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Intraspinal Bullet Migration: A Rare Case Report

İntraspinal Mermi Migrasyonu: Nadir Bir Olgu Sunumu

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ABSTRACT

Bullet migration is rarely reported in the literature. Herein we represent a case of penetrating gunshot injury with bullet migration from thoracic T7 spine to T10. A 34-year-old man was admitted to the emergency department with a gunshot wound on his left shoulder without an exit wound. He was paraplegic. Left hemopneumothorax and humeral fractures were detected on radiological examination. So far, the number of cases with migration is 30, including ours. Treatment is complex and still controversial. All spinal gunshot injuries should be treated as elective cases unless there are life-threatening or other major organ injuries requiring immediate surgery.

Keywords: Intraspinal, bullet, migration

ÖZ

Literatürde mermi migrasyonu nadiren bildirilmiştir. Burada torakal T7 omurgadan T10'a mermi migrasyonu olan penetran ateşli silah yaralanması olgusunu sunuyoruz. Otuz dört yaşındaki erkek hasta çıkış deliği olmadan sol omzunda vurularak acil servise başvurdu. Paraplejikti. Sol hemopnömotoraks ve humerus kırığı radyolojik incelemede görüldü. Şimdiye kadar, olgu sayısı bizimki de dahil olmak üzere otuzdur. Tedavisi karmaşıktır ve hala tartışmalıdır. Yaşamı tehdit eden veya acil ameliyat gerektiren diğer önemli organ yaralanmaları olmadığı sürece tüm spinal ateşli silah elektif olgu olarak tedavi edilmelidir.

Anahtar Kelimeler: İntraspinal, mermi, migrasyonu

Introduction

Spinal gunshot injury (GSI) is a devastating event with severe morbidity and mortality. The expected lifelong healthcare cost for a 25-year-old patient with tetraplegia is more than $4.5 million per patient in 2011, even if labor loss is not involved. Although initially it was regarded as only a type of military injury, its frequency has increased with the increased use of civilian firearms, especially in urban areas. It is the third most common cause of spinal trauma after traffic accidents and falls from height. However, when only the downtown area is taken into consideration, it ranks the second following falls from the height. In the last decade, an increase in spinal cord trauma has been observed in injuries caused by explosions especially in the military zones. This situation seems to be increasing. Of all the victims, one fourth are men and the incidence is highest in the third decade (1). Thoracic injuries range from simple superficial injuries to life-threatening injuries. A penetrating bullet generally follows a straight trajectory in the body. It may either exit the body or trap inside a tissue. The incidence of gunshot injuries that perforate and trap within the spinal canal is quite low, and migration of a bullet through the spinal canal is rarely reported in the literature (2,3). Herein we present a case of a penetrating GSI of the thoracic spine at T7 with the migration of the bullet within the spinal canal to T10.

Case Report

A 34-year-old man was admitted to our emergency department with chest pain and shortness of breath due to the penetrating GSI. During his first consultation, his general condition was as follows: unconscious, uncooperative, oriented, BP: 77/48 mmHg, heart rate: 166/min, body temperature: 37.4 ^{o}C and saturation: 88% without oxygen. Vital signs were consistent with hypovolemic shock. He was pale and sleepy. On his first physical examination, there was a round entrance wound, 9x6 mm in size with clot which was over the left shoulder without an exit wound (Figure 1 Red arrow). There was limited emphysema in the subcutaneous soft tissues of the left lateral chest wall, the left lung was less involved in respiration, and decreased breathing sound was heard in the upper

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zone of the left hemithorax. The patient was paraplegic with complete loss of sensation below the T4 segment. His poor general status and unstable vital signs allowed limited radiological screening. Chest X-ray was unremarkable. However, contrast-enhanced chest computed tomography (CT) scan demonstrated a subcutaneous emphysema in the lateral wall of the left hemithorax, left hemopneumothorax with a maximum thickness of 30 mm in the left hemithorax, a fractured left humerus, a possible bullet trajectory from the left lung upper lobe posterior, hyperdense consolidation in lower lobe superior and basal segments (Figure 1 White arrows) and bullet entrance at the left inferolateral border of T7 vertebral body into the spinal canal (Figure 2 White Arrow). Bone fragments were also observed in the spinal canal. The bullet migrated inferiorly to the T10 vertebral level (Figure 3). A left tube thoracostomy was performed for hemopneumothorax at emergency room settings. At first, air and more than 1500 cc blood were drained after chest tube insertion. Therefore, the patient underwent an immediate left thoracotomy due to hemothorax and a posterior thoracic laminectomy following a trauma study. The bullet was not removed, the wound tract was irrigated and the dura was tightly closed (Figure 4 White arrow). He was kept intubated in the intensive care unit under sedation for two days postoperatively. No postoperative complication was observed. The patient was discharged on the 9th day of hospitalization and transferred to a rehabilitation unit. The patient's recovery was uneventful except for paraplegia. Two years after the surgery, the patient had no neurological impairment. Written informed consent was obtained from the patient for publishing the individual medical records.

Discussion

GSI of the spine are mainly caused by suicides, accidents, and assaults. They account for 13-17% of all spinal cord injuries each year (2). The

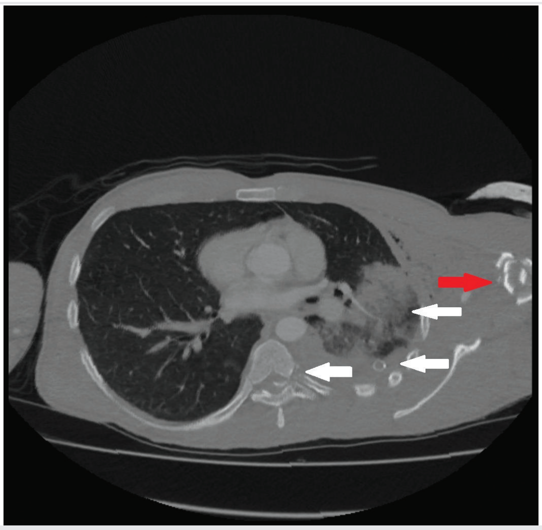

Figure 1. Axial computed tomography scan demonstrates fracture of the left humerus (red arrow), left hemopneumothorax, chest tube and possible trajectory of bullet in the upper lobe (white arrows)

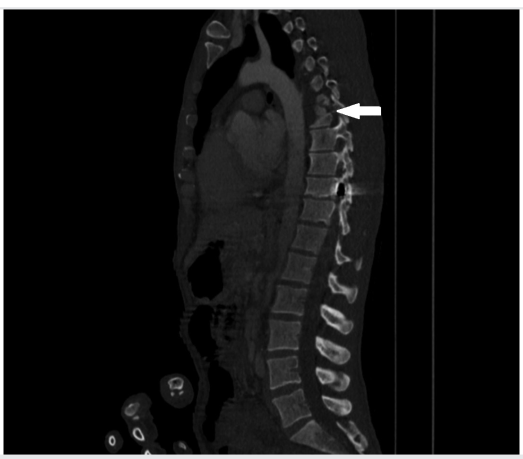

Figure 2. Sagittal computed tomography scan demonstrates the entrance of the bullet from the left inferolateral border of T7 vertebral body (white arrow) and intracanalicular bone fragments

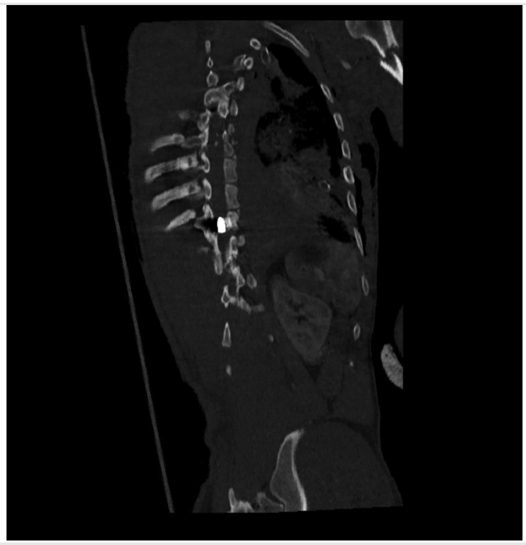

Figure 3. Sagittal computed tomography scan shows the bullet lodged within the spinal canal at T10 level

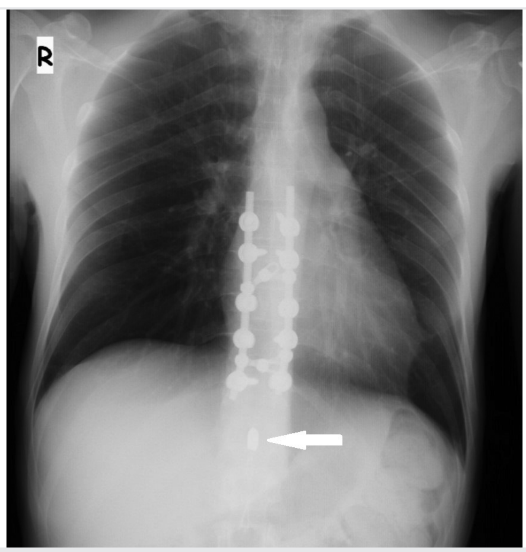

Figure 4. Patient's postoperative X-ray showing the bullet located at T10 level (white arrow)

most common site is thoracic spine (66%), followed by lumbar spine (17%) and cervical spine (6%). Approximately 40% of the patients are shot from the back and 19% are shot in the chest. In thoracic vertebrae, the canal/cord ratio is less than that of the lumbar spine and cervical spine, so the bullet is more destructive in the thoracic region than in other spine levels. In most reported cases, the migration is directed caudally. It has been observed that migration typically occurs between T10 and first sacral vertebra, as the relative narrowing of the spinal canal above the level of T10 is considered a primary factor in limiting the migratory distance and direction. It can result in varying degrees of severe and structural neurological deficit including infections, radiculopathy, paralysis, hydrocephalus, and Lhermitte's sign depending on the site of bullet impact (2). Bullets cause significant damage to the surrounding tissue along the trajectory due to the dispersion of both thermal and kinetic injury. The weapons with a velocity higher than 609.6 m/s are called high-energy bullets, whereas those with a velocity lower than 457.2 m/s are called low-energy bullets. Our case includes an injury due to a low-energy bullet. As in our case, low-energy bullets have different types of wounds. The types of damage include laceration, penetration, crushing/contusion and a temporary cavity for a shorter term. As described in the literature, our patient had a bullet trajectory showing linear extension from the left upper to the lower lobe in the anterior-posterior plane (Figure 1). The bullet passed through the thorax and stopped at the T10 vertebral level (4). As in our case, weapons with low energy in civilian use are much more different than those used in military. Low-energy or civilian GSI almost always causes direct contact or injury due to vertebral fractures that further increase existing damage, while high-energy or military weapons can cause cord injury leading to paralysis with the spread of high energy through the soft tissue and massive necrosis of the cord. In the literature, 49-83% of patients had a complete injury, 12-43% had an incomplete injury and 17-20% had cauda equina injury (5-7).

Intraspinal gunshot wounds and consequential damage are difficult to assess only with symptoms. Further radiological techniques should be employed to better identify the damage. The radiological examination, usually with conventional direct X-ray and non-contrast-enhanced CTs, is often used to locate the bullet and to detect bone fractures or fragments. Although magnetic resonance imaging (MRI) has advantages and is preferred in all spinal examinations, its use is controversial due to the possibility of bullet migration with a strong magnetic attraction, which may cause more soft tissue or neurological damage in GSIs. Todnem et al. (6) used MRI for an intraspinal bullet and showed that the MRI could be safely used in GSIs with bullet from low-speed civil injuries where the bullet was coated with non-ferromagnetic metals such as copper. However, this does not apply to high-speed steel military GSIs. As in our case, ballistic data are often absent in medical settings and, like most; they need to be treated urgently. Therefore, the use of MRI is rare. We used contrast-enhanced thorax CT.

Although the migration of a bullet in the skull to the central nervous system is known since 1916, reports of bullet migration in the spinal canal are rare in the following several decades. In 1982, Tanguy and his colleagues published the first intraspinal bullet migration. There are a limited number of reports from the last 36 years describing intraspinal migration specifically. Since then, the number of cases increased from 14 in 2000 to 30 in 2018, including our case (Table 1) (3,6). Most reported cases were caudal and cephalad migration has been reported only in 4 cases (7).

Treatment is complex and still controversial. Some authorities advocate conservative treatment and others advocate surgery. While civil literature recommends conservative non-surgical treatment, surgery for for exploration and debridement of the wound and removal of the bullet is recommended in times of war. Differences in the pathophysiology of both injuries may cause this. Bumpass et al. and Yashon et al. recommend conservative therapy for low-speed injuries unless there is infection or persistent cerebrospinal fluid (CSF) leaks. Heiden et al. and Stauffer et al. have shown that surgical intervention, regardless of the type of injury, provides no additional benefit. Methylprednisolone has no further advantages.

Interestingly, despite the absence of clear guidelines for surgery, there is consensus on surgery in the presence of persistent CSF fistula and infection, neurological deterioration, severe pain, bullet migration, vertebral instability, and finally cauda equine syndrome. In the literature, the first one is the most crucial evidence for surgery. Even GSI is asymptomatic initially; it causes a robust fibrotic reaction and becomes symptomatic within a few years. The bullet and metals in the full metal jacket destroy the axons and myelin, and cause a significant amount of gliosis in the spinal cord tissue. This effect is higher in copper but less in lead. There is limited number of cases in the literature (1,3,6,7).

Surgical removal of an intraspinal bullet may be further complicated by positional migration during operation. The position of the patients may change the final location of the bullet at any time due to the gravitational forces, breathing movements or the physiological movements of the cerebrospinal fluid. In the literature, the period has been reported to continue up to 27 years after the injury (6). This difficult situation was solved by ultrasonography (US) in a recent article. The authors used an electric motor drill for L5 laminectomy to avoid the bracing effect of bone rongeur. If rongeur has a repulsive effect, it is more doubtful for an electric motor drill not to have a vibration to create a propelling effect (1). This situation needs discussion and verification.

Although injury gives rise to hemopneumothorax and spinal cord injury, we believe that the reason why death did not occur in our case was the fact that major vascular structures of the left lung were not affected. In our case, the bullet could not be removed. The bone fragments in the spinal cord were removed and dural tear was tightly closed to prevent leakage and infection. However, none of the complications mentioned above have been encountered so far. These should be checked at every possible stage during surgery. We believe that the use of US is beneficial in cases where conventional intraoperative radiology fails. However, we believe that this should be confirmed by case series.

Table 1. Summary of all cases of migrating spinal bullets reported in the literature, including the treatment modality used and outcome measures

Authors	Year	Age/gender	Primary entrance	The entry point in the spine	The initial location of the bullet in the spine	Intraoperative location of the bullet	Pre-treatment neurological status	Treatment	Surgical findings	Post-treatment neurological status
Arasil	1982	22/F	Cranium	-	C4	C4	Lhermitte's sign	C3-C4 laminectomy	-	Complete recovery
Tanguy	1982	10/M	Cervical spine	C6	C6	S2	No neurological deficit initially Meningitis 3 months later	Conservative initially, S1-S2 laminectomy Three months later	-	Complete recovery
Kerin	1983	17/M	Cranium	-	L4	L4	(R) hemiparesis, hemianesthesia, perianal pain, urinary hesitancy	L4 laminectomy	-	Recovery of perianal pain, urinary hesitancy
Karim	1986	18/M	Abdomen	T11-T12	L4-L5	L4-L5	(L) leg pain, (L) drop foot, low back pain	Hemilaminectomy	Dura intact	Complete recovery
Soges	1988	27/M	Abdomen	T11-12	S1-S2	Migrated upwards	Loss of sensation (L) in legs, urinary urgency, perianal anesthesia	Sacral laminectomy	-	Complete recovery
Yip	1990	17/M	Thoracic Spine	T7	S1	S1	Paresthesias in both feet diminished ,perianal sensation	S1 laminectomy	-	Partial recovery
Young	1993	19/F	Cranium	-	C5	-	Asymptomatic	C5-C6	-	No change laminectomy
Conway	1993	35/M	Abdomen	-	L4-L5	L4-L5	Cauda equina after nine years	L4-L5 laminectomy	Dura intact, reactive fibrosis	Near complete recovery
Avci	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
Oktem	1995	20/M	Chest	T6	S2	-	Paraplegia	Conservative	Dural tear at T6 level with no spinal cord injury on postmortem examination	No change
Tekavcic	1996	21/M	Cervical Spine	C6	T10	T10	Paraplegia, wrist flexion weak	C6-T4 and T9-T10 laminectomy	Dural tear at both sites. The dural tear was replaced by lyophilized dura.	No change
Rajan	1997	24/M	Right mastoid	C1	T6 to S2 over Three years	-	Mild weakness of (L) upper limb, right foot hypoesthesia	Conservative	-	Complete recovery
Gupta	1999	25/M	Chest	-	S1	L3. Head elevation lead bullet migration to L5	Radicular symptoms, bilateral foot drop, urinary retention, S1-S4 hypoesthesia	L5-S2 laminectomy	-	Complete recovery
Kafadar	2006	44/M	Abdomen	L1	S2	S2	Paraplegia	S1-S2 laminectomy	Dura was greyish black at S2	Partial recovery
Singh	2007	20/M	Lumbar spine	L5	L4-L5	L2. Head end elevation lead to bullet migration at L3-L4	A backache, left foot numbness	L3-L4 laminectomy	-	Complete recovery

Cagavi	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, improvement of anal tone
Rawlinson	2007	16/M	Cervical Spine	C3	T1-T2	-	Quadriplegia	Conservative	-	Partial recovery
Moon	2008	50/M	Lumbar spine	L3	L2	L2	A backache, bilateral leg pain, right gastrocnemius, right extensor hallucis weakness, bladder, bowel incontinence	Initially conservative, later L2-L3 laminotomy	-	Partial recovery
Ben	2008	14/F	Lumbar spine	L3	L3 to S1, S1 to L3 and finally T12	Head elevation lead to bullet migration to L5-S1	Radiculopathy	L5-S1 laminotomy	-	Complete recovery
Castillo Rangel	2010	36/F	Cranium	-	T4 over	T4	Quadriplegia, T4 sensory loss	T4 laminectomy,	-	Partial recovery
Jun	2010	42/M	Abdomen	L1	S2	S2	Cauda equina syndrome	L1, S2 laminectomy	Bone fragments in the canal at L1	Near complete recovery
Farrugia	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 laparotomy
Hunt	2012	24/M	Thoracic Spine	T8-T9	T9-T10	-	Paraplegia, the sensory level at D8	Conservative	-	Partial recovery
Ghori	2014	35/M	Thoracolumbar spine	T12-L1	L5-S1	L5-S1	No deficit initially, cauda equina 15 months later	L5 laminectomy	-	Complete recovery
Bordon	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
Ruy	2015	30/M	Abdomen	Probably T12-L1	L2-L3	L2-L3	Neurogenic claudication after one year	L3 laminectomy	-	Complete recovery
Chan	2015	27/M	Lumbar spine	L2	S1	L4-L5	Bilateral drop foot and bilateral reduced sensation in S2 to S4 dermatomes 48 h later	L5 laminectomyspine	-	Complete recovery
Koban	2016	29/M	Abdomen	L2	L3	L3	No deficit	L3/partial L2 laminectomy	No CSF fistula	-
Baldawa	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
Present case	2018	34/M	Chest	T4	T7	T10	Paraplegic with complete sensory loss below T4 segment	Thoracotomy and thoracic vertebra laminectomy	Bone fragments in the canal at T7	No change

Conclusion

The pathophysiology of GSI is complex. The critical factor that determines the amount of tissue damage depends on the amount of energy delivered to the affected tissues. Ballistics, whether the bullet is low-energy or high-energy, should be considered in treatment. Surgical indications should be clear. All GSI patients should be treated as elective cases unless there are other major organ injuries requiring immediate surgery. Surgery should be performed by a specialist team with the support of radiological imaging. Concomitant injuries further increase the complexity of the pathology. Treatment, especially surgical procedure, needs a multidisciplinary approach and should be individualized, thus considering hemodynamic factors, associated injuries, the extent of the neurological damage and the location of the bullet.

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