Analysis of orthopaedic injuries in CT pan scans of polytrauma patients at a quaternary academic hospital

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Abstract

Background

In South Africa, doctors commonly treat patients suffering major trauma, often with multiple injuries, which necessitates the demand for a rapid diagnostic assessment. Whole body computed tomography (CT pan scan) allows for a rapid multisystem injury diagnosis. There is a scarcity of literature evaluating the extent of orthopaedic injuries in CT pan scan of polytrauma patients. The aim of the study was to evaluate the local epidemiology of orthopaedic injuries in polytrauma patients who underwent a CT pan scan.

Methods

A retrospective, observational analysis, based at an academic hospital, was done of polytrauma patients who underwent a CT pan scan during a two-year period. A database was compiled by accessing the picture archiving and communication system.

Results

A total of 296 polytrauma patients had a reported CT pan scan; 85% were male and 15% were female with a median age of 33 years. The most common mechanism of injury was motor vehicle accidents (33.1%). A total of 1 012 injuries were identified; 196 were spinal fractures (mostly cervical), 137 were pelvic/sacral fractures, and 101 were long bone fractures of the upper and lower limbs. The most frequent non-orthopaedic injury sustained was a chest injury. In a pedestrian-vehicle accident, the most common combination of injuries was a chest injury with an associated pelvic/sacral injury. Interpersonal and intentional injuries were significantly associated with a higher risk of thoracic spine fractures (relative risk [RR] 1.8, CI 1.1–2.9), whereas road traffic accidents were significantly associated with a higher risk of scapula/clavicula fractures (RR 2.0, CI 1.2–3.5) and a higher risk of tibia/fibula fractures (RR 3.5, CI 1.2–10.3).

Conclusion

The majority of polytrauma patients were young males involved in road traffic accidents. A patient involved in a road traffic accident is 3.5 times more likely to sustain a tibia/fibula fracture as opposed to any other fracture. One in four patients who sustained a chest injury had an associated cervical spine injury, and one in three patients had a pelvic/sacral injury, and similarly with head injuries. The findings of this study highlight injury patterns that should be anticipated in polytrauma patients.

Level of evidence: Level 3

Keywords: CT pan scan, orthopaedic injuries, polytrauma, whole body computed tomography

Introduction

Traumatic injuries account for ten per cent of the global burden of disease.[1] The proportion of traumatic injuries is greater in low-to-middle-income societies, with 90% of all global cases of trauma-related mortality occurring in these countries.[2] South Africa represents one of these countries, being a middle-income country, with the reported rate of trauma-related mortality being six times higher than the global rate.[2]

In South Africa, we frequently see patients who have sustained major trauma, suffering from multiple injuries. These patients are often described as polytrauma patients, which is defined as a combination of two or more severe injuries occurring in two or more anatomical areas; rarely, two or more severe injuries in one region where one injury is life-threatening.[3]

This significant burden of trauma necessitates the demand for a rapid diagnostic assessment of injuries for appropriate therapeutic intervention. The introduction and popularisation of whole body computed tomography (CT pan scan) allows for a rapid multisystem injury diagnosis of trauma patients. The definition of a pan scan is a CT scan of the head/brain, spine, chest, abdomen, pelvis and extremities that occurs in a single series at the scanner. The administration of contrast is given as per the protocols.[4]

The use of a CT pan scan has a unique role in the polytraumatised patient, as it is more sensitive for the detection of head, spinal, thoracic, abdominal and pelvic injuries compared to conventional radiography.[4] In addition, a CT pan scan has been shown to be associated with a reduction in mortality rates, and has a proven benefit over targeted CT examination.[5]

Despite the benefit of a CT pan scan in the assessment of polytrauma patients, there is no international consensus or validated clinical criteria for the selection of trauma patients who should undergo this scan. Rather, as highlighted by Gunn et al., the decision to do a CT pan scan is based on one of three indications, these being: the mechanism of injury (MOI), the location of injury or the physical examination correlating to the injury severity score.[4,6]

Even with the widespread acceptance of the use of a CT pan scan in the assessment of polytrauma patients, there is a scarcity of literature evaluating the extent of orthopaedic injuries in polytrauma patients. Therefore, the aim of the study is to evaluate the local epidemiology of orthopaedic injuries in polytrauma patients who have undergone a CT pan scan.

The objectives of the study are:

- To determine the prevalence of orthopaedic injuries in polytrauma patients
- To identify the orthopaedic injuries sustained in polytrauma patients who underwent a CT pan scan
- To evaluate the relationship between orthopaedic injuries, non-orthopaedic injuries sustained and other contributing factors (epidemiological data and mechanisms of injury)

Methods

This study was based at a quaternary level state hospital in Johannesburg, South Africa. A retrospective, observational analysis of patients who underwent a CT pan scan was done over a two-year period from 1 January 2018 to 31 December 2019. Polytrauma patients aged 18 years and older who presented to the trauma unit and required a CT pan scan were included in the study. For this study, the polytrauma patients included had a combination of injuries in two or more anatomical areas. Patients who had no reported injuries, an isolated system injury or no orthopaedic injuries were excluded from the study.

A database was compiled for the evaluation period 1 January 2018 to 31 December 2019. The data were retrieved from the picture archiving and communication system (PACS) by selecting 'CT' as the modality of investigation, followed by using the descriptive term 'CT pan scan'.

Statistical analysis

Statistical analysis was performed using Statistica, version 13.3. Non-normal data were described using medians and interquartile ranges (IQRs). The qualitative data were reported using frequencies and percentages. Categorical variables were analysed using the chi-squared test (or Fisher's exact test).

Category A injuries included interpersonal and intentional injuries: assault, gunshot wound (GSW), injury from a heavy object, and unintentional injuries, such as fall from a height (FFH). Category B injuries included road traffic accidents: motor vehicle accident (MVA), pedestrian-vehicle accident (PVA), and train accidents, respectively. All unknown mechanisms of injury were excluded from these categories.

Results

Over the two-year study period, a total of 21 466 patients attended the trauma casualty. Of these patients, a total of 4 856 patients were deemed priority resuscitation patients. A total of 954 CT pan scans

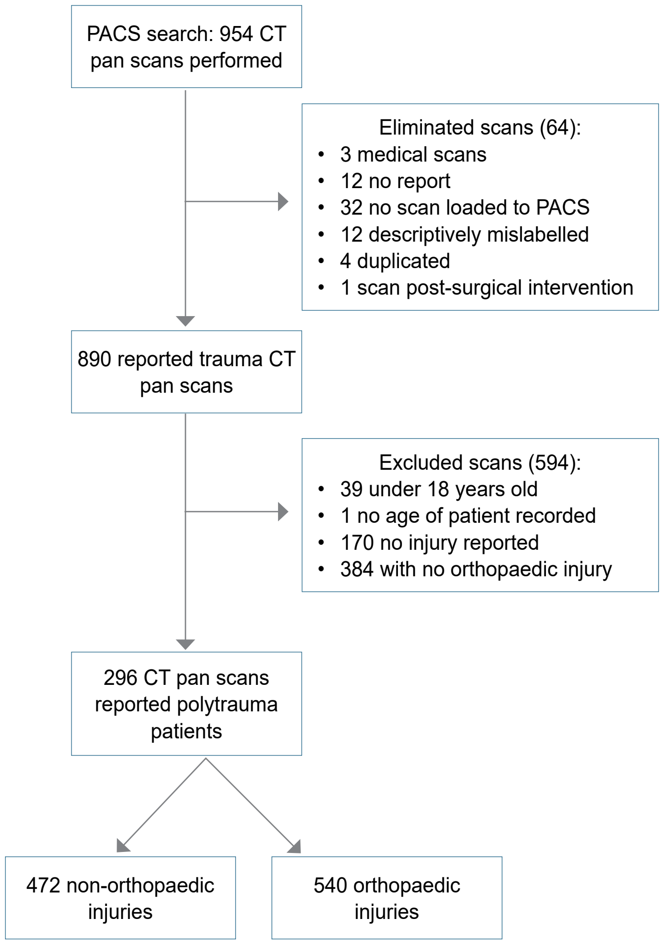

Figure 1. CT pan scan search flow chart

were found on PACS when the previously mentioned parameters were used. Of these, 64 CT pan scans were eliminated (*Figure 1*). After exclusions were applied, there were 296 polytrauma patients that had a reported CT pan scan. Therefore, the incidence of polytrauma patients identified by CT pan scan is 1%. Nevertheless, one-third (33%) of the trauma CT pan scans performed diagnosed patients with polytrauma injuries.

Of the 296 CT-reported polytrauma patients included, 85% were male (n = 252) and 15% were female (n = 44) with a male to female ratio of 5.6:1.0. The median age of the patients was 33

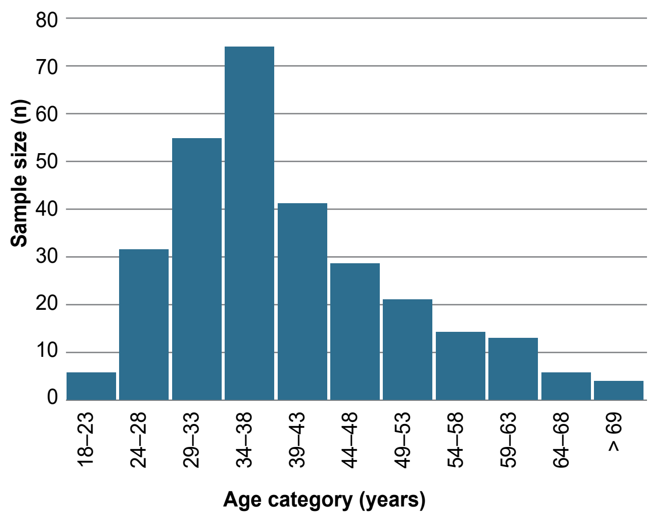

Figure 2. Age distribution of polytrauma patients (n = 296)

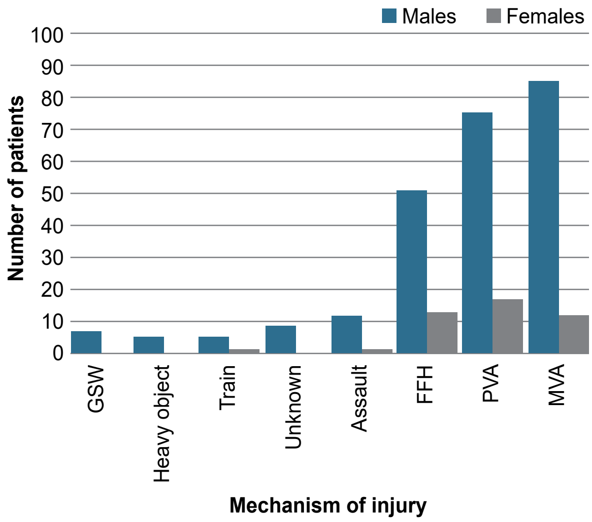

Figure 3. MOI based on sex

years (interquartile range of 28–42 years). The male age range was 18–79 years whereas the female age range was 18–68 years. *Figure 2* shows the age distribution of the study population.

The five most common MOI were: MVA (33%), PVA (31%), FFH (22%), assault (4%) and unknown MOI (3%). *Figure 3* shows the MOI frequencies based on sex.

There were 1 012 injuries found among the 296 patients included in the study. There was a total of 472 (47%) non-orthopaedic injuries and 540 orthopaedic injuries reported in this sample. The prevalence of orthopaedic injuries in polytrauma patients was 53% (95% CI 51.7–54.9%). Fractures accounted for 94% (n = 508) of all orthopaedic injuries while joint injuries accounted for the remaining 6% (n = 32) of orthopaedic injuries. *Figure 4* shows the frequency of each injury reported.

One hundred and ninety-six (196) spinal fractures were detected in 152 of the 296 patients on whom a CT pan scan was performed. The relative frequency of the different spinal fractures and combinations of injuries sustained is shown in *Figure 5*.

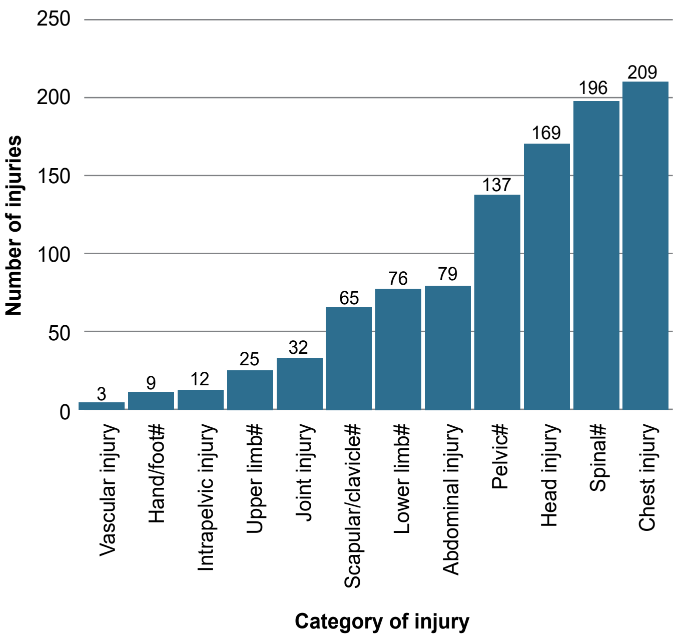

Figure 4. Frequency of all injuries sustained in polytrauma patients

#: fractures

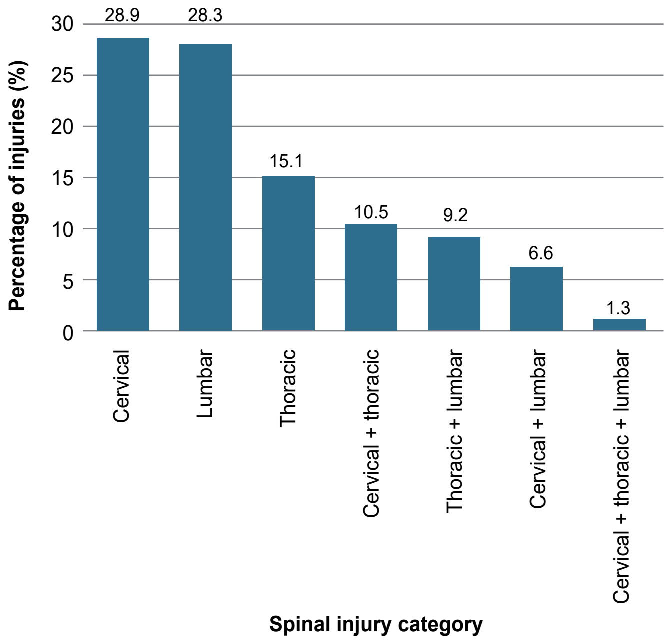

Figure 5. Spinal injuries

There was a total of 137 pelvic/sacral fractures reported on CT pan scan. Forty-five of these were acetabular fractures and two had associated posterior hip dislocations. There were 29 sacral fractures, including sacral alar fractures and sacroiliac joint diastasis injuries. The remaining injuries included pubic rami or iliac blade fractures.

Of the 296 patients included in the study, a total of 101 long bone fractures were sustained in 85 patients. The majority of long bone fractures involved the lower limbs (75%), while 25% were upper limb fractures. Of all long bone fractures, 78% were isolated long bone fractures while 22% were multiple long bone fractures. The relative frequency of the different long bone fractures and combinations of fractures is shown in *Figure 6*.

The upper limb joints (shoulder and elbow) only represented 29% of joint injuries. The knee and ankle joint injuries represented 56% and 15%, respectively.

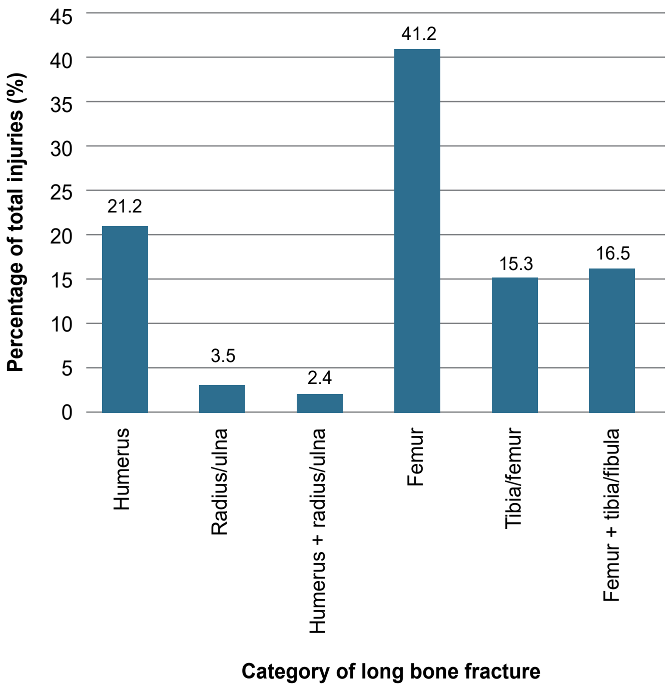

Figure 6. Relative frequency of long bone fractures

There were only three reported vascular injuries among the 296 patients included. These were a thoracic aortic pseudoaneurysm, a descending aorta intimal flap and a popliteal vessel injury after sustaining a Shatzker-6 tibial plateau fracture.

In our sample, 48% (n = 142) of patients had sustained multiple fractures. There were 19 patients with two or more long bone fractures; of these, 13 patients had a combination of femur and tibia/fibula fractures. In addition, there were 25 patients that had sustained pelvic/sacral fractures with an associated long bone fracture. Furthermore, 18 patients with spinal fractures had also sustained long bone fractures. Interestingly, 34% (48/142) of patients with multiple orthopaedic injuries had a scapula/clavicle fracture. The most common orthopaedic injury in this group were pelvic/sacral fractures, and 32% of these patients had an associated lumbar spine fracture.

The most common non-orthopaedic injury sustained was a chest injury with 209 injuries reported. *Table I* shows the percentage of head and chest injuries with various orthopaedic injuries sustained. The most common combination of orthopaedic and non-orthopaedic injuries identified in the study was a chest injury with an associated pelvic/sacral fracture secondary to a PVA. The most common orthopaedic injury associated with either a head injury or chest injury or abdominal injury was a pelvic/sacral fracture.

Table I: Percentage of head and chest injuries associated with orthopaedic injuries

	Cervical spine injury	Pelvic/ sacral injury	Upper limb injury	Lower limb injury
Head injury	27%	34%	7%	26%
Chest injury	25%	33%	8%	22%

Category A (interpersonal and intentional injuries) mechanisms included: assault, fall from a height, a gunshot wound and injury from a heavy object. Category A mechanisms were significantly associated with a higher risk of thoracic spine fractures (relative risk [RR] 1.8, CI 1.1–2.9). None of the assaulted patients, that were CT pan scanned, suffered a lower limb long bone fracture (femur or tibia/fibula).

Category B (road traffic accidents) injuries included: MVAs, PVAs and train injuries. Category B mechanisms were significantly associated with a higher risk of scapula/clavicula fractures (RR 2.0, CI 1.2–3.5) and a higher risk of tibia/fibula fractures (RR 3.5, CI 1.2–10.3).

Discussion

The aim of the study was to describe the orthopaedic injuries sustained in polytrauma patients that underwent a CT pan scan. With a paucity of studies looking specifically at this subject, we compared the data obtained from the current study to the findings reported in similar studies that reported on polytrauma injuries, not only identified on CT pan scan.

In the current study, we had a predominance of males (85%). This is similar to the 83% male predominance reported by Donovan et al. at tertiary level Grey's Hospital, and the 80% male predominance described by Dhaffala et al. from the Mthatha Hospital Complex, both located in South Africa.[7,8] However, when compared to the international burden of disease as reported in Spain by Barrera et al., they found a 75% male majority in their polytrauma patients.[9]

The median age of the population studied was 33 years. This is comparable to studies from Chris Hani Baragwanath Academic Hospital (CHBAH), Botswana and India reporting mean ages of 33.0, 33.5 and 35.2 years, respectively.[3,10,11] In comparison to a local and an international study, the mean ages reported were 44.4 and 43.9 years, respectively.[8,12] The IQR of 28–42 years found in the current study is in keeping with the age ranges of polytrauma patients reported at an Indian tertiary care centre where 57.7% of their trauma patients were aged 21–40 years old and similarly at Grey's Hospital where 60.3% of their patients were aged 20–39 years old.[7,13]

The mechanism of injury is an important aspect of trauma and orthopaedics, which relates to the severity of an injury and the number of injuries sustained. The most common MOI to cause polytrauma in patients seen is either high velocity injuries (MVA/PVA) or high energy trauma (FFH). *Table II* highlights and compares the five most common MOIs observed in the current study, as well as those reported in five other studies.

Of note, road traffic accidents are the most significant mechanism of injury in our study (64%). This is a similar trend reported by other similar studies, and highlights the deficiency in road safety awareness and practices among pedestrians, passengers and drivers. This finding highlights the need for improved road safety education, as well as improvements to public transport infrastructure to possibly reduce the number of traffic-related accidents.

Falls from a height represented the second largest mechanism of injury in our study (22%). This is in stark contrast to local studies, with CHBAH reporting only 6% injuries due to fall from a height. A possible explanation for this finding is that the study hospital is located in close proximity to the Johannesburg central business district, with a large number of residents living in high-rise buildings. Thus, the large number of high-rise buildings is expected to be a significant contributor to the trauma burden due

Table II: A comparison of MOIs reported in various studies

Reference	Current study	Leshoele[11]	Kalsotra et al.[13]	Donovan et al.[7]	Manwana et al.[10]	Jarman et al.[14]
n	296	289	258	8 722	372	815 298
	%	%	%	%	%	%
Road traffic accident	64	86.9	76.4	28.17	25.5	29.2
Motor vehicle accident	33	54.7	51	18.48		
Pedestrian-vehicle accident	31	32.2	25.4	9.69		
Fall from height	22	6.0	10.5	2.42	39	47.9
Assault	4	4.5	10.9	18.06	15.3	7.2
Unknown	3	<1		1.63		11.6
Gunshot wounds		32			1.1	1.2
Miscellaneous			2.2		5.1	

to falls from a height, unlike CHBAH where there are virtually no high-rise buildings. In comparison to two international studies by Jarman et al. and Manwana et al., the authors reported that falls were the most common MOI; however, these studies included all types of falls in this category, i.e., falls from a height and falls of the elderly.[10,14]

In 2017, Pelonomi Hospital in Bloemfontein, South Africa, reported that 50.6% of all hospital visits were due to interpersonal and intentional violence.[15] In this study, only 4% of polytrauma injuries were due to interpersonal and intentional violence. However, upon review of the casualty statistics, it shows that 43.5% of patients seen at the trauma unit was because of interpersonal and intentional violence. Similar trends were seen in the Western Cape, with Groote Schuur Hospital reporting 38% of patients seen due to assault.[16] This highlights that the prevalence rates of interpersonal violence are similar across South Africa, but that the patients seen are less likely to be polytrauma patients. The burden of violence in South Africa is emphasised by the crime rate of 77.3%, which is the third highest crime rate in the world.[17]

In the analysis of spinal fractures (196/1012), these accounted for most of the orthopaedic injuries reported on a CT pan scan. The only other study to have also shown this was published by Shannon et al.[5] The authors also used CT pan scans which were compared to clinically suspected injuries. *Table III* compares the number of injuries observed in the current study compared to those reported in other studies. The most common spinal fracture was a cervical spine fracture (72/196) which had concomitant thoracic spine injuries 11% of the time. This is comparable to Nelson et al. who reported a 9% noncontiguous cervicothoracic vertebral fracture rate.[18] Thus, a high index of suspicion for thoracic spine trauma is required when a cervical spine fracture is identified in a polytrauma patient.

When analysing the number of pelvic/sacral fractures, these represented 25% of the orthopaedic injuries sustained in the sample size. Pelvic/sacral fractures showed a proportionally higher prevalence in the study population when compared to other studies. However, the global prevalence of pelvic fractures is estimated at 2–8%, but in polytrauma patients this is reported to increase to 20–25%, which is comparable to our study.[20] A reason for the high number of pelvic/sacral fractures seen in the study is based on the MOI (road traffic accidents and FFH), which tend to be high velocity and high energy injuries leading to increased incidence of pelvic fractures. In addition, the quaternary hospital receives more complex trauma cases that may have been transferred to this hospital for further management.

The prevalence of long bone fractures is predominantly lower limb fractures, and this is comparable to the other studies cited in *Table III*. However, it is believed that the CT pan scans performed on the study population has under-reported on the total number of lower limb fractures due to where the scan sequence was terminated. Many of the scans were performed to the level of the proximal femora which may result in injuries being missed distal to the point of termination. It is important to note that an extended scan should be requested if there is an index of suspicion for injury to the lower limb (vascular or fractures that would require a CT scan).[21]

The reported number of upper limb fractures in comparison to other studies is markedly lower, and this also raises the suspicion for under-reporting in the study population. The upper limbs are notorious for not being included in the CT field based on the position of the upper limb.[12]

Chest injuries are the most common non-orthopaedic injury, comprising rib fractures, lung contusions and haemopneumothoraxes as the most common injuries reported. This is a similar finding to those reported in other studies (*Table III*) which is to be expected since the chest is one of the largest body cavities that is often involved in both blunt and penetrating trauma.[22] From *Table I*, the polytrauma patients that present with chest injuries also have a high incidence of orthopaedic injuries, similarly with head injuries. It is important to identify combined injuries, especially with chest and head injuries, as these are critical factors in determining whether a patient requires early total care or damage control orthopaedics.

Based on the results obtained from this study, should a patient be involved in a road traffic accident, they are 3.5 times more likely to sustain a tibia/fibula fracture as opposed to any other fracture. These road traffic accident patients are also twice as likely to sustain scapula or clavicle fractures compared to the other MOIs.

The study is based on a large sample size for a select group of patients, over a two-year period. Thus, we have established a significant data bank on which further studies can be conducted.

Table III: A comparison of the number of injuries reported in various studies

<table>
<tr><th>Reference</th><th>Current study</th><th>Sampson et al.[19]</th><th>Shannon et al.[5]</th><th>Kalsotra et al.[13]</th><th>Banerjee et al.[12]</th></tr>
<tr><td>n</td><td>296</td><td>255</td><td>588</td><td>285</td><td>14 583</td></tr>
<tr><td>Investigation</td><td>CT pan scan</td><td>CT pan scan</td><td>Pan scan</td><td>X rays + CT</td><td>X rays + CT</td></tr>
<tr><td>Orthopaedic injuries</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spinal fractures</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>C spine</td><td>72</td><td>26</td><td>62</td><td rowspan="3">22</td><td></td></tr>
<tr><td>T spine</td><td>55</td><td rowspan="2">48</td><td>85</td><td></td></tr>
<tr><td>L spine</td><td>69</td><td>55</td><td></td></tr>
<tr><td>Long bone fractures</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Upper limb</td><td>25</td><td></td><td></td><td>174</td><td>3 266</td></tr>
<tr><td>Lower limb</td><td>76</td><td></td><td></td><td>461</td><td>5 381</td></tr>
<tr><td>Pelvic/sacral</td><td>137</td><td>67</td><td>60</td><td>30</td><td></td></tr>
<tr><td>Hand/foot</td><td>9</td><td></td><td></td><td>163</td><td>1 487</td></tr>
<tr><td>Scapula/clavicle</td><td>65</td><td></td><td></td><td>27</td><td>2 640</td></tr>
<tr><td>Trauma injuries</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Head injury</td><td>169</td><td>127</td><td>158</td><td>153</td><td>7 277</td></tr>
<tr><td>Chest injury</td><td>209</td><td>311</td><td>399</td><td>81</td><td>9 319</td></tr>
<tr><td>Abdominopelvic injury</td><td>91</td><td>89</td><td>78</td><td>89</td><td>3 281</td></tr>
</table>

The study encompasses a wide spectrum of orthopaedic and non-orthopaedic injuries, identified and confirmed objectively by a consultant radiologist.

A limitation of the study was its retrospective nature and there was no follow-up on the patient outcomes of the identified injuries. With regard to spinal fractures, there was no collection of data regarding the presence or absence of neurological dysfunction, which may be a consideration for further research. The CT pan scan protocol includes patients who are deemed clinically stable to undergo a CT pan scan; thus those patients who were deemed to be too unstable were not pan scanned and thus may not reflect the injury patterns of these unstable polytrauma patients. There is no set protocol as to the level of termination of the CT pan scan and this could lead to injuries being missed on the CT pan scan. In South Africa, there are periods of power outages during which CT scans are performed offline. The CT scan images and reports are not transferred to the PACS once the servers are back online.

Conclusion

The majority of polytrauma patients seen are young males who sustained injuries during road traffic accidents. The most common orthopaedic injury detected in our cohort, overall, was a spine fracture, most commonly involving the cervical spine. A patient involved in a road traffic accident is 3.5 times more likely to sustain a tibia/fibula fracture as opposed to any other fracture. The most common non-orthopaedic injury sustained is a chest injury; importantly, one in four of these patients sustained an associated cervical spine injury and one in three a pelvic injury, three similarly with head injuries. The most common combinations of injuries were a chest injury with an associated pelvic/sacral fracture secondary to a PVA. The findings highlight the significant burden of orthopaedic injuries in polytrauma patients. In addition, the findings of this study highlight injury patterns that could be anticipated in polytrauma patients.

Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (clearance number: M201131), as well as the Hospital Research Committee and Management. Informed consent was waived by the Ethics Committee due to the retrospective nature of the study and lack of identifying data.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

WL: report design, data collection, literature review and analysis, article drafting, final approval and submission

DN: report design, literature review and analysis, article drafting and final approval

BM: report design, literature review and analysis, article drafting, final approval and submission

SO: data analysis, article drafting, article review and final approval

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