



Original Article

Gunshot injury to spine: An institutional experience of management and complications from a developing country

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ABSTRACT

Purpose: Gunshot wounds are the second leading cause of spinal cord injuries. Surgical intervention for gunshot injury to the spine carries a high rate of complications. There is a scarcity of data on civilian gunshot injuries to the spine in Pakistan. Approximately 60 cases over the last 10 years have been recorded, with unusual presentation and neurological recovery. Thus it is imperative to fill this gap in data, by reviewing cases of civilian gunshot injuries to spine presenting at a tertiary care hospital (Aga Khan University Hospital, Karachi).

Methods: This is a retrospective cohort study. Patients of all ages who presented to the emergency department of Aga Khan University Hospital, with gunshot injuries to spine between January 2005 and December 2016 were included in the study. Data were collected on neurological status (American Spinal Injury Association score was used for the initial and follow-up neurological assessment), extent of cord transection, motor and sensory deficits. The patients were further grouped into those with cord transection, and those with fractures of the bony spine but an intact spinal cord. These patients were then followed and the outcomes were recorded.

Results: A total of 40 patients were identified. The mean \pm SD of patients age was (30.9 \pm 9.5) years. Of the 40 patients with gunshot wounds, 31 had the medical imaging performed at the facility, and hence they were included in this categorization. The remaining 9 patients were excluded from this additional grouping. Thirteen patients were managed surgically and 27 patients underwent the conservative management. The mean \pm SD of follow-up was (8.7 \pm 7.2) months. In our study, the thoracic spine was the most commonly injured region in gunshot injuries. Of the 31 patients with medical imaging performed at our institute, 17 (54.8%) had cord transection, of whom 8 (47%) ultimately developed paraplegia.

Conclusion: The prognosis of gunshot injuries to the spine can be varied depending on whether the spinal cord is intact or transected. This will help healthcare providers to plan the further management of the patient and counsel them accordingly.

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Introduction

Gunshot wounds (GSWs) are the second leading cause of spinal cord injury, following road traffic accidents in the United States. Gunshot injury, which was predominant in military population, is now increasingly seen in civilian population.¹ According to de Barros Filho TE et al.,² the incidence of penetrating injuries to the spine has increased lately, and caused 13%–17% of all spine injuries.

Although thoracic injuries are the most common following gunshot, cervical spine injuries may be the most destructive. The main prognostic factor considered for recovery is the initial neurological status.^{2–5}

GSWs to the spine are commonly thought to be stable. However, there is a potential for instability if the bullet passes transversely through the spinal canal, fractures pedicles and facets. The anatomical distribution of GSWs shows that there is a predominant injury to the thoracic region contributing to 50% of all the cases followed by lumbosacral wounds in 30% and cervical spinal in 20%, (the least likely place in the observed patients). Injuries in the cervical spinal cord are associated with airway lesions and vascular

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lesions, requiring tracheostomy or emergency intubation.⁶ Compared with incomplete neurological deficits, cervical GSWs are more likely to cause complete neurological deficits.⁷

There is a wide spectrum of pathologies associated with GSW in the spinal cord which include complete myelopathy, incomplete injury, cord contusion and extradural/intramedullary hematoma. The complete myelopathy incurs a total loss of sensations to the victim with decreased benefit of using steroids, whereas an incomplete spinal cord injury occurs when an injury survivor retains some feeling below the site of the injury. Spinal contusions occur when the spinal cord is bruised, often causing inflammation and bleeding from blood vessels near the site of injury.⁸ Marked variance in outcomes of spinal cord injuries was witnessed as a transition from World War I to World War II. Owing to the advancement in treatment of spinal trauma and better neurosurgical approaches, the mortality rate significantly declined.^{5,9,10}

The GSW is considered a special type of blunt trauma, which can either be a direct or an indirect tissue injury. The direct injury is the formation of a wound track which results in a rupture of the tissue following the edge of the advancing bullet. The injury may range from dural tear to a total cord transection. The wound track is a permanent cavitation with areas of irreversible tissue damage causing necrosis and sloughing, contributing to the formation of wound track. As opposed to direct injuries, indirect injuries are due to the shock wave energies or the cavitation wave effect.³ The authors were interested in understanding the prognostic factors and recovery outcomes in patients who had a spinal cord fracture with cord transection as opposed to those who have an intact spinal cord. Are there any differences between the two cohorts? We aimed to evaluate the spectrum of presentation in patients who report to the Aga Khan University Hospital with GSW to the spinal cord and to assess the outcomes based on the type of intervention provided. The study also aimed to judge the consequences of complete cord transection following spinal gunshot trauma vs. a partial or intact spinal cord.

Methods

This is an institutional retrospective study conducted at Aga Khan University Hospital, Karachi, Pakistan. A multi-variate proforma was used to address the objectives of the study, which included patient demographics such as the age and gender, the spinal level of gunshot injury, the immediate presentation in the emergency department, the immediate and definitive intervention provided and the outcomes. Radiological imaging was used to assess the integrity of the spinal cord. Furthermore, follow-up clinical notes were used to assess the therapeutic success or failure of the treatment provided. The analysis was then done to find trends in the data and report co-relations between cord transection and neurological outcomes.

Patients of all ages with gunshot injuries to spine presenting to the emergency department between January 2005 and December 2016 were included. Patients with incomplete records and unavailable radiological data were excluded. We used American Spinal Injury Association score for the assessment of neurological status. Consequently, patients were divided into five subsets depending upon neurological status, respectively (A) Complete cord injury; (B) Intact sensory but impaired motor function; (C) More than half of key muscles below injury level have a power strength less than 3; (D) More than half of key muscles below injury level have a power strength more than 3, and (E) Normal motor and sensory function.

A second method based on computed tomography and X-Ray imaging was utilized to check the extent of damage, as a result of which patients were classified into two groups: those with cord

transection and those with fractures of the bony spine but having an intact spinal cord.

Results

Forty patients were involved in the study. The mean \pm SD of patients age was (30.9 \pm 9.5) years. In hospital, 27 of the patients were treated conservatively while 13 received surgical intervention. The most pertinent indication for surgery was to eliminate the risk of mechanical instability (5 patients, 38.5%), followed by infection (3 patients, 23%). The in-patient stay, presented as mean \pm SD was (12.2 \pm 8.5) days and follow-up (8.7 \pm 7.8) months. Among other complications of GSW, the most prevalent was bedsores of 12 patients (30.0%) followed by urosepsis of 7 (17.5%). Among the patients who were treated conservatively, all of them were discharged without any mortality, whereas those who underwent surgical treatment, 4 (30.7%) died primarily due to sepsis. A detail characteristic of all patients can be visualized in Table 1.

A total of 17 (42.5%) patients were presented with complete cord transection (Figs. 1 and 2) which is secondary to penetrating bullet wound to the spine. Of these 17 patients, 7 (41.1%) were paraplegic and only 6 (35.2%) recovered after the course of hospital management. Other outcomes include quadriplegia, diaphragmatic paralysis and lower limb paresthesia. The 14 (45.2%) patients with intact spinal cord (Fig. 3), all recovered well.

Discussion

The management of GSW is categorized into acute or initial treatment and definitive treatment. In the acute phase, the aim is mainly to provide advanced trauma life support.² The treatment involves securing the airway by endotracheal/orotracheal intubation or tracheostomy. As soon as possible, chest radiograms should be done to find the exact location of the bullet and to check if there are bone or tissue damages. In addition to the radiograms, arterial blood gas should be ordered to evaluate the patient's hemodynamics. Treatment of non-neurological injuries takes preference over the neurological ones which are usually life-saving, and hence exploration of neck, chest and abdomen take precedence over spine

Table 1
Demographic characteristics of patients in the study.
(n = 40).

Variables	n (%)
Gender	
Male	37 (92.5)
Female	3 (7.5)
Region of gunshot	
Cervical	9 (22.5)
Thoracic	20 (50.0)
Lumbosacral	11 (27.5)
ASIA scoring	
A	25 (62.5)
B	1 (2.5)
C	6 (15.0)
D	5 (12.5)
E	3 (7.5)
Sensory deficits	
Present	32 (80.0)
Absent	8 (20.0)
Bowel impairment	
Present	27 (67.5)
Absent	13 (32.5)
Bladder impairment	
Present	33 (82.5)
Absent	7 (17.5)

ASIA: American Spinal Injury Association.

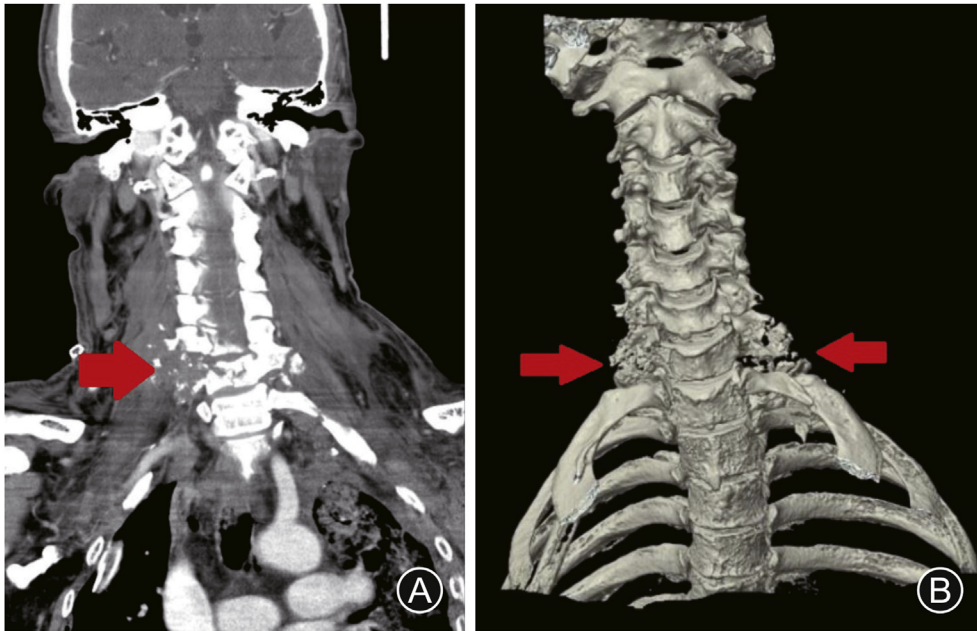


Fig. 1. The spinal injury with cord compromise/transection. (A) C₆–C₇ cord transection; (B) 3D reconstruction computed tomography scan.

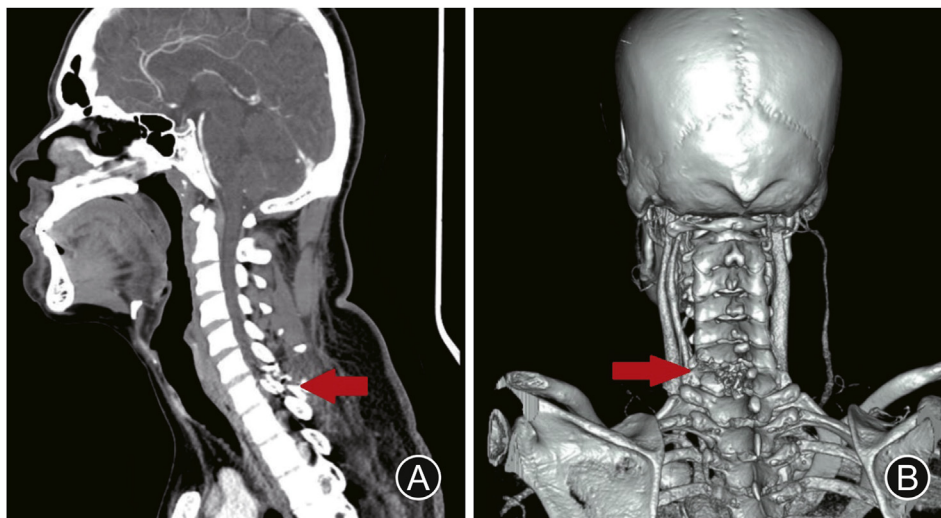


Fig. 2. The spinal injury with cord compromise/transection. (A) Cord transection at the level of C₇; (B) 3D reconstruction computed tomography scan.

surgery. Broad spectrum antibiotics should be started to patients who have perforations in the gastrointestinal tract.^{3,7,11}

On the other hand, definitive treatment is started after careful evaluation of the extent of neural compression. The mode of treatment can be either conservative or surgical. Conservative management focusses on the protection of the integument, thereby eliminating the chances of infection spread. It is started to be done by aseptic cleaning of the wound and periodical changing of the dressing along with broad-spectrum antibiotics, then gradual shift towards culture specific medicines. To further ensure proper ventilation, it should install the pulmonary support and carefully monitor to ensure unremarkable oxygen saturation.^{3,7}

The primary objective of performing surgery is to improve the neurological deficits, stabilize the spine and effectively treat the injury. Although it is commonly assumed that neurological deficits will be improved after removal of the bullet, it is not always the

case. Literature indicates that the majority of gunshot injuries to the spine is not significantly improved after decompressive surgeries, yet there are studies which indicate the incentive of bullet removal to establish improved motor function.^{9,12}

There are differences in approaches to GSW in the military and the civilian. Military camps usually do not have an access to as much facilities as civilians have, especially during a war or combat. The increase of violence in urban areas has led to the increased incidences of GSW in the civilian especially among young people. There is a marked variation in terms of projectiles of the ammunition in civilian and military population. The projectiles are marked as “low velocity or high velocity”. The low velocity is generally around 350 m/s and the high velocity between 600 m/s and 700 m/s. However, the military rifles are usually operating at a supersonic range of about 700–960 m/s. There are many factors such as cavitation, deposition and location of the wound that need

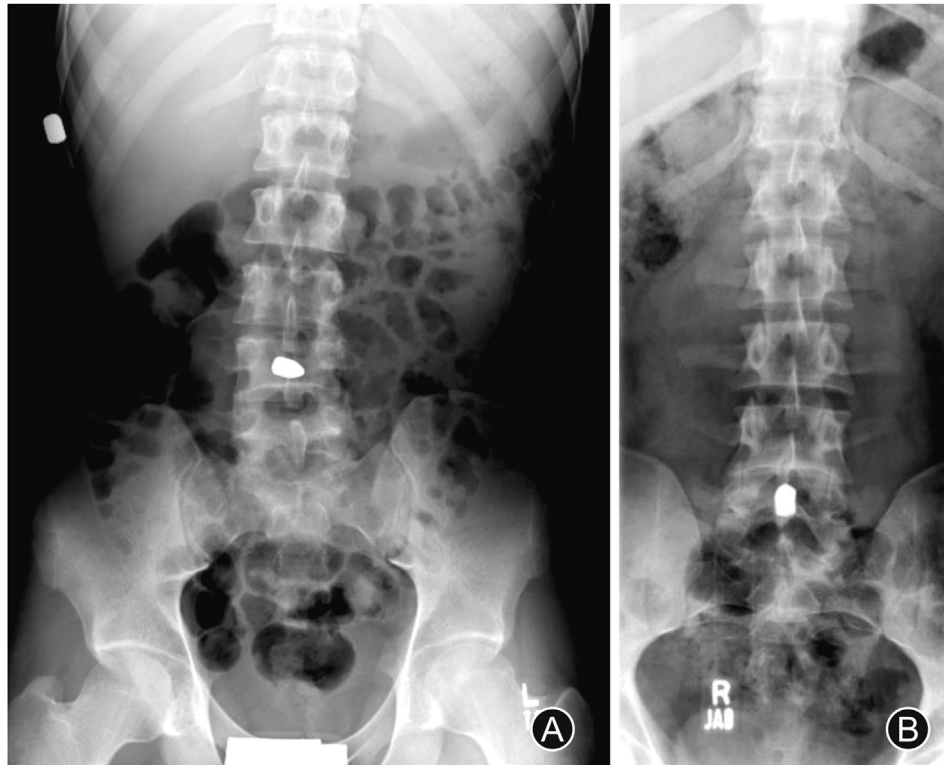


Fig. 3. Examples of bony spine injury with no intact spinal cord. (A) Bullet traversing the spine at the level of L₄; (B) Bullet lodged at the level of L₅.

to be considered when looking for injuries, but only the physical properties of the bullets do not have the impact. A bullet can either stay in the body where it delivers all its energy and creates a blind wound with only an entrance aperture or perforate the body to create an exit wound. It too depends on the location and size of the perforated tissue.^{2,9–11,13}

Spinal gunshot injuries in civilian carry a great disease burden, especially in the low-resource setting, where patients are paraplegic for life and have marked functional deficits. As the patient is often one of the few or the only breadwinner of the family, this can have grave consequences in terms of household economics. The financial burden struggled by patients involves recurrent hospital admissions, bedsores and physiotherapy. In countries, like the United States, the state funds the healthcare and treatment, which will have a staggering effect on the economy system. If pay for a 25-year-old tetraplegic patient of the expected life-time health-care, it will cost approximately \$4.5 million. The scenario becomes even more worrisome in low and middle income countries such as us, because the mode of healthcare payment is “out of the pocket”, with the bulk of the burden carried by the patients and their families alone.

The recovery of patients with cord transection depends on the extent of damage. Spinal cord injuries can lead to paraplegia or quadriplegia, which is a devastating condition with no cure as of yet.¹⁴ This manifestation is due to apoptosis, contributing to neuronal and glial cell death resulting in neurological dysfunction.¹⁵ Our study corroborates the aforementioned findings, which are all the patients with an intact spinal cord recovered well as opposed to only 35.2% of the patients with spinal cord transection. However, the new cellular therapeutic interventions, including transplantation of Schwann cells from olfactory nervous system and activated macrophages, have excellent prognosis with the prerequisite of an intact spinal cord. Improved locomotor function can be achieved with rehabilitation since the spinal circuitry below the

lesion site maintains active and retains functional neuronal properties.¹⁴

Even though the study on human subjects is limited, Fouad et al.¹⁶ showed a success with regeneration of spinal cord after complete transection in rats. The strategy was multifold and aimed at reducing inhibitory cues in the glial scar, providing a growth-supportive substrate for axonal regeneration, and regenerating axons to exit the bridge and re-enter the spinal cord. Significant improvements were observed in the Basso, Beattie, and Bresnahan score and in forelimb/hindlimb coupling. This recovery was accompanied by the increased number of both myelinated axons in the spinal cord bridge and serotonergic fibers that grew through the bridge and into the caudal spinal cord.¹⁶

Vales et al.¹⁷ postulated the idea of using olfactory ensheathing cells (OECs) from the olfactory bulb to promote axonal regeneration and functional recovery, when they were transplanted immediately or 1 week delayed into the T8 transected rat spinal cord. OEC transplants promoted the recovery of functional outcomes, as shown electrophysiologically by return of motor evoked potentials and reduction of hindlimb hyperreflexia, and the recovery of movements of hindlimb joints. Axonal regeneration was proven histologically by demonstrating long axonal outgrowth of raphespinal, coeruleospinal, and corticospinal tracts within the caudal cord stump.¹⁷

Through this study, we wanted to provide an insight into the presentation, prognosis and recovery of civilian patients with gunshot injuries to the spine in a third world country. Small sample size and inability to record the condition of the patients over the years constitute the weakness of the study.

With gunshot injuries in civilians becoming an increasingly common problem, there is an ever increasing value of ensuring prompt clinical decision making when faced with such patients. This can be improved in studies such as ours which provide details of patient prognosis and outcomes following different paths of

management. We hope that through this study, among others, we can contribute to the facilitation of more effective management in these patients.

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Ethical Statement

The study was approved by the Ethics and Review Board of Aga Khan University Hospital.

Declaration of Competing Interest

All the authors agree that there's no conflict of interest associated with this manuscript.

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