Epidemiological Trends of Spine Trauma: An Australian Level 1 Trauma Centre Study

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Abstract

Knowledge of current epidemiology and spine trauma trends assists in public resource allocation, fine-tuning of primary prevention methods, and benchmarking purposes. Data on all patients with traumatic spine injuries admitted to the Alfred Hospital, Melbourne between May 1, 2009, and January 1, 2011, were collected from the Alfred Trauma Registry, Alfred Health medical database, and Victorian Orthopaedic Trauma Outcomes Registry. Epidemiological trends were analyzed as a general cohort, with comparison cohorts of nonsurvivors versus survivors and elderly versus nonelderly. Linear regression analysis was utilized to demonstrate trends with statistical significance. There were 965 patients with traumatic spine injuries with 2,333 spine trauma levels. The general cohort showed a trimodal age distribution, male-to-female ratio of 2:2, motor vehicle accidents as the primary spine trauma mechanism, 47.7% patients with severe polytrauma as graded using the Injury Severity Score (ISS), 17.3% with traumatic brain injury (TBI), the majority of patients with one spine injury level, 7% neurological deficit rate, 12.8% spine trauma operative rate, and 5.2% mortality rate. Variables with statistical significance trending toward mortality were the elderly, motor vehicle occupants, severe ISS, TBI, C1–2 dissociations, and American Spinal Injury Association (ASIA) A, B, and C neurological grades. Variables with statistical significance trending toward the elderly were females; low falls; one spine injury level; type 2 odontoid fractures; subaxial cervical spine distraction injuries; ASIA A, B, and C neurological grades; and patients without neurological deficits. Of the general cohort, 50.3% of spine trauma survivors were discharged home, and 48.1% were discharged to rehabilitation facilities. This study provides baseline spine trauma epidemiological data. The trimodal age distribution of patients with traumatic spine injuries calls for further studies and intervention targeted toward the 46- to 55-year age group as this group represents the main providers of financial and social security. The study's unique feature of delineating variables with statistical significance trending toward both mortality and the elderly also provides useful data to guide future research studies, benchmarking, public health policy, and efficient resource allocation for the management of spine trauma.

Keywords

- ► spine trauma
- ► epidemiology
- ► demographics
- ► spinal injury characteristics
- ► neurological status
- ► registry
- ► prevention

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The variable spine trauma epidemiology study sources, ranging from dedicated clinical-quality spine trauma registries to databases of inpatient rehabilitation facilities, have the ability to create potential bias in epidemiology reporting.[1] There is also potential for variability of spine trauma epidemiology reporting from country to country due to socioeconomic circumstances. Apart from judicious recourse allocation, public health policy making, and benchmarking, knowing country- and region-specific spine trauma epidemiology is useful for the optimization of spine trauma management. Studies have been performed to address this issue but one cannot help to notice that there is a propensity to concentrate more on spinal cord injuries than spine column trauma or both.[1–11] Thus far, there have been only a handful of studies providing data on spine column trauma.[12–16] This study aims to investigate the epidemiology and trending of mortality and the elderly population of both spinal cord and spine column trauma seen at a state-serviced level 1 trauma center using clinical-quality registry data.[17]

Methods

Site

The Victorian State Trauma System was established in 2000. This ensured that 90% of patients statewide with major trauma are treated in a Major Trauma Service annually.[18,19] The Alfred Hospital consistently treats a minimum of 55% of major trauma cases per year in the state of Victoria, Australia. The Alfred Trauma Service admits on average 1,200 patients with severe polytrauma (Injury Severity Score [ISS] > 15) per year. Approximately a third of the patients have spine injuries, with approximately a third of those undergoing spine operative procedures. The Alfred Spine Trauma Service consists of a multidisciplinary team of orthopedists and neurosurgeons. The spine trauma unit is familiar with current spine trauma treatment algorithms and advocates for its use in the management of patients with traumatic spine injuries.[20,21]

Study Cohort and Data Collection

The Alfred Trauma Registry, Alfred Health medical database, and Victorian Orthopaedic Trauma Outcomes Registry (VOTOR) were used to identify all patients with traumatic spine injuries admitted between May 1, 2009, and January 1, 2011, as 1-year patient-reported outcome data became available from May 2009. Collection of demographic, spine injury characteristic, and physician-reported outcome data was performed using the Alfred Spine Trauma Registry minimum data set.[17,22] The Alfred Trauma Registry has full-time clinical nurse specialists who are also staff members of the Alfred Health Trauma Department. Their main roles are to collect, verify, and enter registry data into the Alfred Trauma Registry. Spine and other orthopedic trauma data are then forwarded to the Victorian state trauma registry or VOTOR.

The retrospective clinical data and radiographic review were acquired from The Alfred Health acute care electronic medical database (PowerChart, Cerner Solutions, Kansas City, Missouri, USA).

Statistical Analyses

The data were analyzed separately as a general study cohort, and cohorts of nonsurvivors versus survivors and the elderly versus nonelderly were compared. We defined the elderly population as those aged 65 years and older, in accordance with World Health Organization definition.[23] Variables investigated were demographics, clinical- and spine-specific characteristics, mortality (physician-reported outcome), and convalescence descriptors. All categories containing continuous variables were summarized using frequencies and percentages, and categorical variables were summarized using median and percentile values. Variables trending toward mortality and the elderly were further investigated using logistic (linear) regression analysis. Univariate analysis was utilized to demonstrate variables with statistical significance trending toward mortality and the elderly age group. Parameters used in regression analysis were odds ratios (ORs) and 95% confidence intervals (CIs), and the significance level was set as $p < 0.05$. All analyses were performed using the Statistical Package for the Social Sciences program (Version 20, SPSS Inc., Chicago, Illinois, USA).

Results

General Cohort: Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, a total of 965 patients with traumatic spine injuries with 2,333 spine injury levels were managed at the study hospital (►**Tables 1** and **2**). The cohort comprised 68.7% males and 31.3% females, with a ratio of 2:2

Table 1 Demographics and clinical characteristics of general cohort

Demographic and outcome variables	General cohort ($n = 965$)
Age, mean (± SD)	50.9 (± 20.1)
Sex	
Male	663 (68.7%)
Female	302 (31.3%)
Ratio	2:2
Mechanism of injury	
Motor vehicle occupants	436 (45.2%)
Unprotected road users	121 (12.5%)
Low falls (<1 m)	150 (15.5%)
High falls (>1 m)	183 (20%)
Significant collision (non-road-related)	64 (6.6%)
Other causes	11 (0.2%)
ISS	
Median	14
25th/75th centile	9/22
Severe (ISS > 15)	460 (47.7%)
Traumatic brain injury	
Yes	167 (17.3%)
No	798 (82.7%)

Abbreviations: ISS, Injury Severity Score; SD, standard deviation.

Table 2 Spine injury characteristics of 965 trauma patients with spine injuries

Spine injury characteristics (per segment)	Number ($n = 2,333$)	Incidence (per total spine injuries)
C0–C2	189	8.1%
Occipital condyle	26	1.1%
C1 burst	35	1.5%
Odontoid (type 2)	47	2%
Odontoid (types 1 and 3)	17	0.7%
C2 Hangman's	18	0.8%
C1–2 dissociation	11	0.5%
C1–2 misc.	35	1.5%
C3–C7	497	21.3%
DLC only	76	3.3%
Compression	344	14.7%
Burst	5	0.2%
Distraction	28	1.2%
Translation or rotation	44	1.9%
T1–T12	893	38.3%
DLC only	3	0.1%
Compression	792	33.9%
Burst	44	1.9%
Distraction	42	1.8%
Translation or rotation	12	0.5%
L1–L5	691	29.6%
DLC only	0	0
Compression	612	26.2%
Burst	61	2.6%
Distraction	15	0.6%
Translation or rotation	3	0.1%
Sacrococcygeal	63	2.7%
Management		
Operative	124	12.8%
Nonoperative	841	87.2%

Abbreviations: C1–2 misc., miscellaneous fractures affecting the C1–C2 lamina, body, lateral mass, or spinous process; DLC, discoligamentous complex.

in favor of males. The mean age was 50.9 years. ►**Fig. 1** shows a trimodal peak distribution of these patients in terms of age in groups of 16 to 25 years, 46 to 55 years, and more than 75 years. Motor vehicle accidents (45.2%) and falls from more than 1 m (20%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 47.7% had severe injury with ISS of more than 15; 17.3% of the patients with traumatic spine injuries had traumatic brain injury (TBI). In terms of spine injury characteristics, 42% of the patients had single-level spine injuries with 34% having three levels or more of spine injury (►**Fig. 2**). In all, 93% were neurologically intact with 3% having nerve root injury and 4% having spinal cord injury (SCI) secondary to spine trauma (►**Fig. 3**). There were 189 (8.1%) high cervical spine (C0–C2) injuries with the most common injury being type 2 odontoid fractures. There were 497 (21.3%) subaxial cervical spine (C3–C7) injuries, 893 (38.3%) thoracic spine injuries, and 691 (29.6%) lumbar spine injuries with compression fractures being the most common injury morphologically. There were 63 (2.7%) sacrococcygeal injuries. There was a 12.8% spine trauma operative rate with 87.2% treated conservatively.

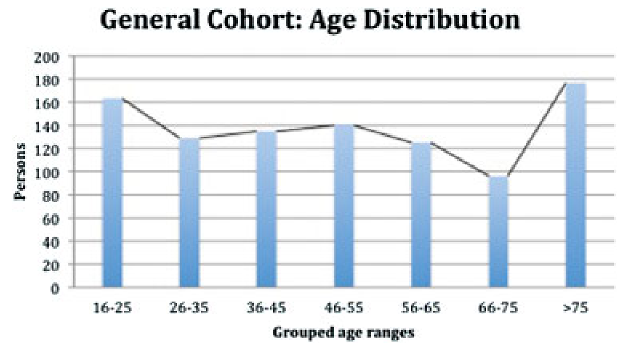

Fig. 1 Distribution of age in 965 patients with traumatic spine injuries.

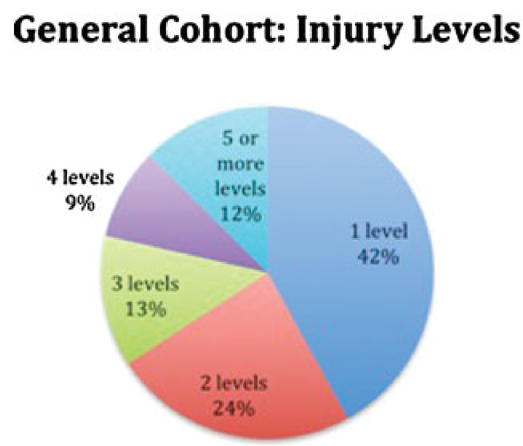

Fig. 2 Distribution of injury levels in 965 patients with traumatic spine injuries.

Nonsurvivor versus Survivor Cohorts (with Spine Trauma): Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, 50 fatalities and 915 spine trauma survivors with a spine trauma mortality rate of 5.2% were managed at the study hospital (►**Tables 3** and **4**).

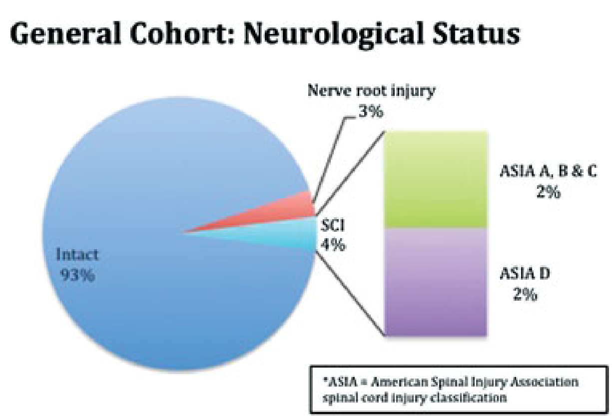

Fig. 3 Neurological status secondary to spinal injury in 965 patients with traumatic spine injuries.

Table 3 Comparison of demographics between trauma nonsurvivors and survivors with spine injuries

Demographic and outcome variables	Nonsurvivors ($n = 50$)	Survivors ($n = 915$)	Odds ratio; 95% CI	p value
Age				
Mean (± SD)	62.6 (± 24.1)	50.3 (± 21.8)	–	–
Elderly (≥65 y)	30 (60%)	258 (28.2%)	3.82; 2.13–6.85	< 0.01
Sex				
Male	40 (80%)	620 (67.8%)	1.9; 0.94–3.86	0.07
Female	10 (20%)	295 (32.2%)	–	–
Ratio	4:1	2:1	–	–
Mechanism of injury				
Motor vehicle occupants	30 (60%)	405 (44.3%)	1.89; 1.06–3.38	0.03
Unprotected road users	0	121 (13.2%)	–	–
Low falls (< 1 m)	12 (24%)	138 (15.1%)	1.78; 0.91–3.49	0.09
High falls (> 1 m)	5 (10%)	178 (19.5%)	–	–
Significant collision (non-road-related)	3 (6%)	61 (6.7%)	–	–
Other causes	0	12 (1.2%)	–	-
ISS				
Median	30	14	14	–
25th/75th centile	17/43	9/22	9/22	–
Severe (ISS > 15)	40 (80%)	420 (45.9%)	4.71; 2.33–9.54	< 0.01
Traumatic brain injury, **yes**	28 (56%)	139 (15.2%)	7.11; 3.95–12.78	< 0.01
Mortality rate	5.2%		–	–

Abbreviations: CI, confidence interval; ISS, Injury Severity Score.
Note: Variables in **bold** demonstrates trend (with statistical significance; $p < 0.05$) toward mortality.

The nonsurvivor cohort comprised 80% males and 20% females, with a ratio of 4:1 in favor of males. The mean age was 62.6 years. Motor vehicle accidents (60%) and falls from less than 1 m (24%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 80% were severely injured, with ISS of more than 15, and 56% of the patients with traumatic spine injuries had TBI. In terms of spine injury characteristics, 42% of the patients had single-level spine injuries and 42% had three or more levels of spine injury. Ninety percent were neurologically intact with 10% having SCI secondary to spine trauma. There were 17 high cervical spine (C0–C2) injuries with the most common injury being occipital condyle (C0) fractures. There were 37 subaxial cervical spine (C3–C7) injuries, 48 thoracic spine injuries, and 35 lumbar spine injuries with compression fractures being the most common injury morphologically. There were five sacrococcygeal injuries. There was a 10% spine trauma operative rate with 90% treated conservatively.

The survivor cohort comprised 67.8% males and 32.2% females, with a ratio of 2:1 in favor of males. The mean age was 50.3 years. Motor vehicle accidents (44.3%) and falls from more than 1 m (19.5%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 45.9% were severely injured with ISS of more than 15, and 15.2% of the patients with traumatic spine injuries had TBI. In terms of spine injury characteristics, 42% of the patients had single-level spine injuries with 34% having three or more levels of spine injury. In all, 93% were neurologically intact with 3.4% having nerve root injury and 3.6% having SCI secondary to spine trauma. There were 17 high cervical spine (C0–C2) injuries with the most common injury being occipital condyle (C0) fractures. There were 37 subaxial cervical spine (C3–C7) injuries, 48 thoracic spine injuries, and 35 lumbar spine injuries with compression fractures being the most common injury morphologically. There were five sacrococcygeal injuries. There was a 10.3% spine trauma operative rate with 89.7% treated conservatively.

Nonsurvivor versus Survivor Cohorts (with Spine Trauma): Significant Trends to Mortality

►**Table 5** shows the univariate associations between spine trauma variables and mortality. Six univariate variables trending toward spine trauma mortality with statistical significance ($p < 0.05$) were identified. They were elderly patients (OR = 3.82; CI = 2.13 to 6.85), motor vehicle occupants (OR = 1.89; CI = 1.06 to 3.38), severe ISS (OR = 4.71; CI = 2.33 to 9.54), TBI (OR = 7.11; CI = 3.95 to 12.78), C1–2 dissociation (OR = 4.39; CI = 1.05 to 18.44), and American Spinal Injury Association (ASIA) grades A, B, and C (OR = 7.71; CI = 2.64 to 22.57).

Elderly versus Nonelderly Cohorts (with Spine Trauma): Demographics, Clinical, and Spine Injury Characteristics

During the 20-month period, 289 elderly and 676 nonelderly patients were managed at the study hospital (►**Tables 6** and **7**). The mortality rate was 10.4% for the elderly cohort and 3% for the nonelderly cohort. The elderly cohort comprised 58.5% men and 41.5% women, with a ratio of 1:4 in favor of males. The mean age was 78.6 years. Falls from less than 1 m (39.1%) and motor vehicle accidents (31.8%) were the

Table 4 Comparison of spine injury characteristics between trauma nonsurvivors and survivors with spine injuries

Spine injury characteristics	Nonsurvivors ($n = 50$)	Survivors ($n = 915$)	Odds ratio; 95% CI	p Value
Total injury levels	142	2191	–	–
Injury levels per patient				
Mean	2.8	2.4	–	–
1	21 (42%)	384 (42%)	–	–
2	8 (16%)	222 (24.3%)	–	–
3	6 (12%)	117 (12.8%)	–	–
4	7 (14%)	79 (8.6%)	1.72; 0.75–3.96	0.20
5 or more	8 (16%)	112 (12.3%)	1.37; 0.63–2.98	0.43
C0–C2 injuries (total)	17 (100%)	172 (100%)	–	–
Occipital condyle	4 (23.5%)	22 (12.8%)	2.1; 0.63–7.01	0.23
C1 burst	2 (11.8%)	33 (19.2%)	–	–
Odontoid (type 2)	2 (11.8%)	45 (26.2%)	–	–
Odontoid (types 1 and 3)	3 (17.6%)	14 (8.1%)	2.42; 0.62–9.44	0.20
C2 Hangman's	0	18 (10.5%)	–	–
C1–2 dissociation	3 (17.6%)	8 (4.7%)	4.39; 1.05–18.44	0.04
C1–2 misc.	3 (17.6%)	32 (18.6%)	–	–
C3–C7 injuries (total)	37 (100%)	460 (100%)	–	–
DLC only	3 (8.1%)	73 (15.9%)	–	–
Compression	28 (75.7%)	316 (68.7%)	1.42; 0.65–3.08	0.38
Burst	1 (2.7%)	4 (0.9%)	3.17; 0.34–29.08	0.31
Distraction	3 (8.1%)	25 (5.4%)	1.54; 0.44–5.34	0.50
Rotation/translation	2 (5.4%)	42 (9.1%)	–	–
T1–T12 injuries (total)	48 (100%)	845 (100%)	–	–
DLC only	0	3 (0.4%)	–	–
Compression	44 (92%)	748 (88.5%)	1.43; 0.50–4.06	0.51
Burst	1 (2.1%)	43 (5.1%)	–	–
Distraction	1 (2.1%)	41 (4.9%)	–	–
Rotation/translation	2 (4.2%)	10 (1.2%)	3.63; 0.77–17.05	0.10
L1–L5 injuries (Total)	35 (100%)	656 (100%)	–	–
DLC only	0	0	–	–
Compression	28 (80%)	584 (89%)	–	–
Burst	4 (11.4%)	57 (8.7%)	1.36; 0.46–3.98	0.58
Distraction	2 (5.7%)	13 (2%)	3; 0.65–13.83	0.16
Rotation/translation	1 (2.9%)	2 (0.3%)	9.61; 0.85–108.71	0.07
Sacrococcygeal injuries	5	58	–	–
Neurological status (total)	50 (100%)	915 (100%)	–	–
Intact	45 (90%)	851 (93%)	–	–
NRI only	0	31 (3.4%)	–	–
ASIA D	0	20 (2.2%)	–	–
ASIA A, B, and C	5 (10%)	13 (1.4%)	7.71; 2.64–22.57	< 0.01
Spine operative rate	5 (10%)	94 (10.3%)	–	–

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; C1–2 misc., miscellaneous fractures affecting the C1 or C2 lamina, body, or transverse process; DLC, discoligamentous complex; NRI, nerve root injury only.
Note: Variables in **bold** demonstrates trend (with statistical significance; $p < 0.05$) toward mortality.

most common injury mechanisms. Of the patients with traumatic spine injuries, 40.5% were severely injured with ISS of more than 15, and 14.9% of the patients with traumatic spine injuries had TBI. In terms of spine injury characteristics, 50.2% of the patients had single-level spine injuries with 27.1% having three or more levels of spine injury. In all, 95.8% were neurologically intact with 0.7% having nerve root injury and 3.3% having SCI secondary to spine trauma. There were 110 high cervical spine (C0–C2) injuries with the most common injury being type 2 odontoid fractures. There were 139 subaxial cervical spine (C3–C7) injuries, 180 thoracic spine injuries, and 148 lumbar spine injuries with compression fractures being the most common injury morphologically. There were 15 sacrococcygeal injuries. There was a 6.6% spine trauma operative rate with 93.4% treated conservatively.

The nonelderly cohort comprised 73.7% males and 26.3% females, with a ratio of 2:8 in favor of males. The mean age was 39.1 years. Motor vehicle accidents (53.8%) and falls from more than 1 m (18.9%) were the most common injury mechanisms. Of the patients with traumatic spine injuries, 50.7% were

Table 5 Significant univariate spine injury variables trending toward mortality

Univariate variables	Odds ratio	95% CI	*p* value
Elderly	3.82	2.13–6.85	<0.01
Motor vehicle occupants	1.89	1.06–3.38	0.03
Severe ISS	4.71	2.33–9.54	<0.01
Traumatic brain injury	7.11	3.95–12.78	<0.01
C1–2 dissociation	4.39	1.05–18.44	0.04
ASIA A, B, and C	7.71	2.64–22.57	<0.01

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; ISS, Injury Severity Score.

severely injured with ISS of more than 15. Of the patients with traumatic spine injuries, 18.3% had TBI. In terms of spine injury characteristics, 15.2% of the patients had single-level spine injuries with 37.1% having three or more levels of spine injury. In all, 91.6% were neurologically intact with 4.3% having nerve root injury and 4.1% having SCI secondary to spine trauma. There were 79 high cervical spine (C0–C2) injuries with the most common injury being occipital condyle (C0) and C1 burst or Jefferson-type fractures. There were 358 subaxial cervical spine (C3–C7) injuries, 713 thoracic spine injuries, and 543 lumbar spine injuries with compression fractures being the most common injury morphologically. There were 48 sacrococcygeal injuries. There was an 11.8% spine trauma operative rate with 88.2% treated conservatively.

Elderly versus Nonelderly Cohorts (with Spine Trauma): Significant Trends to Mortality

►**Table 8** shows the univariate associations between spine trauma variables and the elderly age group of more than 65 years. Seven univariate variables trending toward the elderly with statistical significance ($p < 0.05$) were identified. They were females (OR = 1.99; CI = 1.49 to 2.65); falls of less than 1 m (OR = 11.09; CI = 7.38 to 16.66); one level of spine injury (OR = 1.58; CI = 1.20 to 2.09); type 2 odontoid fractures (OR = 4.88; CI = 2.13 to 11.17); subaxial cervical spine (C3–7) distraction injury (OR = 4.36; CI = 2.02 to 9.41); ASIA A, B, and C neurological grades (OR = 2.99; CI = 1.17 to 7.66); and patients without neurological deficits (OR = 2.13; CI = 1.12 to 4.02).

Table 6 Comparison of demographics between elderly (65 y and above) and nonelderly patients with traumatic spine injuries

Demographic and outcome variables	Elderly (*n* = 289)	Nonelderly (*n* = 676)	Odds ratio; 95% CI	*p* value
Age, mean (± SD)	78.6 (± 8.3)	39.1 (± 14.1)	–	–
Sex				
Male	169 (58.5%)	498 (73.7%)	–	–
Female	120 (41.5%)	178 (26.3%)	1.99; 1.49–2.65	<0.01
Ratio	1:4	2:8	–	–
Mechanism of injury				
Motor vehicle occupants	92 (31.8%)	364 (53.8%)	–	–
Unprotected road users	22 (7.6%)	79 (11.7%)	–	–
Low falls (< 1 m)	113 (39.1%)	37 (5.5%)	11.09; 7.38–16.66	<0.01
High falls (> 1 m)	55 (19%)	128 (18.9%)	1; 0.71–1.43	0.97
Significant collision (non-road-related)	1 (0.4%)	56 (8.3%)	–	–
Other causes	6 (2.1%)	12 (1.8%)	1.17; 0.44–3.16	0.75
ISS				
Median	13	17	17	–
25th/75th centile	9/20	9/24	9/24	–
Severe (ISS > 15)	117 (40.5%)	343 (50.7%)	–	–
Traumatic brain injury, yes	43 (14.9%)	124 (18.3%)	–	–
Mortality rate	10.4%	3%	3.8; 2.12–6.81	<0.01

Abbreviations: ISS, Injury Severity Score; SD, standard deviation.
Note: Variables in **bold** demonstrates trend (with statistical significance; $p < 0.05$) toward the elderly.

Table 7 Comparison of spine injury characteristics between elderly (65 y and above) and nonelderly patients with traumatic spine injuries

Spine injury characteristics	Elderly ($n = 289$)	Nonelderly ($n = 676$)	Odds ratio; 95% CI	p value
Total injury levels	599	1,734	–	–
Injury levels per patients				
Mean	2.1	2.6	–	–
1	145 (50.2%)	263 (15.2%)	1.58; 1.2–2.09	<0.01
2	66 (11%)	162 (24%)	–	–
3	32 (11.1%)	91 (13.5%)	–	–
4	23 (8%)	63 (9.3%)	–	–
5 or more	23 (8%)	97 (14.3%)	–	–
C0–C2 injuries (total)	110 (100%)	79 (100%)	–	–
Occipital condyle	5 (4.5%)	21 (26.6%)	–	–
C1 burst	14 (12.7%)	21 (26.6%)	–	–
Odontoid (type 2)	39 (35.5%)	8 (10.1%)	4.88;2.13–11.17	<0.01
Odontoid (types 1 and 3)	10 (9.1%)	7 (8.9%)	1.03; 0.37–2.83	0.96
C2 Hangman's	12 (10.9%)	3 (3.4%)	3.1; 0.85–11.38	0.09
C1–2 dissociation	9 (8.2%)	5 (6.7%)	1.32; 0.43–4.10	0.63
C1–2 misc.	21 (19.1%)	14 (17.7%)	1.1; 0.52–2.31	0.81
C3–C7 injuries (total)	139 (100%)	358 (100%)	–	–
DLC only	19 (13.7%)	57 (15.9%)	–	–
Compression	93 (67%)	251(70.1%)	–	–
Burst	1 (0.7%)	4 (1.1%)	–	–
Distraction	15 (10.8%)	13 (3.6%)	4.36; 2.02–9.41	<0.01
Rotation/translation	11 (7.8%)	33 (9.3%)	–	–
T1–T12 injuries (total)	180 (100%)	713 (100%)	–	–
DLC only	0	3 (0.4%)	–	–
Compression	160 88.9%)	632 88.6%)	1.02; 0.61–1.72	0.92
Burst	10 (5.6%)	34 (4.8%)	1.17; 0.57-0.243	0.66
Distraction	9 (5%)	33 (4.6%)	1.08; 0.51–2.31	0.83
Rotation/translation	1 (0.5%)	11 (1.5%)	–	–
L1–L5 injuries (total)	148 (100%)	543 (100%)	–	–
DLC only	0	0	–	–
Compression	130 (87.8%)	482 (88.8%)	–	–
Burst	14 (9.5%)	47 (8.7%)	1.10; 0.59–2.06	0.76
Distraction	2 (1.4%)	13 (2.4%)	–	–
Rotation/translation	2 (1.4%)	1 (0.1%)	7.42; 0.67–82.46	0.10
Sacrococcygeal injuries (total)	15	48	–	–
Neurological status (total)	289 (100%)	676 (100%)	–	–
Intact	277 (95.8%)	619 (91.6%)	2.13; 1.12–4.02	0.02
NRI only	2 (0.7%)	29 (4.3%)	–	–
ASIA D	0	20 (3%)	–	–
ASIA A, B, and C	10 (3.3%)	8 (1.1%)	2.99; 1.17–7.66	0.02
Spine operative rate	19 (6.6%)	80 (11.8%)	–	–

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval; C1–2 misc., miscellaneous fractures affecting the C1 or C2 lamina, body, or transverse process; DLC, discoligamentous complex; NRI, nerve root injury only.
Note: Variables in **bold** demonstrates trend (with statistical significance; $p < 0.05$) toward the elderly.

Elderly versus Nonelderly Cohorts (with Spine Trauma): Descriptors of Convalescence

Of the 258 elderly spine trauma survivors, 26% were admitted to the intensive care department with 55.2% of them requiring ventilation (►**Table 9**). The elderly cohort had a mean hospital length of stay of 12.9 days. The majority (69.4%) was discharged to rehabilitation facilities, 28.3% were discharged home, and only 0.8% discharged to high-level nursing care facilities.

Of the 657 nonelderly spine trauma survivors, 29.1% were admitted to the intensive care department with 78.5% of them requiring ventilation. The nonelderly cohort had a mean hospital length of stay of 10.7 days. The majority of patients (58.9%) were discharged home, 39.7% discharged to rehabilitation facilities, and none required high-level nursing care.

Discussion

Our general cohort epidemiological findings concur with current literature. The reported annual incidence of spine column trauma and SCI is 640 and 10 to 83 cases per million

Table 8 Significant univariate spine injury variables trending toward the elderly

Univariate variables	Odds ratio	95% CI	*p* value
Female	1.99	1.49–2.65	<0.01
Low falls (<1 m)	11.09	7.38–16.66	<0.01
1 spine injury level	1.58	1.20–2.09	<0.01
Type 2 odontoid injury	4.88	2.13–11.17	<0.01
Subaxial cervical spine (C3–7) distraction injury	4.36	2.02–9.41	<0.01
ASIA A, B, and C	2.99	1.17–7.66	0.02
No neurological deficits	2.13	1.12–4.02	0.02

Abbreviations: ASIA, American Spinal Injury Association classification of spinal cord injury; CI, confidence interval.

populations, respectively.[1,5,9,10,12,15,24] In Australia, the age-adjusted rate of persisting SCI from traumatic causes was similar to previous years at an estimated 15 new cases per million populations.[25] Using these figures, spinal cord injuries are ~1.6 to 13% of total patients with traumatic spine injuries. Our study with 4% incidence of SCI falls within this range.

We also showed male predominance and motor vehicle accidents and falls being the main injury mechanisms.[1,7,12,26,27] We also found the thoracic and lumbar spine segments as the most common spine injury segments, compression injuries as the most common subtype of fracture in the cervicothoracolumbar axis, and an overall low incidence of neurological deficit in patients with spine trauma.[1,12,28]

Interestingly, we found that there were three peaks in the age distribution of our spine trauma cohort of 965 patients. These peaks corresponded to age groups 16 to 25 years, 46 to 55 years, and more than 75 years, altogether representing almost 50% of our patient cohort. This finding validates our observations in a pilot study of a spine trauma clinical quality registry.[17] Spine trauma has been generally reported as having a bimodal peak with one in the early 20s and another in the elderly population[29] or a gradual decline from a peak in early adulthood.[1,26] Our finding of a peak in the 46- to 55-year age group is especially significant as this age group commonly provides financial security to the society and as such shows the value of targeting general preventive services, health promotion, and health services to enable more effective prevention of spine trauma and to hasten medical recovery, enabling prompt return to the workforce. Peaks seen in early adulthood and the elderly are easily explained. The first peak, secondary mainly to motor vehicle accidents, is explainable by the more prevalent risk-taking behavior in this age group, and the secondary peak in the elderly, mainly due to falls from standing height, is commonly due to polypharmacy and normal age-related physiological changes such as failing eyesight and incoordination. Also, as medical knowledge and medication improves, so do the average life span of the society. This leads to an increase in the elderly population compared with previous decades. This finding is unlikely to be simply inherent in our study population, as it has also been shown in a recent spine trauma epidemiology study.[15] The reason for the middle peak, however, is not obvious, and one that requires further study.

Table 9 Descriptors of convalescence in trauma survivors with spine injuries

Descriptors of convalescence	Elderly ($n = 258$)	Nonelderly ($n = 657$)
Intensive care		
Admission	67 (26%)	191 (29.1%)
Ventilation/admission	37 (55.2%)	150 (78.5%)
Hospital LOS (d)		
Mean	12.9	10.7
Median	9.1	6.2
25th/75th centile	5.7/15	3.4/12.7
Discharge destination		
Home	28.3%	58.9%
Rehabilitation	69.4%	39.7%
High-level care	0.8%	0
Others	1.6%	1.4%

Abbreviation: LOS, length of stay.

Spine Trauma Mortality Trend

Our center's mortality compares favorably with published reports of spine trauma mortality ranging from 5 to 16.7%.[13,26] When comparing the spine trauma nonsurvivors and survivors, there were six main findings: (1) members of the elderly group cohort were twice as likely to die as the nonelderly, (2) nonsurvivors had more low falls (second most common injury mechanism) than survivors (third most common injury mechanism), (3) nonsurvivors had a higher rate of severe polytrauma, (4) nonsurvivors had a higher rate of TBI, (5) nonsurvivors had more C1–2 dissociation injuries, and (6) nonsurvivors had more significant spinal cord injuries. Apart from falls as a presumed significant injury mechanism, univariate analysis confirmed the rest as variables with statistical significant mortality trends. The study's finding is significant as a patient with severe polytrauma is likely to be hemodynamically compromised and at significant risk of death. This requires strict adherence to assessment and intervention based on the Advanced Trauma Life Support course of the American College of Surgeons where the urgent normalization of vital signs and the maintenance of rigid cervical collar fixation and thoracolumbar spine precautions are recommended until the absence of injury is confirmed. It is also known that that severe TBI raises the likelihood of mortality in patients with traumatic spine injuries. Our practice is to maintain spinal precautions in all TBI patients with unstable spine trauma requiring surgery until they demonstrate ability to survive. Also, surgery is usually contraindicated in this group of patients as the majority will have high intracranial pressures and be at risk of herniation syndromes and sudden death. These findings are not novel; however, they emphasize the need for more funding and research into improving primary prevention of motor vehicle accidents and falls, the treatment of traumatic brain injuries, and medical management of the ever-growing population of elderly patients with traumatic spine injuries.

Spine Trauma Elderly Trend

When comparing elderly and nonelderly patients with spine trauma, there were seven main findings: (1) elderly females were four times more likely to have spine trauma than their male counterparts, (2) low falls were the most common injury mechanism, (3) the elderly had a lower rate of severe polytrauma and TBI but higher mortality rate, (4) nonsurvivors had a higher rate of TBI, (5) the elderly had more single-level spine injuries, (6) the elderly had more odontoid type 2 and subaxial cervical spine distraction injuries, and (7) the elderly had fewer neurological deficits and more significant spinal cord injuries. The elderly patient with spine trauma is at risk not only from high-energy trauma mechanisms but also low-energy ones such as falls from less than 1 m. The elderly are also more likely to have multiple medical comorbidities leading to decreased physiological ability and reserve. This would explain why an elderly patient with spine trauma has a higher mortality rate despite having less severe polytrauma, less TBI, and less multilevel spine injuries. Also, the injury pattern commonly associated with elderly patients and low falls are type 2 odontoid fractures and cervical distraction injuries. An interesting observation is the lower operative rate despite a higher proportion of patients with significant SCI. In our center, this is likely due to our conservative approach to elderly patients with central cord syndrome without spine fractures and discoligamentous injuries.

Elderly patients show a lower rate of admission and treatment in the intensive care department when compared with nonelderly patients, despite a higher mortality rate most likely due to a practice of conservative approach to medical management with importance placed on prognostication of outcome. Elderly patients also have a longer mean and median hospital length of stay as they are more disabled due to a slower convalescence from a poorer premorbid physical condition and insufficiency of social support for independent living. A large proportion will then require inpatient rehabilitation rather than be discharged home. This finding further corroborates the need for more geriatric research into the primary prevention of falls and development of age-specific spine trauma management guidelines to increase and improve geriatric convalescence facilities.

Study Strength and Limitations

This study is a single-center epidemiological study. Despite treating the majority of spine trauma in our state, this study is unable to determine the incidence and prevalence of SCI and spine trauma in southeastern Australia or the Victoria State. A study with the base population (denominator) of the entire catchment area or the Victoria State is the logical next step.

A retrospective observational study was performed on the patient cohort, which was recruited by the Alfred Trauma Registry in a prospective manner. The patient cohort is a well-defined patient population with collection of spine trauma demographic, clinical characteristic, and spine injury characteristic variables based on the Alfred's spine trauma clinical-quality registry minimum data set.[17]

The use of linear logistic regression analysis allowed the identification of epidemiological trends with statistical significance to mortality and the elderly age group. Multivariate analysis was not performed, as the purpose of this study was to delineate the epidemiology and spine trauma trends at a level 1 trauma center.

Future Directions

Statistically significant variables identified in this study should be considered for inclusion in future spine trauma studies investigating mortality and the elderly population of patients with traumatic spine injuries.

Data from the study are also essential for benchmarking purposes (e.g., mortality rate and convalescence data) and invaluable as the data give insight into the recovery and discharge parameters of such patients. Similar studies will greatly assist in primary prevention, policy making, and resource allocation.

Conclusion

This study provides baseline spine trauma epidemiological data as seen in a state service level 1 trauma center. The trimodal age distribution of patients with traumatic spine injuries calls for further studies and intervention targeted toward the 46- to 55-year age group as this group represents the main providers of financial and social security. The study's unique feature of delineating variables with statistical significance trending toward both mortality and the elderly also provides useful data to guide future research studies, benchmarking, public health policy, and efficient resource allocation for the management of spine trauma.

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