Percutaneous Retrieval of an Embolized Kyphoplasty Cement Fragment From the Pulmonary Artery: A Case Report and Literature Review

Nicole A. Lamparello[1*], Vijay Jaswani[1], Keith DeSousa[2], Maksim Shapiro[1,2], Sandor Kovacs[1]

1. Department of Radiology, NYU Langone Medical Center, New York, NY, USA

2. Department of Neurology, NYU Langone Medical Center, New York, NY, USA

* **Correspondence:** Nicole A. Lamparello, MD, NYU Langone Medical Center, 560 First Avenue, New York, NY 10016, USA (*Nicole.Lamparello@nyumc.org*)

Radiology Case. 2016 Jul; 10(7):40-47 :: DOI: 10.3941/jrcr.v10i7.2806

ABSTRACT

We present a case of a 41-year-old man with symptomatic pulmonary cement embolism following percutaneous vertebral augmentation, which was successfully retrieved via a percutaneous endovascular approach, a novel technique with only two prior cases reported. Cement leakage, including venous embolization of cement into the cardiopulmonary circulation, is a known potential complication following percutaneous kyphoplasty and vertebroplasty. While many patients with pulmonary cement embolism are asymptomatic and likely go undiagnosed, others experience respiratory distress and hemodynamic compromise requiring surgical and medical intervention. The optimal management for pulmonary cement embolism must be tailored to fit each individual patient, dependent upon the acuity of the clinical presentation, coexisting patient comorbidities, and the risks of systemic anticoagulation. In our patient, cement migration was visualized in real-time during vertebral augmentation. Endovascular retrieval by our Interventional Radiology section obviated the need for anticoagulation therapy or more invasive open surgical procedures.

CASE REPORT

CASE REPORT

A 41-year-old man with epilepsy presented to our institution for treatment of thoracic compression fractures sustained during a seizure three months prior. The patient continued to experience severe mid-thoracic pain despite conservative treatment. Thoracic MRI at an outside institution (images not available for review) revealed T7 and T8 compression fractures with T2 and STIR signal hyperintensity at the superior endplates, consistent with non-healing. Bone scan, performed to further evaluate fracture status, showed corresponding increased uptake at T7 and T8, indicating metabolically active fractures (Fig. 1a-c). After weighing the risks, benefits and alternatives, decision was made to proceed with kyphoplasty in a young patient with non-healing, symptomatic compression fractures.

The patient underwent T7 and T8 biplane fluoroscopic kyphoplasty under general anesthesia. Following uneventful bilateral parapedicular vertebral body access and creation of paired ~1 mL cavities using kyphon balloons, polymethylmethacrylate cement material was slowly injected into the right aspect of the T7 vertebral body. Cement extravasation into a right paraspinal vein was noted following

deposition of approximately 0.6 mL of cement, less than the volume of the created cavity (Fig. 2a). Cement injection was terminated immediately and the cement was allowed to solidify. In real time, the tubular-shaped intravenous cement fragment was observed to migrate into the azygous vein and subsequently into the right atrium. The patient's vital signs under general anesthesia remained stable, and gentle cement injection was carefully completed in the left aspect of the T7 vertebral body, as well as the T8 vertebral body, without further complications or cement displacement (Fig. 2b).

Upon extubation the patient was tachypneic and hypoxic with oxygen saturation 87% on room air. Post-kyphoplasty chest CT confirmed the presence of a round high density foreign body in the right upper lobe pulmonary artery without evidence of peripheral perfusion defect (Fig. 3a,b,d,e and Fig. 4). Additional smaller linear fragments of cement were also identified in the right lower lobe and segmental pulmonary arterial branches, likely secondary to cement fragmentation during the single embolization episode (Fig. 3 c,f and Fig. 4). Transthoracic echocardiography performed at the bedside showed no evidence of right heart strain. The patient complained of nonproductive cough on deep inspiration and chest discomfort. Vascular Surgery, Cardiothoracic Surgery, and Interventional Radiology were consulted regarding optimal management. Treatment options were discussed with the patient, who was a less than ideal candidate for long term anticoagulation therapy given recent kyphoplasty and history of epilepsy. Open surgical embolectomy was not favored given technical difficulty and operative hazard in the context of relatively mild symptomatology. A decision was made to attempt percutaneous retrieval by Interventional Radiology to avoid long-term anticoagulation and prevent long-term consequences of an indwelling thrombogenic foreign body.

Using sterile technique the right common femoral vein was cannulated and a 6 French introducer sheath was placed. A Bentson wire was advanced into the inferior vena cava and a 6F pigtail catheter was manipulated through the right heart chambers and into the right main pulmonary artery with the aid of a tip-deflecting wire. Right main pulmonary arteriogram via hand injection (so as to not dislodge the fragment) demonstrated an 8 x 13mm filling defect within the right upper lobe pulmonary artery (Fig. 5a). The tip-deflecting wire was exchanged for an Amplatz guidewire and an 8F 80cm vascular sheath was placed and positioned in the proximal right pulmonary artery. Through this sheath, the right upper lobe pulmonary artery was selectively catheterized using a 6F 100cm Berenstein catheter and hydrophilic guidewire combination.

The hydrophilic guidewire was removed and a 20mm loop snare was introduced through the 6F Berenstein catheter. Once the cement was captured by the snare, the cement and snare were retracted against the distal tip of the 8F sheath for stability and to prevent accidental dislodgement of the cement fragment (Fig. 5b). At this point, multiple interventional suites in our institution were scoured for a vascular sheath large enough to accommodate the 1.3cm cement fragment. The largest sheath available at the time was 24F with an inner diameter of 8mm, too small to safely accommodate the cement fragment. Decision was made to extract the embolus through the femoral venous access site using controlled force.

Under continuous fluoroscopic observation, the snare, catheter, and sheath were simultaneously withdrawn from the pulmonary artery, through the triscupid valve apparatus, into the inferior vena cava, and pulled distally through the right common iliac vein, external iliac vein and out the femoral vein access (Fig. 5c-e), while applying manual compression on the femoral vein both proximal and distal to the site. After removal of the fragment, manual compression was applied to the site for approximately 10 minutes to achieve hemostasis. Gross specimen revealed a 1.3cm irregular piece of polymethylmethacrylate cement (Fig. 5f).

Shortly after intervention, the patient reported "feeling better" with resolved cough and 99% oxygen saturation on room air. There was no swelling or hematoma at the right groin access site. Follow-up chest radiograph showed no residual radiopaque foreign body within the right upper lobe (Fig. 6). The patient was discharged in stable condition the following day without anticoagulation therapy.

DISCUSSION

Etiology & Demographics:

For percutaneous kyphoplasty and vertebroplasty, leakage of polymethylmethacrylate (PMMA) cement is a known and often self-limiting complication. Cement may leak into the perivertebral soft tissues or epidural space, extravasate into the foraminal space, intervertebral disc space or spinal canal, or migrate to perivertebral veins, often with no or transient clinical consequence. The frequency of cement leakage in the literature ranges from 9% to 49% in percutaneous kyphoplasty and 41% to 88% in percutaneous vertebroplasty [1,2].

Conversely, vascular migration of cement into the pulmonary arteries, termed pulmonary cement embolism (PCE), is a less common but potentially fatal subtype of cement leakage. Recent case reports and case series have cited an incidence of PCE between 2.1% to 26% [3,4]. Overall, the risk of PCE appears to be higher in vertebroplasty than kyphoplasty. In a review of 95 case reports citing complications of vertebroplasty and kyphoplasty, there were 34 cases of PCE, all occurring after percutaneous vertebroplasty [5]. However, in a study by Choe et al., 3 of 65 vertebroplasty procedures (4.6%) and 1 of 25 kyphoplasty procedures (4%) developed PCE on post-procedural imaging [4]. All patients remained asymptomatic and there was no statistical correlation in this study between the risk of developing PCE and the type of procedure performed. Since symptoms may be mild or absent and post-procedure imaging of the chest is not routinely performed, PCE likely goes undetected, underreported and untreated. In a review of 86 cases of PCE, 18 were symptomatic (21%), 62 were asymptomatic (72%) and 6 cases did not specify (7%) [5]. Symptoms of cement pulmonary embolism include shortness of breath, dyspnea, tachycardia, cyanosis, chest pain, cough, hemoptysis, dizziness and sweating. Given the thrombogenic properties of polymethylmethacrylate cement, patients can present months to

years postoperatively with cardiopulmonary consequences and potentially irreversible pulmonary parenchymal damage, necessitating medical and/or surgical intervention [6].

Differential Diagnoses:

History is crucial in determining the etiology of the high density material within the pulmonary artery. For example, a history of vertebral augmentation, as in our patient, would favor a cement foreign body. Similarly, history of a central venous catheter or inferior vena cava filter may suggest that the high density material is a fragmented piece of catheter or filter strut. In these cases, the morphology of the foreign body also helps to distinguish the etiology. A hollow tubular dense foreign body likely represents a fragmented catheter; a linear metallic density may represent a fractured filter strut; and a high density irregular/linear/round fragment may represent embolized cement. In a patient with history of intrathoracic surgery, string-like high density material in the pulmonary artery may signify suture material.

Also on the differential diagnosis of high density material in the region of the pulmonary artery includes a calcified granuloma eroding into the pulmonary artery, calcified lymph node, and a calcified thrombosed pulmonary artery aneurysm. Calcified granulomas have been shown to erode through adjacent vessels and airways; however, chest CT often demonstrates stigmata of granulomatous disease elsewhere in the lungs and mediastinum. A calcified lung mass, such as a carcinoid, may be confused for high density material in the pulmonary artery, yet carcinoid tumors are well-circumscribed and endobronchial in location. Finally, a calcified thrombosed pulmonary aneurysm can also present as a high density calcified material in a dilated lobar or subsegmental pulmonary arterial branch.

Management & Prognosis:

Given the increased popularity and frequency of percutaneous vertebral augmentation techniques to treat vertebral body disease, knowledge of appropriate management options of common, and uncommon, complications is of great importance. To date, there are no guidelines published on the detection or management of PCE. PCE management should be decided on a case-by-case basis. While many patients are asymptomatic at the time of diagnosis, symptomatic PCE has been reported in up to 21% of patients, occurring months to years after vertebral augmentation [5, 6]. Furthermore, the gravity of symptomatic PCE should not be overlooked, as there are at least 6 cases of fatal PCE cited in the literature [6]. Thus, the diagnosis of PCE, even in an asymptomatic patient, requires thoughtful consideration of appropriate management.

Other important considerations include patient symptoms, absolute or relative contraindications to systemic anticoagulation, and the presence of comorbidities that significantly increase morbidity and mortality during invasive surgery. Additionally, the inherent features of the cement embolus fragment should be considered, including size, shape and pliability. Small, linear or "string-like" and bendable cement fragments are more apt for endovascular extraction as they can be easily maneuvered through the heart and veins. However, the specific size range and consistency of the cement fragments is unknown given the novelty of endovascular technique. In the first reported case of percutaneous PCE retrieval, Bose et al. described using a 25mm loop Amplatz loop snare and balloon tip pulmonary wedge catheter to capture the ~1cm spherical shaped cement embolus [7]. Zhao et al. reported using a 25mm loop snare; however, the size of the embolus was not described [6]. In our case, a 1.3cm amorphous piece of cement was extracted via a loop snare.

Our case illustrates an example of PCE detected on intraoperative fluoroscopy, which caused hypoxia and chest discomfort, warranting intervention. Through percutaneous endovascular retrieval we eliminated the need for anticoagulation therapy or more invasive surgical procedures, such as open thrombectomy, in a high-risk patient. To our knowledge, there have only been two prior case reports of percutaneous PCE retrieval described in the literature [6,7]. In a symptomatic patient with significant coexisting comorbidities predicting high surgical risk and/or high risk for anticoagulation, and in the setting of a favorable appearance of the cement fragment, minimally invasive percutaneous endovascular retrieval should be considered as first line treatment.

TEACHING POINT

Pulmonary cement embolism is an uncommon, but potentially life-threatening complication of vertebral augmentation. Percutaneous endovascular retrieval of the embolized cement fragment should be considered as a first-line management option in an appropriate patient population with inherently favorable features of the cement embolism.

REFERENCES

1. Hulme P, Krebs J, Ferguson S and Berlemann U. Vertebroplasty and Kyphoplasty: A Systematic Review of 69 Clinical Studies. Spine. 2006;31(17):1983-2001. PMID 16924218.

2. Lee IJ, Choi AL, Yie M, Yoon JY, Jeon EY and Koh SH. CT Evaluation of local leakage of bone cement after percutaenous kyphoplasty and vertebroplasty. Acta Radiologica. 2010;51(6):649-54. PMID 20528649.

3. Venmans A, Klazen CA, Lohle PN, can Rooij WJ, de Vries J and Mali WP. Percutaneous vertebroplasty and pulmonary cement embolism: results from VERTOS II. AJNR. 2010;31:1451-3. PMID 20488908.

4. Choe DH, Marcom EM, Ahar K, Truong MT and Madewell JE. Pulmonary embolism of polymethyl methacrylate during percutaneous vertebroplasty and kyphoplasty. AJR. 2004;183;1097-1102. PMID 15385313.

5. Krueger A, Bliemel C, Zettl R and Ruchholtz S. Management of pulmonary cement embolism after

percutaneous kyphoplasty: a systemic review of the literature. Eur Spine J. 2009;18;1257-65. PMID 19575243.

6. Zhao Y, Liu T, Zheng Y, Wang L and Hao D. Successful percutaneous retrieval of a large pulmonary cement embolus caused by cement leakage during percutaneous vertebroplasty: case report and literature review. Spine. 2014;39(26). PMID 25271513.

7. Bose R and Choi JW. Successful percutaneous retrieval of methyl methacrylate orthopedic cement embolism from the pulmonary artery. Catheter Cardiovasc Interv. 2010;76:198-201. PMID 20665860.

FIGURES

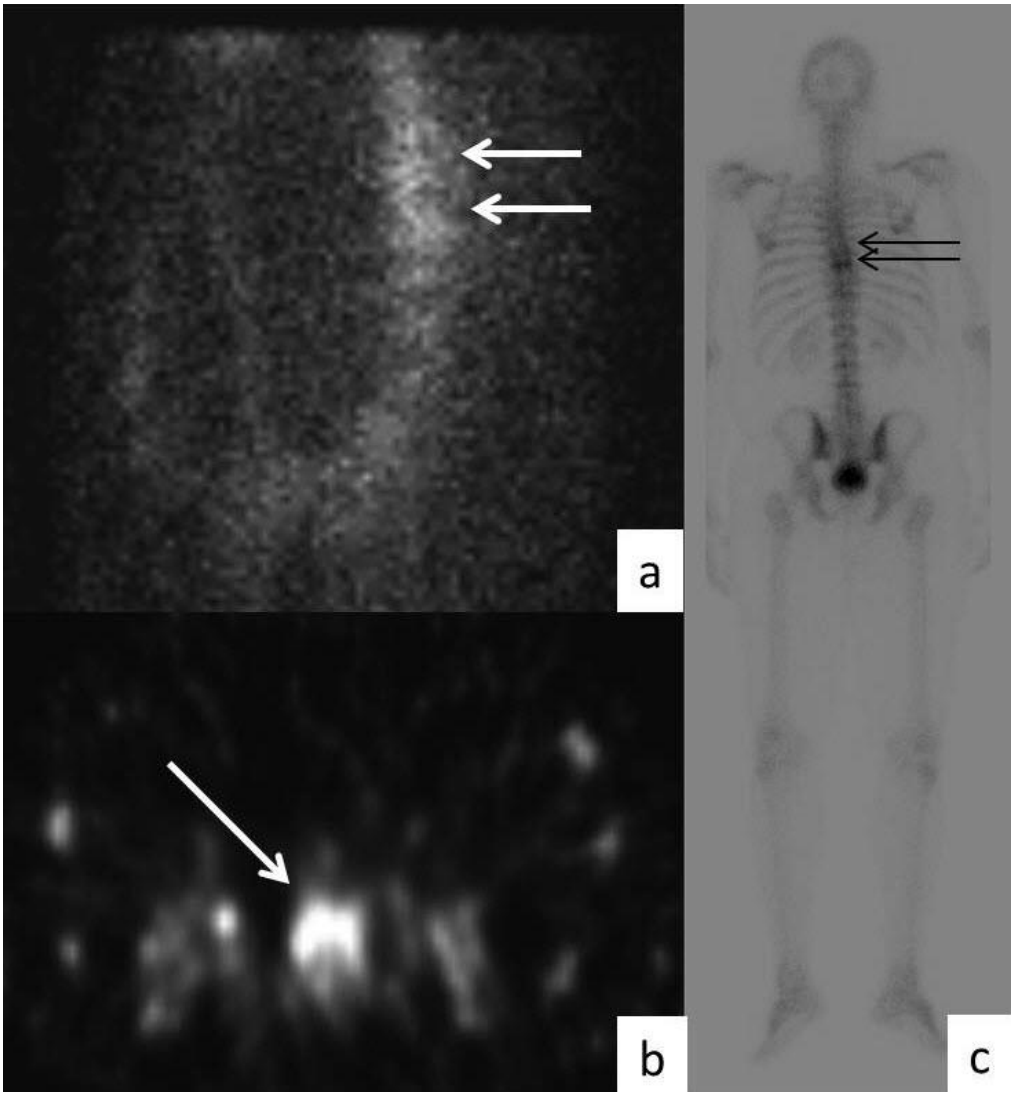

Figure 1: A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology. (a) Planar posterior left oblique view of the chest, (b) axial SPECT of the chest at the T8 level, and (c) whole body bone scan demonstrate increased uptake in the mid thoracic spine, corresponding to the T7 and T8 vertebral body levels (arrows), indicating metabolically active fractures.
Technique: 27mCi Tc-99m MDP IV, obtained 4 hours after injection of radiotracer.

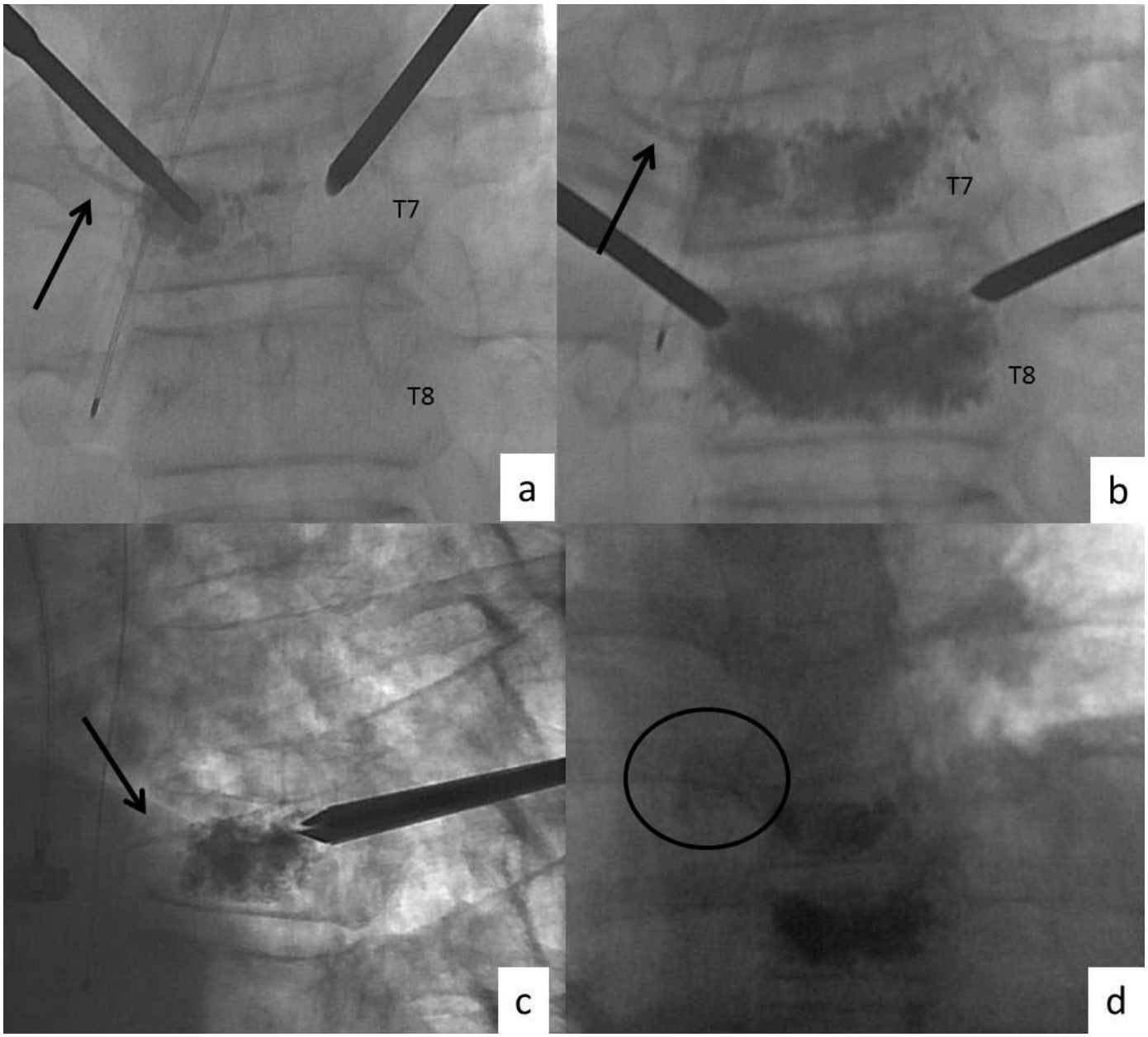

Figure 2: A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology. (a) Anteroposterior fluoroscopic view during 0.6cc polymethylmethacrylate cement injection in the right aspect of T7 shows tubular-shaped kyphoplasty cement migrating into a right T7 paravertebral vein (arrow). (b) Final anteroposterior fluoroscopic image demonstrating completion kyphoplasty of the T7 and T8 vertebral bodies. Again seen is a tubular-shaped piece of kyphoplasty cement in a right T7 paravertebral vein (arrow). (c) Lateral fluoroscopic view demonstrating the leaked cement in a paravertebral vein (arrow). (d) Anteroposterior fluoroscopic images demonstrating an irregularly-shaped fragment of cement in the right atrium (circled).
Technique: 70-73 kV, 167- 498 mAs.

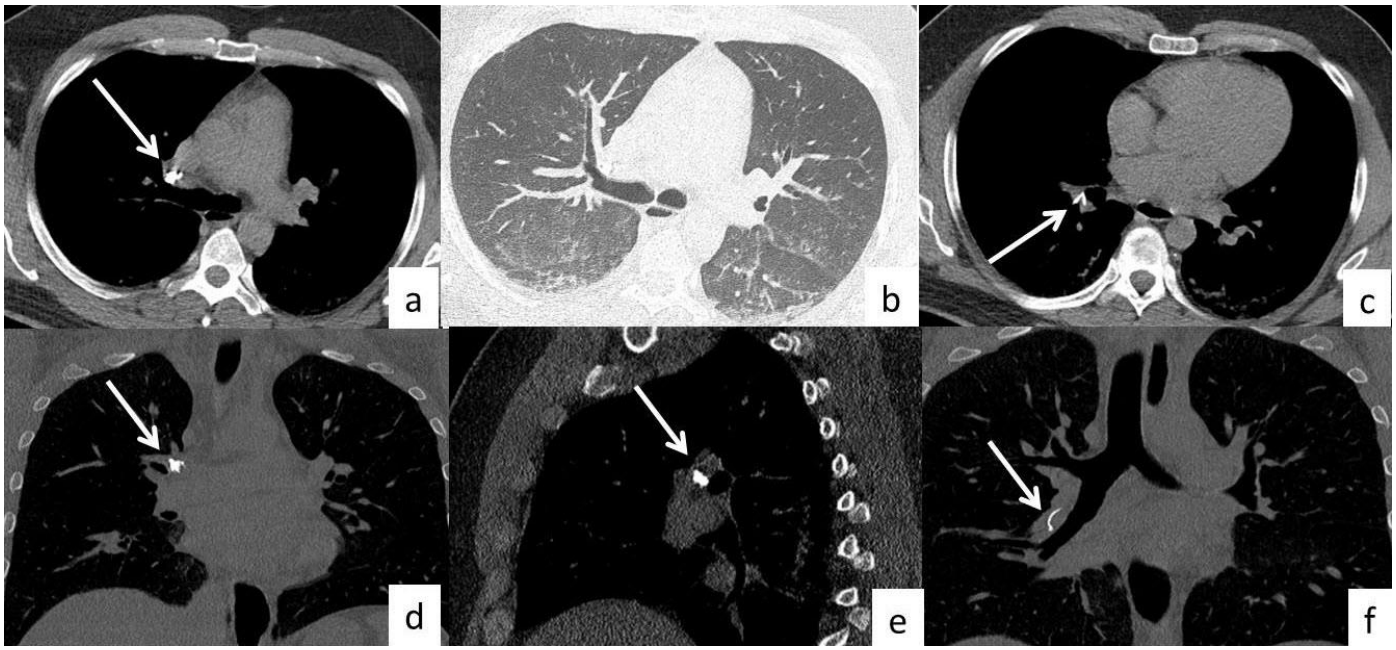

Figure 3: A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology. (a) Noncontrast axial CT image of the chest demonstrates a high density foreign body in the central right main pulmonary artery. (b) Lung windows at the same level of the foreign body show no corresponding parenchymal abnormality. (c) Noncontrast axial CT image of the chest demonstrates linear "V-shaped" cement in lower lobe segmental pulmonary arterial branches (arrow). (d) Noncontrast coronal CT image of the chest demonstrates a high density foreign body in the central right main pulmonary artery. (e) Noncontrast sagittal CT image of the chest demonstrates a high density foreign body in the central right main pulmonary artery. (f) Noncontrast coronal CT image of the chest demonstrates linear cement in a lower lobe segmental pulmonary arterial branch (arrow).
Technique: 120 kV, 77 mAs, 5mm slice thickness (figure 3a,c) and 1mm slice thickness (figure 3b), 2mm slice thickness (figure 3d-f).

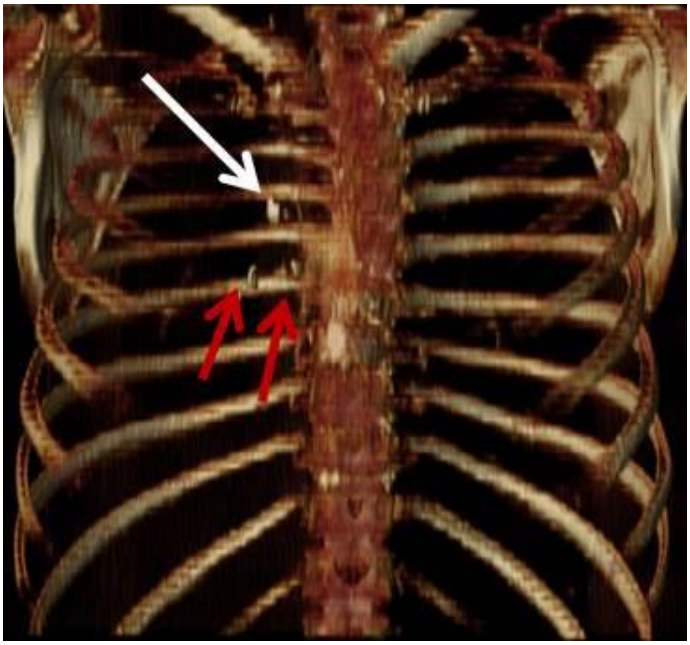

Figure 4 (left): A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology. 3D coronal volume rendered image demonstrating the cement fragment in the region of the right upper lobe pulmonary artery (white arrow), as well as smaller linear fragments in right lower lobe segmental pulmonary arterial branches (red arrows).

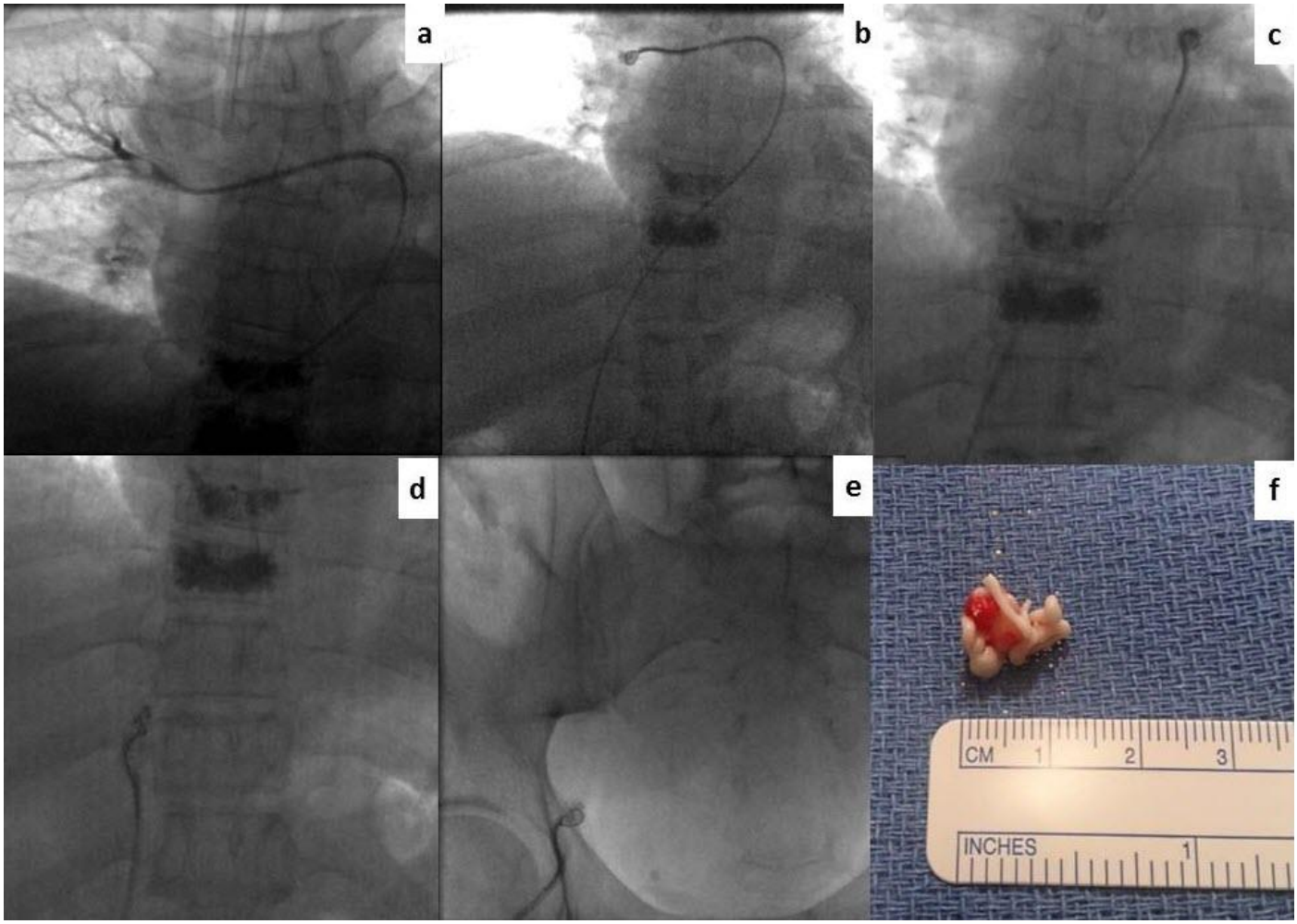

Figure 5: A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology (a) Anteroposterior fluoroscopic image during selective right pulmonary arteriography shows an 8 x 13mm filling defect in the proximal right upper lobe main pulmonary artery. (b) Anteroposterior fluoroscopic image demonstrates the radiopaque cement embolus captured by a 20mm snare. (c-e) Anteroposterior fluoroscopic images as the cement as the cement embolus was withdrawn by the snare through the pulmonary artery, triscupid valve apparatus, into the inferior vena cava, and pulled distally through the right common iliac vein. (f) Intraprocedural photograph of the 1.3cm piece of retrieved polymethylmethacrylate kyphoplasty cement.
Technique: Figures 4a-c: 80 kV, 3mAs. Approximately 20cc of Ultravist 300 nonionic contrast by hand injected (figure 4a).

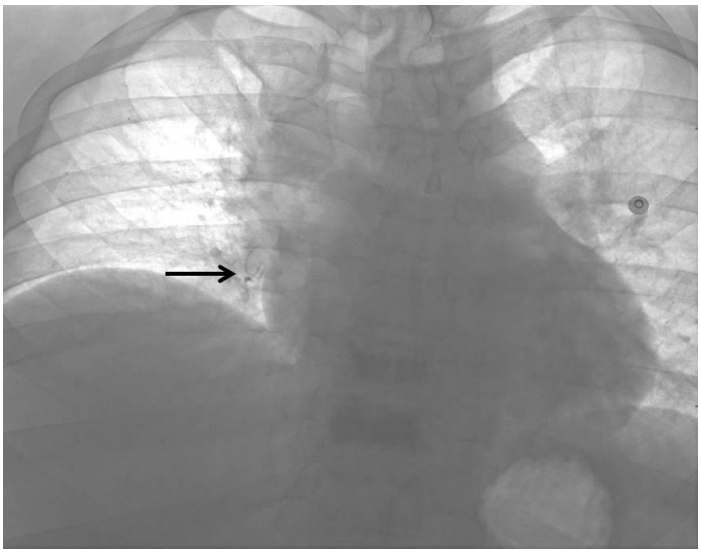

Figure 6 (left): A 41-year-old male patient underwent kyphoplasty for treatment of vertebral body compression fractures complicated by right pulmonary artery cement embolism status post percutaneous endovascular retrieval by Interventional Radiology. Anteroposterior fluoroscopic spot radiograph demonstrates successful retrieval of the cement fragment in the right upper pulmonary artery. Note that smaller curvilinear pieces of cement remain in the lower lobe segmental pulmonary arterial branches (arrow).
Technique: 80 kV, 3mAs.

Etiology	Systemic migration of cement into the cardiopulmonary circulation during percutaneous vertebral augmentation.
Incidence	Occurs at a rate between 2.1% to 26% of patients following vertebroplasty and kyphoplasty.
Gender ratio	No specific sex predilection.
Age predilection	No specific age predilection.
Risk Factors	Poor bone integrity, cement consistency (viscosity), extent and caliber of vertebral body-associated veins.
Treatment	Anticoagulation, surgical embolectomy, open heart surgery, endovascular retrieval.
Prognosis	Wide spectrum from uneventful recovery to death.
Imaging Findings	Tubular/linear/round piece of high density material in a paravertebral vein, IVC, right atrium, right ventricle and/or pulmonary artery.

Table 1: Summary table for pulmonary cement embolism.

Differential Diagnosis	Imaging Findings
Foreign Body	Cement: - Radiograph/CT: tubular /round/ linear high density fragment.
	Fragmented catheter: -Radiograph: medium density tubular catheter fragment. -CT: medium density tubular fragment with hollow lumen.
	Fragmented wire or inferior vena cava filter strut: - Radiograph/CT: linear foreign body, metallic density.
	Post-surgical material: -Radiograph/CT: "string-like" high density material.
Calcified granuloma	-Radiograph /CT: round calcification within a pulmonary nodule. Usually other granulomas are present.
Calcified thrombosed pulmonary artery aneurysm	-Radiograph /CT: saccular dilatation of the pulmonary artery containing a calcification. No contrast opacification on CT pulmonary angiogram.
Calcified lymph node	-Radiograph /CT: calcified hilar lymph node. Usually other calcified lymph nodes are present in the mediastinum and hilum.
Calcified carcinoid	- Radiograph /CT: well-circumscribed endobronchial mass containing internal calcifications.

Table 2: Differential diagnosis table of high density material in the pulmonary artery.

ABBREVIATIONS

CT = Computed tomography
PCE = Pulmonary cement embolism
PMMA = Polymethylmethacrylate

KEYWORDS

Pulmonary Cement Embolism; Pulmonary Angiogram; Kyphoplasty/Vertebroplasty; Endovascular Retrieval; Intervention