Medicine®

OBSERVATIONAL STUDY

OPEN

The Diminishing Role of Pelvic Stability Evaluation in the Era of Computed Tomographic Scanning

Chih-Yuan Fu, MD, Lan-Hsuan Teng, MD, Chien-Hung Liao, MD, Yu-Pao Hsu, MD, Shang-Yu Wang, MD, Ling-Wei Kuo, MD, and Kuo-Ching Yuan, MD

Abstract: Pelvic fractures can result in life-threatening hemorrhages or other associated injuries. Therefore, computed tomography (CT) scanning plays a key role in the management of pelvic fracture patients. However, CT scanning is utilized as an adjunct in secondary survey according to traditional Advanced Trauma Life Support (ATLS) guidelines, whereas pelvic x-ray is used as a primary tool to evaluate pelvic stability and the necessity of further CT scanning. In the current study, we attempted to evaluate the role of CT scanning in the era of advanced technology. The significance of pelvic stability was also analyzed.

From January 2012 to December 2014, the trauma registry and medical records of pelvic fracture patients were retrospectively reviewed. A 64-slice multidetector CT scanner was used in our emergency department as a standard diagnostic tool for evaluating trauma patients. Pelvic x-ray was used as a primary tool for screening pelvic fractures, and pelvic stability was evaluated accordingly. CT scans were performed in patients with unstable pelvic fractures, suspected associated intra-abdominal injuries (IAIs), or other conditions based on the physicians' clinical judgment. The clinical features of patients with stable and unstable pelvic fractures were compared. The patients with stable pelvic fractures were analyzed to determine the characteristics associated with retroperitoneal hemorrhage (RH) or IAIs. Patients with stable pelvic fractures were also compared based on whether they underwent a CT scan.

A total of 716 patients were enrolled in this study. There were 533 (74.4%) patients with stable pelvic fractures. Of these patients, there were 66 (12.4%) and 50 (9.4%) patients with associated RH and IAI, respectively. There were no significant differences between the patients with associated RH based on their primary evaluation (vital signs, volume of blood transfusion, and hemoglobin level). Similarly, the demographics and the primary evaluation results (symptoms, coma scale, and white blood cell counts) of the patients with associated IAIs were also not significantly different from the patients without associated IAIs. Furthermore, the time to definitive hemostasis (surgery or angioembolization) was not significantly different between the unstable patients who underwent a CT scan or those who did not.

In the management of pelvic fracture patients, the role of pelvic stability is not significant in the evaluation of associated RH or IAI. Routine CT scanning is suggested for pelvic fracture patients because of the rapid scanning time and sufficient information produced.

(*Medicine* 95(16):e3421)

Abbreviations: AIS = Abbreviated Injury Scale, ATLS = Advanced Trauma Life Support, CT scan = computed tomography scan, ED = emergency department, IAI = intra-abdominal injury, ISS = injury Severity Scale, PXR = pelvic x-ray, RH = retroperitoneal hemorrhage, SBP = systolic blood pressure.

Editor: Johannes Mayr.
Received: November 9, 2015; revised: March 21, 2016; accepted: March 23, 2016.
From the Department of Trauma and Emergency Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan.
Correspondence: Chien-Hung Liao, Department of Trauma and Emergency Surgery, Chang Gung Memorial Hospital, 5, Fu-Hsing Street, Kwei Shan Township, Taoyuan, Taiwan (e-mail: gymetliao@gmail.com).
CY-F and LH-T contributed equally to this work.
The authors report no conflicts of interest.

ISSN: 0025-7974
DOI: 10.1097/MD.0000000000003421

INTRODUCTION

Pelvic fractures usually result from high-kinetic energy trauma and can cause life-threatening hemorrhages from the retroperitoneal arteries.[1,2] In addition, pelvic fractures are often associated with a high mortality rate because of the associated abdominal and pelvic organ injuries.[1–3] Therefore, immediate recognition of the presence of the concomitant intra-abdominal injuries (IAIs) and retroperitoneal hemorrhage (RH) can be critical when evaluating pelvic fracture patients.

The conventional Advanced Trauma Life Support (ATLS) guidelines suggest that a pelvic x-ray (PXR) can be an effective screening tool to evaluate pelvic fractures.[4–6] The mechanical stability of the pelvis can also be evaluated accordingly. Unstable pelvic fractures have been suggested to be associated with a higher probability of IAI or RH because of the possible higher energy of the trauma.[7,8] The reported rate of RH in unstable pelvic fractures ranges from 18% to 62.5%.[1,5,9] In contrast, stable pelvic fractures have often been considered minor injuries and are normally treated conservatively. However, 7% to 10% of stable pelvic fracture patients with RH require angioembolization for hemostasis.[5,9] In addition, associated IAIs are easily overlooked in the evaluation of patients who are thought to have minor injuries. Furthermore, sacro-iliac joint disruption may be missed on the primary PXR, resulting in some patients with unstable pelvic fractures being initially classified as having a stable fracture.[10,11] Therefore, the information from PXR only may be of limited use in evaluating patients with pelvic fractures. The role of the conventional classification of mechanical stability on the primary PXR should thus be reconsidered.

The importance of diagnostic imaging studies has been well recognized to play a key role in the management of pelvic fractures, and the quality of the imaging can reduce the morbidity and mortality of trauma patients.[12] In addition to the primary PXR, a secondary CT scan may provide improved resolution and facilitate the detection of small fractures, IAIs, and/or active arterial hemorrhages.[13–16] Based on CT findings, the subsequent treatment (operation or angioembolization) can be performed. In the evaluation of patients with unstable pelvic fractures, a CT scan is usually required because of the high probability of associated IAI or RH. However, there are no effective and reliable markers to predict whether a CT scan will be required when evaluating patients with stable pelvic fractures. Therefore, emergency department (ED) physicians face a dilemma in the evaluation of patients with stable pelvic fractures because of the possibility of missed IAI or RH. In the current study, we attempted to determine the feasibility and reliability of the primary tools (ie, the classification of fracture patterns on PXR, clinical presentation or laboratory data, and so on) in the evaluation of IAIs and RH among patients with pelvic fracture without an additional CT scan. Furthermore, the role of CT scanning in evaluating patients with pelvic fractures is also discussed. This study was approved in our institution with an institutional review board (number: 103–0830B).

METHODS

From January 2012 to December 2014, we retrospectively reviewed the trauma registry and the medical records of trauma patients at our level I trauma center. In our institution, a 64-slice multidetector CT scanner and resuscitation rooms are integrated in the same area of the ED, and 24-hour attending physicians (trauma surgeons and interventional radiologists) and at least 2 nurses are on standby in this area. Therefore, patients can be transferred between the resuscitation room and the imaging study suites rapidly under continuous resuscitation. In other words, this facility provides equal patient safety in both the CT scan rooms and the resuscitation rooms. Additionally, the operating and angiography rooms are available 24 hours per day, and an angioembolization can be performed within 1 hour.

During the 36-month investigational period, patients with pelvic fractures were the focus of this study (international classification of diseases-9 [ICD-9] = 808). Patients who were pregnant, were younger than 18 years, or underwent out-of-hospital cardiac arrest without response to resuscitation and died in the ED finally were not included. All of the enrolled patients were identified and treated according to our established algorithm, which was based on the ATLS guidelines (Figure 1).[4] PXR and sonographic examinations were performed as adjuncts to the primary survey. The patients with systolic blood pressure (SBP) over 90 mm Hg after resuscitation (if needed) were classified as stable pelvic fractures or unstable pelvic fractures according to their PXR. The patients with unstable pelvic fractures underwent routine CT scanning because of the high-energy nature of their injury. In contrast, a CT scan was performed in some patients with stable pelvic fractures based on clinical presentation or the physicians' clinical judgment. Then, the subsequent treatment (surgery, angioembolization, or observation) was performed according to the results of the CT scan, or the patients were treated conservatively without a CT scan.

However, some pelvic fracture patients with unstable hemodynamics after resuscitation (SBP less than 90 mm Hg) require definitive treatment. Surgery (laparotomy) was performed to treat intra-abdominal hemorrhage when the sonographic examination was positive. Other patients underwent

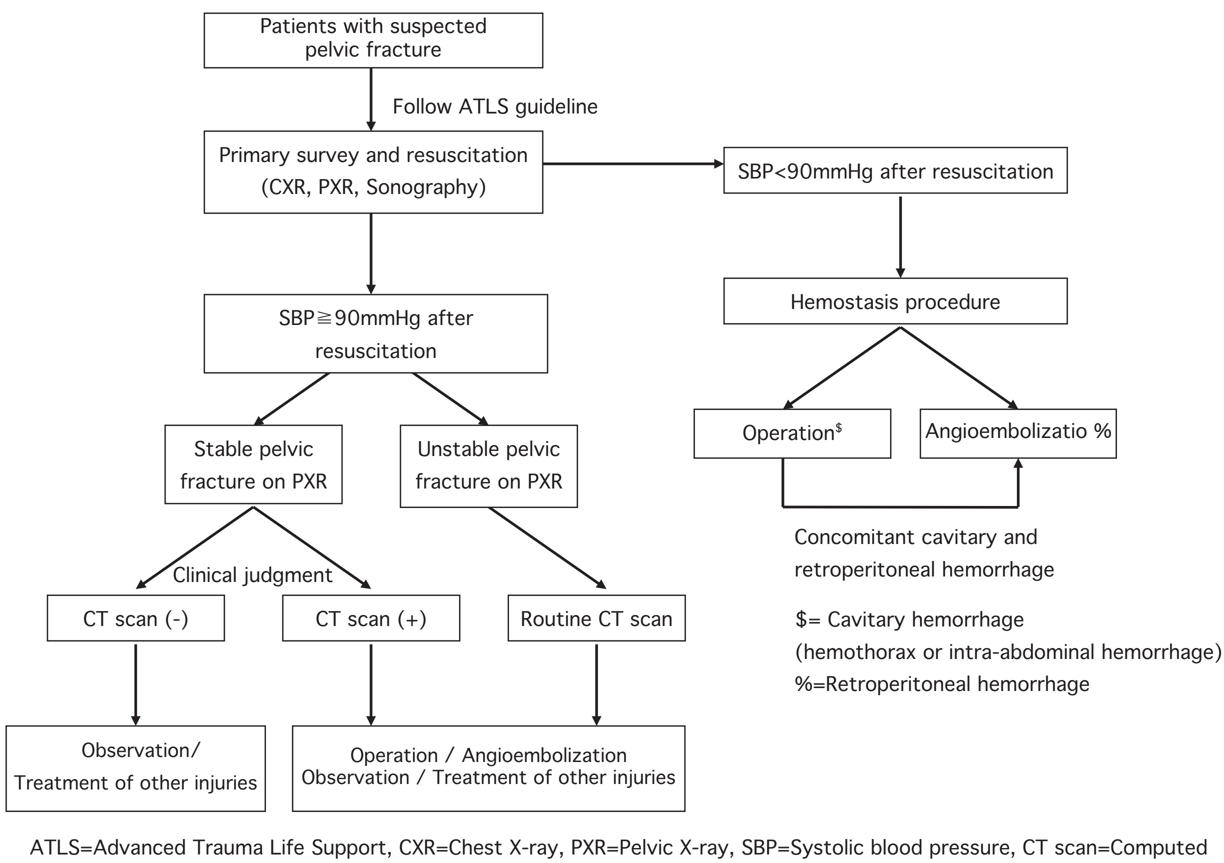

FIGURE 1. The established algorithm for the management of patients with pelvic fractures.

angioembolization for possible RH that could not be detected on sonography.[17] In the rare case of a patient with concomitant intraperitoneal and retroperitoneal hemorrhages (with positive results on both sonography and retroperitoneal hematoma expansion intraoperatively), a postlaparotomy angioembolization was performed after the intra-abdominal hemorrhage was controlled. In these unstable patients, the CT scan was not always performed because of their critical condition, and treatment was initiated without the secondary survey.

In the present study, the demographics and clinical conditions were investigated and compared between the patients with stable pelvic fractures and those with unstable pelvic fractures. The Abbreviated Injury Scale (AIS) scores for the pelvis, Injury Severity Scale (ISS) scores, number of blood transfusions, associated injuries (IAIs or RH), and outcomes of both groups of patients were routinely recorded. Furthermore, the patients with stable pelvic fractures were analyzed in detail. These patients' characteristics with or without associated IAIs or RH were compared. The roles of primary evaluation in the detection of the associated injuries for such patients were discussed. In addition, patients with unstable hemodynamics after resuscitation who underwent a hemostasis procedure were also investigated. Among these patients, we investigated the influence of CT scan evaluations on the time interval between arrival and definitive treatment.

In this study, the imaging results were reviewed retrospectively by both board-certified trauma surgeons and radiologists. The Young–Burgess classification system was used to evaluate the pelvic fracture patterns. Lateral compression type III, anteroposterior compression types II and III, vertical shearing, and combined-type fractures were defined as unstable, and other patterns were considered stable.[3,18] All of the data are presented as percentages of patients or as means with standard deviations. Numerical data were compared using the Wilcoxon 2-sample exact test, and nominal data were compared using Fisher exact test. All statistical analyses were performed using the SPSS computer software package (version 13.0, Chicago, IL). A value of $P < 0.05$ was considered statistically significant.

RESULTS

During the 36-month study period, 748 pelvic fracture patients visited the ED of our institution, and 32 patients met the study's exclusion criteria. Therefore, 716 patients were enrolled in this study. The mean patient age was 40.8 years. Of these patients, 432 were male (60.3%) and 284 were female (39.7%). Twenty percent of them had associated RH (n = 143) and 122 (17.0%) had associated IAIs. According to their primary PXR, 183 (25.6%) patients had unstable pelvic fractures, and the other 533 (74.4%) patients were classified as having stable pelvic fractures. The overall average ISS of the patients was 15.3.

Table 1 compares the demographics and clinical conditions of the patients with stable pelvic fractures and those with unstable pelvic fractures on their PXR. The patients with unstable pelvic fractures had significantly higher pelvis AIS (3.8 ± 1.9 vs 1.4 ± 1.3; $P < 0.001$) and ISS (20.2 ± 13.7 vs 8.4 ± 5.8; $P < 0.001$) than those with stable pelvic fractures.

TABLE 1. Demographics of the Patients With Pelvic Fractures and Comparisons of the Characteristics of Patients With Unstable and Stable Pelvic Fractures Based on the PXR

	Results of PXR Examination		
Variables	**Unstable Pelvic Fracture (n = 183)**	**Stable Pelvic Fracture (n = 533)**	***P***
Demographics			
Age	38.4 ± 26.5	41.6 ± 19.7	0.533†
Sex (n)			<0.001‡
Male	83 (45.4%)	349 (65.5%)	
Female	100 (54.6%)	184 (34.5%)	
AIS of the pelvis (scale)	3.8 ± 1.9	1.4 ± 1.3	<0.001†
ISS (score)	20.2 ± 13.7	8.4 ± 5.8	<0.001†
Clinical condition			
Blood transfusion, mL	893.7 ± 712.4	218.6 ± 182.5	<0.001†
Associated IAI (n)			<0.001‡
Yes	56 (30.6%)	66* (12.4%)	
No	127 (69.4%)	467 (87.6%)	
Associated RH (n)			<0.001‡
Yes	93 (50.8%)	50* (9.4%)	
No	90 (49.2%)	483 (90.6%)	
Outcome			0.004
Survival	176 (96.2%)	530 (99.4%)	
Mortality	7 (3.8%)	3§ (0.6%)	

Values are reported as the mean ± SD.
IAI = intra-abdominal injury, ISS = Injury Severity Scale, PXR = pelvic x-ray, RH = retroperitoneal hemorrhage.
*In the patients with stable pelvic fractures (n = 533), there were 107 patients with associated IAI or RH (IAI = 66, RH = 50, both IAI and RH = 9).
†Wilcoxon rank-sum test.
‡Fisher exact test.
§Two of these 3 patients died due to bowel perforation related sepsis. They did not receive the CT scan initially in the ED. The further CT scan and subsequent surgery were performed over 24 hours after admission.

The patients with unstable pelvic fractures also had a significantly higher requirement of blood transfusion (893.7 ± 712.4 vs 218.6 ± 182.5 mL; $P < 0.001$) and mortality rate (3.8% vs 0.6%; $P = 0.004$). In patients with unstable pelvic fractures, 30.6% and 50.8% had associated IAI and RH, respectively. These percentages were significantly higher than those of the stable pelvic fracture patients. However, 107 (20.1%) patients with stable pelvic fractures continued to suffer from IAIs, RH, or both (IAI = 66, 12.4%; RH = 50, 9.4%; both IAI and RH = 9). Of these 107 patients, 83 (77.6%) received an initial CT scan in the ED. In contrast, the other 24 (22.4%) patients had no specific signs or positive results on their primary evaluation. Therefore, they received the conservative observation only without the initial CT scan. Then, the CT scan was performed during hospitalization because of further deterioration (eg, hypotension, a drop in hemoglobin level, sepsis, severe abdominal pain). Furthermore, bowel perforation was not initially identified in 2 patients because they were unconscious. These patients received CT scans over 24 hours after admission because of progressed deterioration. The operations were performed accordingly, but the patients eventually died due to uncontrolled sepsis.

Tables 2 and 3 show the comparisons between the stable pelvic fracture patients (n = 533) with and without associated IAI/RH. Of the patients with RH (n = 50, 9.4%, 50/533, angioembolization: 37), the SBP was slightly lower than in the patients without RH (103.4 ± 62.3 vs 126.2 ± 81.8 mm Hg; $P = 0.032$). However, the average SBPs in these 2 groups both exceeded 100 mm Hg. Except the SBP levels, there was no significant difference in the heart rate, hemoglobin level, or the sonography results between the patients with and without associated RH. Similarly, in the patients with associated IAIs (n = 66, 12.4%, 66/533, surgical treatment: 18), there was no significant difference in the primary evaluation and clinical presentation relative to the patients without associated IAI.

Table 4 shows the characteristics of the 63 patients with hypotension after resuscitation who underwent a hemostasis procedure (surgery: 18, angioembolization: 45). Of these, 49 (77.8%) underwent a CT scan. Among the patients who underwent surgery (n = 18), 50% (9/18) had a CT scan. The mean duration between arrival at the hospital and entering the operating room for these patients was 53.5 ± 11.7 minutes, which was not significantly different from that of the patients who did not undergo a CT scan (53.5 ± 11.7 vs 44.5 ± 20.1 minutes; $P = 0.517$; Table 4). Similarly, CT scans were performed in 88.9% (40/45) of the patients who underwent angioembolization for RH. Similarly, there was no significant difference in the time between the arrival at the hospital and the arrival at the angiography suite between the patients who did and did not undergo a CT scan (106.6 ± 41.3 vs 118.4 ± 50.3 minutes; $P = 0.622$; Table 4). A comparison of the mortality rates revealed no significant difference between the patients who underwent a CT scan and those who did not (14.3% vs 14.3%; $P = 1.000$).

DISCUSSION

The high mortality rate associated with pelvic fractures usually results from the associated IAIs or RH. Unstable pelvic fractures have been reported to correlate with a high probability of associated IAI and RH.[3,5,7,18] Similar to previous reports, in the current study, the patients with unstable pelvic fractures had a significantly higher probability of IAI and RH than the patients with stable pelvic fractures (Table 1). However, almost one-tenth of the patients with stable pelvic fractures on their PXRs had concomitant IAI (12.4%) or RH (9.4%). Further

TABLE 2. Demographics of Patients With Stable Pelvic Fractures and Comparisons of the Characteristics of Patients With and Without Associated RH

	Stable Pelvic Fracture (N = 533)		
Variables	**Associated RH (+) (n = 50)**	**Associated RH (−) (n = 483)**	***P***
Demographics			
Age	42.2 ± 21.9	41.5 ± 33.2	1.000*
Sex (n)			0.028†
Male	40 (80.0%)	309 (58.0%)	
Female	10 (20.0%)	174 (42.0%)	
AIS of the pelvis (scale)	1.6 ± 0.9	1.4 ± 0.8	0.886*
ISS (score)	11.1 ± 8.0	8.1 ± 5.4	0.041*
Primary evaluation			
Blood transfusion, mL	1014.9 ± 713.5	122.4 ± 178.3	<0.001*
SBP, mm Hg	103.4 ± 62.3	126.2 ± 81.8	0.032*
Heart rate, bpm	96.1 ± 21.6	87.2 ± 33.7	0.173*
Hemoglobin, mg/dL	13.3 ± 6.0	11.4 ± 8.9	0.265*
Sugar, mg/dL	194.2 ± 48.4	90.6 ± 87.2	<0.001*
Sonography			0.092†
Positive	4 (8.0%)	15 (3.1%)	
Negative	46 (92.0%)	468 (96.9%)	

Values are reported as the mean ± SD.
AIS = Abbreviated Injury Scale, RH = retroperitoneal hemorrhage, SBP = systolic blood pressure.
*Wilcoxon rank-sum test.
†Fisher exact test.

TABLE 3. Demographics of Patients With Stable Pelvic Fractures and Comparisons of the Characteristics of Patients With and Without Associated IAIs

	Stable Pelvic Fracture (N = 533)		
Variables	**IAI (+) (n = 66)**	**IAI (−) (n = 467)**	***P***
Demographics			
Age	42.5 ± 21.0	41.5 ± 38.4	1.000*
Sex (n)			0.167†
Male	38 (57.6%)	311 (66.6%)	
Female	28 (42.4%)	156 (33.4%)	
AIS of the pelvis (scale)	1.8 ± 0.4	1.3 ± 1.0	0.024*
ISS (score)	17.6 ± 8.2	7.1 ± 4.9	0.011*
Primary evaluation			
GCS <13 (n)			0.623†
Yes	6 (9.1%)	35 (7.5%)	
No	60 (90.9%)	432 (92.5%)	
Abdominal pain (n)			0.545†
Yes	47 (71.2%)	351 (75.2%)	
No	19 (28.8%)	116 (24.8%)	
Peritoneal sign (n)			0.895†
Yes	30 (45.5%)	206 (44.1%)	
No	36 (54.5%)	261 (55.9%)	
WBC, μ/L	18433.5 ± 7314.7	15714.9 ± 8317.8	0.696*
CRP, mg/L	26.6 ± 18.4	20.1 ± 24.4	0.941*
Sonography			0.719†
Positive	3 (4.8%)	16 (3.4%)	
Negative	63 (95.2%)	451 (96.6%)	

Values are reported as the mean ± SD.
CRP = C-reactive protein, GCS = Glasgow Coma Scale, IAI = intra-abdominal injury, WBC = white blood cell.
*Wilcoxon rank-sum test.
†Fisher exact test.

TABLE 4. Comparisons of Pelvic Fracture Patients With Hypotension After Resuscitation Who Did and Did Not Have CT Scans and Underwent a Hemostasis Procedure (Surgery or Angioembolization)

	N = 63		
Variables	**With CT Scan (n = 49)**	**Without CT Scan (n = 14)**	***P***
Age	51.6 ± 23.7	44.2 ± 21.8	0.144*
Sex (N)			0.763†
Male	28 (57.1%)	7 (50.0%)	
Female	21 (42.9%)	7 (50.0%)	
ISS (score)	22.4 ± 18.9	20.6 ± 17.1	0.619*
Outcome			1.000
Survival	42 (85.7%)	12 (85.7%)	
Mortality	7 (14.3%)	2 (14.3%)	
Time to the hemostasis procedure (surgery or angioembolization), minutes			
Surgery (N = 18)	With CT scan (n = 9)	Without CT scan (n = 9)	
Time to operating room, minutes	53.5 ± 11.7	44.5 ± 20.1	0.517*
Angioembolization (N = 45)	With A/P CT scan (n = 40)	Without A/P CT scan (n = 5)	
Time to angiography room, minutes	106.6 ± 41.3	118.4 ± 50.3	0.622*

Values are reported as the mean ± SD.
Angioembolization was specific to the hemostasis of retroperitoneal hemorrhage.
*Wilcoxon rank-sum test.
†Fisher exact test.

deterioration may occur in these patients, and there are also potential legal ramifications if a significant injury goes undetected.[19,20] These facts indicated that the conventional classification of pelvic stability based on the primary PXR may be insufficient for the management of such complicated injuries.

It is therefore important to identify a marker that could facilitate early detection of RH in stable pelvic fracture patients. Once identified, the hemostasis procedure could be performed immediately, thus preventing hemodynamic instability. A change in vital signs may be observed as the presentation of shock in the ED. Indeed, tachycardia is emphasized as an early sign of shock. However, several studies have demonstrated that heart rate is poorly correlated with hypotension and shock because of its dependence on numerous additional factors, such as pain, sympathetic stimuli, or medication.[21] Therefore, tachycardia alone is not a highly sensitive or specific indicator that emergent intervention is needed. Hypotension (eg, SBP $<$90 mm Hg) is also an indicator of hemodynamic instability, but it is well accepted that a patient may enter a state of profound shock long before reaching a critically low blood pressure.[22,23] In the current study, there was no significant difference in the heart rate between the patients with and without associated RH in the patients with stable pelvic fractures. Although the patients with associated RH had significantly lower SBP than the patients without associated RH, on average, neither of these patient groups exhibited meaningful hypotension after resuscitation (Table 2).

In addition to the measurement of vital signs, laboratory analyses, such as the base deficit based on blood gas analysis, serum lactate, or hemoglobin level, may be useful for determining a patient's hemodynamic status or prognosis.[24,25] However, laboratory processing times are prolonged by volume demands induced by ED overcrowding, and the results may be unreliable during the early phases of injury. Thus, although blood tests may be useful, they may be inadequate or impractical in critical or emergent situations, such as mass casualty incidents.[26,27] In the current study, there was no significant difference in the hemoglobin levels between the stable pelvic fracture patients with and without RH. Our previous study showed that higher glucose on admission indicated the need for angioembolization in stable pelvic fracture patients.[25] The results of the current study also support the above conclusion. However, in addition to blood loss, other factors may contribute to hyperglycemia. Therefore, a reliable and easily accessible marker for the early detection of associated RH in patients with stable pelvic fracture is needed.

In addition to RH, the associated IAI should also be considered in the evaluation of the patients with stable pelvic fractures. Sonography was applied to screen the possibility of intra-abdominal hemorrhage based on the abnormal accumulation of intra-abdominal fluid. However, hollow organ perforation, which does not present as intra-abdominal fluid accumulation, was sometimes overlooked. During the primary survey, information obtained from the PXR and sonography is usually insufficient, and a diagnostic tool with a better resolution and image quality is needed to achieve an accurate diagnosis. In this study, an associated IAI occurred in 12.4% (66/533) of the patients with stable pelvic fractures. These injuries should be evaluated with CT scans. No clear clinical guidelines are currently available regarding the decision to order CT imaging, and thus, imaging was performed based on the physicians' clinical judgment or the patients' complaints of abdominal symptoms. However, the lower abdominal pain related to pelvic fractures sometimes mimics the symptoms of peritonitis, and as a result, patient reports of abdominal symptoms are unreliable. Furthermore, concomitant head injuries that lead to a loss of consciousness may make it difficult for patients to describe their symptoms clearly.[28] Table 3 reveals that it is difficult to identify patients with associated IAIs during the primary evaluation because of their nonspecific clinical presentation. Furthermore, laboratory tests for white blood cells or C-reactive protein, which are used to detect peritonitis, are not reliable and feasible in the early stages of trauma evaluation. The possibility of missing a diagnosis also presents physicians with a dilemma in the evaluation of patients with concomitant pelvic fractures and IAIs.

In the current study, some patients did not initially receive CT scans in the ED, which resulted in patient death. (Table 1) Thus, CT scans and additional treatment were delayed, and only insufficient and nonspecific information was provided in the ED. The delayed diagnosis of a bowel or mesenteric injury can result in significant morbidity and mortality due to hemorrhage, peritonitis, or abdominal sepsis.[29,30] The timely diagnosis of IAIs depends on early detection by CT imaging because the clinical signs and symptoms of these injuries are not specific and usually develop late. The necessity of operating may also be detected earlier based on CT imaging. We agree that most patients with stable pelvic fractures can be treated conservatively. However, given the above reasons, it is difficult to identify patients with concomitant IAIs or RH among patients with stable pelvic fractures based solely on primary tools. CT imaging can provide sufficient and accurate information to evaluate IAIs. Therefore, CT scan is recommended when evaluating patients with stable pelvic fractures because there is no effective or reliable marker that can predict IAIs or RH.

When evaluating pelvic fracture patients with unstable hemodynamics after resuscitation, hemorrhage should always be considered first. Therefore, the early detection of the origin of the hemorrhage is important. The subsequent hemostatic procedure can be performed accordingly. A CT scan can provide efficient information about both intraperitoneal and retroperitoneal injuries that can help ED physicians to make appropriate treatment decisions.[15,16,31,32] This technique has traditionally been considered part of a secondary survey that can only be performed after the patient's hemodynamics are stabilized. In fact, unstable patients without response to resuscitation require definitive treatment according to the physical examinations and primary tools (eg, PXR or sonography examinations) without a CT scan examination. Moreover, the CT scan has been considered unnecessary and may delay definitive treatment. Our previous study suggested performing angioembolization under critical conditions without CT scanning.[17] However, the facility advancements have improved patient safety during a CT scan because the evaluation can be completed very rapidly without interrupting resuscitation. The overall study time required for a multislice spiral CT scan (including both transportation and scanning times) is less than 10 minutes; thus, an evaluation can be completed during the time lag required to prepare for surgery/angioembolization. Additionally, the CT and resuscitation rooms are integrated in the same area of the ED. Patients can be transferred between the resuscitation room and the imaging study suites very rapidly while receiving continuous resuscitation. In this study, 63 patients with unstable hemodynamics underwent definitive hemostasis (eg, surgery or angioembolization). Additionally, no significant difference in the time to definitive hemostasis between the patients who did or did not receive a CT scan was noted (surgery: 53.5 ± 11.7 vs 44.5 ± 20.1 minutes; $P = 0.517$; angioembolization: 106.6 ± 41.3 vs 118.4 ± 50.3 minutes; $P = 0.622$). Furthermore, the outcomes were not significantly different between the patients who did or did not receive a CT scan (mortality rate: 14.3% vs 14.3%; $P = 1.000$) (Table 4). These results demonstrate that a CT scan does not delay definitive hemostasis or result in worse outcomes. Although CT scans are not recommended for unstable patients, the difficulties of CT scanning seem to have been overcome by the above mentioned changes.

The limitations of this study include its retrospective nature. A possible selection bias may have limited our conclusions. In the current study, few patients had pelvic fractures diagnosed using CT scans that went undetected on PXR. Therefore, patients with pelvic fractures must exist who showed normal PXR and did not receive an additional CT scan. Furthermore, we retrospectively studied the patients with pelvic fractures (ICD-9 = 808) in the current study; thus, those who showed normal PXR and did not receive additional CT scans cannot be studied in detail. In addition, approximately 10% of patients with RH (9.4%) and IAIs (12.4%) showed normal PXR or stable pelvic fractures on PXR. These cases of RH or IAI were diagnosed with additional, incidental CT scans for nonspecific reasons. Thus, the true percentage of cases of RH or IAI that did not require treatment must be higher than the reported results. Therefore, we believe that the application of routine CT scanning may provide more information for physicians' decision-making. The traditional classification of pelvic stability based on PXR should be re-evaluated because of the advancement in imaging technologies. Further studies with larger sample sizes and prospective designs are needed to establish algorithms for the most appropriate diagnostic tools to use in the ED. The cost and effectiveness of routine CT scanning should also be evaluated regarding patients with pelvic fractures.

CONCLUSIONS

In the management of patients with pelvic fracture, the role of pelvic stability is not significant when evaluating associated RH or IAI. A routine CT scan is recommended for pelvic fracture patients.

REFERENCES

1. Cryer HM, Miller FB, Evers BM, et al. Pelvic fracture classification: correlation with hemorrhage. *J Trauma.* 1988;28:973–980.
2. Gänsslen A, Giannoudis P, Pape H. Hemorrhage in pelvic fracture: who needs angiography? *Curr Opin Crit Care.* 2003;9:515–523.
3. Burgess AR, Eastridge BJ, Young JWR, et al. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma.* 1990;30:848–856.
4. Committee on Trauma. Advanced Trauma Life Support. 9th ed. Chicago, IL: American College of Surgeons; 2012.
5. Fu CY, Wu SC, Chen RJ, et al. Evaluation of pelvic fracture stability and the need for angioembolization: pelvic instabilities on plain film have an increased probability of requiring angioembolization. *Am J Emerg Med.* 2009;27:792–796.
6. Obaid AK, Barleben A, Porral D, et al. Utility of plain film pelvic radiographs in blunt trauma patients in the emergency department. *Am Surg.* 2006;72:951–954.
7. Osterhoff G, Scheyerer MJ, Fritz Y, et al. Comparing the predictive value of the pelvic ring injury classification systems by Tile and by Young and Burgess. *Injury.* 2014;45:742–747.
8. Manson T, O?Toole RV, Whitney A, et al. Young-Burgess classification of pelvic ring fractures: does it predict mortality, transfusion requirements, and non-orthopaedic injuries? *J Orthop Trauma.* 2010;24:603–609.
9. Brian JE, Adam S, Joseph PM, et al. The importance of fracture pattern in guiding therapeutic decision-making in patients with hemorrhagic shock and pelvic ring disruptions. *J Trauma.* 2002;53:446–451.
10. Fu CY, Wu YT, Liao CH, et al. Pelvic circumferential compression devices benefit patients with pelvic fractures who need transfers. *Am J Emerg Med.* 2013;31:1432–1436.
11. Juhl M, Møller-Madsen B, Jensen J. Missed injuries in an orthopaedic department. *Injury.* 1990;21:110–112.
12. Scalea TM, Simon HM, Duncan AO, et al. Geriatric blunt multiple trauma. *J Trauma.* 1990;30:129–132.
13. Fu C, Yang S, Liao C, et al. Hypotension does not always make computed tomography scans unfeasible in the management of blunt abdominal trauma patients. *Injury.* 2015;46:29–34.
14. Fu CY, Wang SY, Hsu YP, et al. The diminishing role of pelvic X-rays in the management of patients with major torso injuries. *Am J Emerg Med.* 2014;32:18–23.
15. Bozeman MC, Cannon RM, Trombold JM, et al. Use of computed tomography findings and contrast extravasation in predicting the need for embolization with pelvic fractures. *Am Surg.* 2012;78: 825–830.
16. Brasel KJ, Pham K, Yang H, et al. Significance of contrast extravasation in patients with pelvic fracture. *J Trauma.* 2007;62: 1149–1152.
17. Fu CY, Wang YC, Wu SC, et al. Angioembolization provides benefits in patients with concomitant unstable pelvic fracture and unstable hemodynamics. *Am J Emerg Med.* 2012;30:207–213.
18. Young JW, Burgess AR, Brumback RJ, et al. Pelvic fractures: value of plain radiography in early assessment and management. *Radiology.* 1986;160:445–451.
19. Streck CJ Jr, Jewett BM, Wahlquist AH, et al. Evaluation for intra-abdominal injury in children after blunt torso trauma: can we reduce unnecessary abdominal computed tomography by utilizing a clinical prediction model? *J Trauma Acute Care Surg.* 2012;73:371–376.
20. Aaland MO, Smith K. Delayed diagnosis in a rural trauma center. *Surgery.* 1996;120:774–778.
21. Mizushima Y, Ueno M, Watanabe H, et al. Discrepancy between heart rate and makers of hypoperfusion is a predictor of mortality in trauma patients. *J Trauma.* 2011;71:789–792.
22. Graham CA, Parke TRJ. Critical care in the emergency department: shock and circulatory support. *Emerg Med J.* 2005;22:17–21.
23. Abou-Khalil B, Scalea TM, Trooskin SZ, et al. Hemodynamic responses to shock in young trauma patients: need for invasive monitoring. *Crit Care Med.* 1994;22:633–639.
24. Callaway DW, Shapiro NI, Donnino MW, et al. Serum lactate and base deficit as predictors of mortality in normotensive elderly blunt trauma patients. *J Trauma.* 2009;66:1040–1044.
25. Fu CY, Wang YC, Wu SC, et al. Higher glucose on admission is associated with need for angioembolization in stable pelvic fracture. *Am J Emerg Med.* 2012;30:26–31.
26. Lee C, Lee N, Chuang M, et al. The impact of overcrowding on the bacterial contamination of blood cultures in the ED. *Am J Emerg Med.* 2012;30:839–845.

27. Hwang U, Baumlin K, Berman J, et al. Emergency department patient volume and troponin laboratory turnaround time. *Acad Emerg Med*. 2010;17:501–507.
28. Giannoudis PV, Grotz MRW, Tzioupis C, et al. Prevalence of pelvic fractures, associated injuries, and mortality: the United Kingdom perspective. *J Trauma*. 2007;63:875–883.
29. Oztürk H, Onen A, Otçu S, et al. Diagnostic delay increases morbidity in children with gastrointestinal perforation from blunt abdominal trauma. *Surg Today*. 2003;33:178–182.
30. Fang JF, Chen RJ, Lin BC, et al. Small bowel perforation: is urgent surgery necessary? *J Trauma*. 1999;47:515–520.
31. Pereira SJ, O'Brien DP, Luchette FA, et al. Dynamic helical computed tomography scan accurately detects hemorrhage in patients with pelvic fracture. *Surgery*. 2000;128:678–685.
32. Dalinka MK, Arger P, Coleman B. CT in pelvic trauma. *Orthop Clin North Am*. 1985;16:471–480.