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RESEARCH

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Hemothorax due to inferior phrenic artery injury from blunt trauma: a case series and systematic review

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Abstract

Background Hemothorax is a common complication of thoracic trauma, often associated with morbidity and mortality. While intercostal and internal mammary arteries are commonly involved, the inferior phrenic artery (IPA) is rarely the source of hemothorax following blunt trauma. We aimed to investigate the prevalence of IPA-related hemothorax by describing a single-center case series and to outline the characteristics and management of hemothorax secondary to IPA injury with a systematic review.

Methods We conducted a chart review of patients with trauma to identify patients with hemothorax due to IPA injury at a Japanese tertiary care hospital between 2013 and 2019. We performed a systematic review of published studies about this condition by searching PubMed, EMBASE, and ICHUSHI from their inception to January 18, 2025, summarizing their clinical characteristics, treatment, and prognosis.

Results Among 231 patients with hemothorax following blunt trauma, 3 (1.3%) were caused by IPA injury. The systematic review identified published articles for 16 additional reports, yielding 19 reports for analysis. IPA injury was typically diagnosed after 1 day to 3 weeks post-injury, with 94% of patients presenting with shock. Transcatheter arterial embolization (TAE) was the primary treatment, although many patients required additional interventions such as thoracotomy and hematoma evacuation. Complications included pneumonia, and the mortality rate was 11%.

Conclusions Hemothorax due to IPA injury following blunt trauma may be rare and potentially life-threatening. While endovascular techniques such as TAE were effective in many cases, repeated bleeding and substantial hematoma necessitated repeat interventions or surgical procedures. Despite an overall favorable prognosis, significant risks for complications and mortality remained. Thus, early recognition and increased awareness of IPA injury in patients with trauma are essential for improving outcomes.

Keywords Inferior phrenic artery, Hemothorax, Chest trauma, Transcatheter arterial embolization, Arterial redistribution

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Introduction

Thoracic trauma is common, occurring in approximately 60% of patients with polytrauma [1]. Hemothorax accounts for 5.9–31.8% of these cases [2, 3], with a reported mortality rate of up to 42.3% [4, 5]. Although most patients with hemothorax can be managed through observation and/or tube thoracostomy, treatment and its complications can be costly [6]. Moreover, thoracic trauma, including hemothorax, can impact long-term quality of life [7, 8]. Thus, timely and appropriate hemothorax treatment is essential to mitigate individual and societal burdens.

Hemothorax can result from injury to thoracic structures and blood vessels [9], with the aorta, pulmonary arteries, intercostal arteries (ICA), and internal mammary arteries (IMA) representing the primary arteries implicated [5]. With the increased use of angiography in trauma assessment, less common sources of bleeding have been identified, including the inferior phrenic artery (IPA). The IPA is a paired artery that typically originates from the abdominal aorta or celiac trunk at the level of the T12–L2 vertebrae [10, 11], running beneath the posterior parietal peritoneum and supplying the inferior surface of the diaphragm [10, 11]. Although the IPA can be involved in penetrating or iatrogenic injuries [12, 13], hemothorax due to IPA bleeding from blunt trauma has rarely been reported. To the best of our knowledge, no studies have elucidated the prevalence of IPA injury among patients with hemothorax due to blunt trauma or provided an overview of this condition.

We aimed to report three cases of life-threatening hemothorax due to bleeding from IPA and estimated the prevalence of this clinical condition. We conducted a systematic review of similar cases to summarize the characteristics, treatments, and prognoses.

Methods

This study was approved by the Institutional Review Board of the Kurashiki Central Hospital. To estimate the prevalence of hemothorax due to IPA injury following blunt trauma, we reviewed the institutional registry and medical charts of patients with trauma from July 1, 2013, to June 30, 2019. Our institution, Kurashiki Central Hospital, is a 1,131-bed tertiary care hospital located in Kurashiki, Okayama Prefecture, Japan. Our institution serves patients from the southwestern region of the prefecture, which has approximately 800,000 residents and 60,000 emergency visits annually. Our institution annually treated approximately 400 patients with trauma, including approximately 160 patients with severe trauma, defined by an Injury Severity Score of ≥ 16. Herein, we describe the patient characteristics and clinical outcomes associated with hemothorax due to IPA injury.

We conducted a systematic review of previously published case reports and series. We included case reports and case series from peer-reviewed journals and conference proceedings on hemothorax with bleeding from the IPA following blunt trauma, confirmed endovascularly or during surgery. We excluded cases related to penetrating trauma, iatrogenesis, and idiopathic bleeding and those with apparent diaphragmatic injury diagnosed immediately after injury. The review protocol has been registered in the University Hospital Medical Information Network Center (UMIN000056029).

We searched PubMed, EMBASE, and ICHUSHI (Medical Central Journals in Japanese) databases without language restrictions. Our search strategy was based on a systematic review of the IPA [10], as represented in Supplementary Table 1. We updated our search on January 18, 2025. Additionally, we screened the reference lists of the included case reports and searched Google Scholar to further identify potentially relevant reports.

Two authors (AK and YK) independently conducted the literature search and verified the eligibility of the reports. Any disagreements or uncertainties were resolved through discussion with a third author (RE). When available, we contacted the original authors via e-mail to assess eligibility for our review or obtain relevant data.

We used descriptive statistics to summarize the clinical characteristics, treatment, and prognoses of hemothorax caused by IPA injury in patients with blunt trauma.

Results

Chart review

A total of 708 patients with thoracic trauma, including 231 patients with hemothorax due to blunt trauma, were treated at our hospital between July 1, 2013, and June 30, 2019. Among them, three patients, comprising 0.4% (95% confidence interval [CI], 0.1 to 1.2) of all patients with thoracic trauma and 1.3% (95% CI, 0.3 to 3.7) of all patients with hemothorax due to blunt trauma, had hemothorax due to IPA injury. All three patients underwent TAE performed by attending-level interventional radiologists.

Case series

Case 1

An 81-year-old male with a history of post-pyloric gastrectomy presented to our emergency department (ED) with right-sided chest pain that developed immediately after a fall. Chest radiography and computed tomography (CT) revealed right hemopneumothorax with multiple right rib fractures (8th–12th). The patient underwent a right tube thoracostomy, and 250 mL of blood was drained. Although the vital signs were normal on admission, systolic blood pressure suddenly decreased to 60 mmHg at 37 h post-injury. The chest tube collected 700 mL of fresh blood within 1 h, and the blood continued to drain at >300 mL/h. Repeat CT revealed an enlarged hemothorax with contrast extravasation near the 11th–12th fractured ribs (Fig. 1A). Angiography confirmed active bleeding from the right IPA (Fig. 1B), which was embolized with N-butyl-2-cyanoacrylate. No obvious extravasation from the right ICA (11th–12th) or lumbar artery (L1) was observed. Hemodynamic status normalized after TAE, and the patient was admitted to the intensive care unit (ICU). However, blood restarted to drain from the chest tube. Another repeat CT scan 7 h post-TAE showed a massive right hemothorax with extravasation near the diaphragm and fractured ribs, prompting tube thoracostomy. Repeat angiography revealed extravasation from the 12th ICA and 1st lumbar artery, which were completely embolized using a gelatin sponge. After 9 h, the blood flow from the chest tube increased to 200 mL/h, and the patient went into shock. An emergency thoracotomy was performed. After the evacuation of approximately 5000 mL of blood from the right pleural space, we identified a 4 cm laceration in the right hemidiaphragm with active bleeding from the IPA. After laceration repair and IPA transfixion suturing, the patient became hemodynamically stable without further bleeding. During the 24 h period, the patient received 30 units of red blood cells (RBC), 34 units of fresh frozen plasma (FFP), and 30 units of platelet concentration (PC). The patient developed postoperative ventilator-associated pneumonia but otherwise had a good clinical course and was transferred to a rehabilitation hospital on day 17 of hospitalization.

Case 2

An 86-year-old female with a history of hypertension had fallen and hit her right chest, for which she did not seek medical advice 3 weeks before admission. Four days before referral, she underwent elective total knee arthroplasty at another hospital and was started on edoxaban as an antithrombotic prophylaxis. The patient was found to have a right hemothorax with shock and was referred to our hospital. On arrival, the patient was in shock with a pulse of 91 beats/min and blood pressure of 85/43 mmHg. Tube thoracotomy and resuscitation with blood components were performed, and approximately 1000 mL of fresh blood was drained. CT revealed the right hemothorax with contrast extravasation near the fractured ribs (8th–10th), and the 9th ICA was considered responsible for the bleeding. During angiography, the 8th–10th ICAs were examined, and extravasation from the 9th ICA was confirmed positive and embolized using a gelatin sponge. Hemodynamic status normalized after TAE, and the patient was admitted to the ICU. However, the chest tube continued to drain at 50 mL/h, and the patient's blood pressure gradually decreased. A chest radiograph obtained at 5 h post-TAE revealed a white-out of the right lung. Repeat CT showed a right-tension hemothorax with active bleeding from the right IPA into the thoracic space without hemoperitoneum (Fig. 2A). The right IPA was embolized using a gelatin sponge during repeat angiography (Fig. 2B). During the 14 h of resuscitation, the patient received 24 units of RBC, 24 units of FFP, and 30 units of PC. Although hemodynamic status stabilized after repeated TAE, a thoracotomy was performed to remove the massive hematoma. No active bleeding was observed intraoperatively; however, a laceration and hematoma were observed in the right lower lobe and diaphragm, which were adhered to each other. The right thoracic cavity contained more than 2000 mL of clotted blood, but no active bleeding was observed. The patient had an uneventful postoperative course and

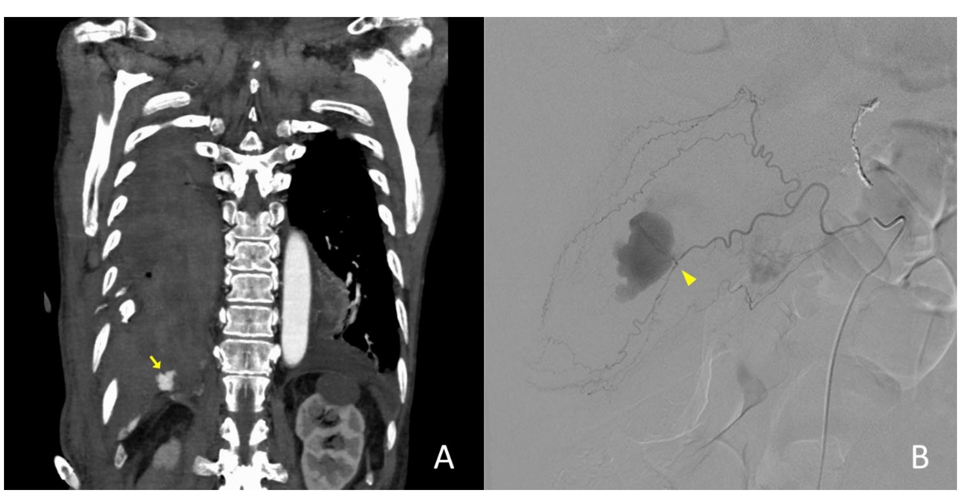

Fig. 1 Computed tomography and angiography in Case 1. (**A**) Enhanced computed tomography revealed a right hemothorax with contrast extravasation near the fractured rib. (**B**) Angiography demonstrated active bleeding from the right inferior phrenic artery

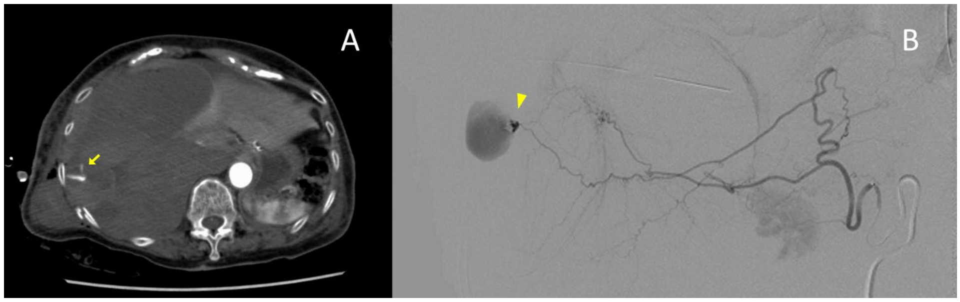

Fig. 2 Computed tomography and angiography in Case 2. (**A**) Repeat computed tomography revealed a right tension hemothorax and recurrent contrast extravasation. (**B**) New contrast extravasation from the right inferior phrenic artery was identified

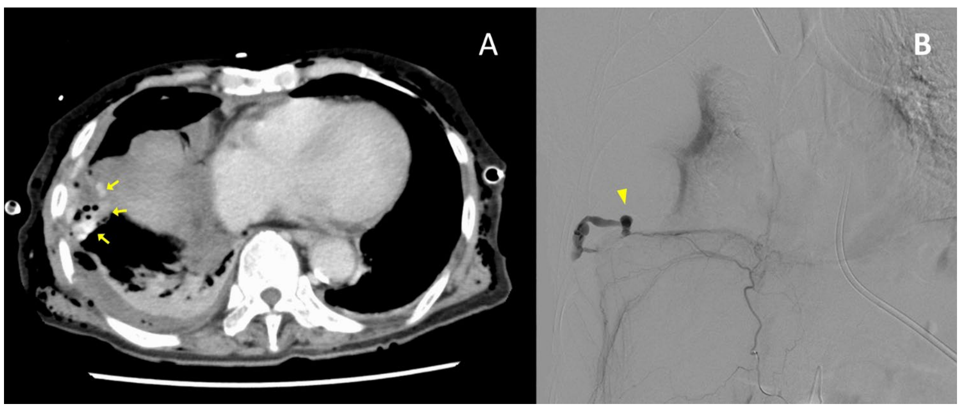

Fig. 3 Computed tomography and angiography in Case 3. (**A**) Computed tomography confirmed a right hemothorax with contrast extravasation into the pleural space. (**B**) Initial angiography revealed active bleeding from the right inferior phrenic artery

was transferred to another hospital for rehabilitation on day 27 of hospitalization.

Case 3

An 89-year-old male with liver cirrhosis due to hepatitis C virus infection was transferred to our ED after a fall. Upon admission, physical examination revealed marked subcutaneous emphysema throughout the patient's body with stable vital signs. CT revealed bilateral pneumothorax and mild hemothorax with multiple right rib fractures (6th–8th). The pneumothorax was resolved with a tube thoracotomy. A slightly bloody pleural effusion was initially drained at a rate of 20 mL/h from the right chest tube, which became serous after admission. However, on day 4, the chest tube suddenly started to drain fresh blood at a rate of ≥ 150 mL/h, and the patient went into shock. Repeat CT confirmed a right hemothorax with contrast extravasation near the fractured ribs (7th and 8th) without hemoperitoneum (Fig. 3A). The right ICAs (5th–9th) and IPA were examined during angiography. Extravasation from the right IPA was identified and embolized using a gelatin sponge (Fig. 3B). Although the bleeding stopped after TAE, the patient remained hemodynamically unstable, with the chest tube draining at a rate of > 100 mL/h, and a transfusion was required. Repeat angiography performed 9 h after the first TAE identified a new extravasation from the 7th ICA, which was embolized using a gelatin sponge. The total blood drained exceeded 3000 mL. During the course of treatment, the patient required 18 units of RBC, 24 units of FFP, and 10 units of PC. Although the bleeding was well controlled with the second TAE, the patient died on day 27 of hospitalization from non-resolving renal failure, likely associated with liver cirrhosis.

Systematic review

Our search yielded 53 titles and abstracts. After applying our inclusion and exclusion criteria, 16 case reports (6 in English and 10 in Japanese) were included (Fig. 4) [14–29]. In one report, rapid intrathoracic fluid accumulation after pericardiocentesis for cardiac tamponade raised the suspicion of hemothorax [25]. The details of the 19 patients, including our three patients, are listed in Table 1. The median age of the patients was 75 (range, 21–89) years, and 9 (47%) patients were male. The most common causes of injury were traffic accidents ($n = 9$, 47%) and falls ($n = 8$, 42%). The sites of concomitant abdominal organ injuries were the liver ($n = 6$, 32%) and spleen ($n = 3$, 16%). Among the 15 (79%) patients with rib fractures, 13 had multiple rib fractures, with the lower ribs involved in 10 patients for whom detailed information about the rib fractures was available. Seventeen

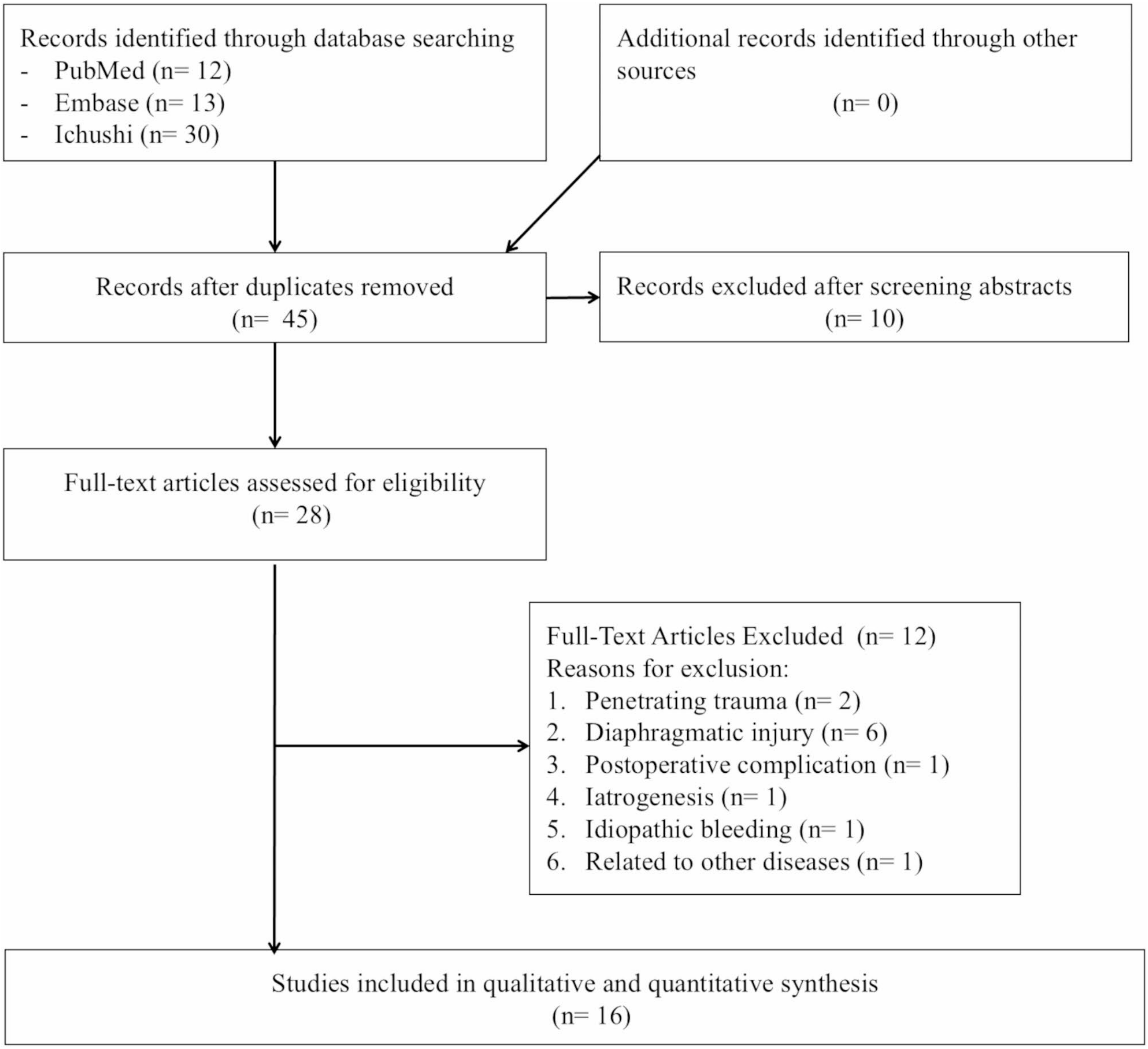

Fig. 4 Study selection

patients (89%) had peri-diaphragmatic organ injuries including ribs.

IPA injury was diagnosed or manifested in 13 (68%) patients 1 day or more after the initial injury (range: 1 day to 3 weeks). One patient (5%) was diagnosed immediately after injury [21]. All but three patients had involvement of the right IPA [20, 26, 28]. Four patients had pseudoaneurysms [19, 23, 27, 29]. Among the 17 patients with reported hemodynamic status at the time of diagnosis, 16 (94%) experienced shock, and the remaining patient exhibited at least tachycardia [17]. Tube thoracostomy was the mainstay treatment. All but one patient [28] underwent TAE to treat bleeding from the IPA. Four patients required an additional TAE to stop bleeding from the ICA ($n=4$) and IMA ($n=1$) in addition to the IPA. Three patients, including one of our patients, required thoracotomy and ligation or suture to control bleeding from the IPA [26, 28]. Furthermore, six more patients, including one of our patients, required surgical hematoma evacuation [15, 18–20, 22]. The clinical course was reported for 15 patients; empyema [27], critical illness myopathy requiring tracheostomy [15], prolonged mechanical ventilation [29], ventilator-associated pneumonia (our Case 1), and non-resolving renal failure (our Case 3) were reported in one patient each. Among the 18 patients with reported in-hospital prognoses, 2 (11%) died.

Table 1 Clinical characteristics of 19 cases (16 reported cases and our 3 cases)

Author/ Year	Age	Sex	Mechanism of injury	Other areas of injury in the torso	Rib fracture	Timing of diagnosis or manifestation	TAE for other thoracic arteries	Side	Symptoms	Complications	Procedures including hemostatic technique	In-hospital prognosis
Jones/ 1993	21	M	Motorcycle accident	- Bil PTx, pulmonary contusion - Liver laceration - Splenic fracture - Rt hemorrhage	NR	16 d after injury	-	Rt	Shock, hypoxia	Uneventful	TAE with polyvinyl alcohol particle	Survived
Ueshima/ 2008	64	F	Traffic accident	- Rt hemothorax - Liver injury	NR	1 d after injury	Rt ICA and IMA	Rt	Continued bloody drainage from ICD	NR	TAE with NBCA	Survived
Aoki/ 2015	81	F	Traffic accident	- Pelvic fracture	No	60 min after arrival	-	Rt	Shock	Uneventful	TAE with NBCA	Survived
Yamanashi/ 2015	75	M	Motorcycle accident	- Rt multiple rib fracture - Liver injury - Hemorrhagic pleural effusion	Rt 7–8, 10–11	24 h from admission	-	Rt	Sudden bloody drainage, hemodynamic instability	Empyema due to Klebsiella pneumoniae	TAE with GS	Died
Umesaki/ 2016	88	F	Unclear	- Rt multiple rib fracture	Rt, multiple	NR	-	Rt	Rt lateral chest pain	Prolonged mechanical ventilation	TAE	Survived
Inokuma/ 2017	66	F	Unclear	- Rt rib fracture	Rt 11, 12	4 d after chest pain	-	Rt	Tachycardia	Uneventful	TAE with NBCA	Survived
Maeshima/ 2017	54	M	Fall	- Rt rib fracture	Rt 9	1 d after injury	-	Rt	Shock, dyspnea	Uneventful	TAE with NBCA	Survived
Miyanaga/ 2017	75	F	Ejection from vehicle	- Bil tension PTX, rib fracture, pulmonary contusion - Liver/spleen injury - lumbar vertebral fracture	Most of all ribs	2 d after injury	-	Rt	Shock, Increased bloody drainage from ICD	Required tracheostomy, Critical illness myopathy	TAE Hematoma evacuation	Survived
Fujimoto/ 2018	33	F	Fall	- Rt rib fracture	Rt 11	2 wk after injury	-	Rt	Shock, Rt flank pain	Residual hematoma	TAE Hematoma evacuation	Survived
Matsushiro/ 2018	78	F	Vehicle rollover	- Tension PTx - Multiple rib fracture - Liver/splenic injury	Multiple	1 d after injury	-	Rt	Increased bloody drainage from ICD, hemodynamic instability	NR	TAE with GS Hematoma evacuation	Survived
Nakaizumi/ 2019	58	M	Collision with a car	- Bil multiple rib fracture - Rt PTx - Lt HTx, pulmonary contusion	Bilateral and multiple	6 d after injury	-	Lt	Shock and progressive anemia	NR	TAE with NBCA Hematoma evacualtion and rib fixation	Survived
Hachiya/ 2019	72	F	Collision with a car	- Bil multiple rib fracture - Pulmonary contusion - Liver injury - Pelvic fracture	Multiple	Immediately after admission to ICU	-	Rt	Shock and increase bloody drainage from ICD	NR	TAE	NR

Table 1 (continued)

Author/Year	Age	Sex	Mechanism of injury	Other areas of injury in the torso	Rib fracture	Timing of diagnosis or manifestation	TAE for other thoracic arteries	Side	Symptoms	Complications	Procedures including hemostatic technique	In-hospital prognosis
Muronoi/ 2020	58	M	Fall	- Lt rib fractures - Thoracic (Th11) and lumbar (L1, 2 3) vertebral fractures	Lt 11, 12	17 h after injury		Lt	Shock	Uneventful	Thoracotomy/ suture of the diaphragm	Survived
Okamoto/ 2022	70s	M	Motorcycle accident	- Rt multiple rib fracture, pulmonary contusion	Rt 4–9	1 d after injury	-	Rt	Shock, hypoxia	Uneventful	TAE Hematoma evacuation	Survived
Fukuda/ 2024	80s	F	Fall	- Rt HPTx, multiple rib fracture	Multiple	Immediately after injury	-	Rt	Shock, hypoxia	Uneventful	TAE with GS	Survived
Our case 1	81	M	Fall	- Rt HPTx, multiple rib fracture	Rt 8–12	37 h after injury	Rt ICA	Rt	Shock	Ventilator-associated pneumonia	TAE with NBCA Thoracotomy /ligation	Survived
Our case 2	86	F	Fall	- Rt rib fracture	Rt 8–11	3 wk after injury	Rt ICA	Rt	Shock	Uneventful	TAE with GS Hematoma evacuation	Survived
Our case 3	89	M	Fall	- Bil PTx - Rt rib fracture	Rt 6–8	The day of visit	Rt ICA	Rt	Shock	Non-resolving renal failure	TAE with GS	Died

Abbreviations: Bil, bilateral; F, female; GS, gelatine sponge; ICA, intercostal artery; IMA, internal mammary artery; HTx, hemothorax; HPTx, hemopneumothorax; IPA, inferior phrenic artery; Lt, left; M, male; NBCA, N-Butyl-2-cyanoacrylate; NR, not reported; PTx, pneumothorax; Rt, right; TAE, transcatheter arterial embolization

Discussion

Our single-center chart review suggests that the incidence of hemothorax due to bleeding from the IPA may be rare in patients with hemothorax due to blunt trauma. Our systematic review suggests that hemothorax due to IPA injury can present with delayed onset and lead to shock. While it can be effectively treated with TAE alone, surgical procedures such as ligation and hematoma evacuation are often required. Additionally, it can be associated with complications and poor prognosis.

Our study suggests that hemothorax caused by bleeding from the IPA accounts for 1.3% of all patients with hemothorax due to blunt trauma. Similarly, a previous study reported that IPA injury was present in 1 out of 68 patients (1.5%) who underwent TAE to treat traumatic thoracic bleeding [30]. Although these studies examined slightly different patient populations, they concluded that trauma-triggered IPA injuries are rare.

Our systematic review provides several insights into the characteristics of hemothorax resulting from IPA injury. First, approximately 90% of patients with this condition had at least one injury either above (lung or thoracic wall, including ribs) or below (liver or spleen) the diaphragm. The impact that caused peri-diaphragmatic organ injury may have affected the diaphragm itself, potentially leading to IPA injury. Second, if rib fractures were present, the lower ribs were typically involved. The IPA communicates with thoracic vessels such as the ICA and IMA, forming a vascular network through the collateral arteries [10, 31]. Therefore, lower rib fractures may be reasonably associated with bleeding from the IPA via the vascular network. Third, almost all patients with this condition, when diagnosed in the delayed phase, presented with hemodynamic instability. Although the extent of bleeding or hematoma volume has been inconsistently reported in previous cases, the need for subsequent surgical intervention, including hematoma evacuation, suggests significant blood loss. Finally, this condition may share similar complications with thoracic trauma, such as pneumonia [32], which has not been adequately addressed in previous reports. In addition, theoretically, empyema can develop if a substantial residual hematoma remains unevacuated. These complications may necessitate procedures such as tracheostomy or hematoma evacuation.

The IPA mainly supplies the diaphragm and feeds adjacent structures, including the esophagus, liver, and suprarenal glands. Additionally, the IPA is involved in the extrahepatic blood supply to hepatocellular carcinoma [33, 34], extrabronchial causes of hemoptysis [35], and upper gastrointestinal bleeding [36]. As the IPA courses along the inferior surface of the diaphragm, it can bleed into the peritoneal cavity when injured [37]. Our systematic review did not identify any patient with concurrent hemothorax and intra-abdominal bleeding attributed to IPA injury. Furthermore, hemothorax could occur due to the anatomical proximity of the IPA to the diaphragm or potential communication between the retrocrural space and pleural cavity [38]. TAE is a safe and effective treatment if the hemodynamic conditions of the patient allow [33]. However, thoracotomy or laparoscopic intervention should be considered if there is hemodynamic derangement or anatomical disruption that requires surgical correction [13].

The manifestation or diagnosis of IPA injury was delayed in most patients, ranging from 1 h to 3 weeks. Four potential explanations have been proposed for this phenomenon. First, given that the IPA is a relatively thin blood vessel, minor bleeding may take time to manifest clinically if it is initially undiagnosed. Second, an IPA injury may be associated with a diaphragmatic injury, which is often difficult to diagnose and may present later [39, 40]. Although intraoperative findings were limited in prior reports, diaphragmatic injury along with IPA injury was observed during surgery in some cases including our patients (Cases 1 and 2). Third, rib fractures with sharp ends may cause diaphragmatic damage over time [28]. This can be attributed to the frequent involvement of the lower ribs in previously reported cases. Hence, body movements may trigger bleeding from the IPA, possibly due to displaced fractured bones damaging the diaphragm. Fourth, blood flow modifications may occur following embolization of the initial bleeding arteries. Four patients in this review required a second TAE of other arteries after successful embolization of the ICA, IMA, or IPA. Since thoracic vessels form a network of collateral arteries, including the IPA [10, 11, 31, 33], embolization of one artery may increase blood flow to other vessels in bluntly injured areas near the initially embolized vessels [33]. Thus, even though patients with hemothorax undergo successful TAE, vigilant monitoring of bleeding from other arteries near the injured sites is essential.

Since the prevalence of IPA injury among patients with hemothorax may be low, screening for IPA injury in all patients with hemothorax is inefficient. Therefore, we propose the following management approach. Initial management should follow the Primary Survey in the Advanced Trauma Life Support guidelines, prioritizing patient physiological status. Thoracostomy is the first-line treatment for hemothorax. However, emergency thoracotomy is the only option for massive hemothorax in moribund patients because it is not feasible to identify the bleeding source otherwise. If an IPA injury is identified during emergency thoracotomy, IPA ligation should be performed. Further investigations should be conducted in hemodynamically stable patients. As outlined in our review, when peri-diaphragmatic organ injury is detected, the diaphragm and surrounding organs should be carefully examined for potential injury. If extravasation is identified on CT, TAE should be considered. The ICA and IMA should be considered first because they are common hemothorax sources. If angiography fails to identify the bleeding vessels, the IPA or other anatomically close arteries should be considered as potential bleeding sources. Once bleeding is controlled, patients should be monitored in the ICU to correct physiologically unstable conditions such as coagulopathy, acidosis, and hypothermia. If a patient's condition deteriorates after thoracotomy or TAE, reassessment for rebleeding should be performed. Patients with peri-diaphragmatic organ injury, lower rib fractures, or hemothorax in the delayed phase should be closely monitored for bleeding from the IPA and/or unnoticed diaphragmatic injury or anatomically close arteries yet to be embolized. In such patients, it is occasionally necessary to consider surgical intervention. A treatment algorithm illustrating this approach is shown in Fig. 5.

Our study has limitations. First, our chart review may have been susceptible to detection bias. While our institution utilizes a protocolized management approach for blunt trauma, not all patients may have undergone uniform diagnostic procedures for hemothorax based on patient conditions. Thus, IPA injuries could have been missed in self-limiting cases or deaths without an autopsy, potentially resulting in an underestimated prevalence of IPA injuries. Second, we could not obtain some missing data for our systematic review because contact information for the original authors was lacking. More reports of similar cases are warranted to better understand the complications associated with this condition. Third, our literature search may have failed to identify studies that reported the frequency of IPA injuries in hemothorax in the full text but not in the abstract, especially if it was not their primary finding. Finally, although we conducted a comprehensive literature search using multiple databases, similar cases may not have been published. Clinicians may opt not to present cases when their patients die from IPA injury, which could lead to a publication bias. As this condition may be rare, accumulating similar cases is needed to ensure better recognition and understanding of this disease.

Conclusions

Hemothorax due to IPA injury following blunt trauma may be rare and potentially life-threatening. Although endovascular techniques are effective in many cases, persistent bleeding and substantial hematoma may require repeated interventions and surgical procedures. While the prognosis can be favorable, significant risks of complications and mortality remain unresolved. Early

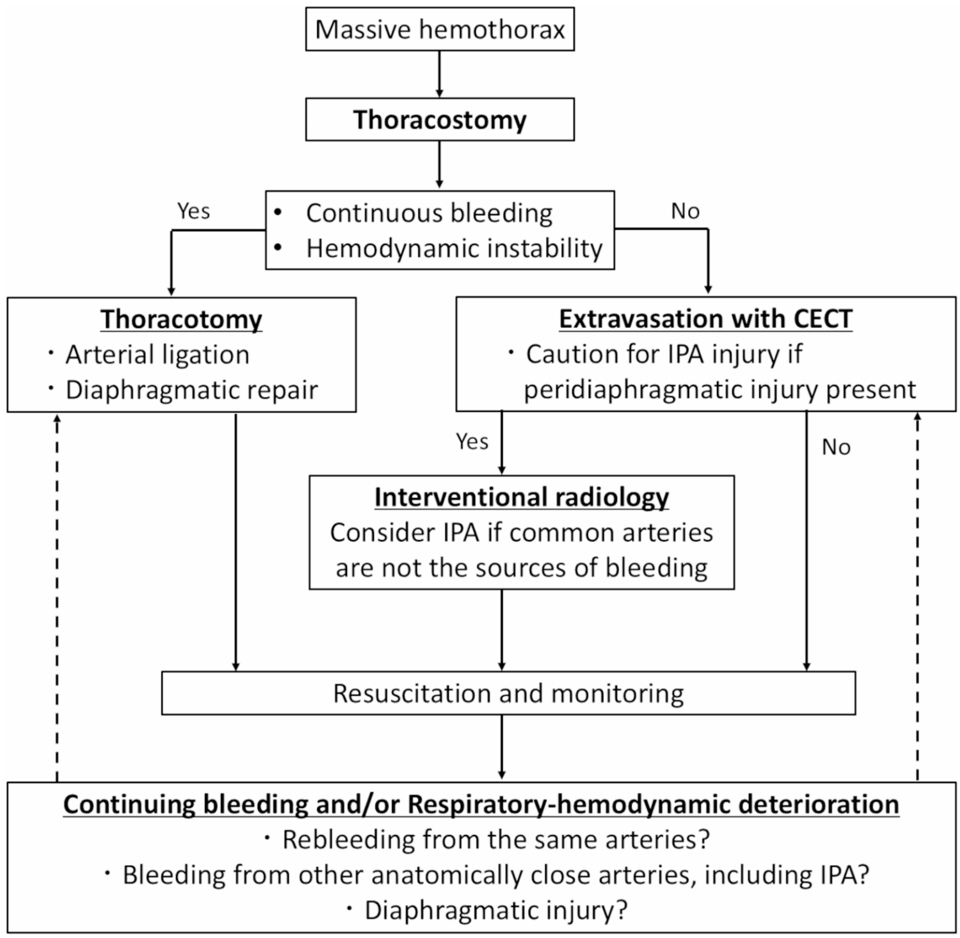

Fig. 5 Proposed treatment algorithm for hemothorax due to the potential/definite inferior phrenic artery injury. Abbreviations: CECT, contrast-enhanced computed tomography; IPA, inferior phrenic artery

recognition and awareness of IPA injury in patients with trauma are crucial for improving patient outcomes.

Abbreviations

CI	Confidence inerval
CT	Computed tomography
ED	Emergency department
FFP	Fresh frozen plasma
ICA	Intercostal artery
ICU	Intensive care unit
IMA	Internal mammary artery
IPA	Inferior phrenic artery
PC	Platelet concentration
RBC	Red blood cells
TAE	Transcatheter arterial embolization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13017-025-00609-3.

Supplementary Material 1

Acknowledgements
Not applicable.

Author contributions
AK conceived the study. All authors took care of the patients, acquired, analysed, and interpreted the data. AK and YK wrote the manuscript. All authors critically revised the manuscript and approved the submission of the final manuscript.

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

Declarations

Ethics approval and consent to participate
This study was approved by the Institutional Review Board of the Kurashiki Central Hospital.

Consent for publication
Consent for publication was waived after the approval by the Institutional Review Board because of the retrospective study design.

Competing interests
The authors declare no competing interests.

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