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Mini Review

The Initial Management of Gunshot Injuries to The Femur

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Abstract

The purpose of this review was to look at issues with varying opinions in the management of gunshot injuries to the femur. These include the necessity for wound debridement, formal irrigation and intravenous antibiotics. Due to the increase in accessibility of high powered weapons by civilians, the civilian Orthopaedic surgeon must be able to diagnose and differentiate between low and high velocity gunshot injuries, as well as be aware of the management protocols of those different scenarios.

Keywords: *Gunshot; Femur; Injuries*

Abbreviations: ATLS: Advanced Trauma Life Support

Introduction

The incidence of gunshot fractures is rising in most countries [1,2]. Increasingly, civilian orthopaedic surgeons will encounter these injuries and will be required to have a working knowledge of the principles of ballistic injury [2]. There has been contradictory advice on the management of gunshot fractures [3]. This includes the role of extensive wound debridement and the view that formal irrigation and intravenous antibiotics may be unnecessary in the management of low velocity injuries.

Discussion

A recent Centres for Disease Control Report reported that there are approximately 81,396 cases of non-fatal firearm injuries which represent a fairly large percentage of the injuries in the population. Gunshot injuries are rising in most countries especially in the United States [2]. In 1985, 65,000 patients in the United States were hospitalized for gunshot injuries. Between January 1983 and December 1984, 15% of the patients admitted to Los Angeles County – University of Southern California Medical Centre had gunshot related fractures [4]. The commonest area for a fracture to occur secondary to a gunshot was the femur [5].

Historically, gunshot injuries have been classified into two types: low velocity and high velocity injuries. In the civilian setting, the vast majority of gunshot fractures are low velocity injuries [2]. High velocity injuries which are commonly seen in military settings occur when the bullet speed exceeds 1,000 feet per second [2].

In certain parts of the world, civilians are increasingly accessing high velocity modern military weapons. There is also increased domestic violence and crimes which all result in hospitals resembling front line military hospitals. The Orthopaedic surgeon will increasingly see these injuries [5, 6].

Open fractures of long bones secondary to gunshot wounds may be either stable or unstable. Stability is a function of the soft tissue envelope and the fracture pattern. It is important to preserve the soft tissue integrity in order to maintain its stabilizing effect. Fracture stability may also be assessed by radiographic pattern. When there is comminution in the neck of the femur, trochanteric and sub trochanteric areas, this is an unstable configuration [4]. High velocity gunshot injuries often cause unique open fractures which are so comminuted, it is difficult to achieve and maintain a reduction [6]. Generally, for stable fractures, limb length and alignment may be maintained with external functional bracing [4]; however, this does not apply to femoral fractures. Unstable gunshot fractures are best treated by internal and or external fixation [4].

The tissue interaction between a projectile and a biological target is another important principle. The kinetic energy of a missile depends on both the mass and velocity according to the equation KE = ½ mv^2 [3]. The amount of energy transferred is dependent on the tissue involved, for example, there would be less resistance to the passage of a bullet through muscle as opposed to bone, and therefore, less energy will be transferred.

The major determinants of the pathological effects of a gunshot injury are the rate of energy transfer which varies along the wound track and energy flux which is the change in the energy divided by the cross sectional area [3,7]. Although energy transfer is difficult to determine, the extent of a bony defect may be used to extrapolate the energy transfer [7].

High velocity missiles are associated with a greater degree of soft tissue damage, soft tissue defects and local wound contamination [3]. A permanent cavity produced by a projectile contains fragments of necrotic muscle and clots. Tissues are stretched as they are thrown aside from the path of the bullet creating a temporary cavity with zones of contusion. Devitalised tissue and haemorrhage within and between muscle fibres also occurs. As the shape of the temporary cavity collapses, contamination may be drawn into the wound [3]. In most civilian injuries, the shock wave and temporary cavitations are considered insignificant [8]. Damage to tissue at a distance from the wounding tract is characteristic of injuries via high velocity missiles [8]. In order to cause a fracture, projectiles will transfer energy of the order of a few hundred Joules to the bone. The pattern and comminution may arise without high local energy transfer and is due to either concentration in a small area or very fast transfer. If the surrounding soft tissue of a highly comminuted fracture is healthy, there is still good healing potential [3].

A bullet may carry viable bacteria into the wound as it is not sterilized by firing [9,10]. Species causing infection in the first few days are mainly commensal [3]. In managing gunshot fractures of the limbs, patients are managed according to ATLS protocol and other injuries are ruled out, including distal neurovascular deficits [2]. Tetanus prophylaxis is given when indicated by history [5,9,10,11]. Unstable injuries are placed on balanced skeletal traction using a tibial pin.

It has been suggested by some that normal saline is the best wound irritant, and that one should avoid chemicals which induce inflammation and swelling [12]. The use of additives such as antiseptics e.g. povidone-iodine, antibiotics e.g. bacitracin and soaps, do not aid in lowering infection rates [13]. There have been studies in which irrigation has been a part of their protocol, but the recommendations as to the specified volume are lacking [14]. Others will irrigate if deemed necessary [5].

It has been suggested by some authors that formal surgical irrigation and debridement of low velocity gunshot wounds are not routinely done [4,9,11]. Howland and Ritchey [8] stated that devitalisation of tissue at a distance from the bullet tracks in low velocity injuries is usually not significant and thus extensive debridement of soft tissues is unnecessary. The greater the energy delivered, the more distant the tissue destruction, and a more favourable environment for the development of infection is created [10]. In managing low velocity injuries, some routinely advocate minimal debridement as part of their protocol [15] while others debride only if deemed necessary [5]. Local wound care with or without excision of the entry or exit wounds under local anaesthesia reduced the incidence of infections in some studies [9,14]. Howland and Ritchey [9] suggested that low velocity gunshot wounds do not require surgical exploration and extensive debridement, and that the degree of superficial debridement should vary according to the judgment of the individual surgeon. Formal debridement should be performed for gross contamination and massive soft tissue destruction secondary to high velocity injuries [10]. When debriding low velocity gunshot wounds, it should be confined to the level of the skin and subcutaneous tissue unlike high velocity injuries which require formal debridement [16]. The most important factor contributing to infection in gunshot wounds was the type of missile used, that is, high velocity versus low velocity injury [17].

There is little dispute about the role of antibiotics in the treatment of penetrating musculoskeletal injuries inflicted by a high velocity weapon or low velocity injuries with significant soft tissue damage (e.g. shotgun injuries). The regime most often recommended is a first generation cephalosporin, an aminoglycoside and penicillin for 48 to 72 hours [18,19]. The role of antibiotics in the treatment of low velocity handgun injuries is less clear. The type, route and duration of antibiotic therapy have been debated over the years [20]. There have been series in which there was no antibiotic protocol [15,20]. Bergman., et al. did not use antibiotics in any of the 65 patients treated with immediate reamed femoral intramedullary nails. All of their patients healed, and none had an infection. There is no single widely accepted antibiotic protocol [19]. Some authorities in the past asserted that no antibiotics were required in the routine management of fractures from low velocity missiles because of low infection rates in their series despite no antibiotics being used [6,14]. This conflicted with Patzakis., *et al*. [16] who reviewed 78 gunshot fractures and compared the results of one group receiving no antibiotic treatment with those having treatment with two separate antibiotic protocols. They found a significant reduction in the rate of infection in the patients treated with appropriate antibiotics. There were 25 patients who received no antibiotics, 26 received penicillin and streptomycin and 21 received cephalothin. Of these, one patient in the no antibiotic group developed an infection. The three other patients who developed an infection, that were in the antibiotic groups, had all received a shotgun blast. Brien et al [11] had a protocol which utilized a three-day course of intravenous antibiotics based on their low infection rates. Most investigators advocate 1 to 2 days of intravenous antibiotic therapy for fractures treated with internal fixation [19]. Currently there has been a trend toward oral therapy especially in cases which may be managed as outpatients as this is more cost effective [19]. Some investigators have compared the efficacy of oral antibiotics to intravenous administration in the treatment of low velocity gunshot fractures and found no difference in infection rates [2,10,21]. Mauffrey [2] and Knapp., *et al.* [21] found in separate studies that oral ciprofloxacin for three days was just as efficacious in preventing infection as an intravenous cephalosporin.

Clasper and Rowley looked at 47 patients with femoral fractures secondary to gunshots, most of which were high energy. These patients arrived at the receiving centre greater than 24 hours post injury. None of the patients received irrigation, debridement or antibiotics prior to transfer. All patients were definitively managed on traction. Three patients required amputations for persistent infection despite multiple debridement's at the receiving centre. 48 patients healed with no evidence of infection but four had a limb length discrepancy which was all managed with shoe modifications. The authors did not advocate for delayed treatment but wanted to demonstrate that most patients with high energy injury will have good soft tissue and bone healing even with delayed treatment [7].

Appropriate fixation with an intramedullary device has been said to reduce the chance of infection when used appropriately to stabilise high velocity injuries [6]. Retrograde nailing is an acceptable alternative to ante grade nails in terms of shortening, angulation and infection rates [5]. Once there is only mild to moderate soft tissue contamination, immediate intramedullary nailing will result in lowered mortality rates and reduced average hospital stay [20].

Suthiyakumar., *et al*. [22] recently performed an extensive literature review on gunshot-induced fractures of the extremities. They felt that the literature was generally of low quality and that better quality randomized, controlled trials are needed to establish more sound recommendations and guidelines. Future studies are needed to determine whether serial debridement's, placement of antibiotic bead pouches, negative pressure wound vacuums, or other adjuncts are of any significant benefit [22].

Conclusion

High velocity gunshot fractures should be managed with aggressive debridement, copious irrigation and a 2 to 3 days' course of an intravenous first generation cephalosporin plus or minus an aminoglycoside. Low velocity wounds do not need formal or copious irrigation. Minimal debridement will adequately address entry and exit wounds as well as a three days' course of oral antibiotics for the stable low velocity gunshot fractures. For the unstable gunshot fractures which require internal fixation, they should be placed on 24 to 48 hours of an intravenous cephalosporin.

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