Submitted: 05 October, 2023 Accepted: 26 December, 2023 Published: 08 June, 2024 DOI:10.22514/sv.2024.070

Open Access
Signa Vitae

ORIGINAL RESEARCH

# Angioembolization for geriatric stable pelvic fracture with active bleeding—the possibility of massive hemorrhage due to corona mortis

Yook Kim[1], Jeong-Uk Lee[2], Jae Young Yang[2], Hyun-Chul Shon[2], Younghoon Sul[3], Eic Ju Lim[2,*]

[1]Department of Radiology, Chungbuk National University Hospital, Chugbuk National University College of Medicine, 28644 Cheongju, Republic of Korea
[2]Department of Orthopaedic Surgery, Chungbuk National University Hospital, Chugbuk National University College of Medicine, 28644 Cheongju, Republic of Korea
[3]Department of Trauma Surgery, Chungbuk National University Hospital, Chugbuk National University College of Medicine, 28644 Cheongju, Republic of Korea

***Correspondence**
limeicju@chungbuk.ac.kr
(Eic Ju Lim)

## Abstract

Pelvic hemorrhage is a major cause of mortality in polytrauma patients with pelvic fractures. However, studies on stable pelvic fracture and corona mortis requiring angioembolization (AE) are limited. This study aimed to elucidate the characteristics of patients with stable pelvic fractures requiring AE and describe the findings related to corona mortis involvement leading to large pelvic hematomas. We conducted a retrospective observational study in a level-one trauma center between 2018 and 2023. We included patients who underwent AE for traumatic pelvic hemorrhage, as indicated by an initial computed tomography (CT) scan. Patients with unstable pelvic fractures and negative AE findings were excluded. Demographics, fracture details, arteries targeted for embolization, and the presence of corona mortis and huge pelvic hematoma (hematoma rim distance exceeding 5 cm and extending beyond the midline while compressing the urinary bladder) were evaluated. Clinical outcomes, including 24-h transfusion requirements and mortality rates, were also evaluated. Our patients included 10 women and one man, with a mean age of 75.6 years. All patients sustained injuries involving the superior and inferior rami fractures. The internal pudendal (six patients), obturator (six patients), and aberrant obturator (five patients) arteries required AE. Five of these aberrant obturator arteries, which developed corona mortis, originated from the external iliac artery, and four out of five patients with aberrant obturator arteries had huge pelvic hematomas. We transfused 2.9 units of packed red blood cells on average, and one patient passed away 2 days after sustaining injuries. Attention should be directed towards cases with a huge hematoma on the CT scan or hemodynamic instability, even in the presence of a stable ramus fracture, in old patients. In such situations, evaluating the external iliac artery for angioembolization of the injured corona mortis is imperative.

## Keywords

Geriatric; Elderly; Pelvic fracture; Angioembolization; Corona mortis; Fragility pelvic fracture

## 1. Introduction

Pelvic hemorrhage is a major cause of mortality in polytrauma patients with pelvic fractures [1, 2]. The administration of tranexamic acid, pre-peritoneal packing (PPP), and angioembolization (AE) have been utilized for hemorrhagic control [1–4]. PPP is effective in hemorrhagic control of venous and bone bleeding owing to its rapid action [5, 6]. AE has been utilized for arterial bleeding, mainly for unstable pelvic fractures. The literature commonly cites the internal iliac artery and its branches, such as the superior gluteal artery, internal pudendal artery, and obturator arteries, as targets for embolization [7, 8]. However, studies investigating AE for stable pelvic fractures, which generally do not require surgical stabilization, are limited. The pelvic ring disruption is minimal in such cases; therefore, the propensity for bleeding may often be overlooked.

We performed AE in patients with arterial bleeding, even when the pelvic fracture was stable, if there was evidence of extravasation on the CT scan. In addition, we anecdotally observed a severe hemorrhage on the CT scans associated with corona mortis. Corona mortis, an anatomical variant representing an anastomosis between the obturator and the external iliac or inferior epigastric arteries, is well-recognized in orthopedic surgeries (Fig. 1) [9, 10]. With variation in the location and anastomosis vessels, corona mortis is susceptible to iatrogenic injury during pelvic-acetabular fracture surgery. In addition, injured corona mortis results in a major hemorrhage, and achieving effective hemostasis once a hemorrhage occurs is challenging.


  

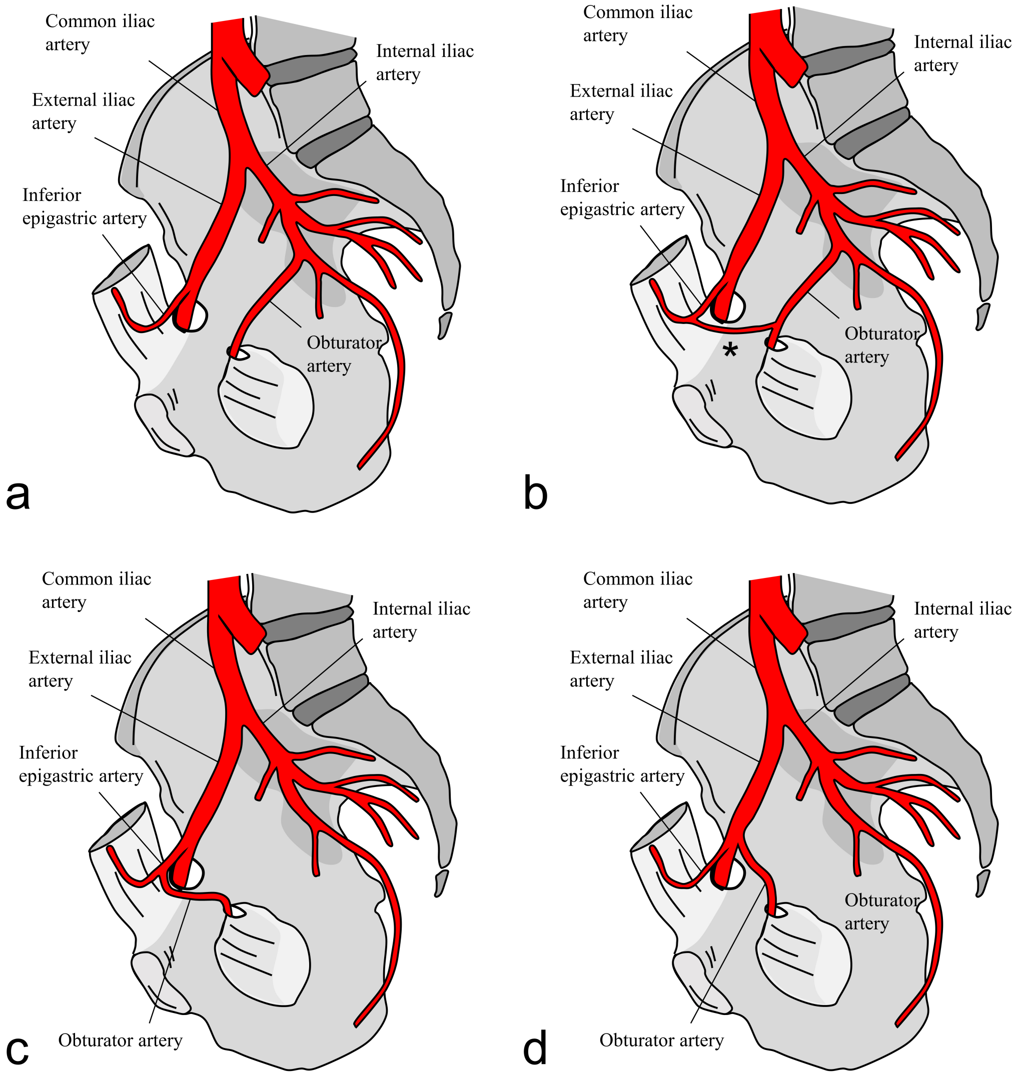


**FIGURE 1. Illustration of the origin of the obturator artery.** (a) The obturator artery originates from the internal iliac artery (normal anatomy). (b) Anastomosis (asterisk) between the obturator and inferior epigastric arteries. If this anastomosis is injured, it is divided into the obturator artery from the internal iliac artery and the aberrant obturator artery from the inferior epigastric artery of the external iliac artery. (c) Aberrant obturator artery originating from the inferior epigastric artery of the external iliac artery. (d) Aberrant obturator artery, which originates directly from the external iliac artery.

However, corona mortis injury in a stable pelvic fracture is scarcely reported in the literature. Thus, we investigated patients with stable pelvic fractures who required AE. This study aimed to elucidate the characteristics of patients with stable pelvic fractures requiring AE and describe the findings related to corona mortis involvement leading to huge pelvic hematomas.

## 2. Materials and methods

A retrospective observational study was conducted between April 2018 and March 2023 in a level-one trauma center. Our institution in Cheongju, Chungbuk Province, South Korea is a tertiary care university-affiliated hospital with 800 beds, accommodating 2.5 million people, with almost 450 patients presenting with an Injury Severity Score (ISS) >15 annually. This study was approved by our institutional review board. We included 101 patients who underwent AE for traumatic pelvic hemorrhage as identified in the initial abdominopelvic (AP) computed tomography (CT) scan. Patients with Tile B and C pelvic fractures (AO/OTA 61 B and C [11]) and pathologic, pediatric, and open fractures were excluded from the study. Subsequently, patients who had no evidence of pelvic arterial bleeding in angiography were also excluded, resulting in a final inclusion of 11 patients (Fig. 2).

Patient data, including demographics, the use of antiplatelet agents, injury severity scale (ISS) scores, and physiology at admission, were extracted from medical records. Demographics included age, sex, mechanism of injury, and origin of admission. Fall from height, road traffic accidents, and industrial injuries were considered "high-energy mechanism of injury" and simple falls and falls from the ground level were categorized as "low-energy mechanism of injury" [12]. The abbreviated injury scale scores for the head, chest, abdomen and extremities were individually evaluated, and ISS scores were subsequently calculated. Physiology at admission consisted of systolic blood

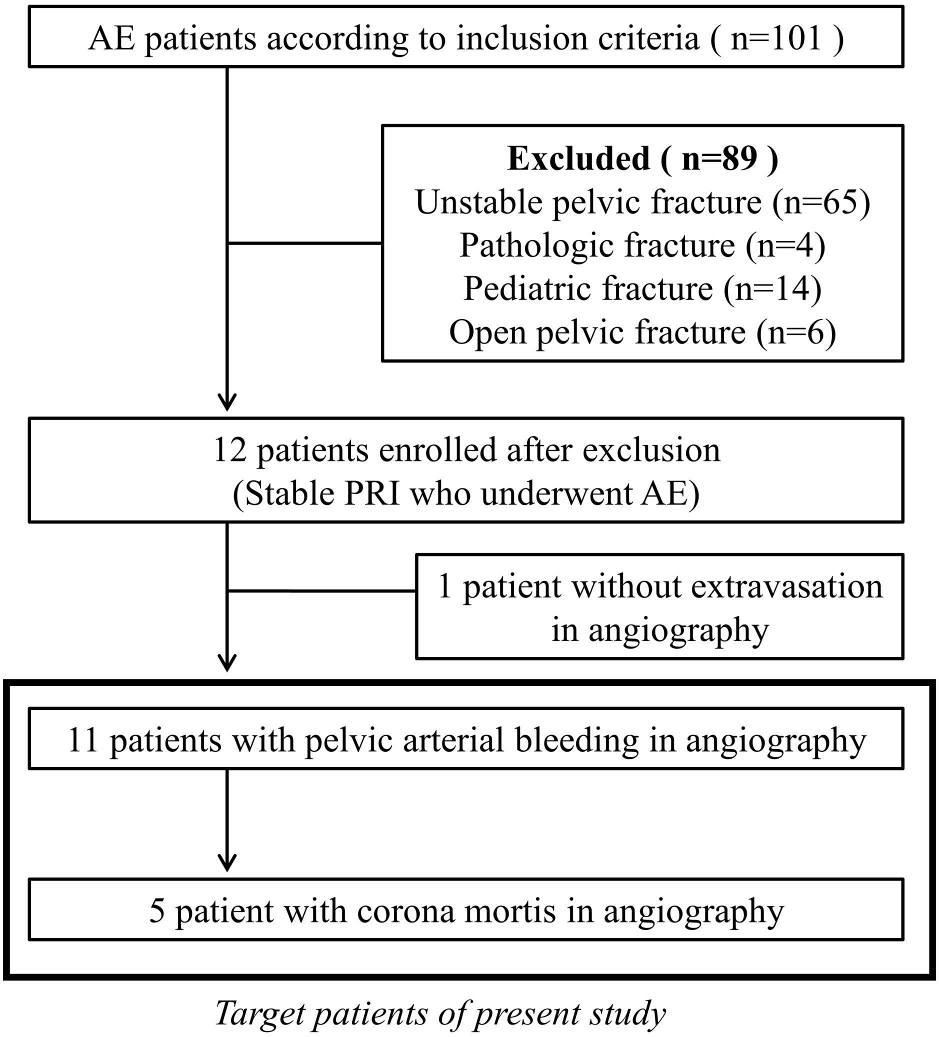


**FIGURE 2. Flow diagram of patient enrollment.** AE: angioembolization; PRI: pelvic ring injury.

pressure (SBP), heart rate (HR), Glasgow coma scale (GCS), and hemodynamic instability. Hemodynamic instability was defined as SBP of ≤90 mmHg or HR ≥120 beats per minute on arrival.

Details of the fracture were assessed through plain pelvic radiographs and pelvis CT scans. For ramus fractures, bilaterality, complete anterior pelvic ring disruptions (*i.e.*, concurrent superior and inferior rami fracture), and fracture location were evaluated. The location of the fracture was evaluated using the Nakatani system [13]. In this system, fractures medial to the obturator foramen were classified as Zone I, while those lateral to the obturator foramen were classified as Zone III. Fractures between Zones I and III were classified as Zone II. Posterior pelvic ring involvement (PPRI), characterized by a fracture in the sacrum or ilium near the sacroiliac joint or any displacement of the sacroiliac joint, was also evaluated. Additionally, whether patients underwent any surgical intervention for their pelvic injuries was investigated.

Following our institution's protocol, AE was performed whenever there was hemodynamic instability in the pelvic fracture *via* radiography, active bleeding was suspected based on the abdomen and pelvic CT scan regardless of hemodynamic instability, or ongoing arterial bleeding was strongly suspected, such as continuous transfusion requirement, regardless of CT findings, even in cases of minor fractures. After inducing local anesthesia with 2% lidocaine, all patients underwent transfemoral arterial catheterization. No specific protocol was followed when patients with pelvic trauma underwent angiography. However, a flush aortography was often obtained with a pigtail catheter, followed by selective arterial catheterization. A diagnostic angiogram was conducted when the bleeding focus was selected using a 1.7–2-F microcatheter, and embolization was performed under fluoroscopic monitoring depending on observed bleeding signs or the operator's preference. We assessed the time intervals from injury to the CT scan and angiography. The presence of a huge pelvic hematoma—a hematoma with a rim distance exceeding 5 cm and extending the midline while compressing the urinary bladder—on the CT scan was also investigated. An interventional radiologist reviewed all AE images to analyze the arterial system of injured patients. Arteries with active bleeding were treated with AE, and the presence of corona mortis was assessed. We categorized an obturator artery as an "aberrant obturator artery" if it originated from the external iliac artery and crossed the superior ramus. If two or more arteries were bleeding, all of them were recorded. For patients with corona mortis, the origin of the artery responsible for active bleeding was evaluated based on previous literature

(Fig. 1) [14, 15].

According to the AE findings, we identified patients with corona mortis and provided detailed descriptions of their findings.

Transfusion requirement, the success of embolization, length of hospital stay, and mortality were evaluated for clinical outcomes. Transfusion requirements were monitored for 24 h after ER admission. The success of embolization was defined as the stabilization of the hemodynamic statuses of the patients without the need for surgical intervention during their hospital stay.

## 3. Results

Our patients included 10 women and one man, with a median age of 78 years. Nine patients suffered injuries from high-energy incidents, with a median ISS of 25. Five patients experienced hemodynamic instability, and Table 1 describes the additional details.

**TABLE 1. Patient demographics, injury severity scale, and physiologic profile.**

| Parameter (n = 11) | Value (median, IQR) |
|---|---|
| Age | 78 (69–79) |
| Female Sex | 10 (91%) |
| Mechanism of injury | |
| High-energy | 9 (82%) |
| Low-energy | 2 (18%) |
| Origin of admission | |
| Scene | 7 (64%) |
| Transfer | 4 (36%) |
| Antiplatelet drug | 3 (27%) |
| ISS | 25 (16–29) |
| Head AIS ≥3 | 5 (45%) |
| Chest AIS ≥3 | 2 (18%) |
| Abdominal AIS ≥3 | 2 (18%) |
| Extremity AIS ≥3 | 10 (91%) |
| Physiology at admission | |
| SBP | 90 (80–159) |
| HR | 84 (71–103) |
| GCS | 15 (11–15) |
| Hemodynamic instability | 6 (55%) |

*Hemodynamic instability was defined as SBP of ≤90 mmHg or HR ≥120 beats per minute on arrival.*
*IQR: interquartile range; ISS: Injury Severity Scale; AIS: abbreviated injury scale; SBP: systolic blood pressure; HR: heart rate; GCS: Glasgow coma scale.*

Among the patients, three had bilateral pubic ramus fractures, and all of them had complete anterior pelvic ring disruptions. The locations of the fractures were as follows: five patients with Zone I, two with Zone II, and four with Zone III. Ten patients had PPRI, showing anterior cortical disruptions with minimal or no displacement. Two patients underwent surgical management of their pelvic fractures, one involving external fixation lasting 6 weeks and the other involving external fixation and percutaneous sacroiliac (SI) screw. The median time from injury to CT scan was 71 min, and the median time from injury to angiography was 167 min. Four patients had huge pelvic hematomas on their CT scans. Three main arteries had active bleeding, including internal pudendal (six patients), obturator (six patients), and an aberrant obturator artery originating from the external iliac artery (five patients). One patient experienced bleeding in the lateral sacral artery (Table 2).

**TABLE 2. Details for fracture and angioembolization.**

| Fracture profile | Value |
|---|---|
| Bilateral ramus fracture | 3 (27%) |
| Complete anterior pelvic ring disruption | 11 (100%) |
| Ramus fracture location | |
| Zone I | 5 (45%) |
| Zone II | 2 (18%) |
| Zone III | 4 (36%) |
| Posterior pelvic ring injury | 10 (91%) |
| Surgery for pelvic fracture | 2 (18%) |
| Details for angioembolization | |
| Time to CT from injury (min) | 71 (59–99) |
| Time to angiography from injury (min) | 167 (146–280) |
| Huge pelvic hematoma on CT | 4 (32%) |
| Arteries for embolization | |
| Internal pudendal | 6 (55%) |
| Obturator | 6 (55%) |
| Aberrant obturator artery (originated from EIA) | 5 (45%) |
| Lateral sacral | 1 (9%) |

*CT: computed tomography; EIA: external iliac artery.*

The median transfusion requirement within the first 24 h was two units of packed red blood cells (PRBC). Ten patients underwent embolization successfully. However, one patient passed away two days after the injury. The median length of hospital stay was 20 days (Table 3).

**TABLE 3. Clinical outcome.**

| Parameter | Value |
|---|---|
| 24-h transfusion (PRBC units) | 2 (0–5) |
| Success of embolization | 10 (91%) |
| Mortality | 1 (9%) |
| Length of stay | |
| Hospital, days | 20 (12–69) |
| Intensive care unit, days | 2 (2–4) |

*PRBC: packed red blood cells.*

For the five patients with corona mortis, we have provided detailed findings in Table 4. Ramus fractures were located in Zone I (four patients) or II (one patient), and all these patients had PPRI. The obturator artery was identified as the source of active bleeding in all patients with huge pelvic hematoma. However, there were differences in the origin of the obturator arteries (Fig. 1). Three patients (Patients 3, 4 and 7) had anastomosis between the obturator artery and the inferior epigastric artery. This anastomosis was injured and divided into the obturator artery from the internal iliac artery and the aberrant obturator artery from the inferior epigastric artery of the external iliac artery. One patient (Patient 6) had an aberrant obturator artery with active bleeding that originated directly from the external iliac artery, while another (Patient 9) had an aberrant obturator artery originating from the inferior epigastric artery of the external iliac artery (Fig. 3). Neither patient had any trace of the obturator artery from the internal iliac artery. One patient underwent surgical management for the pelvic fracture, involving 6 weeks of external fixation and a percutaneous SI screw, and all angioembolizations were considered successful.

## 4. Discussion

In this study, several consistent characteristics were observed among patients who underwent AE for stable pelvic fractures. Most of these patients were old women, and they had PPRI, although the displacement was none or minimal. The arteries with active bleeding were mainly the internal pudendal and obturator arteries. However, patients with corona mortis had an aberrant origin of the obturator artery from the external iliac artery, leading to the development of huge pelvic hematomas. In addition, three out of four patients with huge hematomas experienced hemodynamic instability upon admission. Thus, remaining vigilant even while dealing with structurally stable pelvic fractures in old patients is crucial, as arterial bleeding with huge pelvic hematoma from corona mortis can occur.

The high risk of bleeding in old patients has been extensively studied [16]. Old patients often have arteries with atherosclerosis, limiting the ability of injured vessels to spontaneously stop bleeding by vasospasm [17]. In addition, the tamponade effect provided by the surrounding tissue is decreased due to the diminished turgor in frail soft tissues. Furthermore, while old patients may experience changes in their hemostatic systems that increase the risk of thromboembolism, they also face a bleeding risk associated with antithrombotic therapy, especially when combined with multiple morbidities [18]. Antiplatelet agents, administered to three of the patients in our study, had no independent effect on morbidity or mortality in pelvic fracture [19]. However, there was an increased likelihood of receiving PRBC for patients with antiplatelet therapy. Dietz *et al.* [20] reviewed eight case reports on hemorrhage in fragile pelvic fractures and concluded that anticoagulants, such as warfarin, seem to increase hemorrhage risk. This study had a high proportion of female patients (91%, 10/11). There were 55 male patients (54%) of a total of 101 in the initial enrollment; however, it was not presented as data in the manuscript. After excluding patients with unstable pelvic ring injury, the proportion of female patients increased. We presumed that the reason the stable pelvic ring injury occurred as a fragility fracture in the patients included in this study was related to osteoporosis [21].

In the literature, the main trunk and branches of the internal iliac artery, including the internal pudendal, obturator, and

**TABLE 4. Details for patients with corona mortis.**

| | Age | Sex | Mechanism of Injury | ISS | Ramus fracture Location | PPRI | SBP for admission (mmHg) |
|---|---|---|---|---|---|---|---|
| Patient 3 | 67 | F | High | 26 | Zone II | Yes | 80 |
| Patient 4 | 79 | F | Low | 16 | Zone I | Yes | 70 |
| Patient 6 | 82 | M | High | 22 | Zone I | Yes | 159 |
| Patient 7 | 79 | F | High | 19 | Zone I | Yes | 159 |
| Patient 9 | 78 | F | Low | 25 | Zone I | Yes | 80 |
| | HRD (mm) | Huge pelvic hematoma | Artery for embolization | | Origin of the embolized artery | Surgical management | Success of embolization |
| Patient 3 | 55 | Yes | Obturator<br>Aberrant obturator | | IIA<br>IEA form EIA | No | Yes |
| Patient 4 | 119 | Yes | Obturator<br>Aberrant obturator | | IIA<br>IEA form EIA | No | Yes |
| Patient 6 | 56 | Yes | Aberrant obturator | | EIA | No | Yes |
| Patient 7 | 39 | No | Internal pudendal<br>Obturator<br>Aberrant obturator | | IIA<br>IIA<br>IEA from EIA | Yes | Yes |
| Patient 9 | 116 | Yes | Aberrant obturator | | EIA | No | Yes |

*ISS: Injury Severity Scale; PPRI: posterior pelvic ring involvement; SBP: systolic blood pressure; HRD: Hematoma rim distance; IIA: internal iliac artery; IEA: inferior epigastric artery; EIA: external iliac artery.*

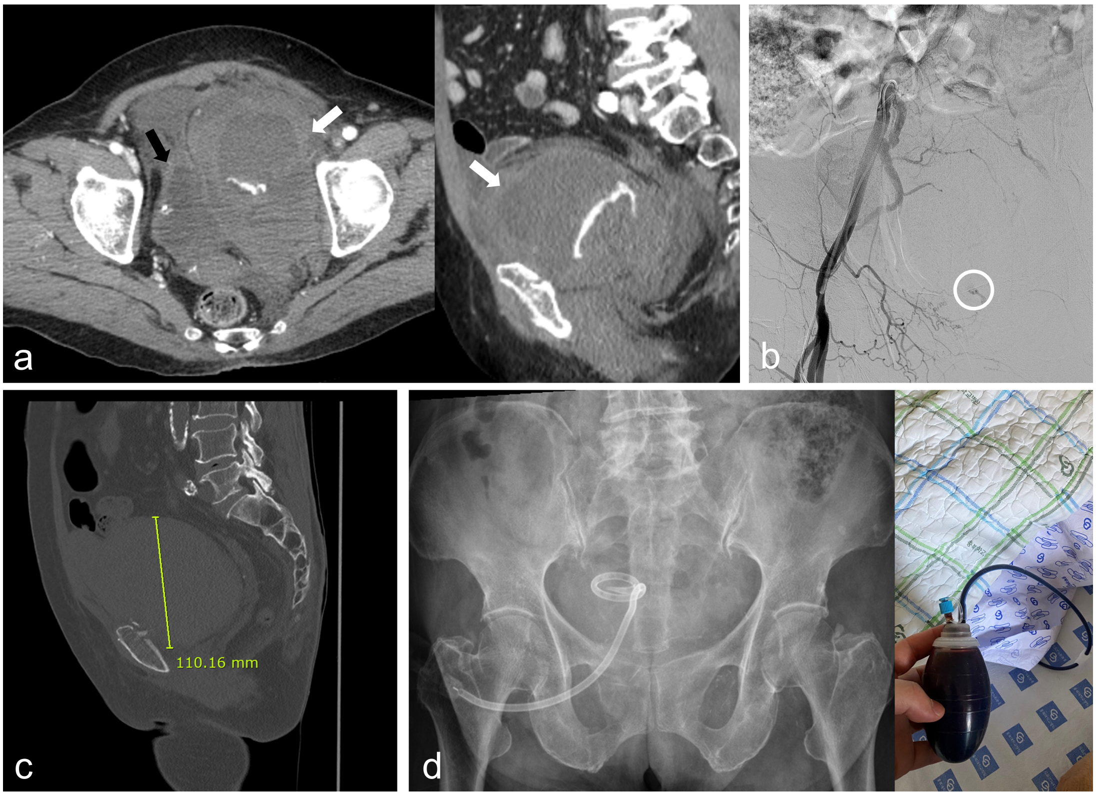


**FIGURE 3. Case example.** A female patient aged 78 years injured from a fall was admitted to the emergency department with a systolic blood pressure of 80 mmHg. (a) An enhanced abdominal CT scan demonstrated extravasation, resulting in a huge hematoma (white arrow), which extends beyond the midline while compressing the urinary bladder (black arrow). (b) Angiography of the external iliac artery revealed active bleeding of the aberrant obturator artery (white circle), which was controlled with embolotherapy. (c) One week after the injury, pelvic CT revealed a huge hematoma with a rim distance of 110 mm. (d) Symptomatic hematoma was drained with a percutaneous pigtail catheter, and the abdominal discomfort improved.

superior gluteal arteries, were the major sources of arterial bleeding in pelvic fractures [3]. Similarly, in our study, the internal pudendal and obturator arteries were the main arteries that actively bled in angiography. Considering the anatomy of the superior gluteal artery, which traverses through the greater sciatic notch, this artery was possibly not injured in our study [22]. Meanwhile, in patients with corona mortis, we observed active bleeding from an aberrant obturator artery originating from the external iliac artery. Clinically, the internal iliac artery is typically targeted for pelvic embolization, and AE of the external iliac artery is not a routine procedure for interventional radiologists [23]. Without a thorough understanding of the anatomy of corona mortis, the bleeding from an artery originating from the external iliac artery can be missed. Although not presented in the manuscript, corona mortis was identified in 13 of the 65 patients with unstable pelvic fractures who were excluded from present study. Among them, five patients had bilateral corona mortis. Therefore, if a patient has a ramus fracture and hematoma with active bleeding, checking whether variant arteries are visible in an enhanced CT scan and systematically visualizing the internal and external iliac arteries using angiography are necessary.

Classifying stable pelvic fractures according to PPRI can be controversial [24]. Clinically, we consider the fractures investigated in this study as stable pelvic fractures because the PPRI was limited to anterior cortical disruption without displacement, and most of the patients did not undergo surgical treatment, except for two patients who underwent external fixation, which was removed after 6 weeks. In this study, most patients sustained high-energy injuries, which explains why AE was performed despite the stable pelvic fractures. However, two patients sustained low-energy injuries resulting in fragile pelvic fractures associated with huge hematomas. We inferred that vascular injury itself, rather than the injury mechanism, is crucial to active bleeding and hematomas. Thus, considering the possibility of pelvic hemorrhage even in cases of stable pelvic fractures, regardless of the mechanism of injury, is crucial. Our indications for AE (hemodynamic instability with pelvic fracture, active bleeding observed using a CT scan, and suspected ongoing arterial bleeding regardless of the CT scan findings) may detect these cases with substantial hemorrhage in stable pelvic fracture, although not validated in this study.

Symptomatic hematomas can be large enough to compress other organs. However, no evidence-based treatment guideline for managing symptomatic hematoma currently exists. Hagiwara *et al.* [25] reported a case in which brain death occurred due to abdominal compartment syndrome developed from a huge pelvic hematoma. Wang and Wang recommended tailoring treatment selection after blunt injury based on factors such as anatomical position, visceral injury, and hemodynamic status [26]. We did not perform any intervention for hematoma after embolization in all patients except for one. This exception arose because the patient complained of persistent abdominal pain for 1 week, leading to us inserting a pigtail catheter to drain the hematoma (Fig. 3). However, this is a special case, and treatment selection should depend on the size of the hematoma and the presence of symptoms.

This study has several limitations. First, the sample size was relatively small. Specifically, only five cases of active bleeding originating from corona mortis were included. However, noting that not many reports exist on AE in stable pelvic fractures is essential. Most studies on AE of corona mortis have been conducted on cases of unstable pelvic fractures [27], where the focused examination of hematoma arising from corona mortis can be complicated by other injuries. Thus, the findings in our study hold significance despite the limited number of cases. Second, volumetric analysis was not performed for hematomas. While we used rim distance measurements to define huge hematomas, we did not measure the actual hematoma volume, which would provide a more accurate estimate of the actual bleeding volume. Further studies should consider analyzing the relationship between hematoma volume and hemodynamic status.

## 5. Conclusions

Despite old patients having structurally non-displaced pelvic fractures, these fractures may still exhibit extravasation requiring AE. Furthermore, in patients with corona mortis, a huge hematoma can develop, potentially leading to hemodynamic instability. Our study's results should be interpreted with caution, owing to the small sample size and lack of volumetric analysis for hematoma. However, remaining vigilant and considering the possibility of AE when there is a huge hematoma on a CT scan or observing hemodynamic instability, even with stable ramus fractures, is imperative. In such cases, the external iliac artery should be checked for potential AE of the injured corona mortis.

### AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the conditions of the ethics committee of our university.

### AUTHOR CONTRIBUTIONS

EJL—writing-original draft, formal analysis, visualization, investigation and resources; YK—conceptualization, data curation; JUL—investigation and resources, validation; HCS—writing-review and editing; YS—methodology and supervision. All authors have read and agreed to the published version of the manuscript.

### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of the Chungbuk National University Hospital (protocol no. 2023-09-023). Informed consent was obtained from all individual participants included in the study.

### ACKNOWLEDGMENT

Not applicable.

### FUNDING

This research received no external funding.

### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### REFERENCES

[1] Hundersmarck D, Hietbrink F, Leenen LPH, Heng M. Pelvic packing and angio-embolization after blunt pelvic trauma: a retrospective 18-year analysis. Injury. 2021; 52: 946–955.

[2] Li P, Liu F, Li Q, Zhou D, Dong J, Wang D. Role of pelvic packing in the first attention given to hemodynamically unstable pelvic fracture patients: a meta-analysis. Journal of Orthopaedics and Traumatology. 2022; 23: 29.

[3] Lindahl J, Handolin L, Söderlund T, Porras M, Hirvensalo E. Angiographic embolization in the treatment of arterial pelvic hemorrhage: evaluation of prognostic mortality-related factors. European Journal of Trauma and Emergency Surgery. 2013; 39: 57–63.

[4] Adams JD, Marshall WA. The use of tranexamic acid in hip and pelvic fracture surgeries. Journal of the American Academy of Orthopaedic Surgeons. 2021; 29: e576–e583.

[5] Cothren CC, Osborn PM, Moore EE, Morgan SJ, Johnson JL, Smith WR. Preperitonal pelvic packing for hemodynamically unstable pelvic fractures: a paradigm shift. Journal of Trauma: Injury, Infection & Critical Care. 2007; 62: 834–842.

[6] Kim H, Jeon CH, Kim JH, Sun H, Ryu D, Lee KH, *et al*. Transarterial embolisation is associated with improved survival in patients with pelvic fracture: propensity score matching analyses. European Journal of Trauma and Emergency Surgery. 2021; 47: 1661–1669.

[7] Vaidya R, Waldron J, Scott A, Nasr K. Angiography and embolization in the management of bleeding pelvic fractures. Journal of the American Academy of Orthopaedic Surgeons. 2018; 26: e68–e76.

[8] Nakajima K, Yamaguchi K, Abe T, Taniguchi H, Mizukami S, Sekikawa Z, *et al*. Extravasation and outcomes in computed tomography and angiography in patients with pelvic fractures requiring transcatheter arterial embolization: a single-center observational study. Journal of Trauma and Acute Care Surgery. 2022; 92: 873–879.

[9] Darmanis S, Lewis A, Mansoor A, Bircher M. Corona mortis: an anatomical study with clinical implications in approaches to the pelvis and acetabulum. Clinical Anatomy. 2007; 20: 433–439.

[10] Elhence A, Gupta A. Corona Mortise-anatomical variants and implications in pelvic-acetabular surgery: an evidence based review. Journal of Orthopaedics. 2023; 37: 9–14.

[11] Meinberg E, Agel J, Roberts C, Karam M, Kellam J. Fracture and dislocation classification compendium—2018. Journal of Orthopaedic Trauma. 2018; 32: S1–S10.

[12] Almigdad A, Mustafa A, Alazaydeh S, Alshawish M, Bani Mustafa M, Alfukaha H. Bone fracture patterns and distributions according to trauma energy. Advances in Orthopedics. 2022; 2022: 8695916.

[13] Berk T, Zderic I, Schwarzenberg P, Pastor T, Lesche F, Halvachizadeh S, *et al*. Evaluation of cannulated compression headless screws as an alternative implant for superior pubic ramus fracture fixation: a biomechanical study. International Orthopaedics. 2023; 47: 1079–1087.

[14] Daeubler B, Anderson SE, Leunig M, Triller J. Hemorrhage secondary to pelvic fracture: coil embolization of an aberrant obturator artery. Journal of Endovascular Therapy. 2003; 10: 676–680.

[15] Paz SI, Wang JY, Haider S, Silva RA, Yoon DY. Beware: the corona mortis, "crown of death". Annals of Vascular Surgery—Brief Reports and Innovations. 2022; 2: 100144.

[16] Forssten MP, Sarani B, Mohammad Ismail A, Cao Y, Ribeiro MAF, Hildebrand F, *et al*. Adverse outcomes following pelvic fracture: the critical role of frailty. European Journal of Trauma and Emergency Surgery. 2023; 49: 2623–2631.

[17] Henry SM, Pollak AN, Jones AL, Boswell S, Scalea TM. Pelvic fracture in geriatric patients: a distinct clinical entity. The Journal of Trauma: Injury, Infection, and Critical Care. 2002; 53: 15–20.

[18] Tschan SL, Bolliger D. Coagulation and aging: implications for the anesthesiologist. Current Anesthesiology Reports. 2021;11: 387–395.

[19] Stawicki S, Christy J, Jarvis A, Evans D, Gerlach A, Lindsey D, *et al*. The impact of antiplatelet therapy on pelvic fracture outcomes. Journal of Emergencies, Trauma, and Shock. 2011; 4: 64.

[20] Dietz SO, Hofmann A, Rommens PM. Haemorrhage in fragility fractures of the pelvis. European Journal of Trauma and Emergency Surgery. 2015; 41: 363–367.

[21] Ando J, Takahashi T, Ae R, Matsumura T, Sasao W, Abe M, *et al*. Epidemiology of fragility fracture of the pelvic ring: a regional population-based study in Northern Japan. Archives of Osteoporosis. 2023; 18: 131.

[22] Kwon H, Jang JH, Moon NH, Rhee SJ, Ryu DY, Ahn TY. Superior gluteal artery injury in pelvic ring injury and acetabular fracture: Single center observational study. To be published in Journal of Orthopaedic Science. 2023. [Preprint].

[23] Schuchardt P, Yasin J, Davis RM, Thimmappa N, Bhat AP. Pelvic trauma: what the radiologist needs to know. Contemporary Diagnostic Radiology. 2019; 42: 455–464.

[24] Putzeys G, Dekeyser T, Garré P, Chesser T, Pottel H. Posterior pelvic ring involvement detected with CT taken within a week of admission in acute fragility fractures of the pelvis (FFP) does not predict failure of conservative treatment: a retrospective cohort study. BMC Musculoskeletal Disorders. 2023; 24: 320.

[25] Hagiwara A, Fukushima H, Inoue T, Murata A, Shimazaki S. Brain death due to abdominal compartment syndrome caused by massive venous bleeding in a patient with a stable pelvic fracture: report of a case. Surgery Today. 2004; 34: 82–85.

[26] Wang F, Wang F. The diagnosis and treatment of traumatic retroperitoneal hematoma. Pakistan Journal of Medical Sciences. 2013; 29: 573–576.

[27] Marsman J, Schilstra S, van Leeuwen H. Angiography and embolization of the corona mortis (aberrant obturator artery). A source of persistent pelvic bleeding. RöFo: Fortschritte auf dem Gebiete der Röntgenstrahlen und der Nuklearmedizin. 1984; 141: 708–710.


**How to cite this article:** Yook Kim, Jeong-Uk Lee, Jae Young Yang, Hyun-Chul Shon, Younghoon Sul, Eic Ju Lim. Angioembolization for geriatric stable pelvic fracture with active bleeding—the possibility of massive hemorrhage due to corona mortis. Signa Vitae. 2024; 20(6): 44-51. doi: 10.22514/sv.2024.070.