

Relationship of biological factors to survival in spinal gunshot injuries

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ABSTRACT

BACKGROUND: Gunshot injuries are the third leading cause of spinal injuries, after falls from a significant height and traffic accidents. Severity of spinal damage from gunshot injury depends upon certain mechanical and biological factors. The aim of the present study was to investigate the effect of biological factors on survival in cases of spinal gunshot injury.

METHODS: A total of 110 cases of spinal gunshot injury admitted multiple times to emergency services between 2012 and 2014 were included. Age, sex, region of trauma, additional organ or systemic involvement, treatment modalities (conservative, surgical), and mortality rates were analyzed. Effects of biological factors on survival were evaluated.

RESULTS: Mean age of the study population was 25.51 ± 11.74 years (min: 4; max: 55) and 95.5% of the population was male. Regions of trauma were thoracic in 50 (45.4%) subjects, cervical in 42 (38.2%), and lumbar in 18 (16.4%). Most common American Spinal Injury Association (ASIA) score was category A, as was found in 77 (70%) cases. No significant correlation was found among age, sex, ASIA score, treatment modality (conservative or surgical), and survival ($p > 0.05$). Additional organ or systemic injury was present in 66 (60%) patients. Additional organ or systemic injury significantly affected survival, independent of the spinal region of trauma ($p < 0.01$).

CONCLUSION: Spinal gunshot injuries are complex, with unclear treatment protocol. Irrespective of the indications of spinal surgery, additional organ injuries unfavorably affect survival in cases of spinal gunshot injury. Appropriate management of all biological factors directly affects mortality rate in cases of spinal gunshot injury.

Keywords: Biological factors; spinal gunshot injury; survival.

INTRODUCTION

Spinal gunshot injuries are the third most common cause of spinal injuries after falls from a significant height and traffic accidents.^[1] While incidence varies by region, involving political and ethnic factors, spinal gunshot injuries are responsible for 13–17% of all spinal injuries.^[2] Although some properties

may resemble those of other traumatic spinal injuries, certain principles of follow-up and therapy are dissimilar.

Severity of spinal gunshot injury depends upon certain mechanical and biological factors.^[3] Among these, mechanical factors include gunshot type, bullet or shrapnel velocity and size, bullet trajectory, and distance between target and firearm.^[3,4] Biological factors include vertebral level of injury (cervical, thoracic, or lumbar), vertebral column instability, dural tear/cerebrospinal fluid (CSF) leakage, metallic or bony fragments retained in the spinal canal, contaminated tissue within the canal, and presence of additional organ or systemic injuries.^[3] While mechanical factors are non-modifiable, well-organized management of biological factors positively contribute to survival. The aim of the present study was to explore the effects of biological factors on survival in cases of spinal gunshot injury.

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MATERIALS AND METHODS

A total of 110 patients admitted multiple times to emergency services following spinal gunshot injury between 2012 and 2014 were enrolled. Effects of age, sex, region of trauma, additional systemic injury, and treatment modality on survival were analyzed. Cases of pure spinal and/or additional organ injury were included.

Airway, breathing, and circulation were initially checked by emergency services, and were followed with detailed physical and neurological examination. Clothing was removed with care, and location of foreign body entry, and if present exit, was determined. No deep manual examination was performed through the entry and/or exit holes (particularly in cases of abdominal injury). Additional systemic injuries accompanying spinal injury were evaluated by relevant consulting physicians. Appropriate radiological tests were performed once circulation and breathing were stabilized. Admission examination was scored according to the Medical Research

Council (MRC) Scale for Testing Muscle Strength, and neurological injury was scored using the American Spinal Injury Association (ASIA) scoring system.

In patients with primary injuries at cervical, thoracic, and lumbar levels (Figs. 1–3), exploration for additional injury was conducted due to the proximity of primary injury to vital organs and systems. In the event of organ injury, the affected organ or system was primarily treated. After general stabilization, surgery was performed when 1 or more of the following conditions was present: incomplete injury, progressive neurological deficit, foreign body (bullet or shrapnel) in the spinal canal compressing the structures or with potential to migrate, biomechanically instability, or CSF leakage that did not improve with conservative therapy (Table 1).

Effects of biological factors (vertebral column instability, CSF leakage, metallic or bony fragments retained in the spinal canal, contaminated tissue inside the spinal canal, and presence of additional visceral organ injury) on survival were explored.

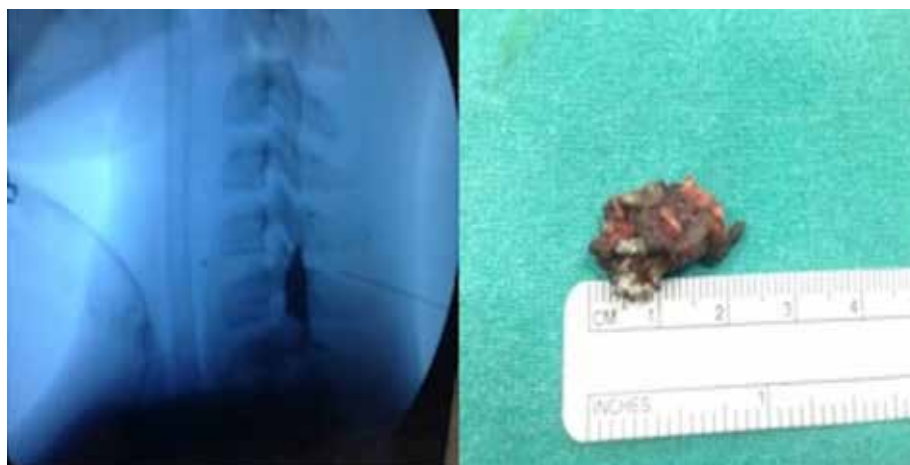


Figure 1. Radiological and gross appearance of shrapnel fragment with intramedullary location compressing the cord at the C7-Th1 level.

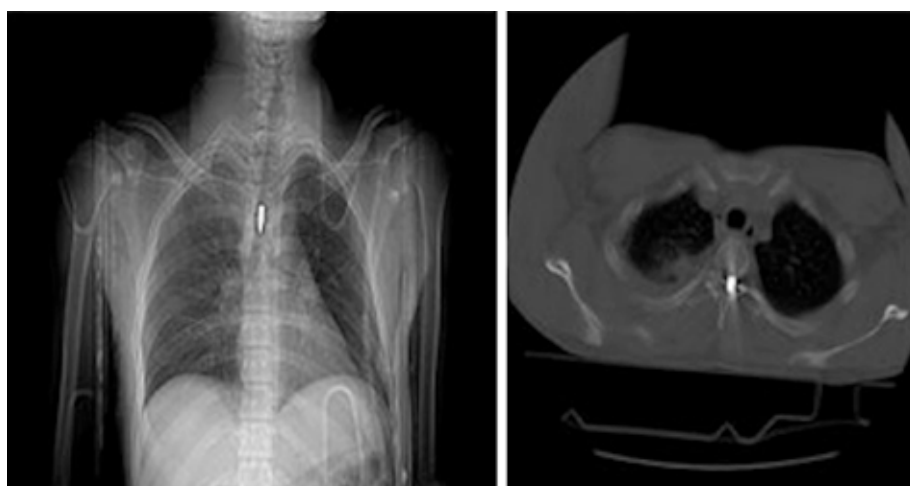


Figure 2. Scenographic and axial-section computed tomographic images of a bullet in the thoracic region of the spinal canal.

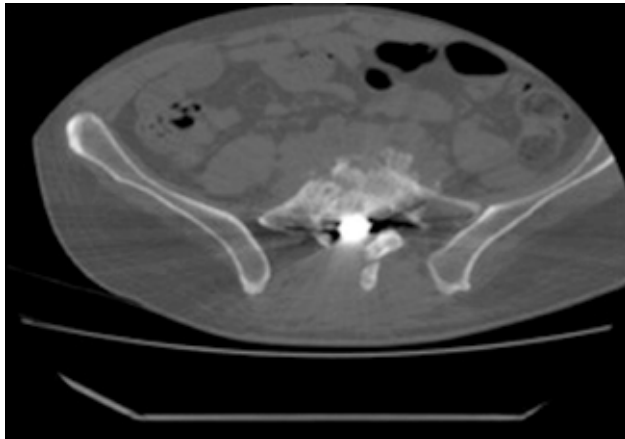


Figure 3. Shrapnel fragment in the spinal canal at the S-1 level.

Study data were analyzed using SPSS software (version 16.0; SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov test was used to test normalcy of descriptive statistics (mean, SD). Chi-square test was used to compare data. Factors affecting mortality and morbidity were determined by logistic regression analysis. Results were evaluated with a confidence interval of 95%, and a p value of less than 0.05 was considered statistically significant.

RESULTS

Mean age was 25.51 ± 11.74 years (min: 4; max: 55), and 95.5% of the population was male. Regions of trauma were thoracic in 50 (45.4%) subjects, cervical in 42 (38.2%), and lumbar in 18 (16.4%). ASIA score was most frequently category A, as was determined in 77 (70%) patients. Age, sex, ASIA score, and treatment modality (conservative or surgical) were not significantly correlated with survival ($p > 0.05$) (Table 2).

Additional organ or systemic injuries were present in addition to spinal injury in 58 (52.7%) patients (Tables 2, 3). Regardless of cervical, thoracic, or lumbar region of these injuries, it was detected that additional organ or systemic injuries significantly affected survival ($p < 0.01$). Among 66 patients who underwent conservative management, additional systemic and/or organ injury was found in 35, and 18 (51.4%) died during treatment ($p < 0.05$). Of the 44 patients managed surgically, additional systemic and/or organ injury was found in 23 patients, and 9 (39.13%) died (Table 3).

Nine (23.8%) patients with cervical injury underwent surgery. Two cases of vertebral artery injury were treated with embolization, 1 of whom died of cerebellar ischemia. Two of 3 patients with esophageal injury died of mediastinitis (Table 4). Twenty-four (48%) patients with thoracic injury underwent surgery. The majority of patients with additional organ or systemic injuries ($n=35$, 70%) had thoracic vertebral injuries, owing to proximity of abdominal and thoracic organs. Thoracic traumas were generally managed with tube thoracostomy, while thoracotomy was used when necessary. Relevant

Table 1. Criteria for surgical management in spinal gunshot injuries

	Cervical	Thoracic	Lumbar
Decompression in incomplete injury	2	4	–
Progressive neurological deficit	2	6	1
Mass effect or presence of foreign material with risk of migration in the canal or			
medulla spinalis	2	5	4
CSF fistula	1	3	1
Instability	2	6	5
Total	9	24	11

Table 2. Age, sex, American Spinal Injury Association score, and treatment modality (surgery or conservative management) did not significantly affect the survival rate in the general study population ($p > 0.05$)

	n	%
Sex		
Male	105	95.5
Female	5	4.5
Spinal trauma region		
Cervical	42	38.2
Thoracic	50	45.4
Lumbar	18	16.4
American Spinal Injury Association		
A	77	70
C	9	8.1
D	18	16.4
E	6	5.5
Additional injury		
Yes	58	52.7
No	52	47.3
Treatment modality		
Surgery	44	40.0
Conservative	66	60.0
Mortality		
Alive	75	68.2
Dead	35	31.8

organ repairs were conducted by members of the general surgery department, particularly in cases of abdominal injury (Table 5).

Eleven (61.1%) patients with lumbar injuries underwent sur-

Table 3. Distribution of the patients according to the treatment modality and additional organ- system injuries. Additional organ injuries significantly increased the mortality rate in surgically and conservatively managed patient groups ($p<0.01$)

	Additional injury in conservatively managed patients (n=66)		Additional injury in surgically managed patients (n=44)	
	Yes	No	Yes	No
Cervical (n=42)	13 (died:10)	20 (died:3)	3 (died:3)	6 (died:1)
Thoracic (n=50)	17 (died:6)	9 (died:3)	18 (died:5)	6 (died:1)
Lumbar (n=18)	5 (died:2)	2	2 (died:1)	9
Total	35 (died:18)	31 (died:6)	23 (died:9)	21 (died:2)

Table 4. Additional organ injuries and their outcomes in cervical injuries

	n	Treatment modality	Mortality	Cause of mortality
Vertebral artery injury	2	Embolization	1	Cerebellar ischemia
Tracheal injury	1	Surgical repair	1	Pneumonia
Esophageal rupture	3	Primary Repair	2	Mediastinitis
Hemopneumothorax	10	Tube thoracostomy	6	Pneumonia and sepsis
Total	16*		10*	

*Additional injury was significantly effective on mortality ($p<0.01$).

Table 5. Additional organ injuries and their outcomes in thoracic injuries

	n	Treatment modality	Mortality	Cause of mortality
Brachial plexus injury	1	Conservative		–
Cerebral edema + contusion	3	Antiedema therapy	3	Cerebral herniation, pneumonia
Hemopneumothorax	18	Tube thoracostomy	5	Sepsis, Pneumonia
Intraabdominal and thoracic injury	7	Surgical repair	3	Sepsis, Pneumonia
Intraabdominal organ injury	6	Primary repair	3	Sepsis, Intraabdominal infection
Total	35*		14*	

*Additional injury was significantly effective on mortality ($p<0.01$).

Table 6. Additional organ injuries and their outcomes in lumbar injuries

	n	Treatment modality	Mortality	Cause of mortality
Lumbar plexus injury	1	Conservative	–	–
Intraabdominal organ injury	5	Surgical repair	2	Sepsis, intraabdominal infection
Iliac artery and vein injury	1	Surgical repair	1	Hypovolemia and DIC
Total	7*		3*	

*Additional injury was significantly effective on mortality ($p<0.01$).

gery. Seven (38.8%) patients in this group had additional organ injury. Gastrointestinal systemic injuries were surgically managed. One patient with iliac artery and vein injury died of hypovolemia and disseminated intravascular coagulopathy,

in spite of surgical intervention (Table 6). Spinal infection and intraabdominal infection was detected in 6 patients with thoracic and lumbar injuries, 5 of whom died in spite of surgical drainage and wide-spectrum antibiotics.

As patients admitted to study centers were from foreign countries, and returned to their country of origin following medical care, no long-term follow-up data were available.

DISCUSSION

Spinal gunshot injury is most frequently observed in the thoracic region, followed by the lumbar and cervical regions,^[4,5] as a larger area of the thoracic region. This may be due to the thoracic region being a select target in military combat. Rates of mortality in cervical region injuries is reportedly higher due to concomitant vertebral artery injury and respiratory dysfunction.^[6-9] Spinal injuries were presently most commonly located in the thoracic region, (45.4%) followed by the cervical region (38.2%) and the lumbar region (16.4%). Cervical injuries were associated with the highest number of deaths (n=17). Thirteen of these patients had additional organ injuries, including vertebral artery, tracheal, and esophageal injuries, which significantly affected the mortality rate. Fifteen (30%) patients with thoracic injury died, 11 of whom also had thoracic and lung injuries. Three (16.6%) patients with lumbar injury died of intraabdominal organ injury and/or diffuse infection. Additional injuries seem to have led to significantly increased mortality in injuries of all 3 regions. (p<0.01).

Infectious complications including empyema, spinal abscess, intraabdominal sepsis, psoas abscess, subcutaneous abscess, and acute infection of bullet trajectory may occur after spinal gunshot injuries.^[10] Lower extremity pain syndrome or new neurological deficits may occur as a result of arachnoiditis.^[3] Septic complications of lumbar region injuries are more common than thoracic and cervical injuries, because a bullet usually crosses the gastrointestinal system.^[11,12] Romanick et al. reported that early bullet removal prevented infectious complications, particularly in cases with abdominal injury.^[13] Venger et al. reported a higher contamination rate in cases with bullet removal in bronchial and hollow organ injuries.^[14] Spinal infections were presently particularly observed in 6 patients with thoracic and lumbar region injuries accompanying intraabdominal injuries. Five patients died from diffuse intraabdominal infection, while 1 patient was treated with abscess drainage, irrigation drains, and wide-spectrum antibiotics.

The role of surgical therapy in spinal gunshot injuries is controversial. To date, many researchers have reported that surgical therapy had no benefit for neurological recovery in cases with complete neurological deficit without instability. However, laminectomy performed within 24–48 hours is recommended in cases with partial neurological deficit or, particularly, cauda equina syndrome, secondary to a bony or metallic fragment in the canal. Absolute indications for surgery include cutaneous or pleural CSF fistulae and progressive neurological deficit with radiologically demonstrable neural compression. The other indication for surgery is instability due to spinal fracture, which is observed in 10% of cases.^[15] These were accepted as criteria for surgical therapy in patients surgically managed.

Spinal gunshot injuries are usually biomechanically stable.^[16] Isiklar et al.^[17] and le Roux et al.^[18] reported instability rates of 10% and 12%, respectively. It has been reported that acute or chronic instability may develop in transverse fractures crossing the vertebral facet and pedicle in the lumbar region.^[19] In the present study, Denis' 3-column theory was used for instability evaluation.^[20] One of 42 cervical injuries was managed by anterior stabilization (due to disrupted corpus integrity), and another was managed by posterior stabilization. Thoracic injuries are more stable, due to the costotransverse joint and thoracic cage, while the cervical and lumbar regions are more prone to biomechanical instability.^[3,18] Six cases of 50 with thoracic vertebral injury underwent surgery due to instability. These predominantly occurred with facet or pedicle fracture at more than 1 level of the thoracolumbar junction. Five of 18 cases with lumbar injury underwent surgery due to instability. The present instability rate at all regions was 11.8%.

Dural injury and CSF leakage are significant risk factors for meningitis.^[3] It has been reported that a lumbar subarachnoid drain after laminectomy, in addition to a primary dural repair, or repair with a dural graft, benefits dural repair in patients with persistent CSF leakage.^[21] An external lumbar drainage catheter was implemented in 5 patients with persistent CSF leakage, in spite of dural repair, and in 7 patients who were conservatively followed. CSF leakage was brought under control by placement of a lumbar drainage system in all cases.

In cases of spinal gunshot injury, spinal cord injury directly occurs as a result of bullet heat and pressure. However, low-energy injuries may also lead to neural injury, due to spinal cord or nerve root compression by metallic fragments or fractured bony parts. A retained bullet in the spinal canal may lead to delayed neurological signs and symptoms, depending on reactive changes around the bullet.^[21,22] Rarely, spinal canal compression by a disc fragment may occur following bullet-induced nucleus pulposus injury.^[3,23] It is presently believed that neurological injury occurred due to spinal cord compression by bullet or shrapnel, thermal effect, direct injury to spinal cord, or bony fragments in the spinal cord. Risk of bullet migration within the spinal canal was present in the lumbar region.^[24-26] Surgery was conducted on 1 patient for cauda equina syndrome, which developed 2 days after an L2 gunshot injury.

Conclusion

Spinal gunshot injuries are complex, with unclear treatment protocol. Criteria for surgical intervention include incomplete neurological deficit, CSF fistula, mechanical instability, risk of foreign material migration within the canal, and bullet intoxication. Irrespective of the indications of spinal surgery, additional organ injuries unfavorably affect survival in spinal gunshot injuries. Thus, appropriate addressing and management of biological factors directly affect mortality in cases of spinal gunshot injury.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - ÖZET

Spinal ateşli silah yaralanmasında biyolojik faktörlerin sağkalımla ilişkisi

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AMAÇ: Ateşli silah yaralanmaları yüksekten düşme ve trafik kazasına bağlı yaralanmalardan sonra, spinal yaralanmaların en sık üçüncü nedenidir. Ateşli silah yaralanmasına bağlı spinal hasarın şiddeti ateşli silaha bağlı mekanik faktörler ve biyolojik faktörlere bağlıdır. Bu çalışmada, omurga ve/veya omurilik yaralanması bulunan ateşli silah yaralanmalarında biyolojik faktörlerin sağkalım üzerine etkileri değerlendirildi.

GEREÇ VE YÖNTEM: 2012–2014 yılları arasında çoklu merkez acil servislerine getirilen spinal ateşli silah yaralanması olan 110 olgu çalışmaya alındı. Hastaların yaş, cinsiyet, travma bölgesi, ek organ ve sistem yaralanma olması, tedavi şekilleri (konservatif, cerrahi), mortalite durumları incelendi. Biyolojik faktörlerin sağkalım üzerine olan etkileri değerlendirildi.

BULGULAR: Çalışmamıza alınan 110 olgunun yaş ortalaması 25.51±11.74 yıl (minimum: 4; maksimum: 55) olup, hastaların %95.5'i erkekti. Hastaların yaralanma bölgelerine göre dağılımında; torakal 50 (%45.4), servikal 42 (%38.2) ve lomber 18 (%16.4) idi. ASIA skoru 77 (%70) olgu ile en sık A kategorisinde idi. Yaş cinsiyet, ASIA skorunun ve tedavi şeklinin (konservatif veya cerrahi), survey üzerine etkili olmadığı görüldü (p>0.05). Hastaların 58'inde (%52.7) spinal yaralanmaya ek organ ve sistem yaralanması tespit edildi. Spinal bölge ayırımı bakılmaksızın ek organ ve sistem yaralanmalarının sağkalım üzerinde istatistiksel olarak anlamlı etkisi olduğu saptandı (p<0.01).

TARTIŞMA: Spinal ateşli silah yaralanmaları kompleks bir yaralanmadır ve tedavi protokolleri tartışmalıdır. Spinal ateşli silah yaralanmasında spinal cerrahi endikasyonundan bağımsız olarak ek organ yaralanması sağkalımı olumsuz etkilemektedir. Bu nedenle biyolojik faktörlerin iyi yönetilmesi mortalite üzerinde doğrudan etkilidir.

Anahtar sözcükler: Biyolojik faktörler; spinal ateşli silah yaralanması; survey.

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