

Review Article

Penetrating spinal injuries and their management

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Abstract

Penetrating spinal trauma due to missile/gunshot injuries has been well reported in the literature and has remained the domain of military warfare more often. Civic society's recent upsurge in gunshot injuries has created a dilemma for the treating neurosurgeon in many ways as their management has always involved certain debatable and controversial issues. Both conservative and surgical management of penetrating spinal injuries (PSI) have been practiced widely. The chief neurosurgical concern in these types of firearm injuries is the degree of damage sustained during the bullet traversing through the neural tissue and the after-effects of the same in long term. We had an interesting case of a penetrating bullet injury to cervical spine at C2 vertebral level. He was operated and the bullets were removed from posterior midline approach. Usually, the management of such cases differs from region to region depending on the preference of the surgeon but still certain common principles are followed world over. Thus, we realized the need to review the literature regarding spinal injuries with special emphasis on PSI and to study the recent guidelines for their treatment in light of our case.

Key words: Gunshot wounds, missile, penetrating spinal injury

INTRODUCTION

Penetrating spinal injuries (PSI) to spine have been on the rise recently. Missile and non-missile PSI (MPSI and NMPSI, respectively) account for most of the military and civilian wounds. We encountered a case of PSI and hence, reviewed the current literature involving MPSI and NMPSI in order to outline the current management protocol.

CASE HISTORY

We had a 27-year-old male getting admitted with a history of gunshot injury 48 hours back. He was not able to move his right

half of the body and had sustained two bullets in occipito-cervical region. On examination, his vitals were stable and had some difficulty in vocalization. His power in the left upper and lower limbs was grade V, while in the right upper and lower limbs it was grade 0. He had developed Brown-Sequard syndrome with loss of sensations on left side with a sensory level at C2. There was areflexia on the right side while reflexes were normal on the left. There was no bowel/bladder involvement. There was a cerebrospinal fluid (CSF) leak from the wound at the back which was sutured. He was given steroids at the previous center and was started on antibiotic prophylaxis. Computed tomography (CT) of the cervical spine [Figure 1] revealed one bullet lodged in the right half of canal at C2 vertebral level and the second within the subcutaneous tissue of the neck on the left side. As the ferromagnetic property of the bullet was not known, magnetic resonance imaging (MRI) for assessment of the cord injury was not possible. The patient was placed in prone position and midline suboccipital approach was taken to expose the subocciput and C1-C3 lamina bilaterally. The right lamina of C2 was fractured. C2 laminectomy was done to retrieve the first bullet. The dura was completely torn and the cord was lacerated locally. Once the

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bullet was removed, the cord was adequately decompressed and started pulsating well. He was electively ventilated for 24 hours and was gradually weaned off the ventilator. Postoperative MRI showed extensive cord edema although the cord substance was well preserved [Figure 2]. The patient was mobilized and was discharged after aggressive rehabilitation. Though the power on the right was still grade 0, he regained the preoperative power on the left side after initial deterioration.

DISCUSSION

Missile firearm injuries are encountered during military warfare and often create a dilemma in the minds of neurosurgeons as to when and how to intervene. Low and high velocity bullets both can cause significant neural damage as they pass through the tissues. It is well known that the degree of damage depends upon the properties of the bullet and those of tissues receiving it. The bullet transfers its energy to the tissue depending on its mass and velocity (energy = mass × velocity²). Along with the mass, shape and composition of the bullet can be crucial in determining the severity of injury. Also, the velocity is twice more lethal than the mass of the bullet. The bullet causes damage by directly destroying the tissues in the path as well as by creating pressure waves and cavitation. Gunshot injuries to atlanto-axial spine are rare. Only few cases have been reported in the literature.^[1,2] Only 20% of spinal gunshot injuries involve cervical cord and only 5% involve the axis.^[3] On the other hand, non-missile injuries are seen in civil life with objects like knives, wooden material, screw drivers and other multitude of materials, and pose similar treatment challenges. Cervical and thoracic spine is usually the most commonly affected region.

Their management starts from the time of injury and extends till the rehabilitation period.

The “Golden Hour” management: Resuscitation

The relevance of “first do no harm” cannot be better understood than in patients with PSI. Over-aggressive and over-zealous management could lead to further deterioration in the neurological function. The importance of immediate

immobilization, care of open wounds, maintenance of hemodynamic stability and early transfer to higher center capable of dealing with PSI cannot be over-emphasized.

The patients of PSIs should be resuscitated by the standard ATLS protocol (ABCDE) as in cases of other types of spinal injuries. Figure 3 shows an algorithm for management of penetrating injuries to neck.

Radiological considerations

Plane X-rays demonstrate major bony injuries and the foreign bodies including bullets. Dynamic X-rays can provide vital information about stability. The National Emergency X-Radiography Utilization Study (NEXUS) evaluated patients with cervical spine injuries. Presence of any one of the following NEXUS criteria after a thorough assessment by history and examination makes radiological work up mandatory. In today's times, however CT and MRI form the mainstay of the investigation along with plain X-rays. MRI was ruled out in our patient although few reports suggest that low velocity bullets having copper jackets are non-ferromagnetic and hence MRI may be performed.^[4] But, in an emergent setting it may be difficult to know the exact composition. Despite the metallic artifacts due to the bullet, the presence of bullet within the canal could be seen well. CT forms the best investigating modality in such emergent settings. Bony anatomy can be well delineated and decisions regarding stability can be made more objectively. CT myelography is another option in these cases but whether it is feasible in emergent settings is doubtful. CT of spine showed both the bullets and only right lamina fracture (entry point) was evident and thus the injury was considered stable. Penetrating wounds of spine are the third most common cause of spinal cord injury^[5] and hence every minute radiological detail (axial, sagittal, and three-dimensional reconstructions) must be studied thoroughly.

Indications for bullet retrieval

The chief indications for bullet retrieval are:

1. Progressive clinical deterioration of patient with an incomplete injury of cord^[6]



Figure 1: CT images showing bullets at C2 level and in the subcutaneous tissues of occipital region

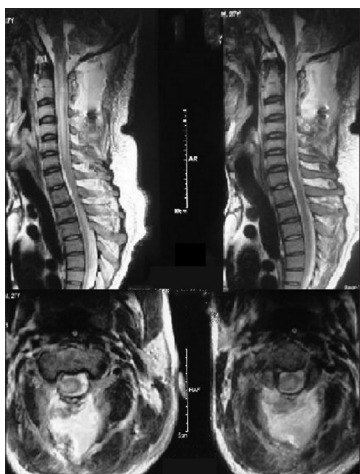


Figure 2: Post operative MRI showing cord signals from cervico-medullary junction to C6 vertebral level. Axial images showing the C2 laminectomy defect and preserved cord substance at the affected level

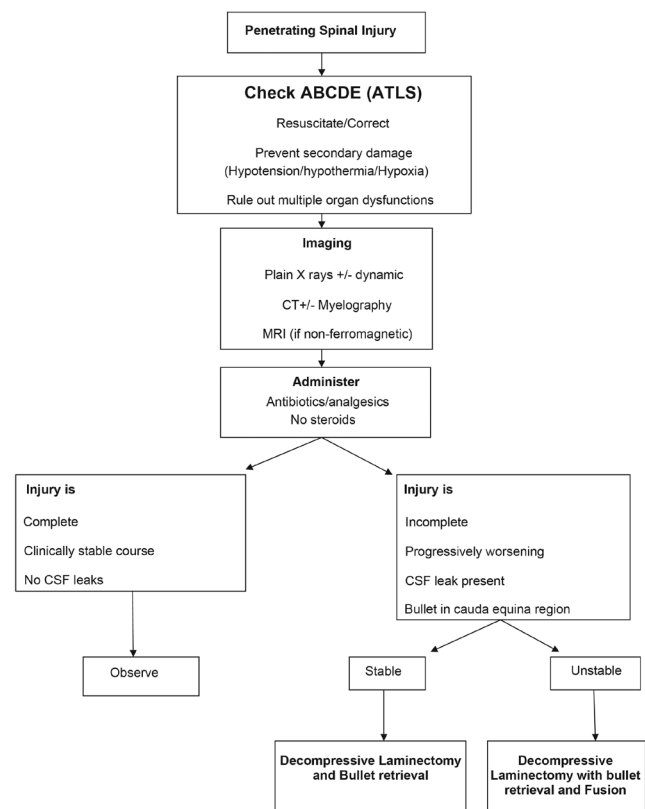


Figure 4: Algorithm for overall management of a patient with PSI

2. Migration of bullet within the canal^[4,7,8]
3. Dural leaks and impending risk of meningitis
4. Possible copper and lead toxicity^[9-11]

In the most recent military and civilian literature review regarding penetrating spinal injuries, Klimo *et al.*^[12] have tried to echo these indications in an emphatic way, although the data remains inadequate. The final word still remains that decompressive laminectomy should be attempted for patients with incomplete injuries and if unstable, instrumentation should

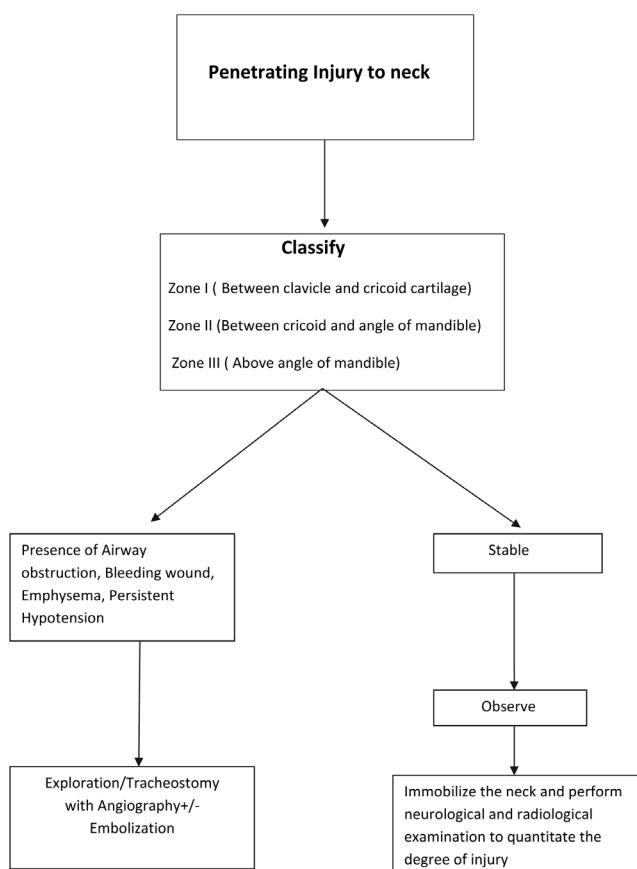


Figure 3: Algorithm for management of penetrating neck injuries

also be done. Bhatoe and Singh have extensively reviewed the literature in relation to military warfare like Korean and Vietnam conflicts.^[13] They advocate surgery in partial deficits and in injuries affecting the cauda equina region. Cervical spine according to them must be decompressed at all times if indicated as even a single nerve root may be useful in the rehabilitation of patients. In contrast, Le Roux and Dunn^[14] analyzed 49 cases of gunshot injuries and advised a conservative approach except where bullet is in the region of cauda equina. Waters and Adkins^[15] further stress that operative decompression is more beneficial for incomplete injuries between D12 and L4. If there is no CSF leak, exploration should not be attempted till a fair trial of conservative management with antibiotic cover (covering gram positives, gram negatives and anaerobes) has been given.

Role of methyl-prednisolone

The NASCIS (National Acute Spinal Cord Injury Studies) have been undertaken in order to define the utility of methyl-prednisolone in acute spinal cord injuries. Bracken and Shephard^[16] recommended the role of steroids in indirect blunt spinal injury within first eight hours. But, Levy *et al.*^[17] advocated that steroids do not offer any significant advantage in penetrating injuries to spine (as compared to blunt trauma) and thus must be avoided. Heary *et al.*^[18] and others have shared the same thought as far as PSI is concerned.^[19] The risk of immune compromise and subsequent infection is much higher than any

other expected benefit. Hence, steroids are not administered in any PSI nowadays.

Role of delayed surgery

Gupta *et al.*^[20] reported a similar case where the bullet had lodged behind the atlas arch and there was no dural breach. The patient was neurologically intact and the bullet was not removed till there was pus discharge from the track despite antibiotic coverage, seven days after the injury. The bullet was retrieved by the far lateral approach and the patient did well.

Wandering bullets, spinal stability and rehabilitation

There have been occasional case reports of wandering bullets and hence final confirmation by image intensifier in the operating room after final positioning becomes mandatory^[7,8] As far as stability is concerned, we based our criteria on the three-column concept of Denis as described for thoraco-lumbar fractures^[21]. We had to do C2 laminectomy in our patient so as to remove the bullet in this incomplete injury at an eloquent area of spine and also to seal off the dura to prevent risk of meningitis. The patient improved gradually and no CSF leak ensued later. This patient had a stable injury but as C2 spine is essential for nuchal muscular attachments and forms an essential element for providing posterior stability, the patient can develop instability/kyphosis during the follow-up and should be kept in close surveillance with serial dynamic X-rays. Rehabilitation forms an integral part of PSI as these patients are prone to develop medical complications after surgery. *Spinal Cord Injury Rehabilitation (SCIRehab)* project has identified some of the positive interventions. The SCIRehab project includes 1,500 patients with acute spinal cord injuries, with outcome data being abstracted from medical records (clinical outcomes data) at six spinal cord injury rehabilitation facilities and obtained from patient interviews at 6 and 12 months after injury. Apart from possible neurological improvement, the other aim of surgery is early mobilization. This reduces the incidence of pneumonia, deep venous thrombosis and pressure sores in these patients. Active physiotherapy of paraplegic/hemiplegic patients is therefore an integral part of neurosurgical exercise. Low molecular heparin also must be given in these patients in order to prevent thrombo-embolism while caring for pressure points and therapeutic interventions like hyperbaric oxygen therapy (HBOT) may help in managing these wounds.

NMPSI

As far as NMPSI is concerned, various case reports have been found in the literature where wooden fragments and metallic objects like nails have been found to have entered the spinal column accidentally^[22-24]. Singh *et al.* have reported an accidental penetrating injury to cervical spine from a nail gun^[25] The patient had no deficit and the nail was retrieved from posterior midline approach. The foreign body in all such cases of NMPSI should be removed in the operating room and no attempt should be made to remove it casually without adequate preparation and exposure. Excess manipulation must be avoided and dural repair should be done if required.

Postoperative imaging must be done to confirm the cord injury as soon as feasible.

The overall management of a patient with PSI is summarized in Figure 4.

CONCLUSION

Penetrating missile and non-missile injuries need patience and meticulous planning. Indications for surgery must be clear and if possible, conservative management should be preferred over the aggressive surgical removal of foreign bodies so that fresh iatrogenic deficits can be avoided. Bullet removal can be safely recommended exclusively for those with incomplete nature of injury with progressive deterioration or a new deficit arising in the observation period. Monitoring serum levels of lead and copper can be done till toxicity can be established and till that point the bullets can be left *in situ* if they are not compromising neural tissue. Surgical exploration if needed should be done by the experts only and must not be completed in haste. Optimal exposure in such injuries is the key to favorable outcome. Decompressive laminectomy with or without instrumentation is the workhorse in all these cases along with watertight closure of dura. If there is no risk of infection, CSF leaks can be sutured and patients can be started on prophylactic antibiotics till frank sepsis is suspected conclusively due to the foreign body itself. Sound anatomical knowledge and skills often pave the pathway for a reasonable and satisfactory outcome.

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