

Angioembolization and laparotomy for patients with concomitant pelvic arterial hemorrhage and blunt abdominal trauma

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Abstract

Background Treatment of patients with concomitant pelvic arterial hemorrhage and blunt abdominal trauma (BAT) is challenging. Controversies remain over the diagnostic approach and the priority of available treatment resources. **Methods** Between 1999 and 2008, 545 patients were admitted due to concomitant BAT and pelvic fracture. Seventy-six patients receiving both angiography and laparotomy were studied. Focused abdominal sonography for trauma (FAST) was used as the primary triage tool in the early 5 years and multi-detector computed tomography (MDCT) in the later 5 years. The clinical courses and results were retrospectively analyzed to determine if the evolution of the clinical pathways for managing these patients resulted in improved outcomes. **Results** Performing laparotomy solely based on FAST during the early 5 years resulted in a high nontherapeutic laparotomy rate (36%). Contrast enhanced MDCT, as the primary triage tool, accurately disclosed active intra-abdominal and pelvic injuries and was helpful in promptly tailoring the subsequent

treatment. Additional surgical trauma was avoided in some patients and nontherapeutic laparotomy rate decreased to 16%. Multiple bleeders were found in 70% of positive angiograms; bilateral internal iliac artery embolization for the purpose of damage control showed a lower repeat angioembolization rate for these severely injured patients. **Conclusion** The revised clinical algorithm served well for guiding the treatment pathway. Priority of laparotomy or angiography should be individualized and customized according to the clinical evaluation and CT findings. Angiography can be both diagnostic and therapeutic and simultaneously treat multiple bleeders; thus, it has a higher priority than laparotomy. The primary benefits of our later clinical pathway were in reducing nontherapeutic laparotomy and repeat angioembolization rates.

Keywords Pelvic fracture · Blunt abdominal trauma (BAT) · Angiography · Transarterial embolization (TAE) · Laparotomy

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Introduction

Patients with pelvic fractures have a high incidence of associated abdominal injuries [1]. The combination of abdominal and pelvic injuries makes appropriate evaluation and treatment a challenging task. Abdominal and pelvic injuries can mimic each other, making it difficult to achieve the correct diagnosis. These injuries may lead to exsanguination and death rapidly. The mortality rate of concomitant pelvic fracture and blunt abdominal trauma (BAT) was reported to be as high as 40% [2]. Thus, the decision-making process needs to be fast and safe. However, management of these patients involves various fields of expertise. The decision is also greatly influenced by the

availability of institutional resources and skillfulness of the personnel-in-charge. Currently, there is no consensus as to the best diagnostic and treatment strategy for these patients.

For the initial evaluation, most trauma protocols suggest that the abdomen can be screened with focused abdominal sonography for trauma (FAST), diagnostic peritoneal aspiration (DPA), or lavage (DPL) [3–6]. Laparotomy will be performed if hemoperitoneum is disclosed in a hemodynamically unstable patient. If the abdomen is negative for free fluid and the patient remains unstable, angiography will be performed. Computed tomography (CT) scans are usually reserved for hemodynamically stable patients [5]. For the treatment, controversies remain regarding the priority of laparotomy, angioembolization, pelvic fracture reduction and stabilization, and peritoneal pelvic packing [3–11].

Recently, though the fundamental goals of treating multiple trauma patients have not changed, the means of achieving these aims has evolved markedly. Advances in CT scan technology significantly increased the scan coverage area and decreased the scan time [12]. With the use of multidetector CT (MDCT) scanners, CT can reliably depict arterial injuries, differentiate arterial from venous hemorrhage, and detect hollow organ injuries [12–14]. MDCT was reportedly used to tailor the subsequent treatment [2, 13]. Moreover, CT was proposed to be used in hemodynamically unstable patients in some recent reports [13, 14]. Angiography and transcatheter arterial embolization (TAE) are popular as an effective means of controlling arterial hemorrhage [15–18]. Nowadays, most trauma surgeons agree that an ongoing unstable hemodynamic status indicates arterial hemorrhage and suggest early embolization as the most appropriate treatment [5, 15–18].

Concomitant pelvic arterial hemorrhage and BAT requiring both angiography for hemorrhage control and laparotomy for the treatment of BAT represents an extremely severe injury. However, to the best of our knowledge, only a few studies aimed at determining diagnosis and treatment strategies for patients with concomitant pelvic fracture and BAT [2, 3, 19, 20]. No study has focused on patients with concomitant pelvic arterial hemorrhage and BAT requiring both angioembolization and laparotomy for the treatment. In this retrospective study, we analyzed our experience to manage this specific group of patients and determined if the changes in our protocols for managing these patients were associated with improved outcomes.

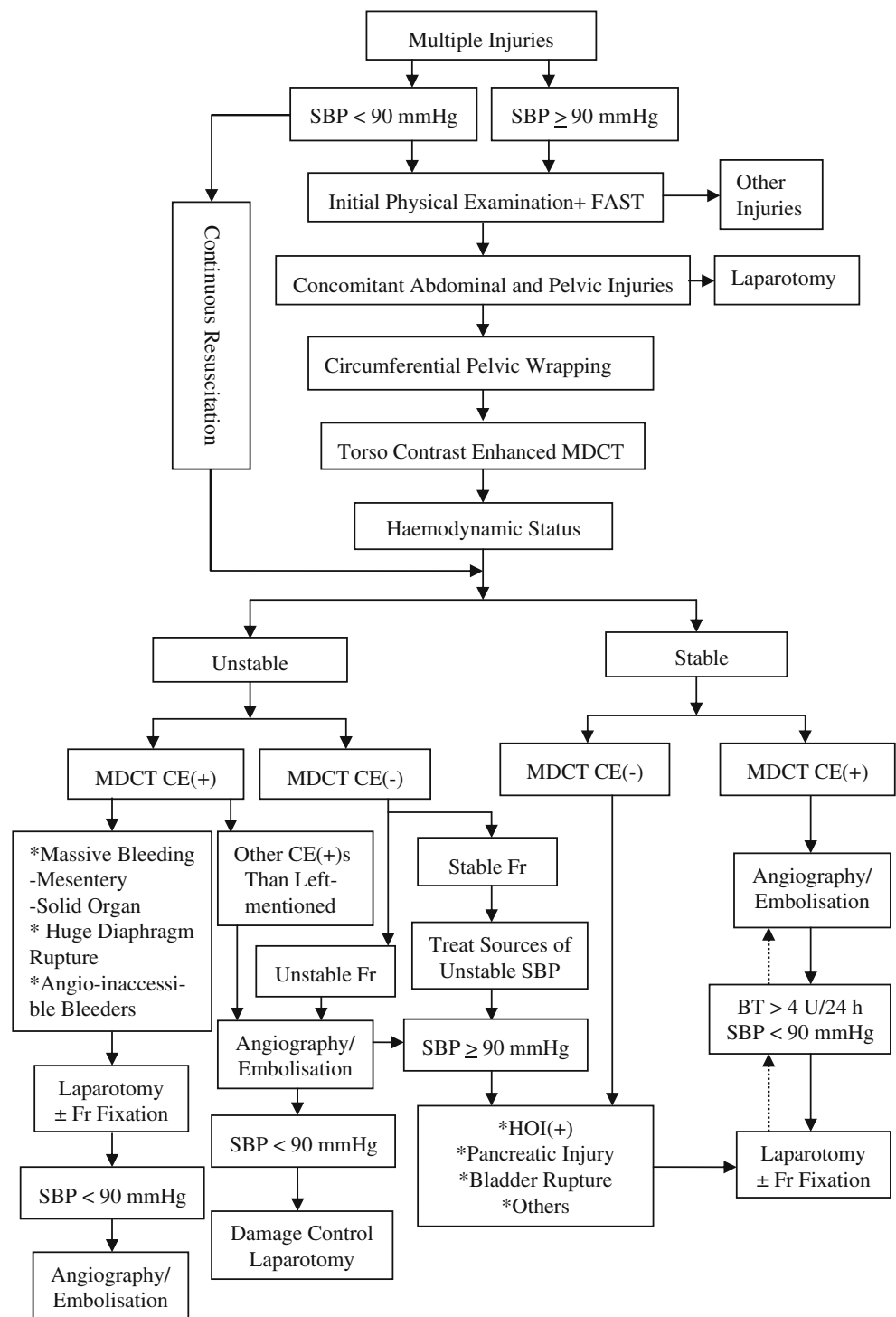
Materials and methods

This study was performed at the Chang-Gung Memorial Hospital, Linko, a level I trauma center. During a 10-year period between January 1999 and December 2008, 1,648 patients with pelvic fractures were admitted. Patients

referred from other hospitals for definitive treatment of pelvic fractures and patients who died in the emergency suite were excluded, leaving 1,517 patients for further study. Among these patients, 545 (36%) had associated abdominal injuries, 246 received angiography, and 165 underwent laparotomy. Seventy-six patients received both angiography and laparotomy for the treatment of concomitant pelvic arterial hemorrhage and BAT, and constituted the study group (group I). Among them, 45 were treated between 1999 and 2003 (group IA) and 31 in the later 5 years (group IB). The remaining 469 patients with concomitant pelvic fracture and BAT who did not undergo both angiography and laparotomy were used as the control group (group II). The medical records were retrospectively reviewed.

Patients were resuscitated in accordance with the guidelines of the American College of Surgeons Committee on Trauma Advanced Life Support [21]. During the early 5 years, a clinical pathway for the management of pelvic fractures was used based on the hemodynamic status, presence of intracavitary hemorrhage, and stability of pelvic fracture [22]. At initial evaluation, all patients with suspected abdominal and/or pelvic injuries underwent abdominal FAST for the survey of cavitory hemorrhage. According to the clinical pathway, patients with unstable hemodynamic status despite fluid resuscitation and evidence of significant free fluid on FAST would receive exploratory laparotomy. Angiography would be ordered if the patient (1) was hemodynamically unstable in the absence of other bleeding sources, (2) had an unstable pelvic fracture, (3) had a CT showing contrast extravasation in the pelvis or a large pelvic hematoma, or (4) had a stable pelvic fracture and remained hemodynamically unstable after more than 4 U blood transfusion in 24 h. During the later 5 years, the algorithm evolved to include contrast-enhanced MDCT in the primary triage when the patient's condition allowed it (Fig. 1). Patients with massive intracavitary hemorrhage with unstable hemodynamic status would be directly sent to operation room for emergent laparotomy or thoracotomy. The other patients would receive contrast-enhanced MDCT with continuous resuscitation and monitoring during the examination by a trauma team member. The subsequent treatment strategy was tailored according to the results of MDCT. If both abdominal and pelvic injuries needed intervention, laparotomy took precedence only when the MDCT showed (1) major mesenteric tear with active bleeding, (2) massive contrast extravasation from intraperitoneal solid organs in patients who remained hemodynamically unstable despite fluid resuscitation, (3) a massive diaphragm rupture with chest compromise, and (4) contrast extravasation from angioembolization inaccessible vessels. Angiography took precedence in most other situations.

Fig. 1 Algorithm for the management of concomitant blunt abdominal trauma and pelvic fracture patients between 2004 and 2008 (*SBP* systolic blood pressure, *Fr* fracture, *MDCT* multi-detector computed tomography, *CE* contrast extravasation, *ICU* intensive care unit, *HOI*, hollow organ injury)



Angiography was usually performed via a femoral approach. Indications for embolization included active contrast extravasation and/or pseudoaneurysm. At the discretion of the interventional radiologist, TAE was performed with one or more of the following materials: steel coils, Gelfoam pledgets, or polyvinyl alcohol particles. TAE of bilateral internal iliac arteries (IIA), unilateral IIA, or selective arteries was decided by the

radiologist-in-charge to achieve cessation of arterial bleeding. Successful embolization was confirmed by angiographic evidence showing no further bleeding and the return of hemodynamic stability. The angiographs were reviewed by a radiologist (Y.C. Wong). The angiographic findings, need and success rate of TAE, and need and results of repeat angiography were recorded.

Statistics

All statistical analyses were performed using SPSS statistical software program (version 13.0 for Windows). Continuous data were presented as mean \pm standard deviation, and categorical data were presented as numbers and percentages. Comparisons between different groups were made using chi-square or Fisher's exact test for categorical data, and Student's *t*-test or Mann–Whitney nonparametric test for continuous data when appropriate. A two-tailed *p* value <0.05 was considered statistically significant.

Results

Patient background

The demographic data, physiological and laboratory variables, and clinical results of groups I and II patients are shown in Table 1. Compared to group II patients, patients in group I were extremely and severely injured based on ISS; and the pelvic fractures and BAT were more severe on the basis of AIS for the pelvis and the abdomen. Group I patients suffered from more blood loss as denoted by the lower initial hemoglobin level and a greater transfusion requirement. The mortality and morbidity rates were significantly higher in group I.

Modification of treatment strategy according to the clinical pathways

Among these patients, 45 were treated during the early 5 years and 31 in the later 5 years. A total of 762 patients with acute pelvic fractures were admitted in the early 5-year period; 267 of them had concomitant BAT and pelvic

fractures. A total of 755 patients with acute pelvic fractures were admitted in the later 5 years; 278 of them had concomitant BAT and pelvic fractures. The patient number remained constant in the two time periods. However, the incidences of patients undergoing both angiography and laparotomy in all acute pelvic fractures decreased from 6% (45/762) to 4% (31/755) ($p=0.108$); and it decreased from 17% (45/267) to 11% (31/278) ($p=0.055$) in patients with concomitant BAT and acute pelvic fracture in the later 5-year period.

Angiography was performed before laparotomy in 24 (53%) group IA patients; laparotomy took precedence over angiography in 21 patients. Angiography was performed before laparotomy in 19 (61%) group IB patients; laparotomy took precedence over angiography in 12 patients.

Patient background of groups IA and IB

The demographic data, physiological and laboratory variables, and clinical results of groups IA and IB patients are shown in Table 2. The demographic data, physiological and laboratory variables for both groups were essentially identical, except that group IB patients had a significantly higher ISS and AIS for the pelvis. The complication rates were high in both groups. In total, there were 21 deaths (28%). Two of them died as a result of neurological trauma, four as a result of multiple organ failure, 12 as a result of exsanguinating hemorrhage, and three as a result of associated medical diseases. Group IB patients had a similar mortality rate as group IA (9/31, 29% versus 12/45, 26%).

Results of laparotomy

Laparotomy was performed because of persistent unstable hemodynamic status with positive FAST or CT findings of

Table 1 Comparison of demographic data, physiological and laboratory variables, and outcomes between patients requiring both laparotomy and angiography (group I, $n=76$) and patients with concomitant pelvic fracture and blunt abdominal trauma who did not undergo both laparotomy and angiography (group II, $n=469$)

	Group I	Group II	<i>p</i> value
Age (years)	33.2 \pm 17.0	35.6 \pm 16.4	0.265
Gender (M:F)	50:26	282:187	0.348
ISS	35 \pm 13	25 \pm 11	<0.001*
AIS for the pelvis	3.9 \pm 0.8	3.0 \pm 0.8	<0.001*
AIS for the abdomen	3.3 \pm 0.8	2.5 \pm 0.8	<0.001*
Fracture stability (stable:unstable)	32:44	333:136	<0.001*
Initial hemoglobin level (gm/dl)	9.5 \pm 2.5	10.7 \pm 2.7	<0.001*
Initial shock	60 (79%)	225 (48%)	<0.001*
Open fracture	13 (17%)	46 (10%)	<0.001*
Total BT (U)	14.6 \pm 11.7	4.7 \pm 4.4	<0.001*
ICU stay (days)	7.7 \pm 9.6 (1–51)	3.5 \pm 7.1 (1–31)	0.006*
Hospital stay (days)	46 \pm 49 (1–210)	28 \pm 25 (1–119)	0.005*
Complication	48 (63%)	228 (49%)	<0.001*
Mortality	21 (28%)	37 (8%)	<0.001*

M:F male/female, ISS Injury Severity Score, AIS Abbreviated Injury Scale, BT amount of blood transfusion, ICU intensive care unit

*Statistically significant

Table 2 Comparison of demographic data, physiology and laboratory variables, and outcomes between patients requiring both angiography and laparotomy for the treatment of pelvic arterial hemorrhage and abdominal injuries between 1999 and 2003 (group IA, $n=45$) and between 2004 and 2008 (group IB, $n=31$)

M/F male/female, *ISS* Injury Severity Score, *AIS* Abbreviated Injury Scale, *INR* International Normalized Ratio, *Time interval* time interval between arrival at ER and initial definitive therapy, *BT* amount of blood transfusion, *ICU* intensive care unit

*Statistically significant

	Group IA	Group IB	<i>p</i> value
Age (years)	33.3±16.6	33.2±17.7	0.988
Gender (M:F)	29:16	21:10	0.766
ISS	32±11	41±14	0.003*
AIS for the pelvis	3.7±0.8	4.3±0.8	0.008*
AIS for the abdomen	3.2±0.8	3.5±0.9	0.136
Open pelvic fracture	8 (18%)	5 (16%)	0.851
Unstable pelvic fracture	26 (58%)	18 (58%)	0.980
Initial hemoglobin (gm/dl)	9.0±2.6	10.1±2.4	0.081
Prothrombin time (INR)	2.17±2.12	1.87±1.13	0.514
Time interval (min)	155±120	150±150	0.751
Total BT (U)	13.5±14.8	15.8±7.6	0.483
Hospital stay (days)	48.6±47.4 (1–207)	41.9±50.7 (1–210)	0.560
ICU stay (days)	7.5±10.3 (1–51)	8.0±8.7 (1–42)	0.828
Angiography precedent	24 (53%)	19 (61%)	0.492
Nontherapeutic laparotomy	16 (36%)	5 (16%)	0.038*
Complication	29 (64%)	19 (61%)	0.779
Mortality	12 (27%)	9 (29%)	0.821

intraperitoneal free fluid in 50 patients, the development of peritoneal signs on physical examination and suspected hollow organ injury on CT or DPL in 12 patients, abdominal compartment syndrome in 11 patients, and others in three patients. When no therapeutic intervention was performed at laparotomy, the surgeon-in-charge classified this laparotomy as a nontherapeutic laparotomy. Twenty-one laparotomies were classified as nontherapeutic; 16 (36%) in group IA and five (16%) in group IB patients ($p=0.038$).

Results of angiography/TAE

Extravasation of contrast medium and/or pseudoaneurysm were found in 56 angiograms (74%) and TAE was performed for 54 patients. TAE was planned to be performed later in one patient who developed profound shock during angiography. TAE was shifted to surgical hemostasis due to inaccessible bleeder in the other patient. Twenty angiograms showed no definitive or subtle signs of arterial bleeding and two patients received empiric embolization. Seventeen angiograms showed

active bleeding at one anatomical site, ten at two sites, 18 at three sites, nine at four sites and two at five sites. Thirty-one patients received bilateral IIA embolization, 14 had unilateral IIA embolization, and nine had superselective arterial embolization.

The details of angiography/embolization results of group I patients are shown in Table 3. No angiography-related complication, such as groin hematoma, pseudoaneurysm/fistula, and acute renal failure was noted. Bilateral IIA angioembolization was more frequently applied to group IB (19, 61%) patients than group IA (12, 27%) patients. Repeat angiography was performed in 21 (28%) patients, in nine of them after previous bilateral IIA TAE and in 12 after unilateral IIA TAE or superselective TAE ($p=0.052$). Though the rates of repeat angiography did not differ too much between groups IA and IB, the rate of repeat TAE was lower in group IB patients (5, 19% versus 9, 30%). Fourteen (67%) repeat angiographies showed positive findings and TAE was performed again. After successful repeat TAE, ten patients survived, while four patients died (one of multiple associated diseases and three of exsanguinating hemorrhage).

Table 3 Comparison of angiography/embolization data between patients treated between 1999 and 2003 (group IA, $n=45$) and between 2004 and 2008 (group IB, $n=31$)

TAE transarterial embolization, *IIA* internal iliac artery

*Statistically significant

	Group IA	Group IB	<i>p</i> value
With positive findings	31 (69%)	25 (81%)	0.298
TAE (bil IIA:unil IIA:selective:nil)	12:9:9:15	19:6:1:5	0.031*
Repeat angiography	13 (29%)	8 (26%)	0.768
Repeat TAE	9 (30%)	5 (19%)	0.158
Mortality due to exsanguination	7 (16%)	5 (16%)	1.0
Angiography-related complication	0	0	1.0

Priority of treatment options

Angiography took precedence over laparotomy in 43 (58%) group I patients. Laparotomy with or without fracture stabilization had priority in 33 patients. The demographic data, physiologic and laboratory variables, and results of two treatment priorities are shown in Table 4. Patients in whom angiography was priority had a higher incidence of unstable pelvic fractures with higher AIS for the pelvis, and thus, a slightly higher blood transfusion requirement. However, the clinical results did not differ too much when either angiography or laparotomy took precedence. In the later 5 years, angiography took precedence more frequently because intra-abdominal injuries were accurately disclosed by MDCT and the treatment was tailored accordingly.

Discussion

The main challenge for trauma surgeons who manage a patient with concomitant pelvic arterial hemorrhage and BAT is to determine the most immediate threat to life. However, timely management of these patients is impaired by incomplete histories, hemodynamic instability, associated injuries and diseases, and the necessity of a time-critical decision involving many disciplines. Though a number of protocols to treat pelvic fractures can be derived from the literature [2–11], the associated abdominal injuries were often included in these protocols as a part of the treatment pathway for the pelvic fracture and received scanty attention and discussion. A thorough review of these patients to generate an effective algorithm or clinical

guidelines will be helpful to improve the treatment results of such complicated and critical patients.

Current treatment protocols for pelvic fractures rely greatly on FAST to determine the necessity of exploratory laparotomy [4–6]. The CT scan is not used as an initial triage tool [5, 11]. Patients will be rushed to laparotomy if fluid resuscitation fails to stabilize the hemodynamic status and a sizable hemoperitoneum is disclosed on FAST. However, FAST reportedly was not a sensitive triage tool for pelvic fracture and severely injured patients [23, 24]. Besides, the detection of hemoperitoneum is currently not a critical indicator for the surgical management of BAT. Hemoperitoneum on FAST confirms bleeding, but not necessarily active bleeding [25, 26]. Traditionally, CT was not recommended for hemodynamically unstable patients because the procedure often required to transport the patient to areas away from personnel and equipment to manage life-threatening contingencies and the length of time involved was long [5, 11]. Currently, many hospitals have a new generation CT scanner in the emergency room. Fang et al. [14] reported that it only took an average of 10.3 min for a MDCT examination. The results of this study showing similar time interval between arrival at the ER and initial definitive treatment (either laparotomy or angiography) between group IA and IB patients confirmed that initial definitive treatment was not delayed by CT examination. Though patients' condition was critical, only one group IB patient went to the operation room for hemodynamic instability and never made it to the CT scanner. The mortality in the first 24 h of patients suffering from multiple trauma who were admitted to a level I trauma center is due to hemorrhage and exsanguination [27, 28]. A detailed

Table 4 Comparison of demographic data, physiology and laboratory variables, and outcomes between patients with priority for angiography/embolization ($n=43$) and priority for exploratory laparotomy ($n=33$)

	Angiography	Laparotomy	<i>p</i> value
Time period (group IA:group IB)	24:19	21:12	0.675
Age (years)	30.6±14.0	36.6±19.9	0.134
Gender (M:F)	28:15	22:11	0.850
ISS	36±13	34±13	0.456
AIS for the pelvis	4.1±0.8	3.7±0.8	0.046*
AIS for the abdomen	3.4±0.9	3.2±0.8	0.279
Open pelvic fracture	9 (21%)	4 (12%)	0.370
Unstable pelvic fracture	30 (70%)	14 (42%)	0.017*
Initial hemoglobin (gm/dl)	9.4±2.6	9.5±2.5	0.934
Initial prothrombin time (INR)	2.13±2.06	1.83±0.73	0.527
Total BT (U)	15.4±13.5	13.2±8.0	0.506
Hospital stay (days)	38±38 (1–173)	57±59 (1–210)	0.128
ICU stay (days)	6.8±8.1 (1–38)	8.9±11.4 (1–51)	0.363
Nontherapeutic laparotomy	11 (26%)	10 (30%)	0.648
Repeat angiography	13 (30%)	8 (24%)	0.563
Complication	28 (65%)	20 (61%)	0.686
Mortality	13 (30%)	8 (24%)	0.563

M/F male/female, *ISS* Injury Severity Score, *AIS* Abbreviated Injury Scale, *INR* International Normalized Ratio, *BT* amount of blood transfusion, *ICU* intensive care unit

*Statistically significant

survey of the injury was quickly obtained and a tailored therapeutic plan was generated in an oriented manner, which improved the whole treatment process. The improved treatment associated with the usage of contrast-enhanced MDCT in trauma management is in line with what reported by Huber-Wagner et al. [29]. Some laparotomies were avoided according to the MDCT findings, as reflected by the decreased incidence of simultaneous laparotomy and angiography in the later 5-year period despite the fact that the number of patients with concomitant pelvic fracture and BAT remained constant in both time periods. The ISS and AIS for the pelvis were significantly higher in group IB, indicating that some less severely injured patients did not receive laparotomy, angiography, or both after MDCT examination, leaving those severely injured required both procedures for life-saving. These also reflected that the treatment results were actually improved though the complication and mortality rates remained the same.

The nontherapeutic laparotomy rate of patients with pelvic fracture has been reported to range from 29% to 72% [11, 19]. In the current study, 21 (28%) laparotomies were classified as nontherapeutic; 16 (36%) of them were performed in the early 5-year period. Nontherapeutic laparotomy was attributed to inadequate preoperative study [11, 19]. A nontherapeutic laparotomy may adversely affect the prognosis of the patient [7, 11]. Eastridge et al. [7] reported an increased mortality rate in hemorrhagic shock patients with simultaneous presence of hemoperitoneum and unstable pelvic fracture when the patient underwent laparotomy before TAE for the pelvic fracture. In the current series, the rate of nontherapeutic laparotomy decreased from 36% to 16% in the later 5-year period after adopting MDCT as a primary triage tool.

The priority of addressing the intraabdominal injuries or the pelvic hemorrhage control remains controversial. Recommendations as to the priority of treating patients with a hemodynamically unstable pelvic fracture have ranged from early fracture stabilization, early angiography/embolization, and peritoneal pelvic packing to immediate celiotomy with a positive DPL and/or FAST. We preferred angiography except in situations such as major mesenteric tear with massive bleeding, contrast extravasation from angioembolization inaccessible vessels, contrast extravasation from intraperitoneal solid organs in patients who remained unstable despite fluid resuscitation, and massive diaphragm rupture with chest compromise. Angiography is both diagnostic and therapeutic. Its application should have a high priority in the management of complicated severely injured patients. TAE can be sequentially applied to stop multiple bleeders at various anatomic sites in a single angiographic procedure. In the current series, 39 of 56 patients with positive angiography were

found to have more than one bleeding site and most of them were bilateral IIAs. Ten patients had multiple active bleeders from more than one anatomical area, including two from the face and pelvis, four from the abdomen and pelvis, three from the lumbar artery and pelvis, and the last one had active bleeders from the liver, lumbar artery and pelvis. Angiography and subsequent TAE make it possible to treat multiple active bleeders simultaneously and to avoid further trauma of laparotomy in some cases. Control of the arterial hemorrhage before laparotomy also prevents the aggravation of retroperitoneal bleeding due to reduction of the tamponade effect by laparotomy. Some injuries, such as intestinal perforation, are usually not associated with a large amount of bleeding; thus, delaying repairs until the retroperitoneal arterial hemorrhage is controlled by TAE would decrease the overall blood loss.

The successful rate of angioembolization in experienced hands was reported to be between 85 and 100% [15, 18]. However, a small group of patients suffered from persistent or recurrent hemodynamic instability after an initially successful TAE and needed repeat angiography [22, 30, 31]. Ongoing or recurrent pelvic arterial hemorrhage could be attributed to inadequate resuscitation or transient vasospasm at the time of initial angiography or dislodgement of the embolized material after successful initial TAE. In the early 5-year period, significantly more unilateral IIA or selective TAE to the injured arteries were performed. These may contribute to the higher frequency of repeat TAE of group IA patients. Given the fact that the initial angiography revealed active bleeding in bilateral IIAs in most patients and repeat angiography frequently showed new bleeders in the previously negative contralateral IIA, the concept of “damage control angioembolization” proposed by Velmahos et al. [15] should be performed in this specific group of patients to achieve hemostasis.

Limitations of this study are its retrospective design and one single institute data. However, we reviewed our practice and found that the revised clinical algorithm served well for guiding the management pathway. MDCT accurately disclosed active pelvic and intra-abdominal injuries and was helpful in tailoring the subsequent treatment. Priority of laparotomy or angiography should be individualized and customized by clinical evaluation and CT findings. Angiography can be both diagnostic and therapeutic, simultaneously treat multiple bleeders, and thus have a higher priority than laparotomy. Bilateral internal iliac artery embolization for the purpose of damage control for these severely injured patients is suggested. The primary benefits of our recent clinical pathway appear to be in reducing nontherapeutic laparotomy and repeat angioembolization rates.

Conflicts of interest None.

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