



Clinical characteristics and management of cardiac and/or pulmonary cement embolus after percutaneous vertebroplasty: a single center experience

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Background: Cardiac and/or pulmonary cement embolus (CPCE) caused by the leakage of bone cement after percutaneous vertebroplasty (PVP) are rare but are lethal complications in patients with vertebral compression fracture (VCF). Literature in this field is limited, and guidelines for the management of such complications are unclear. This study aimed to review our center's experience.

Methods: Medical records (clinical characteristics and management) and imaging data (X-ray findings, CT findings, and fluoroscopic findings) of 12 patients with CPCE after PVP between October 2015 and July 2018 at our hospital were collected and examined retrospectively. Their health conditions were also evaluated through a telephone follow-up survey.

Results: Twelve patients with an average age of 76.8±8.5 years were included in our study. One patient who had a cardiac cement embolus and one patient who suffered from an inferior vena cava (IVC) cement embolus were successfully treated via percutaneous retrieval. Ten asymptomatic patients with pulmonary cement embolus (PCE) were managed with conservative observation. All of the patients were alive and remained asymptomatic during the follow-up period (median time, 6.5 months; range, 1–50 months).

Conclusions: More attention should be paid to the possibility of development of CPCE. For patients with cardiac cement embolus, open heart surgery should be considered as a preferred treatment, and percutaneous procedure could be used as an alternative treatment for patients with surgical contraindication or other surgical high-risk factors. For patients with an IVC cement spike, percutaneous retrieval could be recommended. Careful observation and clinical follow-up could be recommended for patients with asymptomatic peripheral or central PCEs.

Keywords: Percutaneous vertebroplasty (PVP); bone cement; embolus

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Introduction

Percutaneous vertebroplasty (PVP) is a therapeutic intervention that involves the injection of bone cement into a diseased vertebral body to stabilize the vertebrae and relieve back pain. This technique has been widely used to manage vertebral compression fractures (VCFs) because of its high efficacy and safety. However, in some cases, fatal complications such as cardiac and/or pulmonary cement embolus (CPCE) may occur as a result of bone cement leakage (1-3).

Currently, evidence regarding cement embolism complications is limited to few case reports, and guidelines for the management of such complications are unclear. Thus, this study analyzed the clinical characteristics and management of CPCE after PVP in VCFs to provide evidence for the management of this life-threatening complication.

Methods

Patient selection

Medical records (clinical characteristics and management) and imaging data (X-ray findings, CT findings, and fluoroscopic findings) of 12 patients with CPCE after PVP between October 2015 and July 2018 at our hospital were collected and examined retrospectively. Their health conditions were also evaluated through telephone follow-up survey. The study protocol was approved by the Zhejiang Taizhou Hospital institutional review board (K20181203) and conducted in accordance with the Helsinki Declaration of 1964 (revised 2008). The need for informed consent was waived because of the retrospective nature of this study.

Clinical management

Case 1

A 70-year-old woman with VCFs of T10 and L4 underwent a successful PVP. She was asymptomatic after PVP. However, her spine X-ray (*Figure 1A*) and her chest and abdomen CT scan (*Figure 1B*) on post-PVP day 1 showed prevertebral cement leakage. She was solely managed with clinical observation due to the lack of symptoms. Unfortunately, CT pulmonary angiogram (CTPA) performed on post-PVP day 5 revealed a cardiac cement embolus of 5 cm long (*Figure 1C*) and a small pulmonary cement embolus (PCE) (*Figure 1D*). She was associated with a high risk of cardiac perforation because the tip of

the cement embolus was inside the myocardium of the right atrium. Therefore, the cardiac cement embolus should be retrieved as soon as possible to avoid potentially catastrophic consequences.

A multidisciplinary team was assembled to ensure an optimal treatment for the patient. Open heart surgery was initially planned to retrieve the cardiac cement. However, the patient was associated with surgical risk factors, such as age (70 years old) and diabetes history. Thus, a percutaneous procedure was recommended. The procedure was performed under electrocardiographic monitoring. A 6-F MPA2 catheter (Cordis Corporation, USA) was initially advanced percutaneously into the right atrium through the right femoral vein. A 5-F loop snare catheter (Shanghai Shape Memory Alloy Corporation, China) was manipulated to snare the cardiac cement. However, snaring the cement was impossible because the thread-like cement from the right atrium to the right ventricle did not have an accessible free end (*Figure 1E*).

A new vascular access was obtained to solve this dilemma by puncturing the right femoral vein and subsequently inserting an 8-F vascular sheath (Cordis Corporation, USA). An 8-F ablation catheter (Biosense Webster Ltd., Israel) was then introduced to relocate the cement, but this procedure also failed (*Figure 1E*). With this dilemma, the cement was attempted to be relocated via an innovative technique. A 0.035 inch guidewire (Terumo Corporation, Japan) and a 5-F TIG catheter (Terumo Corporation, Japan) were advanced into the right atrium via the 8-F vascular sheath. The guidewire was then manipulated to encompass the cement and pulled into the MPA2 catheter by the snare to form a loop. The loop was manipulated to slightly hook the cement. Subsequently, the cement was relocated, and an accessible free end was successfully released (*Figure 1F*). A 12-F long sheath (Lifetech Scientific Corporation, China) was then inserted and introduced to the right atrium by exchanging it with the previous 8-F vascular sheath. Afterward, the snare loop catheter was introduced and manipulated to snare the free end of the cement. The cement was successfully retrieved via the 12-F long sheath (*Figure 1G*). The retrieved cement was approximately 5 cm long (*Figure 1H*). The patient had a good post-procedure recovery and was discharged after 1 week.

Case 2

A 77-year-old woman underwent an uneventful PVP because of the VCF of L4. She was asymptomatic after PVP. However, an inferior vena cava (IVC) cement

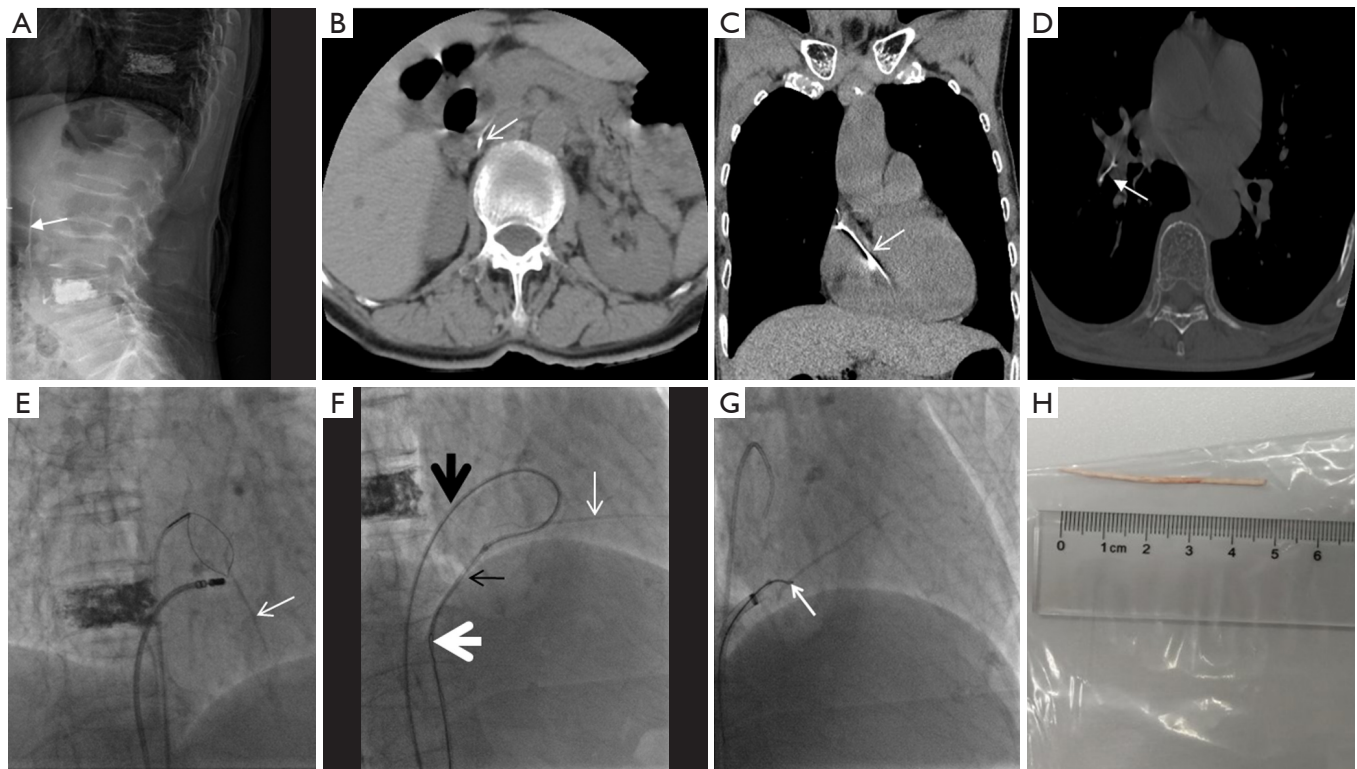


Figure 1 Images from case 1. (A) Post procedure X-ray shows prevertebral leakage of cement (arrow); (B) post procedure CT shows cement leakage into inferior vena cava (arrow); (C) post procedure CTPA shows a high-attenuation thread-like cement of 5 cm length from the right atrium to the right ventricle (arrow); (D) post procedure chest CT shows right central PCE (arrow); (E) fluoroscopy shows thread-like cement from the right atrium to the right ventricle without accessible free end (arrow); (F) TIG catheter (black thick arrow), guide wire, snare loop catheter (white thick arrow) and MPA2 catheter (black thin arrow) are manipulated to form a loop to relocate cement (white thin arrow); (G) cement is successfully snared (arrow) and extracted from 12-F long sheath; (H) the extracted cement is approximately 5 cm long. CTPA, CT pulmonary angiogram; PCE, pulmonary cement embolus.

embolus (*Figure 2A,B,C*) and a small PCE (*Figure 2C*) were revealed by CT performed on postoperative day 1. She was immediately transferred to an angiography room for cement removal to avoid potentially catastrophic consequences. Percutaneous retrieval was performed under electrocardiographic monitoring.

Vascular access was obtained by puncturing the right femoral vein and subsequently inserting a 10-F vascular sheath (Terumo Corporation, Japan). A 5-F loop snare catheter (Shanghai Shape Memory Alloy Corporation, China) was then manipulated to snare the free end of the IVC cement. Subsequently, the cement was snared and successfully retrieved via a 10-F vascular sheath (*Figure 2D,E*). The retrieved cement was approximately 7 cm long (*Figure 2F*). The patient had an uneventful post-procedure recovery and discharged after 5 days. The

two patients were managed with close observation after percutaneous retrieval. The incidence of symptoms and physical signs such as coughing, hemoptysis, tachypnea, dyspnea, cyanosis, precordial chest pain or tightness, irregular cardiac rhythm, palpitation, dizziness, sweating, and hypotension was recorded during the follow-up period.

Conservative observation

Ten patients with asymptomatic PCE diagnosed by X-ray and/or CT findings (*Figures 3,4*) were managed with conservative observation. During the follow-up period, the incidence of symptoms and physical signs such as coughing, hemoptysis, tachypnea, dyspnea, cyanosis, precordial chest pain or tightness, palpitation, dizziness, sweating, and hypotension was recorded.

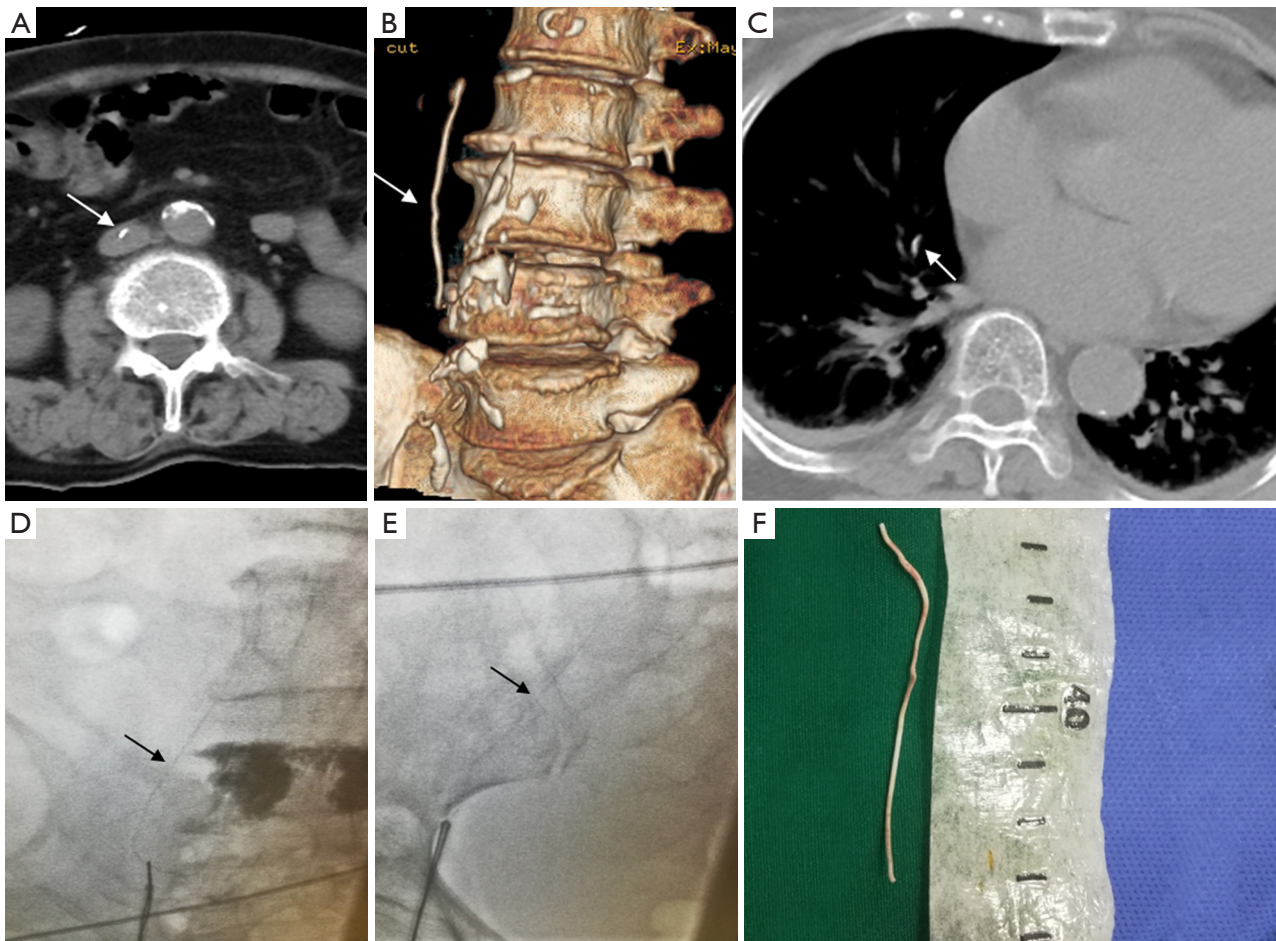


Figure 2 Images from case 2. (A,B) Post procedure CT shows cement leakage into IVC (arrow); (C) post procedure chest CT shows right peripheral PCE (arrow); (D,E) the IVC cement was successfully snared by a 5-F loop snare catheter and extracted through 10-F sheath (arrow); (F) the extracted cement is approximately 7 cm long. IVC, inferior vena cava; PCE, pulmonary cement embolus.

Results

Clinical characteristics

Twelve patients (mean age, 76.8 ± 8.5 years; range, 61–88 years) with CPCE after PVP in VCFs were included in our study. Of these cases, 11 were female and 1 was male. All of the patients were asymptomatic (*Table 1*).

Imaging data

All of the patients with CPCE were diagnosed via X-ray and/or CT findings. One patient had combined cardiac and PCE; one patient had combined IVC and PCE. Of the 12 patients, 11 showed cement emboli located in the right pulmonary arteries, and 9 manifested peripheral embolisms. The number of PCE varied from 1 to 8 (*Table 1*).

Management result and follow-up

Two patients were successfully treated with a percutaneous retrieval procedure and discharged after 7 and 5 days. Ten asymptomatic PCE patients were managed with conservative observation and discharged 3–5 days later. All of the patients were alive and remained asymptomatic during the follow-up period (median, 6.5 months; range, 1–50 months) (*Table 1*).

Discussion

Although PVP is a minimally invasive and relatively safe procedure, the number of PVP-related complications has increased because of the widespread application of PVP. The complications that have been reported include pain,

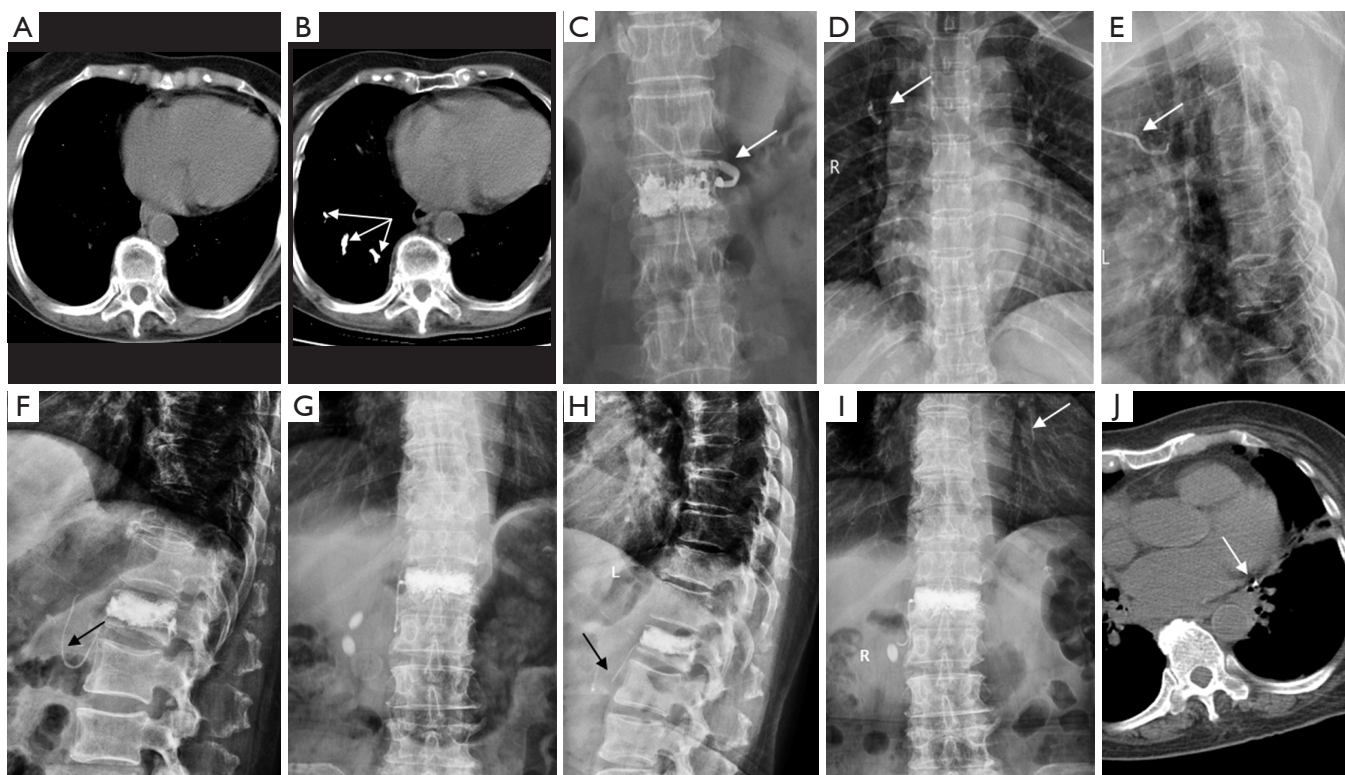


Figure 3 Images from case 3–5. (A,B) Images of case 3, multiple high-attenuation areas (arrows) are diagnosed as peripheral PCEs by comparing with the pre-procedure imaging; (C,D,E) images of case 4, post procedure X-ray shows prevertebral leakage of cement (arrow) as well as right peripheral PCE (arrow); (F,G,H,I,J) images of case 5; (F,G) X-ray performed on post procedure day 1 shows prevertebral leakage of cement (black arrow); (H,I,J) X-ray and CT scan performed on post procedure day 30 shows the previous cement break (black arrow) and migrate into the segmental artery of left inferior lobe (white arrows). PCE, pulmonary cement embolus.

infection, inaccurate needle placement, hemorrhage at puncture sites, cement leakage into the spinal canal, perivertebral tissue leakage, perivertebral venous leakage, pulmonary cement embolism, and cardiac cement embolism (4,5).

CPCE, which is caused by cement leakage migrating from the perivertebral venous to the IVC, right heart, and pulmonary arteries, is the most fatal complication. Most patients with CPCE are asymptomatic (6,7), and only a small percentage (0.4% to 0.9%) of patients may manifest chest pain, coughing, dyspnea, hemoptysis, syncope, acute respiratory distress, and cardiac tamponade (8,9). Similar to observations in other reported studies, our findings revealed that all of the patients with CPCE during the follow-up period remained asymptomatic.

The incidence of PCE is not well documented and appears to be undervalued. Chest X-ray and CT examinations are two common imaging methods. Many

patients may not undergo post-PVP chest X-ray or CT examination because most PCE cases are asymptomatic. Therefore, missed diagnosis cannot be avoided. Varied imaging methods (X-ray or CT) may also contribute to the undervalued incidence of PCE. The incidence of PCE is as low as 3.5% and may reach 28.6% (10). The incidence varies from 1% to 6.8% when only postprocedural chest X-ray is employed (11). However, if sensitive examination such as chest CT is performed, the incidence dramatically increases from 2.1% to 26% (12,13), suggesting that the incidence of PCE may be undervalued if postprocedural chest X-ray is used as the diagnostic modality. In some instances, differentiating PCE from calcifications on chest CT images is difficult, and such a difficulty could lead to misdiagnosis. PCE, unlike pulmonary thromboembolism, has a higher density than lung parenchyma and can be easily recognized on a chest X-ray and CT. However, radiologists should be aware that calcifications are also high in density

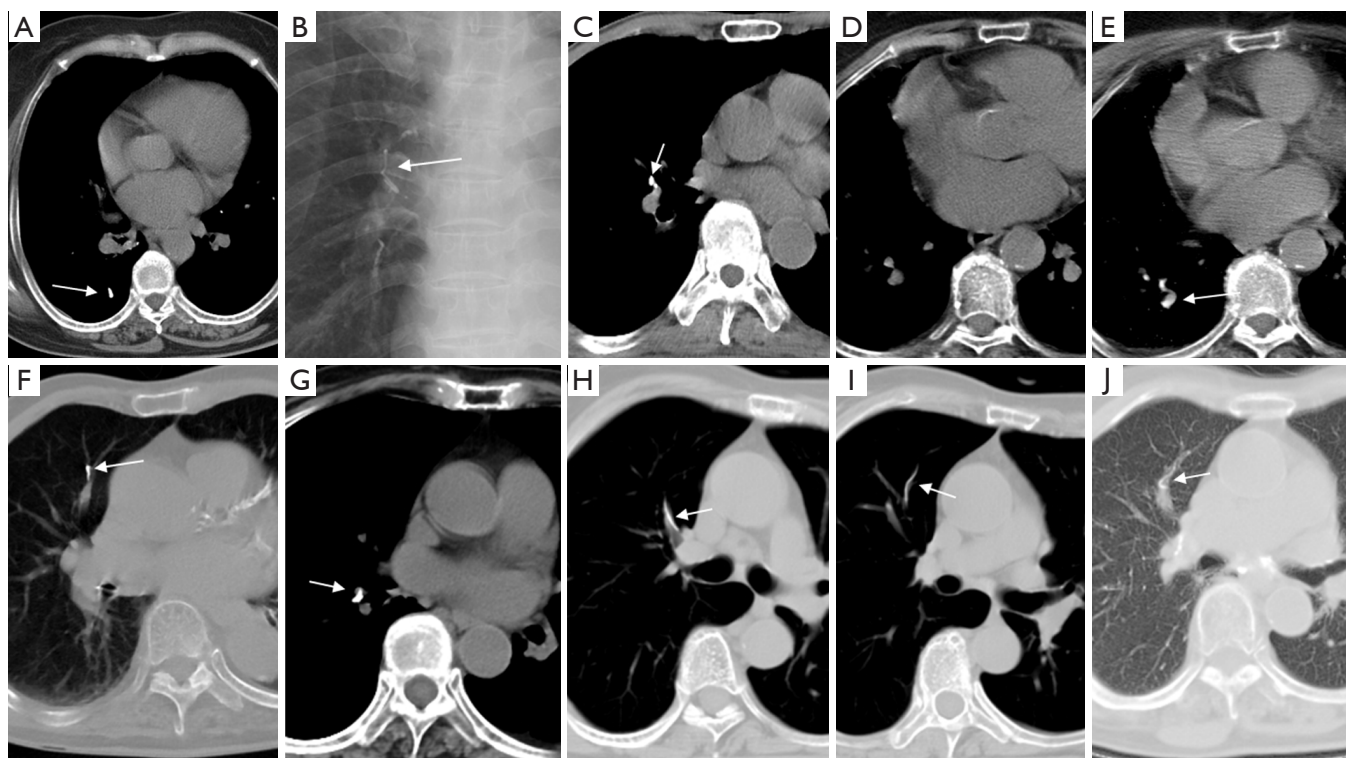


Figure 4 Images from case 6–12. (A) Images of case 6, post procedure CT shows right peripheral PCE (arrow); (B,C) images of case 7, post procedure X-ray and CT scan shows right central PCE (arrows); (D,E) images of case 8, multiple high-attenuation areas (arrows) are diagnosed as peripheral PCEs by comparing with the pre-procedure imaging; (F) images of case 9, post procedure CT shows right peripheral PCE (arrow); (G) images of case 10, post procedure CT scan shows right central PCE (arrows); (H,I) images of case 11, post procedure CT scan shows right peripheral PCE (arrows); (J) images of case 12, post procedure CT scan shows right peripheral PCE (arrow). PCE, pulmonary cement embolus.

and can be difficult to differentiate from PCE in some cases. Thus, radiologists should combine a patient's PVP history and make a cautious diagnosis. The presence of high-attenuation signals in the lumen of the pulmonary artery is highly suggestive of PCE (14). Comparison with a preprocedure chest radiograph or CT is important for the diagnosis of PCE because a newly developed branching high-attenuation signal in the pulmonary artery after PVP should be considered as PCE. Three cases of patients (cases 3, 5, and 8) in our study were diagnosed as PCE through a comparison with pre-procedure imaging.

Cardiac cement embolus and PCE should be dealt with differently because the varied severity of these two entities. Currently, the best treatment for PCEs remains controversial and poorly characterized. Krueger *et al.* (15) theorized that the location of the cement and the severity of symptoms are two major considerations for the appropriate

treatment of PCEs. Therefore, careful observation is recommended for asymptomatic peripheral PCEs. Careful observation and anticoagulation are recommended for symptomatic peripheral or asymptomatic central embolisms. Surgical treatment is recommended for symptomatic central embolisms. However, the benefits of anticoagulation for asymptomatic PCEs remain controversial. Anticoagulation is necessary to reduce the risk of thrombus formation on cement. However, no evidence exists to show the formation of thrombus on the cement. On the contrary, Blinc *et al.* (16) performed an *in vitro* study and demonstrated that the surface of fresh or old cement does not accelerate platelet aggregation or plasma coagulation. In addition, patients with PCE received no anticoagulation therapy and remained asymptomatic during long-term follow-up (17,18), indicating that asymptomatic PCEs may be effectively managed with careful observation. Our results also demonstrated that patients with asymptomatic

Table 1 Clinical characteristics and imaging data as well as follow-up data of patients with cardiac and/or pulmonary cement embolus following PVP

No.	Age (years)/sex (F/M)	Symptoms	Location of CV	Location of embolus	Number of embolus	Size of biggest embolus (mm)	Management	Discharge home (days)	Follow-up period (months)	Outcome
1	70/F	Asymptomatic	T10, L4	Right atrium; central PCEs (right)	1; 3	50×2; 20×2	Percutaneous retrieval	7	4	Alive
2	77/F	Asymptomatic	L4	Inferior vena cava; peripheral PCEs (right)	1; 1	70×2; 5×1	Percutaneous retrieval	5	3.5	Alive
3	88/F	Asymptomatic	L4	Peripheral PCEs (right)	7	16×4	Clinical observation	3	6	Alive
4	61/F	Asymptomatic	L1	Peripheral PCEs (right)	1	50×3	Clinical observation	4	1	Alive
5	84/F	Asymptomatic	L1	Peripheral PCEs (left)	1	23×1	Clinical observation	4	31	Alive
6	79/F	Asymptomatic	T12	Peripheral PCEs (right)	8	7×2	Clinical observation	5	34	Alive
7	70/M	Asymptomatic	L4–L5	Central PCEs (right)	5	20×2	Clinical observation	3	6	Alive
8	80/F	Asymptomatic	T12–L1	Peripheral PCEs (right)	5	4×2	Clinical observation	4	7	Alive
9	84/F	Asymptomatic	T12	Peripheral PCEs (right)	1	8×2	Clinical observation	5	2	Alive
10	79/F	Asymptomatic	L1–L2	Central PCEs (right)	1	6×3	Clinical observation	4	30	Alive
11	68/F	Asymptomatic	T11	Peripheral PCEs (right)	1	33×2	Clinical observation	3	50	Alive
12	82/F	Asymptomatic	L1	Peripheral PCEs (right)	2	16×2	Clinical observation	5	39	Alive

PVP, percutaneous vertebroplasty; F/M, female/male; CV, compressed vertebral; PCE, pulmonary cement embolus.

peripheral or central embolisms could be safely managed with careful observation and clinical follow-up.

Cardiac cement embolus must be removed because of the risk of cardiac rupture and cardiac tamponade (4). Open heart surgery and percutaneous procedure are two feasible options for the retrieval of cardiac cement embolus (19). Our initial plan involved an open-heart surgery to retrieve the cardiac cement embolus. However, given the high surgical risk, poor prognosis, and diabetes history of the elderly patient (70 years old), percutaneous procedure was recommended. However, the percutaneous procedure in the present case was eventful because the cement embedded

into the lateral wall of the right atrium. Many methods were conducted, and the cement was finally retrieved with a modified wire-loop snare technique. Although the cardiac cement embolus was successfully retrieved via the percutaneous procedure in the present study, the percutaneous procedure, requiring highly skilled techniques, remained challenging and dangerous because the shape and size of the cardiac cement embolus in different patients might vary. The percutaneous procedure is less traumatic than an open-heart surgery. However, the percutaneous procedure is more dangerous than the open procedure. In some cases, a complete percutaneous procedure is

impossible. Therefore, open heart surgery should be considered as the preferred treatment, and percutaneous procedure can be used as alternative treatment for patients with surgical contraindication or other surgical high-risk factors.

Lee *et al.* (20) described a patient who developed an IVC cement spike after PVP was treated conservatively because the patient was asymptomatic. This patient died of acute respiratory distress syndrome 3 months later because of a cardiac tamponade caused by the cement spike that pierced the right ventricle. This study indicated that the watch-and-wait policy for IVC cement spikes should not be recommended because of fatal cardiac tamponade. A patient (case 5) in our study developed an IVC cement spike following PVP and was also treated conservatively because the patient was asymptomatic. The post-procedure chest X-ray and CT performed 1 month later revealed that the IVC cement spike broke and migrated into the segmental pulmonary arteries of the left inferior lobe. Fortunately, a serious cardiac event, such as a cardiac perforation or cardiac tamponade, did not occur in this case. Similar to this case, patient 2 with an early percutaneous retrieval of an IVC cement spike had a good patient outcome. Our results demonstrated that the early retrieval of an IVC cement spike could be recommended for patients with IVC cement spike to avoid a potentially fatal complication.

Conclusions

The incidence of PCE caused by cement leakage following PVP appears to be undervalued. More attention should be paid to the possibility of development of CPCE. For patients with cardiac cement embolus, open heart surgery should be considered as the preferred treatment. For patients with surgical contraindications or other surgical high-risk factors, percutaneous procedure could be used as an alternative treatment. For patients with an IVC cement spike, percutaneous retrieval procedure should be recommended. Careful observation and clinical follow-up should be recommended for patients with asymptomatic peripheral or central embolisms.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study protocol was approved by the Zhejiang Taizhou Hospital institutional review board (K20181203) and was conducted in accordance with the Helsinki Declaration of 1964 (revised 2008). Due to the retrospective nature of this study, the need for informed consent was waived.

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