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ORIGINAL ARTICLE

Epidemiology and predictors of spinal injury in adult major trauma patients: European cohort study

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Abstract This is a European cohort study on predictors of spinal injury in adult (≥16 years) major trauma patients, using prospectively collected data of the Trauma Audit and Research Network from 1988 to 2009. Predictors for spinal fractures/dislocations or spinal cord injury were determined using univariate and multivariate logistic regression analysis. 250,584 patients were analysed. 24,000 patients (9.6%) sustained spinal fractures/dislocations alone and 4,489 (1.8%) sustained spinal cord injury with or without fractures/dislocations. Spinal injury patients had a median age of 44.5 years (IQR = 28.8–64.0) and Injury Severity Score of 9 (IQR = 4–17). 64.9% were male. 45% of patients suffered associated injuries to other body regions. Age <45 years (≥45 years OR 0.83–0.94), Glasgow Coma Score (GCS) 3–8 (OR 1.10, 95% CI 1.02–1.19), falls >2 m (OR 4.17, 95% CI 3.98–4.37), sports injuries (OR 2.79, 95% CI 2.41–3.23) and road traffic collisions (RTCs) (OR 1.91, 95% CI 1.83–2.00) were predictors for spinal fractures/dislocations. Age <45 years (≥45 years OR 0.78–0.90), male gender (female OR 0.78, 95% CI 0.72–0.85), GCS <15 (OR 1.36–1.93), associated chest injury (OR 1.10, 95% CI 1.01–1.20), sports injuries (OR 3.98, 95% CI 3.04–5.21), falls >2 m (OR 3.60, 95% CI 3.21–4.04), RTCs (OR 2.20, 95% CI 1.96–2.46) and shooting (OR 1.91, 95% CI 1.21–3.00) were predictors for spinal cord injury. Multilevel injury was found in 10.4% of fractures/dislocations and in 1.3% of cord injury patients. As spinal trauma occurred in >10% of major trauma patients, aggressive evaluation of the spine is warranted, especially, in males, patients <45 years, with a GCS <15, concomitant chest injury and/or dangerous injury mechanisms (falls >2 m, sports injuries, RTCs and shooting). Diagnostic imaging of the whole spine and a diligent search for associated injuries are substantial.

Keywords Spinal cord injury · Spinal fractures/dislocations · TARN registry · Major trauma · Predictors

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Introduction

Civilian trauma accounts for 14% of years of life lost and 10% of death and is the leading cause of death in people aged 5–44 years in developed countries [1, 2]. For patients suffering spinal injuries, the overall mortality has remained relatively unchanged at 17% over the last 20 years [3]. The reported annual incidence rates vary from 19 to 88 per

100,000 persons for spinal fractures [4–6], and 14 to 53 per million for spinal cord injury [3, 4, 7–9].

About half of severe spine injuries are reported not to be suspected in the pre-hospital setting [10]. Identification of spinal injuries during initial trauma evaluation is challenging, as patients often have a reduced level of consciousness due to other injuries or are under the influence of sedative and/or analgesic medication. Early detection of spinal injuries in the Emergency Department is important in order to initiate further diagnostic testing and treatment and to avoid additional spinal injury. The prevalence of spinal cord injury, which represents a small part of all spinal injuries [3], has been previously well documented, mainly in studies from the US and Canada [8, 11–13]. Only a few smaller studies exist on the epidemiology of both spinal fractures and cord injuries, and possible risk factors leading to such injuries [4, 5]. We, therefore, present the largest survey from Europe on the epidemiology of spinal trauma with the aim of defining predictors for such injuries.

Materials and methods

Patients

This is a cohort study using prospectively collected data from the Trauma Audit and Research Network (TARN), a European trauma registry [14]. TARN collects data using a web based data collection and reporting system. Eligible patients included as follows: those presenting with trauma to one of the participating hospitals, who either (a) require hospital admission for ≥72 h or are transferred into a participating hospital for specialist care; (b) require high dependency or intensive care; or (c) die as a result of their injuries within 93 days. Excluded are patients transferred for rehabilitation only, patients with brain injury unrelated to trauma, simple skin lacerations, contusions or abrasions and minor penetrating injuries resulting in blood loss <20%, patients with single uncomplicated limb injuries, and patients over 65 years with isolated fracture of the femoral neck or pubic ramus [15].

Procedures and outcomes

The pre-specified primary outcomes were spinal fractures/dislocations alone or spinal cord injury with or without spinal fractures/dislocations. The inclusion criteria were based on the Abbreviated Injury Scale (AIS) for spinal fractures/dislocations (i.e. fractures/dislocations of spinal vertebrae, pedicles, facets, laminae or the odontoid) and for spinal cord injuries (i.e. cord contusions and lacerations and incomplete and complete spinal cord syndromes). Injuries to the brachial plexus, traumatic disc injuries, fractures of the spinous and transverse processes, spinous ligament, nerve root injuries and strains of the spine were classified as other spine injuries. GCS (Glasgow Coma Score) was determined on admission to the Emergency Department. Injuries were classified using the AIS. The Injury Severity Score (ISS) was calculated [16].

Statistical methods

We included all adult TARN patients (≥16 years) admitted to a TARN hospital between January 1988 and December 2009. We excluded patients with missing data for GCS. To determine the predictors for spinal injury, univariate regression analyses (UVA) were performed followed by a multivariate analysis (MVA) including age, gender, GCS, injury mechanism and associated injuries. Patients were grouped according to their age (16–24; 25–34; 35–44; 45–54; 55–64; 65–74; ≥75) and according to their GCS (15; 13–14; 9–12; 3–8). The injury mechanisms were categorised as road traffic collisions (RTC), falls <2 m (e.g. falling off a chair or ladder or trapping over something), falls >2 m, shooting, stabbing, sports and other injuries (e.g. blast or crush injuries). Associated injuries were divided into head injuries (AIS ≥ 3), and chest, abdomen, extremities and pelvis injuries (AIS ≥ 2 each). Model performance was assessed using the area under the receiver operator characteristic curve. In a sensitivity analysis, we performed multivariable regression analysis after multiple imputation of missing data in the covariate GCS. Finally, we compared characteristics of included patients with those with missing GCS using Mann–Whitney U and χ^2 tests. All P values are two-sided. Analyses were performed in SPSS Release 16 (SPSS Schweiz AG, Zürich).

Results

250,584 (100%) adult patients were entered into the TARN data base between January 1988 and December 2009 (Fig. 1). 33,139 (13.22%) suffered spinal trauma. 24,000 (9.58%) of 250,584 patients had spinal fractures/dislocations alone without clinical neurological deficits. 24.50% ($n = 5{,}879$) involved the cervical, 28.06% ($n = 6{,}734$) the thoracic and 37.09% ($n = 8{,}902$) the lumbar spine. Multilevel injury was observed in 2,485 (10.35%) patients with spinal fractures/dislocations. 4,489 (1.79%) of 250,584 patients had suffered a spinal cord injury with or without a spinal fractures/dislocations. 45.42% ($n = 2{,}039$) of cord injuries involved the cervical, 29.43% ($n = 1{,}321$) the thoracic and 23.81% ($n = 1{,}069$) the lumbar spine. 60 (1.34%) of cord injury patients suffered multiple level cord injury. 416 (9.27%) of cord injury patients were diagnosed with spinal cord injury without radiographic (plain radiography and tomographic scans) abnormality.

Patients with spinal fractures/dislocations or spinal cord injury had a median age of 44.5 years (IQR = 28.8–64.0). 64.94% (n = 18,502) were male. Median ISS was 9 (IQR = 4–17) and median GCS 15 (IQR = 15–15). In patients with spinal fractures/dislocations alone, 36.08% of injuries resulted from RTCs, 30.44% from falls >2 m, 24.38% from falls <2 m and 7.27% from other injuries (Table 1). A similar pattern was observed in patients with spinal cord injury with or without fractures/dislocations (RTC: 40.05%; falls >2 m: 29.90%; falls <2 m: 16.08%; other injuries: 9.56%). Injuries from sports, shooting or stabbing were rare (<3% each). 45% of patients with both spinal fractures/dislocations or spinal cord injury suffered associated injuries to other body regions. A breakdown of associated injuries is shown in Table 1. 26.05% of spinal fractures/dislocations patients had associated injuries involving the extremities, 17.78% the chest, 12.32% the head, 4.98% the abdomen and 3.29% the pelvis. Patients with spinal cord injury had concomitant injuries to the chest in 24.04% of cases, extremities in 23.32%, head in 13.59%, abdomen in 5.93% and to the pelvis in 2.92%.

Table 2 presents the results from univariate (UVA) and multivariate analysis (MVA) of patients with spinal fractures/dislocations alone and of patients with spinal cord injury with or without fractures/dislocations.

Spinal fractures/dislocations

Odds ratios (OR) for spinal fractures/dislocations were decreased in patients aged over 44 years in the UVA and MVA (Table 2). The reduced OR for female gender in the UVA (OR 0.86, 95% CI 0.83–0.88) disappeared after full adjustment (OR 1.01, 95% CI 0.98–1.05). Patients with a GCS of 3 to 8 had an increased OR for spinal fractures/dislocations in the MVA (OR 1.10, 95% CI 1.02–1.19) with respect to patients without spinal fractures/dislocations. We observed the highest OR for spinal fractures/dislocations in falls >2 m, followed by sports injuries and RTCs in the fully adjusted model (fall >2 m: OR 4.17; sports: OR 2.79; RTCs: OR 1.91). Injuries resulting from stabbing had an especially low OR in the crude (OR 0.09, 95% CI 0.06–0.14) and in the adjusted analysis (OR 0.04, 95% CI 0.03–0.06). In the UVA, ORs for associated injuries were

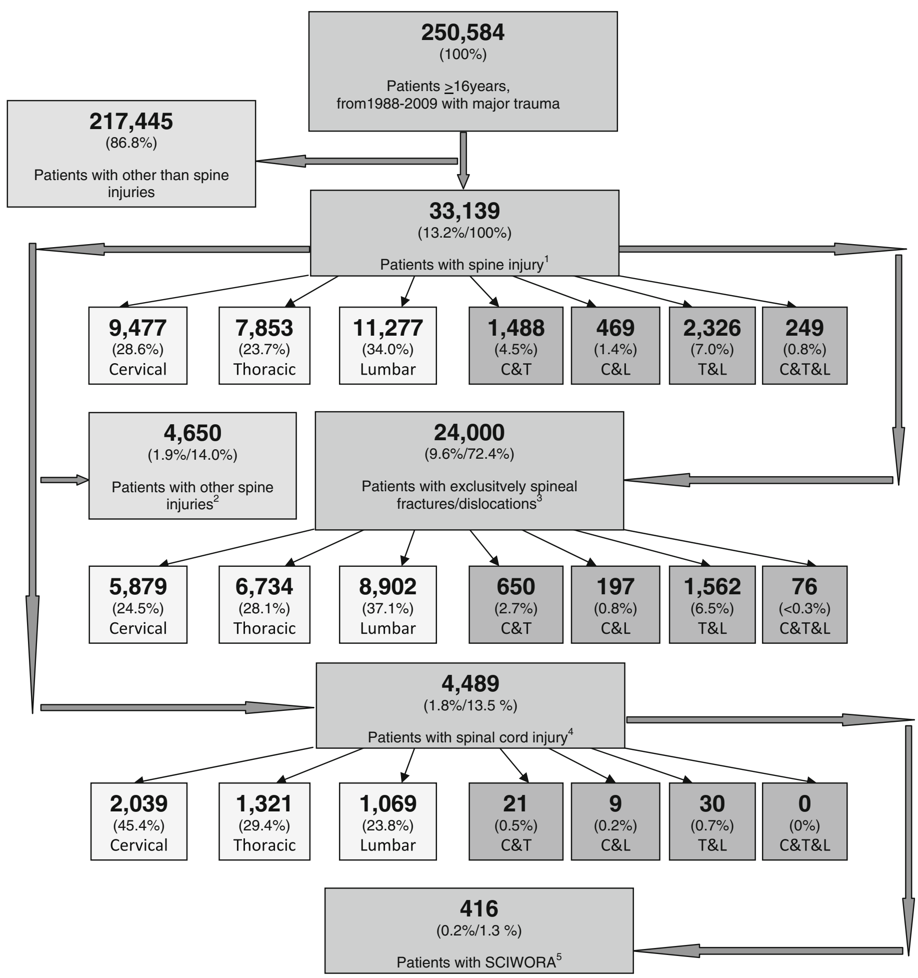

Fig. 1 Flow chart of major trauma patients (1988–2009). *1* Patients with fractures/dislocations of spinal vertebrae, pedicles, facets, laminae or the odontoid. Cord contusions and lacerations and incomplete and complete spinal cord syndromes. Injuries to the brachial plexus, traumatic disc injuries, fractures of the spinous and transverse processus, spinous ligament and nerve root injuries and strains of the spine. *2* Patients with injuries to the brachial plexus, traumatic disc injuries, fractures of the spinous and transverse processus, spinous ligament and nerve root injuries and strains of the spine. *3* Patients with exclusively fractures/dislocations of spinal vertebrae, pedicles, facets, laminae or the odontoid *4* Patients with Cord contusions and lacerations and incomplete and complete spinal cord syndromes, combined with or without spinal fractures/dislocations. *5* Patients with SCIWORA (spinal cord injury without radiographic abnormality)

Table 1 Study population

	All spine injuries n = 28,489 (n [%])	Fractures/dislocations n = 24,000 (n [%])	Cord injuries n = 4,489 (n [%])
Age (years)			
16–24	5,147 (18.07)	4,223 (17.60)	924 (20.58)
25–34	4,812 (16.89)	3,970 (16.54)	842 (18.76)
35–44	4,426 (15.54)	3,623 (15.10)	803 (17.89)
45–54	3,878 (13.61)	3,249 (13.54)	629 (14.01)
55–64	3,313 (11.63)	2,801 (11.67)	512 (11.41)
65–74	2,685 (9.42)	2,328 (9.70)	357 (7.95)
75 and above	4,228 (14.84)	3,806 (15.86)	422 (9.40)
Gender			
Male	18,502 (64.94)	15,207 (63.36)	3,295 (73.40)
Female	9,987 (35.06)	8,793 (36.64)	1,194 (26.60)
GCS			
3–8	1,528 (5.36)	1,213 (5.05)	315 (7.02)
9–12	594 (2.09)	462 (1.93)	132 (2.94)
13–14	1,841 (6.46)	1,526 (6.36)	315 (7.02)
15	19,631 (68.91)	17,029 (70.95)	2,602 (57.96)
Injury mechanism			
RTC	10,457 (36.71)	8,659 (36.08)	1,798 (40.05)
Fall >2 m	8,648 (30.36)	7,306 (30.44)	1,342 (29.90)
Fall <2 m	6,572 (23.07)	5,850 (24.38)	722 (16.08)
Shooting	54 (0.19)	27 (0.11)	27 (0.60)
Stabbing	74 (0.26)	26 (0.11)	48 (1.07)
Sports	511 (1.79)	388 (1.62)	123 (2.74)
Other	2,173 (7.63)	1,744 (7.27)	429 (9.56)
Body region[a]			
Head	3,567 (12.52)	2,957 (12.32)	610 (13.59)
Chest	5,346 (18.77)	4,267 (17.78)	1,079 (24.04)
Abdomen	1,460 (5.12)	1,194 (4.98)	266 (5.93)
Extremities	7,299 (25.62)	6,252 (26.05)	1,047 (23.32)
Pelvis	921 (3.23)	790 (3.29)	131 (2.92)

GCS Glasgow Coma Score, *RTC* road traffic collision

[a] Total of patients greater than total of injured body regions as only patients with injuries with a severity of AIS $\geq$ 2 (chest, abdomen, extremities, pelvis) and AIS $\geq$ 3 (head), respectively, are displayed

increased for thoracic (OR 1.37, 95% CI 1.33–1.42) and pelvic injuries (OR 1.44, 95% CI 1.33–1.55), but results were not robust when adjusting for covariates. Limb injuries were associated with a very low OR for spinal fractures/dislocations in the crude (OR 0.20, 95% CI 0.19–0.20) and adjusted model (OR 0.13, 95% CI 0.13–0.13). Indeed, in the adjusted model all associated injuries reduced the OR of spinal fractures/dislocations (Table 2).

Multilevel injuries were found in 10.35% (n = 2,485) of patients, and predominantly involved the thoracic and lumbar spine. 197 (7.9%) of these patients suffered fractures/dislocations at non-consecutive levels. 76 (3.05%) of 2,485 patients sustained fractures/dislocations at all three levels (Fig. 1).

Spinal cord injury

In patients >44 years, ORs for spinal cord injury gradually decreased with increasing age, in the UVA and MVA (Table 2). Females had a lower OR for cord injury then males in the UVA (OR 0.54, 95% CI 0.51–0.58) and MVA (OR 0.78, 95% CI 0.72–0.85). The OR for spinal cord injury increased with decreasing GCS, before and after full adjustment (Table 2). Injury mechanisms associated with higher ORs for spinal cord injury were sports injuries, followed by falls >2 m, RTCs and shooting injuries in the MVA (sports: OR 3.98; falls >2 m: OR 3.60; RTCs: OR 2.20; shooting: OR 1.19). Chest (OR 1.94, 95% CI 1.81–2.08), abdominal (OR 1.24, 95% CI 1.09–1.40) and pelvic injuries (OR 1.22, 95% CI 1.02–1.45) were related to increased odds ratio for spinal cord trauma in the UVA, but only the effect of associated chest injuries (OR 1.10, 95% CI 1.01–1.20) was robust to full adjustment. Limb injuries showed a low association with spinal cord trauma in the UVA (OR 0.20, 95% CI 0.18–0.21) and MVA (OR 0.17, 95% CI 0.15–0.18). Patients with head injuries had no increased OR for spinal cord trauma in the crude analysis

Table 2 Univariate and multivariate regression analyses

	OR (95% CI)			
	Fractures/dislocations ($n = 24{,}000$)		Cord injury ($n = 4{,}489$)	
	Univariate	Multivariate	Univariate[a]	Multivariate[a]
Age (years)				
16–24	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
25–34	1.00 (0.96–1.05)	1.02 (0.97–1.08)	0.97 (0.88–1.07)	0.98 (0.87–1.09)
35–44	1.04 (0.99–1.09)	1.03 (0.97–1.09)	1.05 (0.95–1.15)	1.08 (0.96–1.21)
45–54	0.96 (0.92–1.01)	0.90 (0.85–0.96)	0.86 (0.77–0.95)	0.90 (0.79–1.01)
55–64	0.79 (0.75–0.83)	0.83 (0.78–0.89)	0.67 (0.60–0.75)	0.81 (0.71–0.93)
65–74	0.91 (0.86–0.96)	0.90 (0.84–0.96)	0.65 (0.57–0.73)	0.78 (0.67–0.91)
75 and older	0.93 (0.89–0.97)	0.94 (0.88–1.00)	0.47 (0.42–0.53)	0.60 (0.52–0.70)
Gender				
Male	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Female	0.86 (0.83–0.88)	1.01 (0.98–1.05)	0.54 (0.51–0.58)	0.78 (0.72–0.85)
GCS				
3–8	0.95 (0.89–1.01)	1.10 (1.02–1.19)	1.62 (1.44–1.82)	1.93 (1.66–2.23)
9–12	0.79 (0.72–0.87)	0.76 (0.68–0.85)	1.51 (1.26–1.80)	1.57 (1.30–1.89)
13–14	1.07 (1.01–1.13)	0.98 (0.92–1.05)	1.44 (1.28–1.62)	1.36 (1.20–1.54)
15	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Injury mechanism				
RTC	1.98 (1.92–2.05)	1.91 (1.83–2.00)	3.15 (2.88–3.43)	2.20 (1.96–2.46)
Fall >2 m	4.66 (4.49–4.84)	4.17 (3.98–4.37)	5.66 (5.16–6.20)	3.60 (3.21–4.04)
Fall <2 m	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Shooting	0.46 (0.31–0.67)	0.29 (0.19–0.44)	3.82 (2.59–5.64)	1.91 (1.21–3.00)
Stabbing	0.09 (0.06–0.14)	0.04 (0.03–0.06)	1.48 (1.10–1.99)	0.48 (0.34–0.67)
Other	0.73 (0.69–0.78)	0.50 (0.46–0.53)	1.49 (1.32–1.68)	0.83 (0.71–0.96)
Sports	3.55 (3.17–3.98)	2.79 (2.41–3.23)	7.89 (6.48–9.60)	3.98 (3.04–5.21)
Body region				
Head	0.74 (0.71–0.77)	0.29 (0.27–0.31)	0.85 (0.78–0.93)	0.29 (0.25–0.33)
Chest	1.37 (1.33–1.42)	0.76 (0.73–0.80)	1.94 (1.81–2.08)	1.10 (1.01–1.20)
Abdomen	1.03 (0.97–1.10)	0.66 (0.61–0.71)	1.24 (1.09–1.40)	0.65 (0.56–0.76)
Extremities	0.20 (0.19–0.20)	0.13 (0.13–0.13)	0.20 (0.18–0.21)	0.17 (0.15–0.18)
Pelvis	1.44 (1.33–1.55)	0.83 (0.76–0.92)	1.22 (1.02–1.45)	0.81 (0.66–1.00)

RTC road traffic collision

[a] After imputation for missing GCS

(OR 0.85, 95% CI 0.78–0.93) and the OR further dropped in the MVA (OR 0.29, 95% CI 0.25–0.33).

In 60 (1.33%) of 4,489 patients we observed cord injuries to more than one level. 9 (15.0%) of these patients suffered cord injury to non-consecutive levels (Fig. 1).

Table 3 indicates that patients with spinal fractures/dislocations alone and missing GCS ($n = 3{,}770$, 15.71%) showed a slightly lower age and higher ISS and were more often male. However, the differences were not clinically significant. Patients with spinal cord injury with or without fractures/dislocations ($n = 1{,}125$, 25.06%), who were excluded due to missing GCS had a higher ISS and were more often male. After multiple imputation for missing GCS in patients with spinal cord injury (Table 2), the effect of GCS was more pronounced than before imputation (GCS 3 to 8: OR 1.93, 95% CI 1.66–2.23; GCS 9–12: OR 1.57, 95% CI 1.30–1.89; GCS 13–14: OR 1.36, 95% CI 1.20–1.54). All other variables were similar after imputation.

Model fit for the multivariable analysis was good with an area under the receiver operator characteristic curve of 0.80 for patients with spinal fractures/dislocations alone and 0.79 for patients with spinal cord injury.

Discussion

Summary of findings

We observed spinal fractures/dislocations alone in 9.6% and spinal cord injury with or without fractures/dislocations in 1.8% of trauma registry patients. Our study

Table 3 Characteristics of patients with complete data compared to excluded patients due to missing Glasgow Coma Score

	Fractures/dislocations		*P* value	Cord injury		*P* value
	Complete data (n = 20,230)	Missing GCS (n = 3,770)		Complete data (n = 3,364)	Missing GCS (n = 1,125)	
Age (median/[IQR])	45.3 (29.0–65.7)	45.0 (28.8–63.9)	0.070	40.6 (27.0–57.9)	40.4 (27.0–59.2)	0.452
Male (n [%])	12,749 (63.0)	2,458 (65.2)	0.011	2,456 (73.0)	839 (74.6)	0.311
GCS (median/[IQR])	15 (15–15)	NA		15 (15–15)	NA	
ISS (median/[IQR])	8 (4–13)	9 (4–22)	<0.001	20 (16–26)	24 (16–30)	<0.001

Presented are numbers and percentages, or medians and interquartile ranges (IQR)

NA not available

suggests that, at initial assessment in the emergency department, further evaluation and special precautions for spinal injuries are warranted, especially, in patients with a lowered level of consciousness and in patients with dangerous injury mechanisms (falls >2 m, sports injuries, RTCs and shooting). Young patients had increased ORs of both fractures/dislocations and cord injuries. Females had a lower OR for spinal cord injury than males. In 10.4% of patients fractures/dislocations occurred at more than one level, strongly indicating that evaluation of the whole spine is important. Almost half of patients suffered concomitant injuries at a severity of AIS $\geq$ 2 and therefore, assessment of further injuries in patients with spinal trauma is important. However, the presence of these associated injuries per se did not increase the OR for spinal trauma when the aforementioned predictors were considered. Except for patients with concomitant chest injury, who have an increased risk for spinal cord involvement and merit careful consideration.

Strengths and weaknesses

The strengths of this study include the multicentre design, the large sample of patients and the appropriate adjustment for potential confounders. The registry-based nature of the study means that some data are inevitably missing. Nevertheless, the main analysis accounted for missing data in analysed covariates using multiple imputation. Finally, adjustment for different types of associated injuries may have introduced co-linearity and, therefore, may have biased our results towards underestimation of associations. However, patients with more than one associated injury with a severity of AIS $\geq$ 2 were rare. TARN includes patients of different European hospitals, the majority of them belonging to the UK (England and Wales 241,758 [96.48%], Republic of Ireland 4,770 [1.90%], Denmark 3,503 [1.40%], Switzerland 553 [0.22%] patients). To ensure uniform data collection all participating hospitals have trained personnel, who are responsible for TARN data collection and are subject to the TARN procedures manual.

Context

In a study of 942 Irish patients with spinal fractures and/or cord injury, Lenehan et al. [4] report that males are consistently at a higher risk across all aetiologies of spinal injuries. This contrasts with our results, where no gender difference for spinal fractures/dislocations alone was observed after adjustment. However, we found an increased OR for spinal cord injury with or without fractures/dislocations in younger males. A higher incidence of spinal cord injury in young males is also reported in prior studies [8–10, 17]. RTCs and falls are in general described as major risk factors for spinal cord injury [3, 9, 17]. But, whereas in the USA, spinal cord injuries resulting from interpersonal violence are frequent (9.8–19.8%) [8, 17], this type of injury mechanism was rare (0.6%) in our study population. However, the MVA revealed shooting as a predictor for spinal cord trauma. Only few data exist on associated injuries in patients with spinal trauma. Two studies from Taiwan reported extra-spinal injuries in almost 30% of patients [18, 19], compared to 45% in our patients. Wang et al. [19] reports 52% of spinal cord injury patients suffering concomitant chest injuries. This supports our finding, that patients with chest injuries have a higher OR for underlying cord trauma. An analysis from the German Trauma Registry in 772 spinal trauma patients showed that 96% of severe injuries of the chest were associated with injury to the thoracic spine. Although, median GCS in spinal injury patients was 15, we observed that patients presenting with lowered levels of GCS showed increased ORs for spinal injury. Lowered levels of consciousness are generally reported as associated with head and cervical spine trauma [10, 20, 21].

Implications

Our data has important implications for the management of patients with spinal trauma. Males, patients <45 years, with a lowered level of consciousness on admission, suspected chest injury and/or dangerous injury mechanisms have increased ORs for spinal trauma and should, therefore, be triaged to specialised trauma centres. Compared to the United States, trauma centres in Europe are usually not formally graded and trauma care might be divided according to surgical sub-specialities between different hospitals. Careful consideration should be given, not only to the experience and available infrastructure of a trauma care centre, but also to the specialisation of the centre with respect to suspected spinal injury.

Conclusions

We present the largest study from Europe of predictors for spinal injuries in adult major trauma patients. Spinal trauma occurred in around 10% of patients. Aggressive evaluation of the spine and special precautions are warranted, especially in males, patients <45 years, with a lowered GCS, concomitant chest injury and/or dangerous injury mechanisms (falls >2 m, sports injuries, RTCs and shooting). Almost half of our patients with spinal injuries suffered extra-spinal trauma and more than 10% suffered spinal injury at multiple levels, indicating that diagnostic imaging of the whole spine and a diligent search for associated injuries are substantial.

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Conflict of interest None.

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References

1. World Health Organization (2009) World Health Report 2009. http://www.who.int/whosis/whostat/EN_WHS09_Table2.pdf 2009. Accessed 06 Dec 2010
2. Krug EG, Sharma GK, Lozano R (2000) The global burden of injuries. Am J Public Health 90:523–526
3. Pirouzmand F (2010) Epidemiological trends of spine and spinal cord injuries in the largest Canadian adult trauma center from 1986 to 2006. J Neurosurg Spine 12(2):131–140
4. Lenehan B, Boran S, Street J, Higgins T, McCormack D, Poynton AR (2009) Demographics of acute admissions to a National Spinal Injuries Unit. Eur Spine J 18(7):938–942
5. Hu R, Mustard C, Burns C (1996) Epidemiology of incident spinal fracture in a complete population. Spine 21(4):492–499
6. Hu R, Mustard CA, Burns C (1996) Epidemiology of incident spinal fracture in a complete population. Spine 21(4):492–499
7. Dryden DM, Saunders LD, Rowe BH, May LA, Yiannakoulias N, Svenson LW, Schopflocher DP, Voaklander DC (2003) The epidemiology of traumatic spinal cord injury in Alberta, Canada. Can J Neurol Sci 30(2):113–121
8. Jackson AB, Dijkers M, Devivo MJ, Poczatek RB (2004) A demographic profile of new traumatic spinal cord injuries: change and stability over 30 years. Arch Phys Med Rehabil 85(11):1740–1748
9. Pickett W, Simpson K, Walker J, Brison RJ (2003) Traumatic spinal cord injury in Ontario, Canada. J Trauma 55(6):1070–1076
10. Schinkel C, Frangen TM, Kmetic A, Andress HJ, Muhr G, AG Polytrauma der DGU (2007) Spinal fractures in multiply injured patients: an analysis of the German Trauma Society's Trauma Register. Unfallchirurg 110(11):946–952
11. DeVivo MJ, Krause JS, Lammertse DP (1999) Recent trends in mortality and causes of death among persons with spinal cord injury. Arch Phys Med Rehabil 80(11):1411–1419
12. Strauss DJ, Devivo MJ, Paculdo DR, Shavelle RM (2006) Trends in life expectancy after spinal cord injury. Arch Phys Med Rehabil 87(8):1079–1085
13. Pickett GE, Campos-Benitez M, Keller JL, Duggal N (2006) Epidemiology of traumatic spinal cord injury in Canada. Spine 31(7):799–805
14. The Trauma Audit & Research Network (2010) https://www.tarn.ac.uk/Login.aspx? Accessed 06 Dec 2010
15. The Trauma Audit & Research Network (2010) The Trauma Audit & Research Network Procedures Manual. Updated September 2010. https://www.tarn.ac.uk/content/downloads/53/Sept10_proc.pdf Accessed 06 Dec 2010
16. Committee on Injury Scaling, Association for the Advancement of Automotive Medicine (AAAM) (2005) The abbreviated injury scale 2005 revision. Des Plaines, Chicago
17. Nobunaga AI, Go BK, Karunas RB (1999) Recent demographic and injury trends in people served by the Model Spinal Cord Injury Care Systems. Arch Phys Med Rehabil 80(11):1372–1382
18. Chu D, Lee YH, Lin CH, Chou P, Yang NP (2009) Prevalence of associated injuries of spinal trauma and their effect on medical utilization among hospitalized adult subjects–a nationwide data-based study. BMC Health Serv Res 9:137
19. Wang CM, Chen Y, DeVivo MJ, Huang CT (2001) Epidemiology of extraspinal fractures associated with acute spinal cord injury. Spinal Cord 39(11):589–594
20. Tian HL, Guo Y, Hu J, Rong BY, Wang G, Gao WW, Chen SW, Chen H (2009) Clinical characterization of comatose patients with cervical spine injury and traumatic brain injury. J Trauma 67(6):1305–1310
21. Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI, National Emergency XRadiography Utilization Study Group (2000) Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. N Engl J Med 343(2):94–99