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Feature Article

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A B S T R A C T

This prospective study evaluated the efficacy of an outpatient management protocol for patients with a gunshot-induced fracture with a stable, nonoperative configuration. Forty-one patients (44 fractures) with a grade I or II open, nonoperative fracture secondary to a low-velocity missile comprised the study population. Patients were treated by a standard protocol, which included 1 g of cefazolin administered in the emergency room and a 7-day course of oral cephalexin. Follow-up visits were performed until complete wound and fracture healing were achieved.

Thirty-two (78%) of 41 patients underwent full follow-up. Average follow-up was 5.2 months. One (2.8%) fracture (distal fibula) developed a superficial infection, which responded to an additional week of oral antibiotics, and no patient developed a deep infection. There was 1 delayed union and 2 patients with painful retained shrapnel. These results demonstrate that patients with stable, low-velocity, gunshot-induced fractures can be managed effectively and safely on an outpatient basis using this protocol.

The incidence of civilian gunshot-related injuries in the United States continues to climb and burden large urban trauma centers. From 1968 through 1991, motor vehicle-related deaths decreased by 21% whereas firearm related deaths increased by 60%.¹ Today, the most common cause of death in teenaged African-American males is firearm homicide.² A report published by the Centers for Disease Control and Prevention (CDC) in 1994 indicated that firearm-related deaths may overtake motor vehicle accidents

as the leading cause of injury-related death by the year 2003.¹

Although the extent of firearm-related mortality is well documented, data on the number of nonfatal gunshot-induced injuries are limited. A study by the CDC using the National Electronic Injury Surveillance System (NEISS) over a 1-year period (1992-93) estimated that 99,025 persons were treated for nonfatal firearm-related injuries in US hospitals. The rate of nonfatal firearm-related injuries treated was 2.6 times the national rate of fatal firearm-related injuries. Of these nonfatal injuries, 51.5% involved an extremity.³

There is extensive literature regarding the treatment of gunshot wounds to the extremities. Many studies examine the treatment of military gunshot wounds, which typically involve high-velocity missiles. However, the orthopedic surgeon today generally deals

with civilian firearm wounds. These can be categorized into three distinct types: 1) low-velocity pistol or rifle wounds, 2) high-velocity rifle wounds, and 3) close-range shotgun wounds. In high-velocity rifle and shotgun wounds, the damage to soft tissue and bone is extensive, as is tissue necrosis. These wounds should be treated in a similar fashion to battle wounds with formal irrigation and debridement in the operating room, intravenous antibiotics, and delayed or secondary closure.⁴⁻⁷

A majority of gunshot wounds treated today are of the low-velocity, low-energy transfer variety. In low-velocity handgun or rifle wounds, soft-tissue damage usually is minimal and extensive debridement is unnecessary. The entrance and exit wounds are small and do not require closure. Previous studies demonstrated the efficacy of infection prophylaxis in low-velocity gunshot-

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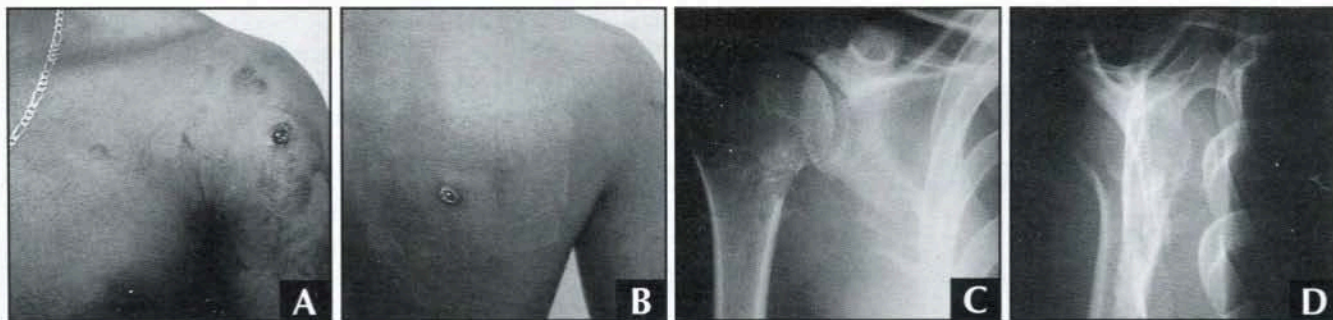


Figure 1: Photographs of a 23-year-old man with a grade I open gunshot wound with a posterior entrance (A) and anterior exit (B). Radiographs illustrate a divot fracture of the proximal humerus (C) and scapula (D).

induced fractures with irrigation and debridement in the emergency room, tetanus prophylaxis, and admission for 24-48 hours of intravenous antibiotics.⁸⁻¹² This remains the standard of care for these patients. However, with the changing socioeconomic factors in health care, some investigators have begun to examine the outpatient management of these patients. Furthermore, infection prophylaxis for the outpatient has not been well defined. Excellent results have been obtained with a variety of treatments ranging from admission for 48-72 hours of intravenous antibiotics to no antibiotics.

This study evaluated the efficacy of outpatient management of nonoperative gunshot-induced fractures using a single dose of intravenous cefazolin with a 7-day course of oral cephalexin.

MATERIALS AND METHODS

Between November 1996 and November 1998, all patients between the ages of 10 and 70 years who presented to the emergency room at Chirby Hospital, New Orleans, La, with a grade I or II open, nonoperative fracture secondary to a low-velocity missile were enrolled in this prospective study after informed consent was obtained. Internal review board approval was obtained prior to enrolling patients in the study. Patients who required hospitalization for medical problems or surgery for gunshot wound injuries were excluded.

On initial presentation to the emergency room, patients with gunshot-induced fractures were evaluated by the

orthopedic service to determine the need for open reduction and internal fixation. Patients with a stable fracture configuration who consented to participate in the study were enrolled. These patients were then treated with our outpatient protocol, which included tetanus toxoid 0.5 mL, irrigation and local wound debridement, closed reduction (if necessary), placement of dressing/splint, and completion of an informed consent form and data sheet. In addition, each patient was given 1 g of intravenous cefazolin and a prescription for 500 mg of oral cephalexin 4 times daily for 7 days.

A total of 44 patients with 47 nonoperative gunshot-induced fractures initially were entered in the study. Three patients were excluded (1 for pregnancy and 2 for failure to sign informed consent form). Thus, a total of 41 patients with 44 fractures comprised the study population. Average patient age was 26 years (range: 16-50 years), and 88% of the patients were male.

Follow-up clinic visits were scheduled for 1, 2, and 6 weeks and thereafter until fracture healing was noted clinically and radiographically. At each clinic appointment, physical examination was performed, the dressing was changed, the wound evaluated, and radiographs obtained. Infection was defined as superficial if persistent drainage, induration, or erythema was noted that resolved with additional antibiotic treatment. A deep infection required admission to the hospital for irrigation and debridement and intravenous antibiotics.

RESULTS

Thirty-two of 41 patients with 35 (80%) of 44 fractures completed the study. Average follow-up was 5.2 months (range: 3-9 months). Thirteen (32%) of 41 patients enrolled in the study had previously sustained a gunshot wound. In addition, of those patients who completed the study, 3 (9.4%) subsequently died from an unrelated gunshot wound within 1 year of the index treatment.

Fractures were classified as a cortical defect (26%), nondisplaced (23%), or comminuted (51%). Soft-tissue wounds were classified using Gustilo's classification. Thirty (85%) of 35 fractures were grade I open fractures and 5 (15%) were grade II open fractures (Figure 1). There were 11 (31%) upper extremity fractures and 24 (69%) lower extremity fractures (Table). The foot and hand were included, which comprised 26% of the study group.

One (2.8%) superficial infection was noted in 35 fractures. No deep infections occurred. The superficial infection occurred in a 44-year-old woman with a gunshot wound to her fibula. At 1-week follow-up, she had a clear, persistent drainage and was given an additional week of oral antibiotics. At her 2-week follow-up examination, there was no erythema and the wound had stopped draining. No further antibiotics were given, and the fracture healed.

Five other complications, unrelated to wound infection, were noted. Two patients developed painful retained

shrapnel, which was removed under local anesthesia (Figure 2). These patients had no further complaints following shrapnel excision. Two patients noted persistent paresthesia distal to the entrance wound, however, they did not undergo further work-up. One patient had delayed union of the proximal humerus. This patient was incarcerated and was not seen in the orthopedic clinic until 6 months after the initial injury. After 3 months of activity restriction, the fracture healed uneventfully.

DISCUSSION

The protocol for treating gunshot-induced fractures depends on the extent of the soft-tissue injury, fracture pattern, and location. When faced with a gunshot wound in the emergency room, one critical factor in the clinical pathway is the soft-tissue wound. Much of what has been written in the past concerning the treatment of gunshot-induced fractures has addressed combat-inflicted wounds. These wounds represent high-energy transfer gunshot wounds. With such an injury, soft-tissue destruction can be extensive due to the temporary cavitation and shock waves.¹³ Management of these wounds has been the subject of extensive investigation, and a treatment protocol exists for these difficult-to-treat injuries. Most surgeons agree the treatment of these wounds consists of irrigation and extensive surgical debridement in the operating room with delayed closure.^{4,14}

In contrast to the high-energy transfer gunshot injury, the soft-tissue trauma sustained following a low-energy transfer gunshot wound is minimal to moderate, and radical debridement typically is not warranted. The orthopedist must rely on his or her clinical judgment to follow the correct clinical pathway when initially evaluating these injuries. Attention to functional disturbance, swelling, and bone and bullet fragmentation as well as soft-tissue disruption usually allows accurate decision making.¹⁵ The primary mechanism

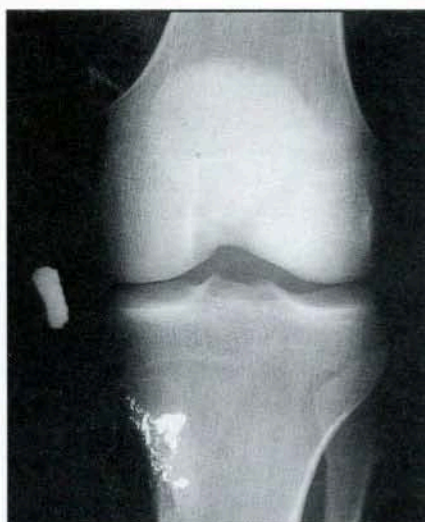


Figure 2: Radiograph shows retained shrapnel, which was removed 1 year after injury.

of injury in low-energy gunshot wounds is the direct laceration caused by the missile.^{13,16}

Controversy arises in discussing wound contamination. These wounds are typically open grade I or II fractures. The mechanism of bacterial contamination involves the vacuum effect created by the temporary cavitation as the missile traverses the skin and soft tissue. This creates a suction phenomenon, which results in dirt and clothing fragments being drawn into the wound.¹⁴ In addition, Thoresby and Darlow¹⁷ reported bullets are not sterilized by firing.

In the past, many have advocated treatment of these wounds in a similar fashion to high-velocity combat-induced gunshot wounds. Ziperman⁴ advocated exploration of all wounds, regardless of location or missile type, as he could not otherwise assess the extent of the soft-tissue injury. Carr and Stevenson¹⁸ recognized the differences between combat and civilian gunshot wounds but recommended similar treatment of these wounds.

As early as 1961, Hampton¹⁹ and others began advocating a more limited approach to civilian gunshot wounds with irrigation and minimal debridement in the emergency room. Hennessy et al²⁰ concluded irrigation, rather than

TABLE
Patient Demographics

	No.
Total no. patients	41
Patients with follow-up	32
Average age (y)	26
Gender	
Female	4
Male	28
Average follow-up (mo)	5.2
Involved extremity	
Upper extremity	11
Hand	3
Forearm	2
Humerus	4
Scapula	2
Lower extremity	24
Pelvis	0
Femur	4
Tibia	4
Fibula	9
Foot	7
Complications	
Nonunion*	1
Painful shrapnel	2
Paresthesia	2
Superficial infection	1
Deep infection	0

*Proximal humerus.

classic debridement, is necessary to remove surface contaminants and debris. Geissler et al,¹¹ who stated the key to local wound management for civilian gunshot wounds is copious irrigation, reaffirmed this. They recommended thorough irrigation with 2-3 L of a 10% iodophor solution.¹¹ Others also have recommended local debridement in the management of these wounds.^{10,12}

In addition to wound management, the issue of antibiotic therapy has been extensively debated for these injuries. Many consider these standard open fractures and treat them accordingly with admission to the hospital for 48-72 hours of intravenous antibiotics. Although this was the gold standard in the past, evidence in more recent studies suggests low-energy transfer gunshot-induced fractures can be treated with oral antibiotics, and some even suggest no antibiotics may be required.^{7,10,12,21}

Few studies comparing infection rates associated with different antibiot-

ic regimens have been performed in a prospective fashion with patients treated as outpatients. In 1988, Woloszyn et al²² treated patients as outpatients with oral cephalexin in a retrospective study and reported no infections in 52 patients.²¹

Dickey et al¹⁰ reported their results of a prospective trial comparing no antibiotic therapy to admission for 24 hours of intravenous antibiotics. They concluded no infection prophylaxis was afforded by the use of intravenous antibiotics.

Giessler et al¹¹ retrospectively compared a random group admitted for 48 hours of intravenous antibiotics to a group given an intramuscular injection of cefonicid, a long-acting cephalosporin. They found no difference in infection rates.

Knapp et al¹² have conducted the largest prospective randomized study to date looking at antibiotic treatment for these fractures. One group was admitted for the administration of intravenous cephapirin sodium and gentamicin for 72 hours and the second group was admitted for administration of oral ciprofloxacin. None of the patients were treated as outpatients. Foot and hand gunshot fractures were excluded from their study. Our study, therefore, represents the first prospective trial using oral antibiotics in which all patients were treated as outpatients.

The decision to use cefazolin and cephalexin in this study was based on the findings of Knapp et al.¹² All four infections in their study were *Staphylococcus aureus*, with one infected with an additional organism, group-D gamma-hemolytic streptococcus. A control group was not included in the present study because the efficacy of the treatment protocol was tested versus the gold standard of admission for intravenous antibiotics, which has a historical rate of infection ranging from 0%-11%.^{11,12} Because the present study did

not include a group that received no antibiotics, the question remains whether any antibiotics are necessary in the treatment of these fractures.

In a study on the impact of gunshot wounds on the orthopedic service at our institution, Brown et al²² reported patients with gunshot-induced fractures comprised 24% of orthopedic admissions, 33% of the average daily orthopedic census, and 14% of all orthopedic surgeries performed. At the time the study by Brown et al²² was performed, the standard for the treatment of low-velocity gunshot-induced fractures was admission for 48 hours of intravenous antibiotics. With implementation of the new treatment protocol, inpatient census associated with these injuries has decreased as well as health-care dollars spent to treat these patients. This is important when one considers 60%-80% of these patients are uninsured.^{22,23}

CONCLUSION

Low-velocity gunshot-induced fractures that do not require operative management for stabilization may be managed by this protocol with excellent results. Irrigation and local wound debridement, a dose of intravenous cefazolin in the emergency room, and a 7-day course of oral cephalexin is as efficacious as admission to the hospital for intravenous or oral antibiotic therapy.

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