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Epidemiology of Cervical Spine Injuries Requiring Surgical Treatment in Plovdiv and Plovdiv Region, Bulgaria

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Conflict of Interest
The authors have no financial conflicts of interest.

ABSTRACT

Objective: Cervical spine injuries (CSI) are associated with high rates of permanent disability and mortality, which increase the socioeconomic burden on healthcare systems worldwide. We aimed to investigate the epidemiology of CSI, frequency of operative treatment, and incidence of associated neurological deficits at regional level.
Methods: We performed a retrospective monocentric study of patients with sustained CSI from January 2017 to December 2021, carried out only in a first-level trauma center in the Plovdiv metro region. Demographic, clinical, and imaging data from the medical records were thoroughly analyzed. Based on the assumption that all patients with CSI were hospitalized in single trauma center, the percentage of cases indicated for surgical treatment was calculated based on the population of the entire Plovdiv metro area.
Results: One hundred forty-nine patients permanently residing in the Plovdiv metro region were included in this study. Of the 149 patients, 97 (65.1%) were surgically treated and 61 (62.9%) were over 60 years of age. The frequency of operative interventions for CSI was 2.9/100,000 patients. Annually, 10.6 people from the Plovdiv metro region suffer from neurological deficits as a result of neck injuries (1.6/100,000 residents). The number of patients with complete spinal cord injury in the surgically treated group was 11 (11.3%); that is, the regional frequency was 2.2 people per year.
Conclusion: In the Plovdiv metro region, a significant annual frequency of neurological deficits requiring surgical intervention for CSI has been established, especially in patients aged >60 years.

Keywords: Spinal fractures; Cervical vertebrae; Spinal injuries; Spinal cord injury; Epidemiology; Incidence; Trauma

INTRODUCTION

The incidence of traumatic spinal injury (TSI) varies between countries with differences in age, sex, level, and severity of injury, which is explained by existing geographical, cultural, and infrastructural differences, as well as by different criteria used to identify and classify patients.[1] The reported incidence of TSI ranges from 12.1 to 57.8/1,000,000 in high-income countries, and from 12.7 to 29.7/1,000,000 in low-income countries.[3] The incidence of cervical

spine injuries (CSI) is estimated to be 19%–52.2% in all cases of TSI.[1] In the USA, 20,000 neck injuries occur annually, accounting for an estimated cost of $9.7 billion. In Europe, CSI results in >40,000 deaths each year.[11] The annual incidence of CSI (fractures and soft tissue injuries) varies among countries and periods. The incidence per 100,000 inhabitants per year is 12 in Canada, 16.5–17.2 in Norway and Sweden, and up to 65 in China.[2,6,9,15] In recent years, there has been an increase in the number of CSI, as well as in the age of affected patients.[8]

Literature data specify that surgical treatment is required in 18%–44.6% of all CSI.[6,8] The increasing incidence and changing demographics of patients with CSI are likely to increase the need for surgical treatment. Few studies have addressed both the incidence of CSI and the accompanying neurological deficits, as well as the need for surgical treatment.[8]

The present study aimed to investigate the epidemiology, type of trauma, neurological symptoms, and frequency of surgical treatment in the second-largest metro region in Bulgaria, with only one neurosurgical first-level trauma center.

MATERIALS AND METHODS

We performed a retrospective monocentric study of patients with sustained CSI from January 2017 to December 2021, carried out in a first-level trauma center in the Plovdiv metro region. The requirement for informed consent was waived in all cases. Inclusion criteria were: patients with permanent address in the territory of the Plovdiv metro region with a recent CSI in the axial (C_0–C_2) and/or subaxial (C_3–C_7) segment of the cervical spine, diagnosed by X-ray, computed tomography, or magnetic resonance imaging. The exclusion criteria were as follows: a) patients with permanent address outside the Plovdiv metro region, b) no imaging evidence of bone or ligament damage, and c) absence of an adequate history of trauma. An adequate trauma history included traffic accidents, falls from height of at least 2 m or a staircase, low-energy trauma with direct blow to the head from a fall from one's own height, sports accidents, and physical attacks. Patients with CSI associated with spinal cord contusion but without radiographic evidence of bone or ligament damage or pathological and osteoporotic fractures were also excluded.

According to the latest population census from 2021, the Plovdiv metro region is the second-largest city in Bulgaria, Plovdiv, with population of 366,511. It also includes other municipalities with a combined population of 299,887, bringing the total number of inhabitants to 666,398. There is one university hospital in the territory of the Plovdiv metro region, which has a neurosurgical clinic that serves as a first-level trauma center carrying out surgical treatment of CSI, to which patients admitted to other trauma centers of lower level are being transferred.

Medical records were retrospectively analyzed for age, sex, type and localization of trauma, presence and type of neurological deficit, method of admission (independently, through first-aid emergency care, or transfer), type of treatment, and length of hospital stay.

Indications for surgery included clinical and imaging data on cervical spinal instability. By instability (acute or chronic), we mean neck trauma that results in neurological deficits, deformities, or pain that may occur as a result of the dysfunction of any of the three subsystems precisely defined by Panjabi: the active musculoskeletal subsystem (muscles and tendons), passive musculoskeletal subsystem (discs, ligaments, joints, and soft tissues), and neural

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and feedback subsystem (force and motion transducers, nerves).[13] Surgical treatment was performed for the following indications: a) unstable injuries, b) progressive neurological deterioration, c) early mobilization in a neurologically compromised patient, and d) >50% reduction in the height of the fractured vertebra. Surgical procedures used to treat neck injuries include occipitospinodesis, anterior screw fixation of the dens axis, anterior decompression (discectomy/corporectomy), fusion with anterior support (titanium plate), posterior stabilization, and combined anterior–posterior 360° stabilization of the axial and subaxial spine.

All patients with severe CSI, with an existing neurological deficit or an indication for surgical treatment, were hospitalized in the single first-level trauma center. Therefore, the need and volume of surgical treatment was calculated taking into account the total population of the Plovdiv metro region.

This study was exempt from review by the Ethics Committee (EC) of UMHAT "St. George" – Plovdiv (EC No. 105/25.05.2023), and the requirement for informed consent was waived because it involved the analysis of data that did not contain personal information. As the analyzed data refers to patients who have already completed treatment, there is no direct risk or benefit to individuals. Therefore, we waived the requirements for consent and approval for this study.

RESULTS

During the study period, 289 patients with CSI were treated at UMHAT "St. George" – Plovdiv. Of these, 149 (51.6%) patients with a permanent residence in the Plovdiv metro region were included in this study (104 males and 45 females). The mean patient age was 62 years. Of the 149 patients, 97 (65.1%) were surgically treated, and 61 (62.9%) were over 60 years of age. Ninety-six (99%) of the 97 patients were surgically treated within the first 48 hour after the traumatic incident. Indications for surgery included clinical and imaging data on cervical spinal instability. Forty-five (30.2%) patients were treated conservatively using a rigid cervical collar for 2 months because their general condition did not allow surgical treatment. In the remaining seven (4.7%), no specific treatment was required. Of the 97 patients who underwent surgery, 68 (70.1%) were male and 29 (29.9%) were female, with male-to-female ratio of 2.3:1. The average length of hospital stay after surgical intervention for CSI ranged from 10 to 23 day.[8,11,14] The mean hospital stay of all patients with CSI in our series was 11 day, that of non-operated patients was 6 day, and that of surgically treated patients was 13 day.

The demographic and clinical characteristics of the operated patients are presented in **TABLE 1**. The distribution of the patients according to their place of residence was as follows: 75 from the city of Plovdiv and 74 from the Plovdiv metro region. The male-to-female ratio ranged

TABLE 1. Characteristics of surgically and conservatively treated patients

Variables	No. of patients (%)	Mean ± SD	Range (min–max)	Annual incidence
Surgically treated patients				
Number and age of patients	97 (100.0)	62±21*	13–94*	19.4
Gender and age by gender				
Male	68 (70.1)	59±19*	13–94*	13.6
Female	29 (29.9)	68±21*	13–86*	5.8
Method of admission				
Independently	20 (20.6)			4.0
Through first aid emergency care	65 (67)			13.0
Transfer from another hospital	12 (12.4)			2.4

(continued to the next page)

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TABLE 1. (Continued) Characteristics of surgically and conservatively treated patients

Variables	No. of patients (%)	Mean ± SD	Range (min–max)	Annual incidence
Hospital stay (days)		13±6	3–35	
Localization				
Axial (C0–C2)	38 (39.2)			7.6
Subaxial (C3–C7)	47 (48.4)			9.4
Combined (C0–C2) and (C3–C7)	12 (12.4)			2.4
Neurological status				
Normal	44 (45.3)			8.8
Radiculopathy	16 (16.5)			3.2
Incomplete spinal cord injury	26 (26.8)			5.2
ASIA C	7 (26.9)			1.4
ASIA D	19 (73.1)			3.8
Complete spinal cord injury	11 (11.4)			2.2
ASIA - B	5 (45.4)			1.0
ASIA - A	6 (54.6)			1.2
Bowel and bladder dysfunction	13 (13.4)			2.6
Mechanism of CSI and their corresponding age in years				
Road accident	23 (23.7)	47±22*	13–80*	4.6
Fall from height >2 m	26 (26.5)	56±22*	13–82*	5.2
Falls from own height	41 (42.3)	72±13*	16–94*	8.2
Sports trauma	3 (3.2)			0.6
Blow to the head	3 (3.2)			0.6
Physical assault	1 (1.1)			0.2
Deceased patients				
Operated axial segment	2 (4.6)			0.4
Operated subaxial segment	5 (9.2)			1.0
Conservatively treated patients				
Number and age of patients	52 (100.0)	61±24*	9–94*	10.4
Gender and age by gender				
Male	36 (69.2)	55±23*	9–94*	7.2
Female	16 (30.8)	73±20*	22–895*	3.2
Method of admission				
Independently	13 (25.0)			2.6
Through first aid emergency care	34 (65.4)			6.8
Transfer from another hospital	5 (9.6)			1.0
Hospital stay (days)		6.4±7.7	1–58	
Localization				
Axial (C0–C2)	18 (34.6)			3.6
Subaxial (C3–C7)	21 (40.4)			4.2
Combined (C0–C2) and (C3–C7)	6 (11.5)			1.2
Distorsio	7 (13.5)			1.4
Neurological status				
Normal	38 (73.1)			7.6
Radiculopathy	8 (15.4)			1.6
Incomplete spinal cord injury				
ASIA - D	4 (7.6)			0.8
Complete spinal cord injury				
ASIA - A	2 (3.9)			0.4
Bowel and bladder dysfunction	2 (3.9)			0.4
Mechanism of CSI and their corresponding age in years				
Road accident	18 (34.6)	54±22*	19–81*	3.6
Fall from height >2 m	13 (25.0)	60±16*	25–94*	2.6
Falls from own height	18 (34.6)	75±20*	9–94*	3.6
Sports trauma	2 (3.9)			0.4
Physical assault	1 (1.9)			0.2
Deceased patients				
Axial segment	3 (16.7)			0.6
Subaxial segment	2 (9.5)			0.4
Combined	2 (9.5)			0.4

ASIA: American Spinal Neurological Association, CSI: Cervical spine injuries, SD: standard deviation.
*Age of subjects (years).

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from 1.4:1 to 3.75:1. During the 5-year study period, the age of the patients showed minimal deviations; however, patients over 60 years suffered more frequently from CSI and required surgery (**TABLE 2**). Notably, there was significant difference in age according to the mechanism of injury (**TABLE 1**).

Of the patients who underwent surgery, 65 (67%) were admitted to the clinic through Emergency Services, 12 (12.4%) were transferred from other hospitals, and 20 (20.6%) were transferred independently. The mean length of hospital stay over the 5-year period was 13±6 day.

Frequency

Annually, 19.4 people from the Plovdiv metro region suffer from CSI, requiring surgical treatment. Given the 666,389 inhabitants of the Plovdiv metro region, the frequency of surgical interventions for CSI per 100,000 inhabitants was 2.9.

Clinical presentation

All the patients had local neck pain and vertebral syndrome. Forty-four (45.4%) patients had no neurological deficits. Neurological deficits were present in 53 (54.6%) patients: 26 had incomplete spinal cord damage, 16 had radiculopathy, 11 had complete spinal cord injury with quadriplegia, and 14 had bowel and bladder dysfunction (**TABLE 1**). The preoperative neurological status of the patients was assessed using the American Spinal Neurological Association scale (**TABLE 1**). Annually, 10.6 people from the Plovdiv metro region are diagnosed with neurological deficit as a result of CSI, or 1.6/100,000 inhabitants (**TABLE 3**).

Localization of the injury

In the surgically treated group, the axial cervical segment was affected in 38 (39.2%) cases, whereas the subaxial cervical segment was affected in 47 (48.4%) cases. In seven (7.2%) patients, combined trauma was found in the axial and subaxial segments of the cervical spine, and in the remaining five (5.1%), CSI was associated with vertebral fractures in other areas of the spine. In patients with combined injuries, surgical intervention in the neck area was performed in either the axial (n=43) or the subaxial (n=54) segments. The average annual incidence of axial, subaxial injuries, and combined injuries was 7.6, 9.4, and 2.4, respectively. The frequency of surgically treated injuries to the upper cervical segment was 1.1/100,000.

TABLE 2. Age distribution of operated patients

Age (years)	Number (%)	Annually	Number/100,000
0–20	6 (6.2)	1.2	0.18
21–40	15 (15.5)	3	0.4
41–60	15 (15.5)	3	0.4
61–80	46 (47.3)	9.2	1.4
>81	15 (15.5)	3	0.4

TABLE 3. Frequency of CSI operations and accompanying neurological deficits in Plovdiv metro region over 5-year period

Variables	Total number annually	Incidence per 100,000 inhabitants per year
Residents	666,987	
Surgical interventions	19.4	2.9
Surgical interventions of axial segment (C_0–C_2)	8.6	1.3
Surgical interventions of subaxial segment (C_3–C_7)	10.8	1.6
CSI with neurological deficit	10.6	1.6

CSI: cervical spine injuries.

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The frequency of combined injuries to the axial and subaxial parts of the cervical spine was 0.15/100,000.

In-hospital mortality

Of the entire series (n=149), 14 patients (9.4%) died. In the surgically treated group, seven patients (7.2%) died. In the conservatively treated group, 7 (13.5%) patients died. In the latter group, six patients had partial or complete damage to the spinal cord, and four of them had combined injuries (skull fracture, brain contusion, intracerebral hematoma, lung, and internal organ injuries). Six of the non-operated patients died within 1–8 day after the injury owing to cardiac and/or respiratory failure. The last deceased patient in this group underwent surgery for a T4 burst fracture and died on day 58 from sepsis and multiple organ failure.

In the deceased patients that underwent surgery, surgical intervention was performed in two (4.6%) cases in the axial segment and in five (9.2%) cases in the subaxial segment. Four patients had complete spinal cord injury, two had incomplete injury, and one had no neurological deficits. Brain contusions were found in two of the deceased cases, and pneumothorax and pneumomediastinum in the other two cases. One patient developed thromboembolism, another developed massive ischemic stroke, and one developed coronavirus disease 2019.

DISCUSSION

Numerous studies have evaluated the incidence of CSI worldwide: 11.8–16.5/100,000 in Norway, 17.2/100,000 in Sweden, and 12/100,000 in Canada, including cases of spinal cord injury without bony or ligamentous injuries of the cervical spine.[2,6] Hackenberg et al.[8] estimated, for the first time, the incidence of both neurological deficits and operative interventions for CSI with bony and/or ligamentous injury in a large German city.

The mean age of all the patients with CSI (n=149) included in our study was 62 years (70 for females, 58 for males). The average age of all operated patients (n=97) was the same (62 years); however, it was lower in the male group (59 years) and much higher in the female group (68 years). Sex and age distribution of CSI were associated with higher incidence of trauma in men of active age. Notably, 61 (62.9%) of the operated patients were over 60 years of age, which unequivocally shows that the risk of CSI increases with age. The mean age of all patients, including that of the surgically treated group, was lower than that reported by Hackenberg et al.[8] (67.5 and 68.1 years), whereas it was higher than that reported by Fredø et al.[6] and Passias et al.[14] (54 and 56 years, respectively). The distribution of the average age of patients according to the method of injury was also of interest. The mean age of the operated patients was 47.9 years for those injured in a road traffic accident, 56.2 years for those who fell from height of >2 m, and 72.7 years for those who fell from their own height. Notably, the average age of road accident victims in our study was low, as expected; however, it was much higher than that of 30.2 years reported by Fernández Londoño et al.[5] A fall from height of >2 m is usually related to a specific job activity and is a characteristic of working-age people. In people aged > 60 years, falls from their own heights were the most commonly observed.

The male-to-female ratio in this study was identical for all 149 patients as well as for the operated 97 patients (2.3:1), coinciding with that reported in Norway by Fredø et al.,[6] but was higher than that reported by Hackenberg et al.[8] (1.03:1 and 1.35;1) and Passias et al.[14] (1.5:1).

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In the USA, 33.5% of CSI were treated surgically, and 26.6% in Norway.[6,14] The percentage of patients who were surgically treated for CSI reported by Hackenberg et al.[8] was 46.9%. The rate of surgical treatment in our study was 65.1%, which was significantly higher than that reported by Hackenberg et al.[8] (46.9%); however, the presence of neurological deficits in the operated patients in this study was 10 times higher.

According to our study, the annual frequency of surgical interventions for CSI in the Plovdiv metro region was 19.4; however, considering the population of the region, the frequency is estimated to be 2.9/100,000 people per year, which is lower than that in Norway (3.0/100,000) and Germany (3.24/100,000).[7,8]

Similar to Hackenberg et al.,[8] we could not determine the exact number of patients with CSI in the Plovdiv metro region who did not require any treatment, were treated conservatively in outpatient settings, or those who died before being transferred to the hospital. A recent study reported that 21–24% of those who died at the scene of the accident had CSI with spinal cord damage.[8]

Of the 149 patients treated with CSI, 64 (42.9%) had neurological deficits; whereas of the 97 operated patients, 53 (54.6%) had neurological deficits. According to this result, the incidence of neurological deficits due to CSI is 1.9/100,000 people per year, and surgical treatment is required in 1.6/100,000 people. The number of patients with complete spinal cord injury among surgically treated patients was 11 (11.3%), with an incidence of 0.33/100,000 people per year. The reported incidence of neurologic deficits after CSI was significantly higher than the reported 23% by Hu et al.,[9] 15% by Fredø et al.,[7] and 9.2% by Hackenberg et al.[8]; however, it was consistent with the reported incidence of 34–65% by Brolin and von Holst,[2] Leucht et al.,[10] and Wang et al.[15]

According to Passias et al.,[14] neurological deficits were observed in 5% and 6.7% of cases of injury to the axial and subaxial segments of the spine, respectively. Of all the 57 patients with axial injuries in this study, 10 (17.5%) had neurological deficits, and of the 43 patients who underwent surgery, 8 (18.6%) had neurological deficits. Of the 71 patients with subaxial injuries, 47 (66.2%) had neurological deficits, and of the 54 patients who underwent surgery, 47 (87%) had neurological deficits.

The in-hospital mortality rate of 9.4% in our study coincided with the reported incidence of fatal outcomes by Pagliei et al.[12] and Deluca et al.[4] during hospitalization as a result of CSI, which varied from 4% to 17%, with the risk of fatal outcomes increasing depending on the severity of the trauma, localization in the upper cervical segments, advanced age, and presence of combined trauma.[12] The in-hospital mortality rate in operated patients (7.2%) was almost twice as low as that in non-operated patients (13.5%); however, we must emphasize that the majority of non-operated patients in our series had combined trauma and severe neurological deficit, and died within few days.

First, we did not provide long-term follow-up data for hospitalized patients with CSI. Second, there is no detailed summary of the surgical approaches based on individual cases. Third, we did not perform thorough statistical analysis to investigate the dynamics of the duration of hospital stay over the studied 5-year period. Despite these drawbacks, to the best of our knowledge, this is the first study to provide summarized data regarding the epidemiology, frequency of applied surgical treatment, and incidence of neurological deficits in patients with CSI in the Plovdiv metro region.

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CONCLUSION

Although the established frequency of CSI in Plovdiv and the Plovdiv metro region is not high (4.4/100,000), the high percentage of patients with neurological deficits (54.6%) requiring surgical treatment, especially in those over 60 years, is striking. Long-term national and international studies that consider contemporary geographical, cultural, infrastructural, and demographic characteristics are essential to assess the exact incidence of CSI, the associated severity of spinal cord and nerve root damage, and the need for surgical treatment.

REFERENCES

1. Barbiellini Amidei C, Salmaso L, Bellio S, Saia M. Epidemiology of traumatic spinal cord injury: a large population-based study. **Spinal Cord** 60:812-819, 2022 PUBMED | CROSSREF
2. Brolin K, von Holst H. Cervical injuries in Sweden, a national survey of patient data from 1987 to 1999. **Inj Control Saf Promot** 9:40-52, 2002 PUBMED | CROSSREF
3. Chiu WT, Lin HC, Lam C, Chu SF, Chiang YH, Tsai SH. Review paper: epidemiology of traumatic spinal cord injury: comparisons between developed and developing countries. **Asia Pac J Public Health** 22:9-18, 2010 PUBMED | CROSSREF
4. Deluca A, Wichlas F, Deininger C, Traweger A, Mueller EJ. Reevaluation of a classification system: stable and unstable odontoid fractures in geriatric patients-a radiological outcome measurement. **Eur J Trauma Emerg Surg** 48:2967-2976, 2022 PUBMED | CROSSREF
5. Fernández Londoño LL, Marchesini N, Espejo Ballesteros D, Álzate García L, Gómez Jiménez JA, Ginalis E, et al. Epidemiological review of spinal cord injury due to road traffic accidents in Latin America. **Med Princ Pract** 31:11-19, 2022 PUBMED | CROSSREF
6. Fredø HL, Bakken IJ, Lied B, Rønning P, Helseth E. Incidence of traumatic cervical spine fractures in the Norwegian population: a national registry study. **Scand J Trauma Resusc Emerg Med** 22:78, 2014 PUBMED | CROSSREF
7. Fredø HL, Rizvi SA, Lied B, Rønning P, Helseth E. The epidemiology of traumatic cervical spine fractures: a prospective population study from Norway. **Scand J Trauma Resusc Emerg Med** 20:85, 2012 PUBMED | CROSSREF
8. Hackenberg RK, Stoll P, Welle K, Scorzin J, Gathen M, Rommelspacher C, et al. Cervical spine injuries requiring surgery in a level I trauma centre in a major German city. **Acta Neurochir (Wien)** 164:35-41, 2022 PUBMED | CROSSREF
9. Hu R, Mustard CA, Burns C. Epidemiology of incident spinal fracture in a complete population. **Spine (Phila Pa 1976)** 21:492-499, 1996 PUBMED | CROSSREF
10. Leucht P, Fischer K, Muhr G, Mueller EJ. Epidemiology of traumatic spine fractures. **Injury** 40:166-172, 2009 PUBMED | CROSSREF
11. Nguyen HL, Vu VC, Nguyen DL, Vo HL, Nguyen QD. Posterior surgical approach for the treatment of lower cervical spine injury with spinal cord paralysis: high postoperative mortality in resource-scare setting. **Eur Rev Med Pharmacol Sci** 26:2960-2969, 2022 PUBMED
12. Pagliei V, Bruno F, Battista G, Iacopino A, Riva C, Arrigoni F, et al. Cervical spine trauma: impact of different imaging classification systems in the clinical decision-making. **Acta Biomed** 92:e2021404, 2021 PUBMED
13. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. **J Spinal Disord** 5:383-389, 1992 PUBMED | CROSSREF
14. Passias PG, Poorman GW, Segreto FA, Jalai CM, Horn SR, Bortz CA, et al. Traumatic fractures of the cervical spine: analysis of changes in incidence, cause, concurrent injuries, and complications among 488,262 patients from 2005 to 2013. **World Neurosurg** 110:e427-e437, 2018 PUBMED | CROSSREF
15. Wang H, Xiang Q, Li C, Zhou Y. Epidemiology of traumatic cervical spinal fractures and risk factors for traumatic cervical spinal cord injury in China. **J Spinal Disord Tech** 26:E306-E313, 2013 PUBMED | CROSSREF