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Original article

Scoring system to predict hemorrhage in pelvic ring fracture

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ABSTRACT

Background: Risk factors for hemorrhage in patients with pelvic ring fracture have been widely reported. Because there are many risk factors, it is thought that prediction accuracy of hemorrhage in cases of pelvic ring fracture could be improved by using a scoring system.
Hypothesis: We investigated the risk factors for massive hemorrhage (MH) and created a novel predictive score of MH in pelvic ring fractures.
Material and methods: We retrospectively reviewed patients with pelvic ring fractures (Abbreviated Injury Score ≥ 3 and age ≥ 16 years) from January 2007 to June 2015. We excluded the cases that might have hemorrhage from other sites sufficient to require a blood transfusion. Massive hemorrhage was defined as hemorrhage requiring transfusion of ≥ 6 red cell concentrate units within 24 h of admission.
Results: The MH group included 27 patients and the non-MH group included 71 patients. Lactate level, AO/OTA classification and extravasation of computed tomography (CT) contrast fluid had a significantly higher risk as a result of multivariable analysis. The combined score using these risk factors according to their odds-adjusted ratios was created to predict for MH: lactate level > 2.5–5.0 (mmol/L) = 1 point, > 5.0 (mmol/L) = 2 points, partially stable (OA/OTA classification B1/B2/B3) = 1 point, unstable (C1/C2/C3) = 2 points, pelvic extravasation of contrast on CT = 4 points. The AUC of the calculated score was 0.93 (95% CI: 0.89–0.98).
Conclusion: The combined score using these risk factors according to their odds-adjusted ratios was created to predict MH and was an effective prediction score.
Level of evidence: IV, retrospective study.

1. Introduction

Pelvic ring fractures are a cause of early death in severe trauma patients. Mortality rates are reported between 8.4 and 13.6% [1]. Mortality with hemorrhagic shock is 34% [2]. Initial management in unstable pelvic ring fractures with hemodynamic instability involves control of the hemorrhage. Deciding whether early blood transfusion is needed is as important as other hemostatic procedures such as angiographic embolization, pelvic packing, or the stabilization of the pelvic ring [3–5]. Delay of transfusion worsens traumatic coagulopathy, and can lead to the need for massive transfusion, multiple organ failure or death.

Many scoring systems for the early prediction of the need for massive transfusion have been reported [6,7]. However, those scores are predictions of overall hemorrhage, including damage to other sites. Therefore, precise prediction of massive hemorrhage (MH) due to a pelvic ring fracture decreases.

Risk factors for hemorrhage in pelvic ring fracture have been widely reported [8,9]. Because there are many risk factors, it is thought that prediction accuracy of MH in pelvic ring fracture could be improved by using a scoring system. However, there are few reports of such a predictive scoring system for MH [10].

In this study, we investigated the risk factors for MH and created a novel predictive score of MH in pelvic ring fractures.

2. Materials and methods

2.1. Study design and patient selection

We retrospectively reviewed the records of patients with pelvic ring fractures (Abbreviated Injury Score [AIS] ≥ 3 and age ≥ 16 years) admitted to the Kochi Health Sciences Center from January 2007 to June 2015. Patient information was collected from the Japan Trauma Data Bank, a trauma patient registration system. Because

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most of pelvic ring fractures are poly-trauma patients, it is difficult to evaluate the hemorrhage only at a pelvic ring fracture. Therefore, we excluded the cases that might have hemorrhage from other sites sufficient to require a blood transfusion. Other exclusion criteria included being dead on arrival, arrival in the emergency department more than 5 h following injury and missing data.

2.2. Setting

The management of pelvic ring fracture was carried out in accordance with Advanced Trauma Life Support guidelines [11]. At the pre-hospital stage or at hospital admission, a pelvic contention belt was applied if an unstable pelvic fracture was suspected. Bleeding sites were diagnosed via chest and pelvic radiography and focused assessment with sonography for trauma (FAST). Bleeding sites were confirmed via whole-body computed tomography (CT) with contrast fluid if the patient's hemodynamic parameters were stable. Patients with hemodynamically unstable pelvic ring fractures (systolic blood pressure < 90 mmHg) were managed with an intra-aortic balloon and directly moved to the operating room or angiographic room for hemostasis without CT. Patients with hemodynamically stable pelvic ring fractures, were moved to the angiographic room if extravasation of CT contrast fluid appeared. The patients were moved to the operating room for fracture stabilization if the fracture was unstable.

If the case was classified as severe trauma upon admission, tranexamic acid was used starting in 2010 (loading dose 1 g over 10 min then infusion of 1 g over 8 h) [12]. Trauma patients with major blood loss were managed when they exhibited poor response to initial fluid resuscitation or were suspected to have active hemorrhage. In these cases, Group O red cell concentrate (RCC) and Group AB fresh frozen plasma (FFP) were used until the patient's blood type could be determined. Once the patient's blood type was determined, a transfusion is performed with a 1:1:1 target ratio for RCC: FFP: platelet concentrate (PC). We also attempted to maintain the patient's hemoglobin concentrations between 7.0–9.0 g/dL [13].

2.3. Data collection

Patient demographics and characteristics were documented in the hospital's electronic patient database or in patient charts at the time of admission. Data evaluated included age, sex, mechanism of injury, time from injury to emergency room arrival, if systolic blood pressure was < 90 mmHg, if heart rate was > 100 beat/min, Glasgow Coma Scale score, lactate level, International Normalized Ratio ≥ 1.2, presence of unstable pelvic ring fracture on anterior-posterior plain pelvic radiographs, AO/OTA classification [14], Young-Burgess classification [15], presence of pelvic CT contrast fluid extravasation, injury site (AIS ≥ 3), ISS, emergency procedures performed, volume of fluid within 24 h of admission, patients receiving RCC before CT, transfusion volume, overall mortality and mortality resulting directly from hemorrhage. Blood samples were collected within 10 min of arrival in the emergency department.

2.4. Definitions

MH was defined as hemorrhage requiring transfusion of ≥ 6 red cell concentrate (RCC) units within 24 h of admission. Lactate levels were categorized into 3 groups (≤ 2.5, > 2.5–5.0 or > 5.0 mmol/L) [16]. An unstable pelvic ring fracture, as assessed on plain anterior-posterior pelvic radiographs alone, defined disruption of the posterior arch. AO/OTA classification and Young-Burgess classification were subclassified into fracture patterns of partially stable (AO/OTA: B1/B2/B3, Young-Burgess: lateral compression (LC)1/LC2/anterior-posterior compression (APC)1) and unstable (AO/OTA: C1/C2/C3, Young-Burgess LC3/APC2/APC3/vertical shear (VS)/Combined Mechanical (CM)) [14,15]. Survival or death was assessed during a 28-day follow-up period.

2.5. Statistical analysis

Patients were divided into MH and non-MH groups and groups were compared with each other. All data are presented as medians (interquartile range) for continuous variables and as numbers (percentages) for categorical variables. Comparisons of group differences for continuous variables were done by the Mann-Whitney U test. Differences between categorical variables were evaluated by Chi-squared test or Fisher's exact test (double the one-tailed exact probability). Two-tailed P values less than 0.05 were taken to indicate a significant difference.

We subjected factors associated with MH to multivariable logistic regression analysis. The factors in reference to previous reports included age, systolic blood pressure, heart rate, lactate levels, unstable pelvic fracture on plain pelvic radiograph, OA/OTA classification, Young-Burgess classification and pelvic extravasation on CT [6–9,16–20]. Because there were few MH cases, we used propensity score adjustment to preserve statistical power by reducing covariates into a single variable. These independent risk factors that were created through a binary logistic regression using propensity score were used to create a novel scoring system to predict MH in pelvic ring fracture. Weighted points were assigned to those independent risk factors for MH according to their odds-adjusted ratios. The ability of the scores to predict MH was estimated with the receiver operating characteristics (ROC) curve. Furthermore, the ability of these scores to predict hemorrhage requiring transfusion of ≥ 10 RCC units within 24 h of admission was estimated with the ROC curve. Statistical analysis was carried out with SPSS version 19 (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Baseline characteristics

During the 8-year, 6-month study period, 168 patients with pelvic ring fracture were enrolled. Ninety-eight patients met the substudy inclusion criteria for this analysis. The MH group included 27 patients (28%) and the non-MH group included 71 patients (72%) (Fig. 1). There were significant differences in age, mechanism of injury, heart rate, Glasgow Coma Scale, lactate level, complication of head injury and ISS between the MH and non-MH groups. Not surprisingly, there were significant differences in the unstable pelvic ring fractures on anterior-posterior plain pelvic radiographs, AO/OTA classification, Young-Burgess classification, pelvic extravasation on CT, emergency procedures, volume of fluid within 24 h of admission, patients receiving RCC before CT, transfusion volume, and mortality resulting from pelvic ring fracture (Table 1).

3.2. Multivariable logistic regression analysis using propensity score and predictive score

After multivariable analysis using propensity score, lactate level (OR: 4.91, 95% CI: 1.58–15.2), AO/OTA classification (OR: 3.56, 95% CI: 1.31–9.68), and pelvic extravasation in CT (OR: 11.8, 95% CI: 3.13–44.7) had a significantly higher risk factor of predicting a MH. However, no increased risk of MH was observed for age, vital sign, unstable pelvic ring fracture on plain pelvic radiography, and Young-Burgess classification (Table 2). The combined score using these risk factors, according to their odds-adjusted ratios (maximum, 8 points), was created to predict for MH (Table 3). At a defined