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Direct withdrawal of a retained foreign body bisecting the thoracic spinal canal in a neurologically intact pediatric patient: illustrative case

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BACKGROUND Nonmissile penetrating spinal cord injury (NMPSCI) with a retained foreign body (RFB) is rare and usually results in permanent neurological deficits. In extremely rare cases, patients can present without significant neurological deficits despite an RFB that traverses the spinal canal. Given the rarity of these cases, a consensus has not yet been reached on optimal management. In a patient with an RFB and a neurologically normal clinical examination, the risk of open surgical exploration may outweigh the benefit and direct withdrawal may be a better option.

OBSERVATIONS A 10-year-old female suffered an NMPSCI to the thoracic spine with an RFB that bisected the spinal canal but remained neurologically intact. Direct withdrawal of the RFB was chosen instead of open surgical exploration, leading to an excellent clinical outcome. The literature was reviewed to find other examples of thoracic NMPSCI with RFB and neurologically normal examinations. Management strategies were compared.

LESSONS For NMPSCI with RFB and without significant neurological deficits, direct withdrawal is a viable and possibly the best treatment option. The use of fast-acting anesthesia without intubation minimizes patient manipulation, speeds up recovery, and allows early assessment of neurological status after removal.

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KEYWORDS direct withdrawal; penetrating spinal cord injury; penetrating trauma; retained foreign body; spinal stab wound

Nonmissile penetrating spinal cord injury (NMPSCI) is an uncommon cause of spinal cord injury (SCI).[1,2] Recent data suggest that less than 1% of all SCIs are due to NMPSCI, although in developing nations and nations without access to firearms, the incidence of NMPSCI is much higher.[1–4] NMPSCI with a retained foreign body (RFB) is rare because most injuries occur from assaults in which the stabbing weapon is usually withdrawn by the attacker. Rarer still is a NMPSCI with RFB that traverses the spinal canal but does not cause a neurological deficit.[3,5–8]

Given the rarity of NMPSCI, especially one involving an RFB and without neurological deficit, a consensus has not yet been reached on optimal management. Some authors advocate for a low threshold for surgical exploration in NMPSCI with laminectomy to ensure decompression of the spinal cord, debridement of any foreign material, direct repair of any cerebrospinal fluid leak, and irrigation of the wound.[4–6,9–12] However, in a patient with an RFB and a neurologically normal clinical examination, the risk of open surgical exploration may outweigh the benefit, and direct withdrawal may be a better option.

We present the case of a 10-year-old female who suffered an NMPSCI to the thoracic spine with an RFB that bisected the spinal canal yet remained neurologically intact. The patient was treated with direct withdrawal rather than open surgical exploration and had an excellent clinical outcome. We review the literature to find other examples of thoracic NMPSCI with RFB and a neurologically normal examination and compare management strategies.

ABBREVIATIONS CSF = cerebrospinal fluid; CT = computed tomography; MRI = magnetic resonance imaging; NMPSCI = nonmissile penetrating spinal cord injury; RFB = retained foreign body; SCI = spinal cord injury.

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Illustrative Case

A 10-year-old female was brought to the hospital after sustaining a penetrating injury with RFB. She had fallen down the stairs in her home, landing flat on her back directly onto a display of trophies. A family member attempted to remove the RFB from her back at home but was unable to pull it out. Neurological examination was normal. She confirmed back pain but no numbness, weakness, or paresthesia.

Radiography and computed tomography (CT) scans revealed a 11 cm × 2 mm thin metal rod that had entered her right upper thoracic paraspinal region, traveled through the T3–4 intralaminar space, traversed the middle of the spinal canal, and then embedded into the left anterior inferior corner of the T4 vertebral body (Fig. 1). It bisected the spinal canal into two halves (Fig. 2). Magnetic resonance imaging (MRI) was avoided because of the risk of heating and mobilizing the metal rod.

The patient was taken to the operating room with a plan to directly withdraw the foreign body. The surgical team and operating room were prepared for emergent exploration if her examination declined either before or after removal. Because the patient was cooperative and her nothing by mouth status was appropriate, a slow, prone, intravenous induction of anesthesia was chosen. Prior to induction, the patient was moved to the operating room table in the prone position with her head turned to the side. Twenty-five micrograms of fentanyl was administered, followed by a slow titration of propofol. Mask ventilation was performed without difficulty.

Once the patient was asleep, the area around the entry site was sterilized and pliers were used to grab the end of the foreign body firmly. In one fluid motion, the rod was firmly removed in the same trajectory that it was directed into the spinal canal. Care was taken to make sure that the direction of withdrawal did not cause the deep end of the rod to fishtail into the spinal cord as it was removed. A small amount of cerebrospinal fluid (CSF) was visible coming from the wound. The wound was then irrigated, sterilized, and sutured closed. The patient's airway was supported with gentle bag-mask ventilation until she became responsive after a few minutes. She underwent serial examination in the operating room and remained neurologically intact. She was then transferred to the pediatric intensive care unit for serial examinations and 24 hours of prophylactic antibiotic coverage. She was discharged 24 hours after admission and followed up in clinic at 10 days and 1 month postremoval. The patient is currently more than 6 months postremoval and has had no deficits or complaints.

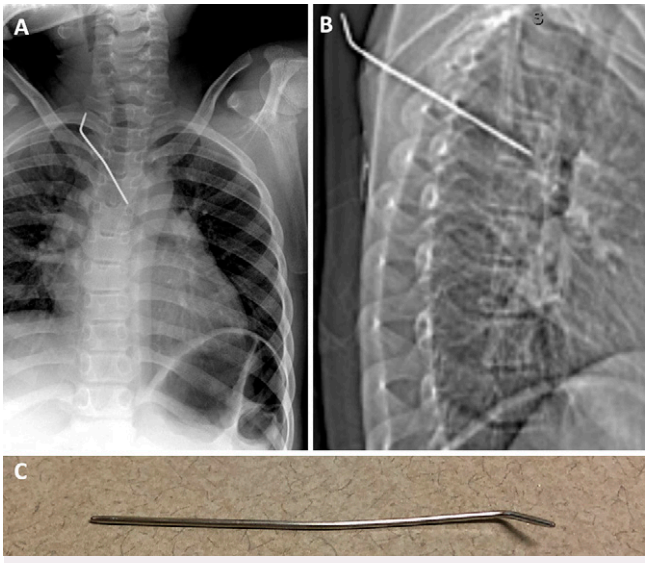

FIG. 1. Anteroposterior (**A**) and lateral (**B**) radiographs showing the metal rod foreign body in the right upper thoracic paraspinal region angling from right to left, superior to inferior, into the left inferior part of the T4 vertebral body. Close-up image (**C**) of the foreign body after removal, an 11 cm × 2 mm diameter thin metal rod.

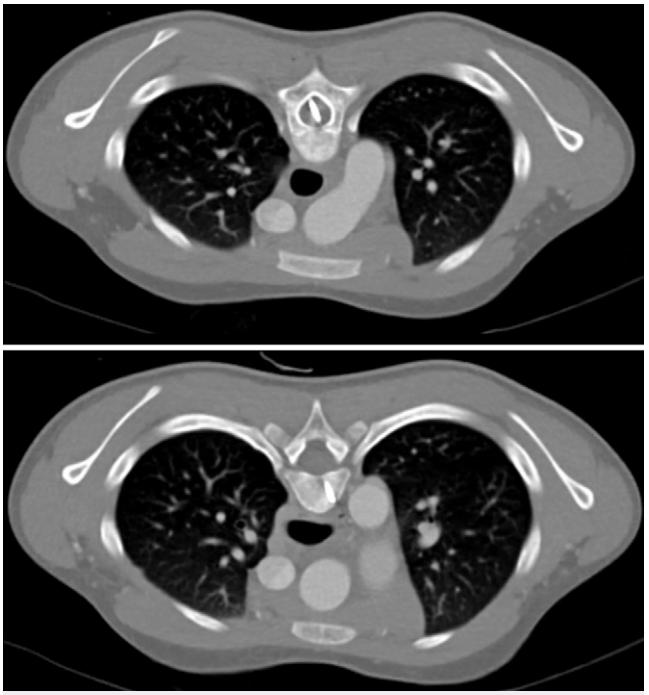

FIG. 2. Axial CT scans showing the foreign body bisecting the spinal cord and embedding into the left side of the vertebral body.

Discussion

Observations

NMPSCI with RFB and without significant neurological deficit is extremely rare. Rates of RFB in spinal stab injuries are highly variable across the literature, from as low as 2.3% to 49%.[3,6,13] Incomplete SCI, usually Brown-Sequard syndrome, is the most common presentation, but between 20% and 30% present with complete SCI.[3,6,7,11,13] In the largest series of spinal cord stab injuries recorded to date, with 450 patients and published by Peacock et al.[2] in 1977, 64% of the injuries were thoracic. Among this group of thoracic injuries, 24% were complete and 76% were incomplete injuries. It is worth noting that the authors did not include neurologically intact patients in their study, because they drew their sample exclusively from their database of patients with SCI. The recent case series of 51 patients of NMPSCI with RFB by Enicker et al.[6] reported 23% complete SCIs, 41% incomplete SCIs, and 36% with no neurological deficit, but they noted that none of the patients presenting without neurological deficit had a foreign body that traversed the spinal canal.

After an extensive review of the literature, we found six case reports that detailed thoracic NMPSCI with an RFB that traversed the spinal canal and were without significant neurological deficit (Table 1). Three patients underwent open surgical management with laminectomy.[5,10,11] One patient had the RFB removed through a minimally invasive tubular retractor without laminectomy.[4] One patient had the RFB directly withdrawn at the beginning of the procedure, and then the entry wound was opened, debrided, and exposed down to the lamina.[8] Last, one patient was treated with direct withdrawal similar to ours, with sterilization and irrigation of the wound but without any further dissection.[14] All patients remained neurologically stable postoperatively and had no complications at the last follow-up.

Lessons

In the three case reports detailing open surgical treatment with laminectomy, the authors recommended open surgery with laminectomy for four main reasons: exposing the RFB for removal; assessing cord compression/injury; visualizing and repairing the CSF leak; and preventing infection. In a patient who is neurologically intact, we would argue that open surgery provides little benefit with significantly added risks of surgery compared to direct withdrawal. In two of these three cases, the RFB still required forceful removal even after laminectomy, because the tip went through the canal and was stuck in the vertebral body. Performing a laminectomy around an RFB that penetrates the spinal cord is more likely to cause harmful movement of the RFB than a firm, fluid removal with direct withdrawal in the proper trajectory. Second, if a patient is neurologically intact, removal of the RFB is sufficient, and further cord decompression is unnecessary. If a patient has a neurological deficit or develops a significant deficit after removal, surgical exploration can be performed to ensure the spinal cord is decompressed. Third, it is not clear that open surgery improves healing for CSF leakage. Only 4% of 450 patients in the series by Peacock et al.[2] had a persistent CSF leak requiring intervention. Tissue dissection and bony removal around the RFB may lead to more space for the CSF to leak into, and laminectomy may unintentionally increase the size of the dural tear. Last, infection is uncommon, only occurring in 2% to 4% of cases,[3,15] and there is no evidence that open surgery lowers this risk compared to direct withdrawal with irrigation of the entry wound, prophylactic antibiotics, and close follow-up. Direct withdrawal also removes the risk of subsequent long-term iatrogenic effects that come with the removal of thoracic lamina or other posterior elements. Of note, the small, thin shape (approximately the same size as a lumbar drain needle) of the foreign body likely increased the odds of success in this patient, as it could be easily accessed and removed without causing significant damage to surrounding tissues. If the foreign body had been larger or had a more complex shape, it may have increased the risk of complications and required a more extensive surgical procedure, especially if the patient had any associated neurological deficits. We would not recommend direct withdrawal unless a patient is neurologically intact.

TABLE 1. Case reports of thoracic NMPSCI with RFB and without significant neurological deficit

Authors & Year	Age (yrs)	Level	Foreign Body	Treatment	CSF Leak	Outcome, FU
Peters et al., 2023	10	T3–4	Metal rod	Direct withdrawal	Yes, spontaneously resolved	Stable, 3 mos
Sarkar et al., 2018[11]	35	T8–9	Nail	Partial laminectomy of T8 & T9	Yes, repaired by primary dural closure w/ fibrin glue, fascia graft onlay	Stable, 12 mos
Li et al., 2012[10]	17	T7–8	Knife	Full laminectomy of T7 & T8	Yes, repaired w/ collagen matrix onlay & fibrin glue	Stable at discharge, no FU
Agarwal et al., 2016[5]	58	T11–12	Knife	Partial laminectomy of T11 & T12	Yes, repaired by primary dural closure	Stable, 3 mos
Yoon et al., 2019[8]	43	T12–L1	Knife	Direct withdrawal followed by wound debridement & exploration but no laminectomy	No	Stable, 2 mos
Moldovan et al., 2019[4]	49	T9	Knife	MI tubular access to foreign body, withdrawal through tube, no laminectomy	Yes, treated w/ Gelfoam	Stable, 2.5 yrs
Sakar et al., 2016[14]	50	T3–4	Knife	Direct withdrawal	No	Stable, 6 mos

FU = follow-up; MI = minimally invasive.

Sarkar et al.[11] describes a case that is similar to ours, with direct withdrawal in the operating room and close neurological examination. One significant difference is that our patient was not intubated. We used propofol and fentanyl, keeping the patient prone with her head turned, and used bag-mask ventilation. This minimized the need for patient manipulation, lowering the risk that the RFB would be disrupted prior to removal. It also allowed for rapid awakening from anesthesia for immediate neurological examination after removal. If the patient declined neurologically after removal, operative exploration would have been performed. We noticed CSF leaking from the entry wound after removal but did not believe that open exploration would be beneficial given the small size (approximately 3 mm) of the wound, approximately the same size that is seen after lumbar drain removal. Close follow-up is critically important for early detection of CSF leaks and potential infections. To our knowledge, this is the first case published in which direct withdrawal was performed without intubation.

One limitation of this review is publication bias. Cases that do not have a successful outcome are unlikely to be submitted for publication with this type of pathology. It is a very rare presentation with only anecdotal evidence. Last, the foreign body in this case was small and thin, and these recommendations may not be applicable to large or more complex-shaped foreign bodies.

For NMPSCI with RFB and without significant neurological deficit, direct withdrawal is a viable and possibly the best treatment option. The surgical team should be prepared for emergent exploration in case there is a progressive neurological deficit after removal. Fast-acting anesthesia without intubation allows removal of the RFB with less patient manipulation and a faster recovery, allowing early assessment of neurological status postremoval. Close follow-up is necessary for early detection of CSF leaks and potential infections.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Peters, Karimian, Wait. Acquisition of data: Peters, Wait. Analysis and interpretation of data: Peters, Karimian, Tuleasca. Drafting the article: Peters, VanHorn, Karimian, Pruden. Critically revising the article: Peters, VanHorn, Karimian, Wait, Daniel, Tuleasca. Reviewed submitted version of manuscript: Peters, VanHorn, Karimian, Wait, Tuleasca. Approved the final version of the manuscript on behalf of all authors: Peters. Administrative/technical/material support: Tuleasca. Study supervision: Wait, Daniel.

Supplemental Information

Previous Presentations

Virtual poster presentation at the 2021 AANS Annual Scientific Meeting, August 2021, Orlando, Florida.

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