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Research Paper

# Outcomes and Complications of Incomplete Spinal Cord Injury in the Thoracolumbar Region

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## ABSTRACT

**Background and Aim:** Improvement of neurological disorders in patients with incomplete spinal cord injury (SCI) remains an important issue worldwide. This study aimed to explore the outcomes and complications of patients with incomplete SCI in the thoracolumbar region within one year after trauma.

**Methods and Materials/Patients:** In this longitudinal prospective study, patients with traumatic incomplete SCI were studied. The demographic and clinical variables including age, sex, site of injury, motor force, sensory disorder, and sphincter dysfunction were recorded on admission and 3, 6, 9, and 12 months after discharge. SPSS software, version 28 was used for data analysis.

**Results:** Out of 120 patients with incomplete SCI, 100 patients were included. The mean age of the participants was 32.39±7.47 years and the mean duration of hospitalization was 14.78±3.81 days. The most common injury site was T12-L1 (43%). Over time, the average motor force of patients increased. The lowest and highest averages were observed during hospitalization and 12 months after discharge, respectively. No significant difference was observed in the paired comparison of motor force at 3, 6, 9, and 12 months after discharge. The frequency of sensory disorders decreased over time. The highest and lowest frequencies belonged to the hospitalization time (81%) and 12 months after discharge (9%). No significant difference was observed between the time intervals of 6, 9, and 12 months, as well as the time of hospitalization and discharge. Over time, the frequency of sphincter dysfunction decreased. Pulmonary infection (12%) and bed sores (9%) were the complications observed during hospitalization. Complications observed 12 months after admission were bed sores (21%) and venous thrombosis (17%).

**Conclusion:** The highest recovery rate of motor force was recorded within the first three months. The frequency of sensory and sphincter disturbances in patients decreased over time with the highest recovery rate during the first six months after the injury.

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## Highlights

- The average force of patients with incomplete spinal cord injury increased over time, with the highest recovery rate during the first three months.
- The frequency of sensory disturbances and sphincter dysfunction in patients decreased over time.
- Pulmonary infection and bed sores were the most complications observed in patients during hospitalization.

## Plain Language Summary

Spinal cord injury is one of the leading causes of disability which significantly impacts patients and the health care system. Neurological problems such as paralysis, loss of sensation and sphincter dysfunction may occur after spinal cord injury, predisposing patients to complications like lung infection and bedsores. In this study, we found that the motor force of patients improved, and sensory disturbance and sphincter dysfunction decreased over time. Lung infection and bed sores were the most observed complications during hospitalization, and after 12 months, bed sores and venous thrombosis were the most common. The highest improvement in motor force was recorded within the first three months. The highest recovery rate of sensory disorders and sphincter dysfunction was observed within the first six months after the injury. Considering the limited data about outcomes and complications of incomplete spinal cord injury in developing countries such as Iran, our study can provide useful information to clinicians and injured people.

## Introduction

Spinal Cord Injury (SCI) is a debilitating neurological condition with a tremendous socioeconomic impact on the injured and the health care system [1]. This complication is one of the main causes of disability, especially among the youth with a great impact on Years Lived with Disability (YLD) [2]. The global incidence of traumatic Spinal Cord Injury (TSI) is about 10.5 cases per 100,000 people [3]. Thoracolumbar spine trauma is the most common area of fracture in the spine [4, 5]. Thoracic and lumbar fractures account for approximately 50% of spinal nerve injuries [6]. This part of the spine is more exposed to pressure than other areas [7]. The most common mechanisms of injuries in this area include motor vehicle accidents, falling, and recreational and work-related injuries, most of which are high-velocity/high-energy traumas leading to additional damages [8]. Spinal cord injury can cause pain, paralysis, spasm, loss of sensation, urinary and fecal incontinence, predisposing patients to pneumonia, sepsis, urinary tract infections, pressure ulcers, and heart disorders [9, 10]. The clinical outcome of SCI depends on the severity and site of the lesion and may include incomplete or complete loss of sensory and/or motor function below the level of injury [11]. In traumatic SCI, primary cell damage occurs, followed by complex secondary damages that cause neuronal and glial cell death, ischemia, and inflammation in a circular manner [9]. Today, much emphasis has been placed on the golden time, where early and simple interventions in the immediate post-injury phase are essential to improve long-term outcomes [1]. Initial stabilization of the spine improves respiratory function and shortens the duration of mechanical ventilation, resulting in a shorter Intensive Care Unit (ICU) stay in patients with thoracolumbar fractures. The surgical strategy in these patients is based on spinal decompression, osteosynthesis, and fracture reduction [6]. One study found that 67% of fractures involved the chest or lower back. Moreover, 30% of patients had multiple fractures and 28% had neurological disorders. The study concluded that despite advances in its management using minimally invasive surgical techniques and achieving good sagittal balance, spinal trauma can still cause significant complications [12]. The likelihood of improvement of these complications varies from person to person and depends on various factors such as the patient's initial condition, the type of injury, the type and location of the vertebral fracture, and the patient's age. Complete spinal cord injury, old age, chest fractures, and fractures associated with dislocations can generally make recovery more difficult [13, 14]. Between 5% to 20% of patients who develop complete SCI after injury, recover completely [13]. Various clinical factors affect the outcome of these patients. Some of these factors are well known, such as hypertension and the patient's age, while some are not well studied. Generally, the quality of evidence is

low, requiring more randomized and controlled studies to confirm the results [15]. Given that studies related to investigating spinal cord injuries are very limited, especially in developing countries [16, 17], this study aimed to evaluate the outcomes and complications of incomplete spinal cord injury in the thoracolumbar region within one year after trauma in patients admitted to Poursina Educational and Medical Center in Rasht, Iran.

## Methods and Materials/Patients

This study was performed in a longitudinal prospective design to investigate the outcomes and complications of incomplete spinal cord injury after trauma. The study population consisted of patients with incomplete spinal cord injuries in the thoracolumbar region who were referred to Poursina Hospital from 2019 to 2021. All patients with traumatic incomplete spinal cord lesions in the thoracolumbar region who were candidates for surgery were eligible for our study. Patients with concomitant traumatic brain injury, severe loss of consciousness during hospitalization, loss of baseline ASIA (American Spinal Injury Association Impairment Scale) scores, and non-cooperative patients were not included in the study.

After the patients were admitted to the neurosurgery ward, a complete history of motor, sensory, and sphincter complaints was taken by a neurosurgery resident. Then the patients underwent a complete neurological examination (motor, sensory, and sphincter).

All demographic characteristics and medical information of the patients were recorded in a database including age, sex, location of spinal cord injury, preoperative and follow-up ASIA scores [18] (Appendix 1), preoperative and follow-up sphincter examinations (voluntary contractions using rectal examination), preoperative and follow-up sensory examinations (superficial touch and pinprick test), treatment and surgery protocol, waiting time for surgery, and imaging findings. All patients received preoperative steroid therapy. They were assessed during hospitalization and followed up for 12 months after discharge for any complications such as bed sores, lung infections, DVT (Deep vein thrombosis), and joint contracture. The required information was recorded in a database. The primary measurement of outcomes including change in motor force, sensory examination, and sphincter function was performed using the ASIA classification, at admission, discharge, and intervals of 3, 6, 9, and 12 months after discharge. Follow-up visits were performed in the Imam Reza Clinic of the Hospital. In order to provide more interpretable results, the ASIA score was grouped based on neural manifestations so that a motor force of 0.5 in the absence of sensation and movement was graded A and only a slight sensation was graded B. Forces 1.5 and 2.5 were graded C, forces 3.5 and 4.5 were graded D, and 5.5 was graded E.

All follow-up assessments were performed by the same neurosurgery resident who administered the initial examination and was not involved in the treatment of the patients. To reduce any potential bias, data analysis was performed by another researcher who did not perform any examinations.

### Statistical analysis

All data were entered into SPSS software version 28 (SPSS Inc. Chicago, II, The USA). Descriptive statistics were expressed as mean, standard deviation, frequency, and percentage. The normality of the data was assessed using the Shapiro-Wilk test, Kurtosis, and skewness. Next, the homogeneity of variance of the studied groups was evaluated using Levene's test. To analyze the research data, according to the relevant hypotheses for quantitative variables, repeated measures with Greenhouse-Geisser correction were used. Bonferroni correction was employed for pairwise comparisons. Cochran's Q test with McNemar was used with Bonferroni correction for pair comparisons of qualitative variables. The significance level was considered 0.05 in all tests.

All patients expressed their consent to participate in the study. The present study was performed after obtaining approval from the ethics committee of Guilan University of Medical Sciences, Rasht, Iran (Code: IR.GUMS.REC.1398.394).

## Results

Out of 120 patients with incomplete spinal cord injury during the study period, 15 did not meet the eligibility criteria. Of the 115 eligible cases, 2 declined to participate and 3 did not complete the follow-up assessments, leaving 100 participants in the final data analysis (70 men and 30 women). The Mean±SD age of the patients was 32.39±7.47 years (ranging from 18 to 65 years). The mean duration of hospitalization was 14.78±3.81 days (ranging from 8 to 26 days) and the mean waiting time for surgery was 20.18±4.50 hours (ranging from 10 to 31 hours). The most common site of injury was T12-L1 (n=43, 43%), followed by L1-L2 (18%), L3-L4 (13%), T1-T2 (10%), T8-T9 (9%), and L4-L5 (7%).

### Treatment data

Patients underwent surgery less than 48 hours after admission. Surgical procedures included screw fixation and decompression (laminectomy and decompression of the spinal canal).

### Follow-up visit data

Table 1 shows the mean force of patients with incomplete spinal cord injury using the ASIA score during hospitalization, at discharge, and 3, 6, 9, and 12 months after discharge. According to the obtained results, the average force increases over time. The highest mean was observed 12 months after discharge and the lowest mean belonged to the hospitalization time.

Table 2 shows the frequency of sensory impairment and sphincter dysfunction in patients with incomplete spinal cord injury using the ASIA score during hospitalization, at discharge, and 3, 6, 9, and 12 months after discharge. According to the results, the frequency of sensory disturbances and sphincter dysfunction decreases over time. The highest frequency of sensory impairment was related to admission time (n=81, 81%). The lowest rate belonged to 12 months after discharge (n=9, 9%). Investigations further revealed that 51 patients (51%) had sphincter dysfunction during hospitalization and discharge, while only 3 patients (3%) suffered sphincter disorder 12 months after discharge.

**Table 1.** Mean force of patients with incomplete spinal cord injury during hospitalization, at discharge, 3, 6, 9, and 12 months after discharge

| Time | % | | | | | |
|---|---|---|---|---|---|---|
| | Zero | One-fifths | Two-fifths | Three-fifths | Four-fifths | Five-fifths |
| 1 | 2 | 7 | 13 | 7 | 1 | 70 |
| 2 | 1 | 1 | 5 | 14 | 5 | 74 |
| 3 | 1 | 1 | 1 | 3 | 17 | 77 |
| 4 | 0 | 1 | 1 | 1 | 20 | 77 |
| 5 | 0 | 1 | 1 | 1 | 18 | 79 |
| 6 | 0 | 0 | 1 | 2 | 16 | 81 |

1: during hospitalization, 2: during discharge, 3: 3 months later, 4: 6 months later, 5: 9 months later, 6: 12 months later

**Table 2.** Frequency of sensory disorder in patients with incomplete SCI during hospitalization, during discharge, 3, 6, 9, and 12 months after discharge

| Time | No. (%) | | | |
|---|---|---|---|---|
| | Sensory disorder | | Sphincter disorder | |
| | Absent | Present | Absent | Present |
| 1 | 19(19) | 81(81) | 49(49) | 51(51) |
| 2 | 31(31) | 69(69) | 49(49) | 51(51) |
| 3 | 51(51) | 49(49) | 80(80) | 20(20) |
| 4 | 76(76) | 24(24) | 88(88) | 12(12) |
| 5 | 90(90) | 10(10) | 95(95) | 5(5) |
| 6 | 91(91) | 9(9) | 97(97) | 3(3) |

**Table 3.** Comparison of the average force of patients with incomplete spinal cord injury in the investigated times

| Time | % | | | | | | Test statistic | Significance |
|---|---|---|---|---|---|---|---|---|
| | Zero | One-fifths | Two-fifths | Three-fifths | Four-fifths | Five-fifths | | |
| 1 | 2 | 7 | 13 | 7 | 1 | 70 | 34.51 | 0.001> |
| 2 | 1 | 1 | 5 | 14 | 5 | 74 | | |
| 3 | 1 | 1 | 1 | 3 | 17 | 77 | | |
| 4 | 0 | 1 | 1 | 1 | 20 | 77 | | |
| 5 | 0 | 1 | 1 | 1 | 18 | 79 | | |
| 6 | 0 | 0 | 1 | 2 | 16 | 81 | | |

Repeated measures with Greenhouse- Geisser correction

Table 3 compares the mean force of patients with incomplete spinal cord injury at different times. The results showed that the trend of changes over time was increasing and significant (P<0.001). Furthermore, based on the results obtained from the two-by-two comparisons between 3, 6, 9, and 12 months after discharge, no significant difference was observed for the force variable. As shown in Table 4, other pairwise comparisons were significant. The results of comparing the frequency of sensory impairment and sphincter dysfunction in participants are summarized in Table 5.

Table 6 shows the pairwise comparison of times for the variables of sensory disorder and sphincter dysfunction. Based on the results obtained in sensory disorder, no significant difference was observed between 6, 9, and 12 months and also between hospitalization and discharge time. Similarly, no significant difference was found in sphincter dysfunction at 6, 9, and 12 months after injury, as well as between hospitalization and discharge and between 3 months and 6 months. Other pairwise comparisons were significant (P<0.001).

Pulmonary infection (12%) and bed sores (9%) were the complications observed during hospitalization. Complications observed 12 months after admission were bed sores (21%) and venous thrombosis (17%). None of the participants showed joint contracture during the study period.

## Discussion

The rate of incomplete to complete spinal cord injuries has been increasing in the last half century [19]. Research has shown that patients who undergo surgery are more likely to improve neurological disorders than those who prefer conservative methods [20]. However, this does not mean complete recovery of neurological disorders in these patients. Only one study investigated the incidence of sensory, motor, and bladder disorders in patients with incomplete spinal lesions after surgi-

**Table 4.** Comparison of the average force of patients with incomplete SCI

| Time | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - |
| 2 | <0.001 | - | - | - | - | - |
| 3 | <0.001 | <0.001 | - | - | - | - |
| 4 | <0.001 | <0.001 | 0.999 | - | - | - |
| 5 | <0.001 | <0.001 | 0.203 | 0.999 | - | - |
| 6 | <0.001 | <0.001 | 0.160 | 0.369 | 0.999 | - |

**Table 5.** Summary of the results of comparing the frequency of sensory impairment and sphincter dysfunction in patients with incomplete spinal cord injury

| Time | Sensory impairment | | Statistic test | Significance | Sphincter disorder | | Statistic test | Significance |
|---|---|---|---|---|---|---|---|---|
| | Absent | Present | 246.65 | 0.001 | Absent | Present | 188.03 | <0.001 |
| 1 | 19(19) | 81(81) | - | - | 49(49) | 51(51) | - | - |
| 2 | 31(31) | 69(69) | - | - | 49(49) | 51(51) | - | - |
| 3 | 51(51) | 49(49) | - | - | 80(80) | 20(20) | - | - |
| 4 | 76(76) | 24(24) | - | - | 88(88) | 12(12) | - | - |
| 5 | 90(90) | 10(10) | - | - | 95(95) | 5(5) | - | - |
| 6 | 91(91) | 9(9) | - | - | 97(97) | 3(3) | - | - |

Cochran's Q Test

**Table 6.** Two-to-two comparison between times for sensory disorder and sphincter disorder in patients with incomplete SCI

| Time | Sensory Disorder | | | | | | Sphincter Disorder | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | 0.786 | - | - | - | - | - | 0.999 | - | - | - | - | - |
| 3 | <0.001 | 0.018 | - | - | - | - | <0.001 | <0.001 | - | - | - | - |
| 4 | <0.001 | <0.001 | 0.001 | - | - | - | <0.001 | <0.001 | 0.999 | - | - | - |
| 5 | <0.001 | <0.001 | <0.001 | 0.354 | - | - | <0.001 | <0.001 | 0.047 | 0.999 | - | - |
| 6 | <0.001 | <0.001 | <0.001 | 0.230 | 0.999 | - | <0.001 | <0.001 | 0.012 | 0.999 | 0.999 | - |

McNemar test with Bonferroni correction

cal or non-surgical treatment in Iran. Therefore, this study investigated the outcomes and complications in patients with incomplete spinal cord injury within one year after trauma. The mean age of patients was 32.39 ±7.47 years. In a study by Rahimi-Movghar et al., the most common age range of patients with spinal cord injury was 20-40 years [21], which is consistent with the results of our study. In the review study by Tee et al., the mean age of the subjects was 50.9 years. They found that three age groups had the highest prevalence; over 75 years, 16-25 years, and 46-55 years, respectively [22]. The difference in this distribution can be due to the high number of road accidents in Iran, which are more common among young and middle-aged people, while in developed countries the age range of patients with spinal cord injury is higher, probably due to higher life expectancy and high rate of falling in the elderly [23].

According to the results, most patients were male. Geuther et al. explained that men were more affected by spinal cord trauma than women [24]. In a study on spinal cord injuries in Kashan province, 21.5% of people were women and 78.5% were men, and the male-to-female ratio was 3.7 to 1 [25]. Another study in Canada reported a male-to-female ratio of 4.4 to 1 [26]. The results of these studies are in line with the results of our study. These findings may be due to men's higher level of social activity.

Based on the results of the present research, T12-L1 and L1-L5 were the most common sites of injury. The least involved region was L4-L5. In a study conducted by Safaei et al. in 2008 in Poursina Hospital, the distribution of injuries in the neck, thoracic and lumbar areas were 11.9, 33.9, and 54.6%, respectively [27]. A study in Australia stated a higher prevalence of lumbosacral

involvement [22]. The results of all these studies are compatible with the findings of the present work. In addition, a common complication of the study participants observed both at admission and during the one-year follow-up period was bed sore. Recent estimates of the prevalence of pressure ulcers during hospitalization vary. The results of a systematic review performed in 2016, including 14 studies conducted in Iran with a sample size of 5973 people, showed that the prevalence of bed sores in Iran is 19% [28]. Another study estimated this rate between 4% and 16% in Iran [29]. In developed countries such as the United States, the prevalence rate of bed sores is between 10% to 30% [30, 31]. The results of these studies are consistent with those of our investigation. Acupressure treatment can cost billions of dollars [32] and may even lead to death in some cases [33]. It is recommended that health policymakers plan to reduce the incidence of bed sores.

The present study disclosed that the mean motor force of patients increased over time, which mostly improved in the first three months after injury. Chan et al.'s study on the functional prognosis of patients with spinal cord injury over one year in China also demonstrated that the rate of Functional Independence Measure (FIM) motor scores in the ASIA A / B / C paraplegic groups increased significantly during hospitalization as well as one month after discharge. In the paraplegia and ASIA D tetraplegia groups, the rate of FIM motor scores increased only during hospitalization and between the sixth and twelfth months after discharge [34]. Moreover, a 10-year follow-up of patients with spinal cord injury in Motiei-Langroudi et al.'s study suggested that motor function did not improve after trauma in any of the patients in grade A, while all patients classified in grades B and C improved by at least one degree. In addition, the rate of motor function improvement was higher in grade C patients [17]. According to the studies, the ASIA score in the early post-traumatic period is the most important criterion in predicting the patient's likelihood of motor rehabilitation [14]. In their study, Wichmann et al. also introduced the ASIA motor score as a predictor of performance in the follow-up [35].

This scoring system has established one of the most accepted and widely used classifications of SCI, classifying patients from A (complete motor and sensory impairment) to E (normal neurological status) [36]. In general, the rate of neurological rehabilitation has been reported to be low in patients with grade A disability, while this figure is as high as 65-75% in patients suffering incomplete injuries (levels C and D) [13, 14, 37]. Different results in improved motor function of patients in different studies can depend on the location of the injury and fracture or due to different injury mechanisms. For example, in the study by Motiei-Langroudi et al., the highest improvement was observed in lumbar vertebral fractures (L3 and lower) and the least improvement in thoracic vertebral fractures (T1-T10) [17]. In the present study, the relationship between the mechanism and the location of the injury with the recovery rate was not investigated as it was not one of the objectives of the study. Although community-based services, assistive technology, and an outpatient referral system are currently available for patients with spinal cord trauma in Guilan Province, further improvement of these policies would be beneficial for patients with spinal cord injuries to maximize their post-discharge function.

According to the obtained results, the frequency of sensory disorders decreases over time. The highest recovery rate of sensory complications was observed in the first six months after the accident. The study by Karamouzian et al. reported that 23.9% improved with grade A at the time of the earthquake and younger patients had better neurological outcomes [13]. The results of another study to evaluate atrophy and predict the outcome of the sensory system in patients with spinal cord injury revealed that at 12-month follow-up, sensory scores remained unchanged and neuropathic pain was more pronounced below the surface. Compared with the control group, patients showed progressive degenerative changes in the cervical cord and brain morphometry throughout the sensory system [38].

Based on the obtained results, the frequency of sphincter disorders decreased over time and the greatest improvement in patients' sphincter disorders was observed in the first six months after the accident. However, the results of urinary disorders in the study by Motiei-Langroudi et al. showed that 73.8% did not improve and complete recovery was observed in only 8.7%. They reported that the prognosis of patients with grades A and B was equally unfavorable considering the urinary disorders. A much better prognosis was observed in grade C patients (more than 85% chance of recovery) [17].

## Conclusion

Most patients with incomplete spinal cord injury were young, middle-aged, and male. The highest recovery rate of motor force occurred in the first three months, and the highest improvement of sensory and sphincter disorders occurred in the first six months after injury.

### Limitations

This study has several limitations. Patients included in this analysis were required to have follow-up neurological examinations, so those who did not participate were excluded from the study. This leads to a bias toward the natural history data presented here, although its exact impact is unknown. Exclusion rates are not reported here. The present study did not consider the effect of other variables on the motor, sensory, and sphincter disorders and their predictive power on outcomes. Despite the importance of the potential predictive power of these variables, examining their predictive value is beyond the scope of this article. Our study only included eligible patients admitted to one medical center in northern Iran which limits the generalization of our findings to all patients with spinal cord injuries.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by Guilan University of Medical Sciences (Code: IR.GUMS.REC.1398.394).

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### Authors' contributions

All authors equally contributed to preparing this article.

### Conflict of interest

The authors declared no conflict of interest.

## References

[1] Hachem LD, Ahuja CS, Fehlings MG. Assessment and management of acute spinal cord injury: From point of injury to rehabilitation. The Journal of Spinal Cord Medicine. 2017; 40(6):665-75. [DOI:10.1080/10790268.2017.1329076] [PMID] [PMCID]

[2] Hall OT, McGrath RP, Peterson MD, Chadd EH, DeVivo MJ, Heinemann AW, et al. The burden of traumatic spinal cord injury in the United States: disability-adjusted life years. Archives of Physical Medicine and Rehabilitation. 2019; 100(1):95-100. [DOI:10.1016/j.apmr.2018.08.179] [PMID]

[3] Kumar R, Lim J, Mekary RA, Rattani A, Dewan MC, Sharif SY, et al. Traumatic spinal injury: global epidemiology and worldwide volume. World Neurosurgery. 2018; 113:e345-e63. [DOI:10.1016/j.wneu.2018.02.033] [PMID]

[4] Wang H, Zhang Y, Xiang Q, Wang X, Li C, Xiong H, et al. Epidemiology of traumatic spinal fractures: experience from medical university-affiliated hospitals in Chongqing, China, 2001-2010. Journal of Neurosurgery: Spine. 2012; 17(5):459-68. [DOI:10.3171/2012.8.SPINE111003] [PMID]

[5] Liu B, Zhu Y, Liu S, Chen W, Zhang F, Zhang Y. National incidence of traumatic spinal fractures in China: Data from china national fracture study. Medicine. 2018; 97(35): e12190. [DOI:10.1097/MD.0000000000012190] [PMID] [PMCID]

[6] Charles Y, Steib JP. Management of thoracolumbar spine fractures with neurologic disorder. Orthopaedics & Traumatology: Surgery & Research. 2015; 101(1):S31-S40. [DOI:10.1016/j.otsr.2014.06.024] [PMID]

[7] Kim BG, Dan JM, Shin DE. Treatment of thoracolumbar fracture. Asian spine journal. 2015; 9(1):133. [DOI:10.4184/asj.2015.9.1.133] [PMID] [PMCID]

[8] Fernández-de Thomas RJ, De Jesus O. Thoracolumbar spine fracture. InStatPearls [Internet] 2021 Aug 30. StatPearls Publishing. [Link]

[9] Ahuja CS, Wilson JR, Nori S, Kotter M, Druschel C, Curt A, et al. Traumatic spinal cord injury. Nature Reviews Disease primers. 2017; 3(1):1-21. [DOI:10.1038/nrdp.2017.18] [PMID]

[10] Hagen EM. Acute complications of spinal cord injuries. World Journal of Orthopedics. 2015; 6(1):17. [DOI:10.5312/wjo.v6.i1.17] [PMID] [PMCID]

[11] Wilson JR, Cadotte DW, Fehlings MG. Clinical predictors of neurological outcome, functional status, and survival after traumatic spinal cord injury: a systematic review. Journal of Neurosurgery: Spine. 2012; 17(Suppl1):11-26. [DOI:10.3171/2012.4.AOSPINE1245] [PMID]

[12] Bouyer B, Vassal M, Zairi F, Dhenin A, Grelat M, Dubory A, et al. Surgery in vertebral fracture: epidemiology and functional and radiological results in a prospective series of 518 patients at 1 year's follow-up. Orthopaedics & Traumatology: Surgery & Research. 2015; 101(1):11-5. [DOI:10.1016/j.otsr.2014.11.012] [PMID]

[13] Karamouzian S, Saeid A, Ashraf GK, Ebrahiminezhad A, Dehghani MR, Asadi AR. The neurological outcome of spinal cord injured victims of the Bam earthquake, Kerman, Iran. Archives of Iranian Medicine. 2010; 13(4):351-4. [Link]

[14] Reinhold M, Knop C, Beisse R, Audige L, Kandziora F, Pizanis A, et al. Operative treatment of 733 patients with acute thoracolumbar spinal injuries: comprehensive results from the second, prospective, Internet-based multicenter study of the Spine Study Group of the German Association of Trauma Surgery. European Spine Journal. 2010; 19(10):1657-76. [DOI:10.1007/s00586-010-1451-5] [PMID] [PMCID]

[15] Costa F, Sharif S, Bajamal AH, Shaikh Y, Anania CD, Zileli M. Clinical and radiological factors affecting thoracolumbar fractures outcome: WFNS Spine Committee Recommendations. Neurospine. 2021; 18(4):693. [DOI:10.14245/ns.2142518.259] [PMID] [PMCID]

[16] Zileli M, Sharif S, Fornari M. Incidence and epidemiology of thoracolumbar spine fractures: WFNS Spine Committee recommendations. Neurospine. 2021; 18(4):704. [DOI:10.14245/ns.2142418.209]

[17] Motiei-Langroudi R, Sadeghian H. Traumatic spinal cord injury: long-term motor, sensory, and urinary outcomes. Asian Spine Journal. 2017; 11(3):412. [DOI:10.4184/asj.2017.11.3.412] [PMID] [PMCID]

[18] Kirshblum SC, Memmo P, Kim N, Campagnolo D, Millis S. Comparison of the revised 2000 American Spinal Injury Association classification standards with the 1996 guidelines. American Journal of Physical Medicine & Rehabilitation. 2002; 81(7):502-5. [DOI:10.1097/00002060-200207000-00006] [PMID]

[19] Sekhon LH, Fehlings MG. Epidemiology, demographics, and pathophysiology of acute spinal cord injury. Spine. 2001; 26(24S):S2-S12. [DOI:10.1097/00007632-200112151-00002] [PMID]

[20] Aito S, d'Andrea M, Werhagen L. Spinal cord injuries due to diving accidents. Spinal Cord. 2005; 43(2):109-16. [DOI:10.1038/sj.sc.3101695] [PMID]

[21] Rahimi-Movaghar V, Sayyah MK, Akbari H, Khorrami-rouz R, Rasouli MR, Moradi-Lakeh M, et al. Epidemiology of traumatic spinal cord injury in developing countries: a systematic review. Neuroepidemiology. 2013; 41(2):65-85. [DOI:10.1159/000350710] [PMID]

[22] Tee JW, Chan C, Fitzgerald M, Liew S, Rosenfeld J. Epidemiological trends of spine trauma: an Australian level 1 trauma centre study. Global Spine Journal. 2013; 3(2):075-84. [DOI:10.1055/s-0033-1337124] [PMID] [PMCID]

[23] Heidari P, Zarei MR, Rasouli MR, Alexander RV, Rahimi-Movaghar V. Spinal fractures resulting from traumatic injuries. Chinese Journal of Traumatology. 2010; 13(01):3-9. [Link]

[24] Geuther M, Grassner L, Mach O, Klein B, Högel F, Voth M, et al. Functional outcome after traumatic cervical spinal cord injury is superior in adolescents compared to adults. European Journal of Paediatric Neurology. 2019; 23(2):248-53. [DOI:10.1016/j.ejpn.2018.12.001] [PMID]

[25] Fakharian E, Tabesh H, Masoud SA. An epidemiologic study on spinal injuries in Kashan. Journal of Guilan University of Medical Sciences. 2004; 13(49):80-5. [Link]

[26] Lenehan B, Street J, Kwon BK, Noonan V, Zhang H, Fisher CG, et al. The epidemiology of traumatic spinal cord injury in British Columbia, Canada. Spine. 2012; 37(4):32E30. [DOI:10.1097/BRS.0b013e31822e5ff8] [PMID]

[27] Safaei MO, Dehnadi Moghadam A, Kamali GH. Spinal Fractures in Admitted Patients in Poursina Hospital. Journal of Guilan University of Medical Sciences. 2008; 17(66):38-43. [Link]

[28] Karimian M, Sarokhani D, Sarokhani M, Sayehmiri K, Mortazavi Tabatabai SA. Prevalence of bedsore in Iran: a systematic review and meta-analysis. Journal of Mazandaran University of Medical Sciences. 2016; 26(136):202-10. [Link]

[29] Soozani A, Raei M, Montazeri AS, Nasiri E, Hamidzadeh A, Pourheidari M. The effect of education on knowledge and performance of nurses in prevention and control of pressure sore. Modern Care Journal. 2012; 9(1). [Link]

[30] Amirifar S, Reza Masouleh S, Pourshikhian M, Monfared A, Kazemnejad Leili E. Predictive value of Braden Scale in pressure ulcer occurrence in hospitalized patients. Journal of Holistic Nursing and Midwifery. 2013; 23(2):8-15. [Link]

[31] Vincent JL, Abraham E, Kochanek P, Moore FA, Fink MP. Textbook of critical care e-book. Amesterdam: Elsevier Health Sciences; 2011. [Link]

[32] Azimiyan J. Assessing the topical high pressure oxygen therapy in healing of bedsore. The Journal of Qazvin University of Medical Sciences. 2010; 13(4):58-63. [Link]

[33] Lyder CH. Pressure ulcer prevention and management. Annual Review of Nursing Researc. 2002; 20:35-61. [DOI:10.1891/0739-6686.20.1.35] [PMID]

[34] Chan SCC, Chan APS. One-year follow-up of Chinese people with spinal cord injury: a preliminary study. The Journal of Spinal Cord Medicine. 2013; 36(1):12-23. [DOI:10.1179/1079026812Z.00000000059] [PMID] [PMCID]

[35] Wichmann TO, Jensen MH, Kasch H, Rasmussen MM. Early clinical predictors of functional recovery following traumatic spinal cord injury: a population-based study of 143 patients. Acta Neurochirurgica. 2021; 163(8):2289-96. [DOI:10.1007/s00701-020-04701-2] [PMID]

[36] Kirshblum SC, Burns SP, Biering-Sorensen F, Donovan W, Graves DE, Jha A, et al. International standards for neurological classification of spinal cord injury (revised 2011). The Journal of Spinal Cord Medicine. 2011; 34(6):535-46. [DOI:10.1179/204577211X13207446293695]

[37] Bravo P, Labarta C, Alcaraz M, Mendoza J, Verdu A. Outcome after vertebral fractures with neurological lesion treated either surgically or conservatively in Spain. Spinal Cord. 1993; 31(6):358-66. [DOI:10.1038/sc.1993.60] [PMID]

[38] Grabher P, Callaghan MF, Ashburner J, Weiskopf N, Thompson AJ, Curt A, et al. Tracking sensory system atrophy and outcome prediction in spinal cord injury. Annals of Neurology. 2015; 78(5):751-61. [DOI:10.1002/ana.24508] [PMID] [PMCID]