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Prediction of extravasation in pelvic fracture using coagulation biomarkers

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ABSTRACT

Purpose: To evaluate the usefulness of coagulation biomarkers, which are easy and quick to analyze in emergency settings, for prediction of arterial extravasation due to pelvic fracture.
Patients and methods: The medical records of pelvic fracture patients transferred to the emergency department of Gunma University Hospital between December 2009 and May 2015 were reviewed. Patients were divided into two groups, those with (Extra(+)) and without (Extra(−)) arterial extravasation on enhanced CT or angiography. Levels of fibrin degradation products (FDP), D-dimer, fibrinogen, the ratio of FDP to fibrinogen, the ratio of D-dimer to fibrinogen, systolic blood pressure, heart rate, the Glasgow Coma Scale, pH, base excess, hemoglobin and lactate levels, the pattern of pelvic injury, and injury severity score were measured at hospital admission, and compared between the two groups. Parameters with a significant difference between the two groups were used to construct receiver operating characteristic (ROC) curves.
Results: The study included 29 patients with pelvic fracture. FDP, D-dimer, the ratio of FDP to fibrinogen and the ratio of D-dimer to fibrinogen were the most useful parameters for predicting arterial extravasation due to pelvic fracture. FDP, D-dimer, the ratio of FDP to fibrinogen, the ratio of D-dimer to fibrinogen, and hemoglobin and lactate levels were significantly higher in the Extra(+) group than in the Extra(−) group (FDP, 354.8 μg/mL [median] versus 96.6 μg/mL; D-dimer, 122.3 μg/mL versus 42.1 μg/mL; the ratio of FDP to fibrinogen, 3.39 versus 0.42; the ratio of D-dimer to fibrinogen, 1.14 versus 0.18; hemoglobin, 10.5 g/dL versus 13.5 g/dL; lactate, 3.5 mmol/L versus 1.7 mmol/L). The area under the ROC curves for FDP, D-dimer, the ratio of FDP to fibrinogen, the ratio of D-dimer to fibrinogen, hemoglobin and lactate levels were 0.900, 0.882, 0.918, 0.900, 0.815 and 0.765, respectively.
Conclusion: Coagulation biomarkers, and hemoglobin and lactate levels could be useful to predict the existence of arterial extravasation due to pelvic fracture. The ratio of FDP to fibrinogen and the ratio of D-dimer to fibrinogen were the most accurate markers. Coagulation biomarkers may enable more rapid and specific treatment for pelvic fracture.

Introduction

Pelvic fracture has been shown to be an independent risk factor for death after blunt trauma. It is associated with increased mortality in the blunt trauma population, with rates ranging from 4.4% to 30% [1–3]. In pelvic fracture, the presence of retroperitoneal bleeding may induce hemodynamic instability, and 5% to 20% of retroperitoneal bleeding events are reported to be of pelvic arterial origin [4]. Thus, the identification of active arterial hemorrhage is important to determine the appropriate treatment strategy. Enhanced computed tomography (CT) is the standard procedure for detection of arterial extravasation [5]; however, angiographic embolization is sometimes required in cases without arterial extravasation on enhanced CT [6,7]. One study reported that approximately 20% of patients without arterial extravasation on enhanced CT eventually underwent transcatheter arterial embolization (TAE) [8]. In the report, the need for TAE should be under consideration if the pelvic injury patient had hemodynamic

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deterioration without arterial extravasation on enhanced-CT [8]. Thus, therapeutic decision-making for pelvic fracture should not be based on enhanced CT alone. Some investigations indicate that other parameters, including unstable hemodynamics, the type of pelvic fracture and higher blood glucose levels, are useful to predict the need for embolization [6–9]. However, the relationship between laboratory data and prediction of arterial extravasation using enhanced CT and/or angiography has not been evaluated.

Recent studies have demonstrated that coagulation biomarkers are useful tools for predicting the severity of trauma, including our previous study [10–12]. Coagulation biomarkers are advantageous for assessing trauma because data can be rapidly obtained at the clinical site without the need for highly specialized staff.

The purpose of this study was to evaluate the usefulness of coagulation biomarkers and other clinical parameters (systolic blood pressure, heart rate, the Glasgow Coma Scale, pH, base excess, hemoglobin and lactate levels, and the pattern of pelvic injury) for the prediction of arterial extravasation in pelvic fracture.

Patients and methods

The study protocol was approved by the institutional review board. The medical records of pelvic fracture patients transferred to the emergency department of Gunma University Hospital between December 2009 and May 2015 were reviewed. Patients who received prehospital treatment comprising only crystalloids and/or packed red blood cell infusions were included, whereas patients who underwent treatment to arrest bleeding due to pelvic fracture were excluded. The Abbreviated Injury Scale (AIS) score and the Injury Severity Score (ISS) were calculated. The dominant region of injury was defined as that with the highest AIS score. Key exclusion criteria were: 1) an AIS score in another region that was higher than the pelvis AIS score, and 2) arterial extravasation in regions other than the pelvis. Patients were divided into two groups, Extra(+) and Extra(−), according to the presence and absence of arterial extravasation on enhanced CT or angiography, respectively. Enhanced CT was performed in the arterial phase and the portal venous phase. Monitoring scanning was initiated 10 s after the start of the contrast media. Breath-hold dual-phase diagnostic scanning was performed 10 s (the arterial phase) and 110 s (the portal venous phase) after the aortic enhancement in the monitoring images reached bolus-tracking threshold attenuation (220 HU). Arterial extravasation was defined as extravascular high-attenuating regions with attenuation similar to or greater than that of the aorta on arterial phase images. Arterial extravasation on enhanced CT was analyzed by at least one radiologist. Angiography was performed in patients with unstable hemodynamics and/or progressive retroperitoneal hematoma, without obvious arterial extravasation on enhanced CT. After TAE, the majority of patients underwent damage control orthopedics. If necessary in the acute phase, external pelvic fixation was performed in our hospital using only a pelvic belt (SAM Pelvic Sling II, SAM Medical Products, Wilsonville, USA). The following parameters were obtained at hospital arrival: levels of fibrin degradation products (FDP), D-dimer and fibrinogen, systolic blood pressure, heart rate, the Glasgow Coma Scale, pH, base excess, hemoglobin and lactate levels, the pattern of pelvic injury, and the injury severity score. Ratios of FDP to fibrinogen (FDP/fibrinogen) and D-dimer to fibrinogen (D-dimer/fibrinogen) were also calculated. All these parameters were compared between the two groups. In addition, the quantity of packed red blood cells transfused within 24 h of the time of injury was compared between the two groups. (In Japan, 1 U of packed red blood cells is approximately 140 mL). FDP and D-dimer were measured using an immunoturbidimetric method using the Cs-2000i and Cs-5100 systems (Sysmex Corporation., Hyogo, Japan).

Statistical analysis

Data are expressed as the mean ± standard deviation (SD). Comparisons of each parameter between the Extra(+) and Extra(−) group were performed using the Mann-Whitney *U* test and Chi-squared test. The efficacy of predicting arterial extravasation was evaluated using the area under the receiver operating characteristic (ROC) curves, with low, medium and high accuracy defined as <0.7, $\geqq 0.7$ to <0.9, and $\geqq 0.9$, respectively [13]. The optimal cut-off point was defined by the maximum of the sum of sensitivity and specificity using the Youden index approach. Statistical analysis was performed with IBM SPSS Statistics version 22.0 (Armonk, NY, USA) A p-value < 0.05 was considered to denote statistical significance.

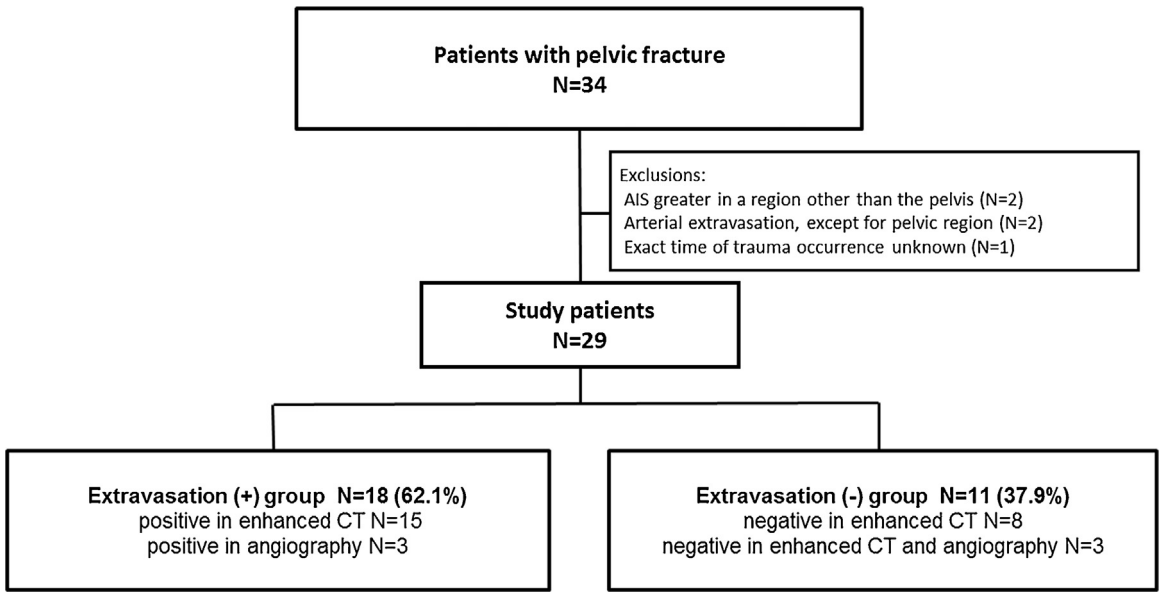

Fig. 1. Study flow chart.

AIS:abbreviated injury scale