# ORIGINAL ARTICLE Traumatic spinal cord injury in Tianjin, China: a single-center report of 354 cases

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Study design: Hospital-based retrospective study.

**Objectives:** The objective of this study was to describe the epidemiological profile of traumatic spinal cord injury (TSCI) in Tianjin Medical University General Hospital, China, from 2009 to 2014.

Setting: Tianjin Medical University General Hospital.

**Methods:** Hospital medical records of patients with TSCI admitted to hospital from 1 January 2009 to 31 December 2014 were reviewed. Collected variables included gender, age, marital status, ethnic group, occupation, etiology, neurological level of injury, American Spinal Injury Association (ASIA)-ISCoS impairment scale at admission, the severity, death and its cause, concomitant injuries and treatment choice.

**Results:** During the study period, 354 cases were identified. Male-to-female ratio was 2.34:1, with a mean age of  $50.1 \pm 15.5$  years. Falls (55.1%), comprising low falls and high falls (33.6% and 21.5%, respectively), were the leading cause, followed by motor vehicle collisions (MVCs) (35.9%). The most common injury site was the cervical spinal cord, especially C4–C6, accounting for 59.3%. Surgery was the major treatment choice (57.6%).

**Conclusion:** The number of TSCI patients increased annually in our center. The mean age at the time of injury was older, and the proportion of males was higher. The leading two causes were falls and MVCs. The SCIs caused by MVCs were increasing. Peasants, workers and unemployed individuals were those at higher risk. Surgery was the major treatment choice. These data may be useful to implement those preventive strategies focused on the characteristics of different groups and pay more attention to high-risk populations.

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## INTRODUCTION

As a devastating condition, traumatic spinal cord injury (TSCI) not only causes permanent serious dysfunction but also leads to disorders of several organ systems, including the respiratory, urinary and autonomic nervous system, as well as bone and joint. It is generally known that TSCI exerts a severe burden on patients, their families and society because of the tremendous cost of health-care treatments, rehabilitation and lost productivity.<sup>1–3</sup> As there is no effective treatment for the cure of TSCI, appropriate prevention is of paramount importance.

The global incidence of TSCI was reported as 9.2 to 246.0 per million residents a year, varying in different geographic regions all over the world, as follows: 20.7–83.0 in America, 8.0–130.6 in Europe, 10.0–77.0 in Oceania and 14.6–246 in Asia and the Middle East.<sup>4</sup> In recent years, some new research about epidemiology of TSCI appeared. Nijendijk *et al.*<sup>5</sup> reported incidence of TSCI surviving the acute phase to be 11.7 per million per annum in 2010 in the Netherlands. Thompson *et al.*<sup>6</sup> reported that incidence of TSCI varied between 10.6 and 22.6 per million per year in Québec, Canada (2000–2011). Also, other countries reported the incidence of acute traumatic SCI as 10.2 per million for Denmark (1990–2012)<sup>7</sup>, 13 per million for Botswana (2011–2013),<sup>8</sup> 25.1–38.1 per million for Finland (2012–2013)<sup>9</sup> and 21.0–32.3 per million for Australia (1921–2011).<sup>10</sup> For Japan, Katoh *et al.*<sup>11</sup> reported a high annual incidence of 121.4 and 117.1 per million, attracting general attention in the world.

Our research team has also reported that the incidence rate was 23.7 per million during 2004–2008 in Tianjin.<sup>12</sup>

We described the epidemiological profile based on 239 TSCI cases in Tianjin Medical University General Hospital (TMUGH).<sup>13</sup>

With the development of economy and the improvement of people's living standards, epidemiological profile of TSCI in Tianjin may change faster than previously. To provide information about recent epidemiologic trend and effective advice on designing prevention strategies for TSCI, medical records of all patients with TSCI admitted to Tianjin Medical University General Hospital from 1 January 2009 to 31 December 2014 were identified and reviewed.

#### MATERIALS AND METHODS

The inclusion criteria for the present study were: (1) spinal cord injury/cauda equina injury of traumatic origin, (2) Tianjin residency at the time of injury.

TSCI has been defined as the occurrence of an acute lesion of neural elements in the spinal canal (spinal cord/cauda equina), resulting in temporary or permanent sensory deficit, motor deficit or bladder/bowel dysfunction.<sup>14</sup> The exclusion criteria were: (1) vertebral injuries in the absence of spinal cord lesion and (2) intervertebral disc disease.

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By reviewing the medical records using diagnostic code of T09.302 of the International Classification of Diseases Version 10, 389 cases admitted to Tianjin Medical University General Hospital from 1 January 2009 to 31 December 2014 were identified, of which only 354 cases matched the inclusion criteria. Twenty-seven cases of intervertebral disc disease, and eight vertebral injuries in the absence of TSCI cases were excluded.

The detailed data regarding gender, age, marital status, ethnic group, occupation, etiology, neurological level of injury, American Spinal Injury Association (ASIA)-ISCoS impairment scale at admission, the severity of injury, death and its cause, concomitant injuries, the time lapse from trauma to hospital admission, the length of hospital stay, clinical complications and treatment choice (conservative treatment or surgery), medication use of methylprednisolone and Neurotropin were collected and analyzed. In the analysis process, the patients were divided into six age groups: 0-15, 16-30, 31-45, 46-60, 61-75 and  $\geq$  76 years. Marital status was categorized as married or unmarried, any possibly 'divorced' and 'widowed' were recorded as 'unmarried', as medical records were often not detailed about marital status. Occupations included peasants, workers, the unemployed, the retired, drivers, office clerks, teachers and students. Etiologies covered motor vehicle collisions (MVCs), falls (including low fall: from a height <1 m and high fall: from a height of 1 m or more), injuries caused by falling objects, sports, injuries involving machinery, collision of head against objects, massage and injuries caused by another person. For neurological level of injury, there were four rough categories: cervical, thoracic, lumbar and sacral segment. Types of injury causing neurological deficits were divided into complete and incomplete injuries, and paralysis was classified into tetraplegia and paraplegia. The severity of motor and sensory functions below injury was evaluated by ASIA-ISCoS scale. Concomitant injuries included head/brain injuries, fractures of ribs, limb or pelvic fractures and others such as pulmonary contusion and pleural effusion.

As for statistical analysis, detailed data were double entered by two researchers, respectively, and then cross-checked two times to assure information accuracy. All data were gathered in a Microsoft Excel spreadsheet (Office 2013; Microsoft, Redmond, WA, USA) and analyzed by IBM SPSS version 19.0 for Windows (International Business Machines Corp, Armonk, NY, USA). Categorical and continuous data are reported as proportions and mean  $\pm$  s.d., respectively.

# RESULTS

The count of TSCI admissions increased steadily despite a constant number of ward beds for orthopedic cases in TMUGH from 2009 to 2014. Figure 1 revealed that the count of TSCI patients displayed a trend of annual growth in the 6 years (2009: 46; 2010: 50; 2011: 55; 2012: 62; 2013: 68 and 2014: 73).

#### Gender and age

Gender and age distributions are shown in Table 1. Among 354 cases, 70.1% (248) of the patients were male and 29.9% (106) were female.



Figure 1 Annual count of the 354 TSCI patients during 2009–2014 in Tianjin Medical University General Hospital.

Male-to-female ratio was 2.34:1. Mean age at the time of injury was  $50.1 \pm 15.5$  years (male  $49.1 \pm 15.4$  years and female  $52.3 \pm 15.6$  years), ranging from 15 to 85 years. The largest age group was 46–60 years, followed by 31–45 years, presenting two peaks of the age distribution and accounting for 63.0%.

# Marital status and ethnic group

With regard to the marital status, more than 90% of all TSCI patients were married. Ethnic group of Han accounted for 98.8% (350), followed by ethnic group of Hui (0.9%, 3 cases) and Man (0.3%, 1 case).

#### Occupations

The occupations of patients with TSCI covered peasants (32.5%), workers (24.3%), unemployed (16.9%), retired (11.9%), drivers (3.4%), office clerks (7.3%), teachers (2.0%) and students (1.7%) (Figure 2). The occupations of peasants and workers accounted for 32.5% and 24.3%, respectively, representing more than half of all cases.

## Etiology of the injuries

As showed in Table 1 and Figure 3, falls (55.1%), comprising low falls and high falls (33.6% and 21.5%, respectively), were the leading cause, followed by MVCs (35.9%). Injuries from falling objects and injuries from sports were both the third causes (2.8%). Furthermore, there were three cases for collision of head against objects, and two injuries involving machinery. Five patients were injured by another person and two injured during massage procedures.

#### Neurological level of injury

As revealed in Figure 4, the neurological level presented bimodal distribution. The most common levels were C4–C6 in the cervical region, followed by T12–L2, accounting for 59.3% and 22.0%, respectively.

## ASIA-ISCoS grade and neurological levels

The proportions of ASIA A, B, C and D injuries were 20.4%, 7.6%, 23.2% and 48.8%, respectively, and the distribution of neurological levels and ASIA grade is shown in Figure 5. As for the severity of injury, 49 patients (13.8%) had complete tetraplegia, 189 (53.4%) had incomplete tetraplegia, 25 (7.1%) had complete paraplegia and 91 (25.7%) had incomplete paraplegia. The leading etiology for complete injuries was MVCs followed by high falls, accounting for 40.5% and 29.7%, respectively. And, 34.6% of incomplete injuries were also on account of MVCs and 37.5% due to low falls.

#### Concomitant injuries

The detailed analysis of all data revealed that the most common concomitant injuries were vertebral fracture (24.6%), followed by head/brain injuries (8.2%), fractures of ribs (5.9%), limb or pelvic fractures (4.5%) and others such as pleural effusion (2.8%). There were 214 patients (60.5%) with no concomitant injuries. MVCs and falls were the top two causes resulting in concomitant injuries in TSCI patients compared with the other causes.

## **Clinical complications**

In the current study, 6.2% of the TSCI patients experienced clinical complications. Pulmonary infections (2.8%), urinary tract infections (1.7%) and bedsores (0.8%) were the top three complications. There were three patients who encountered deep venous thrombosis. All the clinical complications occurred in most of complete TSCIs.

Table 1	Character	istics of	patients	with	TSCI	in	Tianjin	Medical
Universi	ty General	Hospita	I, China	from	2009	to	2014	

Variables	2009	2010	2011	2012	2013	2014	Total
Frequency	46	50	55	62	68	73	354
Age (years)							
0–15	0	0	0	0	1	0	1
16–30	9	6	6	9	8	7	45
31–45	9	12	13	18	11	17	80
46–60	15	20	21	26	29	32	143
61–75	12	10	12	8	15	11	68
76–	1	2	3	1	4	6	17
Average age	49.1	49.6	51.2	46.6	51.8	51.6	$50.1 \pm 15.5$
Gender							
Male	34	39	41	44	42	48	248
Female	12	11	14	18	26	25	106
Marital status							
Married	39	45	50	54	65	66	319
Unmarried	7	5	5	8	3	7	35
Occupation							
Peasants	14	16	15	21	22	27	115
Workers	8	13	16	22	14	13	86
The unemployed	11	5	14	7	10	13	60
Office clerks	2	3	2	3	10	6	26
The retired	5	9	5	6	8	9	42
Teachers	3	0	2	0	2	0	7
Students	2	1	0	1	1	1	6
Drivers	1	3	1	2	1	4	12
Etiology							
MVCs	12	22	23	30	22	18	127
Low fall	20	18	15	13	23	30	119
High fall	11	7	11	14	17	16	76
Falling objects	1	0	2	3	0	4	10
Collision of head	0	0	3	0	0	0	3
Machine	1	0	0	1	0	0	2
Sports	1	3	0	0	3	3	10
Massage	0	0	0	1	1	0	2
Wounded by others	0	0	1	0	2	2	5
Level of injury							
Cervical	35	36	38	42	47	40	238
Thoracic	7	6	8	10	13	18	62
Lumbar and sacral	4	8	9	10	8	15	54
ASIA scale							
A	10	10	14	13	12	15	74
В	7	3	7	9	9	5	40
С	12	13	10	8	14	17	74
D	17	24	24	32	33	36	166

Abbreviations: ASIA, American Spinal Injury Association; MVCs, motor vehicle collisions; TSCI, traumatic spinal cord injury.

## Treatment

One hundred and sixteen patients (32.8%) received conservative treatment, and 204 patients (57.6%) received surgical treatment, whereas the others (34 patients, 9.6%) left hospital against medical advice. Surgery mode included simple decompression (88 patients),



Figure 2 Distribution pie graph of the occupations of the 354 TSCI patients.



Figure 3 Distribution histogram of etiology of the 354 TSCI patients.



Figure 4 Distribution histogram of the injury level of the 354 patients.

and decompression and internal fixation (116 patients), accounting for 43.1% and 56.9%, respectively. Conservative treatments comprised skull traction, neurotrophic medicine such as Neurotropin, hormonotherapy with methylprednisolone and bed rest. The results demonstrated that Neurotropin and methylprednisolone were not only used for conservative treatments but also before surgery treatments. Among the 354 cases, Neurotropin was used in 293 (82.8%), and the duration was 13.4 $\pm$ 13.8 days. Methylprednisolone was used in 235 (66.4%), and the duration was 4.2 $\pm$ 2.2 days. The time lapse from trauma to hospital admission ranged between 1 h and 15 days (mean: 7.5 h). The length of hospital stay ranged between 1 and 661 days (mean: 49.1 days).

# Death and the cause of death

During hospitalization six patients died. Four patients died after surgery, two patients died before surgery. All of them had cervical injuries from MCVs or falls. Two of them died from respiratory failure, three died for multiple organ dysfunction syndrome and one died for cardiac failure.



Figure 5 Distribution histogram of neurological level classified by ASIA-ISCoS impairment scale at admission of the 354 TSCI patients.

## DISCUSSION

The present study is a retrospective and descriptive research. It is generally known that TSCI exerts a substantial financial burden on patients and society on account of the tremendous cost of health-care treatments, decreased quality of life and social participation, as well as lost productivity.<sup>15</sup> Consequently, the research of epidemiological profile can support the effective use of medical resources and the implementation of preventive measures. To our knowledge, such epidemiology research of TSCI from developing countries is comparatively less in comparison with developed countries, mainly because of the lack of National SCI Register System.<sup>16</sup> Our research team has reported some information of epidemiological profile of TSCI in Tianjin, China.<sup>12,13</sup> As time goes by, it is necessary to outline the changing epidemiological profile of TSCI in Tianjin, thus performing more proper application of medical resources and implementation of preventive strategies.

With regard to the mean age, the data were  $50.1 \pm 15.5$  years at the time of injury in the present study, which seemed much higher than ever before. In our previous epidemiological study, it was  $45.4 \pm 14.1$  years<sup>13</sup> and other developing countries' mean age of TSCI was much lower, such as Jordan—33.0 years, Turkey—35.5 years and Iran—31.0 years.<sup>17</sup> Katoh *et al.*<sup>11</sup> reported that the percentage of geriatric patients had increased during the study period. Thompson *et al.*<sup>6</sup> also found the median age was 44.8 years in his research, higher than others' reports.<sup>6</sup> So it may be explained for increasing ageing of the general population in China. What's more, the reason for 35-55-year age group was the most vulnerable may be due to the matter that they were the major social productivity, exposing them to high-risk environments. There is an additional heavy financial burden for these people in the sandwich generation years, e.g., those with both aging parents and younger children.

As for gender, it should be noted that men are more prone to encountering TSCI. The gender distribution (male/female) of TSCI was 2.34:1, which was similar to other studies, and their male/female ratio ranged from 1.73/1 to 4.3/1.<sup>16</sup> Although there are more women choosing to working outside rather than being only a housewife, it cannot cover the fact that men are more responsible for earning for the family and more engaged in work, exposing themselves to risk-taking conditions, which made them more susceptible to suffer from TSCI, especially when working outside.

Few studies reported occupation conditions of TSCI patients. In this study, there was a remarkable phenomenon: peasants and workers accounted for 32.5% and 24.3%, respectively, representing more than half of all patients. With relatively low educational background, people

of these two groups may perform physically demanding work, resulting in them being more susceptible to be subjected to TSCI.

There was no single classification for organizing TSCI etiology. Thus, the common causes were collected in the current study. Several reports demonstrated that the leading etiology of TSCI in developed countries was MVCs.<sup>7,18</sup> As mentioned above in our study, falls (55.1%) were still the leading cause, followed by MVCs (35.9%), in accordance with a report by our research team<sup>12</sup> and many other countries' reports.<sup>5,9</sup> We found that TSCIs caused by MVCs were increasing more than ever before in Tianjin. It can be explained for urbanization progress and increased use of motor vehicles on account of the rapid development of Chinese economy.

As reported in most countries,<sup>9,11,19</sup> cervical TSCI was more common in all types of TSCI. The neurological level of TSCI presented bimodal distribution in our present study, in which cervical TSCI accounted for >59%, with the remainder affecting the thoracic and lumbar regions. Other regions of the spinal column proved to be more stable in the strength and accessory structures compared with cervical vertebrae, and thus it can explain the vulnerability of cervical spinal cord. The final data revealed that the frequency of tetraplegia is higher compared with paraplegia, which was different from other countries.<sup>10,17</sup> The majority of tetraplegia occurred in older population, maybe because they suffered more degenerative diseases of the cervical spine, such as stenosis and ossification of the posterior longitudinal ligament. The proportion of incomplete injuries (ASIA C, D) increased, whereas the proportion of complete injuries (ASIA A) decreased. It can be explained for the improvement of diagnostic technology and the increasing number of preventive measures.

The mortality rate did not vary significantly over time, with the absolute number of deaths following TSCI ranging between 2 (in 2009) and 1 (in 2014). As reported above, the percentages of older individuals suffering from TSCI were increasing, and there was a trend of increasing cervical injury incidence over time. It was reported that breathlessness and a higher death rate were associated with higher cervical injury level.<sup>20</sup> There were higher rates of comorbidities, complications and lower reserve in the older population. With the conditions mentioned above, older individuals might be less likely to accept active treatments when facing severe complications as they did not want to waste money and increase financial burden on their families.<sup>6</sup>

In our survey, 116 patients (32.8%) received conservative treatment, and 204 patients (57.6%) received surgical treatment, and the others (34 patients, 9.6%) left hospital against medical advice. The majority of patients chose to accept a surgery for trying to improve their life conditions. Our result revealed that treatment options were associated with the severity of injuries and that surgery was a common therapy for TSCI patients, especially when complete injuries occurred. Simple decompression (88 patients in our study) was used in TSCI patients without fracture of spine, and TSCI patients who encountered severe spine fracture were treated with decompression and internal fixation (116 patients). Yang *et al.*<sup>15</sup> reported the similar conditions of treatment options in Guangdong. To our knowledge, a few studies reported treatment options.

Among the 354 cases, Neurotropin was used in 293 (82.8%), and the length of treatment was  $13.4 \pm 13.8$  days. The use of methylprednisolone was 235, accounting for 66.4%, and the length was  $4.2 \pm 2.2$  days. Methylprednisolone and Neurotropin are two kinds of the commonly used first-line drugs of SCI in our center. Neurotropin, a non-protein extract isolated from the inflamed skin of rabbits inoculated with vaccinia virus, is a drug used clinically for the treatment of neuropathic pain in Japan and China. Moreover, Neurotropin may activate the descending pain inhibitory system. Although the use of Neurotropin is not an international standard for the treatment of SCI, when patients with traumatic SCI were administered, a sort of neuropathic pain relief has been found in our clinical practice. Some Chinese researchers had reported a better outcome neurological outcome in those patients treated with Neurotropin in the acute stage.<sup>21,22</sup> NASCIS II protocol had proved that treatment with methylprednisolone improves neurologic recovery when the medication is given in the first 8 h. Although there is controversy in using methylprednisolone for the treatment of spinal cord injury nowadays, we find it effective based on the treatment conditions in our center.

Several limitations of our study should be acknowledged and discussed.

First, as a single-center hospital-based descriptive study, the overall incidence rate of TSCI could not be calculated as not all TSCI patients in Tianjin were identified. Second, the number of deaths was recorded to include only those patients in the early stage of hospital stay for acute care. Prehospital data and discharged information were absent, thus the death rate of TSCI was underestimated. Third, there is not a TSCI register system in Tianjin, China. Therefore, identification of TSCI patients was based on the review of medical records. The accuracy of the medical diagnosis of TSCI at that time was doubtful.

# CONCLUSION

In summary, the results of the present study offered epidemiological profile of TSCI in Tianjin, from 2009 till 2014. The count of TSCI patients increased annually in our center. The mean age at the time of injury was older, and the proportion of males was higher. The leading two causes were falls and MVCs. The SCIs caused by MVCs was increasing. Peasants, workers and unemployed individuals were those at higher risk. Surgery was the major treatment choice. These data may be useful to implement those preventive strategies focused on the characteristics of different groups and pay more attention to high-risk populations.

# DATA ARCHIVING

There were no data to deposit.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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