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CASE REPORT

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Multidisciplinary management of thoracic aortic injury with hemodynamically unstable pelvic fracture in the elderly

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Abstract

Blunt thoracic aortic injury (BTAI) is a critical clinical emergency often presenting as severe trauma. The early diagnosis and treatment of BTAI pose significant challenges in its management, especially when patients experience early-stage hemodynamic instability. Presently, in the context of multiple traumas, there is an absence of clearly-defined and comprehensive guidelines capable of accurately determining the optimal timing and sequence of interventions for aortic injuries. This issue is particularly prominent when aortic injuries are complicated by abdominal vascular injuries, which exacerbate hemodynamic instability. This study aims to present two distinct cases of patients with BTAI complicated by pelvic vascular injuries, resulting in hemodynamic instability. These cases were treated at different trauma centers. The successful treatment strategies included the implantation of covered stents for aortic repair and arterial embolization for pelvic vascular injuries. By sharing these cases, we intend to enhance the understanding of the complex management of such combined - injury situations. We underscore that comprehensive aortic computed tomography angiography (CTA) is of crucial importance in the early detection of aortic injuries and other major vascular injuries in high-energy trauma scenarios. Although regional trauma centers have demonstrated positive impacts on patient outcomes, the retrospective nature of this study and its limited sample size necessitate further large-scale research to validate our findings and proposed management strategies.

Keywords Blunt thoracic aortic injury, Internal iliac artery, Trauma, Pelvic fracture

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Introduction

Hemorrhagic shock is one of the leading causes of early death in cases of severe trauma, with non-compressible torso hemorrhage being the primary cause of severe hemorrhagic shock. Non-compressible torso hemorrhage typically includes rupture of thoracic aortic aneurysms and traumatic hemorrhage from thoracoabdominal or pelvic organ injuries [1]. Blunt thoracic aortic injury (BTAI) is a critical condition in clinical practice, often resulting from severe trauma. BTAI patients tend to have complex injuries and often present with multiple systemic injuries. Research shows that among BTAI patients who make it to the hospital, about 30% die within 6 h, and about 50% die within 24 h of admission [2]. The early diagnosis and treatment of BTAI are particularly challenging due to difficulties in early detection and management, especially in cases where hemodynamic instability is present. Making clinical decisions in such situations is especially complex.

Currently, there is a lack of specific guidelines regarding the optimal timing and sequencing of the management for aortic injury concomitantly presenting with unstable abdominal vascular injury. Herein, we report two cases of BTAI complicated by pelvic vascular injury, which led to hemodynamic instability. These cases were successfully treated at different trauma centers. Subsequently, based on these two cases, a comprehensive literature review was carried out. The aims were to summarize the crucial aspects in the early-stage management of similar multiple vascular injuries and to introduce the decision-making process. Additionally, future perspectives in this area of research and clinical practice were also put forward.

Case presentation

Case 1

A 65-year-old female was involved in a motor vehicle crash as a pedestrian approximately three hours prior to presentation. The patient, while walking, was struck by a mid-sized sport utility vehicle (SUV) and propelled six meters. There was no evidence of crushing or dragging. She experienced a brief loss of consciousness lasting ten minutes without associated vomiting. Upon regaining consciousness, she complained of abdominal pain but denied chest pain. Her family transported her to the hospital's emergency department (ED) by private vehicle. Physical examination demonstrated that the patient was in a sem-conscious state and exhibited signs of distress. The Glasgow Coma Scale (GCS) score was determined to be E3V4M5. Her blood pressure (BP) measured 80/56 mmHg, heart rate (HR) was 102 beats per minute, respiratory rate was 18 breaths per minute, and oxygen saturation remained at 95% during the administration of 5 L/min of oxygen via a face mask. Abrasions were observed on the occipital region, left clavicle, and hip. Cardiac and pulmonary auscultation findings were unremarkable. The abdomen was soft with mild tenderness, and the patient maintained full motor strength in all extremities.

Emergency laboratory results disclosed a hemoglobin (Hb) level of 81 g/L, a blood lactate level (Lac) of 3.7mmol/L, a base excess (BE) of −4.6mmol/L, a pH of 7.33, an international normalized ratio (INR) of 1.2, and an activated partial thromboplastin time (APTT) of 51.1 s. Immediately after admission to the ED, the patient's blood pressure and oxygen saturation levels declined. A bedside Focused Assessment with Sonography for Trauma (FAST) examination showed negative findings. In strict accordance with the Advanced Trauma Life Support (ATLS) guidelines, the patient underwent endotracheal intubation. Restrictive fluid resuscitation was initiated, accompanied by an infusion of norepinephrine at a rate of 0.15 μg/kg/min to sustain the systolic blood pressure at 80 mmHg.

Head computed tomography (CT) demonstrated a contusion and laceration in the right temporal lobe. A comprehensive computed tomography angiography (CTA) of the aorta revealed a cystic, irregular, outward - projecting structure arising from the aortic arch. It had a narrow neck connecting to the arch and a visible rupture, measuring approximately 16.3 mm in size, which was indicative of a pseudoaneurysm of the aortic arch (AAST grade III) (Fig. 1A). CT scans also showed multiple fractures at the acromial end of the left clavicle and in the left 3rd to 10th ribs. Both adrenal glands presented with contusions, and there was hematoma formation in the left adrenal gland. Additionally, there was a contusion and laceration of the left kidney, as well as damage to the neck and body of the pancreas accompanied by active bleeding. Fractures were observed in the left sacrum, ilium, acetabulum, and bilateral superior and inferior pubic rami, with surrounding soft - tissue swelling, hematoma formation, and active bleeding (Fig. 1B).

A multidisciplinary discussion attended by specialists from vascular surgery, interventional radiology, cardiovascular surgery, and orthopedics reached the conclusion that due to the patient's hemodynamic instability, emergency intervention was urgently needed. The patient was then transferred to the hybrid operating room.

In the hybrid operating room, for the pelvic fractures accompanied by active bleeding, internal iliac artery embolization was first carried out. Subsequently, for the aortic injury, thoracic aortic stent - graft placement was performed. Angiography of the left internal iliac artery demonstrated multiple scattered pinpoint-like and patchy contrast extravasations, which were in line with multiple ruptures and bleeding, along with the presence of a pelvic hematoma. Gelatin sponges were utilized to embolize the bleeding branches of the internal iliac artery.

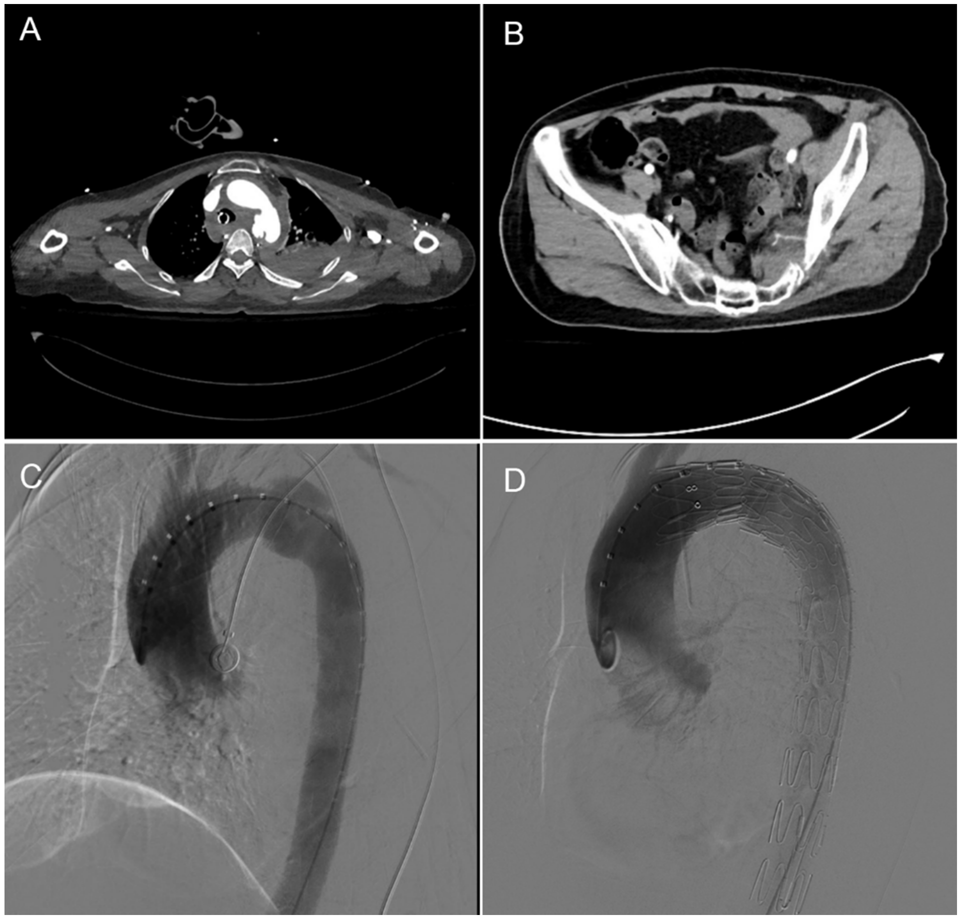

Fig. 1 **A** Pseudoaneurysm of aortic arch and mediastinal exudation; **B** Multiple fractures of the left sacrum, ilium, acetabulum and bilateral upper and lower pubic branches with active bleeding; **C** DSA revealed that the left subclavian artery was narrowed and rough, and 1 cm further, the aorta ruptured and bled, with a tumor-like expansion encasing it; **D** No clear contrast agent leakage was detected in the thoracic aorta post-covered stent

After that, the vascular surgeons repaired the aortic dissection through endovascular stent-graft placement. Intraoperative angiography revealed localized stenosis and roughness in the left subclavian artery. Approximately 1 cm distal to this area, a rupture with aneurysmal expansion and contained bleeding was detected (Fig. 1C). The stent-graft was accurately positioned at the proximal end of the left subclavian artery, effectively covering the rupture site (Fig. 1D). A follow-up angiogram indicated that the brachiocephalic trunk and the left common carotid artery were clearly visualized, while the visualization of the left subclavian artery was slightly delayed. There was no contrast extravasation from the thoracic aorta, and the dissection was completely sealed, with no sign of contrast leakage.

After surgery, the patient was transferred to the intensive care unit (ICU) for intensive supportive care. Despite experiencing respiratory failure and pneumonia, no acute kidney injury (AKI), limb ischemia, or stroke occurred. On the 10th postoperative day, the patient was successfully extubated and transferred to a general ward for further treatment. Subsequently, on the 17th postoperative day, she was transferred to a local healthcare facility for continued rehabilitation.

Case 2

A 65-year-old female presented to the ED with a 1.5-hour history of chest and abdominal pain subsequent to a traffic crash. She was riding an electric scooter when it collided with a car. Post-collision, she complained of chest and abdominal pain, yet denied experiencing chest tightness, shortness of breath, nausea, or vomiting. She was transported to the ED via ambulance 15 min after the accident. The patient had no remarkable past medical history, prior surgical interventions, or known allergies.

Upon initial assessment in the ED, the patient was drowsy, with a GCS score of E3V4M6. Her BP measured 92/57 mmHg, HR was 97 beats per minute, respiratory rate was 20 breaths per minute, and oxygen saturation was 92% while receiving oxygen at a flow rate of 5 L/min through a face mask. Bilateral pupils were 4 mm in diameter and reactive to light. Auscultation of the lungs

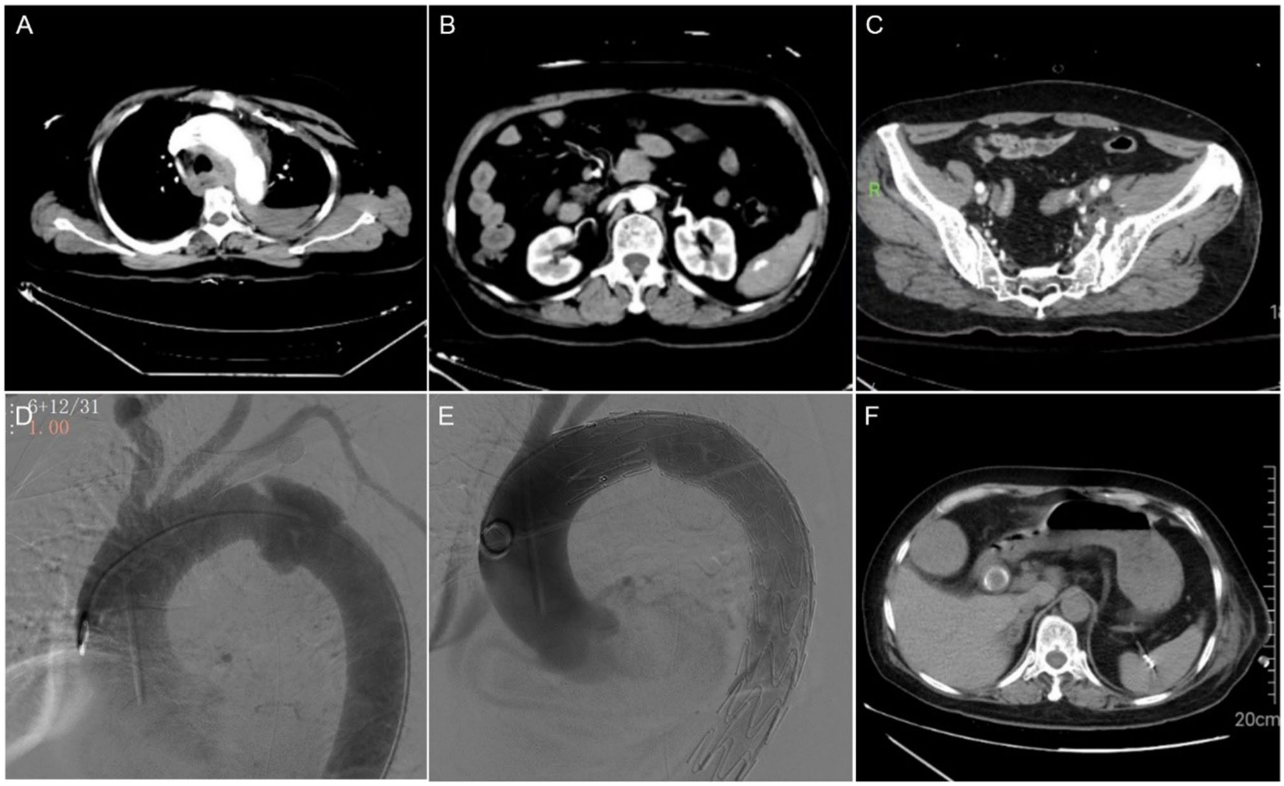

Fig. 2 **A** Aortic arch rupture with bleeding in the mediastinum; **B** Spleen bruise with pseudoaneurysm; **C** Fracture with active bleeding in the left pubic bone branches, left ilium, sacrum, and pubic symphysis; **D** A pseudoaneurysm with dissection was observed on the great curvature of the thoracic aorta, 1 cm from the subclavian artery; **E** Postoperative angiography revealed the absence of pseudoaneurysm and dissection; **F** Disappearance of contrast medium leakage and pseudoaneurysm following splenic artery embolization

revealed fine crackles in both lower lung fields, with diminished breath sounds on the left side. The abdomen was soft and non-tender. Pelvic stability was compromised, and the range of motion of the left lower limb was restricted. Laboratory investigations yielded the following results: Hb level of 89 g/L, Lac concentration of 3.8 mmol/L, BE of – 9.5 mmol/L, pH of 7.30, and an INR of 1.21. During the course of the initial assessment, the patient's level of consciousness progressively declined, with her GCS score dropping to E2V2M4. Concurrently, her blood pressure plummeted to a nadir of 84/52 mmHg. A FAST examination was negative.

Given the decline in the patient's consciousness level, to prevent potential airway obstruction and ensure airway patency, protective endotracheal intubation was promptly performed. Permissive hypotensive resuscitation was swiftly initiated to maintain the systolic blood pressure between 80 and 90 mmHg, and pelvic binder fixation was also carried out simultaneously. Meanwhile, tranexamic acid and blood products were administered as appropriate. However, the patient's circulatory status remained unstable. Consequently, norepinephrine had to be infused at a rate of 0.48 μg/kg/min to sustain a systolic blood pressure of 85 mmHg. Enhanced chest, abdominal, and pelvic CT scans unveiled the following complex injury profile. There was a rupture of the aortic arch accompanied by a mediastinal hematoma, which was classified as AAST grade III (as depicted in Fig. 2A). The left lung presented with contusion, and multiple fractures were observed in the left ribs. Bilateral pleural effusions were present, with the effusion volume being significantly larger on the left side. In addition, a splenic contusion with the subsequent formation of a pseudoaneurysm was identified (Fig. 2B), along with a mesenteric contusion in the mid - abdomen. Furthermore, fractures were detected in the left pubic rami, ilium, sacrum, and pubic symphysis (Fig. 2C).

Given the high suspicion of traumatic rupture of the aortic arch with associated mediastinal hematoma, the patient underwent emergency thoracic aortic stent-graft placement. Intraoperative angiography demonstrated a pseudoaneurysm and rupture located 1 cm distal to the left subclavian artery (Fig. 2D). Post-stent placement, angiography confirmed the resolution of the pseudoaneurysm and rupture, with satisfactory blood flow in the thoracic aorta and major arterial branches (Fig. 2E). Additionally, the patient underwent embolization of the iliac artery and splenic artery (Fig. 2F).

Following the surgical procedures, the patient was admitted to the ICU for close monitoring and critical care. On the fifth postoperative day, due to the presence of multiple rib fractures, she underwent fixation of the fractured left ribs. The patient developed respiratory failure and a pulmonary infection but was spared from acute kidney injury, limb ischemia, and stroke. By the twelfth day of hospitalization, she was successfully weaned from mechanical ventilation and transferred to the general ward for further surgical management of her pelvic fractures.

Discussion

In this report, we present two clinical cases of thoracic aortic injury in elderly patients, both manifesting hemodynamic instability. The lesions were precisely located in the vicinity of the subclavian artery at the aortic arch. The observed hemodynamic instability was presumably a consequence of deteriorated aortic aneurysm subsequent to the aortic injury and possibly related to concomitant vascular damage within the abdominal or pelvic compartments. By achieving successful treatment outcomes for these patients through the combined application of covered stent-graft implantation and arterial embolization, we contribute valuable insights that can guide the management of analogous injuries in future clinical practice.

According to data from the U.S. Centers for Disease Control and Prevention (CDC), BTAI ranked as the second leading cause of death among blunt trauma patients in the United States, surpassed only by traumatic brain injury [3]. A review of the National Trauma Database indicated that 0.3% of all trauma admissions were due to BTAI. Although the incidence of BTAI was relatively low, failure to recognize or diagnose it could be fatal, accounting for nearly 57% of trauma-related deaths. Studies have also demonstrated that among trauma victims with aortic injuries, the mortality rate within the first four hours of hospital admission was 37% [4]. With the rapid aging of the population, it has become increasingly imperative to delineate outcomes and optimize management strategies for elderly trauma patients. Elderly patients encounter unique challenges owing to multiple factors, including a higher prevalence of comorbidities, polypharmacy, poorer functional status, and psychological disorders [5, 6]. Hemodynamic instability associated with BTAI was detected in only approximately half of BTAI cases, with the majority of patients presenting with Grade 1–3 injuries. Isolated BTAI was uncommon, and concomitant injuries, such as vascular damage resulting from pelvic fractures, often gave rise to clinical symptoms and potential hemodynamic instability. This finding was consistent with the two reported cases of thoracic aortic injury, which were accompanied by severe abdominal vascular injuries.

Early mortality in BTAI patients was primarily driven by inadequate tissue perfusion and hemodynamic instability. Acute injuries were associated with high mortality and morbidity rates, underscoring the significance of timely diagnosis and intervention. Although diagnosing BTAI was challenging, various imaging modalities could aid in its detection. For suspected trauma, Point-of-Care ultrasound (POCUS) is the preferred screening method in many emergency departments globally. FAST often reveals hypoechoic areas of free fluid in the chest cavity; however, in our first patient, the FAST yielded negative results, suggesting that a negative FAST does not rule out vascular injury, particularly in hemodynamically unstable patients [7, 8]. The use of transesophageal echocardiography (TEE) necessitates specialized training and is highly operator-dependent. Additionally, this procedure is contraindicated in patients with neck injuries and absolutely contraindicated in those with esophageal injuries [9]. In a 9-year retrospective study, Goarin et al. compared TEE with angiography and CT in 209 patients with blunt trauma. They reported a sensitivity of 98% and a specificity of 100% for TEE in diagnosing injuries. However, TEE has limited visualization of the proximal ascending aorta and its major branches, potentially overlooking injuries such as partial rupture of the subclavian artery. TEE is theoretically suitable for hemodynamically unstable patients with a high suspicion of isolated aortic injury or those unfit for transfer to the radiology department for chest CT or aortic arch angiography. Although TEE can be performed at the bedside on potentially unstable patients, appropriate airway management may be required prior to the procedure [10]. Chest X-ray is a rapid and convenient method for the early diagnosis of aortic injury, with mediastinal widening being the most crucial radiographic sign. However, the sensitivity and specificity of chest X-rays are often suboptimal. Studies have shown that approximately 7.3–44% of patients with aortic injury may have a normal mediastinum, increasing the risk of delayed diagnosis. For remote, non-trauma centers, it can serve as one of the diagnostic tools for suspicion and referral to advanced trauma centers [11, 12]. The gold standard for diagnosing BTAI is chest CTA, with a sensitivity of 95–100% and a negative predictive value of 99–100%. Although many trauma patients initially undergo "pan-scans," including chest CT, the timing of contrast administration may not be optimal for generating a formal chest CTA [13]. However, as demonstrated in our reported patients, we recommend performing a full aortic angiography based on a comprehensive understanding of the patient's injury mechanism. High-energy trauma and hemodynamically unstable patients may benefit from a full aortic CTA evaluation to exclude uncontrolled active bleeding as much as possible. While digital subtraction angiography (DSA) can provide comparable diagnostic efficacy to CTA for the thoracic and abdominal aorta, it is not the preferred method due to its invasiveness [14].

In cases of non-compressible vascular injuries, precisely identifying the blood vessels responsible for the primary problems is of paramount importance for guiding surgical intervention or endovascular treatment. A comprehensive preoperative assessment of the surgical approach can effectively reduce the operation time, potentially lower the incidence of trauma-induced coagulopathy, and subsequently decrease the mortality rate. Super-selective coil embolization, although useful, leads to prolonged operation and fluoroscopy times, as well as increased consumption of contrast agents. Research [15] indicates that, compared to super-selective vascular branch embolization, proximal internal iliac artery embolization does not increase the risk of postoperative complications such as gluteal muscle necrosis and colonic ischemia. Instead, it can significantly shorten the operation time.

Regarding splenic injuries, proximal embolization is associated with a lower probability of causing severe complications (such as life-threatening conditions requiring intensive care) than distal embolization. However, since the spleen is an immune organ, there is an ongoing debate as proximal embolization may result in its permanent infarction [16]. Therefore, for patients requiring urgent aortic surgery with concomitant iliac or splenic artery injuries, the decision of whether to opt for proximal embolization over super-selective embolization should be made on a case-by-case basis. Moreover, the application of resuscitative endovascular balloon occlusion (REBOA) before definitive surgery also merits attention. Balloon occlusion can temporarily control bleeding, creating more favorable conditions for subsequent surgical procedures and enhancing the safety and effectiveness of the operation. Nevertheless, the latest randomized controlled trials suggest that the use of REBOA in hospitals may increase the risk of mortality [17].

The Eastern Association for the Surgery of Trauma (EAST) proposed rapid repair of blunt aortic injuries in its management guidelines. The society classified BTAI into four categories: Grade I, intimal tear; Grade II, intramural hematoma; Grade III, pseudoaneurysm; and Grade IV, free rupture. Grades I and II are typically managed conservatively [18]. However, for patients at high risk of aortic rupture based on clinical symptoms, imaging characteristics, and injury grading, emergency surgical intervention is warranted. For example, Grade III injuries (pseudoaneurysm formation) and Grade IV injuries (aortic wall rupture with hemorrhage), as well as imaging findings suggestive of pseudo-aortic coarctation, all necessitate emergency surgery. Unfortunately, despite advancements in treatment, many Grade IV cases still result in death.

Once antihypertensive medications are initiated for initial management, a final treatment decision must be made. Surgical approaches for BTAI include open surgery and thoracic endovascular aortic repair (TEVAR). Over the past decade, TEVAR has supplanted open surgery as the preferred first-line treatment for BTAI. Although vascular surgeons favor TEVAR, there remains controversy regarding the optimal timing of TEVAR for BTAI. Some studies recommend selective TEVAR, while others report no significant difference in timing [19]. Additionally, a 20-year retrospective review found that conservative management of BTAI was associated with increased mortality rates. When combined with other injuries requiring immediate treatment, the timing of intervention becomes even more critical. However, if a patient has life-threatening injuries or is a high-risk surgical candidate due to comorbidities, aortic repair can be delayed for 24 h with close blood pressure monitoring, without affecting mortality rates [19]. The difference between Case 1 and Case 2 lies in the sequence of aortic injury surgeries. We believe that for vascular injuries that pose an immediate threat to the patient's life, they should be addressed promptly. Subsequently, a thorough examination for other acutely injured blood vessels should be carried out, followed by the implementation of corresponding surgical procedures. Endovascular and hybrid repair techniques for aortic injuries have now become the standard of care due to numerous advantages. Compared to open thoracic aortic repair, these techniques result in less blood loss, shorter operative times, shorter hospital stays, lower rates of surgical site infections, and the avoidance of cardiopulmonary bypass or single-lung ventilation, all of which significantly improve outcomes. Additionally, the rates of mortality, paralysis, and stroke are significantly lower with endovascular repair compared to open surgery [20].

Finally, the clinical characteristics of severe trauma demand promptness in trauma care. In Case 2, the treatment was led by a regional trauma center. In 2016, the Chinese Trauma Surgeon Association launched the China Trauma Care Training (CTCT) program, which holds independent intellectual property rights. This initiative aims to promote the latest concepts and techniques in the field of trauma care and to reinforce standardized protocols widely accepted in practice [21, 22]. By implementing certified trauma training programs and establishing a professional advancement system for trauma surgery instructors, the goal is to enhance trauma management and care capabilities. Since 2016, the CTCT program has conducted training in all provinces across mainland China, with a total of 100,000 trainees. The potential benefits of the CTCT training could reach a population of 1.4 billion. The CTCT training and the promotion of regional trauma center construction have played a positive role in standardizing the treatment of severe trauma. Notably, as of January 2025, the Primary Trauma Treatment Training (3T) program has successfully equipped over 2,000 primary medical personnel nationwide with vital procedural competencies and assessment skills. This strategic initiative has, to a non-negligible degree, strengthened the comprehensiveness of the pre-hospital and in-hospital integrated trauma care framework.

Limitations

Owing to the limited sample size and the retrospective design of this case report, the distinctive features of the patient may lack generalizability. It is imperative to gather a larger volume of data. In the future, if feasible, a dedicated database should be established to facilitate cohort studies. This approach will enable more comprehensive and reliable analyses, enhancing our understanding of the relevant medical conditions and improving the formulation of evidence - based treatment strategies.

Conclusions

In conclusion, the trauma mechanisms witnessed in these cases are typified by high-energy insults, which can directly precipitate multiple non-compressible vascular injuries. As evidenced, this may present as the co-existence of thoracic aortic injury and iliac vascular injury. A thorough and painstaking analysis of these infrequent trauma mechanisms holds paramount importance. For patients who have sustained high - energy traumas accompanied by hemodynamic instability, a comprehensive evaluation of the major arteries is an essential prerequisite. In particular, the implementation of a comprehensive aortic CTA stands out as a critical clinical step. During this diagnostic process, the medical team ought to conduct a meticulous and systematic search for the blood vessel that is most directly implicated in the life-threatening scenario. The accurate identification of this key vessel not only marks a significant diagnostic breakthrough but also serves as the cornerstone for formulating an effective therapeutic strategy. Consequently, this can substantially enhance the patient's probability of attaining a favorable clinical outcome.

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Author contributions
Lei Wang: Writing– original draft. Huamin Ge: Conceptualization. Ziyi Wang: Writing– review & editing. Haiping Zhao, Yufang Zhang: Resources, Data curation. Shouyin Jiang: Writing– review & editing, Investigation, Project administration, Visualization, Shanxiang Xu: Supervision, Validation, Funding acquisition.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval
The study received ethical approval from the Ethics Committee of the Second Affiliated Hospital, Zhejiang University School of Medicine. The approval number is I2024056. All participants provided their informed consent voluntarily. Moreover, informed consent was duly obtained from every patient for the publication of anonymized case-specific details and associated images, ensuring that their privacy and rights were fully respected throughout the process.

Consent for publication
The patients provided written consent for the publication of this case report and images.

Competing interests
The authors declare no competing interests.

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