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Vertebral fractures in motor vehicle accidents–a medical and technical analysis of 33,015 injured front-seat occupants

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ABSTRACT

Spinal injuries pose a considerable risk to life and quality of life. In spite of improvements in active and passive safety of motor vehicles, car accidents are regarded as a major cause for vertebral fractures. The purpose of this study was to evaluate the current incidence of vertebral fractures among front-seat occupants in motor vehicle accidents, and to identify specific risk factors for sustaining vertebral fractures in motor vehicle accidents. Data from an accident research unit were accessed to collect collision details, preclinical data, and clinical data. We included all data on front-seat occupants. Hospital records were retrieved, and radiological images were evaluated.

We analysed 33,015 front-seat occupants involved in motor vehicle accidents over a 24-year period. We identified 126 subjects (0.38%) with cervical spine fractures, 78 (0.24%) with thoracic fractures, and 99 (0.30%) with lumbar fractures. The mean relative collision speeds were 48, 39, and 40 kph in subjects with cervical, thoracic, and lumbar spine fractures, respectively, while it was 17.3 kph in the whole cohort. Contrary to the overall cohort, these patients typically sustained multiple hits rather than simple front collisions. Occupants with vertebral fractures frequently showed numerous concomitant injuries; for example, additional vertebral fractures. The incidence of vertebral fractures corresponded with collision speed. Safety belts were highly effective in the prevention of vertebral fractures.

Apart from high speed, complex injury mechanisms as multiple collisions or rollovers were associated with vertebral fractures. Additional preventive measures should focus on these collision mechanisms.

1. Introduction

Injuries of the spine are a considerable threat to life and quality of life. Compared to injuries of other organ systems, injuries to the spine and spinal cord are associated with the worst functional outcome and the lowest rate of reintegration into work and life activities (Johansson et al., 1993). Great efforts have been focused on improving the safety of cars for both drivers and passengers. The overall mortality in traffic accidents has been markedly reduced over the last few decades. For example, in the early 1990s, more than 10,000 road users were killed on German roads per year. In 2012, 3600 individuals died in traffic accidents; however, over 300,000 individuals were injured (German Federal Statistical Office, 2013). Nevertheless, motor vehicle accidents have been shown to be a frequent cause for spinal injuries (O'Connor, 2006; Bilston et al., 2011; El-Faramawy et al., 2012). Wang et al. recently investigated the occurrence of spine fractures in hospital admissions following motor vehicle accidents. They found that 2530 out of 20,726 drivers or front-seat passengers of 16 years or older had sustained spinal fractures (12.5%) (Wang et al., 2009).

Apart from databases of the US department of transportation there is little data available that both reveals the actual risk of sustaining vertebral fractures in motor vehicle accidents, and which crash circumstances contribute to these kinds of injuries (Pintar et al., 2012). In this study, we aim to evaluate the current risk for vertebral fractures among front-seat occupants in motor vehicle accidents, and to identify specific risk factors for sustaining vertebral fractures in motor vehicle accidents. This might serve as a basis for planning effective preventive measures.

2. Methods

2.1. Data collection by an accident research unit

In 1972, a local traffic accident research unit was established to collect prospective data on all reported traffic accidents within a metropolitan area (Brühning et al., 2005). From 1988, specially trained documentation personnel, that are notified by police

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dispatchers and arrive on scene, often at the same time as rescue personnel, have documented approximately 1000 accidents per year. This record was planned according to a statistical sample design reflecting the overall injury situation in Germany (German in-depth accident study). It is the largest in-depth accident study in Germany (Otte et al., 2012). The circumstances of the crash were investigated by taking photographs and using a 3D-laser scanner (Otte, 2005). Slide and skid marks of involved objects, vehicles, and individuals were measured for later reconstruction of the crash and calculation of collision speeds. Furthermore, they record the technical features of involved vehicles (e.g., weight and size) and on-scene clinical data of injured individuals. Additional data were collected at the hospital that admits the injured occupants, including documentation of X-ray films, diagnosis after the first in-hospital examination, and an estimation of injury severity. A report was written for each accident. The data were classified as demographic data, type of road user (car/truck occupant, motorcyclist, cyclist, pedestrian), delta-v (vehicle collision speed, kilometers per hour, kph), injury severity per anatomic region according to the abbreviated injury scale (AIS), maximum AIS (MAIS), and injury severity score (ISS) (American Association for Automotive Medicine, 1995; Baker et al., 1974; Haasper et al., 2008; Richter et al., 2007).

2.2. Data analysis

The database used in this study comprises all traffic accidents that were documented between 1988 and 2011. Traffic accident reports were analysed to identify the involvement of car front-seat occupants. Data were obtained on the occurrence of vertebral fractures and their location, collision speed, age, sex, AIS scores, MAIS score, ISS, usage of safety belts and deployment of airbags. Subjects diagnosed with vertebral fractures were assigned to a respective group of cervical, thoracic or lumbar vertebral fractures. Data from these groups were compared to the whole cohort of front seat occupants and to a subgroup of the whole cohort consisting of all severely injured subjects as defined by ISS ≥16. In addition, subgroups of drivers and front seat passengers were compared in respect to crash details.

Institutional review board approval was obtained.

2.3. Statistical analysis

All statistical analyses were performed with IBM SPSS Version 20 and 21. The student's *t*-test, Pearson's correlation and multivariate analyses were used as applicable. *P*-values below 0.05 were considered significant; *p*-values below 0.001 were considered highly significant.

3. Results

The database revealed 33,015 front-seat occupants that were involved in motor vehicle accidents over the study period. Among the front-seat occupants, 25,561 (77.4%) were drivers and 7454 (22.6%) were front-seat passengers. We identified 280 subjects (0.85%) with vertebral fractures. Of these, 126 (0.38%) had fractures of the cervical spine, 78 (0.24%) had fractures of the thoracic spine, and 99 (0.30%) had fractures of the lumbar spine. Fifteen individuals sustained vertebral fractures in two regions of the spine and four individuals sustained fractures in all three regions.

3.1. Demographic data

Among all front-seat occupants, the mean age was 38.6 years; 60% were male, 37% female, and 2% unknown (not recorded); 6.3% were aged 65 or older. The mean ages of front-seat occupants with injuries of the cervical, thoracic, or lumbar spine were 39, 41, and 40 years, respectively; 63%, 64%, and 61% were male, respectively; and 9%, 9%, and 13% were aged 65 or older, respectively. There were no children with vertebral fractures and there were two, zero, and three adolescents with cervical, thoracic, and lumbar vertebral fractures, respectively.

Table 1
Collision characteristics.

	All front seat occupants		Fracture cervical spine		Fracture throracic spine		Fracture lumbar spine		No vertebral fracture		Polytrauma (ISS ≥16)	
	33,015	100.0%	126	100%	78	100%	99	100%	32,735	100.0%	816	100.0%
Collision partner												
Car	13,024	39.4	30	18.6	9	11	16	17	12,976	39.6	216	26.5
Truck	1241	3.8	16	9.9	7	8	5	5	1224	3.7	44	5.4
Motorbike	2047	6.2	0	0.0	0	0	0	0	2047	6.3	34	4.2
Bicycle	4657	14.1	0	0.0	0	0	0	0	4657	14.2	120	14.7
Pedestrian	2476	7.5	0	0.0	0	0	0	0	2476	7.6	49	6.0
Object	1753	5.3	44	27.3	10	12	19	20	1685	5.1	120	14.7
Multiple	6974	21.1	70	43.5	57	68	54	57	6833	20.9	214	26.2
Other/unk	843	2.6	1	0.6	1	1	1	1	837	2.6	19	2.3
Impact site												
Front	14,636	44.3	47	29	14	17	27	28	14,552	44.5	377	46.2
Side	6396	19.4	35	22	6	7	11	12	6358	19.4	166	20.3
Rear	3856	11.7	4	2	4	5	0	0	3851	11.8	37	4.5
Rollover	249	0.8	5	3	3	4	2	2	240	0.7	5	0.6
Multiple	6974	21.1	70	43	57	68	54	57	6833	20.9	214	26.2
Other	313	0.9	0	0	0	0	1	1	313	1.0	5	0.6
Unknown	591	1.8	0	0	0	0	0	0	588	1.8	12	1.5
Safety belt												
Belted	27,780	84.1	95	75	57	73	85	86	27,561	84.2	627	76.8
Unbelted	1252	3.8	23	18	17	22	9	9	1205	3.7	79	9.7
Unkown	3983	12.1	8	6	4	5	5	5	3969	12.1	110	13.5
Airbag activation												
None	30,463	92.3	100	79	65	83	80	81	30,235	92.4	721	88.4
Front	546	1.7	9	7	3	4	9	9	528	1.6	18	2.2
Side	296	0.9	3	2	4	5	2	2	289	0.9	13	1.6
Both	1710	5.2	14	11	6	8	8	8	1683	5.1	64	7.8