Ageing population has changed the nature of major thoracic injury

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ABSTRACT

Introduction An increasing proportion of the major trauma population are older persons. The pattern of injury is different in this age group and serious chest injuries represent a significant subgroup, with implications for trauma system design. The aim of this study was to examine trends in thoracic injuries among major trauma patients in an inclusive trauma system.

Methods This was a retrospective review of all adult cases of major trauma with thoracic injuries of Abbreviated Injury Scale score of 3 or more, using data from the Victorian State Trauma Registry from 2007 to 2016. Prevalence and pattern of thoracic injury was compared between patients with multitrauma and patients with isolated thoracic injury. Poisson regression was used to determine whether population-based incidence had changed over the study period.

Results There were 8805 cases of hospitalised major trauma with serious thoracic injuries. Over a 10-year period, the population-adjusted incidence of thoracic injury increased by 8% per year (incidence rate ratio [IRR] 1.08, 95% CI 1.07 to 1.09). This trend was observed across all age groups and mechanisms of injury. The greatest increase in incidence of thoracic injuries, 14% per year, was observed in people aged 85 years and older (IRR 1.14, 95% CI 1.09 to 1.18).

Conclusions Admissions for thoracic injuries in the major trauma population are increasing. Older patients are contributing to an increase in major thoracic trauma. This is likely to have important implications for trauma system design, as well as morbidity, mortality and use of healthcare resources.

Key messages

What is already known on this subject

- The rise in the median age of the trauma population in high/middle-income countries has resulted in a significant rise in the incidence of head and orthopaedic injuries. Yet, how this phenomenon has impacted the prevalence and profile of thoracic injuries has in comparison been poorly characterised.

What this study adds

- In this retrospective study from the Victorian Trauma Registry, there was a rise in the incidence of serious thoracic injuries between 2007 and 2016, with an increasing proportion of such injuries in older patients. This will have an impact on current trauma triage and management tools.

INTRODUCTION

Thoracic injuries are an important cause of mortality and morbidity among the major trauma population, accounting for approximately one-quarter of trauma deaths,[1–5] as well as long-term, functional impairment.[6 7] While traditionally the typical major thoracic trauma patient was a young male involved in a high-speed motor vehicle collision (MVC) with multisystem injuries,[4 8–10] ageing populations and improved healthcare have changed the characteristics of trauma populations in medium to high-income countries.[11 12] Today, a growing part of the major trauma population consists of older individuals who present following low-energy impacts, yet with injuries meeting criteria for major trauma.[13 14]

The impact of these epidemiological changes on specific types of traumatic injuries has been extensively studied. A rise in the median age of patients with traumatic brain and orthopaedic injuries has been reported in numerous studies.[15 16] Falls have even superseded MVC as the primary cause of traumatic brain injury.[15] This trend has considerable implications on the delivery and funding of healthcare, as older individuals typically experience greater lengths of stay, resource utilisation and costs.[17] Nevertheless, the effect of this ageing phenomenon on thoracic injuries, if any, is yet to be fully characterised. Furthermore, among thoracic injuries, there may be differences between patients with multitrauma compared with isolated thoracic trauma patients with respect to their age, mechanism and severity of injury. Characterising these two groups, and the nature of thoracic injuries prevalent in the vulnerable, older population is therefore important to inform the triage and effective allocation of resources in trauma systems.

The aim of the study was to examine the trend in incidence, mechanism and type of traumatic thoracic injuries between 2007 and 2016, among hospitalised major trauma patients across the state of Victoria, Australia.

METHODS

Study design and population

This was a retrospective review of all adult (aged 16 years and older) cases of major trauma with serious thoracic injuries using data from the Victorian State Trauma Registry (VSTR) from 1 January 2007 to 31 December 2016.

The VSTR is a population-based registry that collects data about all hospitalised major trauma

patients in Victoria.[18] A case is included in VSTR if any of the following criteria are met: (1) death due to injury; (2) an Injury Severity Score >12 as determined by the Abbreviated Injury Scale (AIS) (2005 version 2008 update); (3) admission to an intensive care unit (ICU) for more than 24 hours and requiring mechanical ventilation for at least part of their ICU stay; and (4) urgent surgery for intracranial, intrathoracic, or intra-abdominal injury, or for fixation of pelvic or spinal injury. The VSTR has approval from the Department of Health and Human Services Human Research Ethics Committee and all participating hospitals. Only patients with major thoracic trauma, defined as any thoracic injury with an AIS severity score of 3 or greater,[19] were included in the study.

Data extraction

To characterise the profile and trends in thoracic injury among the major thoracic trauma population, data on the demographic, health status, injury mechanism and type were extracted. Postcodes of residence were mapped to the Accessibility/Remoteness Index of Australia (a geographical index of remoteness) and the Index of Relative Socioeconomic Advantage and Disadvantage, which ranks areas in Australia according to relative socioeconomic advantage and disadvantage. Patients' comorbid status was defined using the Charlson Comorbidity Index (CCI), mapped from International Classification of Diseases, Tenth Revision, Australian Modification codes, with a CCI of zero representing no CCI condition.[20–22]

Isolated thoracic injury was defined as the absence of an AIS injury with a severity score of 3 or greater in any other body region. A thoracic AIS of 3 corresponds to a serious injury, which may consist of a rib fracture with an associated flail segment, a major pneumothorax/haemothorax or haemopneumothorax, or three or more isolated rib fractures.[23]

Within the isolated thoracic injury group, we identified the three most frequent types of AIS≥3 thoracic injuries, which were skeletal only injuries, haemopneumothoraces and lung contusions. We then created injury groups based on all possible combinations of these three types of injury, along with a group of 'other' combining all remaining injury types. Their prevalence was examined by age group and mechanism of injury:

1. Skeletal chest only (three or more rib fractures, unilateral/bilateral flail chest).
2. Skeletal chest and haemothorax/pneumothorax.
3. Haemothorax/pneumothorax only.
4. Skeletal chest and lung injury.
5. Haemothorax/pneumothorax and lung injury.
6. Skeletal chest and haemothorax/pneumothorax and lung injury.
7. Other.

Statistical methods

We compared the aforementioned variables between multitrauma and isolated thoracic injury patients. Missing data were specified in the tables. Population-based incidence was calculated for each calendar year based on the Victorian population in 30 June of the corresponding year. Poisson regression, or negative binomial regression, was used to determine whether the incidence rate of major thoracic trauma had changed over the study period. In this case, the count of events in each year is the numerator and the population at risk (that being the population of Victoria, Australia, in each year) is the denominator. Data were checked for potential overdispersion (variance greater than the mean) to ensure that the assumptions of a Poisson distribution were met. Trends in the crude incidence of thoracic injuries were examined by age groups, mechanisms of injury and incidence rate ratios (IRR) with 95% CIs reported. The IRR reflects the average annual relative change over time. In addition, adjustment for changes over time in mechanisms of injury was made using a point prevalence approach, with the numerator being the count of isolated thoracic trauma patients for a specific mechanism of injury, and the denominator being the count of all major trauma patients with that mechanism. Changes in the profile of injury over time were examined by determining the count of thoracic injury within each specific injury group, with the denominator being the count of major trauma patients with isolated thoracic trauma for each year. Data were analysed using Stata V.14 (StataCorp, College Station, TX, USA). P values <0.05 were considered significant.

RESULTS

Between 2007 and 2016, a total of 8805 cases of hospitalised major trauma with a serious (AIS 3+) thoracic injury were recorded. This represented 31% of all major trauma cases. Fifty-three per cent of patients (n=4688) had isolated thoracic injuries, the majority of whom sustained a maximum thorax AIS score of 3. There were notable differences between multitrauma patients with thoracic injuries, and those with isolated thoracic injuries. A greater proportion of patients with isolated thoracic injuries were aged 65 years and above (31%) compared with multitrauma patients aged 65 years or more (22%). In contrast, multitrauma patients were more commonly aged between 16 and 29 years relative to isolated trauma (26% vs 15%) (table 1). Thoracic injuries resulting from MVC and pedestrian incidents were more common among multitrauma patients compared with patients with isolated injury. In contrast, thoracic injuries resulting from low falls were more prevalent among patients with isolated thoracic injuries (table 1).

Overall, there were 781 in-hospital deaths among patients with both isolated thoracic injuries and with multitrauma, accounting for 9% of the total population. The highest proportions of mortality were found among those aged 75–84 years, and 85 years or more (17% and 33%, respectively) (table 2).

Over the study period, adjusting for the increase in the overall population of the state of Victoria, the incidence of thoracic injury increased by 8% per year (IRR 1.08, 95% CI 1.07 to 1.09) (figure 1). While the population-adjusted incidence of thoracic injury increased by 9% per year for blunt trauma, there was no change in the incidence of penetrating thoracic trauma (table 3A).

An increase in population-adjusted incidence in thoracic injury was also observed across all age groups (figure 2), but was most notable in people aged 85 years and older (14% per year), while the smallest increase was among people aged between 16 and 29 years (3% per year) (table 3A).

Isolated thoracic injury

Of all major trauma patients, the proportion of patients with isolated thoracic injuries increased 6% per year (rate ratio 1.06; 95% CI 1.05 to 1.07, p<0.001). Within this group, the proportion of only skeletal chest injuries rose by 6% per year while the proportion declined by 8% per year for haemopneumothoraces, 6% per year for haemopneumothoraces with lung injury and 6% per year for other thoracic injuries (table 3B). Within specific types of isolated thoracic injuries, the lowest proportion of deaths was found among the skeletal chest only injuries (7%) (table 2).

Table 1 Comparison of demographics and injury profile of multitrauma patients with thoracic injuries and patients with isolated thoracic injuries

Characteristics, n (%)	Multitrauma with thoracic injuries (n=4117)	Isolated thoracic injuries (n=4688)
Age group (years)		
16–29	1079 (26)	711 (15)
30–44	933 (23)	923 (20)
45–64	1168 (28)	1639 (35)
65–74	422 (10)	594 (13)
75–84	351 (8)	498 (11)
≥85	164 (4)	323 (7)
Gender		
Male	2981 (72)	3561 (76)
Female	1136 (28)	1127 (24)
Charlson Comorbidity Index weight		
0	2427 (59)	3403 (73)
1	1182 (29)	868 (18)
2+	508 (12)	417 (9)
IRSAD quintile		
1 (most disadvantaged)	588 (15)	695 (15)
2	659 (17)	659 (14)
3	855 (22)	1002 (22)
4	920 (23)	972 (21)
5 (least disadvantaged)	940 (24)	1213 (27)
Missing	155 (4)	147 (3)
ARIA		
Major cities	2750 (66)	3273 (72)
Inner regional	980 (25)	1023 (23)
Outer regional/remote	223 (6)	244 (5)
Missing	164 (4)	148 (3)
Trauma type		
Blunt	3939 (96)	4296 (92)
Penetrating	90 (2)	284 (6)
Other	87 (2)	105 (2)
Missing	1 (0.0)	3 (0.0)
Intent		
Unintentional	3800 (92)	4237 (90)
Intentional self-harm	145 (3)	100 (2)
Intentional other	129 (3)	285 (6)
Other	43 (1)	66 (1)
Mechanism of injury		
MVC	1660 (40)	1370 (29)
MBC	628 (15)	758 (16)
Cyclist	200 (5)	395 (8)
Pedestrian	397 (10)	194 (4)
Low falls (≤1 m)	213 (5)	564 (12)
High falls (>1 m)	580 (14)	603 (13)
Struck/collision with person/object	136 (3)	183 (4)
Other	303 (7)	621 (13)
Thorax AIS severity score		
3	–	3565 (76)
4	–	804 (17)
5	–	300 (6)
6	–	19 (0.4)

AIS, Abbreviated Injury Scale; ARIA, Accessibility and Remoteness Index of Australia; IRSAD, Index of Relative Socioeconomic Advantage and Disadvantage; MBC, motorbike collision; MVC, motor vehicle collision.

Table 2 In-hospital deaths by age and specific injury groups between 2007 and 2016

	n (%)
Total deaths	781 (9)
Age group (years)	
16–29	141 (8)
30–44	106 (6)
45–64	146 (5)
65–74	79 (8)
75–84	146 (17)
≥85	163 (33)
Types of isolated thoracic injuries	
Skeletal chest only	173 (7)
Skeletal chest+haemopneumothorax	199 (7)
Haemopneumothorax only	100 (13)
Skeletal chest+lung	16 (8)
Haemopneumothorax+lung	71 (12)
Skeletal chest+haemopneumothorax	109 (11)
Other	113 (12)

For each mechanism of injury, the proportion of all major trauma patients with isolated thoracic injuries increased. The greatest increase was observed among isolated thoracic injuries caused by being struck by or colliding with an object or person (21% per year), followed by cyclists, low falls and pedestrians (all 9% per year) (table 3C). Skeletal chest injury only constituted the largest proportion of isolated thoracic injuries among the low falls, pedestrian and MVC groups (table 4).

Among patients with isolated injuries, individuals aged 75–84 years, 85 years and above predominantly sustained skeletal chest injuries only. In contrast, the most common type of injury among patients aged 16–29 years were other isolated thoracic injuries, followed by lung injury with haemopneumothorax. Skeletal chest injury with haemopneumothorax was the most prevalent type of injury in patients aged 30–44 years and 45–64 years.

DISCUSSION

We observed a significant rise in the population-adjusted incidence of serious thoracic injuries, overall and across all age groups and mechanisms of injury. This rise was also observed in isolated thoracic injury, with skeletal chest injuries comprising an increasing proportion of injuries within this group. Results of this study also show that thoracic injuries among older patients are contributing to an increase in admissions for major trauma.

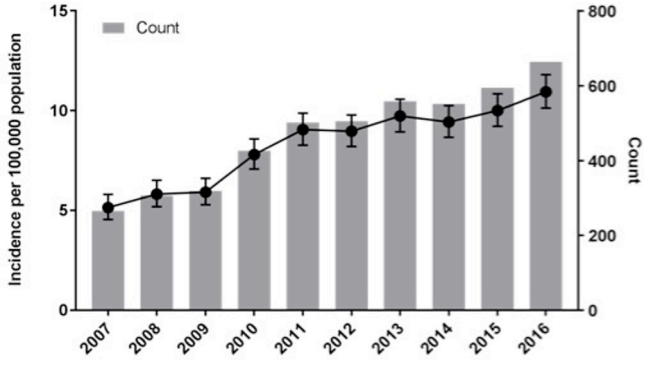

Figure 1 Population incidence and counts of thoracic injuries among the major thoracic trauma population between 2007 and 2016.

Table 3A Rate ratios for demographic characteristics, and type of injury among major trauma patients with thoracic injury. Denominator is the whole population of Victoria

Characteristics	Rate ratio (95% CI)	P value
Age group (years)		
16–29	1.03 (1.00 to 1.06)	0.022
30–44	1.05 (1.03 to 1.07)	<0.001
45–64	1.09 (1.07 to 1.11)	<0.001
65–74	1.10 (1.06 to 1.12)	<0.001
75–84	1.09 (1.06 to 1.13)	<0.001
≥85	1.14 (1.09 to 1.18)	<0.001
Trauma type		
Blunt	1.09 (1.08 to 1.10)	<0.001
Penetrating	0.98 (0.94 to 1.02)	0.309

Table 3B Rate ratios for pattern of injury groups among major trauma patients with thoracic injury. Denominator is all major trauma patients with isolated thoracic injuries

Characteristics	Rate ratio (95% CI)	P value
Skeletal chest only	1.06 (1.04 to 1.08)	<0.001
Skeletal chest+haemopneumothorax	1.00 (0.99 to 1.02)	0.566
Haemopneumothorax only	0.92 (0.89 to 0.95)	<0.001
Skeletal chest+lung	0.94 (0.88 to 1.00)	0.069
Haemopneumothorax+lung	0.94 (0.90 to 0.99)	0.018
Skeletal chest+haemopneumothorax+lung	0.98 (0.94 to 1.01)	0.184
Other	0.94 (0.91 to 0.97)	<0.001

Increases in the incidence of thoracic injuries have been reported in prior studies, and were purported to be due to the increased use of CT.[24] Chest radiography, previously the mainstay investigation, has a low sensitivity for thoracic injuries[25] and the more widespread use of CT among the trauma population could have resulted in an increased rate of detection of previously missed or underestimated injuries.[24]

However, our results suggest that increased use of CT alone may not entirely explain the observed rise in thoracic injuries. Adjusting for changes over time in the number of major trauma patients within each specific mechanism of injury, the proportion of patients with isolated thoracic injuries increased. This is particularly important in the group of patients injured in high-energy impacts, such as motor vehicle and motorcycle collisions. Although the threshold for CT requests has been decreasing for several decades, it is likely that the majority of these patients would have had a CT over the study period.[26]

This study shows that although the majority of thoracic trauma cases continue to be young men who present following MVC, the nature of thoracic trauma is changing. The increase in incidence of thoracic injuries was greatest among patients aged over 85 years. This is consistent with the global trend of ageing of the trauma population presenting with serious injuries as a result of low-energy impacts.[2 9 10] In addition, we found that patients aged 65 years and older, and those in the low fall groups, sustained a greater proportion of skeletal chest injuries, which over the study period comprised an increasingly larger proportion of isolated thoracic injuries. Older individuals have a greater susceptibility to rib fracture, which can therefore arise as a result of lower energy mechanisms than younger adults.[1] These injuries are normally managed expectantly, as adults with adequate respiratory reserve do not commonly require ventilatory support. However, isolated skeletal chest injuries become significant by increasing the risk of complications such as post-traumatic pneumonia among older trauma patients, due to the increased prevalence of pre-existing lung disease, lower functional reserve and immobilisation as a premorbid state or secondary to their traumatic injuries.[1 9 27 28] While there is evidence that transfer to a specialised trauma centre improves mortality in older patients with severe injuries, not every older person, especially individuals with isolated skeletal injury, may benefit from transfer to a specialised trauma centre.[29] In fact, there is evidence that most skeletal chest injuries, with sufficient support, training and resources, and simple and adaptable protocols to follow, could be managed in peripheral centres, and even by general practitioners.[30 31] Further research is required to identify specific cohorts of patients that may be appropriately managed outside of specialised trauma centres in mature trauma systems. This first entails examining the types of interventions currently undertaken in this cohort and their associated outcomes.

Conversely, a number of small recent studies suggest that rib fixation may improve outcomes for selected older patients with severe chest injuries.[32 33] More studies are needed to confirm this, and to identify whom among older patients may benefit from rib fixation.

In this population of major thoracic trauma, rates of in-hospital mortality were equivalent to those reported in the literature.[34 35] Mortality was significantly higher among the very old aged 75 years and older.

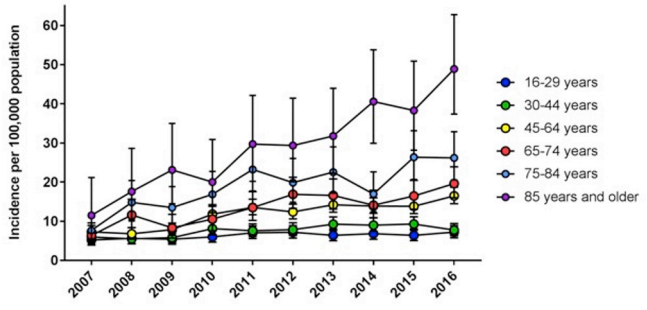

Figure 2 Population-adjusted incidence of thoracic injury among the major thoracic trauma population, shown by age groups.

Strengths and limitations

To our knowledge, this is the most contemporary population-based study to examine the trends in traumatic thoracic injuries over an extensive time period. The VSTR captures all

Table 3C Rate ratios for mechanism of injury among major trauma patients with thoracic injury. Denominator is all major trauma patients who sustained an injury as result of a given mechanism

Characteristics	Rate ratio (95% CI)	P value
MVC	1.06 (1.04 to 1.08)	<0.001
MBC	1.04 (1.02 to 1.07)	0.001
Cyclist	1.09 (1.05 to 1.13)	<0.001
Pedestrian	1.09 (1.04 to 1.14)	0.001
Low falls (≤1 m)	1.09 (1.06 to 1.12)	<0.001
High falls (>1 m)	1.04 (1.01 to 1.07)	0.01
Struck/collision with person/object	1.21 (1.15 to 1.28)	<0.001
Other		

MBC, motorbike collision; MVC, motor vehicle collision.

Table 4 Characteristics and mechanism of injury of patients with isolated thoracic injuries by specific injury groups

Injury type, n (%)	Skeletal chest only	Skeletal chest+haemo pneumothorax	Haemo pneumothorax only	Skeletal chest+ lung	Haemopneumothorax+ lung	Skeletal chest+haemo pneumothorax	Other	Total (n)
Age group (years)								
16–29	83 (12)	101 (14)	133 (19)	12 (2)	144 (20)	68 (10)	170 (24)	711
30–44	238 (26)	310 (34)	103 (11)	19 (2)	51 (5)	102 (11)	100 (11)	923
45–64	551 (34)	664 (40)	117 (7)	42 (2)	21 (1)	151 (9)	93 (6)	1639
65–74	249 (42)	227 (38)	33 (5)	13 (2)	2 (0.3)	45 (8)	25 (4)	594
75–84	223 (45)	178 (35)	30 (6)	15 (3)	3 (0.6)	26 (5)	23 (5)	498
≥85	162 (50)	97 (30)	31 (10)	10 (3)	0	12 (4)	11 (3)	323
Mechanism of injury								
MVC	503 (37)	365 (27)	75 (5)	62 (4)	78 (6)	145 (11)	142 (10)	1370
MBC	203 (27)	309 (41)	41 (5)	22 (3)	43 (6)	93 (12)	47 (6)	758
Cyclist	110 (28)	187 (47)	27 (7)	3 (0.8)	18 (4)	44 (11)	6 (1)	395
Pedestrian	80 (41)	68 (35)	9 (5)	3 (2)	4 (2)	19 (10)	11 (6)	194
Low falls (≤1 m)	278 (49)	195 (35)	73 (13)	4 (0.7)	1 (0.2)	8 (1)	5 (1)	564
High falls (>1 m)	219 (36)	282 (47)	23 (4)	12 (2)	8 (1.3)	39 (7)	20 (3)	603
Struck/collision with person/object	49 (27)	67 (37)	35 (19)	0	8 (4)	18 (10)	6 (3)	183
Other	64 (10)	104 (17)	164 (26)	5 (0.8)	61 (10)	38 (6)	185 (30)	621

MBC, motorbike collision; MVC, motor vehicle collision.

cases of major trauma in the state of Victoria, which enables the robust estimation of the incidence of traumatic thoracic injuries, and reduces the risk of selection bias. An important caveat was the lack of information with respect to pre-existing pulmonary disease and interventions. Patients who died prior to hospitalisation were not captured in this study, therefore the incidence of thoracic trauma may be underestimated. Finally, the cause of death for these patients was unknown. Therefore, any causal link between thoracic injuries and death could not be ascertained. This is particularly relevant in older age groups, where factors other than the initial injury may have contributed to death.

Rapidly increasing rates of admissions for serious thoracic trauma in the older population suggest that we should be exploring better approaches to trauma care in an ageing yet increasingly active population. Furthermore, prevention strategies in the older population have not resulted in major reductions in injury and it is likely that in the near term, there will be even more major trauma presentations in this age group.[36 37]

To shed light on the factors driving the rise in incidence of thoracic injuries, and the changes in the nature of thoracic trauma, a prospective cohort study examining the rate and nature of complications of thoracic injuries and associated mortality may be required. Future research ought to include examination of the types of intervention most effective in this population; specifically, modalities of analgesia, criteria for non-invasive ventilation and tracheostomy, and rib fixation.[32 38 39] Although there is evidence that older trauma patients are undertriaged, triage tools and criteria for transfer to a major trauma service should be reviewed, so that the majority of older patients with isolated thoracic injuries who receive supportive care only that is available in secondary centres can avoid unnecessary transfers.[29]

CONCLUSIONS

Admissions for thoracic injuries in the major trauma population are increasing. The nature of thoracic trauma is also changing, and increasingly involves older and more vulnerable patients, following mechanisms that are not typically associated with such serious injuries. The current trauma triage and management tools must be modified to address these changes.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The VSTR has approval from institutional ethics committees of all 138 trauma-receiving hospitals. This work has received ethics approval from the Monash University Human Research Ethics Committee (MUHREC).

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