Epidemiological profile of 239 traumatic spinal cord injury cases over a period of 12 years in Tianjin, China

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Study design: Hospital-based retrospective review.
Objective: To describe the epidemiological characteristics and trends of traumatic spinal cord injury in Tianjin, China.
Setting: Tianjin Medical University General Hospital.
Methods: Medical records of 239 patients with traumatic spinal cord injury admitted to a general hospital from 1998 to 2009 were reviewed. Variables included gender, age, marital status, occupation, etiology, time of injury, level, and severity of injury. Epidemiological characteristics of different countries were compared.
Results: Over this period, the mean age of patients with traumatic spinal cord injury was 45.4 ± 14.1 years, and the male/female ratio was 4.6:1. In all, 86.2% were married. The leading cause was fall (52.3%), followed by motor vehicle collision (36.4%). The most common injury site was the cervical spinal cord, accounting for 82.0%. Incomplete tetraplegia made up for 59.4%, followed by complete tetraplegia (22.6%). Eight patients died after operation, six of whom died from respiratory complications.
Conclusion: The results of this study are in accordance with that of most other developing countries; falls and motor vehicle collisions were the two leading causes, but the mean age was older. Percentage of the aged with traumatic spinal cord injury was increasing. The low-falls group tended to expand over this period. All these data indicated that the preventive programs should focus on the traffic accidents and falls, and more attention should be paid to the aged for the vulnerability to low fall.

Keywords: Traumatic spinal cord injuries, Epidemiology, Prevention, China, Tetraplegia, Falls

Introduction

Traumatic spinal cord injury (TSCI) results in different extents of neurological deficits. The incidence rates vary in different regions, ranging from 10.4 to 83 per million.[1] Australia reported a rate of 14.5 per million in 1998/1999,[2] southeastern Anatolia Turkey reported 12.06 per million during 1990–1999,[3] Canada reported 42.4–51.4 per million during 1997–2001.[4] In our previous investigation, the crude incidence rate was 23.7 per million during 2004–2008 in Tianjin.[5] Although the incidence rate was low, TSCI usually resulted in many post-traumatic complications, and was a substantial burden to the affected individuals, their families, and society, because of expenses for health care treatments, rehabilitation, and lost productivity.[6–8]

So far, there has been no definitive cure for spinal cord injury (SCI); therefore, the emphasis has been on prevention. The economy, social structure, politics and cultural tradition play important roles in the differences in incidence rates in different regions. For example, gunshot injury was the second cause in Jordan, where firearms are traditionally fired during the celebrations of wedding parties;[9] owing to political turmoil, firearm wounds were the second cause in southeastern Anatolia Turkey during 1990–1994.[3]

This is a retrospective and descriptive study of 239 TSCI cases admitted to Tianjin Medical University General Hospital (TMUGH). TMUGH is one of the biggest general medical centers, serving more than 10 million people in urban and suburban areas of

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DOI 10.1179/2045772311Y.0000000017

Tianjin. Goals of this study were to explore the epidemiological features of the TSCI population in Tianjin, analyze the epidemiological trends, and finally, provide guidance for the implementation of preventive measures and the effective use of medical resources.

Materials and methods

The International Classification of Diseases Version 10 was used in TMUGH during 1998–2009, and diagnostic code T09.302 represented SCI caused by trauma. The national or regional population-based registry of SCI had not been established in China, and so by reviewing the medical records with diagnostic code T09.302 in TMUGH during 1998–2009, 287 cases were identified for the first time. In this process, the international definition of SCI was adopted: 'A case of spinal cord injury 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'.[10] Exclusion criteria were patient age 0–14 years and incomplete medical records or medical records with uncertain diagnosis. A total of 239 cases were identified after excluding 37 pediatric cases and 11 cases without neuroimaging of the spine. In addition, the population data were from the statistical bureau of Tianjin, which usually released data on the population size annually.

In this survey, the detailed information about patients included gender, age, marital status, occupation, time of the injury, etiology, level of injury, and American Spinal Injury Association (ASIA) impairment scale at admission. The patients were divided into six age groups: 15–24, 25–34, 35–44, 45–54, 55–64, and ≥65 years. Marital status was categorized as married, unmarried, and other (divorced and widowed). The time period studied was subdivided into four periods: 1998–2000; 2001–2003; 2004–2006; and 2007–2009. The etiologies included falls (low fall, height < 1 m; high fall, height ≥ 1 m), motor vehicle collisions (MVCs), injury caused by falling objects, collision of head against objects, injuries involving machinery, sports, and massage. According to neurological deficits, injuries were grouped by level: cervical, thoracic, lumbar, and sacral segment. The motor and sensory functions below the injury segment were evaluated using the ASIA scale. The severity was classified as complete or incomplete injury according to the ASIA scale.

In data processing, SPSS V16.0 (IBM, Armonk, NY, USA) statistical software was used. Categorical and continuous data were reported in the form of proportion and means ± SD, respectively. To explore the trend of TSCI population, *t*-test was applied to analyze the difference of the mean age between different time slots. In addition, to implement preventive programs purposefully, the relationships among age, gender, occupation, level, severity, and etiology were analyzed descriptively.

Results

Despite a constant number of ward beds for orthopedic cases at TMUGH from 1998 to 2009, the frequency of TSCI admissions increased steadily, with a growth rate of 14.5% on average. Tianjin's population growth rate was 6.1% during the corresponding period (Table 1 and Fig. 1).

Age

For the 239 cases, the largest age group was 45–54 years, followed by 35–44 years. The mean age was 45.4 ± 14.1 years. *T*-test demonstrated that the mean age in 2004–2006 and 2007–2009 was significantly older than that in 1998–2000 ($P < 0.05$). In addition, the data also revealed that the proportion of 15–34-year-olds had declined from 1998 to 2009. On the contrary, the percentage in the 55–64 age group had increased one-fold in 1998–2000, compared with the number in 2007–2009.

As shown in Fig. 2, for ≥45-year age groups, low fall was the most common cause, and the mean age in the low-fall group was 53.6 ± 14.0 years. In contrast, high fall was more common in the 15–44-year age group. The mean age of the high-fall group (37.3 ± 10.5 years) was much younger than that of the low-fall group.

Similar to high fall, MVCs were the leading cause in the 25–44-year age groups, and the second cause for the other age groups. The mean age of MVCs group was 43.3 ± 12.1 years. Furthermore, more than 80% of patients injured by falling objects belonged to the 25–54-years age groups.

Gender

Over this period, though the frequency of TSCI increased in both men and women, the male/female ratio of the four periods decreased slightly (Fig. 3). The male/female ratio was 4.2:1 as a whole. Falls and MVCs were the two leading etiologies for both male and female patients (Table 2). However, in contrast to female patients, male patients were prone to suffer injury from low fall, while female patients were more apt to acquire injury from MVCs.

Marital status

As shown in Table 1, more than 80% of all TSCI patients were married.

Table 1 Characteristics of patients with TSCI during four time periods

Variables	Time periods				
	1998–2000	2001–2003	2004–2006	2007–2009	Total
Frequency	48	56	63	72	239
Age					
15–24	12.5%	10.7%	6.3%	8.3%	9.2%
25–34	18.7%	12.5%	14.3%	5.5%	12.1%
35–44	27.1%	26.8%	23.8%	27.8%	26.4%
45–54	27.1%	26.8%	27.0%	26.4%	26.8%
55–64	10.4%	12.5%	14.3%	20.8%	15.1%
≥ 65	4.2%	10.7%	14.3%	11.1%	10.5%
Average age	41.6	45.0	47.8	47.7	45.4
Gender					
Male	91.7%	73.2%	79.4%	80.5%	80.8%
Female	8.3%	26.8%	20.6%	19.5%	19.2%
Marital status					
Married	85.4%	85.7%	85.7%	87.5%	86.2%
Unmarried	14.6%	12.5%	9.5%	11.1%	11.7%
Other	0	1.8%	4.8%	1.4%	2.1%
Etiology					
MVCs	39.6%	42.8%	39.7%	26.4%	36.4%
Low fall	27.1%	30.4%	35.0%	44.4%	35.2%
High fall	20.8%	12.5%	12.7%	22.2%	16.7%
Falling objects	10.4%	1.8%	6.3%	4.2%	5.4%
Collision of head against object	2.1%	5.3%	2.1%	1.4%	2.5%
Machine	0	5.3%	2.1%	1.4%	2.1%
Sports	0	1.8%	0	0	0.4%
Massage	0	0	2.1%	0	0.4%

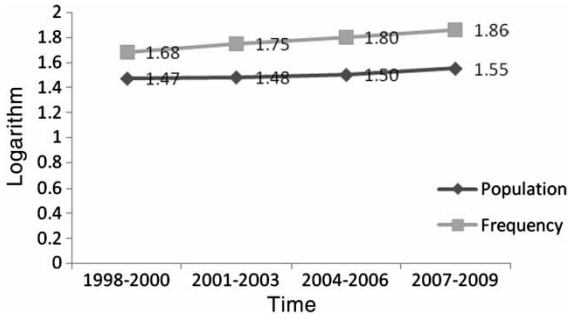

Figure 1 Semi-logarithmic line chart of the trends of population and TSCI frequency during 1998–2009.

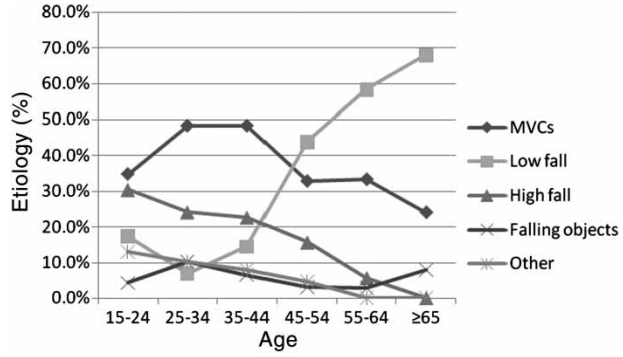

Figure 2 Distribution table of etiology by age.

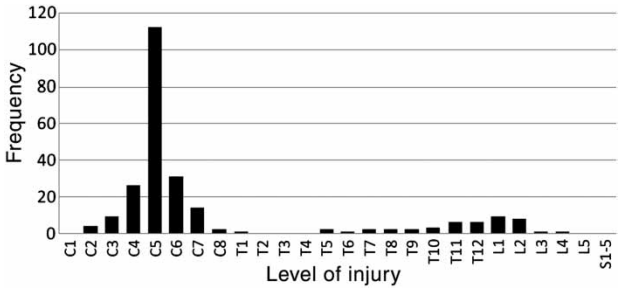

Figure 3 Distribution histogram of the injury level of the 239 patients.

Occupations

The occupations of patients with TSCI included unemployed (48.5%), peasants (20.1%), workers (15.1%), drivers (4.2%), retired (5.0%), civil servants (3.8%), teachers (2.1%), and students (1.2%).

As shown in Table 2, falls and MVCs were the first two causes for both the unemployed and peasants. As the two most common etiologies for workers, 'falls' and 'falling objects' accounted for 62.3 and 13.9% of this occupation, respectively. Furthermore, data also showed that 7 out of 10 drivers were injured in MVCs, and low fall was responsible for all injuries in the retired group.

Etiology

The final data demonstrated that falls were the leading cause, in which low fall and high fall comprised 35.2

Table 2 Distribution characteristics of patients with TSCI by etiology

Variables	Etiology					
	MVCs (%)	Low fall (%)	High fall (%)	Falling object (%)	Other (%)*	Total (%)
Gender						
Male	34.2	36.8	17.1	6.7	5.2	100
Female	45.6	28.3	17.4	0	8.7	100
Level of injury						
Cervical	38.3	40.3	11.7	3.6	6.1	100
Thoracic	20.8	12.5	54.2	12.5	0	100
Lumbar	36.8	10.5	26.3	15.8	10.5	100
Sacral	0	0	0	0	0	0
ASIA scale						
A	43.6	12.8	28.2	6.4	9.0	100
B	48.3	41.4	10.3	0	0	100
C	33.8	46.2	10.3	2.5	10.3	100
D	29.0	47.3	13.0	7.5	3.2	100
Severity						
CQ	50.0	16.7	18.6	1.8	13.0	100
IQ	33.8	49.3	9.2	4.2	3.5	100
CP	29.2	4.2	50.0	16.6	0	100
IP	26.3	21.1	31.6	10.5	10.5	100
Occupation						
Worker	8.3	29.0	33.3	13.9	6.5	100
Peasant	39.6	25.0	16.7	10.4	6.2	100
Driver	70.0	30.0	0	0	0	100
Other occupation**	17.2	58.6	17.3	0	6.9	100
Unemployed	43.8	35.5	12.4	2.5	5.8	100

CQ, complete quadriplegia; IQ, incomplete quadriplegia; CP, complete paraplegia; IP, incomplete paraplegia.
*Including collision of head against object, machine injury, sports, and massage.
**Including the retired, civil servants, teachers, and students.

and 16.7%, respectively. MVCs were the second most common cause (36.4%), followed by injury from falling objects (5.4%). In addition, seven were injured in collisions with objects, five sustained injuries caused by machinery, one fell off horseback, and one was injured during massage – none of the injuries involved violence.

Level of injury

As shown in Fig. 3, the level of TSCI took on bimodal distribution; the first peak focused on the cervical region (more than 80% of total), especially C4–C6, and the second peak at the thoracolumbar region, T11–L2.

This study revealed that the differences of injury level related to mechanisms of injury. For instance, falls and MVCs accounted for 52.0 and 38.3 of cervical injuries, respectively. While high fall and MVCs were the first two etiologies for thoracic and lumbar injuries.

ASIA grade and severity

During this period, percentages of ASIA A, B, C, and D injuries were 32.6, 12.1, 16.3, and 38.9%, respectively.

As for the severity of injury, 54 patients had complete tetraplegia, 142 had incomplete tetraplegia, 24 had complete paraplegia, and 19 had incomplete paraplegia. As shown in Table 2, 43.6% of complete injuries were due to MVCs and 41.0% due to falls. The two most common etiologies for incomplete injuries were low fall and MVCs, accounting for 46.0 and 32.9%, respectively.

Death and the cause of death

During hospitalization, eight patients died after operation; all were men. Four patients, with a mean age >68 years, had injuries from low fall. Two patients, aged 23 and 39 years, had acquired injuries from MVCs. The other two patients, aged 38 and 43 years, were injured as a result of high falls. Among the eight patients, seven had cervical injuries and one had an injury at the level of T11. In the end, four died from respiratory failure, two died from acute pulmonary embolism, and two died of multiple organ failure.

Discussion

In comparison with other countries, China has unique characteristics: one of the biggest developing countries in the world; rapid economic and social development; large population; and the implementation of one-child policy for more than 30 years. Till now, studies on the epidemiological characteristics of TSCI in China have been rare, but the information is needed for optimal use of medical resources and implementation of preventive programs.

In the current study, most injuries occurred in the 35–54-year age group, which was in accordance with the recent report from our research team.[5] However, in many other developing countries,[11,12] such as India in 2003–2004,[13] Turkey in 1990–1999,[3] and Iran in 2003–2008,[14,15] the high-risk groups for TSCI were the 20–40-year age groups. It is notable that the mean age for TSCI in this survey was similar to reports from many developed countries,[11] such as the Netherlands, Norway, and Canada,[16–18] where the mean age of TSCI patients was over 40 years. Meanwhile, this study also demonstrated that the mean age at injury increased steadily. The difference between China and other developing countries might be attributed to two main factors: (1) exclusion of patients aged 0–14 years; (2) implementation of the one-child policy in China, which has resulted in increase of the average age of the population.

In addition, the result revealed that the mean age of the low-fall group was significantly older than that of the MVCs and high-fall groups ($P < 0.001$). It also demonstrated that as age increased, the percentage of low fall increased from 6.9% (25–34-year age group) to 68.0% (≥65-year age group). So the proportion of elderly TSCI patients would expand with the aging of the population. A study of 412 patients with TSCI who were 70 years and older during 1978–2005 found that the percentage of geriatric patients had increased from 4.2 to 15.4% during this period.[19]

The male/female ratio was 4.2:1 in this study, and that of our recent report on TSCI in Tianjin was 5.6:1.[5] In China, most of the women were housewives or were engaged in occupations with low risk of injury, while the men were more likely to work in dangerous occupations.

Reports including the occupation of people with TSCI are rare. In this investigation, unemployed individuals were the largest group, followed by peasants and workers. A study from Anatolia Turkey reported that the largest occupational group suffering from TSCI was civil servants (22.63%), followed by housewives (20.22%), and then soldiers (15.03%) in 1990–1999.[3] Another study about TSCI from Turkey reported that the employed accounted for 71.8% of all TSCI.[20] The differences might be attributed to different economic, social, and political settings.

This study revealed that the main etiologies for different occupations were different, which is an important consideration for preventive measures. There were limitations in the collection of occupational classifications in this study: the retired and patients who were temporary workers or without complete occupational information might be categorized as unemployed; rural migrant workers have the dual roles of peasant and worker.

As in the recent report by our research team,[5] the most common etiology were falls, followed by MVCs, which were the same as in many other developing countries (such as Turkey, India, and Romania).[3,13,21] On the contrary, MVC was more common than falls in most of the developed countries.[2,4,11,22] A likely reason is that there are more cars per person in developed countries than in developing countries.

Furthermore, it should be noted that the proportion of the low-fall group was increasing constantly during this period. In contrast, the proportion of MVCs and high-fall groups was decreasing. This trend was in accordance with a survey from Finland, which reported that during the period from 1976 to 2005, MVCs declined as the top etiology of TSCI.[23] As we know, people are more prone to injury as they age and agility declines. So aging might contribute to this shift, and the proportion of low-fall group may continue to increase with the aging of the population.

The percentage of TSCI caused by falling objects decreased slightly with age. The collected data showed that most of these injuries were caused during house building and agricultural activities, which were usually the occupations of young men. Moreover, five patients were injured when their hair was caught in machinery, and one was injured by massage. Only one patient had acquired the injury in sports. Ye *et al.*[24] reported that high-risk sports, such as diving, gymnastics, etc., were less popular in China. No gunshot injuries were reported, which could be attributed to more stringent gun control than in other countries.

Overall, the level of injury took on bimodal distribution in current study, which was similar to our recent report.[5] Cervical TSCI accounted for more than 80%, with the remainder affecting the thoracic and lumbar segments. Level of injury was associated with the mechanisms of injury and the structures of spinal column. For instance, low fall was apt to result in cervical injuries. High fall was usually associated with cervical and thoracic injuries. As a high-energy trauma, MVCs could lead to SCI of any level, especially cervical injuries. In comparison with other segments of the spinal column, the strength and accessory structures of cervical vertebrae are weak. This may be one reason for its vulnerability. Falling objects usually fall on the shoulder and back, and the force is conducted downward to the thoracolumbar region, leading to spinal fracture or SCI. It was reported that the higher the injury level, the more likely it was that breathlessness was reported, and the higher the death rate.[25]

As in most of the developing countries, the main causes for TSCI, falls and MVCs were the causes of injuries categorized as ASIA A and D, respectively. So ASIA A and D injuries comprised the majority over these years. Low fall was the first cause for incomplete injury, and MVCs were more prone to cause complete injury.

The results in this study indicated that preventive measures and social assistance should be carried out according to epidemiological characteristics to control the expansion of the TSCI population. A detailed description of these programs is as follows:

Improvement of transportation

Widen the roads downtown and set up protective barriers between motor vehicular roads and non-motor vehicular roads. Although difficult to carry out in the populous areas, it is practical in the planning of new roads.

Legislation

Enact strict traffic rules and effective measures of rewards and punishments, and have traffic wardens strengthen enforcement. Institute mandatory occupational safety measures, such as use of safety harnesses and helmets in high-risk occupations. Require high-risk industries to provide safety equipment and guidelines for employees.

Education

Educate the population at risk. Richards *et al.*[26] demonstrated that elementary education was an effective approach for the prevention of SCI. According to epidemiological characteristics, educational programs about TSCI should be tailored for different occupation/age/gender groups.

Social assistance

Expand social support. Many patients lost their jobs as a result of their injuries; quality of life was adversely affected, especially in the elderly. Although the government had been providing social assistance to this vulnerable group, assistance was limited to economic support.

There were several limitations of this study: (1) It was a hospital-based descriptive study about TSCI. Just a portion of all TSCI patients in Tianjin were identified, and so the incidence rate could not be determined; (2) patients aged 0–14 years were excluded; (3) there was no access to information about people who died before arriving at the hospital; (4) the roles of patients in the MVCs were not clearly described; (5) the occupational classification needs to be detailed further, including living conditions and income to help ensure adequate social assistance.

Conclusion

This is a descriptive study of the characteristics of TSCI patients admitted to TMUGH from 1998 through 2009. The results were similar to that of most of the other developing countries. Falls and MVCs were the two leading causes, but the mean age was older than that in many other developing countries. The proportion of the older patients was increasing, as was the proportion of patients injured in the low-fall group. These data indicated that preventive programs should focus on falls and traffic accidents.

Acknowledgements

We express thanks to the staff of Medical Record Room of Tianjin Medical University General Hospital for the help with looking up records. This study was supported by the grants from Key Technology Foundation of Tianjin Health Bureau (07KG2), National Natural Science Foundation of China (30872603), and Research Foundation of Tianjin Health Bureau (09kz104).

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