

GUNSHOT FRACTURES¹

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INTRODUCTION

WHILE the use of cautery and boiling oil has long been abandoned and suppuration is no longer deemed laudable, considerable variation still surrounds the treatment of gunshot wounds. Since the damage resulting from these injuries is dependent upon the type of missile inflicting the wound, the tissues involved and the circumstances which immediately precede and follow wounding, attempts to assess therapeutic efforts are both difficult and of limited application. Hunter (7), nearly 200 years ago, noted the marked differences in the destructive effects of various firearms and was one of the first to recognize the importance of missile velocity in the fate of such injuries. He called attention to the delayed appearance of injury occurring in wounds from high velocity missiles and emphasized that the extent of damage was often imperceptible on first inspection.

Subsequent observations and reports reflect largely the experiences of the military with these wounds. Under circumstances of combat, radical debridement of such injuries and the avoidance of primary suture are accepted principles with which few could disagree. However, in the years since the Korean War there has been a persistent tendency to reject principles evolved during circumstances of war and replace them with procedures deemed more appropriate to civilian life. The wisdom of this practice in the management of gunshot wounds to the extremity skeleton is the subject of this report.

MATERIAL AND METHODS

The x-ray and clinical records were reviewed in 100 cases of extremity fractures secondary to gunshot wounds ad-

mitted to the adult and pediatric fracture services of the Cook County Hospital between January 1, 1957 and September 30, 1960. Similar treatment was employed in each patient, namely, varying degrees of wound cleansing and irrigation carried out on the ward without recourse to general anesthesia or enlarging incisions. In the majority of instances this merely consisted of cleansing of adjacent skin and application of a sterile dressing. In a few instances, the obviously devitalized or discolored skin at the site of entrance or exit wounds was excised and the subcutaneous wound was superficially irrigated with sterile saline solution. Appropriate immobilization procedures, tetanus prophylaxis and antibiotic therapy were then instituted.

Two types of injury are not included in this review: 1) those requiring operation for other reasons, such as major vessel damage or wounds to the abdomen, thorax, or head and neck regions; and 2) shotgun wounds which usually require operative intervention because of the degree of soft tissue damage they create.

This series then represents a nearly continuous group of extremity gunshot fractures subjected to minimal wound care.

SITE OF INJURY

Table I shows the distribution of gunshot fractures. There were 106 fractures in the 100 cases studied, 6 patients having had two or more bones injured. Multiple gunshot fractures of the radius and ulna occurred in 3 patients, of the ulna and humerus in 2 patients, and of a metacarpal and a phalanx in one patient. Representative x-ray views of the various gunshot fractures encountered are illustrated in Figure 1.

TYPE OF FRACTURE

Any fracture that is complicated by a break in the continuity of the skin is a

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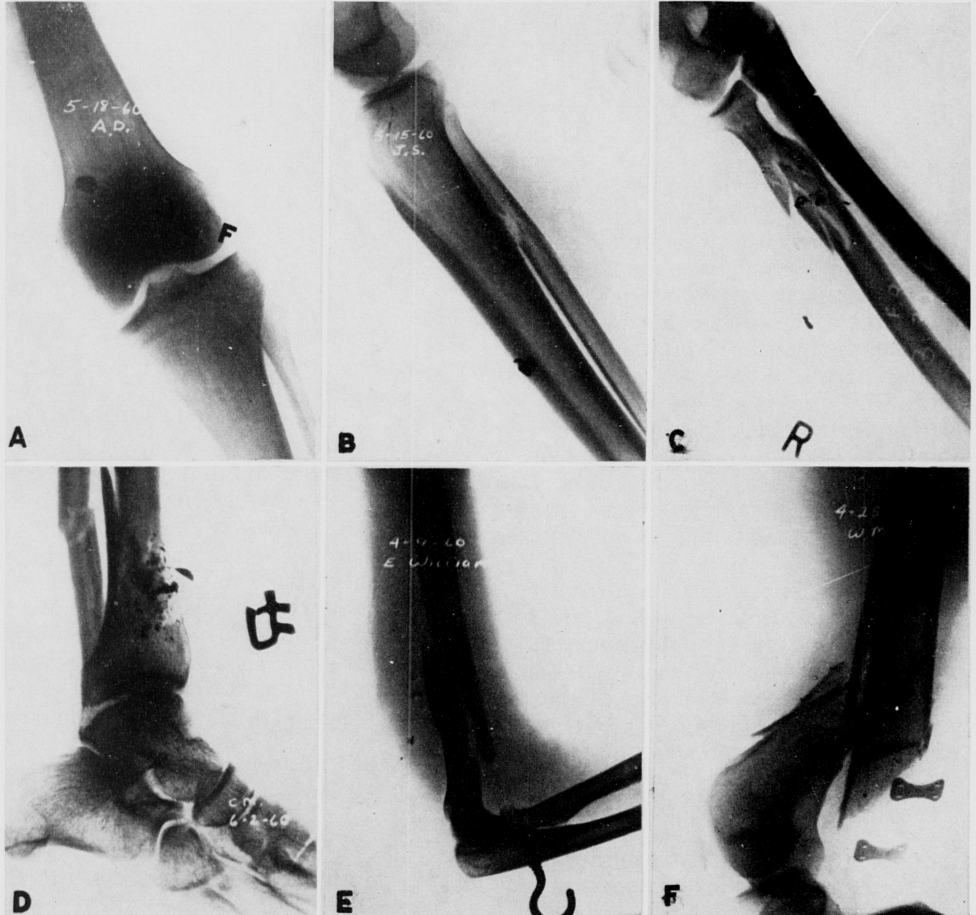


Fig. 1, A to F. A, AP view of knee showing single metallic fragment in femur. Fracture inapparent. B, Lateral view of leg showing incomplete fracture of fibula. C, Fracture distal radius. D, Both bone fracture lower leg. E, Oblique comminuted fracture of humerus treated with skeletal traction. F, Markedly displaced and comminuted supracondylar fracture of femur.

compound fracture, and all gunshot fractures fall into this category. Analysis of the x-rays in our series revealed four basic types of fracture (Table II) and all appeared to be independent of the caliber of the gun inflicting the injury.

WEAPON AND WOUND

The caliber of the gun producing the fracture was identified in 57 cases by an interview with the patient or police or by calibration of the recovered missiles. The hospital record contained no reference to the type or size of weapon in 43 of the cases reviewed.

Wounds were described in detail on all of the charts reviewed. There were 39

patients who showed wounds of entrance but no exit wound, 61 patients had both entrance and exit wounds, and 6 patients had multiple entrance and exit wounds with more than the usual skin damage and contamination.

ASSOCIATED INJURIES

Nerves. In this series of 100 cases of gunshot fractures, 5 patients had evidence of nerve injury, the peroneal nerve being involved in two instances, and the radial, ulnar and median nerve each in one instance. Spontaneous return of nerve function occurred in 3 of the 5 patients during the period of hospitalization, but in the other 2 the neurologic deficit per-

TABLE I.

Distribution of Gunshot Fractures
Cook County Hospital
1957-1960

Clavicle	2
Humerus	19
Ulna	10
Radius	12
Metacarpals	7
Phalanges (hand)	10
Femur	15
Tibia	12
Fibula	5
Tarsals	2
Metatarsals	6
Phalanges (foot)	6
TOTAL	106

sisted until the time of discharge and both these patients were lost to follow-up study.

Vessels. Actual or suspected injury to major vessels is an indication for formal wound exploration in the operating room. This type of injury was excluded from our study except in one instance where transection of the radial artery occurred in association with a gunshot fracture of the radius and was successfully controlled by ligation on the ward.

RESULTS

Soft Tissue Healing. The rate of wound healing and the occurrence of wound complications have been well documented in 77% of the cases in this series (Table III). Most of the 23 patients lost to clinical follow-up were under arrest and were released to prison authorities.

The period of time required for complete skin closure is a time-honored and at times unreliable criterion of the efficacy of wound healing. Where skin edges have been widely excised, a considerable period of time may elapse before complete epithelialization occurs, in spite of the fact that healthy granulation tissue exists and the wound is free of suppuration. Nevertheless, wound healing has been classified as "early" if it occurs within 3 weeks after injury, as "delayed" if it occurs 3 to 6 weeks after injury, and as "prolonged" when the skin remains open after 6 weeks. Reference to Table III will confirm the uniformly good results obtained in the patients studied.

TABLE II.

Type of Gunshot Fractures
Cook County Hospital
1957-1960

Chip fractures	7
Incomplete or punched out fractures	24
Single metal fragment imbedded in bone	13
Comminuted fractures	62
TOTAL	106

TABLE III

Wound Healing of Gunshot Fractures
Cook County Hospital
1957-1960

		Cases
Skin healing		
Early	Less than 3 weeks	74
Delayed	3 to 6 weeks	3
Prolonged	More than 6 weeks	0
Bony healing		
Delayed union		0
Osteomyelitis		0
Lost to clinical follow-up		23
TOTAL		100
Deaths		0
Percentage of wound morbidity (3 of 77)		4%

A more important criterion for the assessment of wound care is the incidence of major infections which prolong hospitalization or endanger life and limb. These are the complications that radical excisional therapy is designed to prevent. Tetanus and gas gangrene were not encountered in our series. Not a single instance of abscess formation requiring surgical drainage was observed. In no instance was there a temperature elevation (which was felt to be caused by the wound) beyond 72 hours after injury.

Bony Healing. The speed and degree of bony healing also appeared to be without complication. Within the period of follow-up study, not a single instance of osteomyelitis or delayed bony union was encountered.

DISCUSSION

Many of the factors involved in the destructive effects of missiles upon tissues are readily evaluated in the laboratory (2, 6). In addition to velocity, the nature

TABLE IV.
 Contrasting Characteristics of Gunshot Wounds Incurred in Military and Civilian Life

	Military	Civilian
Weapon	Garand, M1 rifle, 30 mm machine gun	.45 cal pistol; .22 rifle; .32; .38 revolver
Muzzle velocity	High, 2000 to 10,000 ft/sec	Low, usually less than 1000 ft/sec
Wounding distance	Variable	Usually short range
Wound Pathology	Pronounced cavitation effect with injury to tissues some distance from tract Greater severance of vessels and hematoma formation	Minimal tissue destruction confined to missile tract
Onset of therapy	Often delayed	Usually prompt
Follow-up care	Changing personnel	Usually by same personnel who provided initial treatment
Therapy	Classical debridement with enlarging incisions, excision of devitalized tissues, evacuation of hematoma, irrigation and delayed closure	Controversial

of the tissue traversed, the caliber of the bullet and its characteristics of mass, shape, aerodynamic and hydrodynamic stability deserve consideration. Of all these factors, the most important is velocity. It alone may serve as a reliable indicator of expected damage to tissue.

General agreement exists as to the management of wounds resulting from high velocity missiles incurred during wartime. However, differences in the type of wound produced by civilian firearms in contrast to military missiles (Table IV) suggest that considerably less in the way of surgical debridement is required in their treatment. The excellent reports of Dziemian (2), Morgan (8) and Harvey (6) have shown this to be the case in a large series of both clinical and experimental wounds of the soft tissues of the extremity. It is suggested by the present study that the same considerations may exist when bony injury is associated.

Much of the controversy over wound care centers about the use of the term "debridement." This much abused word usually implies an incision of sufficient length to permit exploration of the entire area of injury. Hampton (5) stated that the objectives should be removal of dead tissue, relief of tension in the wound, evacuation of hematoma, and provision

of adequate drainage. He considered relief of tension the most important contribution of wound debridement. This may be provided by the missile itself in some wounds, but, in general, the deeper the tissues injured, the less adequate the decompression provided by the missile tract. Other components of debridement, including assessment of tissue viability and provision of drainage, can hardly be considered to have been fulfilled in the majority of wounds reported in this series. The previously cited work of Morgan (8) contains examples of wounds treated without debridement. His group reviewed 105 cases of civilian gunshot wounds of the soft tissues of the extremity in which wound care consisted only of application of a sterile dressing after gentle cleansing of the exit and entrance wounds. Appropriate tetanus prophylaxis and antibiotics were used routinely. They observed no instances of immediate or delayed wound sepsis, and reported a mean hospital stay of two days where no bony involvement occurred. Their rather complete follow-up 3 months to 3 years after injury revealed no evidence of delayed wound sequelae in the soft tissue wounds, and they concluded that debridement was unnecessary in such wounds. Similar findings were reported from widely distributed civilian

areas in personal communications cited by Hampton (4), and from the military experiences of Crile (1) and Ferguson (3).

Ziperman (11) opposed these concepts and advocated formal exploration of most missile wounds, regardless of the circumstances surrounding their occurrence. If tissue devitalization was not identified in his cases, the wound was sutured per primum; otherwise delayed closure of the wound was practiced. He warned against hazards of imbedded cloth which is always loaded with bacteria and is far more dangerous than the missile itself. We have observed in otherwise unimpressive gunshot wounds the retention of alarmingly large pieces of foreign material, such as clothing, buttons and leather, which may result in dire consequences of deep wound sepsis and gas gangrene, thus endangering both life and limb.

Though infrequent, these experiences suggest a cautious acceptance of the concept of limited wound care. Additional benefits of formal wound exploration may be cited. With the detection of major vascular injury, exploration is universally advocated to assess and to repair damage to critical vessels and to evacuate hematoma. Yet major vascular injury may occur without being immediately evident and routine wound exploration at the earliest possible moment is of unquestioned benefit in the detection of these cases.

Nerve injury secondary to gunshot wounds is generally managed conservatively. Identification of complete or partial severance at the time of operation may not justify primary repair, but accurate knowledge of such an injury certainly facilitates the time of secondary repair (10).

An additional consideration is cited by Hampton (4) in referring to the unpublished work of Richards. He reported an instance of fulminating sepsis in a civilian wound of the buttock area which was allowed to go undebrided. We have in the past year (since completion of this study) observed two additional examples of wound sepsis with persistently positive cultures for *Clostridium welchii* from civilian gunshot wounds in this area. In neither case was injury of the colorectum responsible.

The significance of bony injury is difficult to assess. Where impact results in fracture, an increased likelihood of soft tissue destruction is anticipated since the fragments of shattered bone act as secondary missiles within the tissues. However, unpublished reports by Richards and Holt (9) in 62 consecutive civilian gunshot fractures treated without debridement revealed no untoward sequelae.

In light of the experiences reported herein, we cannot help but agree with Hampton that "the majority of bullet wounds of the extremity with or without fracture seen in the practice of civilian surgery apparently require no real surgery of the wound." Wounds resulting from shotgun blasts or wounds complicated by other factors, such as actual or suspicious neurovascular injury, constitute special situations usually demanding operative intervention. Moreover, when the appearance of the wound, its location, or the circumstances surrounding its occurrence and treatment are deemed unfavorable, there seems little doubt that recourse to classic measures of formal operative debridement is indicated.

SUMMARY AND CONCLUSIONS

1. Observations are reported on 100 civilian patients with gunshot fractures of the extremities subject to limited wound care.
2. The differences in civilian missile injuries in contrast to military ones are emphasized and the therapeutic implications discussed.
3. While our experiences and those of others suggest that formal debridement is unnecessary in the vast majority of uncomplicated civilian gunshot wounds, caution is advised in the universal application of this principle.

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