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High Energy Transfer Missile Wounds in the Siege of Sarajevo and their Relation to Mine Injuries

Using the example of war-torn Sarajevo, the authors discuss high energy transfer wounds and their complications. Their findings can be extrapolated and applied to the injuries of mine victims.

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Historical Background

In order to survive in a continuous species, it was imperative that hominids hunted efficiently. It is speculative, but distinctly possible, that not only the implements of hunting but also the psychological train of the chase led to, or at least accentuated, the proclivity of our ancestors to kill and eat their fellows. Our modern fragile and tender societies must surely mirror the violence that erupted from conflicts over food, territory and sex.

Because early man possessed the tools for destruction and the tendency to use them, it is not surprising that there is archaeological evidence of injuries and their treatment.

After the invention of representative art around 35,000 BC, scenes from the early societies are portrayed in caves of France and Spain, but with very few actually showing conflict or wounds. Nevertheless, even at this early stage in man’s history, violence is demonstrated, as in the wall painting of an individual who has obviously been struck by several arrows (Figure 1).

There are also many archaeological examples of primitive and quite complex surgery, some of which may even have been effective. Some patients survived despite complex interventions.

With a short leap of over 20,000 years, we learn by the time of the siege of Troy, it was considered essential for all educated Greeks to understand simple medical care.

The other information that we have of the Trojan siege is derived mainly from Homer’s Iliad to which the author gives detailed accounts of the wounds. Fréchot has analyzed Homer’s work and demonstrated that there was a variation in the number of wounds (shown in red in Figure 2) caused by each weapon and the percentage of fatalities (in purple).

It is interesting to note that the chance of actually hitting the enemy was greater with the spear, and with a fatal- ity of 80 percent, it was the best of the weapons. The swordsmen were more accurate, with 100 percent fatality. He was much less likely to hit his opponent, however, who in turn would be close enough to offer a—possibly fatal—response. Slingshots and arrows had a very low hit rate and medium fatality with arrows at the worst. This is a startling contrast with the success of the medieval English bowmen at Crécy and Agincourt. It surely indicates that technological progress and tactics, as well as the English attention to obligatory training, played a large part in the development of the bow before explosive weapons replaced it.

This primitive—though bloody—form of warfare was changed completely by the invention of explosive devices. Although these were initially an inaccurate and relatively weak form of weaponry, they soon developed to combine high-hitting potential with lethal precision.

The science of all weapons, and in fact of all injuries, is to direct sufficient energy into biological tissues to disrupt them. All moving particles are possessed of a certain amount of energy, and when they are stopped or slowed by an object, that energy is transferred to the object and disrupts it. Soft animal tissue is particularly vulnerable and severe wounds occur.

Physics tells us that the amount of energy (E) within a moving object depends on the combined effect of its mass (m) and the velocity (v). This applies to a wounding object whether it is a hit, a bullet or a fragments of a mine.

The actual equation is: Energy (E) = Mass (M)v^3 x Velocity (V) x 2 or E = M^2 x V^2

By and large, the smaller the injuring object in weight, the more accurate its path. Therefore, anti-personnel weapons were designed to be smaller but to travel at a greatly increased speed—hence the effectiveness of a sniper’s bullet. The simple mathematics show that with an object of 10 grams travelling at 10 kilometers per minute, to double the mass will multiply the energy by 20 times (10^2 = 20). But to double the velocity will increase the energy by 400 times—400% Velocity is, therefore, the major factor in determining the energy content of a moving particle.

These forms of injuries are designated “High Energy Transfer Wounds,” and can occur from any object that exerts sufficient energy. There are particular properties of such injuries apart from the initial severe wound. These should be considered in detail because they demonstrate why there is a high complication rate even after good initial treatment, namely the following eight reasons:

1. Massive tissue destruction is characteristic of such wounds, and often the limb cannot be preserved. The missile, whether it is a bullet or a piece of a mine or shell, will fragment further and spread violently through the tissues.

2. The high speed of the missile causes cavities to form, destroying local tissue beyond the site of the track and creating a vacuum that sucks in infected air and contaminated material from clothes, etc.

3. The wounds are always infected, both from the debris of shell or mine fragments and from the material sucked in behind the fast-moving particles or bullet.

4. The tissues are literally torn apart from the energy that is released by the particles slowing down, and this is independent of the direct effect of the missile debris.

5. Injuries to nerves and large blood vessels are 10 times more frequent than in peacetime wounds.

6. The patients are usually shocked from blood loss, and delay in treatment is often fatal.

7. Complex “shattered bone” fractures usually occur.

8. Multiple sites of injury will occur.

Focusing on the injured soldier, the authors provide a description of the types of injuries that could result from the same type of weapon, and the factors that may determine the severity of each injury.

The Siege of Sarajevo 1992 - 1996

The siege of Sarajevo was the longest in modern times. It was an example of a method of warfare as old as recorded history, in which attrition is focused on the civilian population with the ultimate aim of attacking the citizens psychologically and physically. As well as wounding and killing, the weapons used are those of fear, uncertainty and deprivation. All will suffer, but the sick and elderly, the unborn children and infants, and the wounded are particularly vulnerable to starvation and loss of basic amenities. That every one in Sarajevo was effectively in the front line is reflected in the distri-
bution of wounded between military and civilians (Figure 3).

In the summer of 1993, the new non-governmental organization (NGO) HMD Response International asked for volunteers from British Orthopaedic and Trauma surgeons to assist their Sarajevan colleagues. As with all wars, nothing went entirely according to plan, but it began a presence of this NGO in Bosnia that still continues.

By August 1993, the devastation of over a year of war was obvious in the de-stymed buildings and the hospital wards filled with patients suffering from complex wounds. Surprisingly, considering the terrible circumstances in which the surgeons had worked, the level of infection was much lower than expected. This was soon to change. The succeeding months demonstrated the problems from the blockade of food convoys and the effects of a freezing winter. In Sarajevo, the temperature ranges from as high as 40°C in summer to -15°C in winter. The city is set on a high plateau surrounded by mountains that inhibit air transport, and the poor roads, already militarily blocked, were obstructed by heavy snowfalls.

Medical supplies soon failed, and in particular, the devices for fixing fractures were exhausted within weeks of the beginning of hostilities. Undernourished, a local 12-year-old boy was designed by an engineer and two surgeons and produced in Sarajevan throughout the war. This device—the Sarafn—was used in all Bosnia patients. HMD Response International provided a critical component of the fixature—its surgical steel pin—as part of its support programme for the surgical development.

### Management of the Soft Tissue Component of High-Energy Wounds

The majority of the wounds treated in the Sarajevo siege were from shell and bullet wounds. Because the population was confined so severely, reaching mined areas was in itself hazardous. Nevertheless, because of the similarity of high energy transfer wounds, the principles of treatment and the complications that occur are entirely relevant to the study of mine injuries.

War wounds are complex and inevitably get infected. In the early months of the first World War, British Army Medical Officers were inexperienced in treating such terrible wounds, and a massive number of lethal infections occurred. In 1915, orders were given to remove all dead and foreign material and to never primarily close wounds. The technique is known as débridement, from the French in available or release.

This tested method was employed in Sarajevo with great success with the addition of an anti-rotten toxin and antibiotics. Injuries near the burn area were particularly at risk of such infection.

### Nutritional Problems in a Siege Situation

For patients with massive injuries from bullets, shrapnel and mines, the effects of starvation and winter cold increased the incidence of infection. A study between September 1993 and January 1994 showed a massive rise in wound infection.

For patients infected in Sarajevo was at risk from malnutrition for several reasons:

- Poor supply of essential nutrients.
- Increased requirement for protein, carbohydrates and minerals because of increased metabolic response to injury.
- Increased requirement for endogenous heat production during winter because of inadequate heating of the wards—five percent increase for every 10°C drop in temperature.
- Increased requirement for nutrition with infection—10 percent rise in calorie requirement for each 1°C rise in body temperature.

- Poor nutrition that was unpalatable and rejected.
- Poor-quality food that was unpalatable and rejected.

It is easy to envisage a situation in which a severely injured patient—with a 10 percent increase in nutritional requirements—died from wound and vascular damage. Despite the overall success of the Sarafn device (76.97 percent of a studied cohort), there were inevitable complications, as shown in Figure 4.

There are no simple complications of these wounds, and all cause considerable persistent symptoms that are often permanent. Osteomyelitis (6.67 percent) has a particularly sinister recurrent and debilitating effect over many years. An estimate suggests that 15,000 Bosnians suffer from this crippling disease.

Gavruckinevic and Beavis reported the results of radical treatment of chronic osteomyelitis following Bosnian war injuries and found that after an initial period, the incidence began to increase considerably after two years (Figure 5).

### Management of Fractures in High-Energy Wounds

Stabilizing fractures resulting from such injuries is both imperative and difficult. The fractures are often multiple and very unstable, with considerable implant debris. They must be managed without closure of the wound and must be stabilized to allow treatment of other injuries of the arteries and viscera. External fixation is the first choice, but Compland states that devices can be too complex for adverse situations. The suitability and simplicity of Sarafn proved ideal for this work.

The device was used at many sites including shell wound injuries with vascular and wound damage. Despite the overall success of the Sarafn device (76.97 percent) of a studied cohort, there were inevitable complications, as shown in Figure 4.

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### Conclusion

Sarajevo was besieged for nearly four years, and during this time, the population was subjected to all the terms of modern warfare and massive deprivation. Demoralizing the civilian population by depriving them of their basic needs has always been the aim of besieging armies throughout history, and Sarajevo was no exception.

Modern weapons primarily have an anti-personnel role in civil wars of this nature, and the incidence in Sarajevo of high energy transfer wounds in the civilian population reflects this fact. The well-tried immediate treatment of wound exit and adequate debridement, along with stable fracture fixation, proved once again to be effective in producing a satisfactory cohort of results.
The nutritional deprivation was objectively shown to be important in the wounded patients by a significant rise in the infection rate during winter months when the food supply fell well below the required levels. In a war situation where evacuation is not possible and food supplies are precarious, the injured patients must be considered a vulnerable group. Aid agencies should concentrate on relieving this problem as part of their overall medical aid strategy.

Mine injuries were not common among the citizens of Sarajevo because enemy snipers and artillery confined them to a very localized life. Military personnel were most likely to be injured by mines during frontline service. Those civilians who were injured by mines had usually left the city for various reasons such as collecting wood for fuel.

The risks that these unfortunate individuals were prepared to take just to warm their families or obtain meager amounts of food are an indication of the terrible effects of siege warfare on ordinary people.

References

*All graphics courtesy of the authors.

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How NGOs Can Build Peace:
Landmine Clearance and Victim Assistance

Peacebuilding and post-conflict reconstruction are multi-disciplinary from a governance, organizational behavior, executive development and field perspective. Rarely, though, are the tools of competitive advantage, project planning and conflict resolution software used to seek linkages with non-governmental organizations (NGOs) to coordinate resources, particularly to integrate the disparate sectors of landmine and UXO clearance, victim assistance and reintegration across industries. One method is to employ "best practices" from developed countries proven to develop abilities for disabled farmers and youth in post-conflict countries as one of a number of agrarian and health care initiatives built around demining as agricultural preparation. The goal is for NGOs and government departments to change the rules of competition between post-conflict communities by shifting organizational behavior to reflect quality of care as a measure of gaining donor support.

by Maureen Morton

Introduction

Demining and the clearance of UXOs are necessary, extremely dangerous and technically complicated jobs that require cross-functional skills. In a post-conflict situation, many of the most skilled have either fled the community or lost their lives. NGOs who are "first-in" deal with crisis management and life-or-death community stabilization. These organizations generally should have a long-term mandate to reconstruct communities, which requires detailed planning with different interest groups and donors.

There are many national and international organizations that play a role in addressing the problems of landmine survivors: a Mine Action Center (MAC) should involve the relevant organizations, including governmental and non-governmental organizations. Such consumer organizations are important targets of education, information and training, particularly in the areas of self-help, maintenance of devices and the need for accommodations, support and follow-up care. Because so many landmine victims are children, special attention must be directed towards the needs of those who are growing and developing, and for whom most practitioners or orthotics will have a limited period of utility.

Long-term planning requires industrial engineering, operations research, management information systems, logistics, manufacturing, human factors, engineering and operations management. Project risks, both inside and outside a country, need university/industry collaboration. NGOs determine resident skill-sets and academic and technical qualifications, as well as engage industries and associations to support landmine and UXO clearance activities, mine-clearance awareness and victim assistance. Support infrastructure must be built with and by the communities.

A Firm Infrastructure

NGO specialists in mine and UXO clearance must interface with other types of NGOs: medical, advocacy, technical, academic, societal, institutional and religious—all of whom must collaborate with government departments and militaries. Sadly, programs that do the physical demining and true victim assistance are seriously under-funded worldwide. Although expectations have been raised, the demand cannot be satisfied. To reduce post-conflict problems, financial backing and a sense of urgency are needed to clear land and provide occupational programs to allow both amputees and able-bodied individuals to return to their work and farm.

A conceptual industry shift may be taking place from advocacy/military/humanitarian demining to "demining as agricultural preparation." This is happening as individuals from academia and demining NGOs seek the expertise of soil scientists, agronomists and those who specialize in occupational therapy in disabled farming. Every post-conflict country and community is facing environment and rural reconstruction issues. The task for an NGO is to search for the linkages and common denominators, as well as network those disparate groups of individuals to build a consensus across interest groups at home. These vertical linkages are similar to the linkages within the value chain—the way supplier or channel activities are performed affects the cost or performance of a firm's activities (and vice versa). In essence, we must cultivate communities of practice.

Ideas have been presented to deminers from a governance perspective to circumvent military technical sensitivities pertaining to demining and UXO remediation. Once clearance work can be seen as agricultural preparation, it perceptually opens up new opportunities for victim assistance. It especially creates program possibilities for disabled farmers in developed countries to help their counterparts, disabled farmers and disabled deminers in landmine communities. The similarity of occupational and farm injuries such as upper or lower extremity amputations and specifically double or triple amputations, requires the knowledge and coping skills of those who have lived the reality. The process of demining, if they survive an explosion, have to face life severely disabled. The status of the disabled in society is one of exclusion and alienation, which leads to a perception of the disabled as "less than human." Only those rehabilitation programs that solve adversarial problems by developing and proving ability in the newly