Major pelvic fractures

IDENTIFICATION OF PATIENTS AT HIGH RISK

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The identification of high-risk factors in patients with fractures of the pelvis at the time of presentation would facilitate investigation and management. In a series of 174 consecutive patients with unstable fractures of the pelvic ring, clinical data were used to calculate the injury severity score (ISS), the triage-revised trauma score (T-RTS), and the Glasgow coma scale (GCS). The morphology of the fracture was classified according to the AO system and that of Burgess et al. The data were analysed using univariate and multivariate methods in order to determine which presenting features were identified with high risk.

Univariate analysis showed an association between mortality and an ISS over 25, a T-RTS below eight, age over 65 years, systolic blood pressure under 100 mmHg, a GCS of less than 8, blood transfusion of more than ten units in the first 24 hours and colloid infusion of more than six litres in the first 24 hours. Multivariate analysis showed that age, T-RTS and ISS were independent determinants of mortality. A T-RTS of eight or less identified the cohort of patients at greatest risk (65%). The morphology of the fracture was not predictive of mortality. We recommend the use of the T-RTS in the acute situation in order to identify patients at high risk.

Fractures of the pelvis are associated with a high rate of mortality even with modern methods of management.[1-7] Death is usually due to associated head, chest and abdominal injuries,[7-9] often in combination with hypovolaemic shock as a consequence of the pelvic disruption. Despite the development of specialised trauma units, the adoption of standard resuscitation protocols such as the Advanced Trauma Life Support structure, and the use of pelvic stabilisation and interventional radiology,[10-13] a fatal outcome is common. The prompt and accurate appreciation of a patient's injury pattern and its severity is crucial to the planning of early management. It has been suggested that classifications of pelvic fractures and trauma scores may help to identify patients at high risk. Previous studies have identified age, hypotension, a low revised trauma score, a high injury severity score (ISS), the development of a coagulopathy or base deficit, and high transfusion requirements as factors predictive of mortality.[5,10,14-16] However, no study has focused exclusively on the information available at the time of presentation which would assist the surgeon in identifying patients at most risk.

Our aim therefore was to identify those factors which may be used to predict mortality in patients with fractures of the pelvic ring at the time of presentation. This information could be used to facilitate the selection of patients at greatest risk who might benefit from more urgent intervention in order to improve outcome.

Patients and Methods

Between January 1988 and July 2003, 174 consecutive patients with fractures of the pelvic ring were admitted to our institution after blunt trauma. Pathological fractures of the pelvic ring and isolated fractures of the acetabulum or pelvic rami were excluded from the series. There were 123 males and 51 females with a mean age of 39 years (8 to 88). The mechanism of injury was a road-traffic accident in 118 (68%), of whom 50 (42%) had been car occupants, 44 (25%) pedestrians, 20 (11%) motorcyclists and four (2%) bicyclists. In 41 patients (24%), the cause was a fall from a height greater than three metres. Of the remaining 15, six had crush injuries, six had been involved in an industrial accident and in four the mechanism of injury was uncertain.

In all patients data were recorded prospectively on admission to the Accident and Emergency Department. These included systolic blood pressure, respiratory rate and the Glas-

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Table I. Details of the T-RTS.* It is calculated as the sum of the points for each of the three components

GCS†	Systolic blood pressure (mm Hg)	Respiratory rate (per minute)	Points
13 to 15	> 89	10 to 29	4
9 to 12	76 to 89	> 29	3
6 to 8	50 to 75	6 to 9	2
4 to 5	1 to 49	1 to 5	1
3	0	0	0

* T-RTS, triage-revised trauma score
† GCS, Glasgow coma score

Table II. The classification of pelvic fractures in this series according to Burgess et al[19]

Fracture configuration	Number* (%)	Mortality (%)
Anterior posterior compression	27 (*16*)	4 (*15*)
Lateral compression	79 (*47*)	12 (*16*)
Vertical shear	56 (*33*)	14 (*26*)
Combined mechanical injury	6 (*4*)	4 (*67*)

* six patients could not be classified

Table III. The classification of pelvic fractures in this series according to the AO system[21]

Fracture configuration	Number* (%)	Mortality (%)
B1 (open book)	28 (*17*)	4 (*14*)
B2 (lateral compression)	64 (*38*)	7 (*11*)
B3 (combination B1 and B2)	14 (*8*)	4 (*29*)
C1 (unilateral vertical shear)	50 (*30*)	12 (*24*)
C2 (vertical shear; contralateral rotational)	7 (*4*)	2 (*29*)
C3 (bilateral vertical shear)	5 (*3*)	4 (*80*)

* six patients could not be classified

gow coma scale (GCS). Based on these data the triage-revised trauma score (T-RTS) was calculated[17] (Table I). Injuries were scored using the abbreviated injury scale (1990 revision) from which the ISS was calculated.[18] The fractures were classified using two established systems, namely, the mechanistic classification of Burgess et al[19] and Dalal et al[20] (Table II), and the comprehensive AO classification of fracture morphology[21] (Table III). Six patients had incomplete or poor-quality radiographs which could not be classified. The transfusion requirement and fluid resuscitation details in the first 24 hours after admission were recorded. The use of surgical intervention and angiography was in accordance with a standard protocol used in our institution.[22] Patients with an enlarged pelvic volume and hypotension were considered for external fixation. Internal fixation was used for displaced fractures in patients who were stable on admission or could be stabilised to allow internal fixation to be carried out as a scheduled procedure.

Prospective data collected from 1992 were extracted from the registry of the Scottish Trauma Audit Group, and data pertaining to patients admitted between 1988 and 1992 were extracted directly from the patients' hospital notes.

All patients were initially assessed and managed according to Advanced Trauma Life Support protocols.[23] The pelvic fracture was treated non-operatively in 81 patients (48%), by external fixation alone in 36 (21%), by primary open reduction and internal fixation in 34 (20%), by combined external and internal fixation in five (3%) and by initial external fixation with subsequent conversion to internal fixation in 13 (7%). In five cases, the patient died before a decision regarding treatment could be formulated.

Statistical analysis. Using mortality during the initial acute admission as the primary outcome measure, a univariate analysis was performed for each risk factor to identify the level of significance of its association with mortality. Continuous variables were analysed using the Mann-Whitney parametric test and categorical variables by the chi-squared test. We then conducted a multiple logistic regression analysis in order to identify those variables which were independently predictive of mortality. The complete statistical analysis was conducted using SPSS version 11 (SPSS, Cary, North Carolina).

Results

Morphology of the fracture. All patients had rotationally or vertically unstable fractures according to the AO classification. There were 106 (63%) rotationally unstable fractures (type B) of which 64 were lateral compression injuries (B2). Vertically unstable fractures (type C) accounted for the remaining 62 (37%). Six patients had radiographs which could not be classified. According to the classification of Burgess et al[19] there were 27 patients with anteroposterior compression, 79 with lateral compression and 56 with vertical shear fractures, and six patients with combined mechanical injuries.

Mortality. Of the 174 patients, 35 died giving an overall rate of mortality of 20%. Of these 35 patients, 21 (60%) sustained a severe head injury, 14 (40%) a severe chest injury and 13 (37%) severe abdominal injuries in addition to a fracture of the pelvic ring. A severe injury was defined as that scoring four or five on the abbreviated injury scale for that region, and was associated with a significantly higher rate of mortality, compared with patients with lower scores for the same body region ($p = 0.001$, 0.05 and 0.001, respectively). Twenty-eight (80%) of these patients died within 72 hours of admission and the remainder died within three weeks of their injury, from multiple-organ failure.

Univariate analysis

Age and mortality. Patients aged 65 years or over had a significantly greater risk of death compared with younger patients (mortality rate of 56% *vs* 22% in patients under 65 years of age ($p = 0.04$)). Neither the ISS nor the pattern of morphology of the fracture was different from that of younger patients. The revised trauma score was lower in the older patients (median 4.0 compared with 6.9 in the younger group) although this did not reach statistical significance.

Hypovolaemia and mortality. Sixty-nine patients (40%) were hypotensive on admission with a systolic blood pressure ≤ 100 mmHg. The mortality in these patients was 33%, compared with 8% in the normotensive group ($p < 0.001$). Hypotensive patients had a median ISS of 36 compared with 19 in the normotensive group ($p < 0.001$).

GCS and mortality. Twenty-one patients were comatose on admission with a GCS of 8 or less, of whom 14 (67%) died. The mortality in patients with a GCS above 8 was significantly lower (17 of 140 (12%) patients, $p < 0.001$). In the 35 patients who died the median GCS was 9 compared with 15 for the survivors.

Transfusion requirements and fluid balance in the first 24 hours after admission. Fifty-seven patients (33%) with fractures of the pelvic ring required a blood transfusion within 24 hours of admission and received a median of 10 units (1 to 70). The transfusion of ten or more units of blood or the infusion of six or more litres of colloid fluid within 24 hours of admission was found to be significantly associated with mortality ($p = 0.009$ and $p < 0.001$, respectively). The transfusion of crystalloid fluid ($p = 0.436$), platelets ($p = 0.117$) or fresh-frozen plasma ($p = 0.227$) was not significantly associated with mortality.

Configuration of the fracture and mortality. Of the 35 patients who died, four had anteroposterior compression, 12 lateral compression, 14 vertical shear and four a combination of injuries as defined by Burgess et al[19] (Table II). One patient could not be classified. Combined injuries were associated with the highest mortality (67%). Vertical sheer injuries had an associated mortality of 26%, lateral compression of 16% and anteroposterior compression fractures a mortality of 15% of the 35 patients who died. Fifteen patients had type-B and 18 type-C fractures according to the AO classification (Table III). AO type-C fractures were associated with a higher mortality than type-B fractures (29.4% compared with 16.7%). However, neither of the classification systems had a statistically significant association with mortality (AO, $p = 0.068$, Burgess et al, $p = 0.063$). Further analysis of the subgroups of Burgess et al[19] showed no significant association with mortality. Fourteen of our patients (8%) had open fractures and four of these (29%) died. Although this was a greater proportion than that for patients with closed fractures (35/160, 19%), this did not reach statistical significance ($p = 0.403$).

Trauma scores as predictors of mortality. An ISS of over 25 and a T-RTS of eight or less were closely associated with mortality in patients with fractures of the pelvic ring ($p < 0.0001$, for both scores). The median ISS was 20 in survivors and 48 in those patients who died. Similarly, the median full RTS in survivors was 7.48 compared with 3.7 in fatalities. A T-RTS score of 8 or less was associated with a mortality of 65% compared with 13% for a score of more than 8.

Results of multivariate analysis. Using a forward stepwise logistic regression model, the ISS ($p < 0.001$), the T-RTS ($p = 0.013$) and age ($p = 0.006$) were found to be independent risk factors associated with mortality (Table IV). Although the abbreviated injury scale, GCS, and hypotension were significantly associated with mortality on univariate analysis, these were not included in the multivariate analysis since they form components of the ISS and T-RTS. The volume of blood and colloid transfused was not found to correlate with mortality on the multivariate analysis.

Table IV. Results of multiple regression analysis. The Exp (B) is the value by which the odds of the event (mortality) change when the independent variable increases by one unit. The 95% confidence intervals (CI) for this figure are given. The data show that risk of mortality increases independently with both increasing age and ISS. The Exp (B) is less than one for T-RTS as a decreasing score implies a more severe physiological derangement, and so the risk increases as this value decreases

Variable	Exp (B)	95% CI
Age	1.07	1.02 to 1.12
ISS	1.14	1.07 to 1.22
T-RTS	0.68	0.52 to 0.88
Constant	184.93	

Discussion

The overall mortality after fractures of the pelvic ring in our series was 20%. This is comparable with that of other recent series with similar patient populations which have reported rates of mortality of between 9.2%[14] and 30%.[24] Univariate analysis suggested that mortality after fracture of the pelvic ring was associated with a high ISS, low T-RTS, age over 65 years, hypotension, a GCS of eight or less, transfusion of more than ten units of blood or infusion of six or more litres of colloid within 24 hours of admission and the presence of cranial, thoracic and abdominal injuries. However, several of these factors are themselves linked and multivariate analysis was used to demonstrate that age, T-RTS and ISS are each independently predictive of mortality.

Scoring systems for trauma such as the T-RTS and ISS were devised to allow an objective assessment of the physiological and anatomical severity of a patient's injuries. The T-RTS can be used as a field triage score to identify and direct the management of high-risk patients and has the advantage that it can be reliably obtained at the time of presentation. In our study a score of eight or less identified the cohort of patients at most risk. By contrast, the full revised trauma score calculation requires additional steps with coded values and may be difficult to perform at the time of admission.[17] Calculation of the ISS requires the calculation of the abbreviated injury scale for the three most severely injured anatomical regions. This may be difficult to calculate accurately at the time of presentation when information regarding the extent of the injury is incomplete. The abbreviated injury scale values are often modified after presentation on the basis of additional investigations and even post-mortem findings. This information is not available when the patient presents.

Neither the classification of Burgess et al[19] nor the AO system was significantly associated with mortality. The morphology of a fracture of the pelvic ring is a reflection of the mechanism of injury and indicates the likely associated injuries. It may be of assistance in planning immediate management and definitive surgery. Contrary to the findings of Rothenberger et al[2] and Burgess et al,[19] we have been unable to show that these widely used systems of classification are helpful in predicting outcome.

Open fractures were not associated with a significantly increased risk of death, but this may be due to the small number of open fractures in our study. In addition, the location and size of open wounds varied. It is to be expected that fractures involving penetrating wounds in the anorectal region would have a worse prognosis than those with wounds of the iliac wing or anterior aspect of the pelvic ring. With a larger number of open fractures these trends would almost certainly have been demonstrable.[25]

In our study age, ISS and T-RTS were independently associated with the risk of death after pelvic fracture. Standard classification systems of pelvic fractures may be helpful when planning management but did not correlate with the risk of mortality. Based on our findings we suggest that a T-RTS of eight or less can be used in the acute situation to identify the group of patients at highest risk.

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