.[1] Civilians suffer the consequences of internal or transborder displacement, sexual violence, child abductions, and random violence, often equally supplied by both sides of the conflict, particularly in sub-Saharan Africa (SSA). A greater proportion of civilian mortality comes from the disruption of the societal fabric, with resulting insecurity, diseases, and malnutrition, and lack of services, than from direct injury or trauma.[74] Warfare can definitely be seen as also a public health issue.[51]

Epidemiology of War Wounds

Musculoskeletal injuries represent approximately 70% of all war wounds and, although associated with a very low mortality rate when isolated, are responsible for significant morbidity.[1,15,16,67] The ratio lower limb/upper limb is approximately 3/2 and more than 50% of extremity fractures are open.[1,33] Injuries to the head, chest, and/or abdomen have a higher mortality rate, as expected. Bullets have been, until recently, the main cause of penetrating injury to the limbs, but in recent conflicts, this has been replaced by fragmenting weapons such as bombs, shells, grenades, and landmines.[1,10,13,16] Blast injuries are in general dirtier than gunshot wounds and carry a higher potential for infection.[16]

Landmines present a particular problem in that they remain a threat to civilian populations after the conflict is over. Around the world, 88 countries still have landmines, South Korea being the most contaminated country.[50] It is estimated that 35% of the land in Cambodia and Afghanistan is unusable because of mines.[1] Landmines are still present in 23 countries in sub-Saharan Africa. Worldwide, they kill or injure more than 2000 people a month, almost all of them civilians, mostly children.[8,9] Landmines cost approximately $3 to make and up to $1000 to remove. The United Nations estimates that at the present rate of de-mining, it will take 1000 years to remove the existing landmines, at a cost of over $30 billion.[1,9]

The Role of the Volunteer Surgeon

Civilian orthopaedic surgeons who are interested in war surgery have only a few alternatives in which to pursue their interest.[25] The International Committee of the Red Cross (ICRC, www.icrc.org) is the gold standard by which all organizations that provide surgical care for war wounded are measured. It has a long and successful history of running surgical hospitals where casualties, civilians, or combatants are treated according to well-established protocols in a neutral and impartial fashion. Surgeons are in general "on loan" from their national society, which is responsible for most administrative issues, including salary. Assignments are usually of 3 months' duration. Surgeons do any and all types of surgery as part of a surgical team that includes also an anesthesiologist and an operating room nurse. They cover call together and are responsible for one surgical ward, usually with the help of local physicians. The

TABLE 1. *Minimum Surgical Skills Required for War Surgery*

Burr holes
Tracheostomy
Jaw wiring
Thoracostomy
Laparotomy (bowel resection, colostomy, damage control)
Cystostomy
Fracture management (cast, traction, external fixation)
Fasciotomies
Burn management
Skin grafting
Cesarean section

surgeon needs to be polyvalent and technically comfortable with a certain number of procedures that usually are beyond the scope of any subspecialty. Table 1 lists the minimum set of procedures with which the war surgeon should be familiar. It is likely that during any 3-month rotation, a surgeon will have to perform most if not all of these procedures.

Other smaller nongovernmental organizations (NGOs) such as Medecins sans Frontieres (Doctors without Borders, MSF, www.msf.org), International Medical Corps (IMC, www.imc-la.org), or the Italian-based Emergency (www.emergency.it) have part or all of their activity in conflict areas. Surgery is mostly for civilian casualties, and the workload depends on the intensity and the proximity of the fighting. When it is intense and evacuation of the wounded is rapid (a fairly rare occurrence), the hospital can be quickly overwhelmed with fresh casualties. Often, the fighting is sporadic or even seasonal, and transportation is difficult. Many of the ongoing conflicts, particularly in SSA, are chronic, and surgical facilities are close to camps for refugees or internally displaced persons. The surgical workload from war injuries is usually complemented with nonwar-related surgical conditions afflicting the displaced persons or the host population such as abdominal or obstetric emergencies.[40] When things are particularly quiet (also a rare occurrence), a few elective procedures can even be done. The NGO Emergency works slightly different than other similar organizations in that each team or site has both a general and an orthopaedic surgeon, decreasing the number of unfamiliar cases one single surgeon might face and the associated level of stress.

Management Principles

Whichever organization the volunteer chooses, he or she will be faced with challenging problems in challenging environments. War wounds are different from most wounds seen in civilian practice in a developed country. Basic knowledge of some ballistics principles such as cavitation, low- and high-velocity projectiles, or energy wave dispersion with blasts can be very helpful for the surgeon to visualize the extent of potential tissue damage. War wounds are often worse than they appear. High-energy projectiles, deep penetration of foreign material, dirty field conditions, delayed evacuation, and/or ill-advised initial treatment such as prolonged use of tourniquet or primary wound closure may all contribute to wounds with extensive tissue damage and severe contamination. Unless evacuation time is short, which for civilians is usually the exception, life-threatening injuries will have already self-triaged. Still the occasional craniocerebral trauma, penetrating neck wound, significant hemopneumothorax, or severe intraabdominal bleeding will present and require emergent surgical treatment. The surgeon is the one usually in charge of triage. Different classifications and protocols have been described, but they all revolve around the same principle: "do the best for the most" (as opposed to "treat the most serious one first" seen in civilian practice in developed countries). Time should not be wasted on those who have a very poor survival prognosis if this compromises the survival of others less critically wounded. Depending on the number of casualties, priorities need to be established rapidly and decisively, and surgery performed quickly and efficiently. This may mean doing one wide bowel resection as opposed to two or three smaller ones, or amputating a limb that would have had an attempt at reconstruction at home.

More commonly, casualties are brought in after a significant amount of time has already elapsed after injury, from 12 hours to a few weeks. Almost 75% of them have wounds to the extremities.[1] Indications for nonoperative treatment of war wounds are rarely met but do exist: soft tissue injury only, not caused by a landmine, with entry and/or exit wound less than 2 cm and no gross infection.[15,16] Small metal fragments in soft tissue do not generally require removal. The time-proven and universally accepted principle of "wound excision" is the cornerstone of war wound management.[12–14,21,54,60,70] It entails removing all nonmetallic foreign material and all nonviable soft tissue or bone, leaving the wound open. Antibiotics are given when available, as adjunctive therapy, to eliminate the potential culture medium. Fractures are treated with splints, traction, or external fixation, almost never with internal fixation. Closure of the wound is done around the fifth day by delayed primary closure, skin graft, or rotation flaps. Figure 1 illustrates a typical wound from a mine blast. The primary aim of wound excision is to save life and limb (in that order) by avoiding infection. The definitive management of the fracture is less urgent and can be addressed later.[11]

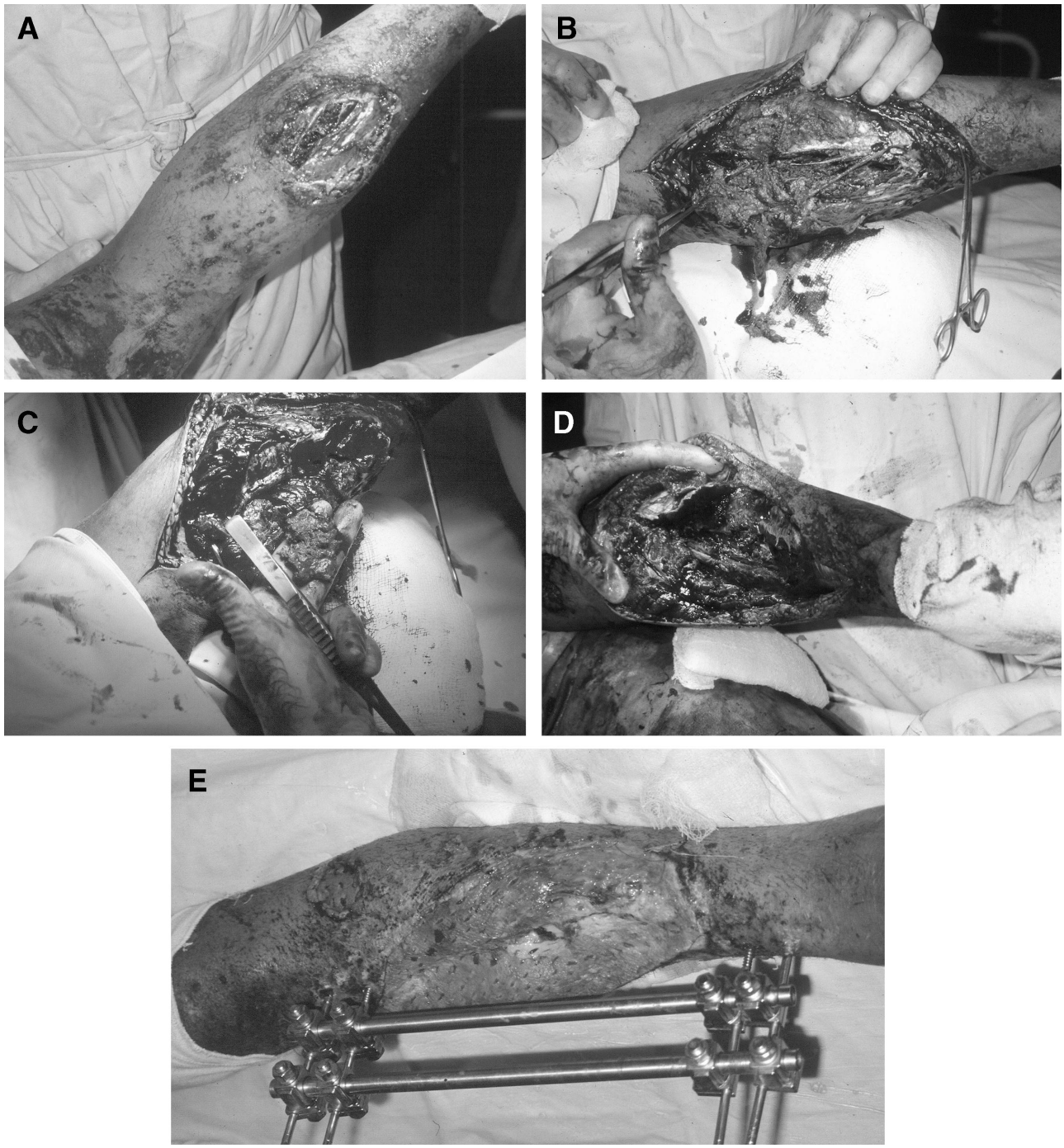

FIG. 1. (**A**) Appearance of left leg on arrival 6 hours after mine injury. The right leg was amputated above the knee. (**B** and **C**) The skin wound has been extended to expose foreign material, including mud and pieces of clothing. (**D**) Appearance of the wound after excision. (**E**) Undisplaced tibial shaft fracture is stabilized with external fixation to allow split-thickness skin grafting 5 days later.

Penetrating injuries to the extremities usually dissipate proportionally more energy to bone and soft tissues and less to skin and fat than blunt trauma.[11,14,54] This is particularly true of blast injuries in which tissue damage and foreign material penetration can extend a significant distance from the point of impact. Bullet injuries can also cause significant tissue damage but are not nearly as commonly associated with foreign material contamina-

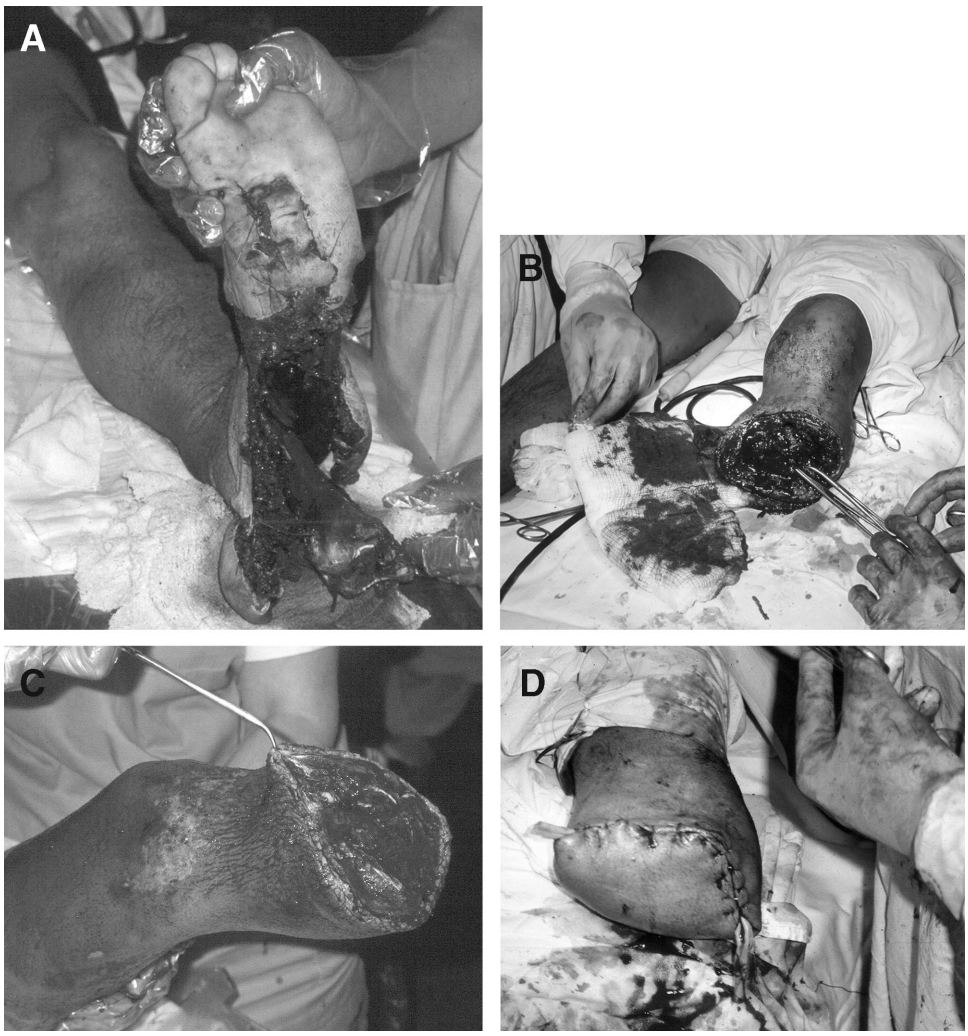

FIG. 2. (**A**) Quasi complete ankle disarticulation from a mine blast. (**B**) Open below-knee amputation through healthy tissues. (**C** and **D**) Appearance 5 days later, before and after delayed primary closure (DPC).

tion. The entire wound needs to be excised, which often requires extending widely the existing wounds. Sometimes, this can only be achieved by amputation, particularly when there are extensive neurovascular injuries. Amputations should be done as soon as the limb is judged to be beyond salvage. The ICRC protocol, followed almost universally, calls for an open amputation with appropriate flaps (as opposed to guillotine-type) at the most distal possible level, through healthy tissues, as shown in Figure 2. A compressive dressing is applied and left untouched until the patient is brought back to surgery 5 days later. If the stump is clean, it is closed, usually over a drain. A new dressing is applied and the drain removed 48 to 72 hours later. If the stump is not clean, it is redebrided or revised as necessary, dressed open, and scheduled again for delayed primary closure (DPC) 5 days later.[21] Amputations for war wounds have been performed for millennia and, although the incidence is declining, it is estimated to still be required in approximately 15% of war-injured limbs.[33] It is also of vital importance that a foreign surgeon be aware and respectful of the local cultural and religious perceptions and implications of amputation. Consent for the procedure should be obtained from the patient when possible and documented. However, there are places where consent is given by a family member, a community or tribal leader, or even a military commander. For females in particular, it is not unusual that the husband or father is the only one to decide. Once amputation is agreed on, the surgical team needs to make sure they know the appropriate way to dispose of the amputated segment. It is sometimes

very difficult and frustrating for the expatriate surgeon to understand the social, cultural, and religious values that often lead the patient and his entourage to refuse a lifesaving procedure. In such cases, the surgeon's role is to provide the best palliation available and eventually a painfree death in dignity.

Most limbs can be salvaged, and, as noted previously, the orthopaedic management of fractures is second in importance only to sound wound management. Internal fixation is not available in any ICRC hospital. Most ICRC surgeons are not orthopedists, and it is felt that the risks of misuse far outweigh the benefits of proper use, considering that alternative treatment modalities also have a proven record of success. External fixation is widely used for tibia fractures and to a lesser extent for humerus or femoral shaft fractures. The main goal of external fixation in war wounds is to maintain acceptable alignment while allowing enough micromotion at the fracture site to promote callus formation. Easy access to wounds is not as important if the initial wound excision was adequate and DPC or skin grafting is done early.[11] Ideally, external fixators are dynamized early and then quickly replaced by some type of functional casting or bracing to further stimulate osteogenesis. External fixators are also used on rare occasions for hemorrhage control in pelvic fractures. Skeletal traction is used for fractures around the hip, some femur fractures, and rarely for some fractures around the elbow or knee. Almost all upper extremity fractures and most fractures of the ankle and foot are treated with closed reduction and immobilization in casts, splints, slabs, or slings. Rarely, percutaneous pinning will be performed without the benefit of fluoroscopic imaging. On occasion, there is a need for an innovative use of an otherwise familiar apparatus such as shown in Figure 3. In general, children are treated conservatively, in traction or with casts/splints.

In areas where conflicts are chronic and transportation difficult and/or costly, the volunteer surgeon is more likely to see complications of neglected war wounds: infections and/or osteomyelitis with ulcers or fistulas, malunions, and nonunions with or without neurovascular damage. The initial wound is not an issue any more, and management of these complications can be individualized according to basic surgical principles, keeping in mind the resource and environment constraints.

War surgery is challenging. A surgeon who is healthy, resourceful, confident, and capable of working in sometimes insecure environments will also find it to be quite rewarding.

FIG. 3. External fixation of complex mandibular fracture after a gunshot wound.

TRAUMA

Burden of Trauma in Developing Countries

The volunteer orthopaedic surgeon is much more likely to work in a war-free area of the developing world. Some missions are very short and focused on a given pathology or procedure (club feet, scoliosis, and so on) and exposure to trauma is minimal. Other missions are of longer duration and more general scope, and focus more on teaching, training, and capacity building (such as those with Health Volunteers Overseas [HVO], www.hvousa.org), where one is certain to be faced with trauma cases, old and new.

The Global Burden of Disease study estimates that approximately 15% of the world's disease burden in 1990 was the result of injuries, both intentional and nonintentional.[52] It predicts this to increase to 20% by 2020. More recent research even suggests that this may be too conservative a prediction.[39,44,45] It is estimated

that by 2010, 25% of healthcare resources in developing countries will be spent on trauma-related care.[27,35,65] Injuries account for a bigger share of the global burden of disease than diarrhea, malaria, and tuberculosis combined, and more than twice that for cancer or HIV.[4,42,47] Mortality and morbidity related to intentional injuries, poisonings, drownings, burns, and falls are increasing, but none so significantly as that related to road traffic accidents (RTAs), which is more within the scope of intervention of the volunteer orthopaedic surgeon.[4,7,23,63]

Epidemiology of Road Traffic Accidents

Road traffic accidents were the ninth leading cause of death worldwide in 1990 and are projected to be the sixth by 2020.[52] They were also ranked as the ninth leading contributor to the global disease burden in 1990 and are forecast to be third in 2020, behind ischemic heart disease (IHD) and unipolar major depression. Injuries related to RTAs are increasingly being recognized as a worldwide neglected epidemic.[20,38,47,53,56,61,72] This was the theme of the World Health Day on April 7, 2004.[59]

In 2002, there were over 10 million vehicle crashes worldwide, responsible for 1.18 million deaths, an average of 3242 deaths per day.[23,72] In addition, between 20 and 50 million people were injured, approximately one fourth of them sustaining a permanent disability.[4,44,49] Ninety percent of RTA-related deaths occur in developing countries.[31,39] The predicted increase in alcohol consumption in developing countries will only compound this situation.[56] Asia has by far the highest absolute number of deaths, but sub-Saharan Africa (SSA) has the highest rate.[55] Because only 10% of all surgical pathology in rural SSA is seen for treatment, it is estimated that 10% of all deaths and 20% of deaths among young adults could be avoided with simple surgical intervention.[2,4,48]

Vulnerable road users such as pedestrians, cyclists, and motorcyclists represent a much higher proportion of road users in low-income countries than in high-income ones. Children are particularly vulnerable, and the death rate in the 5- to 14-year-old age group is three times higher in developing countries (30 per 100,000 vs. 10 per 100,000 in high-income countries).[3,4,72] In Uganda, for example, vehicle ownership has almost tripled over the last 4 years.[36] Unfortunately, the majority of these vehicles are like the overcrowded unsafe one shown in Figure 4. In urban Uganda, RTAs are by far the leading cause of fatal injuries and also the leading cause of injury-related disability. In rural Uganda, RTAs are the leading cause of disability and second only to drownings as cause of death.[36,37] At the Mulago Teaching Hospital in Kampala, RTAs account for 30% of all surgical admissions. When falls and assault injuries are included, injuries account for more than half of all surgical admissions.[37] Similar figures were found in a study from Mozambique.[24] Because most prevention strategies such as driver education programs have proven unsuccessful so far, it is clear that there will be an increasingly important role for prehospital and hospital trauma care for the foreseeable future.[57,71] Other injury prevention strategies appropriate for developing countries are being studied and developed, but their impact may not be felt for many years.[5,22,46]

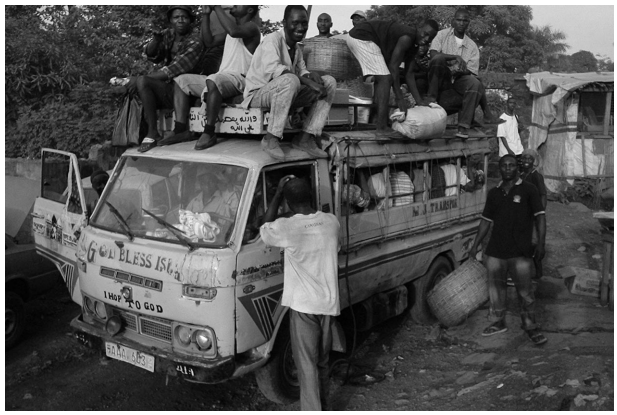

FIG. 4. Overcrowded "taxis" commonly seen in the poorest developing countries.

Need for Orthopaedic Care

It is estimated that two thirds of the world has no access to orthopaedic care.[20] More than 80% of the world's trained orthopaedic surgeons can be found in the 26 developed countries, which account for less than 10% of the world's population.[20,46] To compound the issue, the countries with the greatest needs are usually the ones suffering from the worst brain-drain. At present, SSA counts roughly one formally trained orthopaedic surgeon per five million population. This would translate in the United States to less than 60 orthopaedic surgeons for the country. Obviously, the need and opportunity for volunteer surgeons to provide care, training, and capacity-building are endless. National organizations such as the American Academy of Orthopaedic Surgeons (AAOS) or the Canadian Orthopaedic Association (COA) and international organizations such as the Societe Internationale de Chirurgie Orthopedique et Traumatologique (SICOT) have acknowledged that trauma in developing countries has reached epidemic proportions, and interventions at all levels (prevention, research, clinical, advocacy, and so on) are badly needed. Support of initiatives such as the Bone and Joint Decade and of organizations such as Orthopaedics Overseas are vital

steps in developing and implementing a comprehensive strategy to address this problem.

Management Principles

The volunteer surgeon in a developing country will quickly realize there are two main differences between the problems he or she faces there compared with what he or she faces at home: the type of injury and the available resources. This will vary mostly depending on whether he or she is in a middle-income or (very) low-income country, and if he or she is in a rural or urban setting. In richer developing countries, urban medical facilities often benefit from preferential funding and staffing. Locally injured patients may be seen fairly quickly after the accident, especially if there is a functional prehospital care system. These fresh injuries are treated according to available equipment and materials. Conservative management with casts or traction is still widely used, but inexpensive external fixation devices and internal fixation systems, plates and screws, or intramedullary nails such as the SIGN system, are now more easily available. The single most important barrier to care is usually the patient's inability to pay for it. Even in the absence of a cost–recovery scheme and when the price of implants is low, other associated direct and indirect costs prevent many patients from benefiting from surgical care.

In poorer countries, particularly in rural areas, the situation is somewhat different; in general, the injury is older, has often been treated (usually poorly) elsewhere, and the resources of both the patient and the care provider are severely limited. Onuminya has estimated that at least half of all fractures in Nigeria are first treated by a traditional bone-setter.[58] He has observed fairly good clinical results with extraarticular fractures of the upper extremity, but poorer results with periarticular fractures and fractures of the lower extremity. Traditional treatment may also cause some unusual complications: ischemia, even gangrene, from dressings or splints that are too tight, chemical or thermal burns from oils, plants, or other pomades applied over fractures or wounds, leading to cellulitis or osteomyelitis. This can also be seen when scarification, another traditional treatment, is used. It is not unusual to see patients present days or weeks after the index injury for treatment of local or, more rarely, systemic complications of these traditional treatments such as tetanus or gas gangrene rather than for treatment of the injury itself.

Trauma-related disability, particularly after RTAs, comes mostly from upper and lower limb injuries.[46,49] To minimize this, appropriate orthopaedic treatment is crucial. Remoteness, lack of transportation, abuse of traditional treatments, and poverty all contribute to the late presentation of injuries. Available resources are also extremely important in the decision-making process. Availability of anesthesia, antibiotics, blood, and/or x-rays, the cleanliness of the operating environment, the availability of tourniquets, suction, diathermia, power equipment, basic surgical instrumentation, and more specialized equipment needed for internal or external fixation all need to be factored in the treatment plan. The volunteer surgeon needs to face these challenging management issues. The main goal is to maximize the functional result. If infection is present, this needs to be addressed first with drainage, debridement, antibiotics, and/or immobilization as needed. Definitive management of the underlying bone problem can be done later in a sterile environment.

In developed countries, long years of arduous training with knowledgeable and experienced teachers, familiarity with textbooks and literature, and even medicolegal concepts such as "standard of care" all combine to give the practicing orthopaedic surgeon a fairly clear notion of what is "acceptable treatment" or an "acceptable outcome." In resource-poor environments, one of the most difficult things a volunteer surgeon may have to do is revise some of his or her criteria of "acceptability." In developed countries, conservative treatment, often assessed radiologically, may be judged unacceptable because of costs (length of hospital stay), anticipated outcome (less than the "best possible"), or rarely medicolegal issues, but mostly because the alternative treatment, namely surgery, can usually be performed with a very low risk of anesthetic or surgical complications such as infection. In low-income countries, this is not always the case. Sometimes the lack of imaging technology may be a blessing in disguise, forcing the volunteer surgeon to rely on his experience and clinical acumen instead. Even where x-rays are available, radiologic criteria of acceptability need to be adapted to the context. The potential benefits of surgery need always to be weighed against the deleterious effects of inadequate anesthesia in the short-term or the disastrous outcome of infection in the long-term.

One general principle for the volunteer surgeon is to "leave behind as little as possible," particularly if follow up after his or her departure is questionable. The local surgeon may not be familiar with the procedure(s), or the next volunteer surgeon could on occasion disagree with the treatment plan, and either modify it, or wind up doing procedures he or she does not fully support. Thus, when at all possible, the surgeon should try to avoid staged procedures and provide definitive treatment initially. In fact, it is extremely likely that the initial treatment will

FIG. 5. Mangled right lower extremity that required an above-knee amputation as definitive treatment.

also be the definitive treatment. There is no such thing as a "temporary fusion." In general, if acceptable reduction can be achieved and maintained with manipulation and casting, this should be the treatment of choice. Minimally invasive procedures such as percutaneous pinning, pins-in-plaster, or the disappearing pin technique are preferable to open procedures. Because length of hospital stay is not as crucial an issue as in developed countries, traction, cutaneous or skeletal, is still widely used for almost all pediatric hip and femur fractures, some supracondylar humerus fractures, and for most adult femoral fractures. In more sophisticated centers with clean operating facilities, internal fixation with plates and screws or intramedullary devices can be attempted, particularly if it can be done under tourniquet and without the need for fluoroscopic imaging. In general, internal fixation is best indicated for displaced intraarticular fractures that are still fresh. Pelvic and spinal fractures are usually treated conservatively with bedrest and postural reduction. Amputation is still the best option for severely injured extremities such as that shown in Figure 5.

Neglected injuries are common and troublesome. Most surgeons trained in developed countries have little experience with these problems, which they often face for the first time as volunteers. Function and pain are the key factors that determine the need for treatment. Some malunions and some painless nonunions such as sometimes seen around the elbow, present mostly a cosmetic, not a functional problem, and are best left untouched. When function is significantly compromised, bone grafting, internal or external fixation, bone transport techniques, or any combination of these procedures may be indicated as long as both patient and surgeon are aware of the local constraints. Some chronic dislocations such as shoulder, elbow, or even hip are surprisingly common

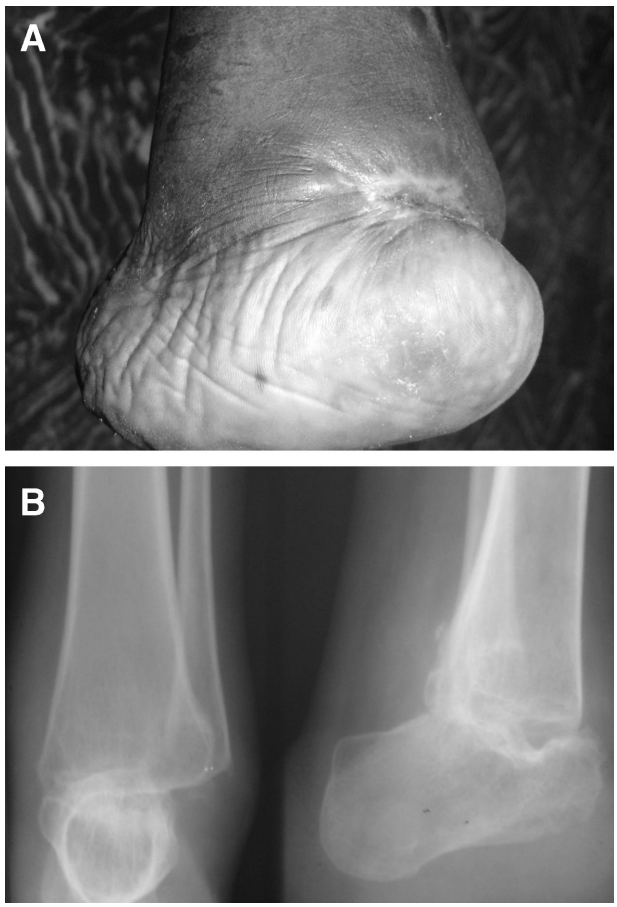

FIG. 6. (**A** and **B**) Clinical and radiologic appearance 6 months after tibiocalcaneal fusion. The patient was full weightbearing without pain.

and often have a painfree and functional, albeit far from full, arc of motion. These are better left untreated. When pain is debilitating, resection arthroplasty, which is very rarely used in developed countries, can give better functional results than heroic attempts at open reduction. Arthrodesis, also rarely used in developed countries, is often the best option for painful or unstable joints after intra- or periarticular injuries and also for some chronic dislocations such as of the finger, knee, and ankle. Amputation is often the best option for some problems such as infected nonunions of the lower extremity provided that there is a reliable and affordable orthotics/prosthetics service available. If not, limb-shortening procedures may be a good alternative to amputation when technically possible.[2] A shoe lift, no matter how big, is still preferable to the lifelong use of crutches or a wheelchair. Where access to prosthetics is a problem, the surgeon may have to perform unfamiliar amputations through the mid- or hindfoot, to try to salvage a weightbearing heel pad, as shown in Figure 6. Chronic injuries

in the pediatric group are also common and can represent unique therapeutic challenges.[3] This is particularly true of neglected fractures of the physeal plate. In the upper extremity, these may require, at some point, a corrective osteotomy. In the lower extremity, where limb-length discrepancy is an issue, corrective osteotomy of malunions of Salter-Harris types III and intra-articular fractures, and on occasion type II fractures, may require completion of the ipsilateral epiphysiodesis to avoid angular deformity. Concomitant contralateral epiphysiodesis may also be required, keeping in mind that the vast majority of these patients will be lost to follow up, and there will be no opportunity to do this as an elective procedure. Patients function better with two legs that are equally short than with a significant limb-length discrepancy. Here again, it is important to emphasize that the surgeon needs to be acutely aware and sensitive to the sociocultural and religious context before deciding on an irreversible procedure. Some patients and/or their family truly believe that death is preferable to amputation, or that the traditional healer may have something better to offer than Western medicine. The same reasoning applies to arthrodesis; in societies where crouching or kneeling is a way of life, for example, hip or knee fusions are almost never indicated.

Finally, the volunteer surgeon will sometimes find that, despite his or her best efforts, "things just don't go as they should." Practicing orthopaedic surgery on patients with rare or difficult problems, in resource-poor environments, can be a humbling experience. Patients are malnourished or have anemia, they are not compliant, the power equipment is down and there is only the hand drill, the only available antibiotic is one you are not familiar with, the plaster-of-Paris is of poor quality, the x-ray machine is broken; everything seems to conspire against surgical success. Complications will always occur, but the surgeon's goal is to minimize the avoidable ones, and often, "less is best." Adhering to fundamental surgical and orthopaedic principles will usually overcome such challenges and allow the experience to be a rewarding one for the volunteer.

NATURAL DISASTERS

Natural disasters, like manmade ones such as war, can have significant repercussions on population health and on healthcare systems, as vividly demonstrated recently in the South Asia tsunami catastrophe. Jan Egeland, the United Nations undersecretary for humanitarian affairs, while speaking recently on the effects of the locust swarm in western Africa, stated that "natural disasters affect at least seven times more people than conflicts." Different advocacy groups may argue the actual figures one way or the other, but no one doubts the magnitude and impact of those disasters. Developing countries are particularly vulnerable to natural disasters because of weak infrastructure, inadequate public health capacity, insufficient healthcare structures, and insufficient human, technical, and material resources. The spectrum of health repercussions can vary widely with the type of natural disaster. Some such as drought and famine, insect swarms, volcanic eruptions, or hurricanes can be predicted to some extent and preventative measures undertaken. Others such as earthquakes, landslides, or flash floods leave little or no time to get ready. Recent events in Gujarat (earthquake), Haiti (landslides), the Caribbean (hurricanes), and South Asia (tsunamis) share similar patterns; a first wave of mortality and morbidity from the physical event itself, and a delayed second wave of problems resulting from a predictable series of consequences.[32] Priorities for surviving populations are the same, whatever the type of disaster: access to clean water, sanitation to prevent the spread of communicable (orofecal route) diseases, shelter to prevent exposure, food, and security. Public health interventions such as vaccination, particularly against measles, or vitamin A distribution will also later on become important. Health care itself, and particularly surgery, as opposed to preventive efforts, is fairly low priority in the early stages of the relief effort. Except for earthquakes, natural disasters tend not to create a proportionally significant number of severe surgical or orthopaedic injuries. People either die or suffer relatively minor injuries.[30]

Earthquakes can cause significant mortality and musculoskeletal morbidity.[66] In 2001, the Indian state of Gujarat sustained a 7.9 Richter earthquake, causing between 20,000 and 30,000 deaths, and approximately 200,000 injuries, 10% of them "serious."[34,64] Approximately 85% of these injuries involve the extremities.[34] Most of the injured received definitive treatment in "buffer zone" hospitals by local doctors. One study noted that international relief agencies, mostly because of lack of coordination, were less effective unless working through local agencies and even concluded that "disaster tourism" by well-meaning agencies had an overall deleterious effect.[64] There is very little need for volunteer orthopaedic surgeons during the immediate postdisaster relief phase. During the reconstruction phase, surgeons may become more useful. Organizations such as MSF (www.msf.org), IMC (www.imc-la.org), International Relief Teams (www.irteams.org), or Medecins du Monde (Doctors of the World, www.medecinsdumonde.org), to name a few, may offer opportunities for volunteers in this phase.

CONCLUSION

In developing countries, the quantity of surgical pathology from intentional and nonintentional injuries will increase significantly for the foreseeable future. Local human and material resources will not be able to follow the pace. So the needs and opportunities for volunteer orthopaedic surgeons will also increase, both for their technical and teaching skills. Sustainable capacity-building, using appropriate technology, will be of paramount importance. Next to gynecologic/obstetric care, good orthopaedic care will become extremely important in reducing the global burden of surgical conditions, injuries in particular. There are already many options available for volunteers to satisfy their humanitarian urges. Whichever avenue they choose, they will have a very positive impact on musculoskeletal care in developing countries and hopefully reap rewards that are proportional to the challenges.

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