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Case report

When the bullet moves! Surgical caveats from a migrant intraspinal bullet

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ABSTRACT

Rarely, spinal gunshot injuries result in migrating intraspinal bullets. Use of MRI is controversial and other radiographic imaging might mimic an extradural bullet, even though it is intradural and migratory. Here, we present a case of spinal missile injury resulting in an intraoperatively mobile intradural bullet. The challenges faced during diagnosis and surgical removal are described. We also show that intraoperative ultrasonography may be useful in clarifying whether the bullet is intradural. A 32-year-old male presented with weakness and paraesthesia in his right leg following an accidental gunshot injury to his spine. Facet joint destruction and an intraspinal bullet were detected. Immediate surgical removal and transpedicular instrumentation was performed. The surgical procedure was complicated by lack of an identifying dural perforation at the bullet entry point and a gliding bullet inside the spinal canal during surgery. Gliding of the bullet was caused by the pushing effect of the bone rongeur and further gliding was avoided by performing the next laminectomy with an electric drill. Where other modalities indicated for a possible extradural location, intraoperative USG clearly showed the intradural position of the bullet and provided clear images without major artifacts. Surgical treatment of a mobile intradural bullet is challenging and open to surprises. Location of the bullet may shift as result of surgical procedure itself. Laminectomy should be performed with a power drill. Where fluoroscopy was inadequate and MRI not available, intraoperative USG proved useful in ascertaining the intradural versus extradural position of the bullet and allowed for a tailored dural opening.

1. Introduction

Rarely, spinal missile injuries (SMI) result in bullets that enter and travel caudally along the path of the spinal canal [1,2]. With intraspinal gunshot injuries, it is difficult to assess the damage merely by evaluating the symptoms. The use of magnetic resonance imaging (MRI) is controversial and is generally avoided. Other radiographic imaging might mimic an extradural bullet, even though it is intradural and migratory [2]. Furthermore, removal of a mobile intradural bullet may prove some surgical challenges. Here we report a case of SMI

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resulting in a mobile intradural bullet with confusing radiological and intraoperative findings. We describe the surgical challenges faced during removal and show the usefulness of ultrasonography (USG) in locating an intradural mobile projectile where other modalities failed.

2. Case description

A 32-year-old male patient presented at the ER following an accidental gunshot injury to his back. He complained of pain and a burning sensation in the right knee along with numbness over his right leg. He was conscious, oriented and cooperative. The bullet entry site was above the right iliac crest and no exit wounds were noted. The movements of the right leg were painful and limited. His neuroexam was also notable for severe weakness on right knee extension and paraesthesia over the front of his right thigh. There was also no patellar reflex on the right.

The abdominal and thoracic CT revealed no intra-abdominal injury. However, lumbar XRs and CT scan revealed a fragmented right L3 pedicle with disruption of the L2-3 facet joint and indentation on the dural sac (Fig. 1A and B). However, the bullet was located inside the spinal canal at the S1 level, just beneath the lamina giving the impression of a possible epidural location. No disruption of bony structures between the spinal entry site and the final resting position of the bullet was found.

Surgical treatment for dural decompression, transpedicular instrumentation and bullet extirpation were planned and the patient was moved to the OR immediately. An L2 laminectomy was carried out and the fragmented L2-3 facet joint was removed. The bony spicules indenting the dural sac and the L3 nerve root were also cleared and the compression was relieved. No cerebrospinal fluid (CSF) fistula or dural perforations were noted, strengthening the idea of the bullet traversing in the epidural space down the spinal canal. Then, under C-arm fluoroscopic guidance, the location of the bullet under the S1 lamina was confirmed (Fig. 2A). Using a Kerrison bone rongeur, an S1 laminectomy was carried out. After the procedure however, the bullet was not found. Re-check with C-arm, located the bullet beneath the L5 lamina, this time. Therefore, the bullet was thought to be pushed cranially with each Kerrison rongeur bite, during laminectomy. Therefore, to avoid further shift in the position of the bullet, L5 laminotomy was performed using an electrically powered surgical drill. For another surprise, the bullet was still not found. Repeat C-arm once more confirmed that the bullet was still at the L5 level. However, to avoid an unnecessary dural opening, the possibility of the bullet being in the epidural space had yet to be ruled out. Out of an instantaneous improvisation, we decided to use intraoperative ultrasonography to ascertain the bullet's intradural location. The intraoperative ultrasound probe (Sonoline G60S ultrasound system, Siemens, VF13-5SP intraoperative transducer, frequency bandwith 5–13 MHz) was introduced into the laminectomy area and the dural surface was scanned in the horizontal plane (Fig. 2B). The sonograms clearly defined the intradural location showing the bullet as a distinct, roundly shaped circular mass underneath cauda equina fibers (thin arrows) incased in the dural sac (thick arrow) (Fig. 2B). The bullet's outer shell left a regular circular hyper-echoic impression containing a hypo-echoic core as well as some inner details. Therefore, the dural sac was opened with a more tailored midline incision. The bullet was found underneath the caudal fibers surrounded by a clear CSF. The bullet was removed (Fig. 2c) and hemostasis was achieved. Following dural closure, L2-3-4 transpedicular instrumentation was performed sparing the right L3 pedicle (Fig. 3). Postoperatively, the patient reported a complete relief of pain in his right leg. Recovery of the patient was uneventful. He was asked to use a lumbar brace for two weeks and started on physiotherapy. Complete recovery of motor function was achieved in two weeks.

3. Discussion

Intraspinal missile migration usually occurs between T10 and S1. Generally, the relative narrowing of the spinal canal at T10 level limits the migration of the bullet in both directions [3,4]. The primary factor for the migration of the bullet is gravitational forces [3]. It was suggested that the respiratory changes and physiological cerebrospinal fluid circulation might assist in the migration of the bullet [5]. In addition, fluoroscopy and intraoperative observations suggest that the patient's position affects the direction of the

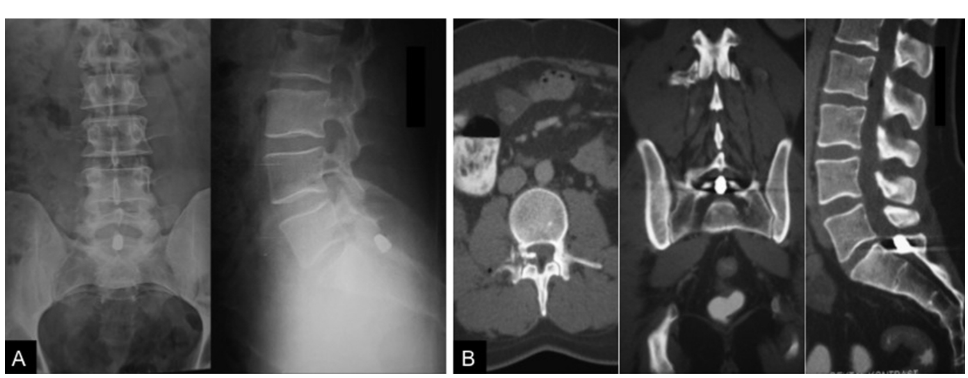

Fig. 1 – (A) Preoperative lumbar X-ray shows a fragmented right L3 lateral process and the bullet lodged at the S1 level. (B) Preoperative lumbar CT-scan. Axial image shows the fragmented right L3 pedicle and L2-3 facet joint. Note the spicules of bone indenting the dural sac. On coronal and sagittal images the bullet's resting position is seen at S1 inside the spinal canal.

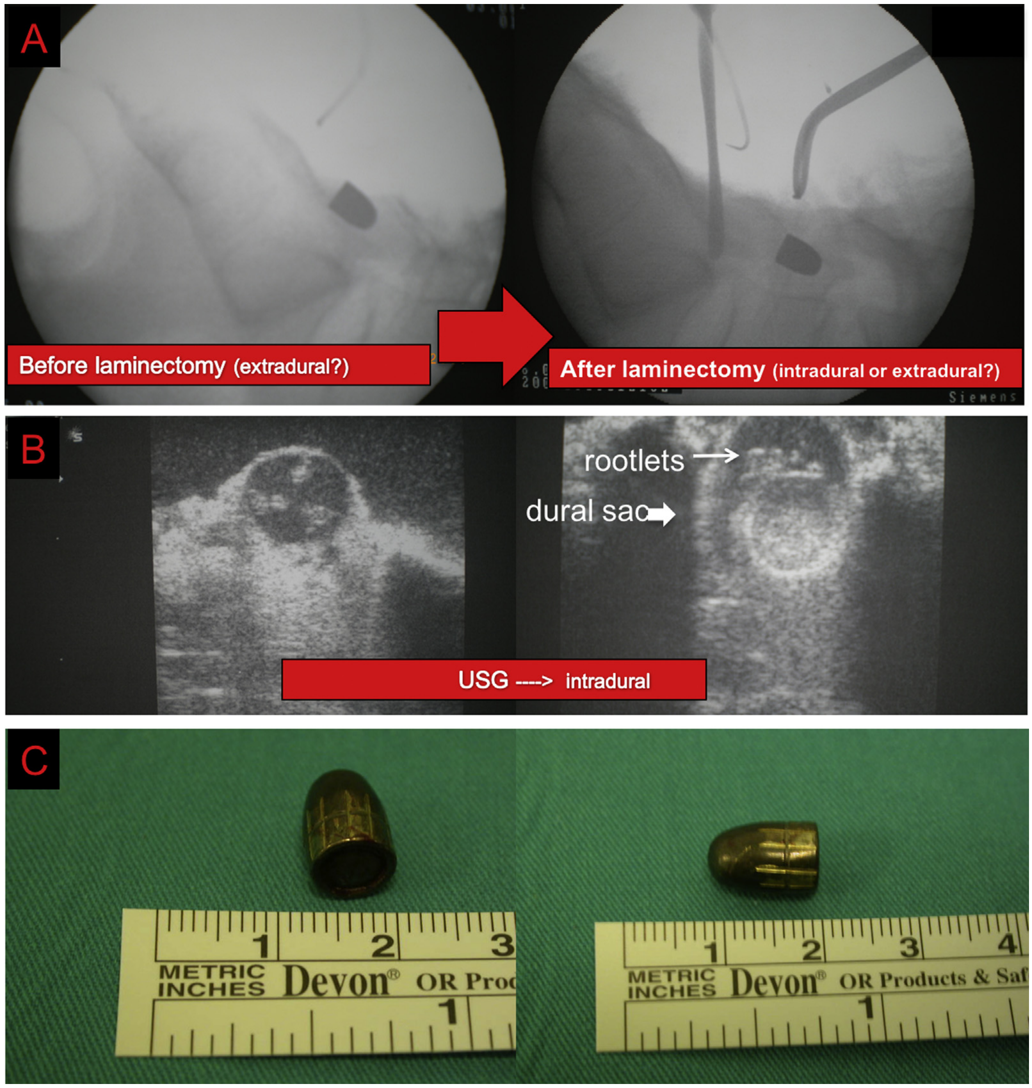

Fig. 2 – (A) With the patient in prone position, intraoperative C-arm scope shows the bullet at the S1 level. On completion of S1 laminectomy the bullet was not found. Recheck with C-arm shows that during laminectomy performed with a Kerrison's rongeur, the bullet was pushed down the spinal canal to the L5 level. Then, L5 lamina was removed and the bullet was still not found. Whether the bullet was intra-or extradural came into question. (B) Use of intraoperative ultrasonogram solves the problem and locates the bullet intradurally. Note the hyper-echoic outer shell encasing the hypo-echoic inner compartment. (C) The bullet after removal.

migration, which usually occurs caudally [4]. In this report, we document that the final position of bullet may also shift during surgery by the pushing effect of the surgical tool used.

The management of bullets that have migrated in the spinal canal remains controversial. Our experience with previous cases indicates that asymptomatic intradural bullets may induce an extensive fibrotic reaction within a few years and become symptomatic. Therefore, surgical removal may be inevitable and also, wise to perform at first presentation. Other authors also suggested that bullet implantations produce a robust fibrotic reaction in the pia and arachnoid layers. Copper in the implantations also destroys axons and myelin, leading to a significant amount of gliosis within the spinal cord tissue. Lead was shown to cause similar but less severe local response [4,6].

Radiography is commonly used to locate the bullet and detect bone fractures or fragments [7]. However more advanced radiological techniques should be utilized for better evaluation of the damage. Computed tomography (CT) images provide better localization of the bullet and demonstrate foreign bodies in the spinal canal more clearly. However, in our case it was not possible to tell the intradural versus epidural location of the bullet. Compared to CT, magnetic resonance imaging (MRI) is capable of better imaging as well as coronal, sagittal and axial visualization of the neural elements. Furthermore, MRI results display markedly less artifacts [2,3]. Despite the advantages of MRI over CT, the use of MRI

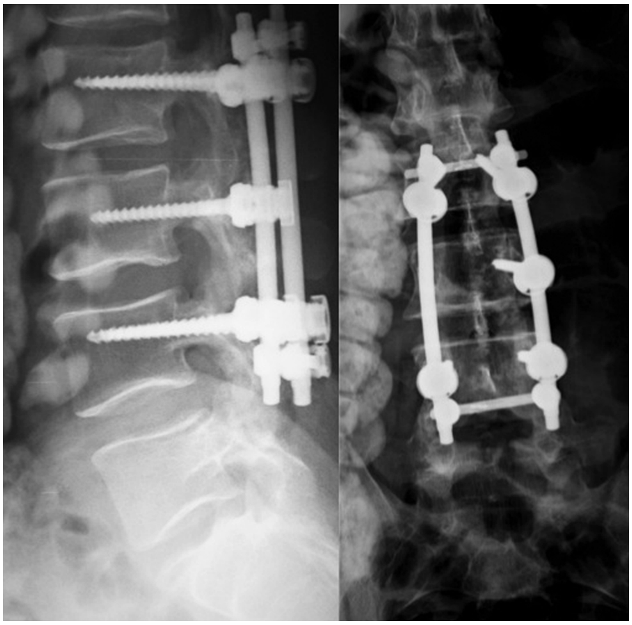

Fig. 3 – Postoperative lumbar X-ray shows the L2–L4 transpedicular instrumentation sparing the right L3 pedicle.

to evaluate gunshot wounds is still controversial due to the possibility of bullet migration by the strong magnetic pull. Such migration might result in more soft-tissue or neurological damage. Kafadar et al. [2] reported the use MRI for an intraspinal bullet and suggested that MRI can be safely used for low velocity (civilian) shotgun injuries where the bullet is jacketed with non-ferromagnetic metals such as copper. They also cautioned against the use MRI in high-velocity (military) gunshot injuries because of steel content. However ballistics data of bullets is mostly unavailable in the medical settings and, as in our case, most of these patients have to be treated on an emergency basis. Therefore, the use of MRI is mostly avoided in the initial management of these patients.

Surgical removal of an intraspinal bullet may be further complicated by positional migration. In our case, with avoidance of the MRI, surgery was planned with XR and CT findings. Our first surprise was lack of CSF fistula and dural tear at the bullet entry point into lumbar spine. Therefore, the possibility of the bullet traveling and lodging in the epidural space was considered. The second surprise came when the bullet was not found after removal of the S1 lamina and repeat C-arm scope detected the bullet at the L5 level (Fig. 2A). Therefore, to avoid the pushing effect of the bone rongeur, L5 laminectomy was performed with an electrically powered drill. However, the bullet was still not found. The intradural location of the bullet still had to be confirmed in order to avoid an unnecessary dural incision. This perplexing situation was solved by ultrasonography. This study describes the first use of intraoperative USG to locate an intradural bullet. In the absence of MRI data and failure of fluoroscopy, intraoperative USG was able to clearly identify the location of the bullet and its relation to caudal fibers (arrows) in the dural space (Fig. 2B). USG images showed no major artifacts and were able to penetrate inside the bullet revealing a stark contrast between the circular hyperechoic outer jacketing and the hypo-echoic content. USG also allowed for a more tailored dural incision.

The case presented in this report is a rare spinal missile injury resulting in a migrating intradural bullet. Reports of migrating intradural missile injuries are scares and less than 15 cases are found in the English literature [1,4,5]. Patients may be asymptomatic or present with various degrees of neural injury. Surgical removal is required in most cases for reasons of immediate neural decompression and prevention of delayed fibrosis. As a result of the urgent nature of these cases and avoidance of MRI, migrating intradural bullets may pose unexpected challenges to neurosurgeons. The aim of this report is to relate the difficulties we faced during the surgical removal of a gliding intraspinal bullet; describe the use of USG to locate the bullet inside the dura and provide some surgical caveats.

- Dural puncture and CSF fistula may not be obvious at the bullet entry site. Bullets may ricochet around and pierce the dural sac at a point not in plain view of the surgical exposure.
- With the avoidance of MRI use, whether the bullet is in the epidural or intradural space may pose a dilemma which C-arm scope fails to solve (Fig. 2A).
- The patients' position or gravitational forces may change the final resting location of the bullet at any time. Therefore, the position of the bullet should be double-checked at every stage during the surgery.
- Intradural bullets can migrate during the surgical procedure due to pushing effect of the bone rongeur bites during laminectomy. We recommend an electrically powered drill be used to perform the procedures on the lamina overlying the bullet.
- Where C-arm scope fails, intraoperative USG can be used to locate an intradural bullet and allows to see its position in relation to neural elements (Fig. 2B) when preoperative MRI is not available or when intraoperative migration occurs. It may also allow for a more precise dural incision.

Conflict of interest

None declared.

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None declared.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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