Egyptian Journal of Neurosurgery

CASE REPORT Open Access

Bilateral Brown-Sequard syndrome regressing to anterior cord syndrome in spinal impalement: 2 unique cases with management pearls

Hardik Lalit Siroya[1], Mohit Juneja[2], Anirudh J. Rao[1], Sonal Chauhan[1], Dhananjaya Ishwar Bhat[1] and Bhagavatula Indira Devi[1*]

Abstract

Background: Non-missile impalement spine injuries are quite uncommon. Most of these patients either present with impaling agent in situ or with a part of retained offending agent. Both the scenarios present unique management challenges especially if patients are clinically stable. The injury becomes more complex if multiple compartments like lung and abdomen also get involved. Non-missile penetrating spinal injury is rarely seen in the Indian settings. The world over it approximately accounts for 0.3–2.1% of spinal injuries. In view such meagre occurrence management decisions are usually driven based on surgeons' experience and patient's condition. Although conservative approaches for retained products have less complications as compared to surgery, long-term outcomes are not available for comparison. Unique management challenges are noted and described. Physical doctrines for management principles of such injuries are also attempted. Noteworthy is that their regression from complete cord syndrome to anterior cord syndrome is extremely short period.

Case presentation: We present 2 unique cases presenting as complete cord transection regressing from bilateral brown Sequard syndrome to anterior cord syndrome following decompression.

Conclusion: Spinal impalements are very rare especially now with strict societal regulations and criminal justice in place. Still now and then we do come across some staggering cases as described above. To establish a treatment protocol and management guidelines in such scarce scenarios is difficult. We attempt to underlie few basic doctrines in this regard with our experience in a tertiary centre.

Keywords: Spine impalement, Penetrating spine, Brown Sequard, Anterior cord

Background

Non-missile impalement spine injuries are quite uncommon [1]. Most of these patients either present with impaling agent in situ or with a part of retained offending agent. Both the scenarios present with unique management challenges especially if patients are clinically stable. The injury becomes more complex if multiple compartments like lung and abdomen also get involved. Non-missile penetrating spinal injury (NMPSI) is seen in the Indian settings rarely. The world over it approximately accounts for 0.3–2.1% of spinal injuries [2].

In view such meagre occurrence management decisions are usually driven based on surgeons' experience and patient's condition. Although conservative approaches for retained products have less complications

*Correspondence: bidevidr@gmail.com

[1] Department of Neurosurgery, National Institute of Mental Health and Neuro Sciences, NIMHANS, Hosur Road, Bengaluru, Karnataka 560029, India
Full list of author information is available at the end of the article

as compared to surgery [3], long-term outcomes are not available for comparison. We present 2 unique cases with complete cord transection regressing from bilateral brown Sequard syndrome to anterior cord syndrome following decompression.

Case report 1 (Fig. 1)

A 25-year-old male presented with history of stab by knife followed by complete paraplegia. On Examination: E4M6V5, Pulse—74, Blood pressure—120/80 mm hg, saturation—97% on room air, Pupils equal and reactive to light, 4 cm SLW in the interscapular region wound was slanting laterally upwards and 1 cm lateral to midline on the right. Multiple abrasions over right scapula and left flank region. Upper limb tone and power normal. Lower limbs flaccid and power-0/5. Bladder—involvement-Present in form or atonic bladder with no sensation. The spinal injury was categorized as ASIA grade-A with complete cord transection with nil sensations present. Pelvic compression test-negative. Investigation: Ct Brain plain showed no bony or parenchymal injury. CT Spine showed retained foreign body going between d6 and D7 lamina and passing through the cord to get dislodged in the D 7 vertebral body. No evidence of cord hematoma or lung injury. Treatment: He underwent D6–D7 Laminectomy and retrieval of foreign body. Intraoperatively the knife metal was piercing the cord in the oblique plain along the posterior midline and extending anteriorly within the substance of the cord. After laminectomy an intraoperative USG helped localizing the aorta and hence avoiding inadvertent injury. Carefully being perpendicular or in line with the plane of trajectory the retained blade was pulled out. Shagging and to and fro motion were avoided in order to cause less injury to cord. The dura was closed primarily. Post-operative CT spine showed D6-D7 laminectomy changes. Post-operative MRI—diffuse cord oedema with trace trajectory of the foreign body. Oedema was extending from D4 to D9 level. On post-operative day 2 patients' pressure and vibration sense had returned. No CSF leak in the post-operative period.

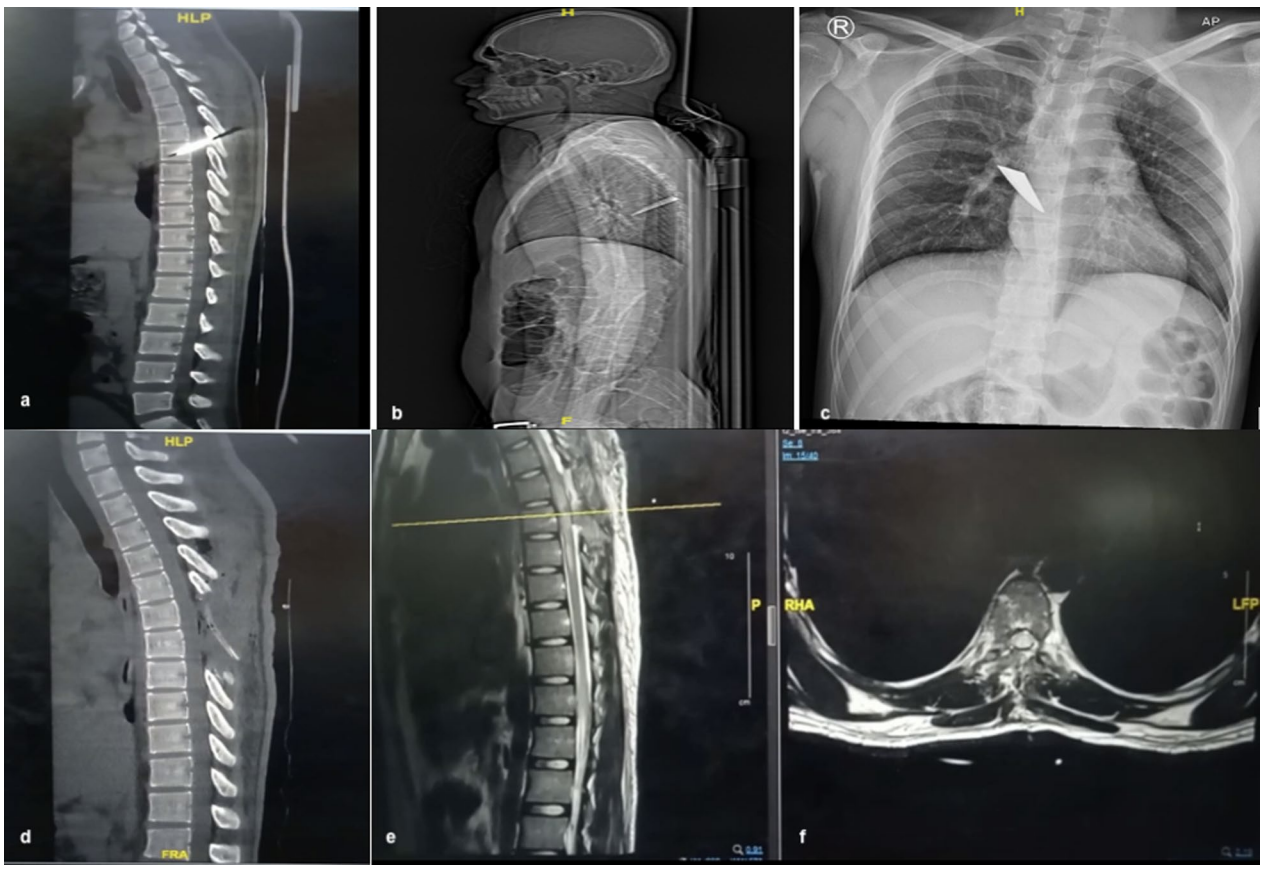

Fig. 1 **a–c** shows blade of knife retained as a foreign body. *Note* The knife though crosses the spinal canal and does not pierce the viscera (pleural cavity). **d–f** Postoperative laminectomy status. *Note* There is diffuse cord oedema extending from D4 to D8 with hypodensity at the level of blade impingement suggestive of transection

Condition at Discharge: Conscious and obeying, pupils are equal and reactive to light, vital signs stable, Lower limbs flaccid and power-0/5. On follow-up of 6 months patient still had paraplegia with flaccidity but preserved pressure and vibration sense suggestive of anterior cord syndrome. Bladder incontinence progressed to automatic bladder, whereas patient persists to be on laxatives for constipation. No follow-up MRI was done.

Case report 2 (Fig. 2)

A 23-year-old female was stabbed by husband followed by bilateral brown Sequard syndrome, ASIA grade A and bladder and bowel involvement in form of atonicity. On Examination: E4M6V5 and vitals stable. Pupils equal and reactive to light. There was a knife in situ at lower dorsal level. Upper limb tone and power normal. Lower limbs flaccid and power-0/5 with complete sensory loss to all modalities. Pelvic compression test-negative. Investigation: Ct Brain plain showed nil bony or parenchymal injury. CT Spine showed metal part of knife impaling between D10 and D11 lamina and passing through the cord anteriorly till the thoracic cavity. No signs of lung injury. Treatment: Multidisciplinary team consisting of general surgeon, vascular surgeon and neurosurgeon undertook the surgery. She underwent D10–D11 Laminectomy and retrieval of impaling object foreign body. Intraoperative findings: the blade of dagger was obliquely directed with piercing of complete cord substance. Intraoperative USG was used to assess its proximity to the aorta. The patient had no visceral or aorta or vascular injury. The dagger was removed in its plane after induction of the patient in operation theatre. No major bleed. Dura was closed primarily. On postoperative day 1 patients' pressure and vibration sense had returned Condition at Discharge: Conscious and obeying, pupils equal and reactive to light, vital signs stable, Lower limbs flaccid and power-0/5. No CSF leak from the wound. On follow-up of 6 months persistent flaccid paraplegia with automatic bladder.

Discussion

It is seen that most of the NMPSIs don't affect the stability of the spine [4] as spine is protected by 3 column construct, whereas these injuries usually disrupt only 1/6th to 3/6th of this construct. Most common sites are cervical and thoracic spine [5]. Management of these injuries requires special attention as a deterrence could be catastrophic. After stabilizing the patient, the major decision holds whether there is a retained part or a complete offending agent in situ.

Our 1st case highlights the management of a retained foreign body with no external milieu. Decision in such patients will depend on whether the patients are clinically intact or with deficits. Although the mode of management in 1st scenario is controversial, we prefer to remove the retained body in any case due to multiple reasons, most common being infection which in most cases is inevitable. 2nd case is not a decision nightmare, as management is straightforward—to remove the in situ Knife.

Management Pearls: Apart from regular ABCDE of management, we propose Few Doctrines which we have also proposed for cranial penetrating injuries:

Treatment algorithm and principles

Every step is critical in such patients. From the time of event till the time of surgery where actual impaling agent was supposed to be removed. Critical events to avoid: Relative motion between the patient and the instrument. Precautions in this regard are elucidated in Table 1.

The most important factor being—"DO NOT DISTURB" the spine-instrument dynamics. Small movement outside can prove to be hazardous as it can cause a significant movement inside the spinal canal (Fig. 3).

We introduce three physical terms which govern important physics principles are described herewith. They are of utmost importance while planning the removal of the penetrating agent.

1. **"REVERSE DUPLICATION/MIMIC"** To remove the instrument in exact same way as it was put or impaled. For this the surgeon must gauge 4 important rubrics.

   We know that $F = MV^2/R(r1 + r2)$ where r1 is resistance offered by surface of penetrating object and r2 is resistance offered by surface of penetrated spine elements and skin. It is the main principle governing any removal or pulling of the object stuck/penetrating through a surface as demonstrated in Fig. 3.

   (a) Force (F)—the directional vector of force is always along the length of instrument. This generates a centripetal force towards the puller. The force required and the directional movement (momentum) depend on multiple factors.
   (b) Mass (M)—Assessing the mass would help in assessing rotational axis and also to and fro axis. More the mass of the object, more rotation the object required while removing. Remember to and fro or staggering movements are hazardous in spine.

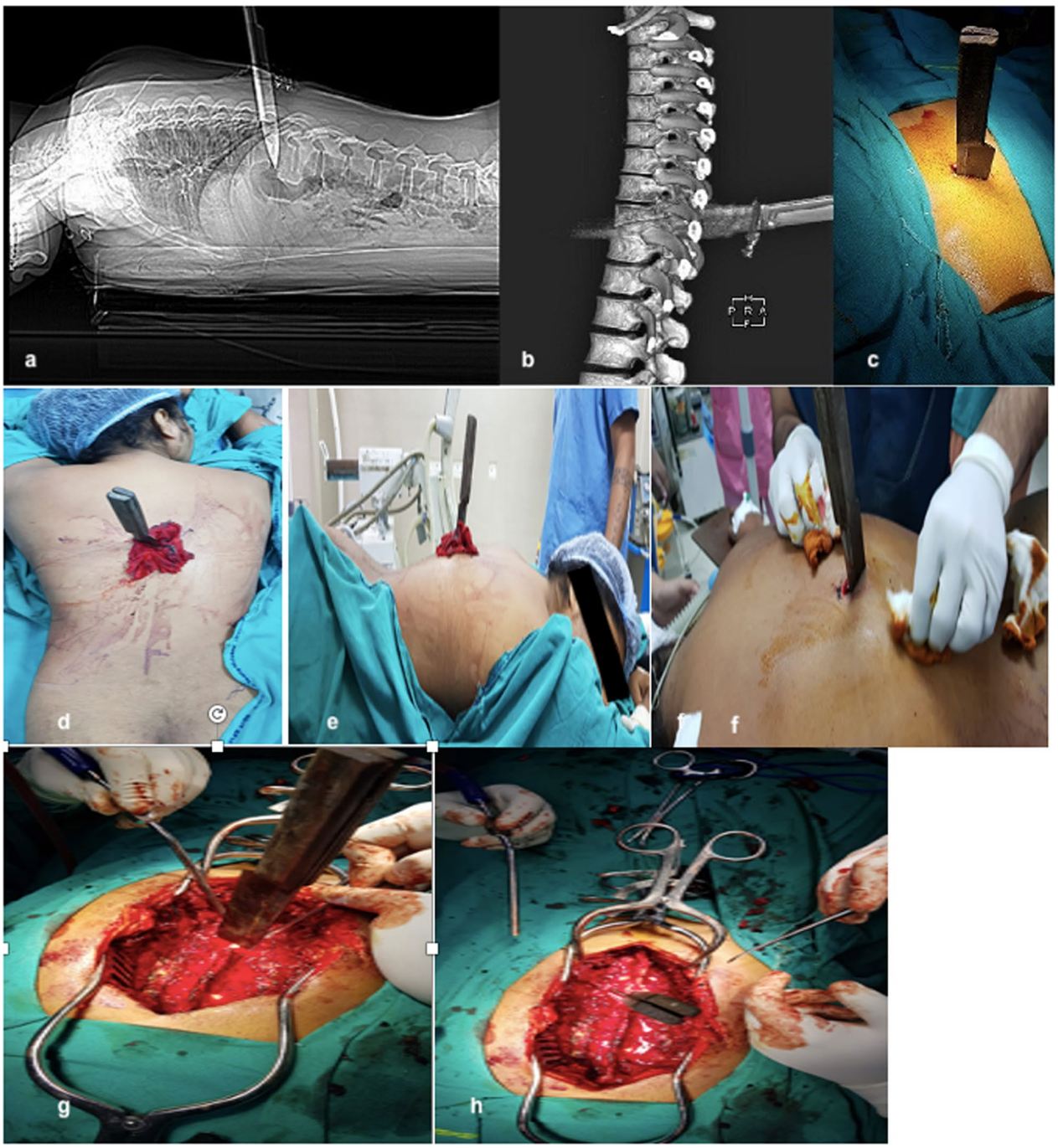

Fig. 2 **a–f** Show patient with complete knife in situ in oblique fashion in the midline. *Note* Knife extending anterior to the vertebral body suggestive piercing of visceral cavity. **g, h** intraoperative photographs of knife blade in between the spinous process and lamina

(c) Velocity (V)—the force with which object is pulled determines the velocity. Controlled constant force is required to avoid acceleration and sudden jerk. It is wise to do guided movements under USG guidance.

(d) Depth of penetration—It is of most significant importance in spine as opposed to skull. Skull has a protective inner and outer table which usually are not encountered in spine. The impaling agents most commonly find the way of least

Table 1 Signifies the prevention to be taken before the patient is finally taken up for surgery if impaling agent is in situ or present as retained foreign body

1	While lifting and triaging the patient in and out of ambulance
2	While changing of trollies and transferring of patients—as straight as possible
3	While doing various radiological investigations which require patient mobility
4	While shifting the patient from general trolly to OT table
5	While intubating the patient—especially in prone position with whole instrument in situ
6	While positioning the patient for surgery
7	Lastly but most important—while doing surgery

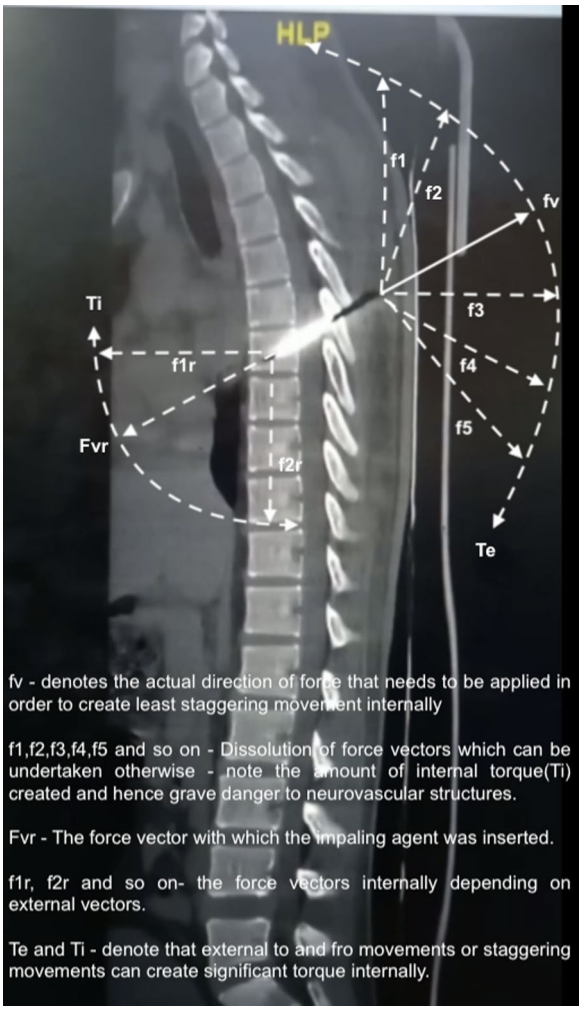

Fig. 3 Illustrates the force and force vectors along with internal and external torque generated while trying to manipulate the impaling agent out of the wound

resistance in between the lamina and through the soft tissue into the spinal canal and till the thoracic or abdominal cavity. The force and velocity required to remove the instrument are usually a constant acceleration (a) as resistance (R) from various soft tissue interfaces is more or less constant (as we take resistance from soft tissues inside spine to more or less same).

2. **"REVERSE INSTRUMENTATION"** The most ideal physics principle for any penetrating injury is to mimic the same movement as the instrument works but in the opposite direction. The same principle of above-mentioned force, mass, velocity and depth interplay but with an added perspective to adept the working of the said instrument. Sometimes an expert/professional may be consulted to remove the instrument.
3. **"CUT SOME SLACK"** If the instrument is too heavy or too long it may need to be cut with a saw in presence of or by a professional like in case of a rod.

For instance:

Knife, sickle, dagger and blade are the instruments where the surfaces within the thickness of the spine are usually smooth providing minimal resistance/friction. In these instruments, thickness is minimal and what mainly constitutes them is their antero-posterior length. Thus, Rotational movement is not advised and hence there is no rotational torque generated. Though, translational to and fro motion can occur in both directions while removing the instrument, lengthwise and breadthwise as shown in Fig. 3 but not advised in spine as the scope of error is very minimal. If practiced it can generate a torque within the skull with direction component away from the knife causing a centrifugal acceleration which can be detrimental as it can cause serious critical structure injury indigenously.

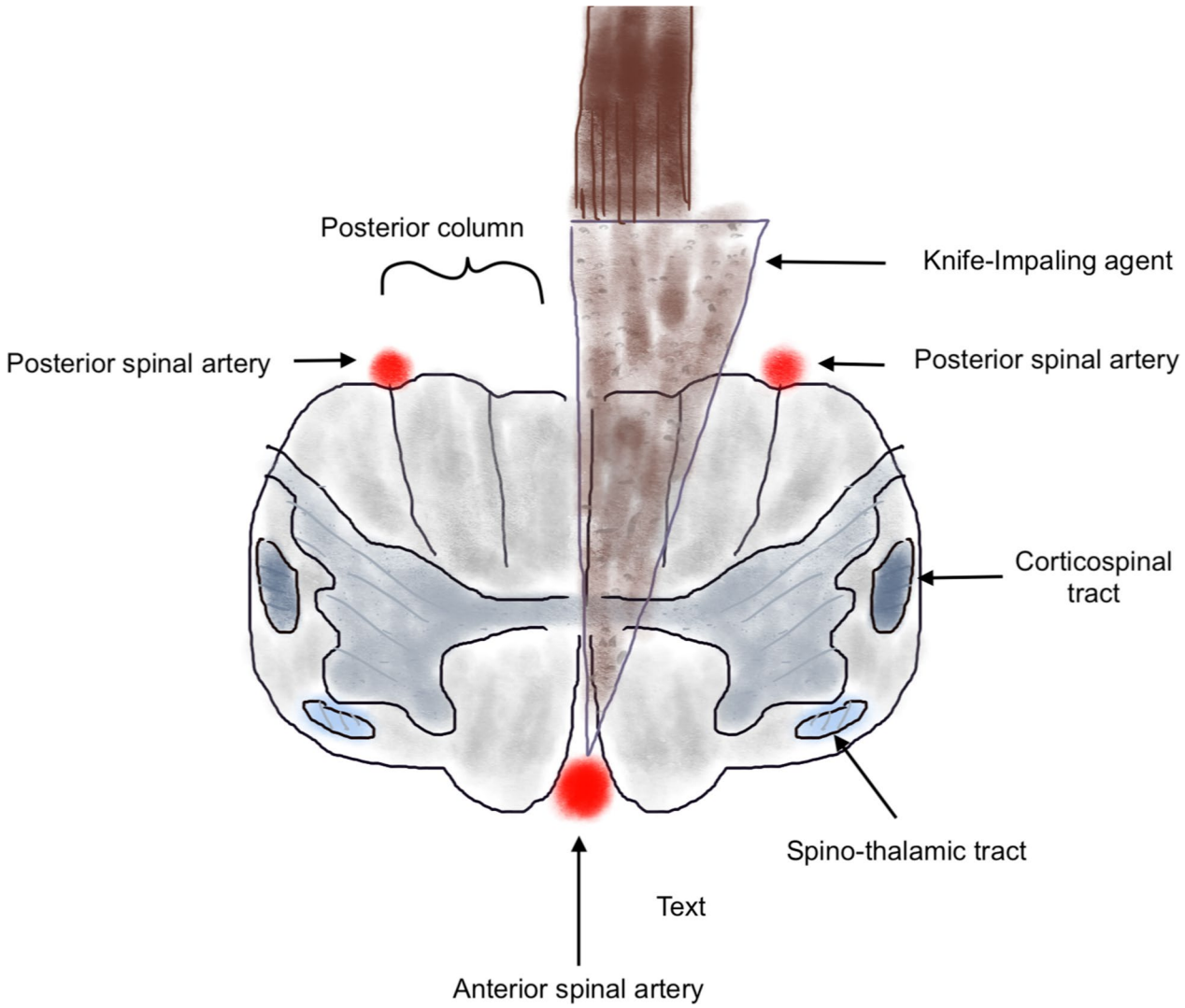

Fig. 4 Demonstrates Knife blade piercing the cord substance in most common scenarios. The brunt of injury is mostly borne by anterior spinal artery and its supply unless direct transection

Regression from bilateral Brown Sequard syndrome to anterior cord syndrome or Unilateral Brown-Sequard 'PLUS' syndrome (Figs. 4, 5, 6)

Figure 4 denotes the usual trajectory of the impaling agent; in this case—Knife or dagger. It is noteworthy that impact and depth usually decide the secondary deficits. Even though the primary picture may be of complete cord transection (Fig. 5), many times it may be deluded in view of spinal shock. In our cases by post-operative day 2 both patients regained their pressure and vibration sense which denotes injury to anterior spinal artery which mainly supplies anterior 2/3rd of the cord. Posterior spinal arteries being 2 in number and their anatomic orientation being paramedian, usually escape primary injury which land only anterior spinal artery to face the brunt. Anterior spinal artery invariably gets injured primarily due to relative lesser resistance in between the lamina and spinous process embarking only soft tissue gateways (Fig. 6). Even if unilateral posterior spinal artery is injured it leads to Brown—Sequard 'Plus' syndrome, i.e. which in addition to Brown-Sequard involves bowel/bladder

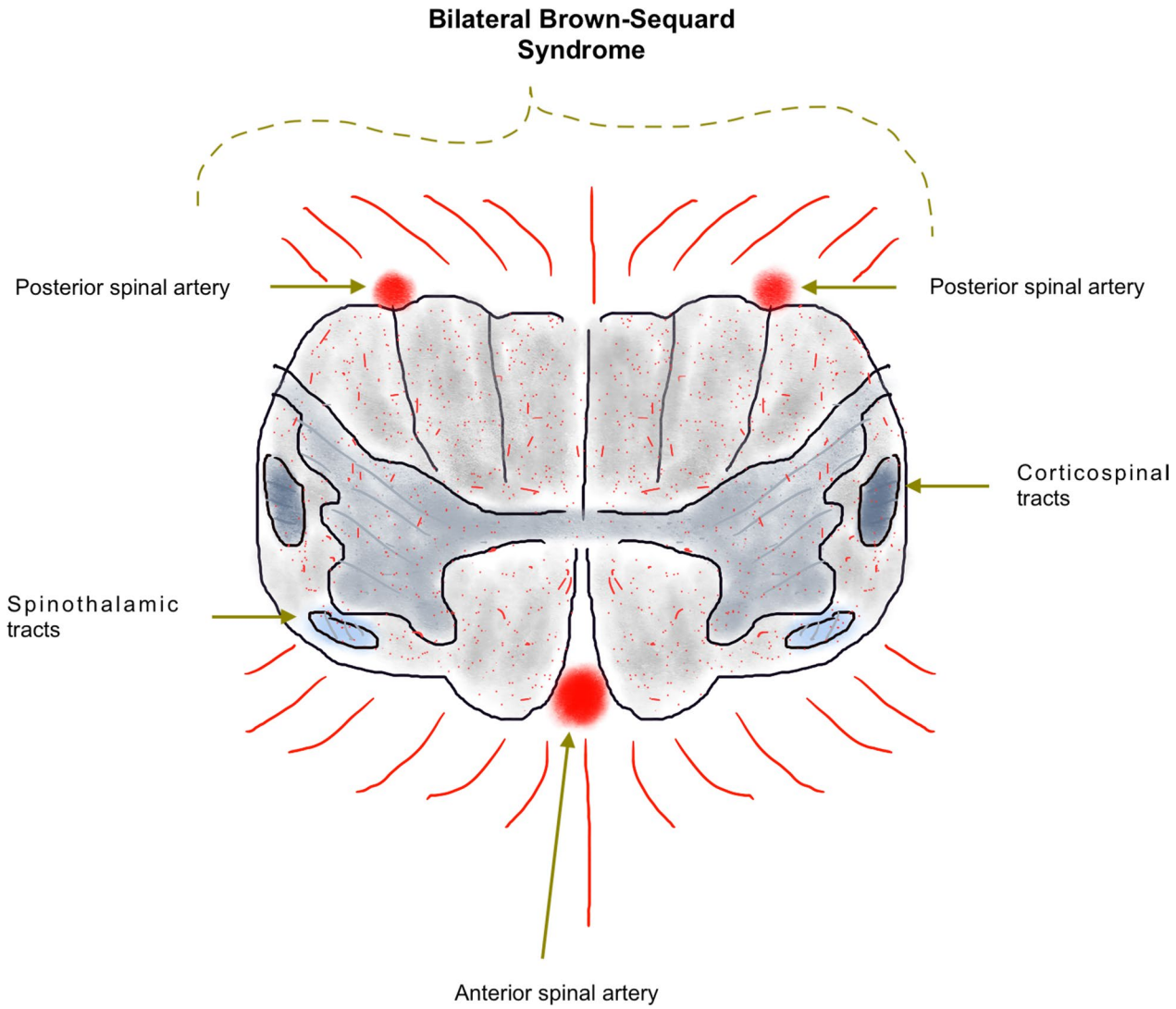

Fig. 5 Illustrates bilateral Brown-Sequard syndrome following either spinal shock or complete cord transection

involvement or contralateral weakness or ipsilateral sensory loss as well. It may also have varied associated features. Whether return of posterior column in immediate post-operative period portends to better prognosis is doubtful as in our case on 6th month follow-up we noticed nil significant improvement. Nonetheless, it rules out complete cord transection, which does give hope for future improvement regardless of the cause. In this regard, the role of preventing secondary insults cannot be glorified more.

Conclusion

Spinal impalements are very rare especially now with strict societal regulations and criminal justice in place. Still now and then we do come across some staggering cases as described above. To establish a treatment protocol and management guidelines in such scarce scenarios is difficult. We attempt to underlie a few basic doctrines in this regard with our experience in a tertiary centre.

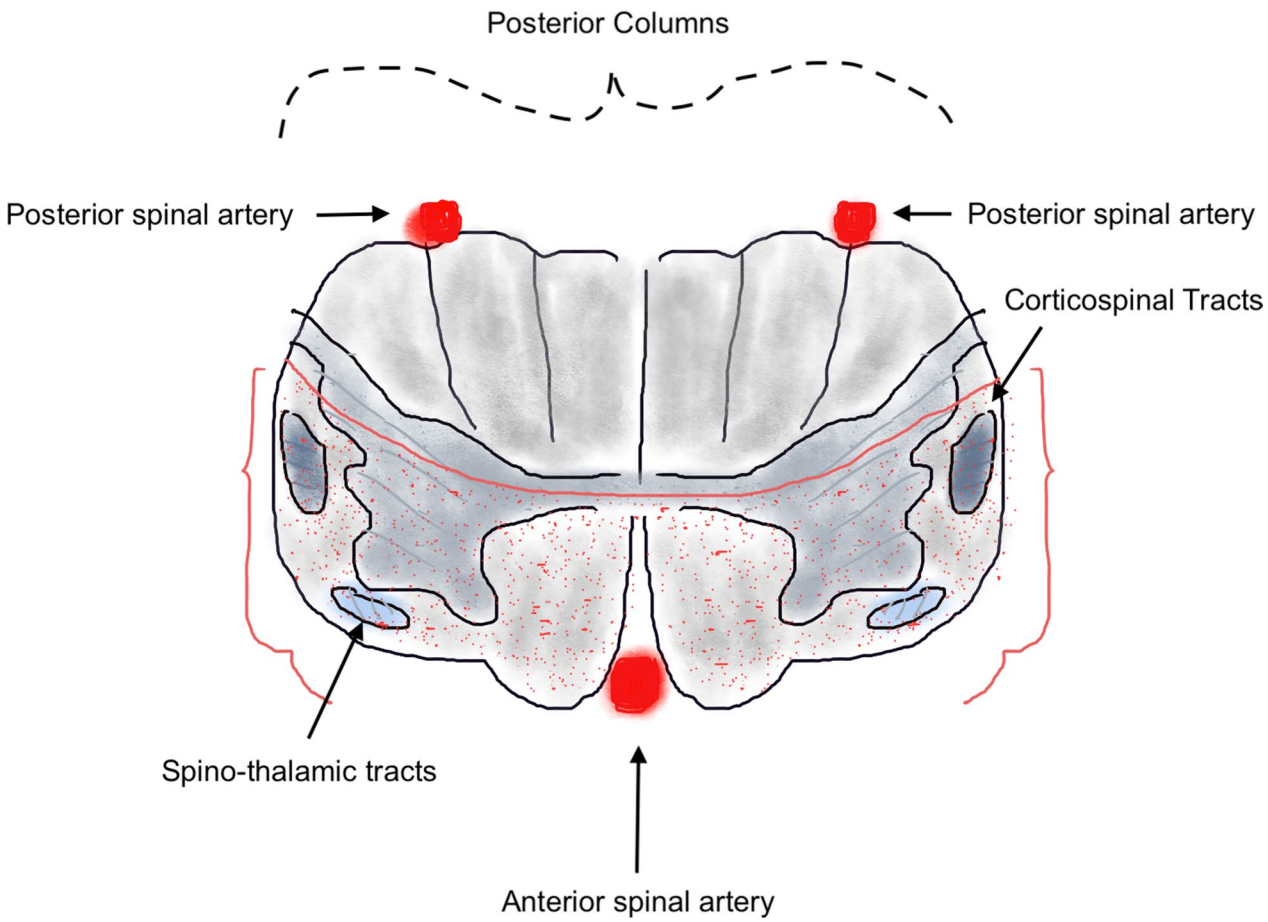

Fig. 6 Shows regression of complete cord syndrome to anterior cord syndrome explained by selective primary injury to anterior spinal artery

Author contributions
HLS contributed to writing the core of the paper, established physical principles, and was involved in surgery along with constructing tables and compiling figures. MJ and HLS were involved in data collection. MJ provided images and assisted in surgery. AR and SC provided images and data. DIB provided inspiration to write and reviewed the technique and management. BID provided inspiration and idea to write and critically reviewed the paper. All authors read and approved the final manuscript.

Funding
There is no funding body or sponsors involved in this study.

Availability of data and materials
All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
Ethical approval was not required for this study in accordance with national guidelines. It is a retrospective case observation. A proper written informed consent was taken from the patient's father and mother for publication of this case report and any accompanying images related to this case. None of the images disclose identity of either the patient or the relatives.

Consent for publication
A proper written informed consent was taken from both the patients for publication of this case report and any accompanying images related to this case. None of the images disclose identity of either the patient or the relatives.

Competing interests
The authors have no conflicts of interest to declare.

Author details
[1]Department of Neurosurgery, National Institute of Mental Health and Neuro Sciences, NIMHANS, Hosur Road, Bengaluru, Karnataka 560029, India. [2]Department of Neurosurgery, AIIMS Raipur, Raipur, Chhattisgarh 492001, India.

Received: 5 February 2022 Accepted: 24 April 2022
Published online: 20 June 2022

References

1. Agarwal P, Burke JF, Abdullah KG, Piazza M, Smith BP, Thawani JP, et al. Stab wound to the intramedullary spinal cord: presurgical and surgical management options for a retained blade to optimize neurological preservation. Surg Neurol Int. 2016;7(Suppl 42):S1096–8.
2. Yoon J, Efendy J, Szkandera B, Redmond M. Non missile penetrating spinal injury. J Clin Neurosci Off J Neurosurg Soc Australas. 2019;67:239–43.
3. Li X, Curry EJ, Blais M, Ma R, Sungarian AS. Intraspinal penetrating stab injury to the middle thoracic spinal cord with no neurologic deficit. Orthopedics. 2012;35(5):e770-773.
4. Shahlaie K, Chang DJ, Anderson JT. Nonmissile penetrating spinal injury. Case report and review of the literature. J Neurosurg Spine. 2006;4(5):400–8.
5. Moldovan K, Telfeian AE, Fridley JS, Gokaslan ZL, Aghion D, Oyelese AA. Minimally invasive approach to non-missile penetrating spinal injury with resultant retained foreign body: a case report and review of the literature. Clin Neurol Neurosurg. 2019;184:105405.

Publisher's Note