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Review Article

Gunshot injuries of the spine

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Abstract

BACKGROUND CONTEXT: Spinal gunshot injuries (spinal GSIs) are a major cause of morbidity and mortality in both military and civilian populations. These injuries are likely to be encountered by spine care professionals in many treatment settings. A paucity of resources is available to summarize current knowledge of spinal GSI evaluation and management.

PURPOSE: The aim was to summarize the ballistics, epidemiology, evaluation, treatment, and outcomes of spinal GSI among civilian and military populations.

STUDY DESIGN: This was a review of the current literature reporting spinal GSI management.

METHODS: MEDLINE (PubMed) was queried for recent studies and case reports of spinal GSI evaluation and management.

RESULTS: Spinal GSI now comprise the third most common cause of spinal injury. Firearms that produce spinal GSI can be divided into categories of high- and low-energy depending on the initial velocity of the projectile. Neural and mechanical spinal damage varies with these types and results from several factors including direct impact, concussion waves, tissue cavitation, and thermal energy. Management of spinal GSI also depends on several factors including neurologic function and change over time, spinal stability, missile tract through the body, and concomitant injury. Surgical treatment is typically indicated for progressive neurologic changes, spinal instability, persistent cerebrospinal fluid leak, and infection. Surgical treatment for GSI affecting T12 and caudal often has a better outcome than for those cranial to T12. Surgical exploration and removal of missile fragments in the spinal canal are typically indicated for incomplete or worsening neurologic injury.

CONCLUSIONS: Treatment of spinal GSI requires a multidisciplinary approach with the goal of maintaining or restoring spinal stability and neurologic function and minimizing complications. Concomitant injuries and complications after spinal GSI can present immediate and ongoing challenges to the medical, surgical and rehabilitative care of the patient.

Keywords: Gunshot wound; Spine; Spinal trauma; Spinal gunshot injuries; Surgical management; MRI after gunshot injury; Metal toxicity

Introduction

A spinal gunshot injury (spinal GSI) can be a devastating event leading to considerable morbidity and mortality of the injured. Once found primarily in military personnel, spinal GSIs now also occur frequently in civilian populations because of the prevalence of firearm involvement in violent crime [1]. Although surgical and medical management of spinal GSIs varies among health-care providers, the overall goals of treatment include maintenance or restoration of mechanical spinal stability and neurologic function, and prevention of the complications of injury and treatment. Concomitant injuries add to the complexity of the pathology and often require a multidisciplinary team of providers for patient care. This purpose of this review is to summarize the ballistics, epidemiology, evaluation, treatment, and outcomes of spinal GSIs among civilian and military populations.

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Methods

A MEDLINE (PubMed) search was performed to identify publications reporting the evaluation, treatment, or basic science of spinal GSIs. Papers were included if the information contributed to the current understanding of the factors that vary over time (eg, epidemiology, antibiotic prophylaxis, indications for surgery, and timing of surgical intervention) or if the information best exemplified the clinical manifestations of the basic science of spinal GSIs (ballistics, magnetic resonance imaging [MRI] after GSI, metal toxicity). The authors' intentions are not to present this information as a meta-analysis or systematic review, given the paucity of scientific studies with high levels of evidence, but rather to summarize the best available information that is necessary to evaluate and treat a patient presenting with a spinal GSI.

Ballistics

Several factors that affect the severity of a spinal GSI are related to ballistics of the projectile. These factors include the velocity, path, and size of the projectile and distance between firearm and target [1]. Firearms with a muzzle velocity less than 2000 ft/second are defined as ''low energy'' and are typically responsible for spinal GSIs in civilian populations. These firearms mainly cause direct injury to tissue as there is little to no blast or cavitation wave effect on the target. In contrast, high-energy weapons, such as the AR-15 and M-16 military assault rifles (Colt's Manufacturing Co., West Hartford, CT, USA), fire with a muzzle velocity of greater than 2000 ft/seconds. The damage produced by these firearms is a result of both the direct impact of the missile and indirect injuries due to shock wave or cavitation wave effects [2]. Although high-velocity firearms were once isolated to military trauma, the use of these weapons has increased in civilian populations as has the observation of the characteristic injury patterns that they produce [3].

The injury pattern and complication profile of spinal GSIs can also be affected by the design of and material used in the manufacture of the bullet (Fig. 1). Many bullets are manufactured with a metallic cover or ''jacket'' designed to protect the lead bullet from deformation during firing and flight. Unjacketed bullets, which may remain undeformed after impact, are most often identified by the small amount of lead along the missile path [4]. Copper-jacketed missiles may be identified on radiographs by visualizing two distinct metal densities and observing a nondeformed object without traces of metal along its path [4]. Semijacketed missiles, in contrast, undergo a large amount of deformation on impact; two

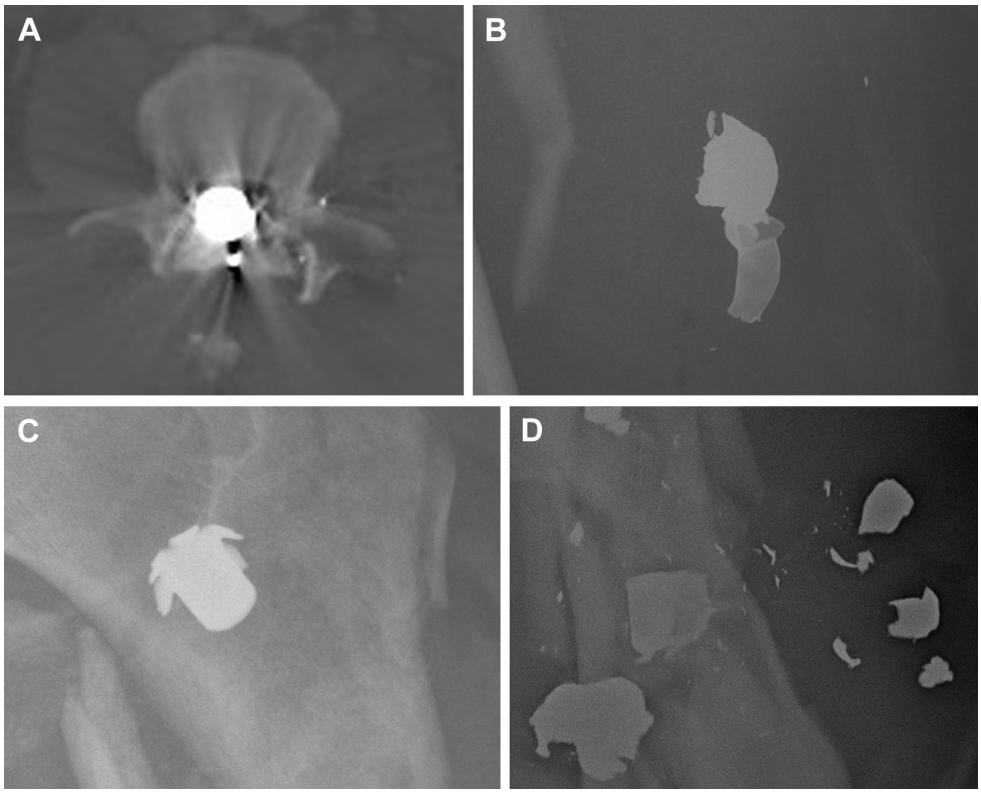

Fig. 1. Imaging findings of several common types of bullet design: unjacketed bullets will typically be undeformed and show a small amount of lead along the missile path (A), copper jacketed bullets will show two distinct metal densities (B), hollow-point bullets flatten, or ''mushroom'' on impact (C), rifle bullets may show ''lead splatter'' on impact (D).