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ARTICLE

Epidemiology of spinal fractures and associated spinal cord injuries in Iceland

Eyrún Arna Kristinsdóttir[1] · Sigrún Knútsdóttir[2] · Kristinn Sigvaldason[3] · Halldór Jónsson Jr.[1,4] · Páll E. Ingvarsson[1,2]

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Abstract

Study design A retrospective epidemiological study.
Setting Landspítali University Hospital, Iceland.
Objectives Assessment of epidemiological data and risk factors for traumatic spinal fractures (SFs) and associated spinal cord injury (SCI).
Methods A retrospective review of hospital admissions due to traumatic SFs during a 5-year period, with analysis of epidemiological parameters and occurrence of concomitant SCI. Patients with asymptomatic SFs and non-traumatic SCI were excluded.
Results A total of 487 patients were diagnosed with a SF or 310 PMI (per million inhabitants), 42 of them (9%, 27 PMI) with an associated SCI. The mean age was 56 years, males were 57%. Falls were the leading cause of both SFs (49%) and SCIs (43%). Low falls (<1 m) caused SFs more often in elderly women (67%, mean age 77 years) and more than 96% were without SCI. Road traffic accidents (RTA) caused 31% of SFs and 26% of SCIs. Seat belts were not used in 20% of car accidents, but information was missing in 27%. Sports/leisure-related accidents caused SFs in 12% of cases, whereof horseback riding accidents were the most common (36%).
Conclusions SFs led to SCI in 9% of patients. Several risk factors were common for SFs and SCIs but two major differences were seen: SFs without SCI were most common in older women due to low falls, while the risk of a concomitant SCI increased in young patients, in males, in falls from high levels and when driving without using seat belts. Preventive efforts should therefore be directed towards these risk factors.

Introduction

Several epidemiological studies have been published on the incidence and prevalence of spinal cord injuries (SCIs) in different parts of the world [1–6]. This extensive work has recently been summarized in meta-analysis reviews describing the world-wide occurence of SCIs [7, 8]. The results of one review showed a highly variable incidence world-wide, ranging from 10.4 PMI (per million inhabitants) in the Netherlands to 83 PMI in Alaska, However, the incidence was most often around 15–30 PMI [7]. Another review from 2014 showed a world-wide incidence of 23 PMI in 2007 [8]. In a 1975–2009 study on SCI in Iceland, the incidence varied considerably, from 12.5 PMI (1995–1999) to 33.5 PMI (2005–2009) [6].

In a literature survey, only a few scientific reports on the incidence of spinal fractures (SFs) and associated SCI were found [9, 10]. Such an approach could be important in the evaluation of risk factors for SCI. SFs alone can cause extensive disabilities, but the addition of a SCI often has immense long-term consequences for the injured individual. The aim of this study was to analyse data on all admissions due to traumatic SFs and related SCIs in Iceland, excluding asymptomatic SFs admitted for other reasons, and search for risk factors that could be helpful in preventive measures in the future.

✉ Páll E. Ingvarsson
palling@landspitali.is

1 Medical Faculty, University of Iceland, Reykjavík, Iceland
2 Department of Medical Rehabilitation, Landspítali - The University Hospital of Iceland, Reykjavík, Iceland
3 Department of Anaesthesiology and Intensive Care, Landspítali - The University Hospital of Iceland, Reykjavík, Iceland
4 Department of Orthopaedic Surgery at Landspitali, Landspítali - The University Hospital of Iceland, Reykjavík, Iceland

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An important difference between this and most other epidemiological studies is that by choosing this approach of direct comparison of symptomatic traumatic SFs with and without SCI (and coded by ICD-10 S and T diagnosis codes), we deliberately omit several groups of both SFs (mainly asymptomatic compression fractures and pathological fractures due to e.g., osteoporosis or skeletal tumor metastasis) and of SCIs (such as all SCIs of nontraumatic etiology, as well as traumatic SCIs due to e.g., dislocation and/or ligament injury, but with no underlying skeletal injury).

Material and methods

This study was a retrospective analysis of hospital records of patients diagnosed with a SF and/or a SCI according to the International Classification of Diseases, ICD-10, at Landspítali University Hospital (LUH) in Reykjavík 2007–2011, the only trauma center in Iceland. The mean size of the Icelandic population during the study period was 315,000 inhabitants [https://www.hagstofa.is/talnaefni/ibuar/mannfjoldi/yfirlit/]. Hospital records were screened for ICD diagnosis of SFs and SCIs as well as multitrauma in case of missed registration for SFs. Patients with diagnosis of SFs of non-traumatic etiology (i.e., pathological compression fractures in tumor metastasis or osteoporosis) and asymptomatic fractures were excluded. Patients with SCI of non-traumatic etiology were also excluded. Data were collected on age, gender, causes and extent of injury, length of hospital stay and outcome. Admissions to the intensive care unit (ICU) and department of rehabilitation were also analysed.

The classification in the Clinical Core Data Set of the International Spinal Cord Society (ISCoS) [11] was used to categorize the etiology of the injury. Several categories were also divided into subcategories, e.g., different types of traffic accidents and sports/leisure-related accidents. Falls were categorized into low falls (<1 m), high falls (1–5 m) and high-energy falls (>5 m) and it was recorded if the falls were work-related. In road traffic accidents, the use of seat belts and whether the accident had occurred in urban or rural areas was recorded.

The spinal column was divided into the upper (C1-C2) and lower (C3-C7) cervical spine, the thoracic spine (Th1-Th10), the thoracolumbal spine (Th11-L1), and the lumbosacral spine (L2-S5). The level and severity of a concomitant SCI was assessed using the ASIA (American Spinal Injury Association) Impairment Scale (AIS), which is a scale from grades A to E, where AIS E is normal sensory and motor function and AIS A is a complete loss of sensory and motor function, including an abscence of motor and sensory function in the lowest sacral segments (S4-S5). AIS B, C, and D are different levels of a partial SCI [12]. Other injuries were recorded and their severity was graded with the Injury Severity Score (ISS) [13]. All patients admitted to the ICU were assessed according to the APACHE II scoring system (Acute Physiology and Chronic Health Evaluation), which is a classifiation system for illness severity according to physiologic variables, age, and comorbidities [14].

Statistical analysis

Data collections that were close to the normal distribution were analysed with parametric tests, the *t*-test for the comparison of two data samples and an ANOVA analysis for the comparison of more than two data samples. Mean values were presented along with the standard deviations. When the data samples were skewed, the non-parametric Wilcoxon and Kruskal Wallis tests were used to compare two and more than two samples, respectively. Median values were presented along with the interquartile range. The comparison of ratios beween two groups was done with either the Chi-square test or, if the groups were too small, the Fisher test. In all cases, the level of significance was set at $p < 0.05$.

Results

Incidence, age, and gender distribution

During the study period 487 patients were diagnosed with SFs at LUH and 42 of them (9%) had a concomitant SCI. The annual incidence of SFs was 310 PMI and 27 PMI for SCI. Males were 56% ($N = 275$) and females 44% ($N = 212$). Figure 1 shows the gender distribution for every 10-year age group. Males were in majority in all age groups below 70 years, but females were in majority in age groups over 70 years. The mean age at injury was 56 years (range 7–102 years), significantly lower in males (50.4 years) than females (62.5 years) ($p < 0.001$). Five patients died during the study period: two as a result of the injury, but three due to other causes.

In Table 1, those diagnosed with a SF only and those who had a concomitant SCI are compared. The mean age in the SF group was significantly higher than that of the SCI group ($p < 0.001$). The age distribution of the two groups can be seen in Fig. 2. The largest age group amongst those with only a SF was 81–90 years (16%, $N = 69$), but 41–50 years amongst those who also had a SCI (21%, $N = 9$).

Sixty seven percent of patients with SCI were admitted to the ICU compared to 19% of patients with SFs ($p < 0.001$). The majority of patients with SCI (81%) were referred to the department of rehabilitation compared to 14% of

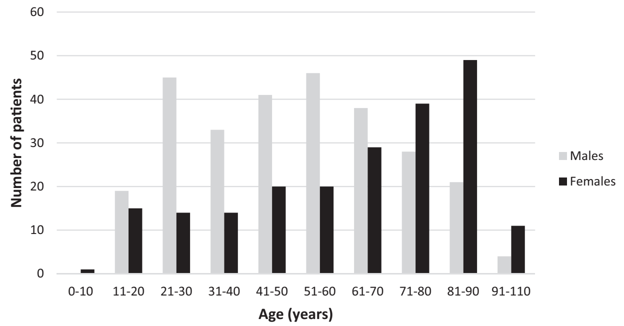

Fig. 1 Gender distribution. Number of patients of each gender shown for every 10-year age group

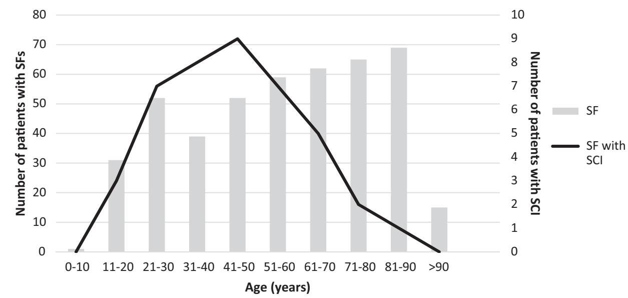

Fig. 2 Number of patients in each age group. Comparison of the age distribution of those with SFs (spinal fractures) and those with SCI (spinal cord injury)

Table 1 Basic clinical epidemiological facts

	SF without SCI ($N = 445$)	SF with SCI ($N = 42$)	p values
Mean age (years)	57 ± 23	45 ± 18	<0.001
Male/female ratio	1.2:1	2.8:1	0.027
Admission to intensive care unit	84 (19%)	28 (67%)	<0.001
Admission to rehabilitation unit	60 (14%)	34 (81%)	<0.001
Duration of stay at ICU (days)	3 (2–7)	4 (3–23)	0.051
Duration of stay in general ward (days)	8 (4–15)	10 (7–16)	0.051
Duration of stay at rehab. unit (days)	33 (17–58)	109 (49–167)	<0.001
APACHE II (median values)	8 (4–14)	10 (6–14)	0.36
ISS (median values)	9 (4–17)	26 (17–34)	<0.001

Comparison of patients with spinal fracture only and those with a concomitant spinal cord injury *ICU* intensive care unit, *APACHE II* Acute Physiology and Chronic Health Evaluation, *ISS* Injury Severity Score

patients with SFs. Their length of stay was longer with a mean duration of 109 vs. 33 days ($p < 0.001$), while the duration of stay in the acute wards and in the ICU did not differ between groups ($p = 0.52$). Of patients with SCI not transferred to rehabilitation, three patients with a relatively mild incomplete injury were discharged home, four were transferred to another institution (either a geriatric ward or nursing home), and one died. No significant difference was found in the APACHE II scores between the two groups ($p = 0.36$), but the median ISS values were significantly higher in the SCI group ($p < 0.001$).

Etiology

Table 2 displays the number of patients in each etiological group as well as the gender ratio, mean age, median values of ISS scores and number of patients with concomitant SCI. Falls were the most common cause of both SFs and SCI. A total of 241 patients (49%) suffered a SF due to a fall. Of these, 160 (67%) were low falls (<1 m), 61 (25%) high falls (1–5 m), and 20 (8%) high-energy falls (> 5 m). Falls led to a SCI in 18 cases (43% of all SCIs), whereof six (33%) were low falls, eight (45%) high falls, and four (22%) high-energy falls. Two low (1%), 20 high (33%), and seven high-energy (35%) falls were work-related, whereof one high and one high-energy fall led to a SCI. Six falls (35%, all of them high-energy falls) were in relation to suicide attempts and one of those led to a SCI. Falls were the only etiological group where females were the majority of patients.

Traffic accidents were the cause of SFs in 151 cases (31%), most commonly due to car accidents ($N = 123$, 81%), where car rollovers were the most common ($N = 71$, 58%). A SCI occured in 11 cases (7% of traffic accidents, 26% of SCI patients): in eight cases due to car rollovers, in two cases due to motorcycle accidents, and in one case due to a bicycle accident.

A total of 58 SFs (12%) were caused by sports/leisure-related accidents. Horseback riding accidents were most common (21 cases, 36%) and females were the majority. Motorcross and winter sports accidents were also quite common with 11 patients (19%) in each group. Fifteen SFs (26%) were categorized in the subgroup "Other sports/leisure-related accidents," e.g., gymnastics ($N = 3$, 5%), off-road vehicle accidents ($N = 4$, 7%), and diving accidents ($N = 2$, 3%). Sports/leisure-related accidents resulted in a SCI in eight cases (19% of all traumatic SCIs), most often due to horseback riding accidents ($N = 3$, 37%). One SCI occurred in each of the five subgroups: motocross accidents, bicycle accidents, gymnastics, four-wheel terrain vehicle accidents, and diving accidents ($N = 5$, 62%, 12% each). Other causes

Table 2 Causes of injury

Cause	SFs (%)	Mean age (± SD)	Gender ratio (male: female)	Median ISS value (IQR)	SCI (%)
Falls	241 (49%)	68 ± 20	1:1.1	8 (4–13)	18 (43%)
Traffic accidents	151 (31%)	43.5 ± 20	02:01	17 (9–28)	11 (26%)
Sports/leisure-related accidents	58 (12%)	40 ± 16	1.4:1	9,5 (9–17)	8 (19%)
Other	37 (8%)	52 ± 22	2.4:1	9 (4–17)	5 (12%)

Number of patients in each etiological category, mean age, gender ratio, median ISS (Injury Severity Score) value, and number of patients with spinal cord injury

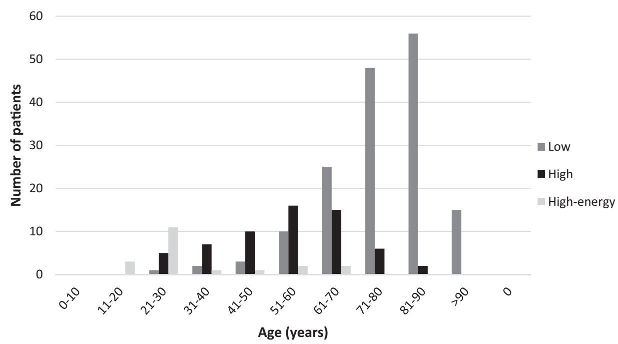

Fig. 3 Age distribution in patients with spinal fractues due to falls. Age distribution shown for low, high, and high-energy falls

($N = 37$, 7.6%) included crush injury, blunt trauma, plane crash, and assault. Five of these patients suffered a SCI as well.

The mean age of the patients varied considerably among etiological subgroups ($p < 0.001$). It was highest amongst those with SFs due to a fall (68 ± 20 years) and lowest in the sports/leisure-related accident group (40 ± 16 years). A significant difference was found in the median ISS values between etiological subgroups ($p < 0.001$), where traffic accidents had the highest and falls the lowest ISS values.

Figure 3 shows the age distribution of patients with SFs due to falls. The largest age group of those with SFs caused by a high fall was 51–60 years, while most of the patients with SFs after high-energy falls were 21–30 years old. Low falls were rare in the younger age groups, but became more frequent with increasing age (mean age 77 years). Low falls were also the most common subgroup (66%) and the only subgroup where women were in majority, or 108 (67%) of the 160 SFs that were caused by low falls. SCI occurred in only six (<4%) of the SFs caused by low falls.

Fractures of the lumbosacral spine were the most common ($N = 201$, 41%), but fractures of the upper cervical spine were the least common ($N = 44$, 9%) (see Table 3). The fractures that most often led to a SCI were those of the lower cervical spine ($N = 11$, 14% of all fractures of the lower cervical spine). Traffic accidents were the most common cause of SFs at both the upper (48%) and lower (57%) cervical cord. However, falls were the most common cause of injury at the thoracic (43%), thoracolumbal (53%), and lumbosacral (61%) level.

Severity of SCI

Of the 42 patients with SFs and associated SCI, 16 (38%) had an AIS A SCI on admission and 23 (55%) had an incomplete SCI. Of those with incomplete injury, three patients (7%) had an AIS B injury, eight (19%) AIS C, and 12 (29%) AIS D. No information could be found on the severity of injury in three patients (7%). As can be seen in Fig. 4, 25 of the 39 SCI patients (65%) with a known grade of injury remained unchanged from admission to discharge, while 13 improved, and only one patient detoriated during the hospital stay. At discharge, the percentage of those who where wheelchair dependent had decreased from 69 to 43%.

Discussion

Incidence

SFs with SCI are serious injuries that often require a long hospital stay and can result in permanent and often extensive disability. Very few studies have been published on the epidemiology of SFs and even fewer on SFs in relation to SCI [9]. No study of this kind has been done in Iceland although a study on the epidemiology of SCIs in Iceland over a 35-year period was published in 2012 [6].

Since the treatment of SCI is centralized to LUH in Iceland, this study should include all cases of SCI during the study period. Therefore, it can be considered population-based. The limitations of the study are that treatment of a few cases of mild SFs due to trauma in local hospitals in the Icelandic countryside can not be fully excluded. Thus, the population-based number of SFs in this material might be slightly underestimated. As the aim of the study was to evaluate traumatic SFs only, it did not include patients with asymptomatic spinal compression fractures often seen in elderly people or patients who progressively developed a SCI following the SF. Such factors might

Table 3 Fracture level and proportion of spinal cord injury

Fracture level	SFs	SCI		
		No. of patients	% of fractures	95% CI
Upper cervical spine (C1-C2)	44 (9%)	3	7%	1.8–19
Lower cervical spine (C3-C7)	76 (16%)	11	14%	7.8–24.8
Thoracic spine (Th1-Th10)	125 (26%)	13	10%	5.9–17.4
Thoracolumbal spine (Th11-L1)	179 (37%)	12	7%	3.7–11.7
Lumbosacral spine (L2-S5)	201 (41%)	3	1%	0.4–4.7

Fracture level as well as number and proportion of patients with a concomitant spinal cord injury

CI confidence interval

AA 10	AB 1	AC 2	AD 3	AE 0
BA 0	BB 1	BC 0	BD 2	BE 0
CA 0	CB 1	CC 3	CD 4	CE 0
DA 0	DB 0	DC 0	DD 11	DE 1
EA 0	EB 0	EC 0	ED 0	EE 0

Fig. 4 Severity of spinal cord injury. Number of patients according to ASIA Impairment Scale (AIS) grade, where the first letter in each pair of letters is AIS grade at admission and the second letter at discharge. Thus, it can be seen that six patients with AIS A at admission had a less severe AIS grade at discharge, and only one person became worse (by change from AIS C at admissin to AIS B at discharge)

underestimate the incidence of SF and SCI following SF found in this study.

SCI was found in 9% of admitted patients due to traumatic SF, which is lower than that seen in a study from Canada [9], where 23.3% had a SCI in relation to their SF. That study only included patients with ISS values > 12, probably excluding SFs due to a minor injury, e.g., a low fall [9]. A study from Chongqing, China [10] shows an even higher ratio of SCI or 44.3%. The authors suggest that this could be due to an increasing use of cars in combination with insufficient road and vehicle safety, expansion in the construction industry and the aging of the Chinese population [10].

The incidence of SCI in Iceland seems to be lower than that reported from Canada [4, 9] and USA [5], where the incidence is 40 PMI. This difference can possibly in part be explained by the fact that violence as a cause of SCI is relatively common in these countries (17.8% and 8.2%, respectively) compared to Iceland, where only three cases of SCI due to violence have been reported in the last three decades. However, the incidence of SCI in Norway [1], Sweden [2], and Finland [3] is lower than in Iceland. The reason for this difference is not clear but could be explained by less road safety in Iceland than in other Nordic countries. Falls were the most common cause of SCI in these countries, while in the last three decades in Iceland it was traffic accidents [1–3, 6].

Gender and age distribution

Males were the majority of patients which is in concordance with the results of a similar study from Canada [9] and two studies from China [10, 15]. Low falls and horseback riding accidents were the only two etiological subgroups with fewer males than females. The reason for this is perhaps a difference in the gender participation in some sports/leisure-related activities. Osteoporosis is common in post-menopausal women, which could explain why older women were in majority amongst those who suffered a SF due to a low fall.

The incidence of SFs increased with age and the 81–90 years group was the largest. However, the 21–30 years age group was also numerous. This bimodal age distribution differs from that seen in other epidemiological studies on SFs, where the age group 31–40 years is largest and the incidence decreases with age [9, 10, 15]. However, a comparison of these studies is difficult due to different inclusion criteria, study groups and possibly different age distributions of the populations studied.

The age distribution of those with SCI was different from that seen amongst those with SFs only. The largest SCI age group was 41–50 years and the mean age at injury was 44.7 years, which is higher than what has been reported earlier (33 years) [7]. Recent epidemiological studies have shown an increase in the mean age at injury amongst those with SCI. The reason for this is unknown but it likely reflects the aging population [5].

Etiology

Falls were the most common cause of both SFs and SCI. More than half of the falls resulting in a SF were low falls in patients with a significantly higher mean age than in high or high-energy falls. High falls and high-energy falls resulted in higher ISS values than low falls, which reflects a more serious injury. The majority of SCI due to falls were high or high-energy falls. It is alarming that about a third of high and high-energy falls were work-related. A recent study on the epidemiology of SCI in Iceland showed that traffic accidents were the most common cause of SCI [6]. However, falls as a cause of SCI increased significantly in 2005–2009 compared to previous years. The reason for this is unknown but might be connected to an economical upswing in Iceland during that period, resulting in an expansion in the construction industry, where most of the work-related falls occurred [6]. Other studies have also shown an increase in the percentage of falls as a cause of SCI. This is likely explained by an increasing proportion of elderly individuals in the population of Iceland as well as in most countries. According to the NSCID (the National Spinal Cord Injury Database), falls are the most common cause of SCI in people over 60 years of age in the United States [5].

Traffic accidents were the second most common cause of both SFs and SCI. Car rollovers were the most common type of traffic accidents. The median ISS value for patients suffering SFs due to a traffic accident was significantly higher than that for other etiological categories. At least 20% of patients with SFs were not using seat belts. That proportion could be even higher since information was missing on 27%. This is alarming and shows the need to keep emphasizing the use of seat belts. A study from China reports similar results [10]. The results from a Canadian study shows traffic accidents to be the most common cause of SFs, as falls are the cause in only 13% of cases. This study exludes everyone with an ISS value < 12, probably excluding patients with SFs and SCI following less severe trauma, e.g., low falls [9].

Severity of SCI

AIS A injury was the most common type of SCI during the study period. AIS D was the most common amongst those with a partial injury. The fractures most often leading to SCI were those of the lower cervical spine, but the highest proportion of a complete SCI was amongst those with fractures of the upper cervical spine. In the Chinese study [10], AIS D SCI was most common, followed by AIS A injury. SCI was most commonly associated with fractures of the lumbar spine, cervical spine, and thoracic spine, respectively, while a complete SCI was most often due to fractures of the thoracic spine. The reason for this difference is unknown.

Conclusions

Hospital admissions in Iceland due to SFs were 310 PMI and 9% suffered a concomitant SCI. An AIS A injury was seen in 38% of SCI patients, and the majority still had that grade at discharge. Elderly women had a high risk of SFs without SCI as a result of low falls. Due to the changing demographic profile with an increasing proportion of elderly citizens in Western countries, including Iceland, this can become a major socioeconomic burden in the future, even if only a small percentage suffer a superimposed SCI. Patients suffering SCI were younger, more often male, fell from higher levels and a disappointingly large proportion of them did not use seat belts while driving. Prevention strategies should aim at increasing car and road safety, enforcing stricter safety regulations in the workplace and encouraging the use of safety equipment in sports/leisure-related activities.

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Compliance with ethical standards

Statement of ethics We certify that all applicable institutional and governmental regulations concerning the ethical use of patient data were followed during the course of this research, including approval by the Ethical Committee and the Chief Medical Executive at Landspítali as well as the Icelandic Data Protection Authority.

Conflict of interest The authors declare that they have no conflict of interest.

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