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Temporary Balloon Occlusion of the Abdominal Aorta in Treatment of Complex Acetabular Fracture

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Background: The aim of this study was to explore the efficacy of temporary balloon occlusion of the abdominal aorta assisting open reduction and internal fixation (ORIF) in the treatment of complex acetabular fracture.

Material/Methods: From August 2000 to October 2011, a total of 48 patients with complex acetabular fracture were enrolled in this study. Average operative time, intraoperative blood loss volume, blood transfusion volume, satisfactory reduction, and postoperative functional recovery rate were recorded and compared between the 2 groups.

Results: A significant difference was observed between the 2 groups in operative time (P=0.003). For intraoperative blood loss and blood transfusion, ORIF combined with temporary balloon occlusion of abdominal aorta techniques appeared to be superior to normal ORIF (blood loss: P=0.007; and blood transfusion: P=0.019, respectively). However, no differences were observed in postoperative blood loss or transfusion (P>0.05). Patients in group A showed better hip function than those in group B (group A: a good-to-excellent rate of 77.8%; group B: a good-to-excellent rate of 78.3%; P>0.05). With regard to the incidence of postoperative complications, there were no significant differences between the 2 groups (group A: 9/18; group B: 11/23; P=0.890).

Conclusions: In the treatment of complex acetabular fracture, temporary balloon occlusion of the abdominal aorta is a reliable technique to assist ORIF surgery to staunch the flow of blood.

MeSH Keywords: Aorta, Abdominal • Balloon Occlusion • Fractures, Bone • Internal Fixators

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Background

The incidence of acetabular fracture is gradually rising due to the increased incidence of high-energy injuries. The hip joint is the most important weight-bearing joint in humans. Therefore, as an intra-articular fracture with deep anatomical position and complex types, acetabular fracture should be treated with accurate anatomic reduction, firm fixation, and early rehabilitation, which can obtain optimal results as soon as possible [1,2]. Usually, acetabular fractures are managed with surgical fixation unless criteria for conservative treatment are fulfilled [3]. However, the treatment of acetabular fractures is a major challenge for most orthopedists, not only due to combined multiple organ injuries, but also due to the complicated fracture type and complexity of surgical reconstruction [4,5].

Most authors agree that positive open reduction and internal fixation (ORIF) during the early stage of complex acetabular fracture helps to restore hip joint function postoperatively [6–9]. However, in recent years many have advocated ileo-inguinal and Kocher-Langenbeck approaches combined with the procedure above, which can develop a bottleneck when performing reduction [10,11]. Moreover, the complications with this fracture, including severe soft tissue injury, intractable reduction, vulnerability of nerve and blood vessels, serious hemorrhage, and unclear exposure of the operative field, might result in difficult reduction, prolonged operation time, and poor functional recovery [12]. Therefore, limiting intraoperative blood loss in orthopedic trauma surgery remains challenging for orthopedic surgeons.

In recent years, the use of an abdominal aortic occlusion balloon catheter to control excessive blood loss during surgery has been developed, including use in cesarean hysterectomy [13] and other pelvic and sacral operations [14]. However, the effect of these techniques in assisting ORIF has been unclear. Therefore, the purpose of this study was to investigate the efficacy of temporary balloon occlusion of the abdominal aorta in ORIF of complex acetabular fractures.

Material and Methods

This retrospective study was approved by the Affiliated Shandong Provincial Hospital of Shandong University Institutional Review Board. Informed written consent was obtained from each participant.

A total of 41 patients, who were treated for acetabular fractures at the Affiliated Shandong Provincial Hospital of Shandong University from November 2000 to November 2010, were enrolled in this study. The type of acetabular fracture was confirmed according to Letournel classification [15]. The inclusion criteria of this study were: 1) subjects with complex acetabular fracture; 2) all patients aged no more than 60 years; and 3) individuals diagnosed with the following types of fractures: anterior column with posterior hemi-transverse fracture, transverse with posterior wall fracture, T-shaped fracture, and both-column fracture. Exclusion criteria were: 1) age over 60 years; 2) pathological fracture or other fractures; 3) cardiac disease, diabetes, vascular disease of lower extremities, cancer, or immunodeficiency; and 4) absence of follow-up information. All data, including patient demographics and operative data, were collected from the hospital records.

All patients received a routine X-ray radiograph, computed tomography (CT) scan, and 3D CT reconstruction before surgery. All operations were performed by the same fellowship-trained surgeon. Under general anesthesia, ORIF of complex acetabular fracture was carried out. Then, the temporary balloon occlusion of the abdominal aorta was performed; it should be used on patients if they have obvious displacement of acetabular fracture, broad dissection area, difficult reduction, or anticipation of severe hemorrhage. The Kocher-Langenbeck approach, as previously described [16], was used to assist intraoperative ORIF. All patients received reconstructive plate fixation of antero-posterior columns of the acetabulum (Figure 1).

Recovery status of patients was recorded. A routine, broad-spectrum antibiotic and non-steroidal anti-inflammatory drug (NSAID) were administered to every patient after the operation. Postoperative functional exercise was performed if pain allowed. After partial weight-bearing at 6~8 weeks postoperatively, we gradually added weight to full weight-bearing, according to the individual state of the patient.

During regular follow-up, we performed X-ray radiography to evaluate the position of screws. The operation time, intraoperative blood loss, and transfusion volume during the operation were recorded. The reduction was assessed according to modified Matta reduction criteria [2]: excellent: anatomical reduction of the fracture; good: 0~1 mm displacement unresolved; medium: 2~3 mm displacement unresolved; and poor: >3 mm displacement unresolved. The hip function was determined based on the modified Merle d'Aubigné and Postel hip scoring system [2,17]: pain: 6 points, walking: 6 points, range of motion of hip joint: 6 points (18 points in total). An excellent score is 18 points; good is 15~17 points; medium is 13~14 points; and poor is <13 points.

Statistical analysis was conducted with SPSS 19.0 software. All variables for each group were compared using a paired *t* test. Independent-samples *t* tests and Mann-Whitney *U* test were used for comparisons between groups. The chi square test was used for ratio comparisons. Statistical significance was set at $P<0.05$.

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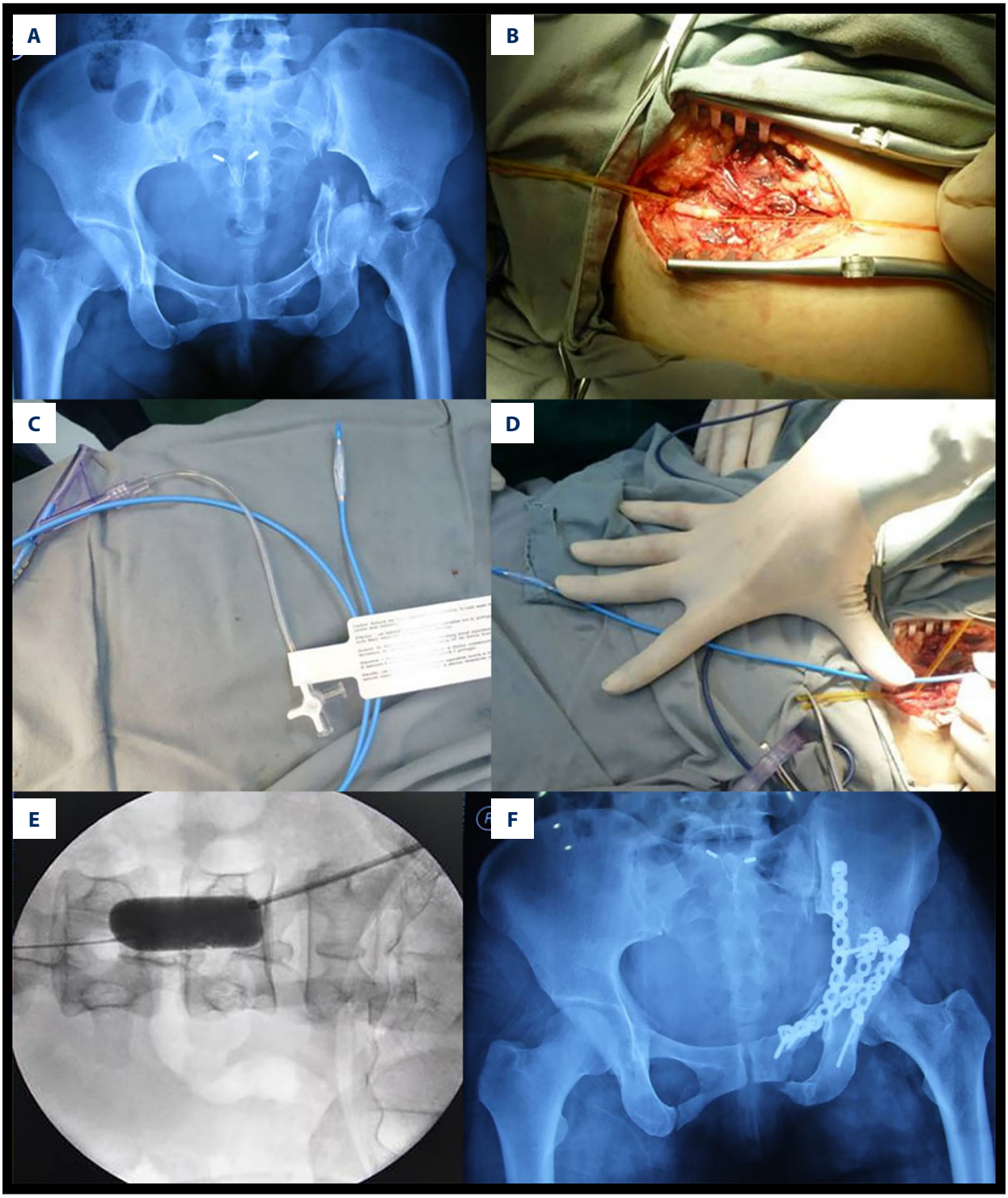

Figure 1. This is a female patient aged 35 years who had a pelvic fracture and a left acetabular both column fracture caused by a traffic accident. (**A**) X-ray radiograph shows left acetabular fracture and bilateral fracture of pubic rami; (**B**) Longitudinal incision away from inguinal ligament, exposing femoral artery, with 2 blocking belts in reserve; (**C**) Fogarty balloon catheter to be deployed; (**D**) Assessing the length of catheter to be used before catheterization; (**E**) Determining the Fogarty balloon catheter to be deployed exactly between L3 and L4 vertebral bodies under radiography; (**F**) Postoperative radiograph showing satisfactory reduction and fixation.

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Table 1. Demographics of subjects including in this study.

Characteristic	Group A	Group B	*P* value
Case	18	23	–
Gender (male/female)	11/7	14/9	0.978
Mean age (years)	34.2 ± 2.5	34.0±2.1	0.947
Letournel classification			0.853
Anterior column with posterior hemi-transverse	6	5	
Transverse with posterior wall	4	7	
T-shaped	5	7	
Both-column	3	4	
Time from injury to surgery (days)	9.1±0.8	9.9±0.7	0.471

Table 2. Comparison of intraoperative and postoperative data between the two groups.

Data	Group A	Group B	*P* value
Operative time (min)	213.3±8.9	248.3±7.0	0.003
Intraoperative blood loss volume (mL)	1247.2±67.1	1526.1±69.9	0.007
Intraoperative blood transfusion volume (mL)	1066.7±59.8	1304.3±72.2	0.019
Postoperative blood loss volume (mL)	106.4±11.5	111.1±9.8	0.756
Postoperative blood transfusion volume (mL)	55.6±21.7	60.9±19.6	0.857
Good-to-excellent rate of reduction	83.3 (15/18)	82.6 (19/23)	0.952

Results

All demographic data are shown in Table 1. There were 18 patients who underwent ORIF combined with temporary balloon occlusion of the abdominal aorta (group A) and 23 patients who only received normal ORIF. The follow-up ranged from 12 to 30 months (mean, 7.5).

Intraoperative and postoperative data are listed in Table 2. The mean time for performing temporary balloon occlusion of the abdominal aorta was 50.5±17.6 min. The mean operative time was 213.3±8.9 min in group A and 248.3±7.0 min in group B. We observed a significant difference between the 2 groups in operative time (P=0.003). For intraoperative blood loss and blood transfusion, ORIF combined with temporary balloon occlusion of the abdominal aorta appeared to be superior to normal ORIF (blood loss: P=0.007; and blood transfusion: P=0.019). However, no differences were observed in postoperative blood loss or transfusion (P>0.05). In group A, we did not observe any complications associated with occlusion of the abdominal aorta, including arterial puncture, renal impairment, spinal cord ischemic injury, ischemic necrosis of abdominal or pelvic organs, and vascular intimal injury. According to assessment of the reduction described by the Matta reduction criteria [2], in group A 10 cases were identified as excellent, 5 as good, 2 as medium, and 1 as poor, with a good-to-excellent rate of 83.3%. In group B, there were 12 cases identified as excellent, 7 as good, 2 as medium, and 2 as poor, with a good-to-excellent rate of 82.6%. The good-to-excellent rates in both groups were comparable (P>0.05). Based on the modified Merle d'Aubigné and Postel system [2], in group A hip function was excellent in 9 cases, good in 5, medium in 3, and poor in 1, with a good-to-excellent rate of 77.8%. In group B hip function was excellent in 11, good in 7, medium in 3, and poor in 2, with a good-to-excellent rate of 78.3%. This suggests that hip function in the 2 groups was equivalent (P>0.05).

With regard to postoperative complications, in group A we observed 2 cases with incision fat liquefaction and 3 cases in group B. Deep venous thrombosis of lower extremities was present in 1 case in group A, 2 in group B, cured by anticoagulant therapy. There was 1 osteonecrosis of the femoral head in group A and 1 in group B, stabilized by conservative treatment. There were 3 heterotopic ossifications in group A and 4 in group B, treated by indomethacin. There were 2 transient paralysis of the sciatic nerve in group A and 1 in group B. There were no significant differences in the incidence of

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complications between the 2 groups (group A: 9/18; group B: 11/23; P=0.890).

Discussion

It is difficult to perform a surgical approach to the acetabulum and to conduct an accurate ORIF due to the complicated anatomical structure and deep location of the acetabulum, as well as the risk of serious hemorrhage. Therefore, a thorough preoperative diagnosis and treatment plan, including the order of reduction and method of fixation, are necessary. A sufficient surgical field must be secured during the actual surgical procedure; therefore, it is important to control bleeding using temporary balloon occlusion of the abdominal aorta.

According to the Letournel classification [15], complex acetabular fractures are usually classified into 4 types: anterior column with posterior hemi-transverse fracture, transverse with posterior wall fracture, T-shaped fracture, and both column fracture. Acetabular fractures are usually caused by high-energy injury with severe associated or multiple injury, including life-threatening head injury and organ injury in the thoracic and abdominal cavities, with severe hemorrhage. Due to the deep anatomical position of the acetabulum, damage to major nerves and blood vessels should be avoided during the operation; therefore, it is necessary to ensure adequate exposure of the operative field to avoid this risk. Several combined approaches for complex acetabular fracture have been developed to control hemorrhage risk [1,17,18]; however, outcomes were not satisfactory.

The balloon catheter was first used in vascular interventional treatment, including angioplasty and perfusion therapy, as well as embolization therapy, to prevent flux and reflux, especially for those who may have an increased risk of severe blood loss during the operation. Crawford et al. [19] first inserted a Fogarty balloon catheter into organ arteries to preclude the blood flux, and then clasped the abdominal aorta and removed the aneurysm. After that, abdominal aorta occlusion was gradually used more in various operations, including removal of gynecological, pelvic, and sacral tumors. This technique can efficiently control intraoperative hemorrhage and limit postoperative complications. Given the severe intraoperative hemorrhage in complex acetabular fractures, we hypothesized that using temporary balloon occlusion of the abdominal aorta might decrease intraoperative blood loss and improve the operative field. The decision to start occlusion should be based on the intraoperative blood loss volume after the exposure of fracture ends.

The occlusion time should be limited to no more than 60 min so that there is less damage from complete ischemia [20]. If occlusion time is over 60 min, the occlusion should be paused (the incision should be staunched using gauze) and resumed 15 min later. In this study, we did not observe any complications caused by occlusion.

Several limitations of this study should be mentioned. First, this was a study based on retrospective analysis, not a randomized controlled trial, which might have resulted in selection bias. Second, the sample size in this study was relatively small; therefore, a randomized control study with larger sample size is needed to provide stronger conclusions. Finally, the follow-up period could be considered as being relatively short since it was only 30 months.

Conclusions

Use of temporary balloon occlusion of the abdominal aorta assisting ORIF in treatment of complex acetabular fractures can effectively prevent excessive blood loss. This new technique can help create a clear operative field by reducing blood flux, thereby making reduction and fixation easier, and shortening the operation time, which improve its effectiveness in treating complex acetabular fractures.

Conflict of interest

The authors declare that they have no conflicts of interest.

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