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Clinical Studies

Patterns of concomitant injury in thoracic spine fractures☆

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ABSTRACT

Background: Thoracic spine fractures (TSFs) are rarely isolated injuries, and they tend to present with a characteristic set of vertebral and non-vertebral injuries based on mechanism of injury. There is limited research on the rates and distribution of injuries that occur concurrently with TSFs. The purpose of this study is to characterize the distributions of these injuries by region of the body and by mechanisms of injury, so that trauma and spine surgeons can efficiently evaluate and treat patients presenting with TSFs.

Methods: We retrospectively reviewed the trauma database records of 683 patients presenting with a TSFs at a single institution from 2015 to 2019. We recorded patient demographics, comorbidities, and associated injuries by body region. We characterized the TSFs using the AO classification system, as well as the presenting physical exam and treatment. All associated injuries among the TSF patients were classified into the following categories: head injury (HI), thoracic injury (TI), non-thoracic vertebral injury (NTVI), abdominal injury (AI), upper extremity injury (UEI), lower extremity injury (LEI), and spinal cord injury (SCI).

Results: The three leading causes of TSFs were mechanical falls (38.4%), falls from height (24.9%), and motor vehicle crashes (MVCs) (23.4%). Patients with a TSF from MVC were statistically more likely to have concomitant injuries of TI, NTVI, AI, HI, UEI, and LEI. TSFs from fall from height were statistically more likely to have TI, NTVI, and LEI. TSFs from mechanical falls had significantly lower rates of all injury locations, but still presented with high rates of additional injury. TSFs from motorcycle crashes (MCCs) presented with TI, AI, UEI, and LEI. There were high rates of treatment for TSFs, with surgery ranging from 5.3% to 20.0% and bracing from 52.3% to 65.7% depending on mechanism of injury.

Conclusions: TSFs after MVCs, mechanical falls, falls from height, and MCCs presented with a predictable pattern of injuries and were rarely an isolated injury. This cross-sectional data may help spine and trauma surgeons better understand patterns of injury associated with TSFs, with the hope of preventing missed injuries and better advising patients with TSFs on severity of injuries.

Introduction

Traumatic spine injury (TSI) is a large source of global morbidity and mortality, with an estimated 768,473 new cases globally a year [1]. The most common mechanisms for these injuries are largely modifiable such as road traffic accidents and falls [1–4]. There are recognized patterns of spine trauma that help aid in efficient and appropriate work-up and management. A mechanistic understanding of injury alone has helped guide first responding physicians in initiating advanced imaging in patients with suspected cervical trauma [3]. It is known that Cervical TSI may be associated with concomitant vascular injury [5–7] and head injury [8–10], while lumbar TSI is associated with concomitant visceral abdominal injury [4,11-13].

While much is known about injury mechanisms and associated injuries in cervical and lumbar spine injuries, thoracic spine fractures (TSFs) are largely understudied. While there are some studies that look at patterns surrounding TSFs, findings are very broad without standard characterization and correlation to mechanism of injury [14–18].

The aim of this study is to better quantify injury patterns associated with mechanisms of injury resulting in TSFs by looking at large numbers of these injuries. We have collected comprehensive data from our Level 1 trauma center over a 5-year period from 2015-2019, including patients managed by the department of Orthopedic Surgery, as well as Neurological surgery, to better define factors and associated injuries that influence management. We also aim to identify how these TSFs were treated (bracing vs surgical management). The goal of this study is that this cross-sectional data may help spine and trauma surgeons, as well as emergency physicians better understand patterns of injury associated with TSFs with the hope of preventing missed injuries and better advise patients with TSFs.

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Methods

Patient selection

After internal review board approval, a retrospective study was conducted at our level one trauma center. Our trauma center is the only level one center in the greater part of the state and deals with both urban and rural trauma. All patients with traumatic TSFs from January 2015 to December 2019 were identified. At our institution, the departments of orthopedic spine and neurosurgery alternate spine coverage. Patients seen during weeks of orthopedic spine coverage were identified from an internally maintained consult database. Patients seen during weeks of neurosurgery coverage were identified from a general surgery trauma registry. Inclusion criteria was any patient 18 years of age or older with a traumatic TSF. Patients with pathologic fractures, spinal metastases, or isolated thoracic transverse process fractures were excluded.

Imaging protocols for trauma activations are standardized at our institution. All trauma activations receive a chest and pelvis radiograph in the trauma bay and a CT of their head, cervical spine, chest (with thoracic spine reformats), abdomen/pelvis (with lumbar spine reformats). Additional imaging was then decided based off physical exam or need for surgical planning.

Injury classification

Documentation and imaging of patients meeting inclusion criteria were reviewed. Demographics collected included date of injury, length of hospital stay, mechanism of injury, and further characterizations of each injury. Mechanism of injury was categorized as either mechanical fall, fall from height (FFH), motorcycle crash (MCC), motor vehicle crash (MVC), pedestrian struck by car (PVC), Sports-related injury, or other. FFH was defined as any fall 5ft or higher.

TSFs were defined by AO/OTA classification. The level of TSF was also noted with the superior endplate of T1 to disc space of T4-5 being defined as an upper thoracic injury, the superior endplate of T5 to the disc space of T10-11 being defined as a middle thoracic injury, and the superior endplate of T11 to the discs space of T12-L1 being defined as lower thoracic injury. If multiple TSFs were identified, patient was categorized by most severe AO classification and both locations of TSFs were recorded. Treatment for TSF was also collected (surgery vs bracing).

Other injuries were categorized by region of the body. Thoracic injury (TI) was defined as non-spine injuries to the thoracic region, specifically rib or sternal fractures, pulmonary contusion, pneumothorax, hemothorax, and cardiac contusions. Non-thoracic vertebral injury (NTVI) was defined as any significant fracture or ligamentous spine injury to the cervical or lumbar spine. Head injury (HI) was defined as skull fracture, any intercranial bleeding, or a concussion with associated loss of consciousness. Abdominal injury (AI) was defined as any clinically significant organ laceration, contusion, pelvic fracture, or abdominal vascular injury. Upper extremity injury (UEI) was defined as any fracture to the bones of the upper extremity, or soft tissue injury requiring reconstruction. Lower extremity injury was defined as any fracture to the bones of the lower extremity, or soft tissue injury regarding reconstruction. Spinal cord injury (SCI) was defined as any injury to the spinal cord resulting in any measurable neurological deficits.

Follow-up

Patient follow-up was collected for both management of TSF and general medical follow-up. TSF follow-up was defined as any appointment in neurosurgery or spine clinic after the date of injury. General medical follow-up was defined as any appointment by any medical provider who is acting as a patient's primary care physician or midlevel.

Table 1

Mechanism (n = 683)	*# of patients*	*Percent*
Fall	262	38.36%
Fall from height	170	24.89%
MCC	35	5.12%
MVC	160	23.43%
OTHER	17	2.49%
Ped vs car	20	2.93%
Sport	19	2.78%

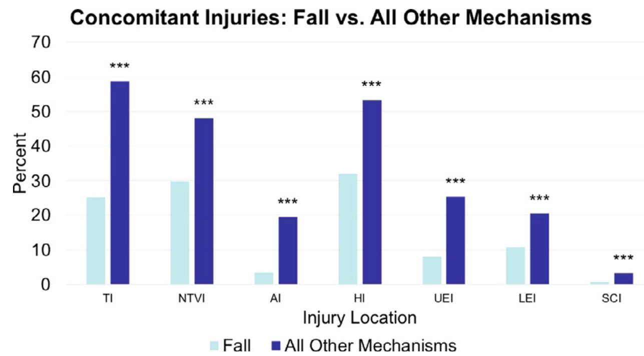

Figure 1. rates of concomitant injury for TSFs from mechanical falls

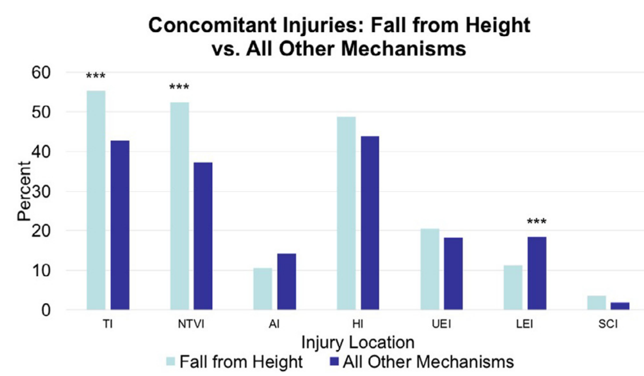

Figure 2. rates of concomitant injury for TSFs from fall from height

Statistical analysis

Rates of TSF per mechanism and concomitant injury by body region were collected. Odds ratios were calculated for body regions within each mechanism.

Results

Over the 5-year period of interest, 683 patients were identified as having a TSF from traumatic mechanisms. Of these 683 patients, 72 (10.5%) had their TSF treated with surgery, while 611 (89.5%) were treated with bracing or closed management Table 1 shows the most common mechanisms of injury resulting in a TSF. Injury demographics for the most common injury mechanisms is provided in Table 2. Injury demographics included were location of concomitant injury, AO classification of TSF, location of TSF, and treatment for TSF.

44 patients (6.4%) died during their initial hospitalization due to severity of their injuries. For the remaining patients, the average spine follow-up was 8.6 months, the average medical follow-up was 18.6 months, and 30 patients (4.3%) were lost to follow-up.

Patterns of concomitant injuries were analyzed for each of the more common mechanisms of injury (Figs. 1-4). Concomitant injury locations with a statistically higher odds ratio are marked with asterisks

Table 2

	Mechanical Fall (n = 262)	Fall from Height (n = 170)	MVC (n = 160)	MCC (n = 35)
Concomitant Injury				
TI	25.2%	55.3%	62.5%	65.7%
NTVI	29.8%	52.4%	49.4%	42.9%
AI	3.4%	10.6%	25.6%	28.6%
HI	32.1%	48.8%	54.4%	60.0%
UEI	8.0%	20.6%	26.9%	45.7%
LEI	10.7%	11.2%	24.4%	37.1%
SCI	0.8%	3.5%	2.5%	5.7%
TSF Classification				
AO A	192	94	100	25
AO B	69	74	55	8
AO C	1	2	5	2
Location of TSF				
Upper	51 (19.5%)	65 (38.2%)	60 (37.5%)	13 (37.1%)
Middle	135 (51.5%)	88 (51.8%)	68 (42.5%)	21 (60.0%)
Lower	119 (45.4%)	70 (41.2%)	70 (43.8%)	16 (45.7%)
TSF Treatment				
Bracing	52.3%	63.5%	61.3%	65.7%
Surgery	5.3%	12.4%	14.4%	20.0%

Table 3

Injury Location	Mechanical Fall (n = 262)	All Other Mechanisms (n = 421)	Odds Ratio	p value
TI	25.19%	58.67%	0.24	< 0.0001
NTVI	29.77%	47.98%	0.46	< 0.0001
AI	3.44%	19.48%	0.15	< 0.0001
HI	32.06%	53.21%	0.42	< 0.0001
UEI	8.02%	25.42%	0.26	< 0.0001
LEI	10.69%	20.43%	0.47	0.001
SCI	0.76%	3.33%	0.22	0.048

Table 4

Injury Location	Fall from Height (n= 170)	All Other Mechanisms (n = 513)	Odds Ratio	p value
TI	55.29%	42.69%	1.66	0.004
NTVI	52.35%	37.23%	1.91	0.0003
AI	10.59%	14.23%	0.71	0.227
HI	48.82%	43.86%	0.97	0.851
UEI	20.59%	18.13%	1.17	0.477
LEI	11.18%	18.52%	0.55	0.028
SCI	3.53%	1.95%	1.84	0.245

Table 5

Injury Location	MVC (n = 160)	All Other Mechanisms (n = 523)	Odds Ratio	p value
TI	62.50%	40.73%	2.43	< 0.0001
NTVI	49.38%	38.43%	1.56	0.014
AI	25.63%	9.56%	3.26	< 0.0001
HI	54.38%	42.26%	1.63	0.007
UEI	26.88%	16.25%	1.89	0.003
LEI	24.38%	14.34%	1.93	0.003
SCI	2.50%	2.29%	1.09	0.881

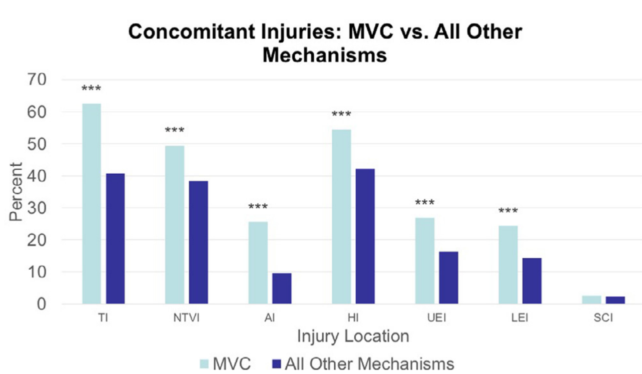

Figure 3. rates of concomitant injury for TSFs from MVCs

Tables 3–6 contain the odds ratios for each injury location based on mechanism of injury.

Discussion

In our cohort, TSFs were rarely an isolated injury and were associated with high rates of concomitant injury across all mechanisms. The patterns of injury that we were able to notice are more clearly defined in Figs. 1-4. Falls, despite a high rate of concomitant injury, had statistically lower rates than all other injury mechanisms. Fall from height was associated with higher rates of TI, NTVI, and LEI. MVCs had a higher rate of all injuries except SCI. MCCs had a higher rate of TI, AI, UEI, and LEI.

There was a variety of TSF location within each mechanism of injury, but all followed the general pattern of highest rate in middle thoracic,

Table 6

Injury Location	MCC (n = 35)	All Other Mechanisms (n = 648)	Odds Ratio	p value
TI	65.71%	44.75%	2.37	0.018
NTVI	42.86%	40.90%	1.08	0.818
AI	28.57%	12.50%	2.80	0.009
HI	60.00%	44.29%	1.89	0.073
UEI	45.71%	17.28%	4.03	0.0001
LEI	37.14%	15.59%	3.20	0.002
SCI	5.71%	2.16%	2.74	0.194

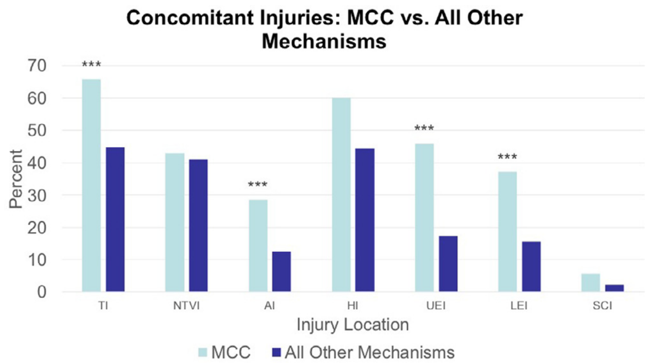

Figure 4. rates of concomitant injury for TSFs from MCCs

followed by lower, then upper. There was also a significant number of patients with injuries that stretched across injury location categories or had multiple thoracic injuries. This further supports the premise that TSFs are rarely isolated injuries, including within the thoracic spine.

Identification of these injury patterns are important to enable expeditious evaluation of the trauma patient and prevent missed injury. There can be a tendency to focus on certain injuries, such as TSFs, and lose sight of other injuries. This can potentially delay diagnosis and appropriate treatment. Awareness that TSFs are rarely isolated and contain certain injury patterns by mechanism as described above will keep the suspicion for additional injuries high.

The larger implication of these patterns is there should be discussion and thoughtfulness to the imaging obtained. While it is standard at most trauma centers to obtain a chest and pelvic radiograph in the trauma bay, completion imaging pathways are not standardized. While many traumas with high energy mechanisms undergo pan scans, sometimes patients have limited imaging at the discretion of the trauma attending. Standardizing pathways will help prevent missed injuries and prevent patients from returning to the scanner for completion imaging.

While some TSFs required surgery, the majority were successfully treated with bracing. Our cohort had good follow-up, both for spine and medically, further solidifying that closed treatment with bracing is a viable option for many TSFs. While this is not novel treatment plans for spine specialists, it is common teaching in general surgery trauma that TSFs usually require surgery. The current version of the Advanced Trauma Life Support (ATLS) textbook currently reflects this sentiment. This highlights the need for further education on the workup and management of spine injuries amongst providers that are not spine specialists.

Surgical management of TSFs was still abundant at 10.5%, although in our retrospective cohort it is harder to delineate why surgery was chosen over closed treatment in each patient. For patients with significant AO type C fracture-dislocations of their thoracic spine, it was clear that this fracture pattern necessitated reduction that would not have been able to be obtained from bracing alone. Other potential surgical patients died prior to surgical management of their TSF due to the severity of their concomitant injuries. While some indications for surgery are clear, there is still a gray zone where either treatment is appropriate. Future prospective studies would need to be conducted to fully determine what factors influence spine specialists' decision to pursue operative management in TSFs.

Conclusion

TSFs are rarely an isolated injury, and present with patterns of concomitant injury distribution based on mechanism of injury. Awareness of these injury patterns can help prevent missed injuries and expedite appropriate workup and treatment. Despite common ATLS teaching, many of these TSFs can be treated conservatively with bracing.

Declaration of Competing Interest

None.

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