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SCIENTIFIC ARTICLE

Civilian gunshot extremity fractures with neurologic injury

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Objective: To verify the hypothesis that neurologic injuries are less prevalent in civilian gunshot injuries than that reported in the military literature, and are more likely to occur with concomitant fracture.

Methods: In order to investigate the incidence and patient variables of gunshot injury with neurologic injury, a retrospective chart review was performed at a single urban trauma center over a five-year period.

Results: One thousand eight hundred and fifty-one patients with gunshot injuries were treated at our center over the five year study period. Of these, 895 patients (48%) had involvement of at least one extremity and 382 (21%) had concomitant fractures. Seventy-four had concomitant neurologic injury. There was a statistically significant difference of 14% (53/382) and 4% (21/513) ($P < 0.0001$) between the group with fracture (53 patients) and the group without fracture (21 patients), respectively, in the occurrence of neurologic insult.

Conclusion: This incidence of neurologic injuries in civilian gunshot injuries is lower than that previously reported in the military population and the presence of a fracture is clearly an additional risk factor for neurologic injury.

Key words: Bone; Fractures; Gunshot; Nervous system; Trauma

Introduction

More than 30,000 fatal and 70,000 non-fatal injuries result from firearms each year in the USA[1]. The number of civilian deaths in the USA due to gunshot injuries is greater than the combined total of US soldiers killed in all the wars ever fought[2]. With the increasing numbers of civilian gunshot injuries it is becoming increasingly important for surgeons to understand the complications that may accompany them. Orthopaedic injuries from gunshot wounds with bone, vascular, muscle, joint, or soft tissue involvement have been thoroughly studied[3–10]. The incidence and prognosis of neurologic injury from low velocity gunshot wounds is not well documented, particularly in the civilian setting where these injuries are predominantly caused by missiles from low velocity handguns. Furthermore, the risk factors for neurological injury and poor outcomes have not been well-identified. The purpose of this study was to determine the incidence of gunshot wounds to the extremities with concomitant neurological injury and whether or not fractures are risk factors for neurologic injury. It was our hypothesis that neurologic injuries are more likely to occur with concomitant fracture and that neurologic function typically recovers in these patients.

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Materials and methods

The study was conducted at Temple University Hospital (TUH), an urban level 1 trauma center which manages a large volume of low velocity civilian gunshot injuries. After receiving Institutional Review Board approval, medical records during the period between January 2002 and June 2007 were reviewed. Three sources were used to identify patients with gunshot injuries to the extremities (with and without fractures) with peripheral neurological injury: hospital medical records, the orthopaedic inpatient database, and the TUH Pennsylvania Trauma Systems Foundation (PTSF) database.

Four separate hospital medical record searches were performed with the following criteria: (i) upper extremity gunshot wounds with nerve injury; (ii) upper extremity gunshot wounds with nerve injury and open fractures; (iii) lower extremity gunshot wounds with nerve injury; and (iv) lower extremity gunshot wounds with nerve injury and open fractures.

The orthopaedic inpatient database was screened using the search terms "GSW" and "gunshot wound" to retrieve

Table 1 Fracture types in patients grouped by upper and lower extremity (total, 67)

Fracture			
Upper extremity		Lower extremity	
Scapula	1	Ischium	2
Clavicle	2	Ilium	3
Humerus	13	Acetabulum	2
Radius	4	Femur	10
Ulna	3	Tibia	5
Triquetrum	2	Fibula	5
Hamate	1	Calcaneus	1
Metacarpal	6	Navicular	1
Phalanx	5	Cuboid	1

Table 2 Nerve injuries documented in upper and lower extremity gunshot wounds in our sample (total, 74)

Nerve injured			
Upper extremity		Lower extremity	
Brachial plexus	5	Sciatic	5
Median	4	Femoral	3
Radial	7	Tibial	1
Ulnar	10	Peroneal	6
Digital	4	Unspecified	17
Interosseous	1		
Unspecified	11		

additional records. These were then reviewed and patients with concomitant neurological injury were identified.

Finally, the TUH PTSF database was searched using Report Writer (Digital Innovations, Forest Hill, MD, USA) and the ICD-9 codes (both diagnostic codes and E-codes) for gunshot wounds, neuropathy, nerve injuries, and extremity fractures.

Various variables were recorded for each patient including age, sex, race, and date of injury, together with injury-related information such as wound location; number of wounds; number of bullets; fractures; nerve and vessel injuries; and injury severity score (ISS). Finally, other pertinent information that was noted included patient history, treatment, and complications due to trauma or surgery.

Results

The hospital medical record search identified 29, the orthopaedic database 27, and the PTSF database search 28 patients suffering gunshot wounds of the extremities with peripheral nerve injury from 2002 to 2007. Due to duplicate entries in more than one database, after all three sources had been cross-referenced the final patient count was 74.

During the study period, 1851 patients aged 16 years and older were admitted with gunshot injuries. Of these, 895 (48%) involved at least one extremity and 382 (21%) had concomitant fractures. Seventy-four (4%) patients were identified as having gunshot injuries to the extremities with neurological injuries. The relevant variables for these patients are as follows: 71 men and 3 women, aged from 16 to 58 years (mean 27 years), with 59 African Americans, 11 Hispanics, 3 Caucasians, and 1 other. Tables 1 and 2 demonstrate the locations of fractures and nerve injuries in these patients.

In the study group, we identified 53 patients (72%) with at least one accompanying bone fracture and 15 (20%) with additional vascular injury, 11 (15%) having both a fracture and vessel injury. Over this five-year period, we therefore report a 14% (53/382) incidence of gunshot extremity fractures resulting in neurologic injuries. Neurologic injury from gunshot injuries to the extremities without fractures, on the other hand, occurred with an incidence of only 4% (21/513), as illustrated in Table 3. A χ^2 test was used to compare the two values and was significant at $P < 0.0001$.

Discussion

Firearms are the leading cause of death for US citizens between the ages of 15 and 24, coming second only to unintentional injuries. As the number of firearms in the USA passes 300 million, or almost half of all firearms worldwide, our emergency departments are receiving more and more patients with injuries inflicted by these dangerous weapons, highlighting the need for the medical community to be familiar with the prognosis and nature of gunshot injuries. Studies have shown that possession of

Table 3 2 × 2 contingency table illustrating number of gunshot wounds grouped by nerve injury and fracture

		Nerve Injury		
Item		+	–	Total
Fracture	+	53	329	382
	–	21	492	513
	Total	74	821	895

Nerve injury was more commonly seen in patients with fractures (53/382, or 14%) than in those without fractures (21/513, or 4%) ($P < 0.0001$).

a firearm increases the chances of being murdered by 41%[11] and of being shot by a factor of 22 for every individual in the household[12].

Most urban gunshot violence is due to low velocity handguns. Handguns account for one-third of the firearms amongst civilians in the USA but are the cause of more than two-thirds of gun-related deaths[13]. The city of Philadelphia sees an average of more than one gun-related fatality each day and a crime rate almost three times the national average[14,15]. It is imperative that orthopaedic surgeons be aware of our findings concerning gunshot injuries because Brown *et al*. have reported that, at certain urban trauma centers, gunshot injuries consume a large portion of orthopaedic resources: 24% of all admissions, 14% of all surgery cases, 15% of all fractures requiring surgical intervention, 26% of all trauma cases, 32% of inpatient days, and 33% of the average daily census[16].

Neurologic damage from projectile missiles can be due to blast effect or, less commonly, to physical disruption of the nerve itself. However, neurologic injury can also occur with fractures—typically due to stretch injury—resulting in neurapraxia. Sunderland showed in 1972 that 25% of military gunshot injuries result in neurologic injury[17]. Furthermore, he documented that peripheral nerve injuries recovered in 68% of these patients. However, this phenomenon has not been well described in civilian gunshot injuries despite their relatively common occurrence in urban trauma centers. We suspected that in our series of patients, whose injuries are essentially from low velocity missiles, the degree of neurologic injury would be less severe than that in the series reported by Sunderland. Furthermore, the 25% incidence of neurologic injury in Sunderland's study is far higher than that seen in our study, which was 4% overall. It may be assumed that the higher energy injuries seen in Sunderland's series most likely account for the more significant soft tissue and skeletal injury, as well as the more profound blast injury phenomenon.

In another important study, Omer described 648 upper extremity nerve lesions from military injuries, of which 331 were caused by low velocity gunshots[18], presumably similar to those seen in our study. Although the incidence of gunshot injury leading to neurologic injury was not described in this study, 227 of the 331 cases had spontaneous nerve recovery by the time of follow-up. Although 46 fractures were identified in this series, data regarding rate of recovery in low velocity gunshot injuries with fractures were not identified.

It can be speculated that since nerve injury is more likely to occur in the presence of skeletal instability, gunshot wounds that cause fractures should have a higher rate of neurologic injuries than those that do not. Indeed, we demonstrated an incidence of neurologic injury in 14% of patients who had a gunshot extremity wound with fracture compared with 4% of patients without fracture. We can conclude that fractures are a risk factor for neurologic injury in civilian patients with gunshot wounds in the extremities.

One of the obvious weaknesses of this study is the lack of clinical follow-up to determine the rate of neurological recovery. This is currently underway and has not been completed yet. Nevertheless, the retrospective data from this study highlights this increased risk and the importance of careful neurologic examination upon presentation.

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Disclosure

The manuscript submitted does not contain information about medical device(s)/drug(s). No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

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