Epidemiology of pelvic and acetabular fractures in a tertiary hospital in Singapore

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Abstract

Introduction: Pelvic and acetabular fractures (PAFs) usually result from high-energy, potentially life-threatening accidents. They are one of the major injuries that lead to death in patients involved in such accidents. We studied the recent epidemiology of these injuries in Singapore.

Methods: This is a retrospective data analysis of all trauma patients who underwent surgery for PAFs from 2008 to 2016 in a tertiary trauma centre in Singapore. Data including patient demographics, mechanism of injury and associated injuries was collected.

Results: A total of 169 patients were admitted for PAFs over the eight-year period. The majority (79.3%) were male. The mean age was 41 (range 13–79) years. Most patients (51.5%) were Chinese. The most common mechanisms of injury were road traffic accidents (53.8%), falls (33.1%) and crush injuries (13.0%). 46.2% sustained acetabular fractures, while 44.4% sustained pelvic fractures. PAFs were most commonly associated with upper and lower limb injuries, followed by spinal and thoracic injuries. Average of length of stay in hospital was 24 (range 2–375) days.

Conclusion: PAF predominantly affects young working males. Compared to previously published local data, there has been a significant reduction in the incidence of PAFs, likely due to improved road and work safety. The demographics of PAFs have changed, with fewer injuries in females (20.7% vs. 33.3%), a reduction in the proportion of injuries in the Chinese (51.5% vs. 70.1%). While road traffic accidents remain the most common cause, crush injuries are now more prevalent (13.0%).

Keywords: Acetabular fracture, epidemiology, injury, pelvic fracture

INTRODUCTION

Pelvic and acetabular fractures (PAFs) usually result from high-energy, potentially life-threatening accidents. PAFs account for 3% of skeletal injuries.[1,2] Studies have demonstrated the incidence of pelvic ring fractures to be 23 per 100,000 persons per year[3] and that of acetabular fractures to be three per 100,000 persons per year.[4] These fractures can result from high-energy traumatic injuries [5] or low-energy injuries such as falls in osteoporotic elderly.[6] Better understanding of the clinical pattern of PAFs would aid in their management.

While epidemiological studies on PAFs have been published overseas, few have been conducted on the local population.[7,8] These studies were conducted several years ago and largely evaluated pelvic ring fractures alone, without including acetabular fractures. Our paper aimed to study the epidemiological factors and management of PAFs in Singapore and to evaluate changes in these areas over the past few years.

METHODS

This was a retrospective study conducted at the Department of Orthopaedic Surgery at National University Hospital (NUH), Singapore. Over an eight-year period from January 2008 to February 2016, 169 patients were admitted to the orthopaedics

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department for treatment of fractures of the pelvic ring and acetabulum. Our study included all patients admitted with a diagnosis code for fractures of the pelvic ring, acetabulum, pubic rami, sacrum, ilium and ischium. These patients were largely treated with surgical fixation of their fractures, either through open reduction and internal fixation, external fixation or percutaneous fixation. A few of the patients were managed conservatively, when patient factors such as age and other comorbidities resulted in unsuitability of surgical treatment.

The medical records, radiographs, computed tomography images and operation notes of these patients were obtained from the hospital admission database and reviewed for retrospective collection of data. The following parameters were analysed: age, gender, ethnicity, nationality, body mass index, mechanism of injury, site of injury, classification of fracture, associated injuries, surgical procedure, surgical approach and length of hospitalisation. The patient demographics were analysed in comparison to the Singapore national census to account for the specific ethnic composition of the local population. Our results were compared to previously published data on pelvic fractures in Singapore, to evaluate the epidemiological changes in local patients with PAFs.

RESULTS

A total of 169 patients were treated for PAFs by the NUH Department of Orthopaedic Surgery between January 2008 and February 2016. Patients were predominantly male (79.3%). The majority (70.4%) were aged 20–49 years, and the most common (26.0%) age group was 20–29 years. The average age of the patients was 41 (range 13–79) years.

51.5% of the patients were Chinese, 14.8% were Malay, 18.3% were Indian and 15.4% were of other ethnicities. The national census of the Singapore population published in January 2011[9] reported an ethnic composition of 74.1% Chinese, 13.4% Malay, 9.2% Indian and 3.3% of other races. In comparison to the national racial distribution, our sample had a high representation of Indians and other races. There was lower Chinese representation, while the percentage of Malay patients was similar to the national ethnic distribution [Table 1].

A significant proportion of the patients were foreigners (47.9%), while 52.1% of patients were Singaporeans or permanent residents. Based on data released by the Singapore Department of Statistics in 2015,[10] the total population of Singapore is 5.54 million. Of these, 3.90 million are Singaporeans or permanent residents (70.4%), while 1.64 million are non-residents (29.6%). Hence, there was higher representation of non-residents among patients with PAFs.

The most common cause of PAFs among our patients was road traffic accidents (53.8%). This was followed by falls from height (28.4%). Crush injuries (13.0%) and low energy falls (4.7%) were not as common among our study population. Among the patients who were involved in road traffic accidents, a majority were motorcyclists (61.5%). Drivers and passengers of motor vehicles such as cars and lorries made up 19.8% of the patients. Pedestrians (13.2%) and cyclists (5.5%) made up much smaller proportions of the patients [Table 2]. Among the patients involved in road traffic accidents, 82.4% were male, while 17.6% were female. In terms of racial distribution, 49.4% were Chinese, 21.9% were Malay, 21.9% were Indian and 6.6% were of other ethnicities.

In our study, the definition of a fall from height is based on the International Classification of Diseases, Ninth Revision (ICD-9).[11] The ICD-9 defines a fall from height

Table 1. Patient demographics (n=169).

Parameter	No. (%)
Gender	
Male	134 (79.3)
Female	35 (20.7)
Age (yr)	
≤19	6 (3.6)
20-29	44 (26.0)
30-39	38 (22.5)
40-49	37 (21.9)
50-59	20 (11.8)
60-69	15 (8.9)
70-79	9 (5.3)
Ethnicity	
Chinese	87 (51.5)
Malay	25 (14.8)
Indian	31 (18.3)
Others	26 (15.4)
Nationality	
Singaporean/PR	88 (52.1)
Foreigner	81 (47.9)

PR: permanent resident

Table 2. Mechanism of injury for pelvic and acetabular fractures.

Mechanism of injury	No. (%)
Cause	
Road traffic accident	91 (53.8)
Car driver/passenger	18 (19.8)
Motorcyclist	56 (61.5)
Cyclist	5 (5.5)
Pedestrian	12 (13.2)
Fall from height	48 (28.4)
Low fall	18 (37.5)
High fall	30 (62.5)
Crush injury	22 (13.0)
Low energy fall	8 (4.7)
Work-related injury	
Yes	42 (24.9)
No	127 (75.1)

as an event in which a person falls to ground level from an upper level. A fall from height can be further classified into low falls (e.g. from a ladder, staircase or chair) and high falls (e.g. from a building). Our study defined a low energy fall as a fall on the same level and not from an elevated level (e.g. due to slipping or tripping). Of the patients who were injured due to falls from height, 37.5% were low falls while 62.5% were high falls.

Almost a quarter of the patients in our study sustained their injuries in workplace accidents (24.9%). A majority (92.9%) of these patients were male while 7.1% were female. Among these patients, 45.2% were Chinese, 9.5% were Malays, 14.2% were Indians, and 31.0% were of other races.

39.6% of the patients sustained isolated pelvic ring fractures, while 52.1% sustained isolated acetabular fractures. 8.3% of the patients sustained combined pelvic ring and acetabular fractures [Table 3]. A majority of the patients (79.3%) simultaneously sustained associated injuries to other parts of their bodies, while 20.7% sustained PAFs alone. In the patients who sustained additional injuries, the most common sites of injury were the upper and lower limbs (61.5%). Spine fractures (24.3%) and injuries to the thorax (25.4%), including lung injuries, pneumothoraxes and rib fractures, were the next most commonly associated injuries. Facial injuries (17.8%), injuries to the abdominal viscera (16.6%), and head injuries (15.4%) were less commonly associated with PAFs in our study population. Among our patients, damage to the pelvic organs (8.3%) was least commonly associated with PAFs. 57 of the patients had available information on their weight and body mass index (BMI). The average BMI was 24.8 kg/m^2 for patients who had associated injuries, while the average BMI for patients without injuries was 26.1 kg/m^2. There was no statistically significant difference in the results ($p > 0.05$). Details on the classification of the injuries are listed in Table 4. The vertical shear type made up the majority of the pelvic fractures (32.8%), and posterior wall acetabular fractures were most commonly seen in patients with acetabular fractures (28.4%).

Table 3. Fracture patterns of the study population.

Parameter	No. (%)
Fracture	
Isolated pelvic ring fracture	67 (39.6)
Isolated acetabular fracture	88 (52.1)
Combined pelvic ring and acetabular fracture	14 (8.3)
Associated injury	
Injuries in other parts of body	134 (79.3)
No associated injuries	35 (20.7)
Site of injury	
Head and brain	26 (15.4)
Face	30 (17.8)
Thorax	43 (25.4)
Abdomen	28 (16.6)
Pelvic organs	14 (8.3)
Spine	41 (24.3)
Upper and lower limbs	104 (61.5)

Out of the 169 patients, four patients were treated conservatively without surgery, while the other 165 were managed surgically. A majority of these surgically-managed patients underwent open reduction and internal fixation (ORIF) (68.5%, n = 113). 27 (16.4%) underwent closed reduction and percutaneous screw insertion under radiological guidance. 9 (5.5%) were treated with external fixation. 12 (7.3%) of the patients had multiple pelvic fractures that required a combination of the above treatment options. A small percentage of patients (2.4%, n = 4) underwent other surgeries such as wound exploration and debridement.

A total of 122 patients in our study underwent ORIF of their PAFs, including patients who underwent a combination of procedures. Of these, eight were excluded from the study of surgical approach as they had undergone combined procedures. [Table 5]. A majority of the ORIF procedures (49.1%) were done through the Kocher-Langenbeck approach. The Pfannenstiel approach (18.4%) and the ilioinguinal approach (14.9%) were the next most commonly used. Other surgical approaches to pelvic fracture fixations were much less commonly used. The average of length of stay in hospital was 24 (range 2–375) days.

DISCUSSION

Our data showed that pelvic fractures occurred more commonly among male patients of working age (20–49 years). Other previously published local data similarly reported pelvic fractures predominantly occurring in young working males.[8] However, there has been a change in the demographics of pelvic fractures in the past few decades. Compared to local data published by Lee and Yeo [7] 30 years ago, there has been a reduction in the incidence of PAFs among female patients, from 33.3% to 20.7%, and an increase in the proportion of males sustaining pelvic fractures, from 66.7% to 79.3%. Road traffic accidents were the most common cause (53.8%) of PAFs in our study, and a majority of the patients involved in road traffic accidents were male (82.4%). A significant proportion (24.9%) of the study population also sustained PAFs through work-related injuries, with a male predominance of 92.9% among this group. This may explain the change in gender ratio among patients with PAFs in our study population.

A similar study on the mortality of pelvic fractures conducted by Ooi *et al* [8] in 2010 also reported that 64% of pelvic fracture patients were male. A similar study conducted from 2008 to 2010 in Qatar showed comparable demographics, with a majority (93.2%) of their patients being male and from a younger age group (average 36 years). The most common cause of injury was also road traffic accidents (49.5%).[12] In comparison, a 16-year study conducted in Scotland from 1988

Table 4. Classification of acetabular and pelvic fractures.

Classification	Frequency	%
Marvin Tile classification of acetabular fractures (*n*=88)		
A1: posterior wall	25	28.4
A2: posterior column	9	10.2
A3: anterior wall and/or posterior column	3	3.4
B1: transverse	9	10.2
B2 : T-Shape	5	5.7
B3: posterior hemitransverse + anterior column	9	10.2
C1: both columns, high	17	19.3
C2: both columns, low	3	3.4
C3: both columns involving sacroiliac joint	8	9.1
Marvin Tile classification of pelvic fractures (*n*=67)		
A: rotationally and vertically stable, sacroiliac complex is intact		
A1: avulsion fractures	0	0
A2: stable iliac wing fractures or minimally displaced pelvic ring fractures	0	0
A3: transverse sacral or coccyx fractures	0	0
B: rotationally unstable and vertically stable, caused by external or internal rotational forces, results in partial disruption of the posterior sacroiliac complex		
B1: open-book injuries	17	25.4
B2: lateral compression injuries	11	16.4
B3: bilateral rotational instability	3	4.5
C: rotationally unstable and vertically unstable, complete disruption of the posterior sacroiliac complex		
C1: unilateral fractures	13	19.4
C2: bilateral fractures with one side of Type B and one side of Type C	14	20.9
C3: bilateral fractures with both sides of Type C	9	13.4
Young Burgess classification of pelvic fractures (*n*=67)		
APC I	0	0
APC II	17	25.4
APC III	7	10.4
LC I	3	4.5
LC II	12	17.9
LC III	6	9.0
VS	22	32.8

APC: anteroposterior compression; LC: lateral compression; VS: vertical shear

Table 5. Surgical management of patients with open reduction and internal fixation.

Surgical approach	Type of fracture exposed	
	Acetabular	Pelvic
Kocher-Langenbeck approach (*n*=56)	A1, A2, B1, B2, B3	-
Stoppa approach (*n*=8)	A2	LC II, LC III
Ilioinguinal approach (*n*=17)	A3, B1, B2	-
Pfannenstiel approach (*n*=21)	B3	APC II, APC III
Iliofemoral approach (*n*=12)	B2, B3	-

APC: anteroposterior compression; LC: lateral compression

to 2003 found that there had been a decrease in proportion of males sustaining such fractures from 75% to 59% in 1988–2003. This was associated with a statistically significant decrease in the incidence of road traffic accidents and increase in low falls (from less than 10 feet) from 17% to 38%. The average age of patients also increased from 46.8 years to 53.7 years during this time period.[4] The changing trend of mechanisms of injury in this population may have accounted for the difference in patient demographics compared to the Singapore population, where more than half of PAF cases were from road traffic accidents.

In the study by Lee and Yeo,[7] the most common (20.1%) age group for pelvic fractures was 50–59 years, although a large proportion of patients were within the working age group (20–59 years). Ooi *et al*'s findings were similar to our study, that pelvic fractures were more common in the younger age group (20–49 years).[8]

Compared to previous findings, the present study had a lower proportion of Chinese patients with PAFs. The racial distribution of the patients studied by Lee and Yeo in 1987 matched the national racial distribution more closely (70.1% Chinese, 15.3% Malay, 13.9% Indian).[7] In contrast, our data showed an increased representation of Indians and patients of other races. This may be explained by the fact that road traffic accidents and work-related injuries made up significant proportions of the injuries among our study population. Among patients who were involved in road traffic accidents, the representation of Malays, Indians and patients of other races was higher. In addition, a large proportion of the patients who sustained their fractures in work-related injuries were Indian (14.2%) and of other races (31.0%), although specific information about the distribution of other races was not available. This increase may correspond to the large number of workers from India and other countries who work in Singapore's construction and manufacturing industries.

Pelvic fractures also tended to occur in foreigners, who made up almost half (42.8%) of the patients who were involved in road traffic accidents. They also made up more than three-quarters (76.2%) of the patients involved in work-related accidents. According to 2016 data from the Ministry of Manpower Singapore, 46.5% of the 1.4 million foreigners employed in Singapore are semi-skilled foreign workers holding work permits who work in the construction, manufacturing, marine, processing or service sectors (excluding foreign domestic workers). Of these, 41.9% (total of 315,500) work in construction.[13] The increased incidence of pelvic fractures among foreign workers may be due to the more dangerous nature of their jobs, increasing their risk of workplace accidents, during which they may sustain PAFs. This is reflected in the significant number of our patients who sustained their injuries during work. The significant numbers of foreigners involved in road traffic accidents may

have also contributed to the prevalence of such fractures among foreigners. A possible reason is their unfamiliarity with local road traffic rules and behaviour, an important factor that should be addressed to reduce the risk of road traffic accidents. Other studies conducted in the international population did not evaluate the incidence of injuries among foreigners or the relation of injuries to work-associated accidents.

Lee and Yeo reported that a majority of patients (51.39%) sustained pelvic fractures from road traffic accidents,[7] similar to our result of 53.8%. Motorcyclists were most commonly injured in these accidents. Other papers have similarly reported that road traffic accidents, especially motorcycle accidents, are the most common mechanism of pelvic fractures.[3,14,15] Road traffic accidents involving motorcycles account for an even larger proportion of acetabular fractures.[16,17]

The present study found an increase in patients who sustained pelvic fractures from crush injuries, as compared to Lee and Yeo's data. They reported that 4.86% of injuries were due to direct impact from falling objects, while our data showed that 13.0% were due to direct impact from a heavy object. The change may be attributed to the rapid urbanisation of Singapore over the past two decades, resulting in the need for a larger labour force in the construction and manufacturing industries, which have an increased risk of work injuries, especially crush injuries by heavy objects, leading to pelvic fractures. This could account for the increased incidence of work injuries and crush as a mechanism of injury in our pelvic fracture patients. There was also an increase in the recruitment of foreign workers in these industries. Over the past decade alone, there has been an increase in foreign construction workers from 180,000 in 2007 to 326,000 in end 2015.[13] It may also explain the trend of increasing numbers of foreign patients and patients of other races in our study population.

Our results highlight the importance of road and workplace safety. Road safety is especially relevant with the increase in car and motorcycle ownership in Singapore. The total number of motor vehicles in Singapore increased by 26.8% over the span of ten years, from 754,992 in 2005 to 957,246 in 2015.[18] During this period, the number of motorcycles in Singapore increased from 139,434 to 143,900. This potentially results in increased road traffic accidents, especially those involving motorcycles. More emphasis should also be placed on safety in the workplace. Safety checklists and adequate personal protective equipment such as safety harnesses are crucial in the prevention of workplace accidents. Ensuring that workers have enough rest can also help prevent accidents resulting from careless mistakes that may occur when the workers are tired. Safer roads and work environments may help lower the risk of accidents causing life-threatening injuries such as pelvic fractures.

A study published by Halvorson *et al*. found that the prevalence of combined PAFs was 5.0%–15.7%.[19] This prevalence was found to vary among different populations. There is currently no available literature on the prevalence of combined fractures in Singapore. Papers previously published in Singapore by Lee and Yeo and Ooi *et al*. studied pelvic ring fractures alone, and did not include acetabular fractures.[7,8] There is also little available literature on combined PAFs in the Asian population. The study of combined PAFs is important because these fractures are a result of higher-energy trauma compared to isolated pelvic or acetabular fractures.[20,21] Better understanding of its prevalence and epidemiology may help in the prevention and management of these high-energy injuries.

Our department has noted an increase in associated injuries in patients presenting with pelvic fractures. 79.3% of our patients sustained injuries to other parts of the body. Based on Lee and Yeo's 1987 paper, 25.7% (37 of 144) of patients with pelvic fractures studied also presented with fractures of the upper and lower extremities, and 4.9% of pelvic fracture patients had associated spinal fractures. In contrast, we reported that 61.5% of our study patients had associated injuries of the upper and lower extremities, while 24.3% of our patients had associated spinal fractures. Lee and Yeo [7] found that 11.8% of patients had head injuries, compared to 15.4% in our study. 4.9% of their patients sustained injuries to the abdominal organs, considerably less than the 16.6% in our study.

There has been a considerable increase in the number of associated injuries in pelvic fracture patients over the past two decades. A possible cause is a larger impact of trauma during injury in recent years, as compared to the 1980s. Increasing speeds of motor vehicles involved in road traffic accidents may have resulted in more injuries sustained. With increasing importance being placed on efficiency and productivity in the 21st century, construction and manufacturing industries may use higher-powered machinery to transport heavier loads at each time, resulting in greater trauma caused by crush injuries in the workplace.

Of the 165 patients who were treated surgically, a majority underwent ORIF, but a significant proportion (16.6%) underwent percutaneous fixation of their fractures. While ORIF remains the standard treatment for PAFs, percutaneous fixation of such fractures is gaining popularity worldwide with promising outcomes. A study of 143 patients with PAFs treated with percutaneous fixation by Qoreishi *et al*. showed excellent outcomes with union of all fractures within three months postoperatively. 93% of the patients in the study eventually returned to their pre-injury jobs.[22] A similar study by Schweitzer *et al*. reported good outcomes in 92.9% of their patients, with 86% returning to their pre-injury jobs.[23]

In terms of surgical approach in open fixation of PAFs, the majority of our patients were operated on via the Kocher-Langenbeck approach, followed by the Pfannenstiel and ilioinguinal approaches. This is consistent with the types of surgical approaches described in other international

studies. Matta published a large series on the management of 494 acetabular fractures in the United States, of which a majority (87.4%) were treated surgically.[24] The Kocher-Langenbeck approach was also the most common approach (43%), followed by the ilioinguinal approach (33%).[24] Another study by Madhu *et al*. conducted in England similarly reported a majority of patients undergoing ORIF through the Kocher-Langenbeck approach (48%), followed by the ilioinguinal approach (21%).[25]

This study was not without limitations. Our data was derived from a single institution, which potentially limits the generalisability of our results. However, in view of our centre's close proximity to the industrial area, our study was able to capture a significant number of patients who sustained their injuries in industrial accidents. The inclusion of this population of patients allowed us to study an important cause of traumatic PAFs.

Our study population only included patients who presented to the orthopaedic department with pelvic fractures for treatment. Patients who died from their injuries in the emergency department and were therefore not treated for their pelvic fractures were excluded. Data on patients who died from their injuries on the scene was also not available. Furthermore, we did not evaluate the severity of injuries of patients with pelvic fractures using tools such as the Injury Severity Score or the Abbreviated Injury Scale. These tools may be considered in future studies on pelvic fractures to assess the severity of trauma.

In conclusion, PAFs are high-energy injuries that have significant morbidity and mortality. In spite of this, there is little available literature on the epidemiology, pattern of injury and management of these fractures in the Singapore population. The gender and racial distribution of PAFs has changed over the past few decades. While road traffic accidents involving motorcycles are still the most common cause, there has been a trend in the mechanism of injury towards workplace accidents involving crush injuries or falls from height. The level of energy of the fractures has also increased, with a greater proportion of patients with associated injuries. Understanding these changes in the epidemiology and patterns of injury is critical for better management of PAFs.

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Conflicts of interest

There are no conflicts of interest.

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