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Epidemiological characteristics of traumatic cervical spinal cord injury in Chongqing, China, from 2009 to 2018

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STUDY DESIGN: Hospital-based retrospective epidemiological research.
OBJECTIVES: To describe the epidemiological and demographic features of patients with traumatic cervical spinal cord injury in Chongqing, China from 2009 to 2018.
SETTING: Army Military Medical University Xinqiao Hospital in Chongqing.
METHODS: All patients diagnosed traumatic CSCI admitted to Xinqiao hospital from 2009 to 2018 were retrospectively reviewed. Data elements referred from the International SCI Core Data Set, included date of birth, date of injury, gender, etiology of injury, vertebral injury, associated injury, ventilatory assistance, and neurological status were collected.
RESULTS: A total of 503 patients with TCSCI met the criteria. The mean age of patients with TCSCI was 50.3 ± 13.9 years (15–85 years), and the male-to-female ratio was 4.7:1. Fall (67.2%) was the leading cause of injury, followed by transport (22.3%). The most common neurologic level of injury (NLI) was C5, accounting for 38.2%. The number of AIS D was the largest, accounting for 42%.
CONCLUSIONS: The results indicated that TCSCI occurred most frequently in the middle age and fall was the leading cause of injury. The number of patients with TCSCI was larger in male than in female. The most common NLI occurred in C5, and AIS D had the largest numbers.

Spinal Cord Series and Cases (2021)7:70 ; https://doi.org/10.1038/s41394-021-00434-1

INTRODUCTION

Traumatic cervical spinal cord injury (TCSCI) is a devastating and potentially life-threatening injury, which often causes severe disability and complications [1–4]. The incidence of spinal cord injury (SCI) is about 10.4–57.8 cases per million population in developed countries, and 12.7–29.7 cases per million population in developing countries [5–7]. 51–55% of SCIs occurred in the cervical spine [7–9]. China is the most populous developing country, and the number of CSCI is also large. It has led to medical and economic burden to families and the country [10]. So it is necessary to investigate the epidemiological characteristics of CSCI and to improve prevention strategies [7, 10].

Patients with TCSCI often require longer hospital stays, more medical cost and are at risk of death due to various complications [8, 11, 12]. The requirement of endotracheal intubation, tracheostomy, or mechanical ventilation is also more common in patients with TCSCI than in the thoracic or lumbar SCI [1, 13–15]. There have been epidemiological studies on SCI in Tianjin, Guangdong and Shanghai [12, 16, 17]. These epidemiological researches in China make the basis for undertaking the study. Chongqing has a total population of about 31,243,200 (2019), as one of the four municipalities in China. However, there are few epidemiological studies on TCSCI in Chongqing [11, 18]. We conducted a 10-year retrospective study to investigate the epidemiological profiles of TCSCI in Chongqing, which hopefully improve appropriate preventive strategies. This is the first epidemiological study on Chongqing, based on International SCI Core Data Set (version 2.0).

METHODS

Participants

Xinqiao hospital is the tertiary referral centers for acute SCI in Chongqing, located in the southwest of China. Retrospective analysis was performed on 503 patients with TCSCI admitted in orthopedics department of Xinqiao hospital from January 2009 to December 2018. All procedures used in this research were approved by the Ethics Committee of the Army Military Medical University. Clinical data were screened from the medical record system according to the International Classification of Diseases (ICD-10) diagnostic code S14 [19]. Exclusion criteria were patients younger than 15 years old, cervical nerve root injury, incomplete medical record, or uncertain diagnosis of TCSCI.

Data collection

Demographic variables and epidemiological features were collected referred by International SCI Core Data Set (version 2.0) [20] as recommended by the International Spinal Cord Society (ISCoS), including date of birth, date of injury, gender, etiology of injury, vertebral injury, associated injury, ventilatory assistance, neurological level of injury (NLI), and American Spinal Injury Association (ASIA) impairment scale. The age was divided into five groups with the interval of 15 years: 15–29, 30–44, 45–59, 60–74, and 75+. Etiology of injury was categorized as sports and leisure, assault, transport, fall, and other traumatic cause. NLI was assessed by International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) (2019 revision) [21]. ASIA impairment scale classification

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Received: 11 January 2021 Revised: 23 July 2021 Accepted: 26 July 2021
Published online: 04 August 2021

was divided into five grades: A, B, C, D, and E, based on sensory and motor examination on both sides of the body.

Statistical analysis

Continuous variables were recorded using mean ± standard deviation. Classification variables were converted to dichotomous variables using frequency and/or percentage records. Statistical analysis was performed using SPSS version 25.0 (SPSS, Chicago, IL) and Excel 2016(Microsoft, Redmond, WA).

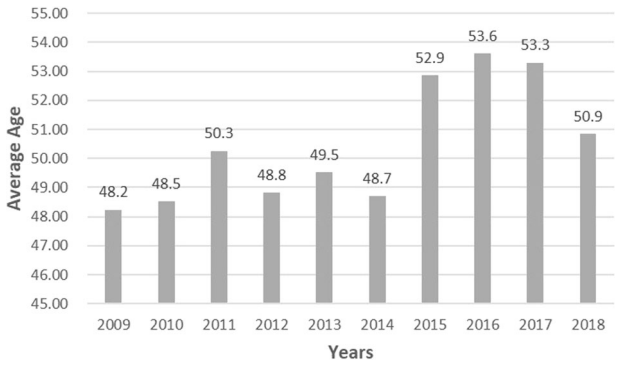

Fig. 1 The average age of TCSCI patients during 2009–2018. TCSCI usually occurred between 45–59 years old, followed by 30–44 years old.

RESULTS

A total of 503 patients with TCSCI were discharged from hospital over the study period, 2010–2018. The average age at the time of injury was 50.3 ± 13.9 years (15–85 years). As shown in Fig. 1, the average age at the time of injury was relatively stable during the 10-year study, ranging from 45 to 55 years old. TCSCI usually occurred between 45 and 59 years old, accounting for 39.4%, followed by 30–44 years (132, 26.2%) and 60–74 years (120, 23.9%) (Table 1).

TCSCI was most common in male (414, 82.3%), while 17.8% (89) were female. The male-to-female ratio was 4.7:1 (Table 1). As shown in Table 1, from 2009 to 2018, the number of males was generally far more than that of female, with a ratio ranging from 3:1 to 11.5:1. The occupations of patients with CSCI included industry workers (143, 28.4%), peasants (127, 25.2%), clerks (85, 16.9%), and the retired (72, 14.4%).

In general, fall was the leading cause of TCSCI, accounting for 67.2% (Table 1). Transport was the second leading cause of injury, accounting for 22.3%. As shown in Fig. 2, in the age group 30–44 years and 45–59 years, fall and transport were the leading cause of TCSCI, while no transport happened to those over 75 years old.

Table 1. Clinical and demographic characteristics of patients with TCSCI in Xinqiao Hospital from 2009 to 2018.

Variables	2009–2010	2011–2012	2013–2014	2015–2016	2017–2018	Total
No. cases	94	118	127	101	63	503
Age (mean ± SD)	48.4 ± 14.1	49.4 ± 14.6	49.2 ± 13.8	53.2 ± 13.4	52.0 ± 13.0	50.3 ± 13.9
Age group						
15–29	6 (6.4%)	13 (11.0%)	10 (7.9%)	6 (5.9%)	4 (6.3%)	39 (7.8%)
30–44	37 (39.4%)	30 (25.4%)	37 (29.1%)	18 (17.8%)	10 (15.9%)	132 (26.2%)
45–59	30 (31.9%)	42 (35.6%)	48 (37.8%)	45 (44.6%)	33 (52.4%)	198 (39.4%)
60–74	20 (21.3%)	30 (25.4%)	29 (22.8%)	27 (26.7%)	14 (22.2%)	120 (23.9%)
75+	1 (1.0%)	3 (2.6%)	3 (2.4%)	5 (5.0%)	2 (3.2%)	14 (2.7%)
Gender						
Male	71 (75.5%)	106 (89.8%)	104 (81.9%)	78 (77.2%)	55 (87.3%)	414 (82.3%)
Female	23 (24.5%)	12 (10.2%)	23 (18.1%)	23 (22.8%)	8 (12.7%)	89 (17.7%)
Etiology of injury						
Sports and leisure	9 (9.6%)	9 (7.6%)	4 (3.1%)	6 (5.9%)	2 (3.2%)	30 (6.0%)
Assault	3 (3.2%)	1 (0.9%)	3 (2.4%)	1 (1.0%)	1 (1.5%)	9 (1.8%)
Transport	25 (26.6%)	30 (25.4%)	27 (21.3%)	19 (18.8%)	11 (17.5%)	112 (22.3%)
Fall	55 (58.5%)	72 (61.0%)	92 (72.4%)	72 (71.3%)	47 (74.6%)	338 (67.2%)
Other traumatic cause	2 (2.1%)	6 (5.1%)	1 (0.8%)	3 (3.0%)	2 (3.2%)	14 (2.7%)
Level of injury and ASIA scale at admission						
C1–C4 AIS A, B, C	21 (22.3%)	29 (24.5%)	38 (29.9%)	40 (39.6%)	27 (42.9%)	155 (30.8%)
C5–C8 AIS A, B, C	32 (34.1%)	37 (31.4%)	30 (23.6%)	22 (21.8%)	16 (25.4%)	137 (27.3%)
AIS D at any level	41 (43.6%)	52 (44.1%)	59 (46.5%)	39 (38.6%)	20 (31.7%)	211 (41.9%)
Vertebral injury						
No (absent)	25 (26.6%)	44 (37.3%)	40 (31.5%)	36 (35.6%)	22 (34.9%)	167 (33.2%)
Yes (present)	56 (59.6%)	59 (50.0%)	68 (53.5%)	52 (51.5%)	29 (46.0%)	264 (52.5%)
Unknown	13 (13.8%)	15 (12.7%)	19 (15.0%)	13 (12.9%)	12 (19.1%)	72 (14.3%)
Associated Injury						
No	63 (67.0%)	55 (46.6%)	65 (51.2%)	52 (51.5%)	24 (38.1%)	259 (51.5%)
Yes	22 (23.4%)	47 (39.8%)	48 (37.8%)	38 (37.6%)	33 (52.4%)	188 (37.4%)
Unknown	9 (9.6%)	16 (13.6%)	14 (11.0%)	11 (10.9%)	6 (9.5%)	56 (11.1%)

TCSCI Traumatic cervical spinal cord injury, *AIS* America Spinal Injury Association Impairment Scale.

The number of AIS D at any level (211, 41.1%) was the largest, followed by C1–C4 AIS A–C (155, 30.8%). The distribution of ASIA grade was shown in Fig. 3A. The neurologic level of injury (NLI) in TCSCI showed a single peak distribution (Fig. 3B). NLI often occurred in the C5 segment, accounting for 38.2%, followed by C4 and C6.The number of NLI above C5 was 182, accounting for 36.2%. Among 503 TCSCI patients, 36.2% had a high cervical neurological lesion (C2–C4).

Among the 503 patients with TCSCI, 52.5% (264) suffered from vertebral injury, 12.5% (63) sustained associated injury as defined by ISCoS (Table 1). During hospitalization, 71 (14.1%) patients suffered respiratory failure, requiring mechanical ventilation (MV). Among them, 34 patients suffered mechanically ventilated pneumonia. There was electrolyte disturbance in 12 patients, hypoalbuminemia in 7, urinary infection in 5, and pressure injury in 2.

A univariate analysis was used to examine the differences between TCSCI patients with and without MV. Patients with AIS A (45.1% vs. 3.1%, $p < 0.05$) or NLI above C5 (67.6% vs. 31.9%, $p < 0.05$) were more likely to suffer from respiratory failure and to need MV. Age and sex had no correlation with requirement for MV (Table 2).

DISCUSSION

There have been several research studies in different regions of China on the epidemiological features of SCI [11, 17, 18, 22, 23]. China is the largest developing country, and its rapid economic development has also brought changes in the epidemiology of SCI [12, 18]. International Spinal Cord Injury Data Sets was proposed by the ISCoS in order to gather data elements to enable worldwide SCI data and outcomes to be assessed and compared [20, 24, 25]. There are few epidemiological studies on SCI, especially TCSCI in Chongqing, China [18]. This is the first Hospital-based retrospective research standard by International SCI Core Data Set for TCSCI in Chongqing.

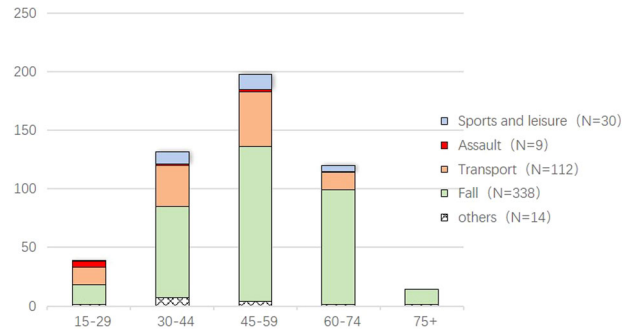

Fig. 2 The etiology distribution differences of TCSCI patients in age group. The age groups were divided into five categories and the etiology was indicated by different colors or patterns.

During the 10 years research, the average age at the time of injury has changed and shows a slight increasing trend from 48.4 years in 2009–2010 to 53.2 years in 2015–2016. TCSCI usually occurred between 45 and 59 years old in Chongqing. In Tianjin, China, the average age of TCSCI was 54 years and most injuries occurred in the 45–65-year between 2008 and 2012 [12]. The results were in accordance with our research. People in this age group bears the burden of the family and is the main force of labor in China. In previous studies, TSCI occurred mostly in male, about four times as many as in female [12, 26, 27]. In our research, the ratio was 4.7:1 in TCSCI, similar to previous conclusions. Ning [18] reported that the male/female ratio on SCI research was 4.33:1 in Chongqing from 2009 to 2013. Overall, men take on more high-risk jobs, while women take on less risky work, some of them are full-time homemakers in Chongqing.

In developed countries, transport was the leading cause of SCI, accounting for 30–50%, followed by fall [7, 28]. Zhou et al. [29] reported that in Tianjin, China, fall (55.1%), was the leading cause of SCI, followed by motor vehicle collisions (35.9%). In our research, fall (67.2%) was the leading cause of TCSCI, and transport

Table 2. Univariate analysis of patients with and without mechanical ventilation.

Variables	TCSCI with MV	TCSCI without MV	X^2 value	*p* value
No. case	71	432		
Age				
≥65	11 (15.5%)	77 (17.8%)	0.23	>0.05
<65	60 (83.1%)	355 (82.2%)		
Gender				
Male	62 (87.3%)	348 (80.6%)	1.05	>0.05
Female	99 (12.7%)	84 (19.4%)		
Etiology				
MVA	13 (18.3%)	99 (22.9%)	22.92	<0.05
High fall	40 (56.3%)	162 (37.5%)		
Low fall	10 (14.1%)	126 (29.2%)		
Struck by object	6 (8.5%)	29 (6.7%)		
Others	8 (11.3%)	10 (2.3%)		
NLI				
C1–C4	48 (67.6%)	138 (31.9%)	33.28	<0.05
C5–C8	23 (32.4%)	294 (68.1%)		
ASIA Scale				
AIS A	32 (45.1%)	18 (3.1%)	115.47	<0.05
AIS B–D	39 (54.9%)	419 (96.9%)		

MV Mechanical ventilation, *MVA* motor vehicle accident, *ASIA* America Spinal Injury Association, *NLI* Neurologic Level of Injury.

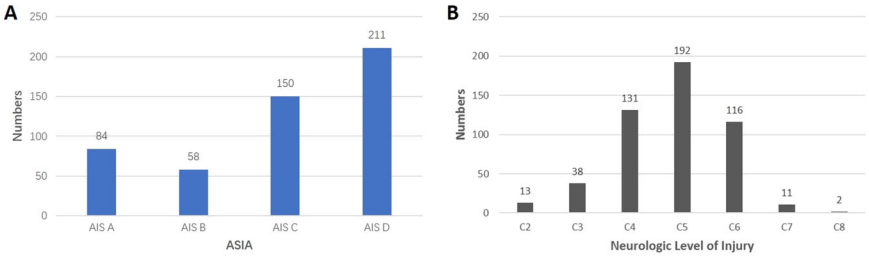

Fig. 3 Distribution histogram. A Distribution histogram of ASIA scale in TCSCI patients. The number of AIS D was the largest. B Distribution histogram of the neurologic level of injury in TCSCI patients. Distribution histogram showed a single peak distribution, whichNLI often occurred in the C5 segment.

(22.3%) was the second most common cause of injury. There are some reasons for this difference. Firstly, the number of cars per capita in developed countries is much higher than that in developing countries, and the probability of traffic accidents is correspondingly increased. Secondly, improvements in car safety, such as the use of airbags and seat belts, and harsh penalties for drunken driving, have reduced the incidence of traffic accidents [30, 31]. Thirdly, Chongqing city is mostly mountainous. The Yangtze River and Jialing River run through it, so there are many bridges and tall buildings here. The ups and downs of the terrain may increase the probability of falls [18].

According to our data, the most common NLI occurred in C5, followed by C4 and C6. Wu et al. [12] and Wang et al. [11] came to the same conclusion in a retrospective analysis of different regions. Thirty-six percent of TCSCI were above C5. As we all known, diaphragm is the most important breathing muscle, and the phrenic nerve, which supplies the movement of the diaphragm, is composed of the anterior branches of C3-5. Due to loss of diaphragm and/or intercostal muscle function, the higher and more complete the level of injury, the more serious the respiratory system will be damaged after CSCI [32, 33].

In a retrospective study, Lenehan et al. [6] and Sekhon and Fehlings [7] found that nearly half of SCI was complete (AIS A), followed by AIS D. However, in our conclusion, AIS D had the largest numbers, while AIS A was far less than AIS D. It is not difficult to find that the proportion of TCSCI caused by transport in developing countries is far lower than that in developed countries. Transport often causes complete SCI, which is more common in young people, while falls are more common in the elderly, and the injuries are mostly incomplete [7, 22, 34]. Xinqiao hospital is the tertiary referral centers for acute SCI in Chongqing. Part of severely injured patients with TCSCI do not have the opportunity to be transferred to our hospital, which may be another reason for the difference.

Nevertheless, there are several limitations in the current study. Firstly, it was a retrospective study. Epidemiological data like education level, ethnicity, length of hospital stay, data about rehab and so on were missing in the study. Secondly, this is a hospital-based descriptive research about TCSCI in Chongqing. China still needs to complete its database of SCI, compared with the well-established database in developed countries. Thirdly, because the number of deaths before hospitalization of TCSCI cannot be obtained, and part of patients refused to be treated and discharged home, this paper failed to further study of mortality.

CONCLUSION

This is a retrospective epidemiological study of TCSCI in Chongqing from 2009 to 2018. The results indicated that TCSCI occurred most frequently in the middle age and fall was the leading cause of injury. The number of patients with TCSCI was larger in male than in female. The most common NLI occurred in C5, and AIS D had the largest numbers. Preventive measures should be taken to reduce the occurrence of TCSCI based on the epidemiological features.

DATA AVAILABILITY

The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request.

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AUTHOR CONTRIBUTIONS

DS: This author helped to analyze and interpret the data, draft, and revise the paper. ZZ: This author helped to design the study, draft, and revise the paper, and approve the final paper.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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