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Orthopaedic firearm injuries in children and adolescents: An eight-year experience at a major urban trauma center

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ABSTRACT

Introduction: The purpose of this study is to describe the epidemiology of orthopaedic injuries incurred secondary to firearms among children and adolescents at a major metropolitan trauma center and to identify risk factors for complications and long-term morbidity.

Methods: A retrospective review was performed of consecutive patients 17 years of age and younger who sustained a firearm injury and required orthopaedic treatment at a major trauma center from 2006 to 2013. Patient demographics, injury mechanism, fracture classification, neurovascular injury, antibiotic administration, and length of hospitalization were recorded. Radiographic studies were used to determine fracture pattern, methods of stabilization, and time to union. Primary clinical outcomes include fracture nonunion, infection, and physeal arrest.

Results: 46 patients with a mean age of 12.7 years were treated for firearm related orthopaedic injuries. 72% of the patients were ages 13–17, while 28% were 12 years of age and younger. There were 28 violent injuries (21 assaults, 7 innocent bystanders) and 16 non-violent injuries (15 unintentional discharges and 1 self-inflicted). There was a bimodal distribution of violent versus nonviolent mechanisms, with the majority of children 12 years of age and under sustaining non-violent injuries and adolescents more commonly injured with a violent mechanism.

There were 44 fractures and 6 traumatic arthrotomies, with eight associated neurovascular injuries. Twenty-five patients had an orthopaedic procedure, with a total of 43 surgeries. Mean hospital length of stay was 6.8 days. There were five deep infections. Four patients developed non-unions and all of these patients had deep infections. The timing and duration of antibiotic therapy was not significantly different between those who did and did not develop infection. Of the non-operatively treated fractures, there were no infections or non-unions at long-term follow-up.

Conclusions: Morbidity and mortality related to firearms is a growing public health problem in the United States. Results of this study suggest that gunshot related fractures had higher than anticipated morbidity, including permanent neurologic deficits, infection (11%) and fracture non-union (9%). More than half of patients underwent surgery and experienced long hospital stays secondary to the complexity of the injury. This epidemiological data on firearm injuries in children and adolescents is an impetus for prospective study, with the goal to increase awareness and develop treatment strategies for firearm-related fractures.

Introduction

Firearm-related injuries are a leading cause of serious and fatal injuries to children and adolescents. While in the past paediatric gunshot wounds were rare and frequently incidental, there has been an increase in civilian gun violence since the late 1980s, with a disproportionately large increase occurring within the paediatric population. In 2010, firearm injuries led to the death of 3459 children and adolescents under the age of 21, representing the cause of death for 25% of adolescents 15–19 years of age. Additionally, there were 9981 non-fatal injuries during the same year, an incidence of 12.64 per 100,000 [1]. The combination of increasing drug- and gang-related crimes and ease of access to firearms may contribute to this increased mechanism of injury.

The rising incidence of firearm-related injuries in the paediatric and adolescent population represents a significant public health

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concern. The resulting complex orthopaedic and visceral injuries have associated short and long-term morbidity. To date, no treatment algorithm has been formulated for the management of paediatric patients with ballistic orthopaedic injuries, nor is there a good understanding of the predictors of poor clinical outcomes. Many population-based studies describe the epidemiology of firearm-related deaths [2,3]. In adults, literature supports non-operative treatment of low-velocity gunshot wounds with local wound care, antibiotics, and outpatient management. For injuries caused by high-energy weapons, or those with unstable fractures or vascular injuries, however, the recommended treatment includes formal surgical irrigation and debridement, fracture stabilization, and intravenous antibiotics [4].

Contrary to the wealth of published literature on adult firearm injuries, studies specific to the paediatric population are sparse. In particular, the few studies that have been published on paediatric orthopaedic injuries report on a small number of patients from centers outside of the United States [5].

The aim of this study is to describe the epidemiology of orthopaedic injuries incurred secondary to firearm injuries among children and adolescents at a major metropolitan trauma center over an eight-year period and to identify risk factors for complications and long-term morbidity.

Materials and methods

After institutional review board approval for data collection and analysis, we retrospectively reviewed consecutive patients 17 years of age and younger who sustained a firearm injury and were evaluated at a level 2 paediatric trauma center over an 8-year period from 2006 through 2013. Patients with orthopaedic injuries as a result of firearms were identified from the institutional trauma registry utilizing ICD-9 codes. Patients that were not evaluated by the orthopaedic service during their hospitalization were excluded.

Demographic information was obtained from the institutional trauma registry and included age at the time of injury, gender, and race. The electronic medical record was utilized to obtain additional details related to their injuries. Pertinent data points included type of firearm (low or high-velocity), nature of the injury (non-violent unintentional, non-violent self-inflicted, violent innocent bystander, or violent assault), and perpetrator (known or unknown, minor or adult). Based on the principles of muzzle velocity and soft tissue injury, handguns were considered low-velocity weapons and shotguns and hunting riffles were considered high-velocity weapons. A non-violent unintentional firearm injury was defined as one that occurred when the gun was accidently discharged during cleaning, hunting, playing, or inspecting it. Violent injuries were defined as intentional acts of injury towards another individual, with the victim being an innocent bystander or intended target. Injury specific variables included number and location of fractures, soft tissue injury, and associated neurovascular injuries. Hospital course, including administration and timing of antibiotics, surgical procedures, and length of stay were documented. Radiographic studies were reviewed to determine fracture location, methods of stabilization, and time to union. Primary outcomes included fracture nonunion, infection, and physeal arrest.

Descriptive statistics was used to determine risks factors for nonunion, infection, and physeal arrest.

Results

Demographics

From January 2006 to December 2013, 46 consecutive patients (36 male and 10 female) were treated at our children's hospital for firearm-inflicted orthopaedic injuries. The mean age of the patients was 12.7 years (range 2–17). 33 (72%) of the patients were adolescents (ages 13–17), and 13 (28%) were twelve years of age and younger. Races included African–American (72%), Caucasian (22%), and Hispanic (6%). The inflicting weapon was a handgun in 38 patients (83%), shotgun in 7 patients (15%), and BB gun in 1 patient (2%). There were 30 (65%) violent injuries (23 assaults, 7 innocent bystanders), 13 (28%) non-violent injuries (12 unintentional discharges and 1 self-inflicted), and 3 injuries (7%) with an unclear mechanism.

Table 1
Demographics.

Average age	12.7 years (2–17)
Weapon	
Handgun	38
Shotgun	7
BB Gun	1
Violent injuries	21
Assault	
Innocent bystander	7
Non-violent injuries	15
Unintentional firing	
Suicide	1
Fractures	44
Arthrotomies	6
Nerve injury	6
Vascular injury	2
Hospital stay	6.8 days (1–42)

Table 1 provides details on the patient demographics.

The cohort was divided into two groups based on ages; 13–17 years of age and 12 years of age and younger. The selected age division was based on a distinct bimodal distribution of violent versus nonviolent mechanisms. The majority of the younger children (62%) sustained their injury by a non-violent mechanism. In contrast, the adolescent group was more likely to have been injured with a violent mechanism (67%). This is illustrated in Fig. 1.

Injury characteristics

There were 44 fractures and 6 traumatic arthrotomies in the 46 patients. Of these, 26 (59%) were lower extremity injuries and 18 (41%) were upper extremity injuries. Fig. 2 shows the distributions of fractures by individual bones. Traumatic arthrotomies occurred in 13% of patients – 4 knees, 1 hip, and 1 wrist. There were 6 peripheral nerve injuries in the 46 patients (13%), including 2 peroneal, 2 radial, 1 radial digital, and 1 brachial plexus. At an average follow-up of 23 months (range 1–99 months), all nerve

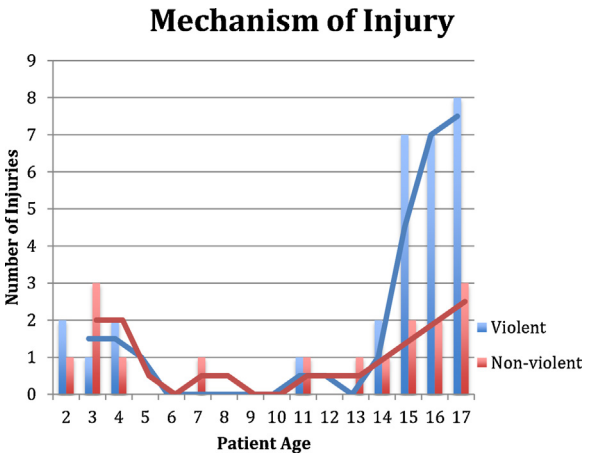

Fig. 1. Distribution of injury mechanism by age.