Investigation of polymethylmethacrylate pulmonary embolus in a patient ten years following vertebroplasty

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ABSTRACT

Percutaneous vertebroplasty (PV) is a procedure commonly used for the treatment of vertebral compression fractures, and the number of procedures has been steadily increasing over the past decade. We report a case of an 81 year old female with a history of breast cancer that developed two vertebral body compression fractures and was subsequently treated with PV. The patient developed a subsegmental pulmonary polymethylmethacrylate (PMMA) embolus as a complication of the procedure. Ten years following the procedure, she remained asymptomatic with the PMMA embolus being discovered incidentally during workup for a suspected chronic obstructive pulmonary disease (COPD) exacerbation. In reviewing the case, we describe the typical presentation of a pulmonary PMMA embolus and consider methods to decrease the incidence of this complication.

CASE REPORT

CASE REPORT

An 81 year old female with a history of breast cancer treated with chemotherapy, long-term high-dose steroids, and external beam radiation therapy for local disease was diagnosed with vertebral body compression fractures of the L2 and L3 vertebrae (Figure 1). The patient subsequently underwent percutaneous vertebroplasty (PV) for stabilization of the L3 vertebral body, as focal tenderness and the greatest degree of compression was appreciated at this vertebral body (Figure 2). A unipedicular approach was performed. In order to perform the procedure, an 11-gauge bone access needle was advanced through the skin, subcutaneous tissues and right pedicle, while simultaneously visualizing the needle's path utilizing fluoroscopy. Once the needle was determined to be in the correct location within the anterior vertebral body, polymethylmethacrylate (PMMA) was injected while imaging with fluoroscopy. During the injection, PMMA extravasation was demonstrated in the posterior vertebral venous plexus. The injection was halted immediately after visualizing PMMA extravasation (Figure 3). The patient was asymptomatic following the procedure.

Although the patient was consented for PV of L2, treatment of this vertebral body was postponed as a precautionary measure given that contrast extravasation was demonstrated into the vertebral venous plexus during the procedure on L3. PV of L2 was performed one month later. A similar unilateral right transpedicular approach was performed. No complications were demonstrated during this procedure. A follow-up chest radiograph demonstrated cement within the L2 and L3 vertebral bodies as well as cement within the vertebral venous plexus (Figure 4).

Ten years later, the patient presented to the emergency department with an episode of acute shortness of breath. A chest radiograph in the emergency department demonstrated findings consistent with a chronic obstructive pulmonary disease (COPD) exacerbation. A nodular density projecting superior to the left hemidiaphragm was also identified on the radiograph. (Figure 5). The patient was treated in the emergency department with nebulizer therapy and discharged home on combivent and prednisone. At follow-up, a non-contrast chest CT was performed to further investigate the nodular density. The CT demonstrated a focal area of scarring in the left lower lobe and a hyperdensity in right subsegmental

pulmonary artery (Figure 6). The average Hounsfield unit (HU) for the subsegmental hyperdensity was 1,100 HU, consistent with a PMMA embolus. Non-contrast coronal MIP images also demonstrated cement extravasation from the vertebral venous plexus into the inferior vena cava (IVC) (Figure 7). The patient reported no respiratory symptoms following vertebroplasty and had no documented respiratory complaints for ten years prior to her emergency department presentation.

DISCUSSION

PV was first described in 1987 by French radiologist Galibert for the treatment of spinal hemangiomas [1]. PV is a procedure in which PMMA is injected into a vertebral body via a unilateral or bilateral transpedicular approach in order to stabilize the vertebra in patients with back pain secondary to vertebral angiomas, osteoporotic compression fractures or malignant vertebral tumors [2]. With PV, a bone needle is used to enter the fractured vertebra through the pedicles. Once the needle is determined to be within the anterior portion of the vertebral body, PMMA is injected, thereby stabilizing the vertebra and increasing the vertebral body height.

Complications from PV include pulmonary PMMA embolus, infection, hemorrhage, neurologic deficit, pneumothorax, hemothorax and fracture of the adjacent vertebral bodies [3]. Pulmonary embolization secondary to PV can occur via spread through the basivertebral vein, to the vertebral venous plexus, to the IVC. Embolization of marrow fat can occur via the same circulatory pathway [4]. Pulmonary embolization is more common in elderly patients and individuals with a history of malignancy. Although PMMA embolus is a feared condition during PV, most patients remain asymptomatic and do not require treatment. Case reports have demonstrated improvement in symptomatic patients treated initially with heparin followed by several months of coumadin therapy. The overall mortality of a PMMA embolus is <1% [5].

The differential diagnosis for a cement pulmonary embolus includes alternative focal endovascular hyperdensities, focal endobronchial hyperdensities, and adjacent pulmonary parenchymal hyperdensities. Focal endovascular hyperdensities include talc in patients with a history of intravenous drug use and a foreign body such as a fractured guidewire [2, 4, 5]. Given that these entities can appear similar to a cement pulmonary embolus, a clinical history is essential. Although focal endobronchial hyperdensities such as aspirated barium and broncholiths may appear similar to a PMMA embolus, determining that these lesions are located within the bronchiole will eliminate them from the PMMA embolus differential. Similar to focal endobronchial lesion, focal pulmonary parenchymal hyperdensities such as granulomas and post-surgical material can be eliminated from the PMMA differential once they are determined to be located within the lung parenchyma [2, 4, 5].

This case demonstrates the most common presentation of a patient with a PMMA embolus. A recent meta-analysis demonstrated that cement leaks occur in 76% of patients undergoing PV [6]. In the meta-analysis, a cement leak was described as any contrast extravasation seen on fluoroscopy during PV. A large prospective trial involving 532 PV procedures investigated the incidence of pulmonary PMMA embolism during PV. In this trial, PMMA embolism was defined as cement migrating directly towards the lungs or within the lungs. The incidence of PMMA embolism was determined to be 2.1%. All of the patients who developed a pulmonary cement embolism remained asymptomatic [7].

Given that pulmonary PMMA embolism occurs in 2.1% of patients undergoing the procedure, it is important to know if PMMA causes an inflammatory foreign body reaction, as this could be a significant finding following the procedure. The lungs often react to a foreign body by producing a granulomatous reaction or fibrosis. Foreign body granulomas are typically seen with material such as talc (associated with IV drug use), sutures or other fibers that are too large to be phagocytized by a single macrophage. Epithelioid and giant cells encompass the foreign body without producing a significant inflammatory reaction in the tissue near the granuloma [8]. Pneumoconioses such as silicosis and asbestosis are characterized by chronic inflammation secondary to activation of macrophages by silica and asbestos fibers, respectively. The chronic inflammation eventually leads to pulmonary fibrosis after 10-20 years [8]. Since PMMA is a foreign body, it is plausible that it could produce a foreign body reaction. However, a follow up of 14 patients with pulmonary cement embolism demonstrated no reactive pulmonary changes after 22 months [9]. The absence of inflammatory change from a PMMA embolus is in keeping with numerous studies which have validated the inert in-vivo nature and biocompatibility characteristics of PMMA [10]. The patient presented in this case provides further evidence that PMMA is inert, as a non-biocompatible foreign body would be expected to incite some inflammatory reaction or fibrosis over a 10 year period.

PV is considered a relatively safe procedure for correcting vertebral compression fractures. Certain procedural changes, such as limiting the volume of injected PMMA, can be implemented to further decrease the risk of PMMA extravasation and pulmonary embolism as case studies have demonstrated increased incidence of clinically significant pulmonary PMMA embolism with large PMMA volumes (9-15 ml) [7]. Furthermore, PV in patients with osteoporotic compression fractures has a lower incidence of vertebral extravasation and PMMA embolism when compared to PV in tumor-related compression fractures [10].

Another option is to perform kyphoplasty rather than PV. Kyphoplasty has been described as balloon-assisted PV. Kyphoplasty is classically performed using a bilateral transpedicular approach. With kyphoplasty, biopsy needles are used to enter the fractured vertebra through the pedicles. Once needle placement is confirmed using fluoroscopy, two balloons are placed within the anterior vertebral body (one balloon through each pedicle), and the balloons are inflated.

Fluoroscopy is used to confirm restoration of vertebral body height. Then, the cavities created by the balloons are injected with PMMA, thereby providing stabilization and increasing vertebral body height [11]. Kyphoplasty is similar to PV in that it is indicated for vertebral body stabilization in patients with back pain. Kyphoplasty is the preferred treatment for compression fractures causing significant kyphosis, as kyphoplasty has been shown to increase vertebral body height more than PV [11].

Although the incidence of pulmonary PMMA embolism with kyphoplasty has not been determined, kyphoplasty has been shown to have decreased rates of intra-procedural cement extravasation. Cement extravasation with kyphoplasty occurs in 14% of patients, compared to 76% of patients undergoing vertebroplasty [6]. Since kyphoplasty has a lower incidence of cement extravasation, it is plausible to postulate that kyphoplasty should have a lower incidence of cement embolization given that cement extravasation is the most important risk factor for developing a pulmonary cement embolus. Given that kyphoplasty increases vertebral height more and has a lower cement extravasation rate than vertebroplasty, kyphoplasty may have been a better choice in this patient.

Incidental subsegmental pulmonary PMMA embolism is not uncommon following PV. It is important to note that subsegmental or segmental pulmonary PMMA embolism is unlikely to be clinically significant if the patient is more than three days out from the procedure. As such, emergency physicians and radiologists need to look for other etiologies to explain respiratory distress in a patient with a remote history of PV with evidence of a small pulmonary PMMA embolus. Furthermore, the evidence presented in this case demonstrates that PMMA appears inert and would not be expected to cause a granulomatous reaction or fibrosis. As such, if there is evidence of granuloma formation or fibrosis in the presence of a PMMA embolus, a broader search for underlying disease needs to be undertaken since the PMMA embolus is most likely not the etiology for the inflammatory findings.

TEACHING POINT

Pulmonary polymethylmethacrylate embolism occurs as a complication of percutaneous vertebroplasty with a rate of 2.1%. Most patients with polymethylmethacrylate embolism remain asymptomatic, and there is no evidence of a chronic inflammatory response to polymethylmethacrylate.

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FIGURES

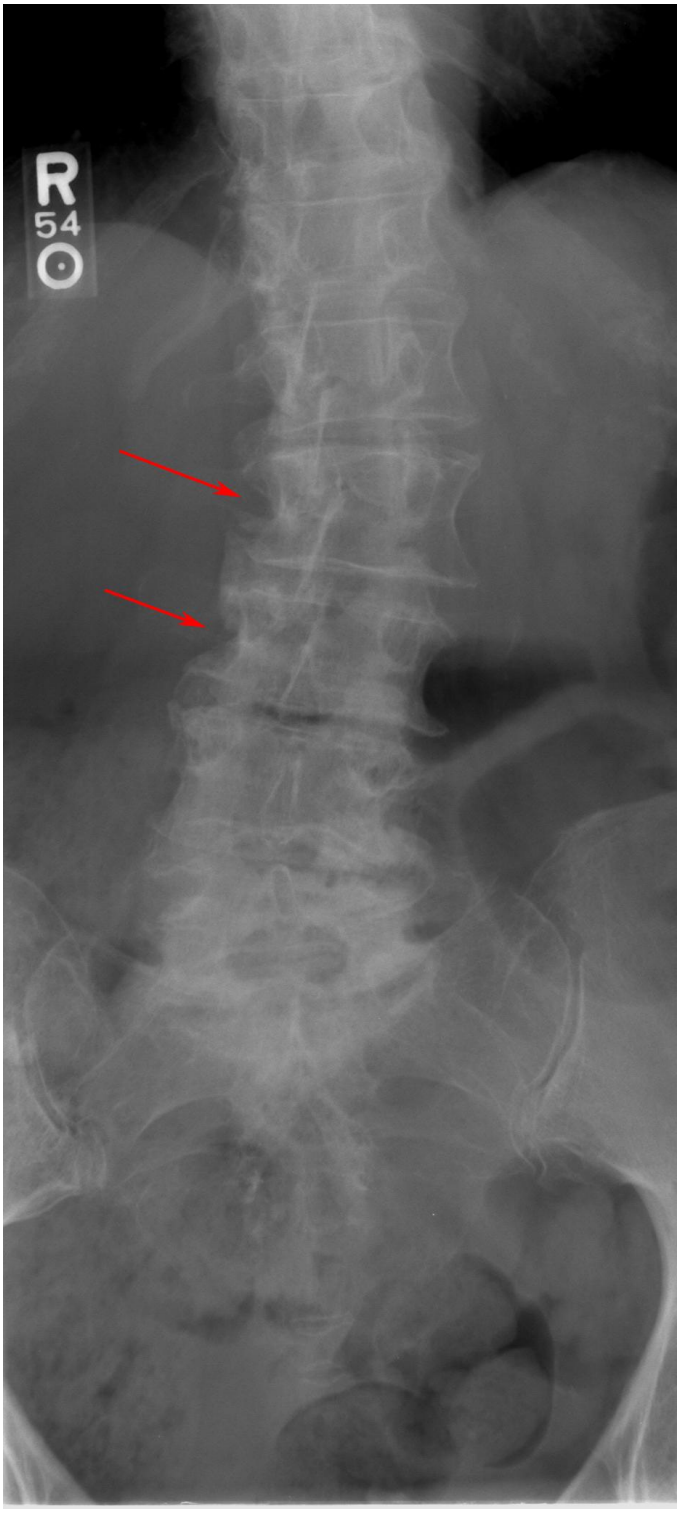

Figure 1: 81 year old female, diagnosed with L2 and L3 vertebral body compression fractures. The AP lumbar spine radiograph demonstrates vertebral height loss, which is greater on the right in both vertebral bodies.

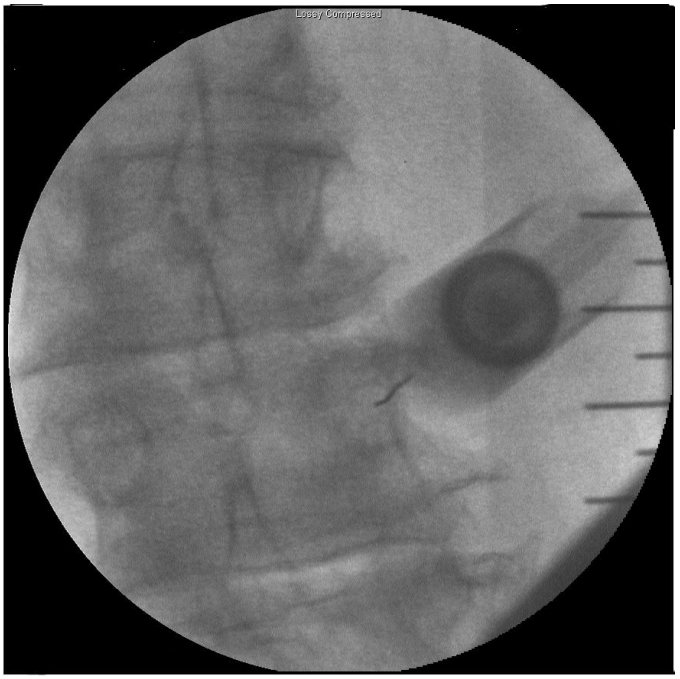

Figure 2: 81 year old female, diagnosed with L2 and L3 vertebral body compression fractures requiring percutaneous vertebroplasty. The pre-procedural fluoroscopic frontal image of the lumbar spine demonstrates no evidence of polymethylmethacrylate extravasation.

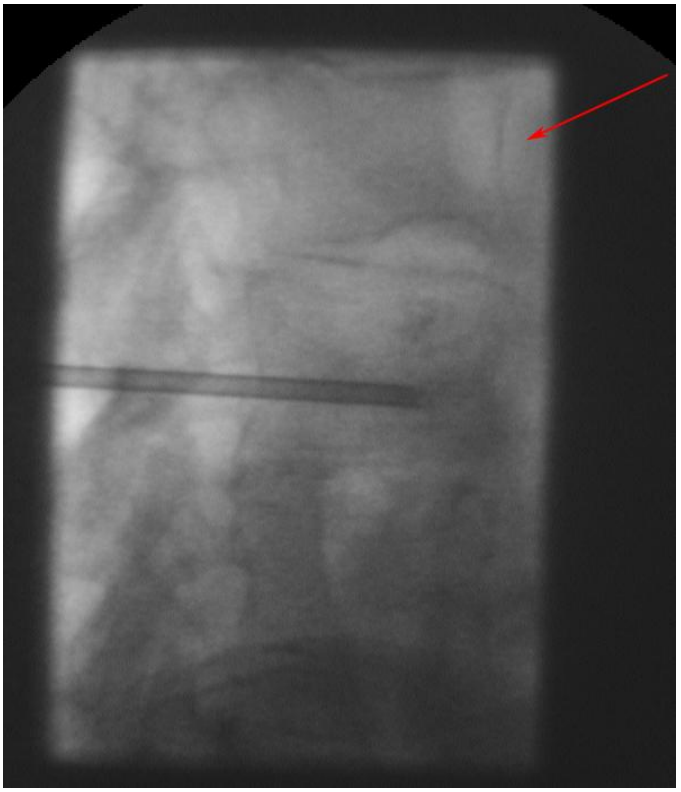

Figure 3: 81 year old female, diagnosed with L2 and L3 vertebral body compression fractures requiring percutaneous vertebroplasty. The intra-procedural lateral fluoroscopic image demonstrates polymethylmethacrylate extravasation into the vertebral venous plexus (arrow) during percutaneous vertebroplasty of the L3 vertebral body.

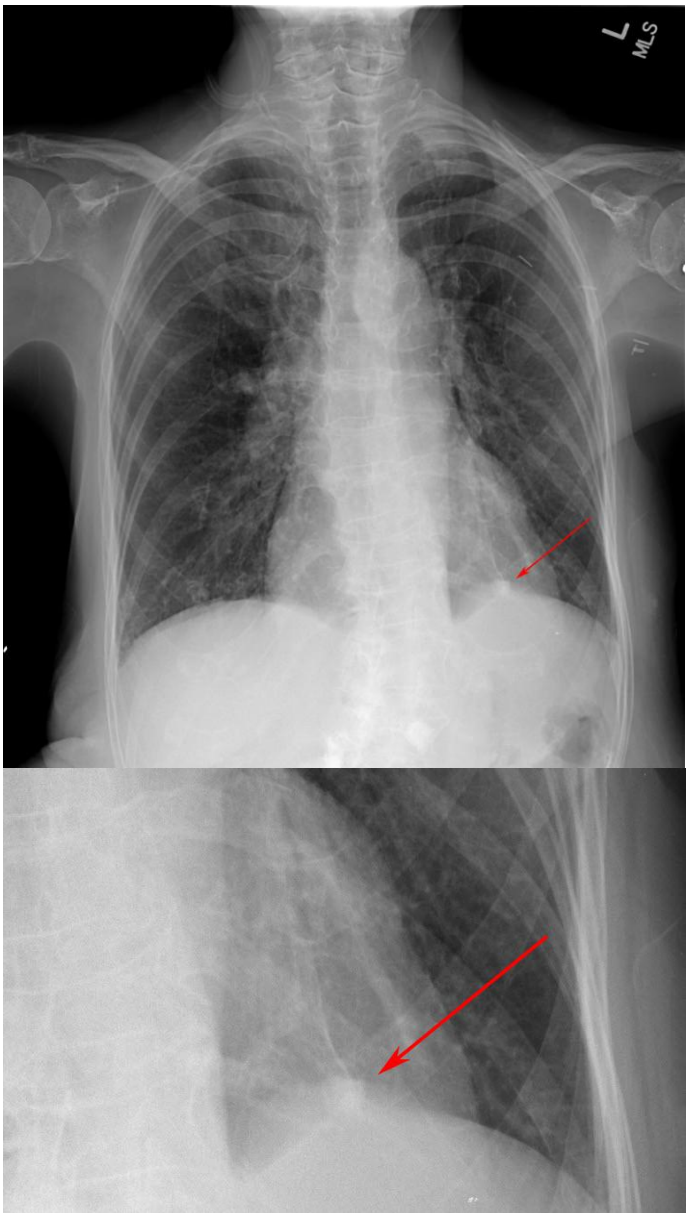

Figure 5 (top, below magnified view): 81 year old female who presented to the emergency department was found to have radiographic evidence of a chronic obstructive pulmonary disorder exacerbation and a nodular density projecting superior to the left hemidiaphragm on a posterior to anterior chest radiograph.

Figure 4 (left, magnified view left bottom): 81 year old female, treated with vertebroplasty of the L2 and L3 vertebral bodies for stabilization of vertebral body compression fractures. Follow-up lateral radiographs demonstrate polymethylmethacrylate within the lumbar vertebral venous plexus (arrow) and the L2 and L3 vertebral bodies.

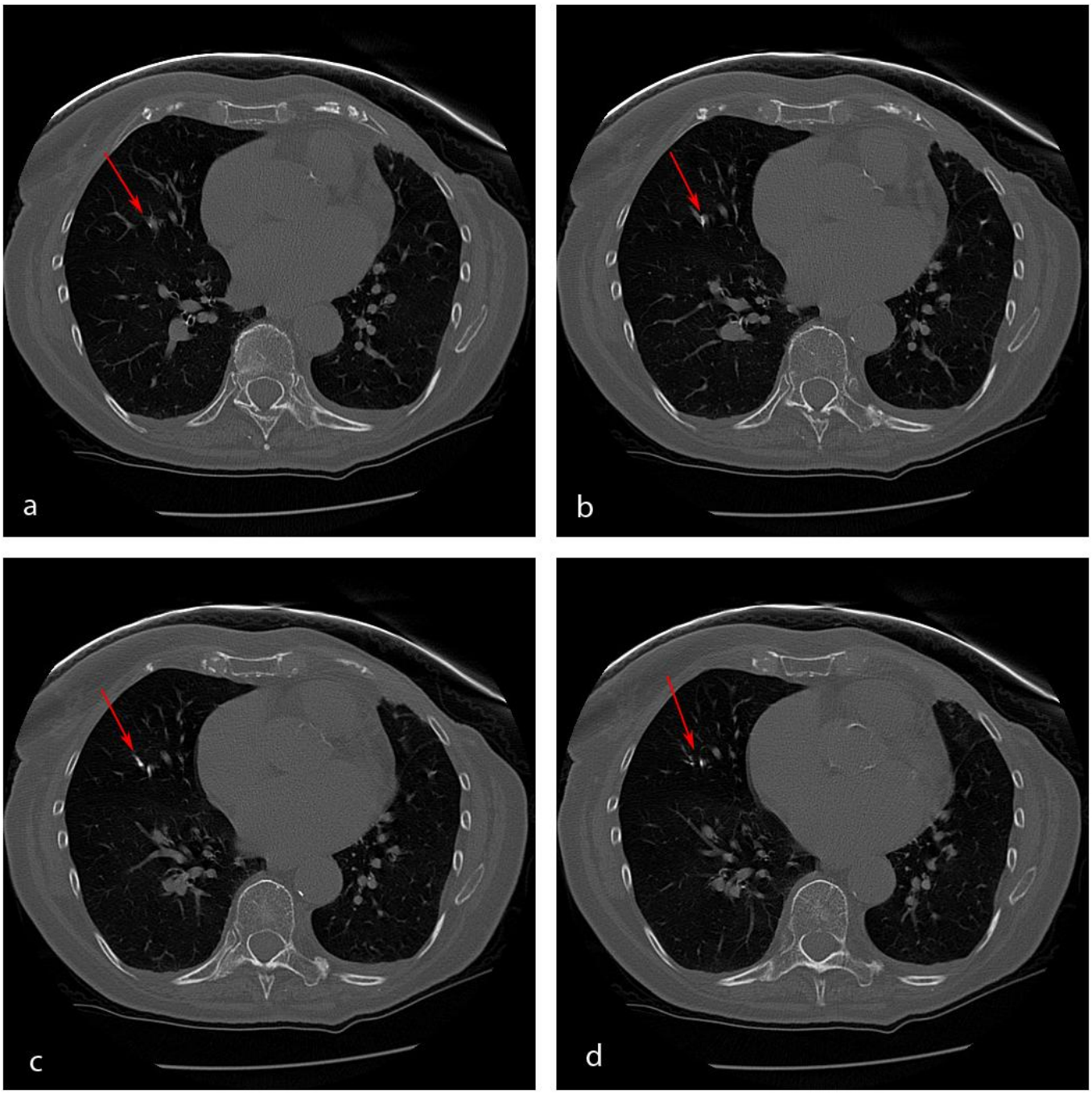

Figure 6: 81 year old female, diagnosed with a cement pulmonary embolism. Select axial images from a non-contrast chest CT (bone windows) demonstrate a hyperdense lesion located in the right subsegmental pulmonary artery consistent (arrows) with a polymethylmethacrylate pulmonary embolism. (Protocol: 16 slice, 120 KVP, 123 mA, 2.5 mm slice thickness, non-contrast)

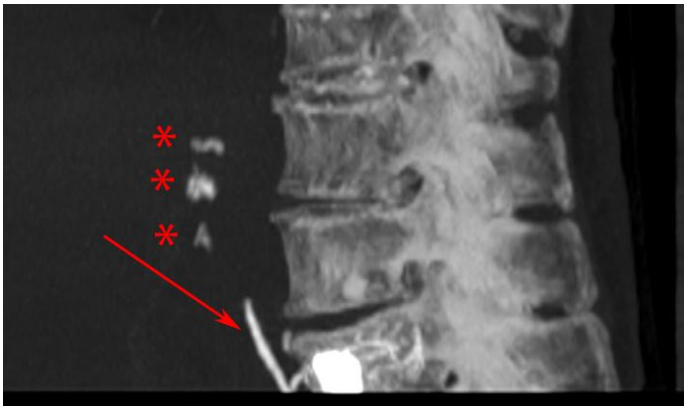

Figure 7 (left): 81 year old female, diagnosed with a cement pulmonary embolism. The maximum intensity projection image from a non-contrast chest CT demonstrates cement extravasation from the vertebral venous plexus (arrow) into the inferior vena cava (*). (Protocol: 16 slice, 120 KVP, 109 mA, 1.25 slice thickness, non-contrast)

Differential	Radiographic findings	CT findings
Cement Embolization	Hyperdense lesion, which may have a globular or branching pattern. This disease is usually diagnosed by CT to localize the hyperdense lesion to the pulmonary artery.	Branching or globular hyperdense material in the pulmonary arterial distribution, best seen in bone windows on non-contrast chest CT. No contrast enhancement.
Alternative focal endovascular hyperdensities (talc from intravenous drug use and foreign body such as fractured guidewire)	Non-specific hyperdense lesion located in a branching or globular distribution.	Branching or globular hyperdense material in the pulmonary arterial distribution, best seen in bone windows on non-contrast chest CT. No contrast enhancement.
Focal endobronchial hyperdensities (aspirated barium, aspirated foreign body, and broncholith)	Usually findings are non-specific and CT is required for further evaluation. Change in position of the calcified lesion on serial films is the most specific finding for a broncholith. Evidence of bronchial obstruction is another clue that a broncholith or aspirated foreign body is present.	Broncholiths and aspirated foreign bodies are usually solitary lesions which narrow or completely occlude the bronchial lumen. Foreign bodies and broncholiths do not enhance with contrast administration. Aspirated barium may be seen as a solitary or multifocal area of hyperdensity within the bronchial lumen.
Adjacent pulmonary parenchymal hyperdensities (granulomatous disease, pneumoconiosis, and post-surgical hardware/sutures)	Non-specific hyperdense lesion located in the branching distribution. Granulomatous disease and pneumoconiosis may have associated lymphadenopathy.	Granulomatous disease: often seen as a calcified nodule located in the lung parenchyma, which may be associated with satellite nodules (histoplasmosis) or caseation (tuberculosis). May enhance with intravenous contrast. Pneumoconiosis: silicosis will have a micronodular appearance predominantly in the upper lobes with associated calcification of hilar nodes. Surgical hardware and sutures are often hyperdense and may create streak artifact on CT.

Table 1: Differential Table [2,4,5]: The differential for a cement pulmonary embolus includes alternative focal endovascular hyperdensities, Focal endobronchial hyperdensities, and adjacent pulmonary parenchymal hyperdensities. Within each category, there are several disease processes, as described in the differential table above.

Etiology	polymethylmethacrylate embolism is secondary to polymethylmethacrylate extravasation during vertebroplasty
Incidence	2.1% of vertebroplasty procedures result in pulmonary polymethylmethacrylate embolism
Gender Ratio	Men and women are affected equally
Age	More common in elderly patients, as vertebroplasty is more commonly performed on these patients.
Risk Factors	History of neoplasm, the use of high volumes of polymethylmethacrylate (>9ml), and the use of vertebroplasty instead of kyphoplasty.
Treatment	Most patients remain asymptomatic and do not require treatment. For symptomatic or central polymethylmethacrylate embolism, case reports recommend the guidelines for treatment of thrombotic pulmonary embolisms, which includes initial heparinization, followed by 6-months of coumadin therapy
Prognosis	Mortality rate is <1%
Imaging Findings	Branching or globular hyperdense material in the pulmonary arterial distribution, best seen in bone windows on non-contrast chest CT. No contrast enhancement.

Table 2: Summary Table [2,4,5,6,7]: this table summarizes the key aspects and imaging findings associated with PMMA embolism.

ABBREVIATIONS

COPD: chronic obstructive pulmonary disease
CT: computed tomography
HU: Hounsfield unit
IVC: inferior vena cava
OA: osteoarthritis
PMMA: polymethylmethacrylate
PV: percutaneous vertebroplasty

KEYWORDS

Pulmonary cement embolus; polymethylmethacrylate; vertebroplasty; kyphoplasty