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Case Report

Kyphoplasty Cement Embolization and Successful Cement Retrieval from Tricuspid Valve Entrapment

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Abstract: This case report details successful percutaneous management of cement embolization, a known complication of kyphoplasty, in a 60-year-old female with osteoporotic compression fractures undergoing T7 and T8 vertebral augmentation. Kyphoplasty, a procedure involving the injection of polymethyl methacrylate (PMMA) cement into the vertebral body, can result in cement leakage with the potential for serious negative outcomes, including pulmonary embolism. In this patient, post-procedure imaging revealed cement extravasation extending into paravertebral veins with embolization terminating in the right ventricle. Traditional treatment options for cement emboli include anticoagulant therapy or operative embolectomy, both of which are either limited in their efficacy, or have significant added risk that must be weighed. However, this report demonstrates the successful use of a percutaneous cement retrieval approach as a viable option for cement retrieval. With retrieval success and the development of an asymptomatic pulmonary embolism, this approach to treatment proved effective in managing the patient's condition without the need for more invasive surgical interventions. This case adds to the current body of literature on cement extravasation in vertebral augmentation procedures, highlighting the importance of careful procedural planning, real-time monitoring, and prompt response to complications. Also, we highlight the use of newer interventional tools that can make cement retrieval more effective.

Keywords: Kyphoplasty, Embolization, Retrieval

1. Introduction

1.1. Clinical Relevance Statement

Cement extravasation is a known complication in kyphoplasty, with outcomes spanning from asymptomatic to life-threatening pulmonary embolism. Treatment options are most often anticoagulant therapy or operative embolectomy. This case demonstrates successful percutaneous cement retrieval as a viable option for high risk cement emboli.

1.2. Background

Vertebral compression fractures (VCFs) are the most common complication of osteoporosis, often leading to significant pain and disability. VCFs in osteoporotic patients occur most frequently in the thoracic and lumbar regions following low impact trauma. In younger patients, these injuries are typically due to high energy trauma such as a motor vehicle accident or high fall. By definition, VCFs diminish vertebral height, causing abnormal flexion of the spine known as kyphotic deformity. [1] The resulting

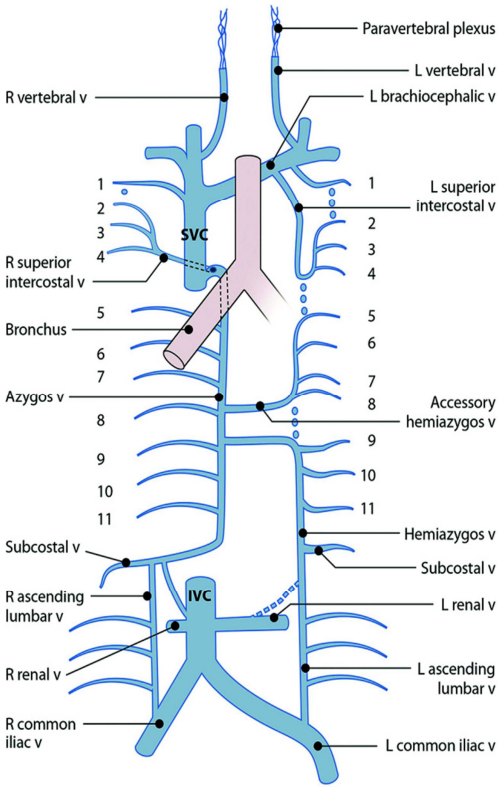
biomechanical compromise makes them prone to progression and places excessive axial load on other spinal cord levels, thereby increasing the risk of adjacent fractures. [1, 8] VCFs are initially managed with 4-6 weeks of conservative treatment, but may require surgical intervention if symptoms persist beyond this time frame. [1] Kyphoplasty (KP) and vertebroplasty (VP) are the two vertebral augmentation procedures indicated in the treatment of refractory, symptomatic VCFs. Both involve percutaneous insertion of a hollow needle following a transpedicular or parapedicular trajectory, guided by X-ray fluoroscopy. Polymethyl methacrylate (PMMA) cement is then injected into the vertebral body to stabilize the damaged bone. [1]

Both forms of vertebral augmentation have been shown to reduce pain and decrease mortality. [3, 12] However, only KP can address vertebral height loss and correct the spinal misalignment associated with kyphotic deformity. [8, 9] The novelty of KP is the use of an inflatable balloon to create a cavity in which cement is injected. [1, 3, 9] This technique effectively reduces the kyphotic angle, restores vertebral body height, and improves mobility. [10, 11] No such cavity is created during VP, and the cement is injected directly into fractured bone fragments. Filling the small spaces requires a more fluid cement consistency to be injected at a higher pressure, thus increasing the likelihood of leakage through intrinsic defects in the bone. VP has demonstrated questionable efficacy in randomized controlled trials and carries an increased risk of new adjacent VCFs compared to KP. [1, 3] KP has ultimately become the preferred procedure, with the American Academy of Orthopedic Surgeons (AAOS) now firmly advising against the use of VP. [1] Regarding mortality benefit, a study comparing kyphoplasty to non-surgical management found a number needed to treat of only 13.5 at 1 year, whereas vertebroplasty compared with non-surgical management was found to have a number needed to treat of 20.8 at 1 year. [19]

Complications of vertebral augmentation are not rare, as we will discuss, yet the vast majority of complications that do occur are asymptomatic. [1, 6, 11, 18] Some inherent risks include infection, bleeding, hematoma, spinal radiculopathy, neurologic deficit, rib fracture, hemodynamic alterations, pneumonia, and hypoxia. [1, 3, 5, 11] The most common complication is cement extravasation, the risk of which is significantly increased with VP compared to KP for reasons described earlier. PMMA can leak into surrounding veins, paravertebral tissue, intervertebral discs, or the spinal canal, potentially giving rise to more severe complications like spinal stenosis, myocardial infarction (MI), and pulmonary embolism (PE). [1, 3, 11, 15] The most common extravasation sites are paravertebral soft tissue and paravertebral veins. [15] The prevalence of PMMA PE is reportedly 0.9% and 0.4% for VP & KP, respectively. The frequency of asymptomatic PE is estimated to be higher given the lack of routine screening following these procedures. [1, 13] However, asymptomatic cement PEs that are incidentally discovered have not been shown to increase mortality. [14] To understand the anatomical basis for PE as a complication of KP, it is important to note the relationship between the vertebral and azygos venous systems draining the thoracic spinal cord. The vertebral venous system, also known as the Batson plexus, consists of three primary communicating paravertebral venous plexuses. These include the external plexus surrounding the vertebral column, the internal plexus surrounding the spinal canal, and the basivertebral veins which lie within the vertebral bodies. The basivertebral veins feed into both the external and internal plexuses, which are connected by the intervertebral veins. [17] The intervertebral veins drain blood into the posterior intercostal veins, which are segmental veins traveling between the ribs from the thoracic spine to the azygos system. The azygos system refers to the azygos, hemiazygos, and accessory hemiazygos veins. On the right side, the posterior intercostal veins drain into the azygos vein. On the left, the 5th to 8th posterior intercostal veins drain into the accessory hemiazygos vein, while the 9th to 11th posterior intercostal veins drain into the hemiazygos vein. The accessory hemiazygos and hemiazygos veins each terminate in the azygos vein after crossing midline around the T8 and T9 spinal cord levels, respectively. It should be noted that there can be significant anatomic variation with the hemiazygos and accessory hemiazygos vein. The azygos vein ascends the posterior mediastinum, eventually coursing over the right main bronchus to join the superior vena cava (SVC). [16]

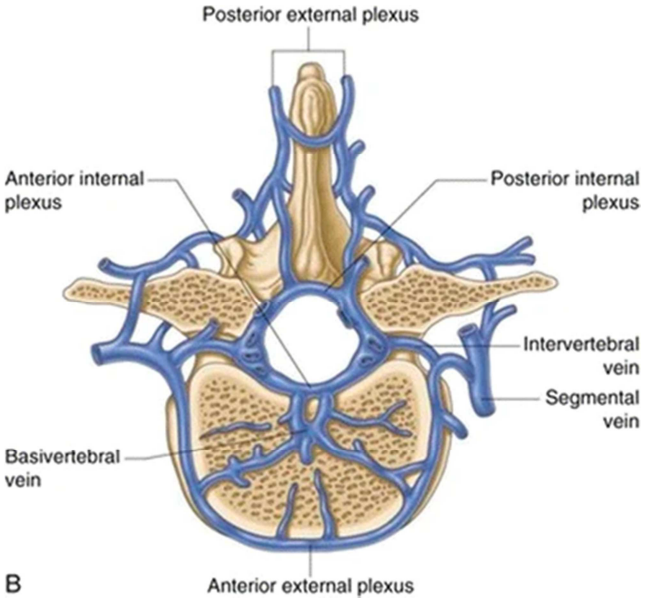
In this case, we describe a 60-year old female who experienced tricuspid valve entrapment of a cement embolism that entered through the SVC, secondary to venous extravasation during KP of T7 and T8. Attempted foreign body retrieval was successful, with a small fragment embolizing to a right lower lobe pulmonary artery resulting in an asymptomatic PE.

Anatomical Images (Figures 1 and 2):



Source: Borg, N., et al.

Figure 1. *Thoracic venous anatomy.*



Source: Köcher

Figure 2. *Vertebral venous anatomy.*

2. Case Presentation

We present a case in which a 60 year old female with a past medical history of osteoporosis and L4 compression fracture received a T7 and T8 kyphoplasty with a complication of cement embolization. Additional past medical history includes Systemic Lupus Erythematosus, hypertension, and hypothyroidism. She presented to her primary care physician with similar pain to what she experienced in her prior L4 fracture. A lumbar and thoracic MRI without contrast was ordered and showed acute compression deformity at T8 vertebral body and acute on chronic compression deformity at T7 (Figure 3). She was then referred to interventional radiology (IR) for evaluation and possible kyphoplasty. IR determined she was a candidate for kyphoplasty, she consented, and the procedure was performed.

During the procedure, after successful balloon placement (Figure 4), cement leakage into a paravertebral vein near T7 was demonstrated (Figures 5, 6 and 7). Upon seeing this venous infiltration, cement injection was immediately ceased and the delivery cannula withdrawn partially. However, cement continued to flow along the vein into the anterior chest on the lateral projection. AP and lateral fluoroscopic images were performed which confirmed cement entry into the heart. To more accurately delineate the position of the cement in the heart, a CT of the chest was performed immediately post procedure. The CT found cement extravasation extending from the T7 vertebral augmentation into the right ventricle as well as cement extending from T8 into the azygos vein at the level of T8 (Figure 8). A follow up chest X-ray found no evidence of pulmonary infiltrates. Cardiology consultation and subsequent echocardiography also confirmed the presence of cement in the right atrium and ventricle, across the tricuspid valve. Cardiology recommendation was also to attempt removal of the cement embolus due to high risk of developing tricuspid valve insufficiency in the long term.

The patient agreed to foreign body retrieval which was performed the same day. The patient was placed supine on the angiography table, right groin was prepped and draped in a sterile manner, local anesthetic was achieved with 1% lidocaine. Under ultrasound guidance and sterile technique, a micro access needle was used to access the right common femoral vein. A 24F Inari sheath accommodating a 24 French Inari catheter was placed, through which a 35 mm gooseneck snare in conjunction with multiple angle catheter was used to engage the tip of the cement which was found extending into the right ventricle.

During this process a 1.8 cm fragment of cement broke off and went into the right lower lobe with no immediate evidence of cardiovascular compromise. Subsequently the snare was used to engage the remaining cement at the tip and guide it into the 24F catheter. Once the length of cement from the azygos arch caudally had been secured in the sheath, traction on the snare along with countertraction on the catheter was used to fragment the cement. These fragments were then removed along with the sheath and the snare from the patient's body into pieces which measured approximately 12 cm in total. An attempt was made to retrieve the 1.8 cm fragment that had gone into the right lower lobe subsegmental pulmonary artery, but after multiple unsuccessful attempts the procedure was ended. Overall, the procedure yielded successful retrieval of the caval and right cardiac portion of the polymethyl methacrylate cement, and a 1.8 cm embolus to the right lower lobe subsegmental pulmonary artery that could not be retrieved.

3. Images

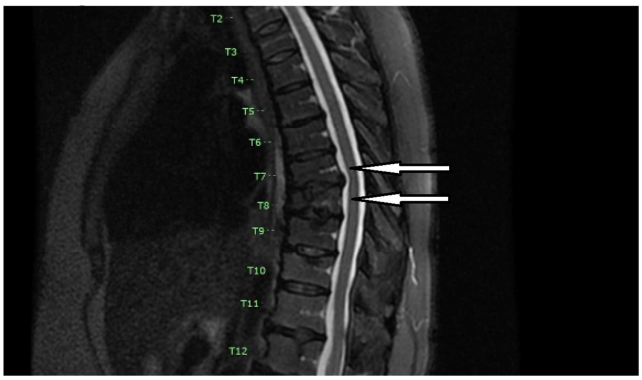


Figure 3. *Compression fractures at T7 and T8.*

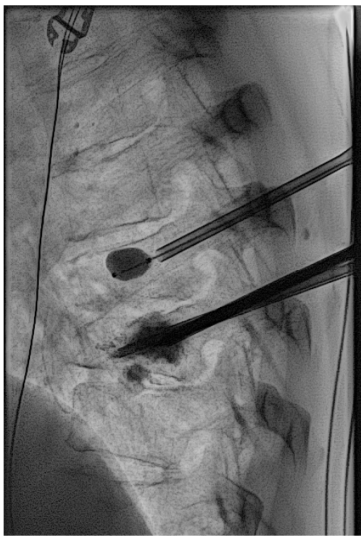


Figure 4. *Prior to infiltration.*

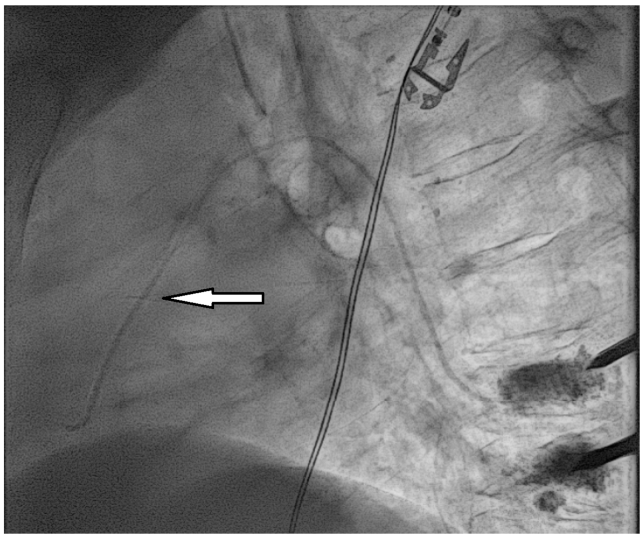


Figure 6. *Infiltration - T7 to azygous system.*

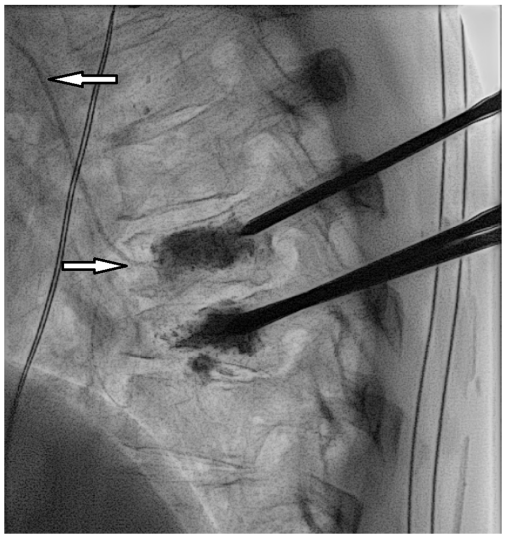


Figure 5. *Infiltration at T7.*

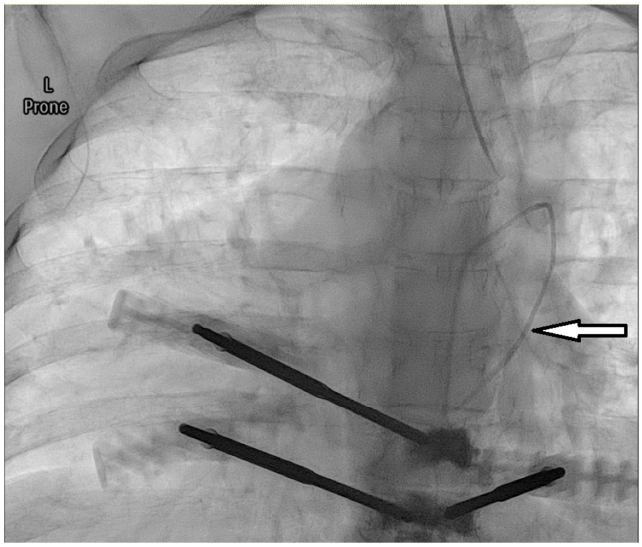


Figure 7. *Infiltration. - coronal view.*

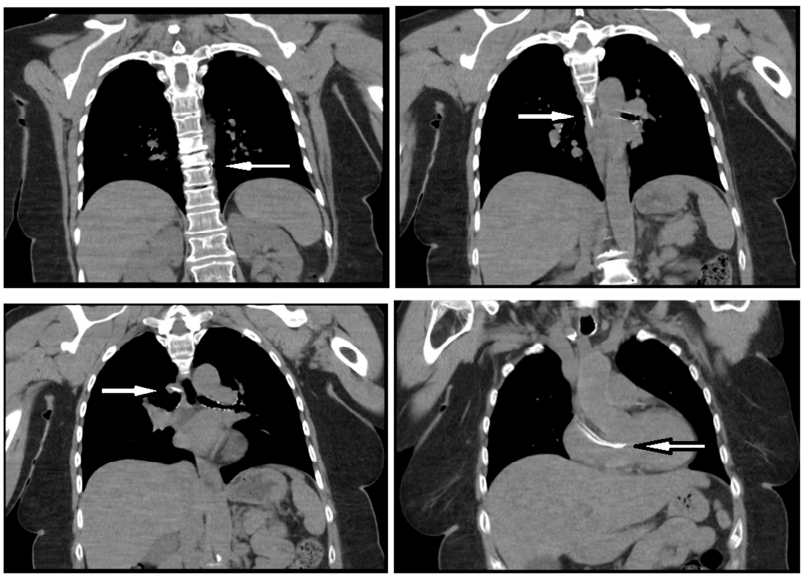


Figure 8. *Post-procedure Ct-Chest (Thorax) W/O.*

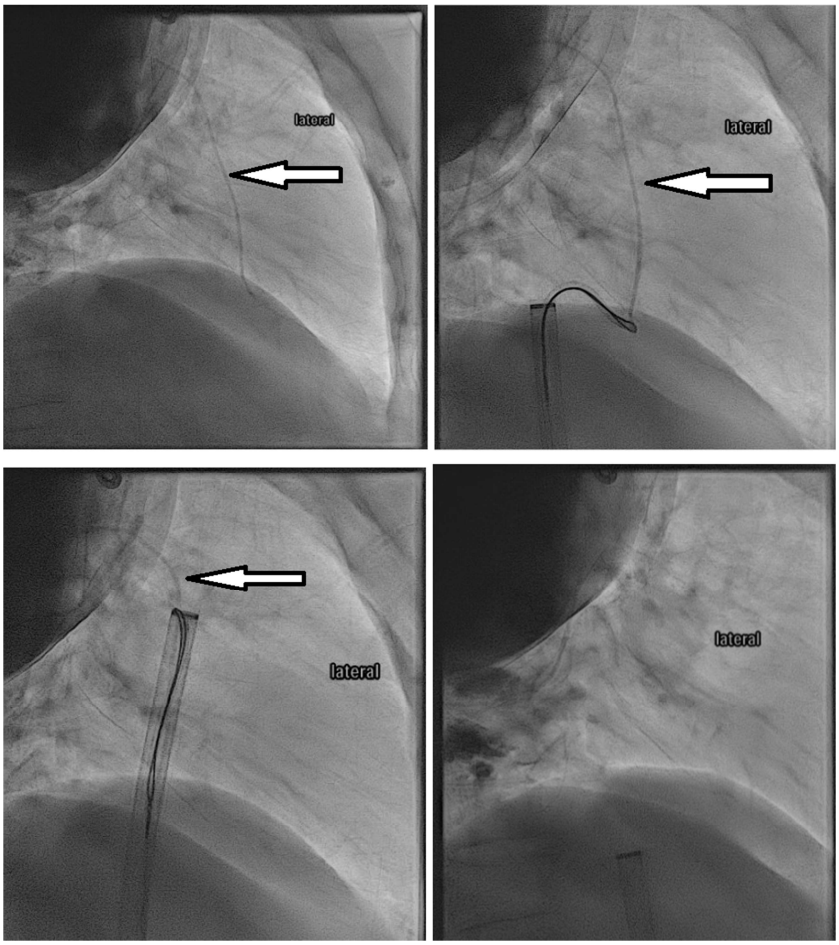


Figure 9. *Retrieval – Lateral.*

4. Discussion

Cement extravasation during vertebral augmentation procedures, although relatively uncommon, is a well-documented complication. A meta-analysis of the risks of vertebral kyphoplasty found the complication rate of cement extravasation to be approximately 7% ($p<0.001$), and was significantly lower than for vertebroplasty. [3] While the complication of cement extravasation is not unheard of, there are relatively few documented cases of cement retrieval. [4] While the cement embolism in this patient was not symptomatic and did not embolize to the pulmonary arteries prior to the retrieval, its location in the right ventricle raised concerns for potential pulmonary embolism. Thus the decision was made to perform fluoroscopy guided cement retrieval.

Most cases that have been reported result in an asymptomatic embolus that did not raise concern for pulmonary embolism and thus did not necessitate retrieval. Embolism can happen in real time or can occur after the procedure is finished, one case reporting embolism as much as five years post procedure. [7] Patients should be watched closely for symptoms such as dyspnea. Typical management includes anticoagulant therapy such as low dose heparin, or operative embolectomy.

The thoracic vertebrae, especially the mid-thoracic region (T7-T8), as seen in our patient, are commonly involved in kyphoplasty procedures due to their susceptibility to osteoporotic fractures. The complicated vasculature in the thoracic region makes cement extravasation somewhat difficult to predict and avoid on both the arterial and venous side. [2, 18] The venous side affected in this case likely includes the basiverterbral vein, interverterbral vein, hemiazygous, azygous, and SVC. The patient's history of systemic lupus erythematosus and hypertension may have further predisposed her to this complication due to potential alterations in vascular integrity and bone quality.

The use of biplane fluoroscopic guidance, as in this case, is essential for visualizing the cement's flow. However, even with optimal visualization, cement leakage can occur, emphasizing the need for minimal cement usage and low-pressure injection. The occurrence of cement leakage into a paravertebral vein near T7 during this procedure underscores this point. Immediate cessation of cement injection upon noticing venous infiltration is a critical step in managing this complication.

5. Conclusion

This case adds to the existing literature on the serious complication of cement extravasation and embolism in vertebral kyphoplasty. It highlights the need for careful

procedural planning, real-time monitoring during cement injection, and a prompt, coordinated response in case of an embolic event. We would like to highlight the value of a collaborative approach between specialties and the value of newer interventional tools that would allow successful cement retrieval in indicated cases.

Abbreviations

VCF: Vertebral Compression Fractures
KP: Kyphoplasty
VP: Vertebroplasty
SVC: Superior Vena Cava
PE: Pulmonary Embolism
MI: Myocardial Infarction
IR: Interventional Radiology
AP: Anteroposterior
CT: Computed Tomography
MRI: Magnetic Resonance Imaging

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Conflicts of Interest

The authors declare no conflicts of interest.

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