

Cauda equina syndrome caused by intradural migration of a bullet: A rare case presentation

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ABSTRACT

Intradural migration of a bullet within the spinal canal represents an exceptionally uncommon clinical scenario and carries the potential for progressive or delayed neurological decline. Although such fragments may initially remain silent, their subsequent movement within the spinal canal can create significant diagnostic and therapeutic challenges. In this report, we present an unusual and instructive case of cauda equina syndrome that developed secondary to the delayed caudal migration of an intradural bullet fragment. We further provide a detailed discussion of the diagnostic evaluation, surgical management, and clinical decision-making considerations associated with this condition. A 32-year-old male patient sustained a gunshot injury in 2022. Initial imaging demonstrated that the bullet had penetrated the spinal canal and become lodged intradurally at the L1-L2 level, although the patient exhibited no neurological deficits at that time. He was, therefore, managed conservatively with routine follow-up. Approximately 2.5 years later, the patient presented with the sudden onset of bilateral lower extremity weakness, progressive gait impairment, and new-onset urinary incontinence. Computed tomography revealed that the intradural bullet fragment had migrated caudally to the S2 vertebral level, resulting in significant compression of the cauda equina nerve roots. Urgent surgical intervention was undertaken, consisting of a partial bilateral laminectomy at the S1-S2 level and microsurgical extraction of the bullet. Postoperative neurological recovery was substantial, with marked improvement in motor function and complete resolution of urinary symptoms. Although intradural bullet fragments may initially appear clinically insignificant in patients who present without neurological deficits, delayed migration poses a serious risk for the development of cauda equina syndrome and other potentially irreversible complications. This case highlights the importance of maintaining a high index of suspicion and considering early prophylactic surgical extraction when intradural localization is identified, even in neurologically intact individuals. Early intervention may prevent severe late complications such as neurological deterioration, infectious sequelae arising from contaminated missile tracts, and possible lead toxicity related to chronic intradural exposure.

Keywords: Cauda equina syndrome; intradural bullet migration; spinal gunshot injury.

INTRODUCTION

Cauda equina syndrome (CES) is a rare but serious neurosurgical emergency that typically results from compression of the lumbosacral nerve roots. Although lumbar disc herniation is the most common cause, spinal gunshot injuries, though uncommon, can also lead to CES through direct trauma or delayed complications. Retained intradural bullets within the spinal canal carry the risk of delayed migration, infection, or lead toxicity, even in initially asymptomatic patients. Intradu-

ral migration of a bullet to the sacral region is exceptionally rare and may result in progressive neurological deterioration. Here, we present a rare case of delayed intradural bullet migration from the L1-L2 to the S2 level, leading to CES, and discuss its clinical implications and management considerations.^[1-3]

CASE PRESENTATION

A 32-year-old male was admitted to the emergency department in May 2022 after sustaining a gunshot wound. On ad-

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Figure 1. A cortical defect approximately 9–10 mm in diameter, corresponding to the bullet entry trajectory, is observed in the right half of the L3 vertebral body, accompanied by a mildly osteoporotic appearance. Axial lumbar CT sections reveal a clear disruption of cortical continuity.

mission, he was hemodynamically stable and neurologically intact. Contrast-enhanced abdominal computed tomography (CT) revealed a Grade I liver laceration and perforations of the duodenum and colon. Emergency laparotomy was performed by the general surgery team. The same CT scan demonstrated a cortical defect approximately 9–10 mm in diameter in the right half of the L3 vertebral body, corresponding to the bullet entry trajectory and accompanied by mild porotic changes (Fig. 1). In sagittal CT sections, the bullet was visualized within the spinal canal at the L1–L2 level, consistent with intradural localization. The entry wound was noted in the right lower abdominal quadrant, and no exit wound was identified. The patient was discharged after stabilization, with neurosurgical follow-up recommended.

During outpatient follow-up, the patient remained asymptomatic, and serial CT scans confirmed that the bullet had not migrated.

In November 2024, approximately 2.5 years after the injury, he presented with progressive bilateral leg weakness, gait imbalance, urinary incontinence, and saddle anesthesia. Neurological examination revealed full motor strength in the upper extremities, while in the lower extremities, muscle strength was 3+/5 on the right and 4+/5 on the left. Laboratory and systemic evaluations revealed no findings suggestive of lead intoxication or infection. New lumbosacral CT scans demonstrated caudal migration of the bullet to the S2 level, compressing the cauda equina nerve roots (Fig. 2).

The patient underwent urgent surgery. Under general anesthesia and in the prone position, a midline incision was made at the L5–S3 level, followed by bilateral partial laminectomy at S1–S2. The dura was opened under microscopic visualization, revealing the bullet within the intradural space. The foreign body was carefully dissected and removed without injury to adjacent nerve roots. The sacral rootlets were clearly visualized, and the dural defect was repaired primarily (Fig. 3). The wound was closed in anatomical layers.

Postoperatively, the patient's lower extremity strength improved significantly, and urinary incontinence resolved. No cerebrospinal fluid (CSF) leakage or wound infection occurred. He was discharged in good condition and referred for rehabilitation, with plans for long-term follow-up.

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

DISCUSSION

Gunshot wounds to the spine are high-energy traumas that frequently result in permanent neurological deficits involving the spinal cord and nerve roots. Such damage may occur due to direct compression by the bullet itself, bone fragments, or disc material. Most cases reported in the literature involve complete paraplegia. In rare instances, however, the bullet may compromise the annulus fibrosus, increase intradiscal pressure, and indirectly lead to spinal cord compression. Importantly, spinal cord injury may occur even without direct penetration of the spinal canal, as the concussive effect of the bullet's impact on the vertebra can be sufficient to cause damage.^[4] In our case, the absence of any initial motor, sensory, or autonomic deficits suggests that the bullet initially settled in a relatively harmless position. However, the subsequent development of symptoms due to delayed migration demonstrates that early neurological silence may be misleading in terms of long-term clinical prognosis.

Most vertebral injuries caused by gunshots are considered stable. Nonetheless, bullets lodged in the lumbar region can damage pedicles or facet joints, potentially leading to acute or delayed instability. When the integrity of the pedicles and facets is preserved, spinal instability is unlikely to develop. In our patient, no signs of spinal instability were observed in the early phase, and spinal CT scans showed no evidence of vertebral fracture or collapse. Therefore, conservative management was initially chosen. However, the emergence of neurological symptoms in the delayed phase underscores the



Figure 1. (a) Sagittal CT image obtained at initial presentation following a gunshot injury demonstrates a hyperdense foreign body consistent with a bullet core located within the spinal canal at the L1–L2 vertebral level. (b) Axial CT scan at the same level (L1–L2) reveals the intrathecal location of the bullet core within the right posterolateral portion of the spinal canal. (c) Preoperative sagittal lumbosacral CT image shows a hyperdense foreign body, approximately 9–10 mm in size, consistent with a bullet core located within the spinal canal at the S1–S2 vertebral level. These findings indicate caudal migration of the intrathecal bullet core from the L1–L2 level. (d) Preoperative axial lumbosacral CT image of the same patient reveals a hyperdense intrathecal foreign body measuring 15×12 mm, localized in the right posterolateral portion of the spinal canal at the S1–S2 level, confirming caudal migration of the bullet core. (e) Postoperative sagittal lumbosacral CT image shows the surgical defect from the partial laminectomy performed at the S1–S2 level. The previously occupied intrathecal space now appears vacant, and no residual bullet-related foreign body density is observed. (f) Postoperative axial CT image of the same patient demonstrates a bony defect corresponding to the laminectomy at the S1–S2 level. No intrathecal foreign body is detected, indicating complete surgical decompression.

need to consider not only structural but also functional and dynamic factors in clinical evaluation.^[5]

Intradural bullet migration was first described in 1916, and the main contributing factors are gravity, CSF flow, and respiratory movements.^[6] Physiological forces such as coughing, peristalsis, and body positioning have also been implicated in the literature.^[7] In our case, the bullet initially located at the L1–L2 level had migrated to the S2 level 2.5 years later. Despite multiple imaging studies during follow-up, no migration was noted until the final evaluation. This suggests that migration may have occurred suddenly over a short period. The passive nature of this movement, likely triggered by positional factors, aligns with findings in previous reports.^[8] The damage caused by a bullet is not limited to mechanical impact; thermal energy, mass effect, and toxic potential due to its metallic composition can also result in significant pathophysiological consequences. In cases without an exit wound, the bullet’s location should be thoroughly investigated even if the patient is asymptomatic. In our patient, no exit wound was observed, and although the bullet was intrathecal, it did not initially cause clinical symptoms. This highlights the importance of timely removal of foreign bodies within the spinal canal due to the potential risks of migration, infection, and neurological deterioration.^[9]

CSF fistula formation due to a bullet in the spinal canal significantly increases the risk of meningitis and constitutes an absolute indication for surgical removal.^[10] Additionally, if the bullet perforates the colon before entering the spinal canal, the risk of infection becomes even higher. In our case, initial evaluation revealed colonic perforation, and emergency laparotomy was performed. The patient did not develop early postoperative infection or meningitis, supporting the



Figure 1. (a) Intraoperative microscopic view demonstrating the careful dissection and excision of the bullet core located between the sacral nerve roots (*) following dural opening at the S1–S2 level. The proximity of the lead fragment to adjacent neural structures is directly visualized. (*) Sacral nerve root. (b) Macroscopic appearance of the excised bullet core following removal. The foreign body was measured against a standard surgical ruler and found to be approximately 15×12 mm in size.

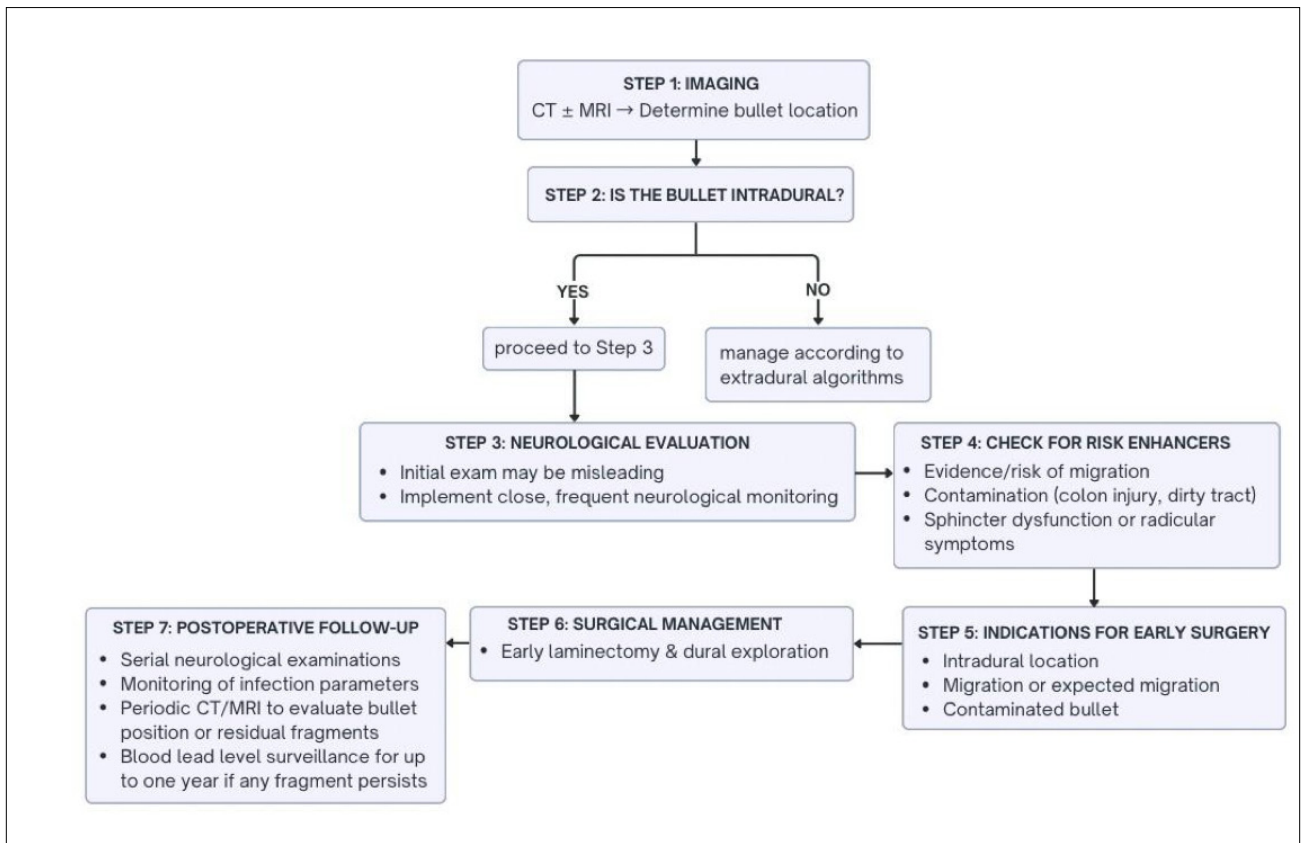


Figure 4. Proposed clinical algorithm for the evaluation and management of retained bullet fragments within the spinal canal.

effectiveness of the chosen surgical approach and antimicrobial therapy.^[11] However, as demonstrated in our case, when neurological symptoms arise due to migration, surgical intervention becomes unavoidable. Therefore, the decision for surgery should be individualized, taking into account the patient’s clinical status, bullet location, spinal stability, and associated injuries.^[1,12]

Intradural free-floating bullets can complicate surgical intervention. To prevent cranial migration during manipulation, reverse Trendelenburg positioning and gentle dissection techniques may be employed.^[13] In our patient, microsurgical dissection was performed, the bullet was successfully removed, the sacral nerve rootlets were visualized, and the dural defect was closed primarily. No postoperative CSF leakage or infection was observed.

Bullets are typically composed of lead, and their toxic effects may manifest in the long term. Blood lead levels peak approximately 3 months after injury and can cause systemic symptoms such as microcytic anemia, encephalopathy, and peripheral neuropathy.^[14] Therefore, regular monitoring of lead levels is recommended for at least one year in patients with retained bullets. Although our patient did not show signs of lead toxicity, the risk should always be considered. Similar cases have been reported in the literature. For instance, Tanguy et al. also advocated surgical removal

of a caudally migrated bullet associated with meningitis three months post-injury.^[15] Even bullets located in the posterior fossa have been reported to migrate into the spinal canal, causing tetraplegia and necessitating urgent surgery. Cagavi et al. described a case of spontaneous caudal migration from L3 to S2 with partial neurological improvement following surgery. Likewise, in our case, a bullet initially considered stable eventually migrated, resulting in severe neurological symptoms and notable clinical improvement after surgery.^[9,16]

The management of retained intradural bullets remains controversial, with no universally accepted guidelines regarding the timing of surgical removal. Waters and Adkins emphasized that early removal of bullet fragments within the spinal canal can reduce the risk of delayed neurological deterioration, lead toxicity, and infection.^[17] Similarly, Ghori et al. reported a case of delayed cauda equina syndrome due to bullet migration and advocated early surgical intervention to prevent irreversible damage.^[18] Harsha and Thomas also described complete neurological recovery after delayed surgery, underscoring the potential for favorable outcomes even in late presentations. Based on accumulated evidence, early removal of intradural bullets (particularly those located in the lumbosacral region) should be considered when feasible, provided that the patient’s neurological and systemic status

allows for safe intervention.^[19]

Gunshot wounds to the lumbosacral spine require meticulous evaluation, particularly when the projectile is located intradurally. Although our patient initially exhibited an intact neurological examination, early imaging clearly demonstrated an intradural bullet. Prior literature strongly indicates that an initially preserved neurological status in such cases may be misleading, as intradural projectiles are prone to late migration and may produce delayed cauda equina syndrome, progressive radiculopathy, or sphincter dysfunction.^[20,21] Although the patient was not taken to surgery at first admission, strict and frequent neurological monitoring was maintained in the early period. However, relying solely on neurological stability without addressing the mechanical and inflammatory risks associated with an intradural bullet presents a potential for avoidable deterioration. Moreover, the patient had undergone colon surgery during the same initial period, suggesting a contaminated bullet tract. Contamination of an intradural foreign body significantly increases the risk of meningitis, arachnoiditis, and other delayed infectious complications. This combination (contamination risk plus intradural migration potential) represents a strong indication for early operative management. Recent illustrative cases have highlighted the technical feasibility and benefit of early extraction for preventing late neurological decline, while additional reports emphasize the challenges in ‘catching’ highly mobile bullets within the dural sac.^[22,23] Bassani et al. further emphasize that even neurologically intact patients with an intradural bullet may warrant early surgical consideration due to the risks of migration, inflammation, or late neurological deterioration, underscoring that the absence of deficits does not eliminate the need for timely intervention.^[24] Our case illustrates that even with appropriately close neurological surveillance, delayed deterioration can occur when the underlying risk factors (migration and contamination) are present. Therefore, this case reinforces the importance of prioritizing early surgical exploration in patients with intradural bullet localization, even in the absence of immediate neurological deficits. It is conceivable that earlier removal at the time of the initial presentation might have prevented the development of cauda equina syndrome in our patient.

Based on current literature and our clinical experience, the structured algorithm presented in Figure 4 provides a systematic and practical framework for the evaluation and management of retained bullet fragments within the spinal canal. This stepwise approach is intended to facilitate early identification of high-risk patients, guide appropriate imaging and neurological monitoring, and assist in timely surgical decision-making when indicated. In lumbosacral gunshot injuries with suspected intradural localization, applying these management principles is essential to prevent serious complications such as migration, infection, and delayed neurological deterioration (Fig. 4).

CONCLUSION

Although intradural bullet fragments may initially remain asymptomatic, delayed migration can lead to significant neurological deterioration. In our case, the patient’s intact early neurological status prompted initial observation; however, the later development of cauda equina symptoms ultimately necessitated surgical removal. This underscores that a normal early neurological examination does not guarantee long-term stability. Based on current evidence, early surgical extraction should be strongly considered in patients with suspected intradural bullet fragments. We believe that the clinical decision algorithm proposed in this study may assist clinicians in identifying high-risk patients at an earlier stage and in preventing delayed neurological compromise.

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OLGU SUNUMU - ÖZ

Intradural kurşun migrasyonuna bağlı gelişen cauda equina sendromu: Nadir bir olgu sunumu

AMAÇ: Spinal kanal içerisinde bir mermi çekirdeğinin intradural yer değiştirmesi son derece nadir görülen bir klinik durumdur ve zamanla ortaya çıkabilen ilerleyici nörolojik bozulma açısından önemli riskler taşır. Bu tür olgularda başlangıçta herhangi bir belirti olmayabilir; ancak yabancı cismin spinal kanal içinde daha sonraki dönemde migre olması tanısız ve tedaviye yönelik ciddi güçlükler oluşturabilir. Bu çalışmada, intradural mermi çekirdeğinin gecikmiş kaudal migrasyonu sonucunda gelişen nadir bir cauda ekuina sendromu olgusunu sunuyor ve tanısız değerlendirme, cerrahi tedavi ile klinik karar verme sürecine ilişkin ayrıntılı bir tartışma yapıyoruz. Otuz iki yaşındaki erkek hasta 2022 yılında ateşli silah yaralanması geçirdi. İlk görüntülemelerde mermi çekirdeğinin spinal kanala penetre olarak L1-L2 seviyesinde intradural olarak yer aldığı saptandı; ancak hastada o dönemde herhangi bir nörolojik defisit bulunmadığından konservatif yaklaşım ve düzenli takip planlandı. Yaklaşık 2,5 yıl sonra hasta, ani başlangıçlı her iki alt ekstremitede güçsüzlük, yürüme bozukluğu ve yeni gelişen üriner inkontinans ile başvurdu. Yapılan bilgisayarlı tomografi tetkikinde intradural mermi çekirdeğinin kaudal yönde S2 seviyesine doğru migre olduğu ve cauda ekuina köklerinde belirgin kompresyona yol açtığı görüldü. Bu bulgular üzerine acil cerrahi müdahale yapıldı ve S1-S2 seviyesinde bilateral parsiyel laminektomi ile mermi çekirdeği mikroskopik teknikle çıkarıldı. Ameliyat sonrası dönemde motor fonksiyonlarda belirgin düzelme izlendi ve üriner semptomlar tamamen geriledi. Her ne kadar intradural mermi çekirdekleri başlangıçta asemptomatik seyredebilse de, geç dönemdeki migrasyon ciddi ve geri dönüşümsüz nörolojik bozulmaya yol açabilir. Bu olgu, başlangıçta nörolojik defisiti olmayan hastalarda dahi intradural lokalizasyon saptandığında, geç komplikasyonları önlemek amacıyla erken cerrahi çıkarımın güçlü biçimde değerlendirilmesi gerektiğini göstermektedir. Erken müdahale, cauda ekuina sendromu gibi ileri derecede nörolojik bozulmaların yanı sıra, kontamine mermi traktına bağlı enfeksiyöz komplikasyonlar ve uzun dönem intradural kurşun maruziyetine bağlı toksisite risklerini azaltmada önemli rol oynayabilir.

Anahtar sözcükler: Cauda equina sendromu; intradural kurşun migrasyonu; spinal ateşli silah yaralanması.

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