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CASE REPORT

Migratory low velocity intradural lumbosacral spinal bullet causing cauda equina syndrome: report of a case and review of literature

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Abstract
Background Migration of the bullet within the spinal subarachnoid space has long been recognized as unusual complication of spinal gunshot injury.
Objective We report a case of migratory low velocity intradural lumbosacral spinal bullet causing cauda equina syndrome. The relevant literature is reviewed and all cases of migratory spinal bullet are summarised, and management strategies are discussed.
Study design Literature review.
Methods A 32-year-old male suffered abdominal gunshot injury for which emergency laparotomy and repair of colonic perforation were performed. The bullet was seen lodged within the sacral spinal canal behind the S1 vertebral body. The probable entry point was at L2–L3 level. Caudal migration of the bullet within the spinal subarachnoid space leads to the appearance of cauda equina syndrome.
Results Bullet was retrieved following upper sacral and lower lumbar laminectomy. Prone positioning of the patient had lead to cranial migration of the bullet at L4 level which was confirmed on fluoroscopy. Laminectomy had to be extended upwards with the patient in reverse Trendelenburg position for bullet removal.
Conclusions Caudal migration of the bullet within the lumbosacral subarachnoid space results in cauda equina syndrome. Surgical retrieval of the bullet ensures the early recovery of neurological symptoms. Prone patient positioning can influence bullet location. Intraoperative fluoroscopy prior to skin incision is essential in addition to preoperative imaging to locate the bullet and thus avoid incorrect lower level laminectomy. Trapping the bullet after durotomy using suction and dissector in reverse Trendelenburg position is a useful aid in bullet removal.

Keywords Spinal bullet · Intrathecal bullet · Migratory bullet · Spine trauma · Cauda equina syndrome

Introduction

Gunshot injuries to the spine though not commonly encountered can result in range of neurological deficit depending on the location and extent of bullet impact [1, 2]. Migration of bullet within the spinal subarachnoid space resulting in appearance of new onset or progressive neurological symptoms is quite rare. We present the case of 32-year-old male who suffered abdominal gunshot injury with migratory intrathecal lumbosacral bullet leading to appearance of cauda equina syndrome.

Case history

A 32-year-old gentleman suffered a homicidal gunshot injury to the abdomen. On arrival in the emergency department 24 h after sustaining gunshot injury, he was

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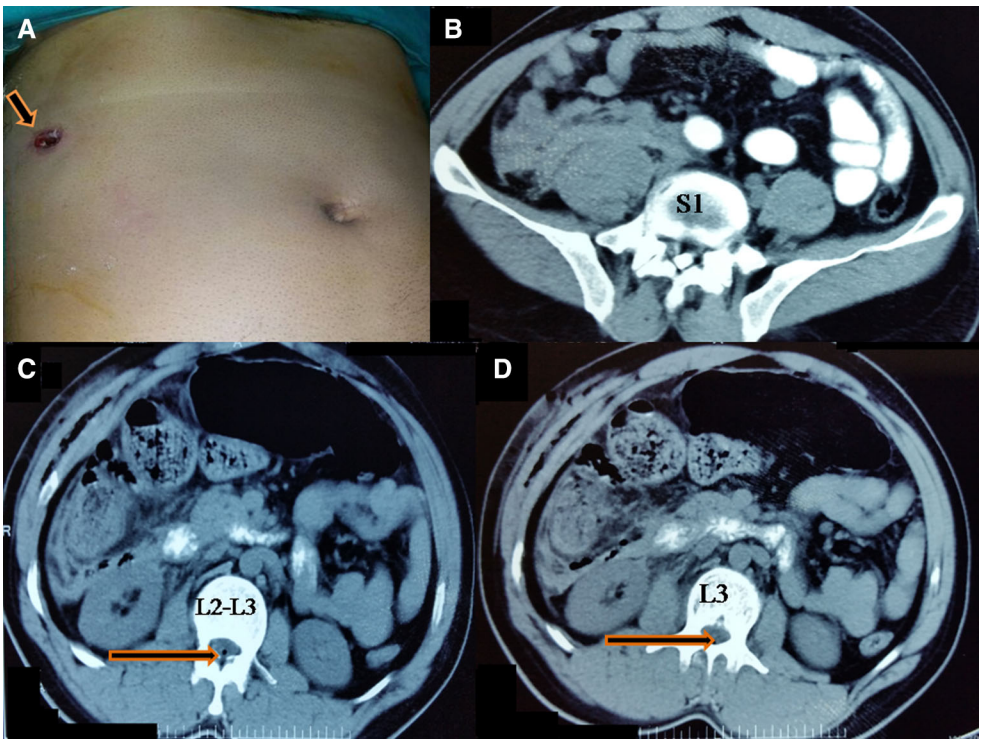

Fig. 1 Entry point of the bullet noted below the right costal margin (**a**). Computed tomography (CT) of the abdomen reveals the bullet lodged behind the body of S1 vertebrae (**b**). Loculi of air were seen within the spinal canal at the level of *L2–L3* vertebral body which suggested the probable entry point in the canal (**c**, **d**)

conscious but appeared pale. His pulse rate was 120/min and BP was 90/70 mmHg. His abdomen was distended and tender. Entry point of the bullet was noted below the right costal margin (Fig. 1a). No exit wound was seen. He complained of paresthesias in both feet and radiating pain along both the thighs. Neurological examination revealed loss of sensation in bilateral L5, S1 dermatome, and perianal region. The anal tone was lax with absent bulbocavernosus reflex. After the initial resuscitation, contrast enhanced computed tomography (CT) of the abdomen was performed which revealed pneumoperitoneum probably due to colonic perforation and associated retroperitoneal hematoma. The right psoas muscle appeared bulky. The bullet was seen lodged behind the body of S1 vertebrae (Fig. 1b). Loculi of air were seen within the spinal canal at the level of L2–L3 vertebral body which suggested the probable entry point in the canal (Fig. 1c, d). On exploratory laparotomy, ascending colonic perforation with massive fecal peritonitis was noted. A right hemicolectomy with ileotransverse anastomosis and drainage of the retroperitoneal hematoma was performed. The bullet tract could not be traced intraoperatively due to significant fecal contamination. X-ray of the lumbosacral spine done on third postoperative day revealed the bullet lying behind the S1 vertebral body (Fig. 2a, b). Upper sacral laminectomy was performed the next day. However, the bullet could not be located at S1 level. The position of the bullet was located using fluoroscopy. On intraoperative fluoroscopy, it was evident that the bullet had migrated upwards behind the body of L4. The laminectomy was extended upwards. Reverse Trendelenburg position was given to prevent further upward migration of the bullet. On durotomy, the bullet was seen lying within the lumbosacral nerve roots. No dural rent was seen at L5-S1 level anteriorly. With the suction placed in left hand at the upper end of the bullet to prevent further upward migration, the bullet was removed with a dissector in right hand without any injury to the nerve roots (Fig. 2c). Water tight dural closure was performed using No 5-0 prolene. Broad spectrum antibiotic coverage (Piperacillin and Tazobactum 4.5 g three times a day iv, Metronidazole 500 mg three times a day iv, and Amikacin 750 mg once a day im) was given for a period of 7 days. On follow-up, he had relief of paresthesia in both feet and improvement in perianal numbness, and had regained bowel continence. X-ray of the lumbosacral spine done reveals the extent of laminectomy (Fig. 2d).

Discussion

Gunshot injuries to the spine account for 13–17% of all spinal cord injuries each year [2]. Gunshot injuries to the spine though uncommon can result in serious neurological deficit [3, 4]. Hyperkinetic projectiles after entering body

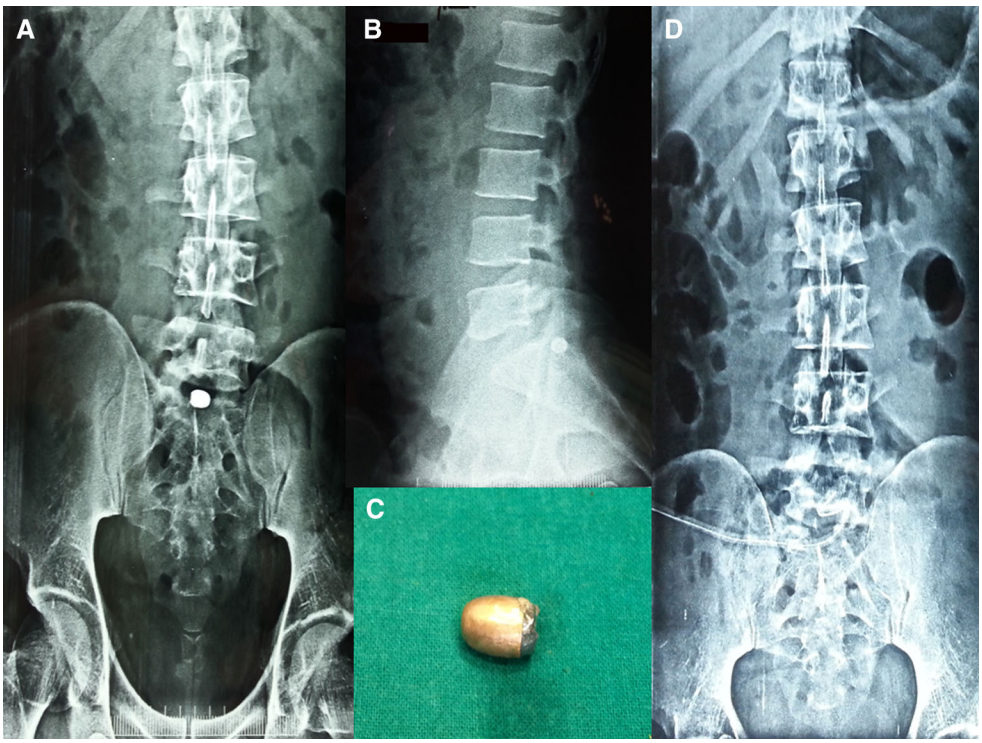

Fig. 2 X-ray of the lumbosacral spine done on third postoperative day revealed the bullet lying behind the S1 vertebral body (**a**, **b**). The bullet after retrieval (**c**). X-ray of the lumbosacral spine reveals the extent of laminectomy (**d**)

cavity travel in straight line exiting on the other side. Sometimes, these projectiles, following dissipation of energy, get lodged within the body cavity or spinal canal [5, 6]. These projectiles cause significant damage to surrounding tissue along the track due to dissipation of both thermal and kinetic injury [7].

Most gunshot injuries cause acute neurological symptoms once the bullet gets lodged intrathecally. The extent of neurological symptoms depends on the site of bullet impact. Very rarely spinal gunshot injury does not cause any neurological deficit [8–10]. However, uncommonly neurological symptoms may occur months to years later after suffering gunshot injury [11–15]. Delayed presentation of neurological symptoms is likely to be due to migration of the bullet intrathecally within the spinal canal [7, 16, 17]. It could also be due to formation of reactive epidural fibrosis around the impacted bullet in the absence of migration [2, 14]. Migration of the bullet within the lumbosacral spinal subarachnoid space is caudally [1, 4, 18]. This caudal migration is aided by gravity, respiration, and physiological cerebrospinal fluid (CSF) circulation, thereby allowing the bullet to migrate away from the conus, inferiorly at the narrowest tapering point of sacral canal, thereby trapping the bullet at this narrowest point [1, 11, 19, 20]. Cephalad migration is prevented by natural narrowing of the spinal canal at D10 level and above D10 [1, 6, 9, 11, 18, 20, 21]. However, few cases with caudal migration of the bullet from the cranium, cervical, or upper thoracic region to lumbosacral region have been reported [6, 8, 11, 16, 18, 19, 22]. The appearance of cauda equina syndrome correlates with this downward migration [5]. Cephalad migration of the bullet within the lumbosacral canal can occur during surgery due to prone patient positioning [5, 23]. Prone position of the patient during laminectomy brings the spinal canal at L3–L4 level to lowest level, thereby causing cranial migration of the bullet [17]. Patient position during surgery can thus influence the location of bullet [7, 23]. Failure to locate the cranially migrated bullet by intraoperative fluoroscopy after patient positioning could lead to incorrect lower level laminectomy [1, 5, 17, 23, 24].

Management of gunshot wound to the spine is a topic of considerable debate [3, 10, 25]. Surgical treatment needs to be individualised taking into consideration patient hemodynamic factors, associated injuries, extent of neurological injury, and location of the bullet [10]. Proponents of conservative treatment cite neurological recovery without removing the bullet [12, 18, 19, 26]. Jeffery et al. reported a 16-year-old male who was asymptomatic for 18 years following gunshot injury to the spine [12]. Rajan et al. described migration of bullet from C1 level to T6 level and then subsequently to S2 level over period of 3 years in 24-year-old male [19]. Proponents of surgical therapy advocate the early removal of bullet in the presence or

Table 1 Summary of all cases of migratory spinal bullet reported in literature including the treatment modality used and outcome measures

Authors	Year	Age/sex	Primary entry point	Entry point in spine	Initial location of bullet in spine	Intraop location of bullet	Pre treatment neurological status	Treatment	Surgical findings	Post treatment neurological status
Arasil [22]	1982	22/F	Cranium	–	C4	C4	Lhermittes sign	C3–C4 laminectomy	–	Complete recovery
Young [8]	1993	19/F	Cranium	–	C5	–	Asymptomatic	C5–C6 laminectomy	–	No change
Tanguy [11]	1982	10/M	Cervical spine	C6	C6	S2	No neurological deficit initially Meningitis 3 months later	Conservative initially, S1–S2 laminectomy 3 months later	–	Complete recovery
Rawlinson [26]	2007	16/M	Cervical Spine	C3	T1–T2	–	Quadriplegia	Conservative	–	Partial recovery
Castillo Rangel [15]	2010	36/F	Cranium	–	T4 over 27 years	T4	Quadriplegia, T4 sensory loss	T4 laminectomy, T3 and T5 hemilaminectomy	–	Partial recovery
Rajan [19]	1997	24/M	Right mastoid	C1	T6 to S2 over 3 years	–	Mild weakness of (L) upper limb, right foot hypoesthesia	Conservative	–	Complete recovery
Hunt [35]	2012	24/M	Thoracic spine	T8–T9	T9-T10	–	Paraplegia, sensory level at D8	Conservative	–	Partial recovery
Tekavcic [32]	1996	21/M	Cervical Spine	C6	T10	T10	Paraplegia, wrist flexon weak	C6–T4 and T9–T10 laminectomy	Dural tear at both sites. Dural tear was replaced by lyophilised dura.	No change
Ben [7]	2008	14/F	Lumbar spine	L3	L3 to S1, S1 to L3 and finally T12	Head end elevation lead to bullet migration to L5-S1	Radiculopathy	L5–S1 laminotomy	–	Complete recovery
Moon [30]	2008	50/M	Lumbar spine	L3	L2	L2	Backache, bilateral leg pain, right gastrocnemius, right extensor hallucis weakness, bladder, bowel incontinence	Initially conservative, later L2–L3 laminotomy	–	Partial recovery
Ruy [14]	2015	30/M	Abdomen	Probably T12–L1	L2–L3	L2-L3	Neurogenic claudication after 1 year	L3 laminectomy	–	Complete recovery
Koban [9]	2016	29/M	Abdomen	L2	L3	L3	No deficit	L3/partial L2 laminectomy	No CSF fistula	–
Kerin [16]	1983	17/M	Cranium	–	L4	L4	(R) hemiparesis, hemianesthesia, perianal pain, urinary hesitancy	L4 laminectomy	–	Recovery of perianal pain, urinary hesitancy
Karim [21]	1986	18/M	Abdomen	T11–T12	L4–L5	L4-L5	(L) leg pain, (L) foot drop, low backache	Hemilaminectomy	Dura intact	Complete recovery

Table 1 continued

Authors	Year	Age/sex	Primary entry point	Entry point in spine	Initial location of bullet in spine	Intraop location of bullet	Pre treatment neurological status	Treatment	Surgical findings	Post treatment neurological status
Conway [13]	1993	35/M	Abdomen	–	L4–L5	L4-L5	Cauda equina after 9 years	L4–L5 laminectomy	Dura intact, reactive fibrosis	Near complete recovery
Singh [23]	2007	20/M	Lumbar spine	L5	L4–L5	L2. Head end elevation lead to bullet migration at L3-L4	Backache, left foot numbness	L3–L4 laminectomy	–	Complete recovery
Farrugia [20]	2010	22/M	Chest	T12–L1	L5–S1	S1	Right ankle dorsiflexion weak, right foot numbness	–	Autopsy–Dural tear at T12 and epidural hematoma and lacerate cauda equina	Died during thoracotomy and laprotomy
Ghori [37]	2014	35/M	Thoracolumbar spine	T12–L1	L5–S1	L5-S1	No deficit initially, cauda equina 15 months later	L5 laminectomy	–	Complete recovery
Present case	2016	32/M	Abdomen	L2–L3	S1	L4-L5	Paresthesias in both feet, radiculopathy, loss of sensation in bilateral L5, S1 dermatome, perianal sensory loss, lax anal tone	L4-S1 laminectomy	No dural tear or CSF fistula	Complete recovery
Yip [6]	1990	17/M	Thoracic spine	T7	S1	S1	Paresthesias in both feet, diminished perianal sensation	S1 laminectomy	–	Partial recovery
Avci [17]	1995	30/F	Abdomen	–	S1	L4	S1 hypoesthesia, loss of Achilles reflex, plantar flexion weak	L4–S1 laminectomy	Dura intact at L4 and S1 level. No CSF fistula at both sites	Complete recovery
Gupta [5]	1999	25/M	Chest	–	S1	L3. Head end elevation lead to bullet migrating to L5	Radicular symptoms, bilateral foot drop, urinary retention, S1-S4 hypoesthesia	L5–S2 laminectomy	–	Complete recovery
Chan [24]	2015	27/M	Lumbar spine	L2	S1	L4-L5	Bilateral foot drop and bilateral reduced sensation in S2 to S4 dermatome 48 h later	L5 laminectomy	–	Complete recovery
Soges [27]	1988	27/M	Abdomen	T11–T12	S1–S2	Migrated upwards	Loss of sensation (L) leg, urinary urgency, perianal anesthesia	Sacral laminectomy	–	Complete recovery
Bordon [28]	2014	27/M	Lumbar spine	L2–L3	S1–S2	L5	Hypoesthesia in perianal area and inside of both thighs, no muscle weakness, normal sphincters	L5–S1 laminotomy	–	Complete recovery

Table 1 continued

Authors	Year	Age/sex	Primary entry point	Entry point in spine	Initial location of bullet in spine	Intraop location of bullet	Pre treatment neurological status	Treatment	Surgical findings	Post treatment neurological status
Oktem [18]	1995	20/M	Chest	T6	S2	–	Paraplegia	Conservative	Dural tear at T6 level with no spinal cord injury on postmortem examination	No change
Kafadar [29]	2006	44/M	Abdomen	L1	S2	S2	Paraplegia	S1–S2 laminectomy	Dura was greyish black at S2	Partial recovery
Cagavi [1]	2007	28/M	Abdomen	L3	S2	S2	Paraparesis, anesthesia below L3, loss of anal tone	L3 and S2 laminectomy	Dural tear at L3. Dura closed using fascial graft	Partial recovery of paraparesis, recovery of anal tone
Jun [4]	2010	42/M	Abdomen	L1	S2	S2	Cauda equina syndrome	L1, S2 laminectomy	Bone fragments in the canal at L1	Near complete recovery

absence of neurological symptoms [1, 3–5, 7, 10, 16, 17, 21, 22, 24, 27–30]. The early bullet retrieval is advocated to prevent worsening or appearance of new neurological symptoms due to bullet migration, meningitis, reactionary epidural fibrosis, long-term effects of lead toxicity, and risk of dystrophic intramedullary calcification [24, 30, 31]. Patients in whom surgical retrieval of bullet was performed had partial to complete recovery of neurological symptoms [4, 13–15, 17, 29]. The early removal of bullet from the lumbosacral canal facilitates recovery from neurological symptoms as axons in this region have ability to regenerate [3, 24]. Only in one case reported by Young et al., removal of the bullet did not result in neurological recovery [8].

Cagavi et al. described spontaneous caudal migration of bullet from L3 to S2 level with symptoms of cauda equina syndrome. Surgical removal of the bullet leads to partial improvement of neurological status [1]. Tanguy et al. advocated removal of caudally migrated bullet following the occurrence of meningitis 3 months after gunshot injury [11]. One of the absolute indications for surgical retrieval of bullet is presence of CSF fistula with subsequent risk of meningitis [31, 32]. Bullets made of copper or nickel, which are likely to cause sterile intraspinal abscess or granuloma and hence merit removal [24, 32]. Waters et al. reported no significant alteration in infection rates if the spinal bullet was not removed [33]. Lead intoxication or plumbism is a rare sequela following retained spinal bullet. Risk of lead poisoning depends on several variables, including the location of the bullet, the duration for which the bullet is exposed to body fluid, mass, and surface area of bullet. Bullets located near the facet joints or intervertebral disc space are more likely to result in plumbism [31, 32]. Bullets located within the joint space are in constant contact with synovial fluid with no fibrous capsule around it [31, 34]. This results in absorption of solubilised lead in bloodstream causing symptoms. Bullets located in the spinal subarachnoid space are in contact with CSF. As CSF has less corrosive power than synovial fluid, the effects of plumbism are unlikely to occur [24, 34]. Retained spinal bullet can lead to worsening of neurological symptoms in the absence of migration due to development of reactive collagenous mass or dystrophic calcification [2, 35]. Ajmal et al. reported two patients who presented with delayed neurological symptoms 14 years and 5 months after gunshot injury due to formation of fibrous tissue around the retained bullet [2]. Hunt et al. described the development of myelopathy in 24-year-old male due to intramedullary dystrophic calcification following retained bullet [35]. Table 1 summarises all the cases of migratory spinal bullet reported in literature including the treatment modality used and outcome measures [1, 4–9, 11, 13–22, 24, 26–28, 35–37].

The present case is unique in certain ways. Location of the bullet in the lumbar spinal canal intradurally following its entry from the right flank through the retroperitoneum is rare. The probable entry point into the spinal canal was at L2–L3 level. Caudal migration of the bullet at S1 level resulted in appearance of cauda equina syndrome. Surgical retrieval of the bullet was performed to ensure the early recovery of neurological symptoms. Intraoperative fluoroscopy prior to skin incision is essential in addition to preoperative imaging to locate the bullet and thus avoid incorrect lower level laminectomy. The authors also demonstrate the technique for removal of bullet. Trapping the bullet after durotomy using suction and dissector in reverse Trendelenburg position is a useful aid in bullet removal.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

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