Spectrum of Complex Non-Missile Penetrating Spinal Injury: A Series of Four Cases with Review of Literature

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ABSTRACT
AIM: Penetrating Spinal injury has been considered rare and accounts for less than 1.5% of traumatic injuries of the spinal cord. Non-missile penetrating spinal injury (NMPSI) is even rare subset of PSI and their optimum management is unclear. Author shares experience of four unusual cases of complex NMPSI, their complications and discuss their management.

MATERIAL AND METHODS: Four NMPSI caused by nail gun, thorn prick, & two by knives (one of them retained) respectively, managed in last eight years were analysed in terms of mode, sites, severity, presentations, complications, management & prognosis.

RESULTS: All four were male with age range from 8-33 years. Two by assault by knives over dorsal spine, one accidental cervical nail injury and one by accidental thorn prick injury in lower dorsal spine. Three were operated to remove foreign bodies & one was managed conservatively. All patients improved with no complication except one who developed trophic ulceration resulting in amputation of right foot.

CONCLUSIONS: Careful transportation, complete assessment, early surgical decompression with laminectomy one level above and below the injury site with removal of the foreign object & repair of the dural tear in NMPSI leads to good outcomes. Late presentation or management have poor prognosis.

KEY WORDS: Nail injury, penetrating spinal injury, stab injury, thorn prick injury

INTRODUCTION
Penetrating injury to the spine is although third but rarest cause of spinal injury after Road traffic accident and fall from height. Bullet injuries to the spine and spinal cord have been adequately covered with concepts in literature as a cause of missile penetrating spinal injury (8). However, other types of non-missile foreign bodies, though rare, are also responsible for the penetrating injuries to the spine, for example knife, fragment of glass (23), nail (13), pencil lead (17) and sugar cane (15). Author experiences four unusual spectrum of non missile penetrating spinal injury with rarest presentations in last eight year in his institute in the form of nail gun injury in cervical spinal cord, thorn prick causing delayed intramedullary abscess in lower dorsal spinal cord, one unretained stab injury causing pneumocephalus and pneumorrhachis (intraspinal air - unusual pathological entity) in the thoracic cord, and one retained knife causing transaction of dorsal spinal cord (Table 1).

CASE PRESENTATION
CASE 1
A 24-year-old man was referred to our institute after he had been stuck in the left side of neck by a nail 2.5 inches in length. The man had been working as a carpenter at a construction site and had accidentally fired a nail while reloading a nail gun. Immediately thereafter, he felt severe pain and noticed drops of blood oozing out from a wound
Table 1: Summary of cases having non-missile penetrating spinal injury

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/sex</th>
<th>Mode of injury</th>
<th>Site of injury</th>
<th>Presentations</th>
<th>Management</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24 years/Male</td>
<td>Accidental Nail gun injury</td>
<td>2nd cervical vertebral level</td>
<td>Nuchal rigidity, restricted neck movement</td>
<td>C2 hemilaminectomy, removal of nail and repair of dural rent</td>
<td>No complication</td>
</tr>
<tr>
<td>2</td>
<td>8 years/Male</td>
<td>Acacia thorn prick</td>
<td>D 11-12 level intramedullary abscess</td>
<td>Progressive sensory motor spastic paraparesis with bladder bowel involvement</td>
<td>D 11-12 laminectomy, midline myelotomy and excision of abscess with tract</td>
<td>Trophic ulcer of right foot leading to amputation of right foot</td>
</tr>
<tr>
<td>3</td>
<td>33 years/Male</td>
<td>Homicidal stab injury with knife</td>
<td>D11 level</td>
<td>Bilateral foot drop, headache, dyspnoea due to pneumorrhachis and pneumocephalus</td>
<td>Conservative management</td>
<td>No complication</td>
</tr>
<tr>
<td>4</td>
<td>25 years/Male</td>
<td>Homicidal stab injury with knife</td>
<td>D10 level</td>
<td>Retained knife blade and Paraplegia (grade 0/5 power) with bladder bowel involvement</td>
<td>D9-11 laminectomy with removal ok knife and conservative debridement of damaged cord with dural repair</td>
<td>Power improved to 1/5 and sensation return to 20% to 30%, No cerebrospinal fluid leak or meningitis</td>
</tr>
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on his left upper neck. He did not experience any loss of consciousness, headache, radicular pain, numbness or any other focal neurological deficit. Plain radiography revealed presence of nail in spinal canal (Figure 1A). Physical examination detected a 2 mm entrance wound over left side of neck. Findings on neurological examination were within normal limits except for mild nuchal rigidity and restricted neck movements. Non-contrast computed tomography (NCCT) (axial and coronal cuts with 3D reconstruction) showed that nail had penetrated the spinal canal at the level of second cervical vertebra, well behind the airway and major vascular structures (Figure 1B, C). Patient was taken into the operating room for neck exploration through posterior midline cervical incision under fluoroscopic guidance (Figure 1D). The nail was entering into spinal canal through the space between lamina of C2 and C3. C2 hemilaminectomy was done and the nail was carefully removed (Figure 2A-C). Dural rent was repaired and anatomical closure of wound was done over drain. His postoperative course was uncomplicated. Drain was removed on third postoperative day, and he was discharged seven days later.

**CASE 2**

An eight-year-old male child presented with progressive spastic paraparesis and sensory loss numbness below the umbilicus with bladder and bowel involvement for the past three months. Magnetic Resonance Imaging (MRI) of the thoracolumbar spine showed an intramedullary lesion at dorsal (D)11- D12level which was presumed to be an intramedullary tumor, most likely an ependymoma (Figure 3A, B). During surgery, we found a fibrous firm tract in the subcutaneous tissue which was going in between the spinous process of D11-D12. Laminectomy was done following which red granulation tissue was seen covering the dura (Figure 3 C). Dura was incised and opened exposing...
Figure 1: Case 1 having nail injury in cervical spinal cord (A) lateral cervical spine X-ray showing nail at the level of axis vertebra, (B) Axial and (C) Coronal section Computed Tomography (CT) scan cervical spine shows penetration of nail in spinal canal from left lateral side, (D) Intra-operative fluoroscopic view of cervical spine with nail.

Figure 2: Case 1 (A) and (B) Intra-operative photos during nail removal from axis vertebra, (C) retrieved nail.
the cord which showed granulation tissue coming out through it. A myelotomy was done, the lesion turned out to be an intramedullary abscess with granulation tissue. The subcutaneous tract was excised along with the abscess (Figure 4A). The tract was then opened, and inside which we found a thorn of Acacia surrounded by fibrous tissue (Figure 4B). After the surgery, on further enquiry, the patient's mother told that he fell down from a tree onto a bunch of wood from the bush of Acacia, six months back. Immediately following the fall, the patient had pain in the back with a very small wound, which healed with local treatment. On reviewing MRI, we found a linear hypointense shadow from the subcutaneous plane to dura at the level of D11-D12. Post operatively, muscle power improved to grade 4/5 while 80% improvement in sensation was reported at eighth month of follow-up. However, he was subsequently lost to follow-up and then presented seven years later with trophic ulcer of right foot with decreased sensation in L5-S1 dermatome (Figure 5A, B). His muscle power was grade 5/5. His repeat MRI showed bulky cord at D11-D12 level with arachanoiditis (Figure 5C). He required below knee amputation for his trophic ulcer.

**CASE 3**

A 33-year old male was admitted to our neurosurgery emergency with a history of homicidal stab injury with a blunt kitchen knife on the left side of lower dorsal back six hour ago. The patient was fully conscious and narrated the history himself. There was no complaint of dyspnoea. The patient complained of weakness in both lower limbs. On examination, he was fully conscious with normal pulse, blood pressure and respiration. The knife was pulled out by the attacker at the time of assault. There was an entry wound of 2 centimeter on left side of back at the level of dorsal 11 vertebral spinal process (Figure 6A). There was minimal bleeding from the wound. On neurological examination, motor power in both the upper limbs was normal and in the lower limbs, it was 2/5 on right side and 1/5 on left side at ankle dorsiflexion (Figure 6B). There was no sensory loss. Anal tone was normal. X-ray of the chest and dorsal spine was apparently normal. MRI dorso lumber spine revealed contusion in spinal cord at conus level (Figure 6C). The day after injury patient complained mild headache and dyspnoea, for that CT thorax and CT head was advised, which revealed Pnemorrhachis (intraspinal air) at the level of D8 vertebra (Figure 7) and pneumocephalus in perimesencephalic cisterns along with anterior horn of
lateral ventricle (Figure 8A, B). We assumed that during stab injury there was transient cerebrospinal fluid (CSF) leak from dural penetration with entry of air into intraspinal and intracranial subarachnoid space due to negative pressure generation. As there was no CSF leak from the wound after admission, the patient was treated conservatively with antibiotics and steroid. On follow-up at three months his power at both ankles improved to 4+/5.

Figure 5: Case 2 in follow-up (A) Right foot trophic ulcer, (B) X-ray right foot shows infective osteomyelitis of right great toe, (C) MRI sagittal cut showing swollen cord without any abscess cavity.

Figure 6: Case 3 of stab injury (A) Left lower dorsal stitched stab wound, (B) Bilateral foot drop, (C) Haemorrhagic contusion of spinal cord at D12 level in MRI spine.
CASE 4

A 25-year-old male was stabbed in the lower dorsal back as a victim of road robbery. The knife was broken when an attempt was made to pull out by assailant. The man was brought to the hospital with the broken knife sticking out through the back. On arrival, he was hemodynamically stable and detailed neurological examination revealed bilateral paraplegia with no bladder bowel sensation. The knife had entered the lower dorsal spinal region slightly on the left side (Figure 9A). CT scan of spine showed retained 12 cm knife in the D10 thoracic spine. The blade had entered through the D10 left side thoracic lamina to cross the spinal canal on the right side of the midline medial to the pedicle and tip was lying in the D10 vertebral body (Figure 9B, C). There was hematoma seen in the canal. As there was a suspicion of cord and dural injury, laminectomy and repair was planned. The patient was positioned prone and anaesthetised in the same position with help of fibre optic laryngoscopy. The stab wound was 2.5 centimetres wide. Incision was placed to include the stab wound. The skin flap was raised and paraspinal muscles were raised from laminae. The lamina through which the knife entered the canal was well defined. Laminectomy was performed one level above and below (Figure 10A, B). The lamina on the left side of corresponding vertebrae was removed and then the lamina with knife was removed. The sharp convex side of the knife was facing medially and it was entering the dural sac. The facet on the left side of the knife was also removed to free the object completely. The knife was removed under vision (Figure 10C). Dural opening was on lateral aspect through which the incomplete transacted cord was seen and a few nerve rootlets were seen pouting through the defect. The dural defect was difficult to repair primarily as it was extending anterior. Dural defect was enlarged to expose the damage cord. Conservative debridement of damaged cord and haemostasis was achieved. The linear defect was patched with muscle graft and closed. Postoperatively, there
was no CSF leak from the wound. Also the entry wound showed no sign of infection and healed primarily. Post-operative X-rays of spine revealed no retained foreign body. There was minimal neurological improvement in the form of flicking movement return of 20% to 30% pain and crude touch sensation in both lower limbs on day third. Patient was discharged with urinary catheter in situ with follow-up advice of bladder-bowel, skin care and physiotherapy.

**DISCUSSION**

Penetrating spinal injuries (PSI) is in itself is very uncommon. It can be divided into two categories:

1) Missile penetrating spinal injuries (MPSI) and
2) Non-missile penetrating spinal injuries (NMPSI) varieties.

Further these two categories can be divided into two types: Metallic and Non metallic.

Gunshot injury is relatively common out of all types of PSI and reviewed in details in available literatures. Another category is NMPSI, which is rare and it is also known as stab injury spine, because it is usually caused by assault. Most victims were stabbed once (incidence 65%) (21), and the weapon is typically knife (incidence 72-84%) (18,21). Our case 3 and 4 were victims of stab injury by knife due to assault. In the largest series from South Africa, assault with axes, screwdriver, bicycle, spokes, garden forks, sickles, have been reported (23). Our case 1 was in category of metallic NPSI caused by accidental nail penetration in cervical cord.

However, other types of non metallic foreign bodies are also responsible for the penetrating injuries to the spine, for
example fragment of glass (23), pencil lead (17), sugar cane (15) and sharpened broomsticks which may present months to years after injury due to reactive tissue formation and these injuries are usually accidental in nature in contrast to stab/ knives injuries . Non metallic penetrating spinal injury usually presents late, when complication like abscess formation, delayed neurological deficit or C.S.F. leak occur . Our case 2 falls in in this category as it was caused by thorn prick in dorsal cord and presented late with intramedullary abscess formation.

Metallic NMPSI mostly has been reported in younger men (18,20,22). NMPSI are typically inflicted from behind at the victim's thoracic level, same as in our two cases 3 and 4. The distribution likely reflects two aspects of the assault: assailants typically aim for neck or chest, and the cervicothoracic region is within the natural sweep of attacker's arm. Laterally directed horizontal stab can cause complete transaction of cord as can pass between two vertebrae but stab from behind usually produce incomplete cord damage (19). In the largest South African series, 21% of the patients presented with complete spinal cord injury and 55% with a modified Brown–Sequard syndrome (18).

Neurological deficit may occur immediately or in delayed fashion. Immediate injury is caused by physical damage to the neural tissue, in-driven bone fragments, vascular injury or countercoup mechanism (5,18,21). Rarest occurrence is Pneumorrachis (PR) and pneumocephalus due to intraspinal air entry due to dural tear through entry wound as seen in our case 3. Although PR per se usually is self-limiting and without further therapeutic consequences, prompt recognition of the underlying cause is essential. The attending spine specialist has to carefully evaluate the associated pathologies leading to PR to enable adequate therapy. If intraspinal air is present, especially if caused by trauma, the spine physician has to consider PR as an initial sign of potentially associated, hidden and severe diseases or injuries.

If general anaesthesia is required in a patient with PR, because of the presumptive diagnosis of a perforation of the dura mater and additional pneumocephalus, the involved anaesthetist should not use inhalational nitrous oxide, because it may cause expansion of intracavitary air and result in an increase in CSF pressure, as nitrous oxide diffuses into the air-filled space. Because of the higher risk of possible meningitis, demonstrable cerebrospinal fluid leaks, if significant or persistent, may have to be repaired or treated by a temporary lumbar spinal catheter.

Delayed neurological deficit may result from a retained weapon (9,11,14,16), infection (4,7), edema (2), or CSF leak (1). The chances of recovery are better than other forms of
injury to the cord. NMPSI may be associated with injuries to bowel, aorta, inferior vena cava, solid organ or even airway if in cervical region.

The transportation of patients with retained weapons is important as it may be manipulated during the process and give rise to new neurovascular insult. No attempt should be made to remove the embedded weapon without proper exposure in the operation theatre. Manipulation or closed removal may be associated with neurological deficit, bleeding, CSF leak and infection (7). Retained foreign body should be looked for if external examination reveals only entry wound.

Plain radiography is the initial investigation in all the cases. A retained metallic object will be shown along with other injuries like haemopneumothorax, emphysema, etc CT scan is a good investigating modality for the patients with NMPSI considering its ability to detect retained foreign body, spinal or paraspinal hematoma and bony fragments. In penetrating neck traumas with spinal injury, prudent use of CT and catheter angiography detect vascular injury and reduce morbidity in these peculiar injuries. The metallic object may produce streak artifacts, however those occurring along with the axis of blades help localizing its tip. Although MR Imaging is a powerful tool for identifying the injury track, cord or root lesion and associated lesions including hematoma, disc herniation, and bone fragments, MRI is controversial as it may be associated with movement and heating of retained metallic objects (19,22). Thakur et al treated 81% of these cases by doing surgical exploration with dural repair and removal of foreign body or simple exploration and irrigation (21). However, others report no difference in outcome following surgical management in patients with complete or incomplete spinal injury (20). Most of the studies have suggested that surgical exploration should be considered in patients with progressive neurological deficits, when there is radiographic evidence of neural compression due to retained foreign material, bone fragment or soft tissue or persistent CSF leakage.

Even patients of NMPSI with delayed presentation with retained foreign body may benefit with surgical exploration and non-intervention may give rise to delayed deficits (6,10). Karlins (11) and Greon (5) has shown improvement in patients even with delayed intervention (11). Retained foreign bodies set in an inflammatory reaction; the severity of which depends upon the kind of metal (21). Peacock et al documented 4% spontaneous subsidence of CSF leak (17). The consensus is that exploration is recommended in case of persistence of CSF leak beyond 96 hours as chances of pseudomeningocele and low pressure headache along with infection rises (12). Without a dural repair, patients may present later with low blood pressure, headache and sixth nerve paresis as reported by Adams et al (1).

Surgical procedure involves laminectomy, defining the normal dura cranial and caudal to the site of stab, and opening the dura with stay sutures. Conservative debridement is carried out and only the detached, non-viable neural tissue is debrided. Haematoma is evacuated and dura is closed, with a dural substitute if necessary. Lumbar subarachnoid CSF drain is inserted for 5-10 days and antibiotics in antimeningitic dosage are administered. Spinal stabilization is generally not required, since these injuries are stable (3). All patients are closely monitored for delayed neurological deterioration, and deafferentation pain. Overall neurological recovery is better than that observed with missile injuries.

**CONCLUSION**

We conclude that in a patients with a non-missile penetrating spinal injury with a retained foreign object 1) Careful transportation in prone or lateral position is recommended, 2) No attempt should be made to remove an externally visible retained weapon in the emergency room and by the paramedics, 3) A complete assessment is must to detect associated injury, 4) surgical decompression with laminectomy one level above and below the injury site, removal of the foreign object in the original trajectory path, and repair of the dural tear is gold standard procedure. Prognosis for the stab injuries is better than the gunshot wound.

**REFERENCES**


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