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ORIGINAL RESEARCH ARTICLE

Patients with pelvic fracture: what factors are associated with mortality?

Chee Kheong Ooi · Hsin K. Goh · Seow Y. Tay · Dong H. Phua

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Abstract
Background Pelvic fracture is one of the major injuries that lead to death in patients who sustain high-impact injuries such as road traffic accidents and falls from height.
Aims This study aims to look at the epidemiology and the significant predictors of mortality in victims with pelvic fracture presenting to the emergency department (ED) of an urban Asian city.
Methods This was a retrospective data analysis of all trauma patients with pelvic fracture who were treated at the ED of an urban adult hospital in Singapore from April 2001 to December 2004. Student's t-test and χ^2 test were used in statistical analysis where appropriate.
Results The study included 179 consecutive patients. Sixty-four percent of patients were males, and 71% of patients were in the 20–49-year-old age group. Road traffic accidents and falls from height were the two most common mechanisms of injury. Mortality rate was 37%. Pelvic fracture severity, shock and coma at presentation, and the presence of concurrent head and chest injuries were associated with increased mortality. Gender, other mechanisms of injury and other concomitant injuries were not associated with increased mortality.
Conclusions The mortality rate of trauma patients with pelvic fracture continues to be high. In such patients, predictors of mortality are the severity of the pelvic fracture, the presence of coma, shock, and head and chest injuries.

Keywords Pelvis · Injuries · Mortality · Risk factors · Singapore

C. K. Ooi (✉) · H. K. Goh · S. Y. Tay · D. H. Phua
Department of Emergency Medicine, Tan Tock Seng Hospital,
11 Jalan Tan Tock Seng,
Singapore 308433, Republic of Singapore
e-mail: chee_kheong_ooi@ttsh.com.sg

Introduction

Pelvic fracture is an injury associated with high mortality in polytrauma patients [1, 2]. Its presentation may lead to rapid exanguination despite maximal resuscitative efforts [3]. It also results in significant morbidity for patients who recover from the initial insult [4, 5]. The majority of trauma patients are young and in the prime of their lives [6–9]. It is therefore important to understand the epidemiology as well as the predictors for mortality in pelvic fracture so that preventive measures can be undertaken and preemptive treatment can be given. There is a paucity of epidemiological studies related to pelvic fracture in the Asian population. The purpose of this study is to look at the epidemiology of pelvic fracture in an Asian population and to determine factors associated with mortality.

Methods

This was a retrospective descriptive study in a 1,300-bed acute urban restructured hospital in Singapore. The study hospital has a trauma team on site, and is equipped with interventional angiography facilities and an intensive care unit. From 1 April 2001 to 31 December 2004, data of all consecutive trauma patients with pelvic fracture who presented to the Emergency Department (ED) were analysed. Data that were collected included: (1) the patient's demographic profile, (2) assessment of physiological parameters upon presentation, (3) causes, nature and mechanisms of injury, (4) injury severity based on the Revised Trauma Score (RTS) and Injury Severity Score (ISS), (5) pelvic fracture severity (classified according to the Abbreviated Injury Score AIS), (6) the presence and severity of other concomitant injuries (classified according to AIS), (7) interventions received, (8) length of stay in the hospital including high

dependency and intensive care unit and (9) survival outcome upon discharge. Student's t-test and χ^2 test were used to look for associations between variables where appropriate. Multivariate analysis using logistic regression was performed to evaluate significant predictors (determined on univariate analysis) that were associated with mortality. The significance level was set to less than 0.05. Statistical calculations were performed using STATA version 11.0 (College Station, TX). The Domain-Specific Review Board (DSRB) of the National Healthcare Group (NHG), which is the institution's ethics committee, approved this study.

Results

One hundred seventy-nine patients were found to have sustained pelvic fracture during the study period. Table 1 shows the demographic characteristics of the patients. They were predominantly male (64%). Seventy-one percent of the patients were aged between 20–49 years old. The most common mechanism of injury was road traffic accidents (52%), followed by falls from height (44%). Motorcyclists (35%) and pedestrians (30%) were the most commonly injured patients. The median ISS was 25 and median RTS was 7. The median total hospital length of stay (inclusive of intensive care and high dependency unit stay) was 9 days. The mortality rate was 37%. Fifty-one percent of deaths occurred in the ED. Pelvic fracture severity, the presence of shock (defined as systolic blood pressure of less than 90 mmHg) and coma (defined as Glasgow Coma Scale of less than 9) at presentation were strong predictors for mortality. The adjusted odds of dying in the presence of shock and coma were 4.44 (95% CI 1.72–11.49, $p<0.01$) and 6.69 (95% CI 2.52–17.74, $p<0.01$), respectively (see Table 2). Elderly age (defined as age ≥65 years old) was associated with higher odds for mortality (adjusted OR 2.52, 95% CI 0.73–8.64, $p=0.142$), but this was confounded by the presence of shock and coma at presentation. The presence of concurrent head injuries (adjusted OR 4.57, 95% CI 1.95–10.73, $p<0.01$) and chest injuries (adjusted OR 7.96, 95% CI 2.79–22.68, $p<0.01$) were associated with increased odds of mortality in these patients. Gender (OR 0.79, 95% CI 0.41–1.48, $p=0.455$), other mechanisms of injury (OR 0.32, 95% CI 0.04–2.83, $p=0.309$) and the presence of other associated injuries were not associated with increased odds for mortality (see Table 3).

Discussion

Pelvic fracture is a serious injury that is associated with significant morbidity and mortality [4, 5]. An unstable pelvic fracture results in uncontrolled haemorrhage from

Table 1 Baseline characteristics of patients

Description	No. of patients (%) (n=179)
Gender	
Male	114 (64%)
Female	65 (36%)
Age (years)	
≤19	11 (6%)
20–29	55 (31%)
30–39	43 (24%)
40–49	29 (16%)
50–59	13 (7%)
60–69	13 (7%)
≥70	15 (8%)
Mortality	67 (37%)
Died in the ED	34 (51%)
Died in the ward (within 24 h)	19 (28%)
(Within 48 h)	4 (6%)
(after 48 h)	10 (15%)
Injury scores	
ISS[a]≥25	90 (50%)
Physiological parameters at presentation	
Shock (<90 mmHg)	65 (36%)
Coma (GCS <9)	54 (30%)
Mechanism of injuries	
Road traffic accident	94 (52%)
Pedestrians	28 (30%)
Motorcyclists	33 (35%)
Falls from height	79 (44%)
Others	6 (4%)
Pelvic fracture severity (by AIS[b])	
1	0 (0%)
2	83 (46%)
3	72 (40%)
4	14 (8%)
5	10 (6%)
6	0 (0%)
Presence of associated injuries	
Head	76 (42%)
Face	44 (25%)
Chest	102 (57%)
Abdomen	90 (50%)
Extremities (bones)	177 (99%)
External (skin, muscle)	90 (50%)
Interventions	
Laporotomy	28 (16%)
Angiography	6 (3%)
External fixation	14 (8%)

[a] Injury Severity Score

[b] Abbreviated Injury Severity Score

Table 2 Odds ratios for significant predictors of mortality (on univariate and multivariate analysis)

Predictors	Crude OR (95% CI)	Adjusted OR (95% CI)
Shock at presentation	10.72 (5.25–21.9)	4.44 (1.72–11.49)
Coma at presentation	19.51 (8.57–44.41)	6.69[a] (2.52–17.74)
Age >65 years	3.96 (1.46–10.69)	2.52[b] (0.73–8.64), p=0.142
Presence of head injuries	7.58 (3.51–16.34)	4.57[c] (1.95–10.73)
Presence of chest injuries	17.61 (5.90–52.50)	7.96[d] (2.79–22.68)

Note: p-values are <0.01 unless otherwise stated

[a] Adjusted for shock, elderly age and the presence of chest injuries only

[b] Adjusted for shock and coma at presentation only

[c] Adjusted for shock and presence of chest injuries only. Coma at presentation was not included in the multivariate analysis for head injury because it was on the causal pathway between head injury (exposure) and death (outcome)

[d] Adjusted for shock, coma and presence of head injuries only

the pelvic venous plexus, the tributaries of the common iliac arteries and from the fractured pelvic bones. An incredible amount of force is required to fracture the pelvis, and this can occur in road traffic accidents or from direct crushing due to a fall from height [10]. The high kinetic energy required to disrupt the pelvis would inevitably result in other significant injuries to the trunk, head and extremities [6, 11]. Uncontrolled haemorrhage leading to shock is the main cause of mortality [1, 2, 12]. Despite the advancement of trauma research and management of pelvic fracture, the mortality from pelvic fracture remains high [1, 13].

In our study, the patients were mostly males (64%) and were aged between 20–49 years old (71%). Forty-eight percent of the male patients were motorcyclists who were involved in road traffic accidents. This demographic trend is similar to studies done in the United States [1, 6–9]. We believe that this is because male and young individuals indulge in more risk-taking behaviour [9]. The relatively cheap price of motorcycles as compared to other vehicles in Singapore also makes them more attractive financially and readily accessible to young adults. In our data, we did not find any association between gender and the risk of mortality (χ^2 test=0.56, p=0.45). A recent report on motorcycle safety in ASEAN countries has advocated stricter traffic regulations governing the use of motorcycles and education regarding responsible driving as two possible interventions to reduce the mortality rate [14].

Pelvic fracture severity is an important factor in determining the risk of mortality. In our study, the odds of dying was significantly increased when the fracture severity was at least grade AIS 4 (see Table 3). The odds of dying

Table 3 Comparison of characteristics between patients who died and survived and the crude ORs for mortality

Description	Died (%)	Survived (%)	Crude OR	95% CI	p-value
Gender (male)	67	61	0.79	0.41–1.48	0.455 (NS)
Age >65 years	21	6	3.96	1.51–10.41	0.005
ISS >25	94	24	49.58	16.51–148.88	<0.01
PF[a] severity					
AIS 2	31	55	1.00 (ref)	-	-
AIS 3	42	39	1.88	0.95–3.72	0.071 (NS)
AIS 4	15	3	7.38	2.09–26.04	0.002
AIS 5	12	2	11.81	2.32–60.07	0.003
Presence of shock	69	17	10.72	5.25–21.90	<0.01
Presence of coma	66	9	19.51	8.57–44.41	<0.01
Presence of head injury	72	25	7.58	3.83–15.00	<0.01
Presence of chest injury	91	37	17.61	7.00–44.29	<0.01
Presence of facial injury	34	20	1.22	0.34–3.43	0.705 (NS)
Presence of abdominal injury	52	48	2.66	1.00–7.07	0.08 (NS)
Presence of external/extemities injuries	86	70	2.31	1.00–4.95	0.06 (NS)

[a] Pelvic fracture

with severity grade AIS 4 and AIS 5 were 7.38 (95% CI 2.09–26.04) and 11.81 (95% CI 2.32–60.07, $p<0.01$), respectively, compared to severity grade AIS 2 as baseline (there were no patients with fracture severity AIS 1 in our study). Various authors [6, 15] have used different scales of measurements to ascertain fracture severity (for example, Young-Burgess classification, location of fracture, stability of pelvic ring, vector of injury etc.) and have concluded that fracture severity is associated with overall injury severity, but not with mortality. Poole et al. emphasized the importance of looking for other associated injuries that might ultimately caused the patient's demise [6]. In our study, shock at presentation was not adjusted as a confounder in the association between pelvic fracture severity and death as it was classified (a priori) as a mediating variable in the causal pathway between pelvic fracture severity and death.

Road traffic accidents and falls from height were the most common mechanisms of injury, accounting for 52% and 44% of the study population, respectively. For patients involved in road traffic accidents, 35% were motorcyclists and 30% were pedestrians (see Table 1). Our result concurs with the trends published in the medical literature [4, 16–18]. This observation is expected as pedestrians and motorcyclists are usually not well protected, and they receive the full impact of the kinetic energy transfer. Thirty percent of motorcyclists and 39% of pedestrians died as a result of their injuries, contributing to two thirds of the overall mortality rate.

Injuries due to falls from height are related to vertical deceleration, where spinal and pelvic fractures as well as retroperitoneal bleeding are more common [19–21]. For this group of patients, at least half of them were males (53%). Of all the patients who sustained pelvic fracture from this mechanism of injury, 44% succumbed to their injuries. Interestingly, trauma due to falls from height is a unique phenomenon to Asian countries. It is an uncommon cause of pelvic fracture in the Western countries compared to road traffic accidents [1, 13]. There are a few explanations for this observation. Fang et al. discussed the association of falls from height in Taiwan with a positive history of mental disorders such as depression and schizophrenia [22]. Unfortunately, we did not collect any data about the patients' psychiatric history. The high concentration of high-rise residential and commercial buildings in Singapore likely contributes to the high rate of falls from height. Our analysis revealed that there was a higher proportion of patients with ISS ≥25 in the falls from height group compared to those who sustained injuries from other mechanisms (52% vs. 48%, χ^2 test=4.8, $p=0.03$). Forty-four percent of fall incidents occurred in public areas, whilst 18% occurred at home. Despite the higher ISS in this group of patients, there was no significant difference in the mean systolic blood pressure or GCS between the falls from height group and those from other mechanisms. Measures that can potentially alleviate the incidence of vertical falls include increasing the awareness of mental disorders such as depression and providing adequate social support. A change in building regulations to reinforce the need for safety barriers in high-rise buildings is also warranted.

Generally, the mortality rate among patients with pelvic fractures ranges from 9–30% [8, 16, 23, 24]. In our study, the mortality rate was higher, at 37% (see Table 1). Fifty-one percent of deaths occurred in the ED. The mean ISS for our study population was 28, much higher than quoted by some authors [7, 8]. This could be due to various reasons. Firstly, the method used for capturing data may have been different. In our study, consecutive trauma patients presenting to the ED who were eligible were included in the study, whereas in other studies, patients were included only if they survived to surgical intensive care [6]. This difference in methodology would have yielded different mortality rates. Secondly, transport time from the scene of the incident to the ED may also play a role. If the transport time was longer, more severely injured patients would have died en route to the hospital. On the other hand, if the transport time was shorter, more severely injured patients might have made it to the ED, but only to die later. The latter setting is applicable to our study, as Singapore's ambulance services adopt the 'scoop and run' policy.

The presence of abnormal physiological parameters is known to predict the risk of mortality [15, 23, 25, 26]. In our study, shock and coma at presentation were strong predictors of mortality. The adjusted odds ratios for mortality for shock and coma at presentation were 4.44 and 6.69, respectively (see Table 2). As shock and coma at presentation confer very poor prognosis for patients, it is therefore imperative to prevent or delay the progression of such abnormal parameters. Training of the newer generation paramedic staff should include the recognition and management of shock at the scene of the incident [27].

Various studies have concluded that injuries sustained concurrently with pelvic fracture contributed significantly to mortality [6, 11]. The results of our study support this observation. Ninety-seven percent of our study population had at least one concurrent injury. Of note, patients who sustained concurrent head and chest injuries had higher odds of dying. Table 2 shows the adjusted odds ratios for head and chest injuries after taking into consideration other significant predictors of mortality. Severe chest injuries affect the respiratory mechanics of the patients, impairing gas exchange, which is vital to the body that is already volume depleted. Significant head injuries increase intracranial pressure. This further impairs the body's attempt to cope with hypoxia and hypovolemia. It is therefore vital to adopt a multi-disciplinary approach in managing a polytrauma patient.

Pelvic fracture in the elderly provides a different challenge to the emergency physicians and trauma surgeons. The physiological changes associated with ageing make this population particularly vulnerable to injuries. Elderly patients with pelvic fracture have the worst outcomes, and they succumb to their injuries more easily despite aggressive resuscitation [10, 28, 29]. Alost et al. observed that exacerbation of the elderly's premorbid condition is a contributory factor to mortality [30]. In our study, patients aged more than 65 years old had a higher risk of mortality at 67% compared to the younger counterparts (χ^2 test=8.68, p=003). This age group also has a higher proportion with ISS ≥25 (71% vs. 47%, χ^2 test=4.26, p=0.04). The odds of dying for a 65-year-old patient with pelvic fracture was 3.96 (95% CI 1.46–10.69, p<0.01). However, this was confounded by the presence of shock and coma at presentation. The adjusted odds ratio was 2.52 (95% CI 0.73–8.64) and was not found to be significant.

Limitations

Our study is limited by its small sample size, which means that the study may not have enough power to detect small differences between groups. This problem is accentuated when stratification is done to look for the effects of confounding, as evidenced by the wide confidence intervals. The retrospective nature of our study also limits our ability to draw conclusions beyond an association of factors with mortality. Another important factor that was not considered in our study is the timing from arrival to the ED to interventions (such as external pelvic immobilization and angiography), which may behave as a confounder or an effect modifier in the association with mortality.

Conclusions

Pelvic fracture is a serious injury that is associated with significant morbidity and mortality. This is a result of the high energy transfer to the pelvic region. Road traffic accidents and falls from height are by far the most common mechanisms of injury. Pelvic fracture severity, shock and coma at presentation, and the presence of concurrent head and chest injuries are important predictors of mortality. It can be seen that the prevention of morbidity and mortality of pelvic fractures requires a multifaceted approach in terms of educating the public regarding injury prevention, as well as the need for paramedical and emergency care staff to recognize various prognostic factors and to mobilise resources to manage them.

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Conflicts of interest None.

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Seow Y. Tay I have been practising as an Associate Consultant for the past year at the Emergency Department, Tan Tock Seng Hospital, Singapore, where I received my postgraduate training in Emergency Medicine in 2005. My special interests are in health services research, emergency geriatrics, trauma care delivery and medical education. I am actively involved in teaching undergraduate medical students (affiliated with Yong Loo Lin School of Medicine, Singapore), tutoring emergency medicine trainees as well as lecturing nursing and paramedical staff (from the Singapore Civil Defence Force). I have also participated in an Outreach Programme for teaching Basic and Advanced Cardiac Life Support in Sihanouk Hospital of Hope, Cambodia. My previous publications include the following:

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