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ORIGINAL ARTICLE

Traumatic spinal cord injuries: evidence from 30 years in a single centre

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Study design: Retrospective data analysis.
Objectives: Traumatic spinal cord injury (TSCI) is a devastating injury that causes a lifelong disability, involving mostly young men. The aim of the study was to analyse some clinical and epidemiological features of TSCI patients admitted to the Spinal Unit of Florence, Italy, during 30 years, from 1981 to 2010.
Setting: Spinal Unit, Careggi University Hospital, Florence, Italy.
Methods: The medical files from the computerised database of the patients who sustained TSCI from 1 January 1981 to 31 December 2010 and received comprehensive care in the same centre were analysed. Information was collected with regard to demographic data, causes of injury, time of injury, associated injuries, treatment of the vertebral lesion and neurological condition at discharge.
Results: A total of 1479 patients were included. The number of two-wheeler road traffic accidents (RTAs) has increased over the years, whereas the percentage of falls and sports accidents has been quite constant. The lesions due to 4-wheeler RTAs tend to decrease. Lesions due to falls mainly affected older persons than those due to sports accidents, with a mean age at the time of injury of 52 and 25 years, respectively. Diving was the most common cause among sports and leisure accidents. Associated injuries were present in 56% of all the cases included.
Conclusion: The cases of spinal cord injury due to two-wheeler RTAs have increased over the years probably because of the increasing diffusion of the use of such a vehicle, and such an eventuality has to be taken into consideration in future prevention strategies.
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Keywords: traumatic spinal cord injury; causes of injury; AIS; associated injuries

INTRODUCTION

Traumatic spinal cord injury (TSCI) is a major event, causing a severe lifelong disability, mainly involving young people at the peak of their social and working life. There is a strong male predominance.[1–7] Several studies have reported that about 40% of the patients affected by TSCI are tetraplegics, and around 40% have a neurologically complete spinal lesion.[2,5–7] The annual incidence of TSCI in Europe has been reported to be about 17.5 patients per million, whereas in North America it is reported to be around 40 per million population.[6,8,9] In sub-Saharan Africa, the incidence is higher owing to gunshots.[10] In Europe, North America, Australia and Japan, the most common causes of injury are road traffic accidents (RTAs), followed by falls and sports and leisure accidents.[6] In a Spanish study, 37% of all traumatic injuries derived from automobile collisions and 14% derived from motorcycle collisions. RTA was the leading cause of injury for individuals up to 45 years of age.[11]

In previous studies, spinal cord injury (SCI) due to falls was significantly more frequent in patients older than 65 years,[6,7,11] and they tend to occur during activities of daily life.[12] Another study conducted in Canada showed that injuries due to falls cause lesions mainly at the cervical, low thoracic and lumbar levels.[4]

As reported in a previous study in our centre, diving is the most common cause among sports and leisure accidents affecting young persons and resulting in the majority of neurologically incomplete cervical SCI cases[13] according to the American Spinal Injury Association–International Spinal Cord Society international standard for neurological classification.[14]

Other causes, such as violence and gunshots, are not common in Europe and in Italy when compared with South America and USA.

TSCIs are frequently high-energy traumas, and associated injuries such as bone fractures, head trauma, pneumothorax and abdominal lesions are frequently present.[15]

Today, in our centre, most patients with acute TSCI undergo surgery early after injury, with the aim of decompressing the spinal cord and/or stabilising the unstable vertebral column. Divanoglou *et al.*[15,16] found in their study that, in Thessaloniki area in Greece, 63 out of 81 cases (78%) were surgically treated for their vertebral lesion after an average time of 10 days, whereas in Stockholm 46 out of 47 (98%) underwent surgery after an average time of 3 days. A surgical stabilisation of the spine may mostly allow the rehabilitation to start earlier and might reduce the risk of complications due to the prolonged forced immobilisation in bed during the acute rehabilitation phase.

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The aim of this study is to analyse the clinical and epidemiological features of TSCI and how the injury panorama has changed over a period of 30 years, in a single centre. Gender and age at the time of injury, the treatment of the vertebral lesion (conservative or surgical) and the presence and type of associated injuries were analysed, and the correlation with the different causes of TSCI was studied.

PATIENTS AND METHODS

The study was conducted at the Spinal Unit of Florence, located in Tuscany, Italy, whose mission is to provide the comprehensive management of TSCI for a population of 3.8 million inhabitants (catchment area). The Spinal Unit of Florence had a 30-bed facility for in-patients until 1999. From 1999 to 2010, it was increased to 50 beds. An average of 20% of the admitted patients resided outside its catchment area. Not all the TSCI persons from Tuscany have been admitted to this Spinal Unit, and for this reason we may not talk about any incidence in terms of TSCI related to the whole population of the catchment area (Tuscany region).

Patients were included after analysing the computerised data files. Only those who received the comprehensive treatment in the Centre, starting from the early acute stage following the trauma, during the period of time from 1 January 1981 to 31 December 2010, were included in the study. Patients with severe head injury were excluded, because they were transferred elsewhere for the rehabilitation.

According to the time of the lesion they were divided into three groups: 1981–1990, 1991–2000 and 2001–2010.

The causes of injury were grouped as follows: falls, RTAs, sports and leisure accidents, and other injuries (violence, hit by a falling object and so on). Falls were then sub-divided into falls from heights and at ground level. RTAs were also sub-divided into 'four-wheeler' and 'two-wheeler' vehicle accidents. The American Spinal Injury Association–International Spinal Cord Society international standard of neurological classification for SCIs was used to classify both the severity and the neurological level of lesion. The levels of lesion were grouped into paraplegia and tetraplegia, according to the definition of the same classification.[14] Age at the time of injury, neurological conditions at discharge and gender were analysed and correlated to each cause of injury.

Associated injuries, divided into five groups: bone fractures, abdominal trauma, thoracic trauma, head trauma and multi-trauma as the combination of associated injuries, were correlated to the various causes of injury. Thoracic trauma included hemo/pneumo thorax, costal fractures and lung trauma. Abdominal trauma included injuries to the liver, spleen and other internal organs. Multi-trauma included more than one associated injury. Bone fractures were furthermore divided into fractures of lower extremities–pelvis and upper extremities.

Treatments of vertebral lesions were defined and classified as Conservative or Surgical. In conservative treatment, no surgical intervention was performed, and treatments such as axial traction, cervical orthosis or Halo cervical immobiliser, or simple immobilisation in bed, were used. In surgical treatment, the patient underwent a surgical procedure by anterior or posterior or combined approach. This last treatment was used both with the aim of decompressing the spinal cord or/and to stabilise the unstable column.

The study followed the ethical rules of Careggi University Hospital, and it was approved by the local ethics committee.

Table 1 Causes of TSCI admitted at the Spinal Unit of Florence during the period 1981–2010

Cause of SCI	*1981–1990*		*1991–2000*		*2001–2010*	
	Number	*%*	*Number*	*%*	*Number*	*%*
Falls	115	38.6	241	37.0	193	36.4
Falls from high heights	63	21.2	160	24.5	141	26.6
Falls at ground level	52	17.4	81	13.5	52	9.8
Road traffic accidents	115	38.6	293	45.0	251	47.4
Four-wheeler	90	30.2	204	31.3	103	19.4
Two-wheeler	25	8.4	89	13.7	148	28.0
Sport and leisure	30	10.0	41	6.3	76	5.8
Others	38	12.8	76	11.7	55	10.4
Total	298	100.0	651	100.0	530	100.0

Abbreviation: SCI, spinal cord injury.

Data analysis and statistics

Groups and subgroups are presented as absolute numbers and percentage.

Comparison between the groups was made by chi-squared analysis. $P<0.05$ was considered statistically significant.

RESULTS

A total of 1479 patients who received comprehensive in-hospital care and rehabilitation following a TSCI during the years 1981–2010 were identified and included in the study.

The number of two-wheeler accidents has increased constantly during the years. The difference was statistically significant both between the periods 1981–1990 and 1991–2000 and between the periods 1981–1990 and 2001–2010 (chi square = 5.079, $P=0.012$, df = 1, and chi square = 36.444, $P=0.0001$, df = 1, respectively), whereas the incidence of falls and sports accidents has been mainly constant (see Table 1), with a slight decrease of the percentage of four-wheeler accidents.

RTAs were the most common cause of trauma, followed by falls (see Table 1). Falls from heights involved more often males, causing more often paraplegia. They were younger than those with falls at the ground level. Patients traumatised after falls were older at the time of injury when compared with those traumatised during sports and leisure.

Mean age at the time of injury, neurological levels expressed as paraplegia or tetraplegia, the presence of associated injuries for each cause and the male/female ratio are shown in Table 2.

With regard to the severity of injury, patients who had sports and leisure accidents more often had neurologically incomplete lesions (AIS B) when compared with other causes of injury (Figure 1). This difference was statistically significant (chi-squared = 12.762, df = 1, $P=0.0004$).

Associated injuries occurred in 56% of patients and were most common in motorcycle (two-wheeler) accidents (see Table 2). The most common associated injury was thoracic trauma followed by bone fractures, whereas abdominal traumas were less frequent, as shown in Figure 2. In all, 36/79 (46%) bone fractures involved the upper extremities and 43/79 (54%) involved the lower extremities.

Surgical approach for the treatment of the vertebral lesion has increased during the years (see Figure 3). This might have been due to both the increase in ability of the surgical teams and the improvement of the procedures in the first-aid department, in terms of shortening the times for the comprehensive management.

The difference in percentage between the periods 1981–1990 and 1991–2000 did not have statistical significance (chi-square = 2.797, df = 1, $P=0.0944$), whereas the differences between the periods 1981–1990 and 2001–2010, and between the periods 1991–2000 and 2001–2010, did reach statistical significance (chi square = 29.904, df = 1, $P=0.0001$ and chi square = 22.245, df = 1, $P=0.001$ respectively).

DISCUSSION

This study is a retrospective data analysis of those patients who were admitted to the Spinal Unit of Florence during a 30-year period following a TSCI. It has taken into consideration only those patients

Table 2 Causes of injury, gender, age at time of injury (median), neurological levels (paraplegia or tetraplegia) and associated injuries in TSCI during the period from 1 January 1981 to 31 December 2010

Cause of injury			*Male*		*Female*		*Median age (min–max)*	*Tetra*		*Para*		*Associated injuries*	
	N	%	N	%	N	%		N	%	N	%	N	%
Falls	549	37	412	75	137	25	53 (18–86)	266	48	287	52	247	45
Falls high heights	364	25	292	80	72	20	51 (22–78)	146	40	218	60	195	54
Falls ground level	185	12	120	65	65	35	60 (18–86)	120	65	65	35	52	28
RTA	659	45	515	78	144	22	36 (16–80)	254	39	405	61	475	72
Four wheelers	397	27	313	79	84	21	38 (16–80)	194	49	203	51	278	70
Two wheelers	262	18	202	77	60	23	31 (16-59)	60	23	202	77	197	75
Sports and leisure	102	7	78	77	24	23	26 (14–51)	74	77	28	23	26	25
Others	169	11	137	81	32	19	40 (14–86)	64	38	105	62	85	50
Total	1479	100	1142	77	337	23	39 (14–86)	623	42	856	58	833	56

Abbreviation: RTA, road traffic accidents.

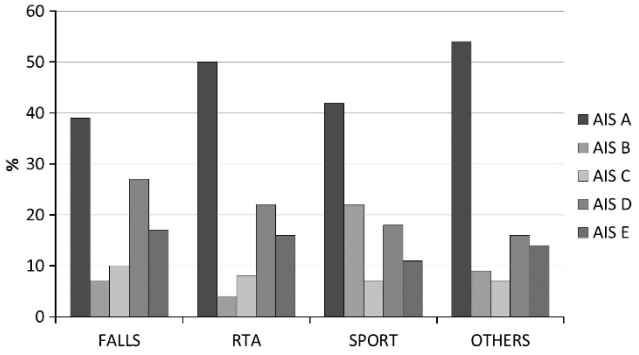

Figure 1 American Spinal Injury Association–International Spinal Cord Society Impairment scale grades related to the 4 different causes (falls, RTA, sport and leisure and others).

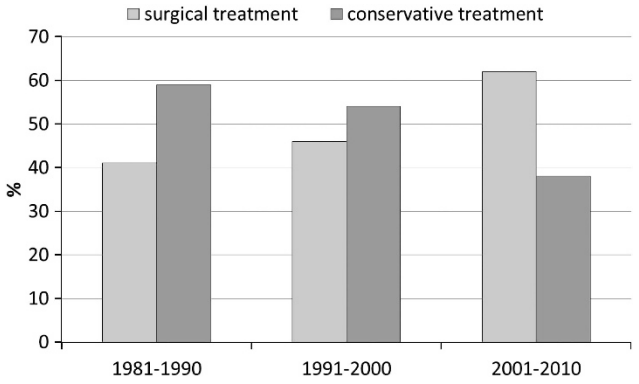

Figure 2 Associated injuries in TSCI during the period from the 1 January 1981 to the 31 December 2010.

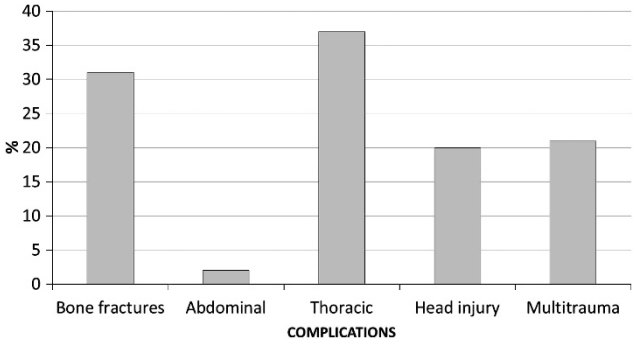

Figure 3 Surgical vs Conservative treatment of the vertebral lesions during the three periods 1981–1990, 1991–2000 and 2001–2010.

who received the comprehensive treatment including the entire rehabilitation programme.

The results show that, among RTAs, two-wheeler vehicle accidents have constantly increased during the years, whereas four-wheeler vehicle accidents have decreased in number and percentage. The percentage of TSCI due to falls, sports accident and other types of trauma has been relatively stable. Furthermore, the mean age at injury for the different aetiological causes and the male/female ratio has not changed during the 30-year period. However, the surgical approach for the treatment aimed to stabilise the damaged vertebral columnhas become more and more frequent with time.

Associated injuries were found to be very common, and they occurred in 56% of the total cases.

In the Tuscany area, a common cause of falls is represented by falling down from the tree when picking fruits, mostly for personal use. The falls from heights result in a high-energy trauma and more often cause a complete SCI. Falls at the ground level are often minor domestic falls and might result in an SCI when there is concomitant spinal canal stenosis.[17,18] In fact, these patients are usually older at the time of injury in comparison to those with other causes of TSCI: the skeletal system is often more rigid and they have problems with their balance, resulting in a higher risk of falls and spinal cord injury.

The increase in the number of two-wheeler vehicle users may explain their increasing risk for accidents and for TSCIs, passing from 8.4% in the first period of the study to 28% in the last decade (see Table 1). The decreased number of TSCIs due to four-wheeler accidents might be explained by the mandatory use of seatbelts, more severe speed limitations, increased checks through alcohol tests and the improved safety measures introduced in vehicles.

Diving accidents, the most common among sports and leisure accidents seen to the Spinal Unit of Florence, caused a statistically significant higher percentage of neurologically incomplete lesions according to the definition of the American Spinal Injury Association–International Spinal Cord Society International Standard of neurological classification (tetraplegia AIS B) when compared with other causes of injury.[13] The diver generally strikes his head on the bottom of the pool or sea, but diving injuries may also occur by

striking another swimmer or a hidden object under the water. The mechanism of this type of cervical injury is generally in hyperflexion and/or compression. Less frequently, there may be hyperextension, lateral flexion or rotation mechanisms. Such phenomena can also be combined.

Other types of injuries, such as gunshots, are less common in Tuscany, as well as in the rest of Europe, when compared with the USA and South America.

TSCIs are often part of a multitraumatic event, and for this reason associated injuries are present in 56% of the cases (see Table 2). Robertson *et al.*[19] reported that two-wheeler vehicle accidents cause multilevel injury, and associated injuries are common. In this study, 75% of the SCI patients with two-wheeler accidents suffered from associated injuries. Trauma to the chest and abdomen might be life-threatening and often requires immediate care. Very commonly, the associated injury is represented by minor head trauma, which may negatively influence the early rehabilitation programme, especially during the first weeks, owing to the cognitive deficits with lack of memory and concentration and a status of depression.

Bone fractures, both in the upper and lower extremities, might interfere with and prolong the rehabilitation period. A fracture to the upper extremities will heavily restrict the autonomy by impairing transfers to a paraplegic patient. For an incomplete injury, a fracture to lower limbs may restrict and further compromise the walking capability.

A surgical intervention to stabilise the spinal column might be helpful in preventing complications due to the prolonged and forced immobilisation in bed and the use of external orthosis (for example, cervical traction, Halo traction or jacket). These complications are represented mostly by respiratory insufficiency, Deep Vein Thrombosis and Pulmonary embolism, and skin lesions. The surgical fixation may also be helpful for the nursing personnel in the management of the SCI patients during the acute stage. These reasons may explain the increase in the percentage of the surgical option in the past 30 years.

This study has several limitations mainly owing to the long study period. The medical files were retrospectively analysed, and possible bias could be due to the different clinical approaches during a 30-year period. In fact, the accuracy of the neurological examination and the standardisation of more appropriate acquired data in the medical files have surely improved during the study period.

Another limitation is due to the data analysis conducted on the computerised database owing to the great amount of included patients. The database does not include the totality of information gathered in the medical files, such as the time lapse between the trauma and the surgery and the modality of RTA (if in the city traffic or on extra-town roads, etc.), which could have been interesting to analyse.

The present study gives important information about causes of traumatic SCI and might be useful in better understanding the phenomenon by the epidemiological point of view, because of the high number of included patients and the period of investigation (30 years). For this reason, it might represent a useful tool for the most appropriate prevention strategies.

For the future, it is essential to collect appropriate data from more and more SCI centres around the world in order to better understand the aetiologies of the trauma and their changes over time, and to improve the prevention strategies. Among them, we like to emphasise the importance of informing the young population to drive in the correct conditions, to respect the speed limits and to avoid dangerous situations on the road.

When diving, young individuals shall be informed not to drink and to analyse the deepness of water before diving.

The institutions need to improve all the prevention strategies, taking into consideration the causes of TSCI.

With regard to the medical care and the acute treatment once the injury has occurred, it is crucial to avoid further damage to the spinal cord by not taking in the right consideration the instability of the column.

Research projects in this area are very welcomed.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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