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CASE REPORT

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A rare case of right atrial perforation and pericardial tamponade following leakage of bone cement

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Abstract

Background Percutaneous vertebroplasty is commonly used to treats vertebral fractures, tumors, and osteolytic vertebral metastases. However, cement leakage during the procedure can lead to severe complications, including cardiac perforation. This report presents a case of right atrial perforation and pulmonary embolism caused by cement leakage, emphasizing the clinical significance of these events and discussing the treatment strategy.

Case presentation A 57-year-old female was admitted to the hospital with a slipped lumbar vertebra and back pain, for which she underwent percutaneous vertebroplasty. On the 10th postoperative day, the patient suddenly developed chest tightness and shortness of breath, accompanied by a gradual decline in hemoglobin levels. After several imaging studies, a diagnosis of right atrial perforation caused by bone cement was confirmed. The patient subsequently underwent open cardiac foreign body removal and made a full recovery, with no residual cardiac dysfunction.

Conclusion This case highlights the rare but serious complication of right atrial perforation caused by bone cement leakage during percutaneous vertebroplasty. The report emphasizes the importance of early identification of bone cement-related complications. While conservative management may suffice for pulmonary embolism, urgent surgical treatment is required for cardiac cement embolism to prevent further complications.

Keywords Bone cement leakage, Heart perforation, Echocardiography

Introduction

Polymethylmethacrylate (PMMA) cement is widely used in vertebroplasty and other orthopedic procedures to stabilize spinal structures and alleviate pain. However, its use carries certain risks, particularly the potential for cement leakage into the venous system, which can result in severe complications such as heart perforation [1]. While this complication is rare, it can be life-threatening when it occurs. Although heart complications due to cement leakage have been documented in the literature [2, 3], early identification and effective management of penetrating cardiac injuries remain challenging in clinical practice.

Case report

The patient was a 57-year-old female admitted with a history of lumbar spondylolisthesis, discovered over 20 years ago, and presenting with lumbago for the past 7 months. Preoperative CT scans revealed L4 vertebral slippage along with degeneration of the L4/5 and L5/S1 intervertebral disc (Fig. 1). After a thorough evaluation upon admission, and with no significant contraindications to surgery, the patient underwent vertebroplasty.

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Fig. 1 Lumbar computed tomography showed L4 vertebral slippage, along with degeneration of the L4/5 and L5/S1 intervertebral disc

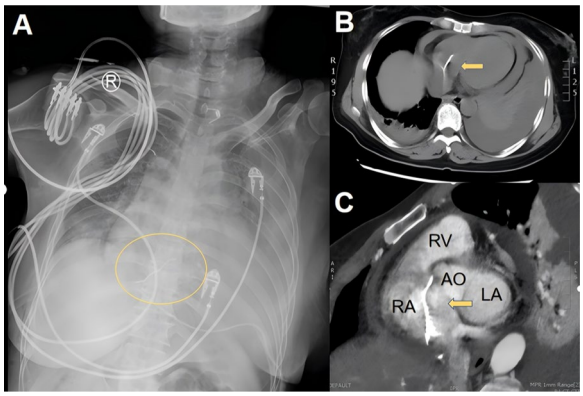

Fig. 2 **A** Chest X-ray showing irregular long cement images highlighted within the yellow circle, **B** CT angiography of the lungs, with yellow arrows pointing to the bone cement in the right atrium, **C** full aortic angiogram, with the yellow arrow indicating a high-density shadow in the region of the right atrium, tricuspid valve, and right ventricle. LA = left atrium, AO = aortic, RA = right atrium, RV = right ventricle

Postoperatively, her vital signs remained stable, and her recovery progressed well.

However, on the 10th postoperative day during hospitalization, the patient developed acute chest tightness and dyspnea, along with a gradual decrease in hemoglobin levels. She had no prior history of heart disease. To rule out cardiac pathology, an electrocardiogram and cardiac enzyme tests were performed, both of which returned normal results. The patient's postoperative wound had healed well, with no signs of gastrointestinal bleeding, such as hematemesis or melena. Additionally, blood cell morphology appeared normal, effectively excluding hematologic disorders. As a result, the progressive decline in hemoglobin was suspected to be due to undetermined blood loss, and the patient was promptly transfused with 2 units of concentrated red blood cells.

On the 11th postoperative day, the patient's chest tightness and shortness of breath persisted. To rule out any issues at the lumbar surgical site, a full abdominal computed tomography (CT) scan was performed. The results showed no significant abnormalities in the surgical site or abdominal organs but did reveal pericardial and pleural effusion. At this time, the patient's albumin level was 29.8 g/L, just below the threshold for hypoalbuminemia, although she had normal levels prior to surgery. Given her overall stable condition and the absence of clear signs of acute heart failure or compressive pericardial effusion, conservative treatment was initiated, including diuresis and albumin infusion. However, despite this approach, there was no reduction in pericardial or pleural effusion. A bedside color Doppler ultrasound of the heart was then performed, revealing moderate pericardial effusion and bilateral pleural effusion. Diuresis was continued, and albumin infusions were administered, as the pleural effusion was suspected to be related to decreased plasma osmotic pressure.

On the 13th postoperative day, the patient's chest tightness and shortness of breath worsened compared to the previous day, raising concerns about potential cardiac and pulmonary issues. A CT scan of the lungs was performed, revealing a surprising increase in pericardial and bilateral pleural effusion compared to the previous scan, as well as a long, dense shadow at the heart (Fig. 2B). Given the patient's elevated pleural effusion and deteriorating oxygenation, she was promptly transferred to the intensive care unit of the thoracic surgery department. A chest tube was inserted on the same day to drain the pleural effusion.

On the 14th postoperative day, the patient's chest tightness and shortness of breath persisted, with 800 ml of fluid drained from the chest tube. The drainage fluid was light red and tested positive for the Rivalta test (+). The total cell count exceeded 50,000, with a white blood cell count of 6,480, indicating an exudate with associated inflammation. A chest X-ray confirmed a large volume of pericardial and bilateral pleural effusions, along with a long, high-density shadow resembling blood vessels near the heart (Fig. 2A). Given the patient's lack of previous cardiac surgery or thoracic trauma, this finding raised concern. That day, pericardiocentesis was performed to relieve pressure from the accumulating pericardial effusion, yielding 190 ml of dark red fluid.

On the 15th postoperative day, a multi-disciplinary team (MDT) meeting was held. By integrating findings from the CT scan and chest X-ray with the patient's clinical symptoms and history, the team hypothesized

that the long, high-density shadow represented leaking bone cement. The MDT discussed whether immediate thoracotomy was necesssary to remove the bone cement. However, only 23 ml of pericardial drainage fluid was collected the following day, suggesting that intracardiac bone cement was unlikely to have caused perforation. The pericardial drainage fluid was confirmed to be exudate. Coagulation tests revealed prolonged prothrombin time (PT) and activated partial thromboplastin time (APTT), a slight decrease in platelet count, and reduced fibrinogen levels, indicating significant coagulation dysfunction and increasing the risk of hemorrhagic complications. The MDT concluded that intracardiac bone cement could potentially be removed via percutaneous intervention, but given the patient's critical condition and coagulation abnormalities, conservative management was prioritized. On the 16th day, the patient received a continuous infusion of 2 units of concentrated red blood cells (Fig. 3).

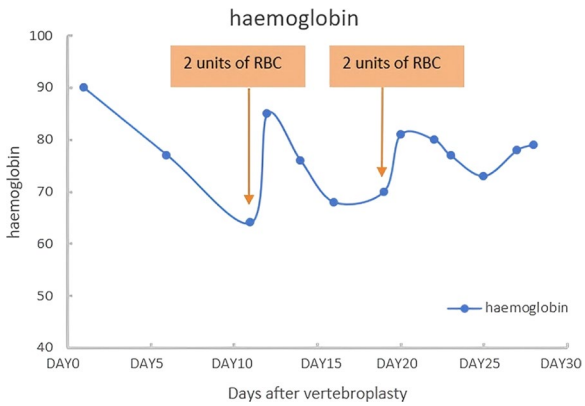

Fig. 3 Trend chart showing changes in red blood cell count following vertebroplasty in the patient

From the 17th to the 24th postoperative day, the patient continued closed chest and pericardial drainage. During this period, the volume of pericardial drainage fluid decreased, and by the 23rd day, no fluid was present. However, the patient's symptoms of chest tightness and shortness of breath persisted, prompting a follow-up echocardiogram, which revealed moderate pericardial effusion. Suspecting possible obstruction of the drainage tube due to fibrinous exudate, a pigtail catheter was deployed as a substitute. On the 24th day, the pericardial drainage fluid volume increased to 200 ml.

On the 25th postoperative day, the volume of pericardial drainage fluid increased to 570 ml, while the patient's hemoglobin level continued to decline. Suspecting active bleeding from the heart, the patient underwent comprehensive CT angiography of the entire aorta. The results revealed a high-density shadow in the region of the right atrium, tricuspid valve, and right ventricle, as well as in the posterior segment of the right upper lobe where the pulmonary artery branches travel (Fig. 2C). A transthoracic echocardiogram also identified a long, floating, hyper-echoic object within the heart (Fig. 4A).

On day 26, the patient underwent emergency cardiac foreign body removal in the cardiovascular surgery department. Intraoperative transesophageal echocardiogram revealed a long, hyper-echoic strip in the right heart region (Fig. 4B). Upon opening the chest, the intraoperative findings confirmed our suspicions. A minor laceration was identified in the inferior vena cava near the side wall of the right atrium (Fig. 5A), accompanied

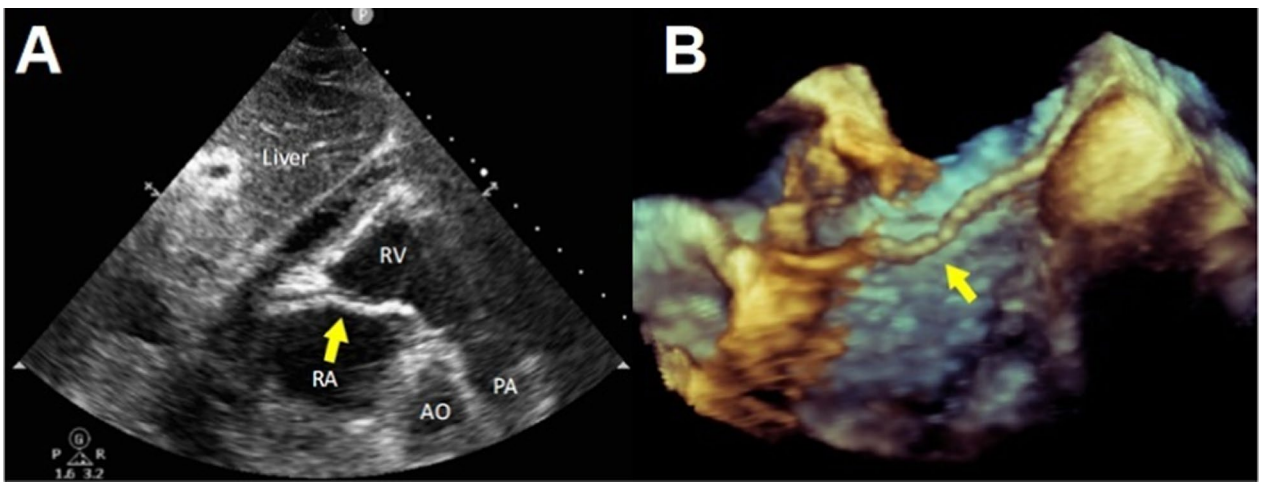

Fig. 4 **A** Transthoracic echocardiogram showing the yellow arrow indicating the entry of bone cement from the right atrium through the tricuspid valve into the right ventricle, **B** transesophageal 3D echocardiogram, with the yellow arrow poingting to the cement floating at the tricuspid valve orifice in the right atrium. AO = aortic, RA = right atrium, RV = right ventricle, PA = pulmonary artery

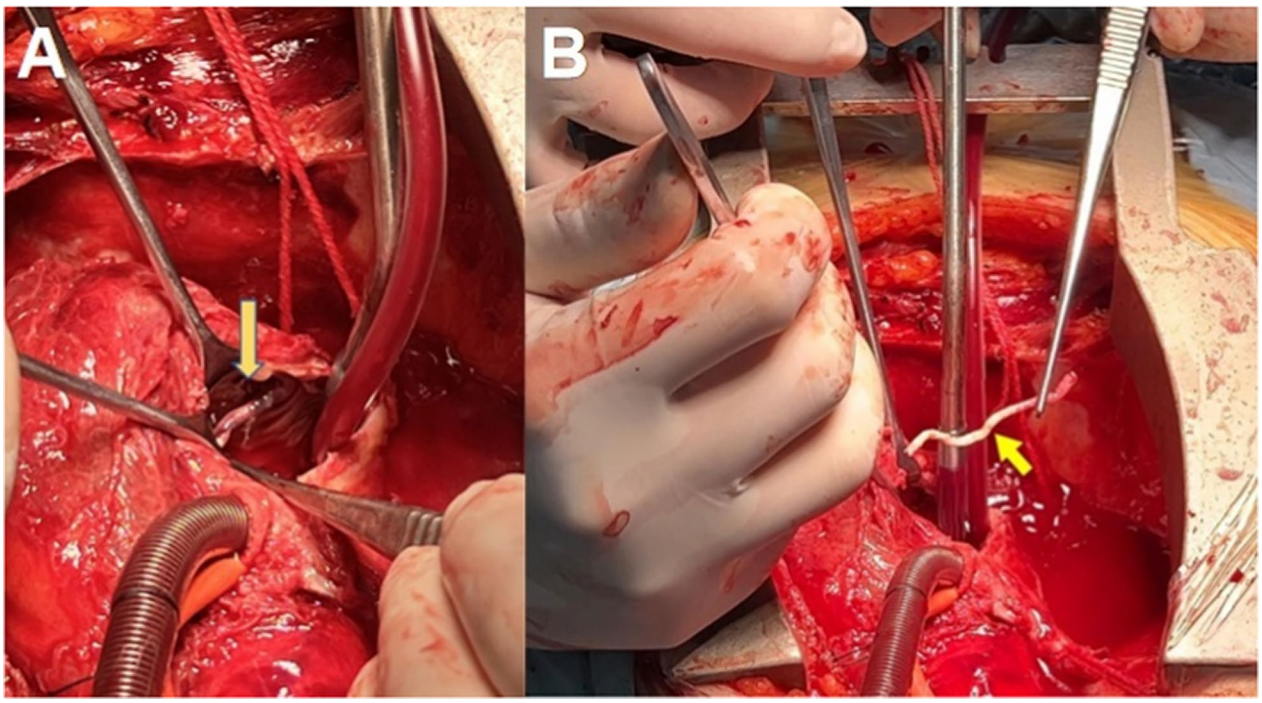

Fig. 5 Surgical field during the open-chest operation. **A** The yellow arrow shows the bone cement crossing into the right atrium, **B** the yellow arrow points to the strip of bone cement, approximately 8 cm long, that was completely removed

by extensive local thrombosis. A long, thin piece of bone cement, approximately 8 cm in length, was located in the right atrium (Fig. 5B). One end of the cement was embedded in the anterior-lateral region of the right atrium near the atrioventricular groove, while the other end extended into the right ventricle through the tricuspid valve orifice. The surgeon successfully removed the foreign body, and the operation was completed without complications.

From the 27th to the 39th postoperative day, the patient underwent several follow-up cardiac examinations, including chest CT and chest X-rays, which showed a continued reduction in pericardial and pleural effusions. The patient was discharged on the 45th day, reporting improvement in all symptoms (Fig. 6).

Discussion

The use of bone cement is now widespread, with cement leakage occurring in some cases. Cement leakage occurs in up to 65% of vertebral fracture treatments [4], and it can lead to potentially life-threatening complications [5], including spinal cord or nerve root compression, as well as systemic issues such as pulmonary embolism, intracardiac embolism, and paradoxical embolism [6]. During vertebroplasty, bone cement can enter the venous system, particularly through the spinal veins and the inferior vena cava, due to excessive injection pressure or overextension. When the cement is in a semi-liquid state, it can enter the right side of the heart via the venous system, where it solidifies within the heart chamber, potentially leading to heart wall perforation or mechanical irritation. Once bone cement particles enter the right ventricle, they can be carried by the blood flow into the pulmonary artery, causing a pulmonary embolism. Though cardiac perforation following vertebroplasty is rare, the survival rate largely depends on timely diagnosis and intervention. Due to its low incidence and potentially life-threatening consequences, case reports of penetrating cardiac trauma are generally published by large, specialized trauma centers. A deep understanding of the disease progression helps cardiothoracic surgeons treat these injuries promptly and effectively, thereby maximizing survival rates after penetrating cardiac trauma.

Most cement leaks do not produce obvious clinical symptoms, and identifying asymptomatic patients can be challenging. Bone cement leaks tend to be long and thin, as they often originate from the vertebral venous system. The symptoms vary depending on how the leaked cement migrates through the venous system to the right heart and pulmonary artery. The symptoms can include acute chest pain, syncope, and life-threatening complications such as pericardial tamponade caused by perforation, as well as acute respiratory distress syndrome (ARDS) due to pulmonary embolism [2, 3]. Therefore, the clinical symptoms of cement leakage are not specific.

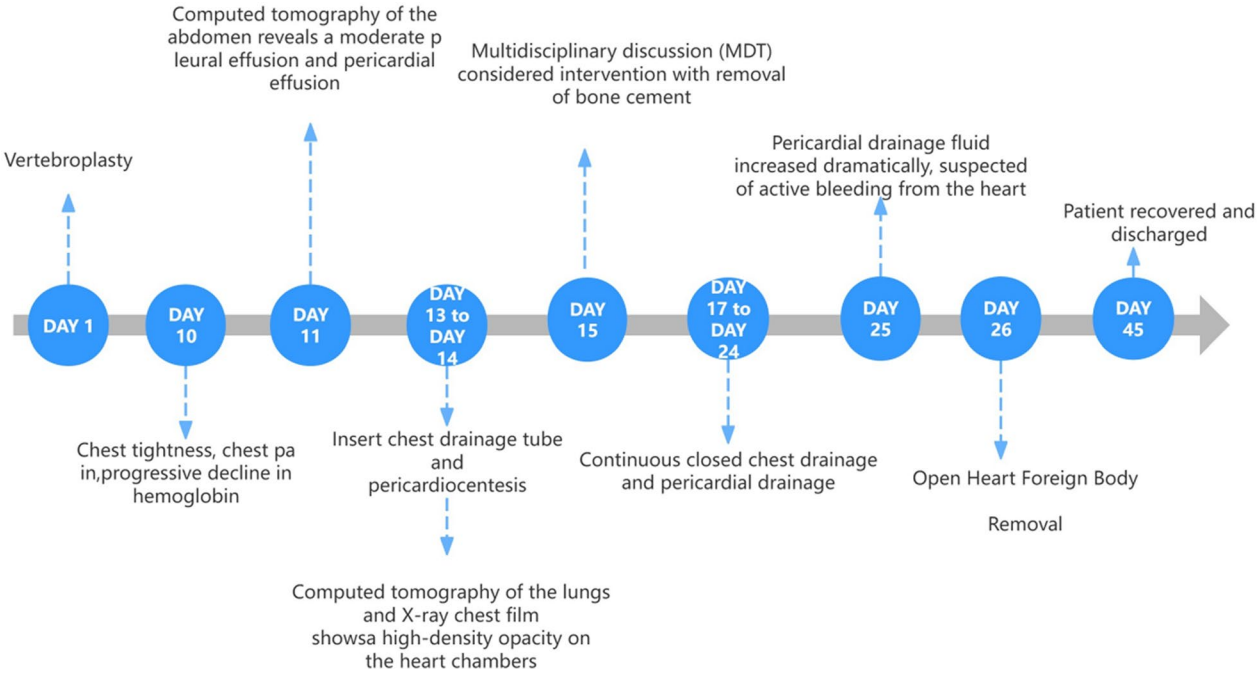

Fig. 6 Flow chart depicting the inpatient treatment process

In our case, the patient experienced sudden chest tightness and shortness of breath. Other cases reported in the literature have shown symptoms such as retrosternal pain, epigastric pain, severe dyspnoea, sudden syncope, and cardiogenic shock, including hypotension, hypoxemia, and cold, clammy skin. In some instances, severe complications like cardiac perforation and pulmonary embolism do not manifest immediately [7]. It has been documented that cardiac perforation caused by cement leakage did not appear until 2.5 years after the operation [8], during which the patient typically did not experience chest discomfort. In our case, the patient developed chest tightness and shortness of breath on postoperative day 10, and pericardial effusion was detected. However, there were no signs of hemodynamic instability or significant symptoms related to the pericardial effusion. At this point, performing a contrast-enhanced chest CT scan would have been a more appropriate step, enabling a better assessment of the condition and potentially preventing any delay in surgical intervention.

To identify leaks in patients following bone cement procedures, in addition to CT of the surgical site, chest X-ray or chest CT should be performed to rule out potential bone cement leaks leading to pulmonary embolism or cardiac foreign bodies. When cardiothoracic surgeons encounter symptoms such as chest pain, unexplained pericardial effusion, or even pulmonary embolism with no clear cause following recent vertebroplasty, it is essential to not only rule out underlying cardiac and pulmonary conditions but also to consider the possibility of cardiac perforation due to bone cement. This can often be identified by the appearance of a long, high-density shadow on chest CT scans. For critically ill or unstable patients, bedside echocardiography is crucial to detect pericardial effusion and guide appropriate intervention.

In patients with penetrating heart injuries, echocardiography is a critical diagnostic and assessment tool, offering a rapid and reliable method for evaluation. Additionally, it is a non-invasive, radiation-free technique that can be easily performed at the bedside, making it highly convenient for repeated use in clinical settings [9–13]. Research has demonstrated that echocardiography is highly accurate in detecting pericardial effusion, with sensitivity ranging from 96 to 97% and specificity approaching 100%. It is also valuable in further characterizing foreign bodies within the heart muscle and chambers [14–16]. Echocardiography provides a visual and real-time representation of the cardiac structure, valve function, hemodynamic conditions within the chambers, and regional wall motion, making it crucial in diagnosing conditions like pericardial tamponade and cardiac foreign bodies. Moreover, it can estimate the volume of pericardial effusion. Experts recommend using echocardiography to diagnose pericardial effusion and search for foreign bodies in all patients with suspected cardiac damage, as it is fast, reproducible, and can influence surgical management [17].

Currently, the treatment strategies for patients with intracardiac bone cement embolism are as follows: Firstly, conservative treatment may be considered for asymptomatic patients. The preferred approach involves anticoagulation with low-molecular-weight heparin or warfarin until the foreign body becomes encapsulated and ceases to pose a thrombotic risk [18]. Secondly, patients with symptomatic right atrial thrombi are typically treated with percutaneous intervention to remove the pulmonary cement embolism [19]. In contrast, patients with significant ventricular involvement or perforation are generally treated with surgical intervention [20]. In this case presented, the medical team initially opted for conservative treatment, as the patient's pericardial effusion remained stable. However, when continuous pericardial tamponade developed and cardiac perforation was suspected, surgical removal of the foreign body was chosen to prevent further damage.

The prognosis for heart perforation primarily depends on early surgical intervention. Additionally, the location and extent of the injury significantly influence the outcome.Some studies suggest that the prognosis for heart perforation combined with left ventricular rupture is worse than that for right ventricular rupture. The survival rate of right ventricular injury is 79%, while for left ventricular injury, it is only 28% [21]. In addition, penetrating heart injuries involving damage to valves, conduction bundles, or the main coronary arteries can lead to heart failure, further complicating the prognosis. The presence or absence of pericardial tamponade also palys a crucial role in determing the outcome. Studies have shown that injuries to the right-sided chambers tend to have a higher survival rate (79%) compared to those involving the left-sided chambes (28%) [21]. Asensio et al. [22] confirmed in a prospective study that cardiac tamponade does not provide any beneficial effect on survival following penetrating cardiac injury. In addition, penetrating or perforating wounds resulting in a breach of the chest or extra-thoracic space with massive bleeding are often associated with early mortality. In the case presented, the patient had a favorable recovery because the bone cement-induced injury was located in the anterior lateral region of the right atrium and did not involve the ventricles, valves, conduction bundles, or coronary arteries.

Conclusion

Penetrating cardiac injury caused by bone cement is rare. It is important that rapid diagnosis and timely intervention are crucial for effective treatment. Conservative treatment may be considered for bone cement that has entered the lungs. However, if it remains within the heart, its elongated shape increases the risk of perforation, which may require an instant thoracotomy to prevent severe complications.

Abbreviations

PMMA	Polymethylmethacrylate
MDT	Multi-disciplinarytreatment
ARDS	Acute respiratory distress syndrome
AO	Aortic
RA	Right atrium
RV	Right ventricle
PA	Pulmonary artery

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Author contributions

RLL and ZRW drafted the manuscript. RLL and ZWZ designed the study. HY, QA, and WCJ were responsible for the data collection and analysis. QW and ZRW revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Second Xiangya Hospital of Central South University, and the study was carried out in accordance with the World Medical Association Declaration of Helsinki. This study was exempt from ethics committee review due to its retrospective nature.

Consent for publication

Written informed consent was obtained from the patient and her families for the use of the information and accompanying images in this study.

Competing interests

The authors declare no competing interests.

Clinical trial number

Not applicable.

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