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Epidemiological profile of 338 traumatic spinal cord injury cases in Shandong province, China

Hongyong Feng[1], Hui Xu[1], Honglei Zhang[1], Changbin Ji[1], Dawei Luo[1], Zhiwei Hao[1] and Kunpeng Li[1]✉

STUDY DESIGN: Hospital-based retrospective review.
OBJECTIVE: To describe the epidemiological characteristics of traumatic spinal cord injury (TSCI) in Liaocheng, China.
SETTING: Liaocheng People's Hospital.
METHODS: Medical records of 338 persons with TSCI admitted to Liaocheng People's Hospital from 2013 to 2017 were reviewed. The detailed information included gender, age, marital status, occupation, time, etiology, level of injury, ASIA grade, spinal stenosis, concomitant injury, treatment, length of stay.
RESULTS: Over this period, the mean age (SD) of persons with TSCI was 50.1 (14.1) years, and the male/female ratio was 3.1:1. 96.4% of all were married. The leading cause was fall, followed by motor vehicle accident (MVA). The most common level of injury was the cervical cord. ASIA grade D and A injuries were the most common, accounting for 48.5 and 29.3% respectively. Among the concomitant injuries, spinal fractures were the most common. Within 24 h, 91.1% of individuals with TSCI arrived hospital, 63.3% of all accepted surgery.
CONCLUSION: The results showed that fall and MVA were the two main causes, so we should focused on preventing fall and reducing MVA. Cervical spinal stenosis can increase the risk of TSCI, so education should be provided to this population to raise their risk awareness. In addition, timely treatment was critical for TSCI, but the data showed that rescue process was not standard, so it was necessary for medical staff to popularize professional knowledge.

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INTRODUCTION

Traumatic spinal cord injury (TSCI) is a catastrophic accident, leading to different extent of neurological deficiency for a long time or permanently, which can be devastating to both physiology and psychology. Until now, there has been no breakthrough in the treatment of TSCI. The disease imposes a heavy economic burden on families and society, so it is of great social significance to implement corresponding preventive measures according to epidemiological characteristics [1, 2]. Epidemiological investigations were carried out in the developed countries firstly, and some countries created the TSCI registration system regionally or nationally. Although relevant research has been gradually carried out in developing countries, the data is few and limited relatively [3, 4]. Due to the differences in social structure, politics, and culture, the epidemiological characteristics of TSCI in different places are not identical. With the development of economic and society, the epidemiological characteristics of TSCI are also changing gradually, therefore we need to pay attention to this research field continuously [5, 6].

As the largest developing country in the world, China has made remarkable economic achievements and undergone earth-shaking changes in its social structure since reform and opening-up. Although some scholars have made some achievements in the epidemiological research of TSCI, the research is still insufficient in this field. Our research team has reported that the crude incidence rate of TSCI is 23.7 per million during 2004–2008 in Tianjin [7]. One of my study has indicated that the epidemiological characteristics of TSCI have changed from1998 to 2009 in Tianjin China [8]. There are also research teams in other provinces of China that have made some achievements in this field, such as Liu H et al. in Beijing, Wang HF et al. in Anhui province, and Chen J et al. in Guangdong province [9–11]. But so far, there have been no report about TSCI in Shandong province. This paper is a retrospective and descriptive study about the epidemiological profile of TSCI cases admitted to Liaocheng People's Hospital in Shandong province. Liaocheng People's Hospital is the largest tertiary class A general hospital in Liaocheng city, serving nearly 6 million people around the city.

MATERIAL AND METHODS

The medical records of all persons with spinal cord injury (SCI) admitted to Liaocheng People's Hospital from January 2013 to December 2017 were screened. Inclusion criteria were: [1] following the definition of SCI: "A case of SCI is defined as the occurrence of an acute lesion of neural elements in the spinal canal (spinal cord and cauda equina), resulting in temporary or permanent sensory deficit, motor deficit, or bladder/bowel dysfunction"

[1]Department of Orthopaedics, Liaocheng People's Hospital, No. 67, Dongchang West Road, Dongchangfu District, Liaocheng City, Shandong Province, China252000. ✉email: kunpengxyz@163.com

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[12, 2], as a result of accidental injury. Exclusion criteria: [1] individuals with unclear consciousness and insufficient imaging examination; [2] incomplete medical records.

In this investigation, the detailed information of people with TSCI included gender, age, marital status, occupation, time of the injury, etiology, level of the injury, American spinal cord association (ASIA) grade, concomitant injury, treatment, length of hospitalization. The people were divided into 6 age groups: 0–15, 16–30, 31–45, 46–60, 61–75, ≥76. The marital status consisted of married, unmarried, and other (divorced and widowed). The etiology included fall (low fall, height < 1 m; high fall, height ≥ 1 m), motor vehicle accident (MVA) (four-wheel vehicle accident, electrical bicycle accident, motorcycle accident), bicycle accident, struck by falling objects, and others. According to the site of injury, the concomitant injuries were divided into craniocerebral injury, chest injury, abdominal injury, spinal fracture, pelvic, and limb fracture.

Statistical analysis was finished with the aid of the SPSS Version 23.0. Categorical and continuous variables were analyzed in the form of proportion and Means (SD), respectively. Meanwhile, the relationships between age, gender, occupation, and etiology were analyzed descriptively.

RESULTS

Of the 595 individuals discharged from the hospital with a diagnosis of SCI during the study period, 338 were diagnosed with TSCI, 255 were diagnosed with nontraumatic SCI, and the other two were excluded for incomplete medical records.

Gender and Age

Among the 338 people, the ratio of male/female was 3.1:1, and the mean age (SD) was 50.1 (14.1) years [male: 49.7 (13.8) years, female: 51.4 (15.1) years]. The 46–60 age group is the largest, followed by the 31–45 age group (Table 1). The high-risk age group was similar for male and female (Fig. 1).

Marital status and occupations

Our research showed that most of them were married, and only a few were unmarried or divorced. According to statistics, the majority were peasant, and the proportion of worker, driver, civil servant, and student were all small. In addition, 24 people were classified as other, of which two were teachers, two were retiree and 20 had no steady job (Table 1).

Etiology

The data demonstrated that fall was the leading cause, followed by MVA, bicycle accident, struck by falling object. Bicycle accident account for about half of electric bicycle accident. In addition, 13 persons got injury for other causes, in which the records of nine were vague, two got injury by running machine, one got injured by collision of the head, one suffered injury from violence (Table 1).

The causes of injury were not identical for male and female. The analysis showed that low fall, high fall, and four-wheel vehicle accident were the top three causes of TSCI for both the male and female. The ratio of male/female was 5:1 in an electric bicycle accident. Among people with TSCI struck by object, the male to female ratio was 13:1 (Fig. 2).

The causes of injury varied more in different age groups. For 31–45 and 46–60 age groups, high fall was the first cause. While for persons with TSCI over 60 years, low fall took place of high fall as the first etiology (Table 2).

Level of injury and ASIA grade

In this study, 324 persons (95.9%) underwent spinal MRI. As shown in Fig. 3, the neurologic level of TSCI took on bimodal distribution, and the first high incidence site was concentrated in the cervical region (77.2%).

Statistical results show that ASIA grade D accounted for almost half of the total, followed by ASIA grade A, C, B, E (Table 1).

Table 1. Characteristics of the study population.

Variable	No.	Pct. (%)
Gender		
Male	256	75.7%
Female	82	24.3%
Age		
0–15	1	0.3%
16–30	29	8.6%
31–45	95	28.1%
46–60	139	41.1%
61–75	54	16.0%
≥76	20	5.9%
Marital status		
Married	326	96.4%
Unmarried	9	2.7%
Others	3	0.9%
Occupation		
Peasant	291	86.1%
Worker	16	4.8%
Civil servant	2	0.6%
Driver	2	0.6%
Student	2	0.6%
Others	25	7.3%
Etiology		
Low fall	75	22.2%
High fall	102	30.2%
Four-wheel vehicle accident	61	18.0%
Electric bicycle accident	41	12.1%
Motorbike accident	9	2.7%
Bicycle accident	23	6.8%
Struck by falling object	14	4.1%
Others Time to spinal injury center	13	3.8%
ASIA grade		
A	99	29.3%
B	18	5.3%
C	55	16.3%
D	164	48.5%
E	2	0.6%
Concomitant injuries		
Craniocerebral injuries	64	18.8%
Chest injuries	67	19.6%
Abdominal injuries	13	3.8%
Spinal fractures	139	40.8%
Limb or pelvic fractures	31	9.1%
Time to spinal trauma center		
≤8 h	188	55.6%
8h-24h	73	21.6%
>24 h	77	22.8%
Treatment		
Conservation	124	36.7%
Surgery	214	63.3%

Concomitant injuries

The most common concomitant injuries were spinal fracture, followed by the chest injury, craniocerebral injury, limb, or pelvic fracture, abdominal injury (Table 1). 146 cases (22.6%) did not have any of the above concomitant injuries.

Treatment

Results of the analysis showed that 308 individuals (91.1%) visited a nearby hospital for the first time within 24 h, and the rest were delayed for ignorance. Two hundred and seventeen persons (64.2%) came to the spinal trauma center after their initial consultation at the primary hospital, while the rest came directly

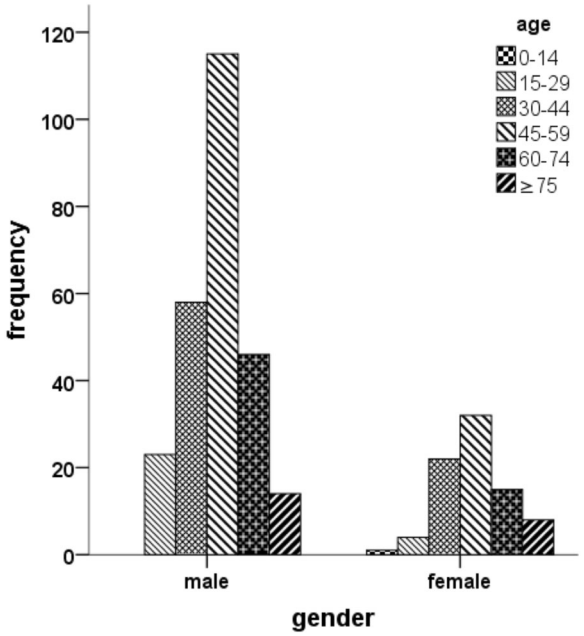

Fig. 1 High-risk age group of different genders. In both male and female patients, 15–29 age group is the most common age group. But in male patients, the proportion of 15–29 age group is higher than that of female patients.

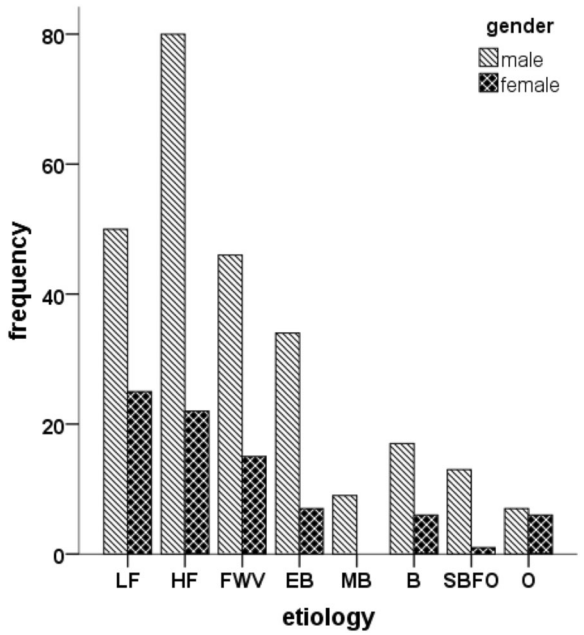

Fig. 2 The ratio of male/female in each etiology. (LF low fall, HF high fall, FWV four-wheel vehicle accident, EB electric bicycle accident, MB motorbike accident, B bicycle accident, SBFO struck by falling object, VO violence and other).

to the spinal trauma center. Overall, more than three-quarters of all reached the spinal trauma center within 24 h (Table 1). Only 46 people received methylprednisolone shock therapy. Two hundred and fourteen individuals received surgical treatment (Table 1). Forty-three persons were transferred to the ICU due to complicated injuries or complications, of which three died due to cardiac arrest and two abandoned treatment. The length of hospitalization ranged from 1 day to 337 days (median: 18 days, 25% percentiles: 10 days, 75% percentiles: 32 days).

DISCUSSION

In this study, the male/female ratio was 3.1:1. In many studies, the male/female ratio ranged from 2.4:1 to 4.7:1 in the same period [8, 10, 11, 13–18]. In China, as in most countries, most women are engaged in various jobs or activities. However, the male/female ratio was higher in some countries, which was due to social status and religion. For example, one report from India showed a ratio of 6.1:1 [19], and that from Saudi Arabia was 7.3:1 [20].

In our study, the average age was 50.1 (14.1) years old, and 46–60 years old was the age of high incidence. Two reports from Guangdong and Anhui Provinces of China showed that the mean age of people with TSCI was 45 years and 41.5 years respectively [10, 11]. Although all the studies were conducted in China, the mean age was different, which can be explained from the following aspects: our hospital was located in an underdeveloped area with a predominantly rural population, while the data of the other two studies were from economically developed areas. In China, for a better life, many young people will go to economically developed areas to work for more income, while the middle-aged and elderly stay in hometown to farm and take care of parents and children, so the aging of the population is more obvious in rural areas.

This study showed that the proportion of peasant was 85.6%, while the proportion was 57.2% reported by Wang HF [10] and 39.0% reported by Chen J [11]. Since the proportion of the rural population was about 83.3% from 2013 to 2017 in Liaocheng city, peasant accounted for a higher proportion in our study. Compared with the reported data from Mexico and India [16, 19], the occupational structure of people with TSCI was more different in our report. Each peasant has his own arable land, so the jobless and unemployed population are relatively small.

Some studies have shown that the etiology of TSCI will gradually change with the development of society. For example, Chen Y et al. found that the proportion of people with TSCI gradually increased due to fall from 1972 to 2014, especially low fall [21]. Barbara-Bataller E et al. also made similar findings in Spain [22]. The proportion of Low fall increase gradually, which is related to the aging of population. It is well known that as the body ages, because the body becomes less flexible, they are more likely to fall in daily life. Degenerative changes of spine, such as spinal stenosis, often occur and worsen with aging. In our study, there were 146 patients with cervical SCI who also had degenerative cervical spinal stenosis, and the older the persons were, the higher the proportion was (Table 3).

Meanwhile, we also found that the percentage of high fall decreased through this period (Table 4). The study period was a period of rapid economic, infrastructure, and urbanization development. According to our investigation, the decline of high fall can be explained from the following aspects: [1] Government departments attach great importance to production safety, which reduces the incidence of high fall in the engineering and construction industry; [2] Agricultural mechanization is rapidly promoted, which reduces the chance of climbing.

Similar to many other studies [7–11, 14–16], four-wheel MVA was second only to fall in this study. According to the report from Riyadh, Saudi Arabia, traffic accidents ranked the first among causes of TSCI, accounting for 85% of all [20]. During 2013–2017, although the number of family cars increased rapidly, the four-wheel MVA did not change much, which was related to the strict enforcement of traffic laws. For example, drunk driving is subject to criminal penalties since 2011.

During the period of our study, the electric bicycle, characterized by light and fast, replaced the traditional bicycle as an important step-by-step tool. The ratio of male/female was 5:1 in the electric bicycle accident. It is well known that men cycle faster because they are more prone to risk taking than women. Due to the strict gun control system, there were no gunshot injuries.

Table 2. The etiology of TSCI in different age groups.

	Age						Total
	0–15	16–30	31–45	46–60	61–75	≥76	
Etiology							
Low fall	0 (0.0%)	4 (13.8%)	16 (16.8%)	26 (18.7%)	16 (29.6%)	13 (65.0%)	75 (22.2%)
High fall	1 (100%)	9 (31.0%)	37 (38.9%)	43 (30.9%)	10 (18.5%)	2 (10.0%)	102 (30.2%)
Four-wheel vehicle accident	0 (0.0%)	10 (34.5%)	20 (21.1%)	20 (14.4%)	10 (18.5%)	1 (5.0%)	61 (18.0%)
Electric bicycle accident	0 (0.0%)	4 (13.8%)	6 (6.3%)	22 (15.8%)	8 (14.8%)	1 (5.0%)	41 (12.1%)
Motorbike accident	0 (0.0%)	1 (3.4%)	4 (4.2%)	4 (2.9%)	0 (0.0%)	0 (0.0%)	9 (2.7%)
Bicycle accident	0 (0.0%)	0 (0.0%)	7 (7.4%)	8 (5.8%)	5 (9.3%)	3 (15.0%)	23 (6.8%)
Struck by falling object	0 (0.0%)	1 (3.4%)	3 (3.2%)	9 (6.5%)	1 (1.9%)	0 (0.0%)	14 (4.2%)
Others	0 (0.0%)	0 (0.0%)	2 (2.1%)	7 (5.0%)	4 (7.4%)	0 (0.0%)	13 (3.8%)
Total	1 (100%)	29 (100%)	95 (100%)	139 (100%)	54 (100%)	20 (100%)	338 (100%)

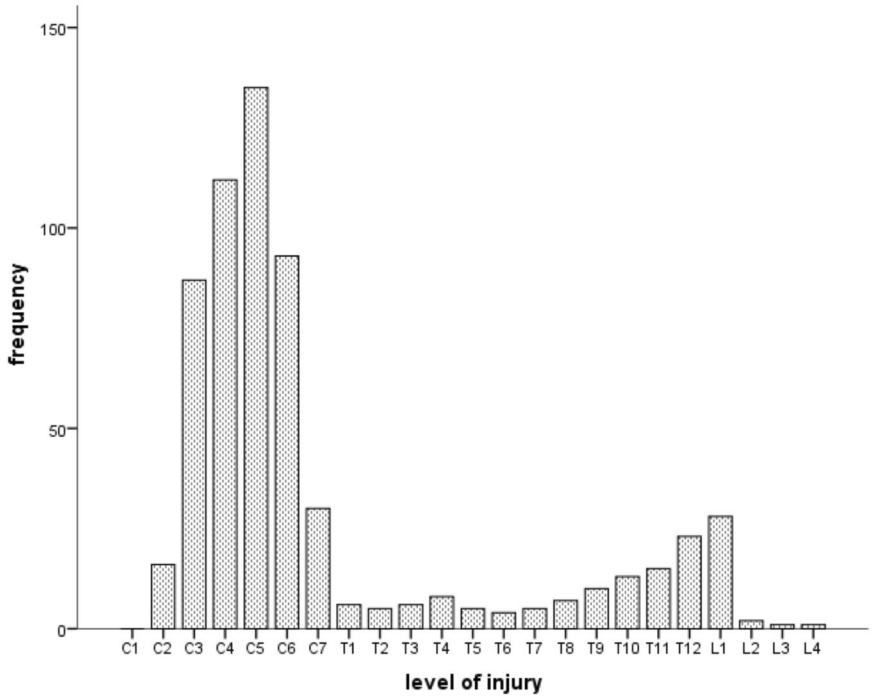

Fig. 3 Neurologic level of TSCI. This graph shows the frequency of TSCI in different parts of the spine in this study. C cervical segments, T thoracic segments, L lumbar segments.

Table 3. Cervical spinal stenosis in patients of different age groups.

	Spinal stenosis		Total
	Yes	No	
Age			
0–15	0 (0.0%)	1 (100%)	1 (100%)
16–30	5 (17.2%)	24 (82.8%)	29 (100%)
31–45	29 (30.5%)	66 (69.5%)	95 (100%)
46–60	60 (43.2%)	79 (56.8%)	139 (100%)
61–75	35 (64.8%)	19 (35.2%)	54 (100%)
≥76	17 (85.0%)	3 (15.0%)	20 (100%)
Total	146 (43.2%)	192 (56.8%)	338 (100%)

As same as many other reports [8, 11, 18, 21, 22], our study also showed that the location of SCI showed a bimodal distribution. This phenomenon is not only related to the etiology but also related to the physiological structure of the spine itself. Our data showed that more than two-thirds of people with cervical SCI have no cervical fracture dislocation, while 56.0% of them have cervical spinal stenosis. This shows that cervical spinal stenosis is likely to increases the probability of cervical SCI, which is worthy of our attention. Further analysis showed that the frequency of cervical spinal stenosis in the low fall was high (Table 5), so low fall may not only be related to age but also may be related to cervical spinal stenosis. In future studies, for patients with cervical SCI combined with cervical spinal stenosis, we could record in detail whether there were clinical symptoms of cervical spinal cord compression before the injury to explore the relationship between the two. Most individuals with thoracolumbar SCI have spinal fracture or dislocation, which is obviously related to the huge force.

Although most of the people with TSCI can go to the hospital in time after injury, due to the lack of comprehensive medical technology in primary hospitals, it is best to send them to the spinal trauma center. Our data showed that 91.9% of persons with ASIA A and 94.4% of persons with ASIA B could visit the spinal trauma center within 24 h, while the probability of persons with ASIA C, ASIA D, and ASIA E visiting the spinal trauma center within

Table 4. The change of etiology from 2013 to 2017.

	time					Total
	2013	2014	2015	2016	2017	
Etiology						
Low fall	14 (17.3%)	8 (11.6%)	19 (29.7%)	19 (27.1%)	15 (27.8%)	75 (22.2%)
High fall	33 (40.7%)	28 (40.6%)	13 (20.3%)	20 (28.6%)	8 (14.8%)	102 (30.2%)
Four-wheel vehicle accident	13 (16.0%)	10 (14.5%)	17 (26.6%)	12 (17.1%)	9 (16.7%)	61 (18.0%)
Electric bicycle accident	8 (9.9%)	10 (14.5%)	4 (6.3%)	7 (10.0%)	12 (22.2%)	41 (12.1%)
Motorbike accident	2 (2.5%)	2 (2.9%)	2 (3.1%)	2 (2.9%)	1 (1.9%)	9 (2.7%)
Bicycle accident	6 (7.4%)	7 (10.1%)	2 (3.1%)	6 (8.6%)	2 (3.7%)	23 (6.8%)
Struck by falling object	2 (2.5%)	1 (1.4%)	2 (3.1%)	3 (4.3%)	6 (11.1%)	14 (4.1%)
Others	3 (3.7%)	3 (4.3%)	5 (7.8%)	1 (1.4%)	1 (1.9%)	13 (3.8%)
Total	81 (100%)	69 (100%)	64 (100%)	70 (100%)	54 (100%)	338 (100%)

Table 5. The relation between cervical spinal stenosis and etiology.

			Etiology								Total
			Low fall	High fall	Bicycle	Electric bicycle	Motorcycle	Motor vehicle collision	Struck by object	Violence and other	
Spinal stenosis	Yes	Frequency	60	15	13	23	3	19	5	8	146
		Ratio	41.1%	10.3%	8.9%	15.8%	2.1%	13.0%	3.4%	5.5%	100.0%
	No	Frequency	10	43	9	15	3	30	2	3	115
		Ratio	8.7%	37.4%	7.8%	13.0%	2.6%	26.1%	1.7%	2.6%	100.0%

Table 6. The characteristics of patients with different ASIA grade.

	ASIA					Total
	A	B	C	D	E	
Etiology						
Low fall	11 (11.1%)	2 (11.1%)	15 (27.3%)	46 (28.0%)	1 (50.0%)	75 (22.2%)
High fall	45 (45.5%)	7 (38.9%)	11 (20.0%)	39 (23.8%)	0 (0.0%)	102 (30.2%)
Four-wheel vehicle accident	20 (20.2%)	4 (22.2%)	8 (14.5%)	29 (17.7%)	0 (0.0%)	61 (18.0%)
Electric bicycle accident	10 (10.1%)	0 (0.0%)	9 (16.4%)	21 (12.8%)	1 (50.0%)	41 (12.1%)
Motorbike accident	2 (2.0%)	1 (5.6%)	3 (5.5%)	3 (1.8%)	0 (0.0%)	9 (2.7%)
Bicycle accident	3 (3.0%)	1 (5.6%)	6 (10.9%)	13 (7.9%)	0 (0.0%)	23 (6.8%)
Struck by falling object	4 (4.0%)	3 (16.7%)	3 (5.5%)	4 (2.4%)	0 (0.0%)	14 (4.1%)
Others	4 (4.0%)	0 (0.0%)	0 (0.0%)	9 (5.5%)	0 (0.0%)	13 (3.8%)
Total	99 (100%)	18 (100%)	55 (100%)	164 (100%)	2 (100%)	338 (100%)
Time to spinal trauma center						
<8 h	71 (71.7%)	15 (83.3%)	33 (60.0%)	69 (42.1%)	0 (0.0%)	188 (55.6%)
8–24 h	20 (20.2%)	2 (11.1%)	10 (18.2%)	40 (24.4%)	1 (50.0%)	73 (21.6%)
>24 h	8 (8.1%)	1 (5.6%)	12 (21.8%)	55 (33.5%)	1 (50.0%)	77 (22.8%)
Total	99 (100%)	18 (100%)	55 (100%)	164 (100%)	2 (100%)	338 (100%)
Concomitant injury						
No	26 (26.3%)	5 (27.8%)	22 (40.0%)	91 (55.5%)	2 (100%)	146 (43.2%)
Yes	73 (73.7%)	13 (72.2%)	33 (60.0%)	73 (44.5%)	0 (0.0%)	192 (56.8%)
Total	99 (100%)	18 (100%)	55 (100%)	164 (100%)	2 (100%)	338 (100%)
Treatment						
Surgery	77 (77.8%)	15 (83.3%%)	36 (65.5%)	86 (52.4%)	0 (0.0%)	214 (63.3%)
Conservation	22 (22.2%)	3 (16.7%%)	19 (34.5%)	78 (47.6%)	2 (100%)	124 (36.7%)
Total	99 (100%)	18 (100%)	55 (100%)	164 (100%)	2 (100%)	338 (100%)
ICU						
No	71 (71.7%)	14 (77.8%)	49 (89.1%)	160 (97.6%)	2 (100%)	296 (87.6%)
Yes	28 (28.3%)	4 (22.2%)	6 (10.9%)	4 (2.4%)	0 (0.0%)	42 (12.4%)
Total	99 (100%)	18 (100%)	55 (100%)	164 (100%)	2 (100%)	338 (100%)

24 h gradually decreased (Table 6). The data also showed that persons with poorer neurological function were more likely to suffer from high-energy injuries, had more combined injuries, and were more likely to need surgical intervention.

Limitations of this study :1) There is no access to the information of individuals who died before hospital. According to the reports, 53% of people with TSCI die before hospitalization in Estonia [23], compared with 15.8% [24] in Alberta, Canada. 2) The data were collected from a single medical center.

Summary

This study summarized the epidemiological characteristics of TSCI in Liaocheng City, China. Among them, male with TSCI accounted for 75.7%, fall and MVA were the top two causes of injury, young and middle-aged were the main victims. In general, cervical and thoracolumbar segments were the most common sites of SCI. Cervical spinal stenosis increases the probability of cervical SCI, which provide a new idea for the prevention. At the same time, our data also showed that there was no standardized process for the rescue of people with TSCI, so it was necessary to popularize relevant professional knowledge in our emergency department and treatment team.

DATA AVAILABILITY

All data generated or analysed during this study are included in this published article and its supplementary information file.

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AUTHOR CONTRIBUTIONS

H.Y.F. was responsible for designing the protocol, conducting the search, analysing data, and writing the report. H.X., H.L.Z., C.B.J., D.W.L., and Z.W.H. were all responsible for collecting and extracting data. K.P.L. assisted in data analysis, literature search, and article correction.

CONFLICT OF INTEREST

The authors declare no competing interests

STATEMENT OF ETHICS

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

ADDITIONAL INFORMATION

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Correspondence and requests for materials should be addressed to Kunpeng Li.

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