

## Intracardiac bone cement embolism as a complication of vertebroplasty: management strategy

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### Abstract

#### Background



Vertebroplasty carries multiple complications due to the leakage of polymethylmethacrylate (PMMA) into the venous system through the iliolumbar or epidural veins. The rate of venous cement complications may vary from 1 to 10 %, with cement extravasation into the venous system in 24 % of patients. Emboli may further migrate into the right heart chambers and pulmonary arteries. Patients may vary in presentation from asymptomatic or symptoms such as syncope to life-threatening complications.

*Case report* We present a case of a 57-year-old lady diagnosed with osteoporosis who underwent a staged antero–posterior fixation with PMMA vertebroplasty of progressive thoraco–lumbar kyphosis caused by osteoporotic fractures to T12, L1 and L2 vertebral bodies. Four weeks after the operation, the patient developed symptoms of left-sided chest pain, tachycardia and tachypnea. CT pulmonary angiogram (CTPA) found a high-density material within the right atrium, whilst ECHO demonstrated normal systolic function. The patient was commenced on enoxaparin at therapeutic dose of 1.5 mg/kg for 3 months and remained asymptomatic. Follow-up ECHO found no change to the heart function and no blood clot on the PMMA embolus.

*Conclusions* Factors influencing the decision about conservative treatment included symptoms, localisation of the embolus, as well as time lapse between vertebroplasty and clinical manifestation. Patients that are commonly asymptomatic can be treated conservatively. The management of choice is anticoagulation with low-molecular-weight heparin or warfarin until the foreign body epithelialises and ceases in becoming potentially thrombogenic. Symptomatic patients with thrombi in the right atrium are commonly managed via percutaneous retrieval, whilst those with RV involvement or perforation are commonly managed with surgical retrieval. Management of individual patients should be based on individual clinical circumstances. Patients presenting with intracardiac bone cement embolism related to spinal procedures require thorough clinical assessment, cardiology input, and if required, surgical intervention.

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**Keywords** Vertebroplasty · Bone cement embolism · Intracardiac embolism

## Case presentation

A 57-year-old lady diagnosed with osteoporosis (Z-score for L3 and L4  $-1.6$ ) underwent a staged antero–posterior fixation with polymethylmethacrylate (PMMA) augmentation of a major and progressive thoraco–lumbar kyphosis caused by osteoporotic fractures to T12, L1 and L2 vertebral bodies (Fig. 1). In the first stage, a T8–L5 vertebroplasty was performed, followed by T9–10 and L3–4 posterior instrumentation. The L1 anterior corpectomy with implantation of the cage was performed in the third stage, but it was complicated with a small tear to the diaphragm, which was repaired during the same session. Four weeks after the operation, the patient developed left-sided chest pain and was found to have ipsilateral transudative pleural effusion as revealed by the chest radiograph (CXR). As she became tachycardic and tachypneic, there was a high index of suspicion of pulmonary embolism, and a CT pulmonary angiogram (CTPA) was performed.

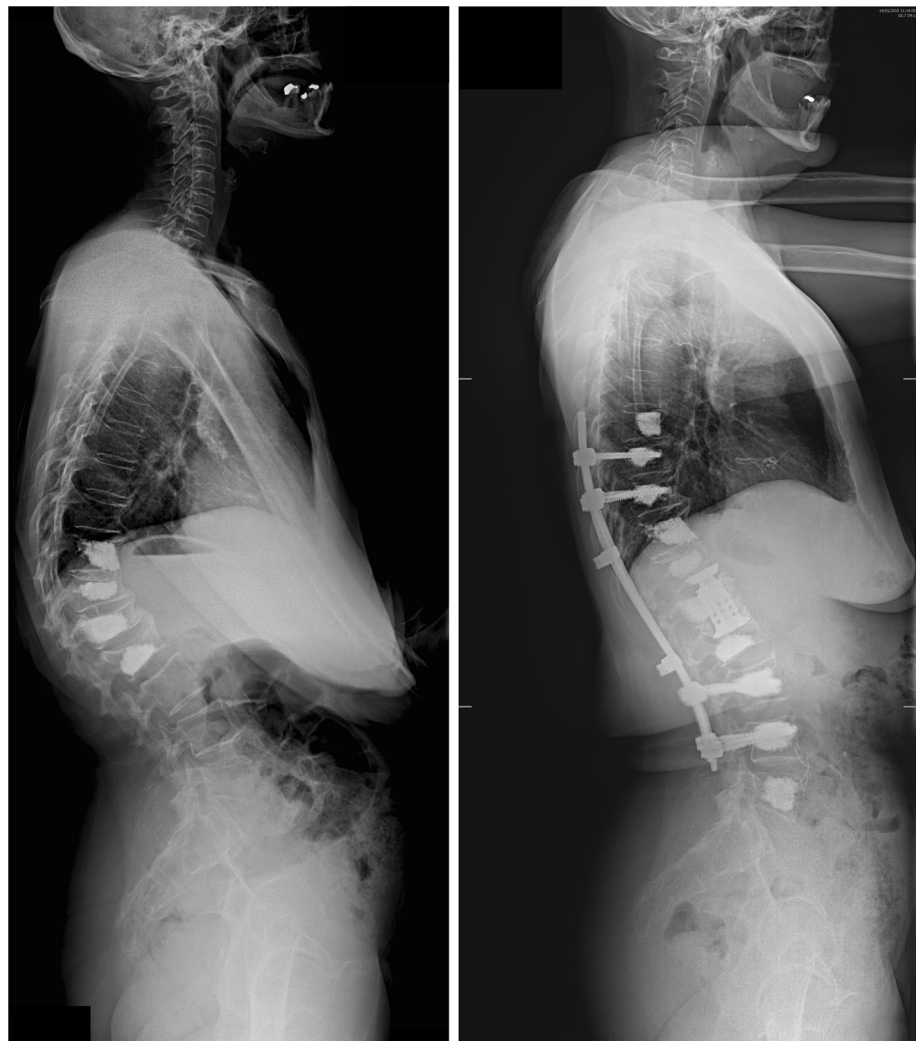
## Diagnostic imaging

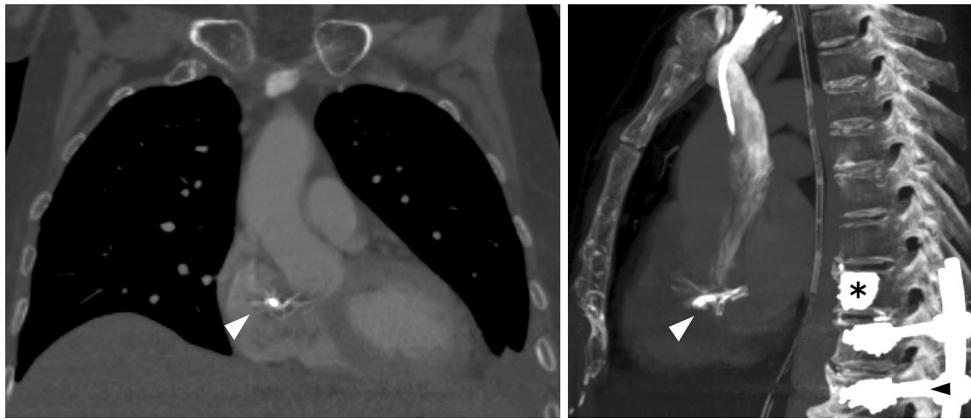
On the CTPA, there was an adequate opacification of the pulmonary trunk. After further analysis of the images available, a filling defect in the right atrium was reported. Its appearance was consistent with a PMMA embolism (Fig. 2).

Cardiac echogram (ECHO) was requested and showed a non-dilated atria and ventricles with normal systolic function. Trivial mitral, tricuspid and pulmonary regurgitations were also reported. A bright echogenic structure was found in the right atrium and recognised as the PMMA embolus. An urgent cardiology review was advised by the reporting radiologist and undertaken immediately (please see “[Procedure](#)”).

Three months later, a follow-up ECHO was performed as per the cardiology recommendation demonstrating unchanged function and diameters of atria and ventricles. Compared to the previous study, there was no change in the

**Fig. 1** Pre- and post-operative whole-spine X-ray showing the extent of cement augmentation of thoracic vertebral bodies





**Fig. 2** CT pulmonary angiogram showing the bone cement embolus (*white arrow*) in the right atrium. *Left* coronal reconstruction; *Right* sagittal reconstruction with elements of the posterior instrumentation (*black arrow*) and cement-augmented vertebral bodies (*black asterisk*) visible

appearance of the PMMA embolus in the right atrium. There was no clot in the cardiac cavities found.

### Historical review of the condition, epidemiology, diagnosis, pathology and differential diagnosis

Despite vertebroplasty being a relatively common and safe procedure for the management of vertebral compression fractures, multiple complications may arise as a result of the leakage of PMMA into the venous system through the iliolumbar or epidural veins. The rate of complications from vertebroplasty may vary from 1 to 10 %, with cement extravasation into the venous system in 18–24 % of patients [1–4]. Emboli may further migrate into the right heart chambers and pulmonary arteries. These complications may range in their presentations from asymptomatic [5] or symptoms such as syncope [6, 7] to life-threatening symptoms such as acute respiratory distress or cardiac tamponade [8–13]. The most commonly reported symptoms seem to be, however, chest pain and dyspnea [6, 11, 14–20].

The majority of cases reported were treated with an open surgery or percutaneous retrieval (Table 1). Only few reports presented patients who developed intracardiac cement embolus and were treated conservatively with anticoagulation and clinical follow-up. In the paper by Pannirselvam and Hee, a patient presented with syncope post-operatively of 9 months vertebroplasty in T10, T11 and L2. Transoesophageal ECHO demonstrated a 2.8-cm mass in the right atrium exiting the inferior vena cava, which was further supported with MRI scan. Consequently, the patient was prophylactically anticoagulated for emboli and had no further symptoms of syncope with no further intervention required to remove the cement embolus [7].

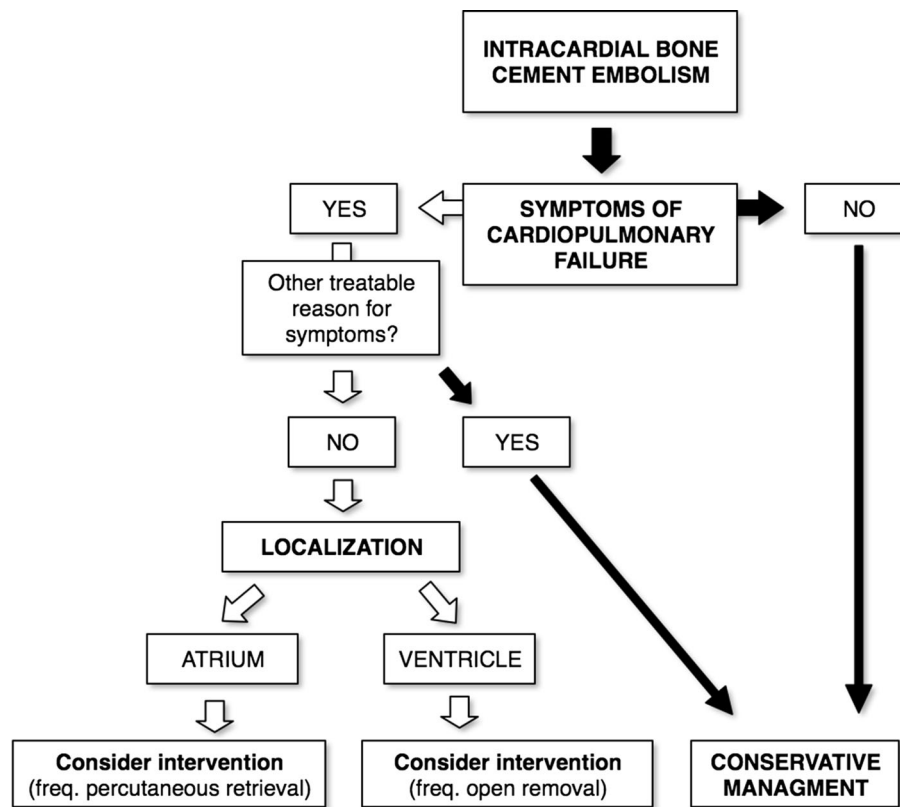
Locations of the cement embolus have varying effects on the cardiac function of a patient. For example, case studies with emboli in the right ventricle had echocardiograms of moderate to severe pericardial effusion [10, 12, 15–17, 20] or haemopericardium [11, 13, 18, 21]. In his description of a 66-year-old female patient with right atrium and ventricle cement deposits, Park et al. surmised that acrylic cement of very low viscosity injected into the vertebral body drained into the RV, causing acute pericarditis [12]. Kim et al. referenced a case of a 71-year-old patient with ‘...images from the axial data reconstructed mid-diastole showed two radio-opaque linear materials in the right atrium and right ventricle, respectively, that in the right ventricle perforated the right ventricular free wall and caused haemopericardium’ [18]. In addition to an embolus found in the right atrium and right ventricle of a patient who underwent vertebroplasty, it was found that the echocardiography exhibited globally decreased cardiac function with poor systolic function (27 %), impaired left ventricular diastolic function, and moderate-to-severe tricuspid regurgitation [17]. Kim et al. also found that tricuspid regurgitation decreased from moderate to mild on follow-up ECHO findings after surgical removal of cement emboli. They have stated that although there is no clear identification of the aggravation of dyspnea, the foreign body could increase PASP and tricuspid insufficiency. In contrast, echocardiograms of emboli within the right atrium have not been found to have associated pericardial effusion, and the echocardiography confirmed normal ejection fraction [7, 19].

The PMMA has been theorised to be thrombogenic [22] due to irregular and porous surface, and a case by Lim et al. found a PMMA with a thrombus attached [6]. In addition, insufficient polymerisation of cement at the time of injection, placement of a needle into the basivertebral vein, low viscosity of cement, and overfilling of a vertebral body

**Table 1** Patients' characteristics, volume and localisation of the cement embolus, method of the treatment and the outcome

Paper	Patient	Condition	Volume of the leak	Symptoms	Embolus	Delay in symptoms	Treatment	Outcome
Pannirselvam and Hee [7]	52 F	T10, T11, L2 #	–	Syncope	RA	9 months	Anticoagulation	Uneventful recovery
Dash and Brinster [5]	73 F	T12, L2, L5 #	–	Asymptomatic	RA, RV, RPA	1 month	Open exploration	Uneventful recovery
Lim et al. [6]	55 F	L2 #	–	Dyspnea	RA, RV	5 years	Open exploration	Uneventful recovery
Armaiz-Garcia et al. [8]	71 F	L1 #	“Massive”	Acute respiratory distress	RPA, RV	–	Open exploration	Uneventful recovery
Caynak et al. [9]	64 F	T4–T9 #	–	Progressive dyspnea	RA, RPA, LPA	2 months	Open exploration	Uneventful recovery
Lee et al. [10]	–	L3 #	–	Worsening dyspnea	RV	3 months	Open exploration	Post-operative ARDS → death
Mattis et al. [11]	71 M	L2 #	5 cm length	Chest pain, epigastric pain, diaphoresis, syncope	RA	4 days	Percutaneous retrieval	Uneventful recovery
Park et al. [12]	66 F	T9 #	–	Pleuritic chest pain	RA, RV	8 days	Open exploration	Uneventful recovery
Son et al. [13]	65 F	L1, L2 #	–	Chest pain and collapse	RA, RV	10 months	Open exploration	Uneventful recovery
Grifka et al. [14]	71 M	“Several compressed vertebrae”	“Some”-not quantified	Chest pain	RA	3 days	Percutaneous retrieval	Uneventful recovery
Farahvar et al. [15]	74 F	L2 #	–	Right-sided chest pain, nausea	RV, RPA	8 h	Open exploration	Uneventful recovery
Gosev et al. [16]	58 F	T11, T12, L1 #	–	Chest pain, shortness of breath	RV, RPA	–	Open exploration	Uneventful recovery
Kim et al. [17]	75 F	–	–	Dyspnea	RA, RV	2 months	Open exploration	Uneventful recovery
Kim et al. [18]	66 F	T8 #	–	Chest pain	RA, RV	7 days	Open exploration	Uneventful recovery
Moon et al. [19]	86 F	L3, L4 #	–	Chest pain and fever	RA, RV	5 years	Open exploration	Uneventful recovery
Tran et al. [20]	68 F	L3, L4 #	–	Chest pain and dyspnea, cardiac shock	RV	1 day	Open exploration + percutaneous retrieval	Uneventful recovery
Bose and Choi [21]	85 F	L3 #	1.5 ml	Hypotension	RA	–	Percutaneous retrieval	Uneventful recovery
Braitch and Row [31]	51 F	L3 #	–	Chest pain and palpitation	RA, RV	5 months	Percutaneous retrieval	Uneventful recovery

F/M female/male, # fracture, RPA right pulmonary artery, LPA left pulmonary artery, RA right atrium, RV right ventricle



**Fig. 3** A simplified decision-making flow chart summarising the available literature describing cases presenting with acute symptoms of cardiopulmonary failure possibly related to a bone cement deposit in the heart. The cardiological decision about attempting

percutaneous retrieval or surgical retrieval would be based on careful consideration of a number of clinical issues, including the precise location and size of the embolism, the presence of any cardiac complications, and the patient's overall clinical condition

could all attribute to causes of cement embolisms post-vertebroplasty [7, 23–25].

The incidence of cardiac cement emboli following vertebral augmentation procedures is not clear. Minor pulmonary embolisms are typically asymptomatic, and systemic evaluation by CT is not routinely performed. One can doubt that a pulmonary cement embolism being found on imaging studies may be an incidental finding. Whilst incidental and insignificant cement leakage into the end plate, paravertebral space or epidural/paravertebral veins occurs in as many as 72–82 % of cases [1, 26], pulmonary or heart cement deposits are reported as occasional despite the widespread use of imaging techniques allowing detection of these emboli. Theoretically, it is not possible to deny that a cement embolism could have been detected incidentally in all cases reported in the literature. Thinking about the clinical presentation, one needs to take into account that cardiopulmonary complications related to percutaneous vertebroplasty are uncommon, even in elderly population; and if they do occur, this should raise suspicion of a cement embolus as its cause [26].

## Procedure

The left-sided hydrothorax was treated with two ultrasound-guided drainages and yielded a total of 600 ml of transudative effusion. This achieved complete regression of chest pain, tachypnea and tachycardia.

Following ECHO findings of an embolus in the right atrium, the patient was reviewed by cardiology specialists and was commenced on 95 mg of (1.5 mg per kg) LWMH every 24 h, to minimise the risk of thrombus forming on the cement. The patient refused to start warfarin. After a cardiology review and a satisfactory follow-up ECHO, she was stopped anticoagulation 3 months after the incident.

Factors influencing decision about conservative treatment included symptoms, localisation of the embolus as well as time lapse between cement augmentation and clinical manifestation. Patients that are commonly asymptomatic can be treated conservatively. The management of choice is anticoagulation with warfarin until the foreign body epithelializes and stops becoming potentially thrombogenic [27, 28]. Although theorised to be less effective, in selected cases of patients with foreign body emboli,

anticoagulation with warfarin may be replaced with low-molecular-weight heparin (LMWH) [27]. Symptomatic patients with thrombi in the right atrium are commonly managed via percutaneous retrieval, whilst those with RV involvement or perforation are managed with surgical retrieval (Table 1; Fig. 3). It is important to acknowledge that possible complications of percutaneous retrieval include further thrombus fragmentation and distal emboli. Moreover, patients with asymptomatic CT findings of large emboli in the right ventricle are treated with open surgery. A decision to intervene would have to carefully balance the risks and benefits of intervention versus continued medical care (potentially with anticoagulation) in the context of the very limited evidence base about the role of intervention in these patients.

### Outcome and follow-up

The patient recovered from the spinal procedure and regained full mobility. She did not develop subsequent osteoporotic fractures and remained under the care of the local osteoporosis service. The patient did not present alarming symptoms regarding her cardiopulmonary performance, and cardiology follow-up was stopped 6 months after the incident.

The reason of the patient presenting 4 weeks after surgery with left-sided chest pain and pleural effusion remains unclear. The direct effect of cement embolism was acknowledged to be unlikely; peripheral pulmonary embolism that was not detected on the CT scan was one of possible explanations.

Key factors determining management included lack of symptoms of chest pain and dyspnea, echogenic findings of associated effusion, as well as localisation of the cement embolus in the RA. The LMWH administered in therapeutic dose appeared to be sufficient in preventing the formation of emboli on a foreign body. Over the time, PMMA is undergoing epithelialisation, which decreases its thrombogenic properties [22, 29]. According to our knowledge, a relevant *in vitro* study has not yet been performed. The presumption might be that the epithelialisation is similar in terms of mechanism and dynamics to neointimal growth after stenting of a non-atherosclerotic artery. Hence, PMMA embolus might be significantly less thrombogenic after 3 months follow-up [29, 30].

Patients presenting with intracardiac bone cement embolism related to spinal procedures require thorough clinical assessment, cardiology, and if required, cardiothoracic surgeon input. If the patient is symptomatic, the emboli should be considered for removal, with the use of either percutaneous or open intervention.

### Compliance with ethical standards

**Conflict of interest** None.

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