Unstable Pelvic Fractures Associated with Femoral Shaft Fractures: A Retrospective Analysis

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Background: Both pelvic fractures and femoral shaft fractures are caused by high-energy injuries. When unstable pelvic fractures and femoral shaft fractures occur concomitantly, the optimal treatment method is controversial. The aim of this study was to establish a reasonable principle for treating such complicated injuries.

Methods: Forty patients sustaining unstable pelvic fractures and concomitant femoral shaft fractures were treated in a 7-year period. The initial management of the fractures was started at the emergency service according to the Advanced Trauma Life Support protocol. Unstable pelvic fractures were wrapped by cloth sheets and femoral shaft fractures were immobilized with a splint. Angiography was performed on patients with unstable hemodynamic status. The definitive treatment for combined fractures was performed after stabilizing the hemodynamics. Closed nailing was used for femoral shaft fractures, and pelvic fractures were treated with various techniques.

Results: The mortality rate was 12.5% (5/40) during admission. Thirty-three patients were followed up for an average of 32 months (range, 12-76 months). There were 33 cases of unstable pelvic fractures and 36 instances of femoral shaft fractures. The union rate for pelvic fractures was 100% (33/33), while femoral shaft fractures had a 94.4% (34/36) union rate. The average healing time was 3.3 months (range, 1.6-8.1 months) and 4.1 months (range, 2.5-18.2 months) for pelvic and femoral shaft fractures, respectively. After fracture, 34 hips (94%) achieved a satisfactory result in the Harris hip score and 30 knees (83%) achieved a satisfactory result in the Mize knee score.

Conclusions: Stabilization of the hemodynamics in patients with combined fractures should be the first aim. Angiography to stop arterial bleeding in the pelvis is often life-saving. The definitive treatment for combined fractures, such as pelvic fractures and femoral shaft fractures, should wait until hemodynamics is stabilized.

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Key words: combined fracture, femoral shaft fracture, pelvic fracture, unstable fracture

At a Glance Commentary

Scientific background of the subject

The concomitant pelvic fractures and femoral shaft fractures are high-energy trauma, causing multiple associated injuries. The aim of this study is to provide a reasonable principle for such complicated injuries.

What this study adds to the field

According to our study, stabilization of the hemodynamics in patients with combined fractures should be the first aim, and angiography is often life-saving.

Both isolated pelvic fractures and isolated femoral shaft fractures are normally caused by high-energy injuries, have a high mortality rate, and are associated with multiple injuries.[1] With the popularization of high-speed vehicles, multiple injuries have become much more complicated and frequent. Despite advancements in modern medical care and technology, treatment of multiple complicated injuries remains a great challenge for all surgeons.

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Mortality rates of 1.5-9.8% and 7.9-42% have been reported for isolated femoral shaft fractures and isolated pelvic fractures, respectively.[1-4] Moreover, the mortality rate may be as high as 50-77% for femoral shaft fractures associated with pelvis, thorax, head, or abdomen injuries.[1] When unstable pelvic fractures and femoral shaft fractures occur concomitantly, the optimal treatment method remains controversial. Liebergall *et al*. described the issue of "floating hip" and defined concomitant ipsilateral pelvic and femoral fractures as type A floating hip.[5] However, to the best of our knowledge, there are few studies reporting clinical and functional outcomes for combined unstable pelvic and femoral shaft fractures.[6] Besides, there is no study discussing about the priority and the optimal treatment for this combined unstable pelvic and femoral shaft fractures. In literature, retroperitoneal pelvic packing and the angiography are both effective tools in control hemorrhage in pelvic fracture, but they will need direct comparison in the future studies.[7,8] Therefore, the optimal treatment is controversial.

The initial management of unstable pelvic fractures has been greatly improved, and wrapping the unstable pelvis is considered to be effective during initial resuscitation.[9] We hypothesize that initial wrapping of unstable pelvic fractures and aggressively performing angiography with embolization to stop arterial bleeding in the pelvis is the most effective initial treatment plan for complex combined fractures. Then, following scheduled plans for treating combined fractures may greatly improve the outcomes in treating such complicated injuries. This retrospective study reports our experience in the treatment of combined fractures. Hopefully, a reasonable principle for treating such complicated injuries might be established.

METHODS

This study had been approved by the institutional review board (IRB) of our institution. From March 2002 to March 2009, 146 adult patients (≥ 15 years) with combined pelvic and femoral shaft fractures were treated at our institution. Only 40 patients with unstable pelvic fractures and femoral shaft fractures were enrolled in this study. Five patients died during hospitalization as a result of severe associated injuries (two patients died as a result of intracranial hemorrhage, two patients died from massive internal abdominal bleeding due to liver laceration, and one patient died from abdominal aortic traumatic rupture). Two patients were excluded due to insufficient follow-up data. Thirty-three patients were followed up for an average of 32 months (range, 12-76 months). Patients' age ranged from 18 to 54 years (average, 30 years) with a male-to-female ratio of 19:14.

Fracture type was classified using the Tile's classification system for pelvic fractures and Winquist classification system for femoral shaft fractures.[10,11] In this study, unstable pelvic fractures were defined in the clinic as pelvic fractures that could be moved manually in any direction, or in plain radiographs and computed tomography (CT) scan images, fractures that were classified as type B or C using Tile's classification system.[6,10] Inclusion criteria for this study included the following: Skeletally mature patients admitted at our institution on the day of injury, concomitant unstable pelvic and femoral shaft fractures, and regular follow-up examinations at our institution for at least 12 months. Exclusion criteria included the following: (1) the patient died before reaching our institution, (2) the patient was transferred from another institution after resuscitation, or (3) the patient had previously received major orthopedic treatments for the pelvis or the femur, such as total hip replacement or internal fixation of the pelvis.

The initial injury management began at the emergency service according to the Advanced Trauma Life Support (ATLS) protocol. Patients with internal abdominal bleeding received laparotomy. We defined unstable hemodynamics as initial systolic blood pressure (SBP) below 90 mmHg or the presence of clinical signs of insufficient organ perfusion (oliguria, mental confusion not due to head injury or intoxication) even after ATLS resuscitation and infusion.[12] At our institution, we prescribed angiography to be the first choice of treatment for stopping arterial bleeding in the pelvis.[8] Angiography was performed as soon as possible for patients with the following conditions: (1) patients with a major pelvic fracture, who had unstable hemodynamics after non-pelvic sources of blood loss had been ruled out; (2) patients with pseudoaneurysm formation or contrast extravasation in the pelvis by CT scanning image; and (3) patients who had initial SBP between 90 mmHg and 100 mmHg and non-pelvic sources of blood loss, but SBP was still below 100 mmHg after massive blood transfusion of more than 4 units within 24 h.[13] All patients with pelvic ring fractures underwent CT scanning of the pelvis at the emergency service. Patients with unstable pelvic fractures were wrapped with a cloth sheet and a temporary long leg splint was applied for the femoral shaft fracture. For the patients with major associated injuries (e.g., intracerebral hemorrhage, blunt abdominal trauma, or pulmonary injuries), the damage control surgeries were done as soon as possible after enough resuscitation and angiographic embolization. An upper tibial traction or an external fixator for femoral shaft fractures was applied before definitive orthopedic treatment. An adjuvant anterior frame of Hoffmann external fixator for unstable pelvic fractures was inserted depending on the decision of orthopedic surgeons.

After hemodynamics of the patient was stabilized, the orthopedic treatment for both fractures was performed as soon as possible.[14] The definitive treatment procedure and the priority for each fracture were decided by individual orthopedic surgeons. Normally, closed reamed intramedullary nailing was the first choice for treatment of femoral shaft fractures, but plating or external fixator was also be considered if the patients had severe pulmonary injuries or open type fractures. Pelvic fractures were treated with various techniques according to the fracture pattern (e.g., sacroiliac screws, plating, interfragmental screws, or external fixator) [Table 1]. Postoperatively, patients were permitted to ambulate with protected weight bearing, depending on fixation stability, as early as possible.

Bone union was defined clinically as no pain or tenderness and radiographically as the presence of solid bridging callus or trabeculae connecting fracture fragments, which could be seen in at least three aspects in the anterioposterior and lateral plain views.[15] Bone healing time was defined as the period between the day of injury and the day of bone union. Non-union was defined as fractures without union after 1 year of treatment or requirement of another surgery to achieve union.[16] Malunion of the femur was defined if one of the following criteria was met: Shortening of more than 2.5 cm, or angular or rotational deformity of more than 10.[15] Pelvic malunion was defined for the patients with one of the following conditions: Vertical displacement or anterioposterior translation more than 10 mm, or symphysis pubis diastasis more than 25 mm, or residual deformity > 15.[17,18]

This combined complicated fracture was due to high-energy trauma, known as floating hip, and associated injuries of lower extremity were often. Besides, the patients with femoral shaft fracture would suffer from knee stiffness occasionally. Therefore, the function of the hip joint was evaluated according to the Harris hip rating system.[19] A total of 100 points was given and a score of 100-90 points was rated excellent, 89-80 points was rated good, 79-70 points was rated fair, and less than 70 points was rated poor. Knee function was evaluated by the Mize scoring system with division into four grades.[20] This rating system was used because of its simplicity and relative practicality. An excellent grade denoted flexion loss of < 10, full extension, no varus or valgus deformity, and no pain. A good grade denoted no more than one of the following: flexion loss of > 20, extension loss of > 10, varus or valgus deformity of > 10, or minimal pain. A fair grade denoted any two criteria listed in the previous category. A failure grade denoted any of the following: flexion of < 90, varus or valgus deformity of > 15, or disabling pain. A satisfactory result included an excellent or good grade.

RESULTS

All injuries were caused by high-energy trauma. Twenty-seven combined fractures (81.8%) were due to traffic accidents and six combined fractures (18.2%) were caused by fall from heights. Five patients died due to severe associated injuries, and the mortality rate was 12.5% (5/40). Most patients had multiple associated injuries [Table 2]. The types of pelvic and femoral shaft fractures are shown in Table 3.

Angiography was performed in 14 patients, and 13 arterial bleeding sites were successfully stopped by embolization. The most common bleeding site was the internal iliac artery (57.1%). One patient had both internal and external iliac artery bleeding. Two patients had no arterial bleeding [Table 4].

There were 33 unstable pelvic fractures and 36 femoral

Table 1: Various techniques for pelvic fractures and femoral shaft fractures

Fixation methods	No.
Pelvic fracture	
External fixator	6
Sacroiliac screws	12
Interfragmental screws	5
Plating	5
External fixator and sacroiliac screws	2
Interfragmental screws and plating	1
Sacroiliac screws and plating	2
Femoral shaft fracture[a]	
Intramedullary nailing	30
External fixator	2
Plating	4

[a]Three patients had bilateral femoral shaft fractures

Table 2: Numbers of associated injuries

Injury	No.
Central nervous system	6
Subarachnoid hemorrhage	3
Subdural hemorrhage	1
Intracerebral hemorrhage	2
Chest	12
Lung contusion	1
Hemopneumothorax	11
Abdominal	13
Gastrointestinal injury	9
Liver laceration	3
Kidney laceration	1
Pelvic arterial bleeding	12
Genitourinary	11
Bladder rupture	7
Urethral injury	2
Genital organ injury	2
Musculoskeletal	40
Tibiofibular	15
Acetabular	2
Spinal	12
Hand	1
Foot	1
Humeral	4
Radioulnar	5

shaft fractures. Twenty-eight femoral shaft fractures were closed type and eight femoral shaft fractures were open type. Of the eight open-type femoral shaft fractures, four fractures were Gustilo type II, three were Gustilo type IIIa, and one fracture was Gustilo type IIIb.[21] Twenty-nine unstable pelvic fractures were closed-type fractures and four were open-type fractures. All 33 pelvic fractures (100%) healed in an average of 3.3 months (range, 1.6–8.1 months), and 34 of the 36 femoral shaft fractures (94.4%) healed in an average of 4.1 months (range, 2.5-18.2 months). There were two non-unions (5.6%) and one malunion (2.8%) in patients with femoral shaft fractures. One femoral non-union was a Gustilo type IIIa open, type IV Winquist comminuted fracture, and the other femoral non-union was a Gustilo type II open, type II Winquist comminuted fracture. The pelvic fractures in both of these patients healed, but femoral shaft non-unions were complicated with osteomyelitis. After repeated debridements, both patients could walk with crutches or a walker without pain at the end of this study. Three patients with open pelvic fractures had wounds over the iliac area (5 cm, 3 cm, and 1.5 cm, respectively), and the wounds were primarily sutured. One patient had rectal laceration and deep perineal laceration, which resulted in pelvic osteomyelitis. Diverting colostomy was performed on this patient, and after repeated debridements and implantation of antibiotic beads, the osteomyelitis was well controlled and all fractures in this patient healed uneventfully [Figure 1]. There were five patients with pelvic malunion. Of the five pelvic deformities, one patient had vertical displacement more then 10 mm, two patients had symphysis pubis diastasis more than 25 mm, and two patients had residual rotational deformity more than 15°. Both of the patients with residual rotational deformity had anterior groin pain, and the other three patients could walk without pain and were unable to return to work.

Wound infections occurred in six femora and five pelvises. One patient had pin-tract infection of the pelvis. All wounds eventually healed with repeated aggressive surgical treatments. Osteomyelitis was noted in three femora, one

Table 3: Fracture types

Fracture types	No.
Pelvic fracture type (*n*=33)	
Tile B	25
B1	16
B2	5
B3	4
Tile C	8
C1	6
C2	1
C3	1
Femoral shaft fracture type (*n*=36)	
Winquist type I	16
Winquist type II	8
Winquist type III	7
Winquist type IV	5

Table 4: Bleeding sites (*n*=13) in 14 patients with angiography

Site	No.
Internal iliac artery	8
Common iliac artery	1
External iliac artery	1
Internal pudendal artery	1
Uterine artery	1
Superior gluteal artery	1
Negative finding	2

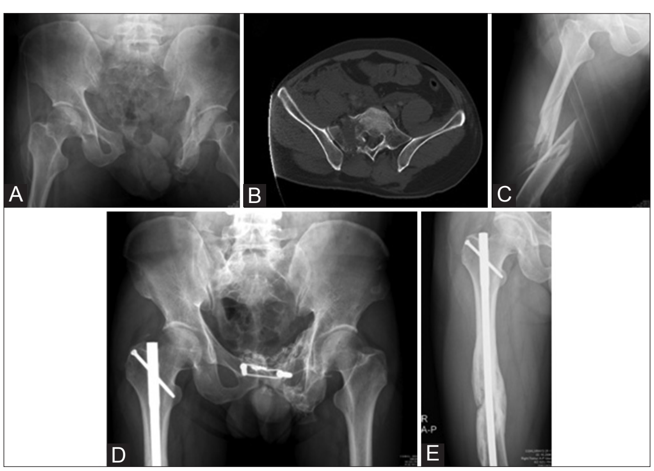

Figure 1: A 32-year-old man sustained a right Tile C1 open fracture (A, B) and a right Winquist type IV femoral shaft fracture (C). Femoral shaft external fixation was performed, followed by anterior internal fixation and antibiotic beads with femoral interlocking nailing (D, E). Pelvic osteomyelitis was under control and all fractures healed

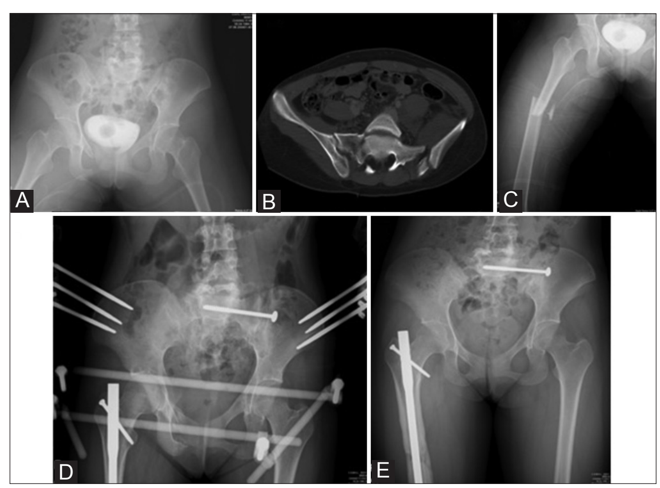

Figure 2: A 20-year-old woman sustained a left Tile B3 pelvic fracture (A, B) and a right Winquist type I femoral shaft fracture (C). After receiving described treatment (D, E), the shaft healed at 3.8 months. Excellent hip and good knee functions were noted at the 21-month follow-up

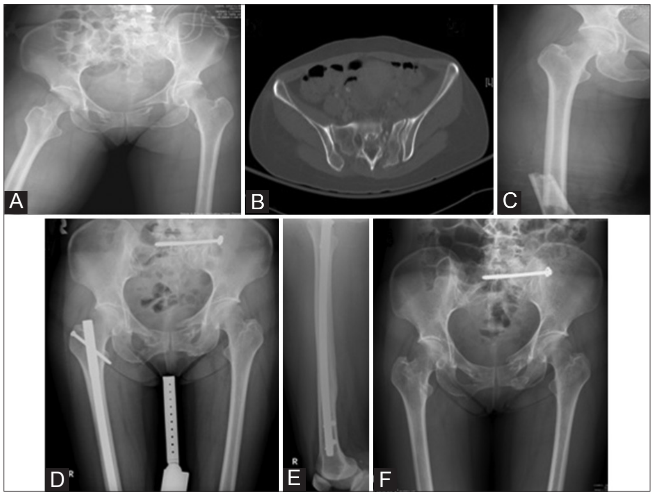

Figure 3: A 45-year-old woman sustained a left Tile C1 pelvic fracture (A, B) and a right Winquist type I femoral shaft fracture (C). After receiving described treatment (D, E), the shaft healed at 3.1 months. At the 22-month follow-up, hip and knee functions were rated as good and excellent, respectively (F)

knee, and one pelvis. One patient had leg length discrepancies of 3 cm, and the patient had limping gait without pain and was able to return to work at the end of this study. No fat emboli or acute respiratory distress syndrome (ARDS) was noted in the whole course of treatment.

Among the 33 patients, hip function was rated as excellent in 21 patients, good in 13 patients, and fair in 2 patients. Knee function was rated as excellent in 24 patients, good in 6 patients, fair in 3 patients, and failure in 3 patients [Figures 2 and 3]. Of all the patients, 94% and 83% had satisfactory hip and knee function, respectively.

DISCUSSION

Despite the improvement of techniques for resuscitation and medical care, management of polytrauma patients in the initial stage is still a great challenge for all surgeons. In our study, the combined fractures resulted from high-energy injury with life-threatening conditions, and the mortality rate was 12.5%. During the orthopedic operation in these patients, the surgeons should closely monitor the stability of hemodynamics and the possibility of associated injuries due to the high-energy injury mechanism. Control of pelvic hemorrhage is one of the key steps to decrease pelvic fracture-related mortality.[22] Initial wrapping for unstable pelvic fractures and early angiography to control arterial bleeding in the pelvis may improve the success rate.[8,23]

The possible bleeding sources in pelvic fractures include arterial, venous, and cancellous bone. Moreover, 35% of major pelvic fractures may be associated with internal abdominal bleeding.[24] In principle, control of internal abdominal bleeding is critical for successful treatment. Angiography is considered to be the optimal choice for controlling active arterial bleeding in the pelvis and should be performed within 90 min on hemodynamically unstable patients with pelvic fractures without other obvious sources of bleeding.[8] In this study, three patients had internal abdominal bleeding. Although emergent laparotomy was performed, all three patients died. More aggressive control of hemorrhage is imperative.

The role of pelvic binding to reduce pelvic volume and consequently reduce venous bleeding has been supported.[25] Knops *et al*. reported that pelvic circumferential compression devices (PCCDs) provided sufficient reduction in unstable pelvic fractures without undesirable over-reduction and significant displacement over the posterior sacroiliac joint. Several PCCDs are available, and each may have a satisfactory effect.[9] Noninvasive pelvic wrapping is another safe and fast method recommended as one of the first steps for prompt application in hemodynamically unstable patients with unstable pelvic fractures.[23] Closed pelvic reduction can decrease bone-associated bleeding, and early fixation helps position the patients for ventilation, decreases pain and discomfort, and helps mobilization.[10] Scannell *et al*. retrospectively reviewed patients sustaining severe injury with femoral shaft fractures and reported that skeletal traction for femoral shaft fracture as a temporization method remained a practical option.[26] Although skeletal traction for the femur is simple, inexpensive, and requires no general anesthesia, early definitive stabilization of femoral shaft fractures is usually necessary to improve patient care.

The reported mortality rates in combined femoral shaft fractures and pelvic injury were 8.7-50%, and death within the first 24 h after injury was most often a result of acute blood loss.[1,4,6] In this study, the mortality was 12.5%, a little higher than 8.7%. It is thought that the number of patients is few in both studies, and the injury severity may be less in the past, so it is difficulty to compare the mortality precisely. We performed aggressive hemostasis with angiography and treated associated injuries in the order as our plan. Finally, we achieved a 12.5% mortality rate. The principle developed by our institution seems to be effective. To control pelvic bleeding, pelvic retroperitoneal packing has been advocated. Although it is feasible, initial pelvic retroperitoneal packing has not yet been accepted worldwide.

In this study, the overall non-union rate of femoral shaft fractures was 5.4% (2/36), but the non-union rate was 25% (2/8) in open femoral shaft fractures, and both of the open femoral shaft fractures became osteomyelitic. The non-union rate reported in previous studies was 1.64-14.1% for isolated femoral shaft fractures.[27,28] These studies differed from our study in that these studies examined isolated femur fractures and our study examined combined fractures.

In the present study, the union rates of pelvis and femoral shaft fractures were 100% and 94.4%, respectively. Patients with concomitantly unstable pelvic and femoral shaft fractures still had satisfactory hip and knee function. This feature may be explained as concomitant ipsilateral femoral neck and shaft fractures.[29] Most of the injury forces may be dissipated in the pelvis and result in less injury in the femoral shaft.[6] As long as infection is prevented, femoral shaft fractures can be treated following the common principle.

There were no fat emboli or ARDS complications in this study. In our institution, the polytrauma patients initially received aggressive angiography and resuscitation at the emergency service. Definitive treatment of pelvis and femoral shaft fractures was performed as soon as possible after hemodynamics was stabilized. This may account for the positive clinical outcomes observed in this study. Robinson *et al*. demonstrated that the outcomes of clinical importance include pulmonary dysfunction because of its relationship with significant morbidity and mortality in polytrauma patients.[30] Numerous studies have established the beneficial effects of early fixation of femoral shaft fractures in terms of reducing the incidence of pulmonary complications and mortality.[13,30] Early fracture stabilization helps patients for mobilization, improvement in pulmonary status, lowered incidence of deep venous thrombosis, and ease of nursing care.[31] Morshed *et al*. reported that delayed internal fixation of femoral shaft fractures between 12 and 24 h reduced mortality by approximately 50%, especially for patients with severe abdominal injury.[32] Pape, *et al*. suggested that patients with chest injuries might benefit from delayed treatment.[33] The major reason and benefit for delayed repair are that well-resuscitated state of the patients has been adequately achieved beyond 12 h.[32] In this study, definitive treatment of combined fractures was delayed until hemodynamics was stabilized for at least 12 h.

While treating the patient with the fracture table for the femoral shaft fracture, it is necessary to move the patient smoothly. Although the traction force of fracture table is much less than the high-energy injury force, the surgeon still should be careful about the over-traction for the femoral shaft fracture to prevent the secondary injury to pelvic fractures or re-bleeding from the pelvic cavity. In addition, the surgeon should also pay more attention to the sterilization of the surgical field because some of these patients had been treated with pelvic external fixator or sheet rapping, and it was helpful to move the sheet close to the anterior superior iliac spine.

To the best of our knowledge, there are no studies specifically discussing about the priority of treatment of the concomitant unstable pelvic and femoral shaft fractures. In our study, the priority for each fracture was decided by individual orthopedic surgeons. In order to decrease the pulmonary complication and prevent the swing of femoral shaft fracture during the treatment of unstable pelvic fracture, some of the 33 patients were treated for femoral shaft fractures prior to the unstable pelvic fractures. On the other hand, some orthopedic surgeons preferred to treat unstable pelvic fracture first in the cause of prevention of secondary injuries to unstable pelvic fractures or re-bleeding from pelvic cavity resulting from traction force when treating femoral shaft fractures, and to decrease the difficulty in anatomic reduction of femoral shaft fractures in patients with unstable pelvic fractures. In our experience, the different priority of treatment of the fractures did not obviously affect the outcomes of these patients. In addition, since this was a retrospective study and the treatment of fractures was not preformed by the same orthopedic surgeon, it was difficult to compare the benefits of priority of surgeries in the patients with concomitant unstable pelvic and femoral shaft fractures. A further prospective study is necessary to establish a more reasonable protocol for the combined unstable pelvic and femoral shaft fractures in the future.

The limitations of our study include that the study was retrospective in design and included a small number of patients. Therefore, a randomized, controlled study could not be implemented. After all, patients with concomitant unstable pelvic and femoral shaft fractures are rare and a sufficient sample size for study is very difficult to obtain. The advantages of our study include that this study is the largest case series reporting concomitant unstable pelvic fractures and femoral shaft fractures. In addition, the follow-up rate was high (94.3%, 33/35 patients). However, continuous improvement of resuscitation and fixation techniques cannot be abandoned.

On the basis of the clinical and theoretical considerations presented, we conclude that initial aggressive resuscitation for stabilization of the hemodynamics, and damage control surgeries done soon after the well resuscitation and angiographic embolization, followed by the scheduled treatment of combined fractures may achieve a high success rate and low mortality rate. Unstable pelvic fractures may be temporarily immobilized with pelvic sheeting. Angiography to stop arterial bleeding in the pelvis is often life-saving. Femoral shaft fractures in combined fractures may be treated following the principle for treatment of isolated femoral shaft fractures.

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