Pelvic Fracture Pattern Does Not Always Predict the Need for Urgent Embolization

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Background: **The intimate relationship between the pelvis and related vasculature can lead to life-threatening arterial hemorrhage after blunt trauma. Unfortunately, hemorrhage related to pelvic fracture is often associated with other serious injuries, complicating clinical decision making. Previous clinical reviews have associated fracture geometry with arterial hemorrhage, specifically implicating those injuries with evidence of major ligamentous disruption (MLD).**

Methods: **We analyzed pelvic fractures for evidence of a relationship between MLD and the need for angiographic embolization. Our trauma registry was reviewed from 1996 to 2002; 283 patients with pelvic fractures arrived in the emergency department with a systolic blood pressure ≤ 90 mm Hg. MLD was defined as anteroposterior compression types II and III, lateral compression type III, combined mechanism, and vertical shear according to the Young-Burgess classification.**

Results: **Thirty-seven (13%) of the patients studied required angiographic embolization for control of pelvic hemorrhage. The pelvic fracture pattern (MLD vs. non-MLD) did not differ significantly between the embolized and nonembolized groups. The predictive value of other variables varied by gender. Age had a significant correlation with the need for embolization in women, whereas Injury Severity Score did not. Conversely, age had no predictive value for men, whereas Injury Severity Score had a significant correlation.**

Conclusion: **The findings in this study suggest that pelvic fracture pattern does not consistently correlate with the patient's need for urgent embolization and should not be used as the sole determinant for angiography. Furthermore, variables such as age and gender should be further investigated, as they may potentially have a predictive value in this clinical setting.**

Key Words: **Pelvic, Fracture pattern, Embolization, Angiography, Urgent.**

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Pelvic fracture frequently occurs in the setting of multisystem trauma. The large amount of kinetic energy necessary to fracture the bony pelvis often leads to concomitant thoracoabdominal injury, complicating the initial clinical evaluation.[1–5] Hemodynamic instability compounds the necessity for prompt, effective triage and swift implementation of definitive therapies. One of the most difficult decisions for a trauma surgeon is whether to proceed to the operating room for laparotomy or transfer the patient to the interventional suite for pelvic arterial embolization. The fractured pelvis has the potential for significant hemorrhage both from the bones themselves and from the disruption of the associated vasculature. Although ultrasound has evolved as a rapid screening tool for abdominal bleeding, to date, no equivalent tool exists for pelvic hemorrhage. Previous reports have implicated specific fracture patterns indicative of major ligamentous disruption (MLD) as having an association with arterial injury.[6] We reviewed the experience at our institution to determine whether those patients requiring embolization displayed a predominance of MLD fracture patterns.

PATIENTS AND METHODS

The Denver Health Medical Center, a state-designated and American College of Surgeons–verified urban Level I trauma center with pediatric commitment, serves as the Rocky Mountain regional trauma center for Colorado and adjoining regions. Our prospective trauma registry was reviewed from 1996 to 2002 to identify patients with pelvic fractures who arrived in the emergency department with a systolic blood pressure less than or equal to 90 mm Hg. Within this group, 37 patients required embolization for control of pelvic arterial injury and were compared with those patients who did not require embolization. Criteria for embolization included active extravasation, pseudoaneurysm, arteriovenous fistula, and truncation of a vessel. The patient subgroups were compared for age, gender, Injury Severity Score (ISS), resuscitation requirements (defined as units of packed red blood cells [PRBCs] transfused in the first 24 hours), pelvic fracture class, and mortality. Pelvic radiographs were reviewed by orthopaedic trauma specialists (S.J.M. and W.R.S.) with fracture classification following the system of Young and Burgess.[7] Lateral compression fracture type III, anteroposterior compression types II and III, and combined mechanism and vertical shear patterns were con-

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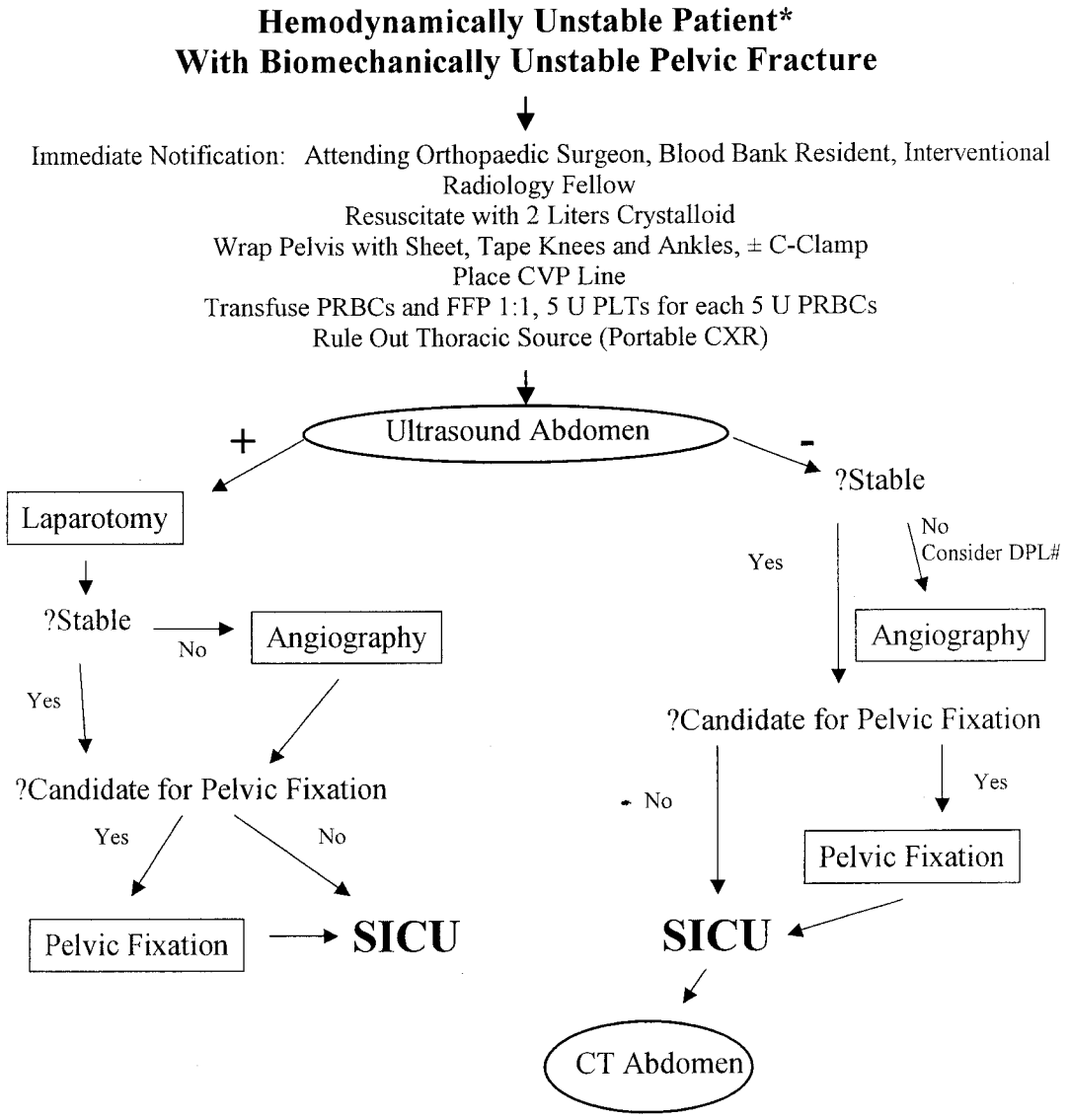

Fig. 1. *Key clinical pathway for management of hemodynamically unstable pelvic fracture at Denver Health Medical Center. #DPL may be warranted in the setting of refractory shock. *Trauma team activation = attending trauma surgeon present in the emergency department on patient arrival. CVP, central venous pressure; PRBCs, packed red blood cells; FFP, fresh frozen plasma; PLTs, platelets; DPL, diagnostic peritoneal lavage; SICU, surgical intensive care unit; CXR, chest radiography.*

sidered indicative of major ligamentous disruption. Lateral compression types I and II and anteroposterior compression type I fracture patterns were classified as non-MLD patterns.

Statistical Analysis

Patient data were maintained with Microsoft Excel version 7.0 software (Microsoft, Redmond, WA). Statistical analysis was performed on an IBM-compatible personal computer using Analyze- It for Microsoft Excel (Microsoft). Continuous data are expressed as mean ± SEM and compared using the Student's *t* test where appropriate. Categorical data are presented as numbers with percentages and compared using χ^2 analysis.

RESULTS

Of the 20,889 patients admitted after blunt trauma, 1,014 (5%) had pelvic fractures. Two hundred eighty-three (28%) patients with pelvic fractures arrived with a systolic blood pressure less than or equal to 90 mm Hg. The mean age for this group was 40.61 years, whereas the mean ISS was 29.90 and the mean 24-hour PRBC requirement was 8.44 units. Within this group, 37 patients (13%) required angiographic embolization to control arterial hemorrhage in the pelvis. Patients were managed according to a key clinical pathway (Fig. 1) previously described by our institution.[8] The demographic data for the study population is summarized in Table 1. The mean ages for nonembolized versus the embolized

Table 1 Clinical Data and Distribution of Fracture Patterns in Blunt Trauma Patients with Pelvic Fracture Presenting with SBP < 90 mm Hg

Clinical Characteristics	Nonembolized (n = 246) (%)	Embolized (n = 37) (%)	*p* Value
Age (yr)	39.9 ± 1.3	45.37 ± 3.4	0.12
Sex			
Male	139 (56.5)	24 (65)	NS
Female	107 (43.5)	13 (35)	NS
Mortality	52 (21)	13 (35)	NS
ISS	29.25 ± 1.56	35.16 ± 2.67	<0.01
24-h PRBCs	7 ± 0.65	18.05 ± 2.13	<0.01
Fracture classification			
LC-I	44 (18)	5 (13.5)	NS
LC-II	62 (25)	13 (35)	NS
LC-III	12 (5)	3 (8)	NS
APC-I	31 (12.5)	3 (8)	NS
APC-II	25 (10)	2 (6)	NS
APC-III	21 (8.5)	5 (13.5)	NS
VS	8 (3)	3 (8)	NS
CM	43 (18)	3 (8)	NS

LC, lateral compression; APC, anteroposterior compression; VS, vertical shear; CM, combined mechanism; NS, not significant; SBP, systolic blood pressure.

group were not significantly different at 39.9 ± 1.3 and 45.7 ± 3.4. The gender distribution between the two groups was also similar. The embolized group had increased injured severity (35.16 ± 2.67) and increased resuscitation requirements (18.05 ± 2.13 units of PRBCs). The mortality, however, did not achieve significance. The use of external fixators, pelvic binding, and C clamps was equally prevalent within the two groups (30%, 11%, and 3%, respectively, for the nonembolized group; and 12%, 0%, and 1%, respectively, for the embolized group).

The distribution of fracture classification within the two groups was equivalent with lateral compression type II fractures predominating in both groups. There was no significant difference in distribution of fractures by class within the groups. Furthermore, fracture patterns of the non-MLD type predominated for both embolized and nonembolized patients (56% and 57%, respectively). Subset analysis by gender (Table 2) reinforced the significant difference between 24-hour PRBC requirement between the nonembolized and embolized patients ($p < 0.01$). Women had a statistically significant correlation between the need for embolization and age ($p = 0.03$), whereas no difference was seen in ISS. Conversely, men displayed a highly significant correlation between ISS and the need for embolization ($p < 0.01$) but demonstrated no difference in age distribution. Although associated abdominal and thoracic injuries were more prevalent in the embolized group, consistent with the increased ISS, this was not reflected in the incidence of laparotomy or thoracotomy, and the distribution did not differ between genders. Mortality did not differ between the groups for women; however, men had a marked increase from 18% in the nonembolized group to 42% in the embolized group. Subset analysis of fracture pattern by gender (Table 3) demonstrates the general distribution of fracture patterns to be conserved for men and women in both the embolized and nonembolized groups.

Table 2 Subset Analysis by Gender

Gender	Nonembolized (%)	Embolized (%)	*p* Value
Female			
No.	107 (43)	13 (35)	
Age (yr)	40.21 ± 2.25	55.15 ± 6.55	0.03
ISS	31.33 ± 1.60	30.07 ± 4.80	NS
24-h PRBCs	5.59 ± 0.77	15 ± 2.85	<0.01
Mortality	27 (25)	3 (23)	NS
Male			
No.	139 (57)	24 (65)	
Age (yr)	39.66 ± 1.47	40.08 ± 3.60	NS
ISS	28.55 ± 1.18	37.91 ± 3.14	<0.01
24-h PRBCs	8.07 ± 0.98	19.7 ± 2.88	<0.01
Mortality	25 (18)	10 (42)	0.02

Table 3 Fracture Classification by Gender

Fracture Class	Nonembolized (%)		Embolized (%)	
	Male (n = 139)	Female (n = 107)	Male (n = 24)	Female (n = 13)
LC-I	16 (12)	28 (26)	4 (17)	1 (8)
LC-II	36 (26)	26 (24)	9 (38)	4 (31)
LC-III	6 (4)	6 (6)	1 (4)	2 (15)
APC-I	20 (14)	11 (10)	1 (4)	2 (15)
APC-II	19 (14)	6 (6)	2 (8)	0 (0)
APC-III	11 (8)	10 (9)	3 (13)	2 (15)
VS	6 (4)	2 (2)	2 (8)	1 (8)
CM	25 (18)	18 (17)	2 (8)	1 (8)

LC, lateral compression; APC, anteroposterior compression; VS, vertical shear; CM, combined mechanism.

DISCUSSION

Pelvic fractures in the hemodynamically unstable trauma patient with multisystem injuries result in complex decision making for the trauma surgeon. Creation of these fractures requires a substantial transfer of kinetic energy that is rarely focused on the pelvis alone. As a result, significant injuries to the head, chest, abdomen, or extremities often accompany pelvic fractures and add considerably to the associated morbidity and mortality.[1–5,9] Effective management, therefore, relies on rapid screening for the source of ongoing blood loss and prompt institution of definitive therapy based on the potential threat to life or limb.

Pelvic fracture hemorrhage arises from bone surfaces, soft-tissue lacerations, and disrupted veins and arteries. Prompt reduction of the pelvic volume is considered a vital step in the initial management of the hemodynamically unstable patient to promote tamponade of bone surfaces and damaged vasculature. Previous work from our institution and others supports an aggressive management protocol for hemodynamically unstable patients with pelvic fractures that focuses on early stabilization of the pelvic ring, either with the use of C clamp or temporary pelvic binders, and the early transfusion of blood and blood products once fracture-associated hemorrhage is suspected.[8] These interventions represent effective temporizing measures for patients with fracture-associated bleeding, but they do not offer definitive treatment. Pelvic angiography has been an established technique for three decades that has evolved into a highly effective means of controlling hemorrhage from the internal iliac vessels and currently represents the definitive therapy for fracture-associated arterial hemorrhage.[10–13] However, transporting an unstable patient from the emergency department to the interventional radiology suite may be a fatal error if the patient requires a laparotomy or thoracotomy to address ongoing torso hemorrhage or concentrated resuscitation in the surgical intensive care unit.

An effective rapid screening tool for arterial hemorrhage associated with pelvic fracture has yet to be identified. The importance of such a tool cannot be overemphasized, as it would represent a key branch point in the management protocol of the multisystem injured patient. Previous reports have correlated fracture pattern with arterial hemorrhage, specifically citing those fracture patterns associated with MLD.[1,6,14] This is intuitive because the source of arterial bleeding is most commonly from damaged branches of the internal iliac artery that span the sacroiliac joint. Eastridge and colleagues documented benefit from emergent pelvic angiography for patients with unstable fracture patterns, even in the face of hemoperitoneum.[15] However, others have been unable to define a clear predictive role for fracture classification.[3,16] Our study fails to document a significant correlation between the need for embolization and fracture pattern. Furthermore, the even distribution of fracture pattern between the two groups in our study suggests fracture class is not a reliable screening tool for predicting the need for angiographic embolization. The correlation of age with need for embolization in our study echoes the findings of other authors.[14,16] However, it is interesting to note that although age for the group as a whole only trended toward significance, it became a highly statistically significant variable for women on subset analysis by gender, but an otherwise invalid predictor for men. The contributive role of osteoporosis to increased fracture-associated complications in the elderly has been raised by others.[17] One review of elderly patients admitted to the hospital with pelvic fracture found that greater than 90% of them had evidence of osteoporosis on initial radiography.[18] The increased occurrence of osteoporosis in women associated with menopause is well established. However, to our knowledge, the propensity toward increased fracture-associated bleeding as a result of this gender difference has not been previously described. The increased prevalence of osteoporosis and resultant bone fragility as women age could account for more fractures versus ligamentous injury with similar force vectors, thereby increasing subsequent arterial injury. This increased bony fragility may also serve to explain the similar values in ISS between the embolized and nonembolized women, illustrating that a more sensitive predictor of need for angiography in women is not the kinetic force applied, but rather the bone strength within the pelvic ring.

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