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Saudi Journal of Biological Sciences

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ORIGINAL ARTICLE

Role of CT scan in theranostic and management of traumatic spinal cord injury



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Received 24 June 2016; revised 12 August 2016; accepted 17 August 2016

Available online 26 August 2016

KEYWORDS

Trauma;
Spine;
CT;
Spinal cord

Abstract Traumatic spinal cord injury (TSCI) is a condition with suffering of neural structures from acute trauma with short-term or permanent sensory and motor problems. This study was conducted with the aim of determining the prevalence of TSCI in Tehran with emphasis on demographic characteristics of patients and to evaluate the effect of computed tomography (CT) in determining fracture type and severity grade of injury among TSCI patients. In a cross-sectional study, all TSCI and spinal fracture patients ($N = 520$) who referred to the main trauma center in Tehran, Iran, in 2013 and 2014 were selected. Radiography and CT scan were prepared and reported blindly by two radiologists. Majority of the patients was 21–30 years male, married and their most common occupation was car driver. A significant difference was observed between gender and etiology ($P = 0.001$). The main etiology was traffic accident followed by falling from height. While the most common location of injury for males was thoracic vertebrae followed by lumbar vertebrae; for females it was lumbar followed by thoracic. Majority of patients had ASIA (American Spinal Injury Association) impairment scale of E (normal), followed by B (sensory incomplete). Most of the cases were hospitalized less than one week. Age of the patient and duration of hospitalization had a significant association ($P = 0.015$). The results showed that in traumatic spinal cord events, traffic accident and falling from height are the main etiologies; hence, authorities in Iranian health system could consider preventive policies to decline the load and TSCI effects in hospitals and population.

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1. Introduction

Traumatic spinal cord injury (TSCI) is a condition in which the neural elements suffer from acute trauma, resulting in short-term or permanent sensory and motor problems. TSCI can be prevented and it is the most devastating conditions in both developed and developing countries. The TSCI situation is not yet known in the world, which complicates

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Peer review under responsibility of King Saud University.



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the preventive policy decision making in fight against TSCI (Jazayeri et al., 2015). Traumatic injuries of the spine and spinal cord are common and potentially devastating lesions (Parizel et al., 2010). In fact, spine injury considered as one of the most feared traumas due to possibility of making paralysis. Spinal cord injury (SCI) is a main cause for disability (Van Goethem et al., 2005). Moreover, patients with TSCI have a higher lethality than the normal population (Hagen et al., 2012). Additionally, trauma could be considered as the main cause of death mainly due to traffic overload (Acosta et al., 1998). Trauma may also cause other related neurological conditions such as paraplegia, quadriplegia (Sekhon and Fehlings, 2001). It is important to mention that patients with inclusive spinal trauma with low motor or sensory response have little chance of improvement (el Masry and Short, 1997). However, patients with incomplete injury have good prognosis; they have better chances of fast diagnosis to treat fracture, hematomas, and so forth, that may compress the spinal cord (Rivlin and Tator, 1978; Robinson, 2000). Spine trauma injuries could be divided to fractures and dislocations, traumatic disk injuries, ligamentous injuries, whiplash injuries and spinal cord injuries (Van Goethem et al., 2005). Moreover, based on morphology vertebral fractures can be classified into wedge, (bi) concave, or crush fractures or the mechanism of injury (flexion-compression, axial compression, flexion-distraction, or rotational fracture-dislocation lesions) (Parizel et al., 2010).

Diagnostic medical imaging is known as a significant part of the spinal trauma prognosis, diagnosis and management (Goldberg and Kershah, 2010). Imaging modalities could play a critical role in the evaluation of acute and chronic spine injury. The injuries of spinal cord and soft-tissue can be investigated by magnetic resonance imaging (MRI). In addition, spine fractures can better characterized by computed tomography (CT) (Van Goethem et al., 2005). In the management of spinal cord injuries in both acute and chronic settings, imaging using CT and MRI is necessary. MRI is useful in showing the status of ligamentous integrity and visualizes internal impairments of the spinal cord (Holmes et al., 2002). Conventional angiography in diagnosis of vascular injuries has a more limited role due to high radiation absorbed dose and low differential contrast; while it can be better evaluated using CT- or MRI-angiography (Goldberg and Kershah, 2010). Furthermore, the “standard of care” in imaging of the spine in trauma patients is constantly changing with the increasing availability of new imaging modalities and techniques (Phal and Anderson, 2006). Multi-detector CT (MDCT) provides more accurate and expeditious imaging of the spine than previously CT generations (Phal and Anderson, 2006). MRI of the thoracic and lumbar spine provides the same advantages as it has in the cervical spines. It is appropriate in the visualization of non-displaced vertebral body fractures (Phal and Anderson, 2006). Sagittal cross section images make it possible to assess injury at noncontiguous levels. MRI also allows assessment of ligaments, disk, and soft tissues, as well as the spinal cord, conus medullaris, and cauda equine (Phal and Anderson, 2006; Rostamzadeh et al., 2015).

The main objective of the study is to determine prevalence of TSCI in patients referred to the main trauma center in Tehran, Iran, with respect to the demographic characteristics of the patients to assess the role of CT scan in determination of

fracture types and severity of the injury among the TSCI patients.

2. Materials and methods

2.1. Materials

This cross-sectional study was conducted on all TSCI and spinal fracture referring to Imam Khomeini Hospital Complex, the largest trauma center in Tehran, Iran, from February 2013 to December 2014. The study was planned for all clearly traumatic patients who were referred to emergency department of this center and had pain and sensorimotor symptoms, also those who were suspected having spinal cord trauma. Inclusion criteria were TSCI, age range of 18–65 years and ability to speak and understand Persian language fluently. Exclusion criteria were existence of cognitive impairment, history of mental diseases, and coincidental chronic diseases. After the reception, neurosurgeon requested conventional radiography and CT scan for patients with pain and sensory-motor symptoms. Radiographs were prepared from cervical, thoracic and lumbar vertebrae by a radiography system (Shimadzu Co., Ltd., Kyoto, Japan). Furthermore, CT scans were obtained from those vertebrae regions applying a MDCT scanner (16 slices, Aquilion, Toshiba Medical Systems, Otawara, Japan) with the following factors: 120 KVp, 110–220 mAs, 2 mm slice thickness, 25 cm field of view, matrix size 512 × 512, supine position with pitch factor of 1–1.5 and lateral topogram image associate with multi-projection reconstruction in axial and sagittal plans. The images were uploaded to picture archiving and communication system (PACS) (Marco pacs, CA, USA). Finally, two radiologists with at least 10 years of experiences in the field of neuroradiology blindly reported and confirmed the location of injury, vertebral morphology and fracture type, as well as making a decision for potential further treatment procedures. We also provided a registry database profile including the following parameters: gender, age, marital status, etiology, duration of stay in the hospital (hospitalization), type and level of SCI in accordance with the American Spinal Injury Association (ASIA) criteria based on the neurologist or neurosurgeon report (Table 1), severity of injury, medical procedures and other factors which already mentioned.

The present study has been reviewed and approved by the ethics committee of the Imam Khomeini Medical Imaging Center (Ethics committee No: IR20.82). The required data were collected by reviewing the medical files of the associated wards. Questionnaire of the study was approved by the scientific committee of the center. Also, any identifiable details were kept private and confidential, and recorded in a privacy enhanced database. In the next step, the obtained data were read and analyzed by researchers. A proposed list including clinical variables was used, which described the demographic and clinical characteristics of patients. As above-mentioned, the lists were derived using physician, and patient data were collected using standardized clinical forms. Moreover, radiological findings respecting the trauma were evaluated precisely. The findings were including compressive fracture, burst fracture, dislocation, bone swelling, spinal canal narrowing, spinal canal compression, vertebral listhesis, and fractures related to posterior elements (FRPE) (e.g. articular facets, lamina,

Table 1 International scaling of ASIA for classifying of TSCI severity.

Grade	Description
A	Complete: No sensory or motor function preserved in S4-5 (the lowest sacral segments)
B	Sensory incomplete: Sensory but no motor function preserved below the neurologic level (extending through S4-5)
C	Motor incomplete: Motor function preserved below the neurological level; majority of key muscle have a grade less than 3
D	Motor incomplete: Motor function preserved below the neurological level; majority of key muscle have a greater than or equal to 3. There must be some sparing of sensory and/or motor function in the segments S4-5
E	Normal: although sensory and motor functions are normal but patient may have abnormalities on reflex examination

spinous and transverse processes, pedicle, lateral mass and arch). In addition to CT scan, an MRI imaging procedure was also performed for those patients who were eligible to do the MRI scanning. In this article we use term of “MDCT visualization” in order to explain “sensitivity of MDCT to imaging of vertebrae fractures and other vertebrae abnormalities”. The MRI was applied for evaluation the degree of sensitivity of the obtained CT slices. This study does not report the results of MRI, since our intention was to demonstrate MDCT visualization.

2.2. Statistical analysis

Statistical analysis was carried out using SPSS (Version 19; SPSS Inc., Chicago, IL, USA). Chi-square test was also used for nominal and ordinal variables. P -value < 0.05 is considered as significant difference.

3. Results

Tables 2–4 show the results of this study with 520 TSCI patients (406 males, 114 females). Table 2 summarizes demographic characteristics of the study population. Majority (78.1%) of the patients were male. Most of the cases (71%) were married, followed by singles (18.4%). Their most common occupation was car driver (19.6%), followed by building worker (15.6%). None of the female patients were car/motor/bicycle driver or building worker. The most high risk age-group was 21–30 years old (y/o), males (30%), females (23.7%).

Table 3 demonstrates the findings of the study for the two genders. There was a statistically significant difference between genders in etiology ($P = 0.001$). Traffic accident (44.6%) and falling from height (29.8%) were the most common etiology. Notice that in the tables we split the traffic accident into car accident and motorcycle/bicycle accident. While the most common location of injury for males was thoracic vertebra (TV) followed by lumbar vertebra (LV), for females it was LV followed by TV. Majority of the patients had the impairment ASIA scale of E (normal) (26.2%), followed by ASIA scale of B (23.3). The longer duration of hospitalization for both males and females was less than one week followed by more than 4 weeks.

Characteristics respecting the patients age-group are revealed in Table 4. As can be seen here, plurality (28.7%) of the patients was 21–30 y/o. In all age-groups, traffic accident was the main etiology; except for less than 10 y/o, with falling from height. In all age-groups LV was the main location of injury; except for 11–20 y/o and 21–30 y/o, with TV. Age of the patient and the duration of hospitalization had a

Table 2 Demographic characteristics of the patients participated in the study.

Characteristics	Male	Female	Total
Age (year)			
< 10	14	8	22
11–20	47	16	63
21–30	122	27	149
31–40	81	24	105
41–50	56	18	74
51–60	49	13	62
> 61	37	8	45
Total	406	114	520
Marital Status*			
Married	293	76	369
Single	61	21	82
Divorced	17	6	23
Widowed	0	8	8
Unknown	35	3	38
Total	406	114	520
Occupation			
Gardner	12	0	12
Mason	11	0	11
Student	54	24	78
Farmer	23	0	23
Car driver	102	0	102
House worker	0	45	45
Motor driver	26	0	26
Welder	14	0	14
Telecom staff	3	0	3
Power staff	7	0	7
Horseman	5	0	5
Mountaineer	8	1	9
Newborn or children	14	8	22
Emeritus	26	8	34
Others	14	16	30
Trainer	6	12	18
Building worker	81	0	81
Total	406	114	520

* $P < 0.001$.

significant association ($P = 0.015$). The age-groups with less than 10, as well as 31–40, and 41–50 y/o stayed more than 4 weeks in the hospital. FRPE were detected in more than 50% in all age-groups among males and females, except for 51–60 years females.

The main etiology of injury in the all levels was traffic accident; except for TL in which falling from height was main etiology. The duration of hospitalization was less than one week, two weeks, and more than 4 weeks for LV, TV and the others, respectively. Compressive fracture, burst fracture, dislocation,

Table 3 The relation of main characteristics with gender.

Characteristics	Male	Female	Total
Etiology*			
Car accident	160	45	205
Motor/bicycle accident	21	0	21
Falling from height	115	40	155
Violence	46	4	50
Sport/recreation	37	8	45
Others	27	17	44
Total	406	114	520
Level of injury			
Cervical vertebrae	105	22	127
Thoracic vertebrae	127	30	157
Lumbar vertebrae	115	41	156
Cervical/Thoracic	25	8	33
Cervical/Lumbar	18	7	25
Thoracic/Lumbar	16	6	22
Total	406	114	520
Impairment			
Alive	375	111	486
Dead	31	3	34
Total	406	114	520
Impairment scaling			
ASIA scale A	42	15	57
ASIA scale B	96	25	121
ASIA scale C	62	14	76
ASIA scale D	76	20	96
ASIA scale E (normal)	99	37	136
Death	31	3	34
Total	406	114	520
Duration of hospitalization			
< 1 week	103	28	131
1 week	41	16	57
2 weeks	61	11	72
3 weeks	44	14	58
4 weeks	68	19	87
> 4 weeks	89	26	115
Total	406	114	520

* $P = 0.001$.

bone swelling, spinal canal narrowing, spinal canal compression, vertebral listhesis, and FRPE were less detected in LV. Age and gender have important effects on the percentage of visualization of injuries characteristics. Each age-group as well as each gender had its own etiology and location of injury. TV injury is almost more common in all age-groups and for the both genders. The most important etiology for almost all age-groups and both genders was traffic accident. For males, the second etiology was violence; while, for females it was falling from height.

4. Discussion

This study determined distribution of demographic characteristics of TSCI patients in Tehran, Iran. The age and gender were weighty factors affecting on the etiology and location of injury and impairment. Traffic accident was the most important etiology for both males and females as well as almost in all age-groups. While, violence was the second important etiology among males; in females it was falling from height. Since majority of the patients (71%) were married,

percentage of married cases was higher than other groups in all categories. Additionally, none of the female patients were motor/bicycle driver or building worker. This was a normal situation; since in Iran ladies are not officially eligible to drive motor/bicycle. Normally women have no intention to work as a building worker. We also found that none of the injured women were car driver. This might be due to the fact that women usually drive more carefully than men!

In the recent years, many studies have reported the epidemiology of TSCI. Initial studies investigated the descriptive epidemiology such as incidence rates, age, gender, race, etiology, level and completeness of injury (De vivo, 2012). In a study by Rahimi-Movaghar et al. (2009) found that prevalence of TSCI in Tehran ranged from 1.2 to 11.4 per 10,000 people. Moreover, Chabok et al. (2010) and Haddadi and Yousefzadeh (2015) in two separate studies, reported that motor vehicle accident and falling from height were the most common causes of TSCI in Guilan and Mazandaran (two provinces in north of Iran), respectively.

From scientific point of view, studies on the long-term incidence of TSCI are vital and essential to identify the high-risk groups, create awareness, establish trends, predict the needs, and thus contribute to effective health care planning of this condition. Although researches reveal that more than 80% of the world's population is spread across more than 100 developing countries, information regarding TSCI from these countries is still meager. Besides, an established national spinal trauma or SCI is lacking among the developing countries (Robert and Zamzami, 2013). It is known that there are different potential etiologies of TSCI; the most frequent etiology is traffic accidents, followed by falls, violence and sports/leisure activity incidents (Hagen et al., 2012).

There are available data of TSCI epidemiologic in 41 countries of the world, most of which are attributed to European and high-income countries. Therefore, it is necessary to pay more attention to developing and low-income countries for planning appropriate cost-effective preventive methods against TSCI (Jazayeri et al., 2015). While, the annual incidence of TSCI varies from 2.3 to 83 patients per million in some studies around the world (Robert and Zamzami, 2013; Noe et al., 2015; Hagen, 2015), in another study, the incidence of TSCI varied from 3.6 to 195.4 patients per million in Canada and Ireland, respectively (Jazayeri et al., 2015). There are valuable reports of TSCI for Australia, Canada, USA, and high-income European countries. While, there are no valuable reports of TSCI for African and Asian countries. Moreover, a decreasing or stable trend of TSCI incidence is observed in Australia, Austria, Canada, France, Iceland, New Zealand, Turkey and USA; but it increases in Ireland, Italy, Norway, Russia, Saudi Arabia, Spain and Taiwan, which this can be attributed to having a developed recognition, registration and health care system in these countries (Jazayeri et al., 2015). In addition, Saudi Arabia with a population of over 28 million has one of the highest rates of TSCI in the world (Robert and Zamzami, 2013). Furthermore, the prevalence ranges from 236 to 1800 per million in India and USA, respectively. Finally, the average age at the time of injury also varies from 26.8 years in Turkey to 55.5 years in the USA; the ratio of males to females varies from 0.9 in Taiwan to 12.0 in Nigeria (Hagen et al., 2012).

TSCI could cause substantial changes in a person's life. The post-injury physical and psychosocial adjustments are complex

Table 4 The relation of main characteristics with age.

Age group (Year)	Characteristics						Total
	Etiology						
	Car Accident	Motor/bicycle Accident	Fall from height	Violence	Sport/recreation	Others	
< 10	4	0	9	6	0	3	22
11–20	18	6	11	14	10	4	63
21–30	55	11	38	19	18	8	149
31–40	36	3	34	6	15	11	105
41–50	36	0	25	4	2	7	74
51–60	33	0	23	1	0	5	62
61+	23	1	15	0	0	6	45
Total	205	21	155	50	45	44	520
<i>P</i> -value	< 0.0001						
	Level of injury						
	CV*	TV	LV	CT	CL	TL	
< 10	5	4	6	3	1	3	22
11–20	12	27	20	2	2	0	63
21–30	39	49	36	9	9	7	149
31–40	28	29	32	7	4	5	105
41–50	21	15	25	5	3	5	74
51–60	13	19	23	4	3	0	62
61+	9	14	14	3	3	2	45
Total	127	157	156	33	25	22	520
<i>P</i> -value	0.545						
	Duration of hospitalization						
	< 1 week	1 week	2 weeks	3 weeks	4 weeks	> 4 weeks	
< 10	2	0	5	3	5	7	22
11–20	14	6	15	6	14	8	63
21–30	37	22	15	14	29	32	149
31–40	29	11	11	14	14	26	105
41–50	15	7	6	13	10	23	74
51–60	21	6	16	4	4	11	62
61+	13	5	4	4	11	8	45
Total	131	57	72	58	87	115	520
<i>P</i> -value	0.015						
	Fractures related to posterior element						
	Not detected			Detected			
< 10	1			21			22
11–20	26			37			63
21–30	56			93			149
31–40	43			62			105
41–50	32			42			74
51–60	26			36			62
61+	20			25			45
Total	204			316			520
<i>P</i> -value	0.048						

and extremely challenging, and there is a high risk of serious complications both in the acute phase and several years after the trauma. Fortunately, international literature showed that long-term survival in people with TSCI has significantly increased over the last 50–60 years (Lidal, 2010). In fact, a marked improvement in the acute medical management as well as highly specialized TSCI rehabilitation have contributed to changes in morbidity and mortality patterns in this group of patients. However, more knowledge is required about outcomes in people surviving more than 20 years after the injury

(Lidal, 2010). Moreover, TSCI may account for a significant proportion of musculoskeletal injuries worldwide (Ihegihu et al., 2014). It should be noted that during TSCI, the results could be devastating and may result in death or long-term disability, which can be cause life changing, because if spinal cord once damage is done; it is usually permanent.

Moreover, about 10,000 traumatic cervical spines and 4000 traumatic thoraco-lumbar fractures are detected in the USA each year. Despite this fact that the number of individuals sustaining paralysis is lower than individuals with brain injury,

but their socioeconomic costs are significant. Since most of the spinal trauma patients survive their injuries, almost one out of 1000 inhabitants in the USA are currently being cared for partial or complete paralysis (Van Goethem et al., 2005). The potential costs may include direct and indirect costs. While direct costs include death, hospitalization, rehabilitation, medications, diagnostic tests (CT scan and MRI), indirect costs may consist of increasing disability among younger people, loss of production, absence from work, psychiatric effects on families, and establishing more specialized centers for injured TSCI patients. It is worth to mention that 60–70 years ago the general prognosis for people with SCI was poor (Lidal, 2010). The immediate survival after the injury was short, and the one year survival rates were low as a result of medical complications such as renal failure and pulmonary infections (Frankel et al., 1998; Samsa et al., 1993). However, in 1954 Donald Munro pointed out that the outlook for these patients was becoming more optimistic, and he was particularly studied the possibilities of making people with SCI ambulatory and capable of working (Munro, 1945). The results of the mentioned study reported the importance of an active social life, and stated that “people with full self-care ability should be able and should be expected to go to work” (Munro, 1945). In the early 1970s, the first TSCI care system program was initiated in the USA (De vivo, 2012). Since then, advances in emergency medical techniques, acute care and SCI rehabilitation led to a significant increase in longevity for this group, and an increased interest in long-term outcomes on morbidity, mortality and quality of life has been developed (Lidal, 2010).

The average age at the time of injury varies from 26.8 years in Turkey to 55.5 years in the USA (Hagen et al., 2012; Hagen, 2015). The findings of our study showed that the most high risk age-group was 21–30 y/o, in both males and females, which is similar to Denmark study in 1990–94; but not in 2010–12 (Noe et al., 2015). Despite the present study with declining injury by being older, average age at injury increased in an aging population at risk in the USA (De vivo, 2012) and China (Ning et al., 2011), which is very different from the results of the present study. To explain the difference, it might be reasonable to think that the percentage of elderly people will not increase until the rate of their mortality is high (De vivo, 2012). In fact, elderly people will generally have incomplete and/or lower level of injuries, and will have also high degrees of independence and good health. In addition, elderly people due to less willingness to participate, harder to follow long-term and less compliant with study protocols are more likely to have cognitive difficulties (De vivo, 2012).

The most important etiology in the present study was traffic accident for both males and females, followed by violence (in males) and falling from height (for females). These findings either are sometimes similar to or different from other studies. For instance, in a study in Denmark, from 1990 to 2012, the proportion of transport-related injuries decreased from 56.9% to 36.8% and fall-related injuries increased from 11.1 to 35.5% during this period (Noe et al., 2015). In another study by Hagen et al. (2012) reported that the most frequent etiology was traffic accidents, followed by falls, violence and sports/leisure activity which are not completely similar to our study. It should be mentioned that although incidence and prevalence of TSCI in USA are higher than the rest of the world (De vivo, 2012), the main etiology is very different from

the rest of the world; because the American experience indicates that about 90% of the total mortality from trauma occurs on the battlefield for Americans (Bellamy et al., 1986). Moreover, there is evidence that injuries due to falls are increased (De vivo, 2012), for instance in China (Ning et al., 2011), which is similar to our present findings.

In addition, shorter duration of hospital stay in rehabilitation and the increase of discharges into nursing homes can cause many difficulties for participants to complete the study protocols before discharge (De vivo, 2012). The possibility of increasing preexisting medical conditions and secondary medical complications indicated that a higher percentage of people will not meet inclusion criteria for participating in the research studies. The rate of cervical injuries is increasing, while the rate of neurologically complete injuries is decreasing. Generally, recognition in population life expectancy isn't reflected in the SCI population (De vivo, 2012). Due to an increase in age and changes in US health care delivery, treatment outcomes are changing. Increasing likelihood of preexisting medical conditions and secondary medical complications will mean that a higher percentage of people will not meet eligibility criteria for research studies (De vivo, 2012).

Imaging methods may include CT scan and MRI (conventional and advanced technology). CT scan is indeed a gold standard for diagnosis (confirmation of TSCI is done by imaging), determination of natural history of disease (staging), estimation of length of disease, prognosis (severity of disease) and the quality of response to treatment procedures. It should be noted that at the first step, it might not be used due to the possibility of existence of some metal particles inside the tissue. Location of the injury could be diagnosed via imaging technology (Schriger, 2006). Imaging techniques can evaluate the constancy of the spine, and to define the repercussion of the trauma on the diameters of the spinal canal and neural foramina (Schriger, 2006). The etiology of fracture is different according to age and gender, for example young males mostly suffer from trauma; but elderly females' fractures are due to osteoporosis (Johnell et al., 2005). In addition to accidents, there are other etiologies for trauma such as fall, sports, Violence (Tapias et al., 2003). Treatment of spinal injury includes stabilization, determining the location and extent of SCI. Most of the cases undergo surgical operation followed by medications such as Methylprednisolone, which could have side effects as well (Bracken et al., 1990). Radiographs are usually used to make diagnosis; however, there are some instances of spinal damage due to fractures which have elapsed radiographs. CT or MRI can ensure diagnosis of spinal fractures in cases where movement of spinal column is contraindicated due to the probability of neurological damage (Holmes et al., 2002). When radiographs do not visualize injury areas sharply, CT defines fractured areas better (Rowan et al., 2002). CT can also detect soft-tissue changes. CT together with myelography can diagnose spinal canal abnormalities better than isolated utilization of those techniques. Initially, the patient had ASIA scale A of neurological function which ended up in recovering to ASIA scale D. Methods for diffusion-weighted MRI of the spinal cord have revolutionized imaging of early brain injury (Assaf et al., 2000). So far, the edema-related swelling of neural elements and misalignment of spinal elements are only visible by these methods (Assaf et al., 2000). New methods are able to track migration of transplanted cells, cell migration and differentiation, and long-tract

integrity using paramagnetic tracers and molecular diffusion. Some victims injured in motor vehicle accidents, sporting events, falling down, suicide and gunshot injuries (McDonald and Sadowsky, 2002).

This is the first time that the data were collected from the largest trauma center, i.e. Imam Khomeini Hospital Complex, in Tehran, the capital city of Iran. Strength of this study was the possibility of collection of comprehensive information about the patients including demographic, radiological, neurological, and rehabilitation properties. The present study has also some limitations. First, there was no access to the data before 2013 due to lack of TSCI registry system. Second, there was no access to the available patients' data in other trauma centers across Iran. Third, there was no available data regarding the effects of other issues such as war and armed conflicts.

4. Conclusion

This study revealed that traffic accidents followed by falling from height are the main etiology among Iranian TSCI patients. According to the results of this study, authorities in the health systems should consider making proper decision in order to decline the effects of TSCI in the population and hospitals. It is recommended that a national registry database can be established for spinal cord injuries by the Ministries of Health, so that the etiological pattern of spinal cord injuries are known in the country. The authorities then can formulate specific policies to governments for preventing and establishing a better care system for TSCI patients.

Acknowledgment

We thank Mr. Omid Rostamzadeh for his collaboration in data collection and his grateful assistance. The authors also thank Dr. Mahmoud Azimi for his neurological examinations. This study was financially supported by the Shahrekord University of Medical Sciences.

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