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CASE REPORT

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Retrograde Flow Cement Leakage during Kyphoplasty

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ABSTRACT

Objective: *To report a rare event of a retrograde flow of cement leakage during balloon kyphoplasty and discuss the possible mechanism.*

Methods: *We present a 55-year-old male patient, who underwent a 4-level balloon kyphoplasty for Langerhans histiocytosis that had spread to the spine. With the patient prone under general anesthesia, intrathoracic pressure was raised as a precaution measure to prevent cement embolic complications as a protocol reported elsewhere.*

Results: *During the last vertebral body procedure (L1), cement leakage was noticed to flow downward in a retrograde fashion into the segmental vertebral vein and the procedure was immediately discontinued. Cement leak did not follow the predictable upward blood flow through the anterior or lateral segmental vein into the vena cava, but instead, the cement followed a retrograde downward path into the Batson's vein. No adverse cardiopulmonary effect was observed. Evidence of pulmonary cement embolism was detected in a routine thoracic computed tomography six week later.*

Conclusion: *To our knowledge this is the first case in the English-speaking literature to highlight a retrograde cement intravascular flow most likely as a result of increased intrathoracic pressure.*

Keywords: : balloon kyphoplasty, cement leakage, pulmonary embolism, intrathoracic pressure, retrograde flow.

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INTRODUCTION

During the last decades percutaneous vertebroplasty (PVP) and percutaneous balloon kyphoplasty (PKP) have been increasingly used for the management of painful osteoporotic vertebral compression fractures (OVCFs) and osteolytic spinal tumors (1). Cement leakage is a frequent and well described complication of these procedures that may cause pulmonary and neurological complications (2-4).

Pulmonary embolism is related to an increased interosseous pressure during the balloon inflation that squeezes away fat, bone marrow, and cement particles during cement injection. Both events may take place. This was experimentally confirmed in a ship model using different filling materials resulting in serious cardiopulmonary complications (5-8).

Several surgical technical tips have been advocated to prevent or minimize the risk of cement leakage including correct placement of the balloons, high viscosity cement, slow cement insertion, careful and frequent fluoroscopy control, volume, rate and the pressure of cement injected (1, 4). Furthermore, other measures such as proper positioning of the patient and positive pressure ventilation have been also advocated as necessary applications (9, 10). Correct patient positioning can influence intrathoracic and intra-abdominal pressure and their effect on venous return and vertebral venous system (11, 12). In a detailed article on the anatomy and physiology of the vertebral venous system and the complications related to the application of PVP and PBK, Groen et al point out the value of elevation of intrathoracic and intra-abdominal pressure during balloon inflation and cement insertion, in order to avoid undesirable cement extrusion and cardiorespiratory events (13). In a previous report, we demonstrated no untoward complications of multilevel PBK (1–8 levels on the same sitting) in a cohort of 63 patients (31 treated for osteoporotic fractures and 32 for osteolytic tumors). The technique of manipulating intrathoracic pressure during cement insertion was successfully performed and well tolerated by patients (12).

The purpose of this communication is to discuss the observation of a rare event of retrograde cement leakage during PBK and discuss its possible mechanism. ❑

CASE

We describe the case of a 55-year-old male patient diagnosed with multiple-level spinal dissemination of multiorgan Langerhans histiocytosis resulting in severe back pain. MRI (T1- and T2-weighted images) revealed an osteolytic lesion at the L1 vertebral body. The lesion expanded the posterior-lateral wall of the vertebral body with extension into the left pedicle and L1 transverse process. Gadolinium enhanced T1-weighted fat saturated images revealed additional disease infiltration of the T12, L2 and L3 vertebral bodies, not seen on the plain MRI. Percutaneous needle biopsy under computed tomography (CT) control revealed the diagnosis of Langerhans histiocytosis.

The patient's initial conservative management with appropriate bracing and oral analgesics failed. The pain continued to deteriorate and for this reason it was deemed necessary to proceed with a 4-level PBK (T12-L2) with polymethylmethacrylate (PMMA).

General anesthesia was induced with Fentanyl and Propofol and maintained with Sevoflurane (12). A non-depolarizing neuromuscular blocking agent, left to the anesthesiologist's choice, was given to facilitate tracheal intubation. A catheter was placed in the radial artery for obtaining blood gas analysis and monitoring invasive arterial blood pressure. Adhesive electrodes oximetry for monitoring the regional cerebral oxygenation were stuck symmetrically on the forehead, high above the eyebrows to avoid positioning over sinus cavities (12). The, the patient was placed in a prone position on a Jackson surgical table and the procedure was performed in the usual fashion (14). The transpedicular approach was selected. The mean balloon inflation volume was 6.04 mL (range 4.5–7 mL) and the mean amount of injected bone cement was 5.83 cc (range 3.8–8.5 cc). Bone cement (PMMA) containing 35% barium sulfate (Vebroplast, Leader Biomedical) was used. The setting time of this cement (at a temperature of 21°C in our operating theater) is approximately 12 min. The bone cement setting time allows 0.5–1 min for mixing time, 4.5 min for filling the cement inserter, 4–5 min for holding time, 4.5–5 min for

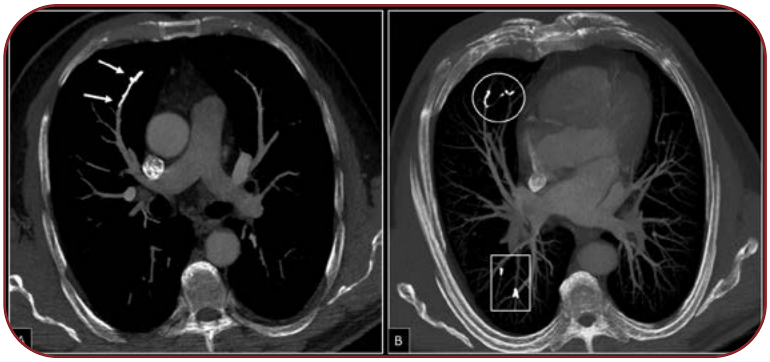

FIGURE 1. A) Postoperative lateral plain lumbar spine radiograph; (B) sagittal reconstruction of lumbar spine CT; and (C) corresponding 3D volume rendering of the obtained CT, demonstrate cement leakage into the paravertebral venous system (white arrows)

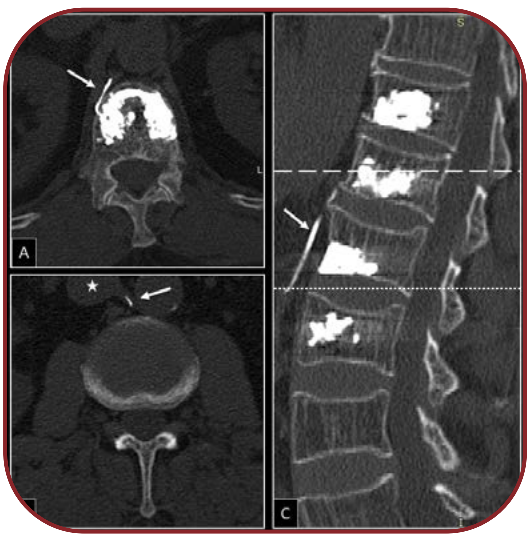

FIGURE 2. (A) Axial lumbar spine CT image (at the level indicated by the white long-dashed line seen in part C of the figure) and (B) axial lumbar spine CT image at a more caudal level (indicated by the white round-dotted line seen in part C of the figure), display retrograde cement leakage (white arrows) into the Batsons paravertebral vein, caudally directed towards the inferior vena cava (white asterisk)

working time and 4–4.5 min for hardening time. The cement is considered to have the ideal level of viscosity when it is not runny any more, becomes doughy, does not stick to the fingers and can stand erect at the tip of the bone cement inserter when pushed out (14). Fluoroscopy control in a lateral view was used. The intrathoracic pressure was momentarily raised by increasing the positive end-expiratory pressure (PEEP) by 10–20 cm H_2O during the process of balloon inflation and cement insertion.

FIGURE 3. (A) Axial maximum intensity projection (MIP) images of a computed tomography pulmonary artery angiography (CT-PA) demonstrate pulmonary artery cement embolism in a segmental and in subsegmental branches of the right upper lobe (white arrows) as well as (B) in subsegmental branches of the right middle lobe (white circle) and right lower lobe (white rectangle)

During the last cement augmentation of the L1 vertebral body, cement leak was observed to flow in the segmental vertebral vein and cement insertion was discontinued. It is of interest to note that cement leak did not follow the predictable upward blood flow through the anterior or lateral segmental vein into the inferior vena cava (IVC) but instead, the cement material followed a retrograde downward pathway into the Batson's vein (Figure 1A). The patient remained stable and no adverse cardiopulmonary changes were observed. Soon after surgery, lumbar spine CT revealed the cement leakage in a downward antidromal direction towards the Batson's paravertebral vein, short of leaking into the IVC (Figure 1B, 1C and Figure 2).

Six weeks later, a routine thoracic CT imaging, which was performed for assessing the response to histiocytosis treatment, detected pulmonary cement embolism (Figure 3). The patient remained asymptomatic. ❑

DISCUSSION

This case presentation demonstrates the value of specific precaution anesthesiological measures during cement augmentation procedures to prevent or minimize intravascular cement leakage.

Apparently, PVP and PBK are safe procedures provided certain technical surgical and anesthetic precautions are untaken. Severe neurological or systematic complications related to cement extravasation have been published (15). Reported complication related to cement extrusion from the vertebral body include hypotension, pulmonary embolism of bone marrow or cement, adult respiratory distress syndrome (ARDS), cement cardiac perforation, cerebral cement embolism, intraforaminal cement leakage with nerve root compression, spinal cord compression causing paraplegia or cauda equina syndrome and cement intravascular extension (1, 13).

Knowledge of the lumbar vertebral venous anatomy and function is important for physicians who perform cementoplasty in order to understand, anticipate and manage possible complications associated with PMMA extrusion (16). Vertebral venous plexus (VVP) was initially described by a medieval anatomist and physician Andreas Vesalius in 1543 (17). The pioneering research of Gilbert Breschet in the 19th century and Oscar Batson in the 20th century not only elaborated on the anatomy of the VVP but also clarified its function and clinical significance (17, 18). Vertebral venous plexus is an extensive network of valveless veins within and around the vertebral column with multiple interconnections to the vena cava (18). The VVS can be divided into three interconnecting structural sections: 1) the internal vertebral venous plexuses (anterior and posterior IVVP), consisting of the epidural veins; 2) the basivertebral (intravertebral) veins that lie horizontally inside the vertebral body from the anterior to the posterior part of the vertebra, connecting the internal-to-external vertebral venous system; and 3) the external vertebral venous plexuses (anterior and posterior EVVP) that encircle the vertebral column and are connected with the IVVP *via* the intervertebral veins. Throughout numerous connections with the azygos venous system and the ascending lumbar veins, the EVVP merges with the venae cavae. Extensive connections also with the subcutaneous vertebral veins and sacral venous plexus exist. Both the IVVP and EVVP extend along the length of the vertebral column (13). New evidence supports that one third of the population has valves in the posterior EVVP that are mostly bicuspid. All other divisions of the VVP remained valveless (19). The lack of valves is directly related with one of the most significant features of the VVP, which is its bidirectional flow (16). This suggests that blood can flow in either direction forward or backward; depending on intrathoracic, intra-abdominal pressure (respiration, coughing, staining, etc.) or hydrostatic factors (changes of posture, gravitation forces) (13).

Cement leakage is classified into three types: type C – leakage via cortical defect to paravertebral tissue; type B – leakage to the spinal canal via basivertebral veins; and type S – leakage to segmental veins. The incidence of local cement leakage is often underestimated as seen on plain fluoroscopy. Yeom *et al* reviewed the CT scans and radiographs of patients who underwent PVP for painful OVCFs. Computed tomography is a more sensitive imaging than fluoroscopy, as it identifies leakage more frequently by a factor of 1.5 (20). The majority of type-B (93%) and type-S (86%) extravasations are missed or underdiagnosed on a lateral radiograph view which is almost the standard view used during the cementation. Only 7% of intracanal cement leakage is accurately identified on fluoroscopy during surgery (20). Cement leak into the perivertebral veins with subsequent pulmonary cement embolism varies from 4.6 to 6.8% (up to 52% in radiologic studies) (21, 22). Cortical bone destruction by malignant lesions and liquid cement insertion are major risk factors for cement extravasation into the corresponding veins, azygos vein, vena cava, and pulmonary circulation (23).

Local anesthesia has been widely used during PBK, and especially during PVP, due to lower hospitalization cost and the ability to monitor intraoperative neurological injuries by performing the surgical intervention while the patient is awake. However, local anesthetics cannot be injected into the vertebral body; thus, some patients experience unbearable pain during the procedure, which results in poor patient cooperation and consequently, in longer operative time (24). Furthermore, the manipulation of intrathoracic and intra-abdominal pressure which can efficiently reduce cement and bone marrow embolism can only be achieved when the patient is under general anesthesia (12, 13). El Saman *at al* evaluated the possible role of intrathoracic pressure during PMMA-injection for augmenting pedicle screws engagement (25). They suggested that the rise of positive end-expiratory pressure (PEEP) by 10–15 cm H_2O prior to PMMA-injection can diminish the cement leakage rate. Elevation of PEEP causes a compression of intrathoracic organs like the vena cava, right and left atrium and ventricle and in turn, a drop in cardiac output, resulting in limited blood backflow to the heart muscle (25). Therefore, high intrathoracic pressure may significantly impair venous return to the heart, causing hemodynamic circulatory collapse, especially in elderly patients with cardiopulmonary compromise. Therefore, the elevation of intrathoracic and intra-abdominal pressure technique should be applied very briefly and only during the process of balloons inflation cement insertion. Gauze without saying and constant communication between the surgeon and the anesthesiologist is imperative (13).

In our case, despite the application of the recommended surgical and anesthesiological preventive measures, the risk of cement migration and pulmonary embolism was not prevented. However, was it diminished? We can argue that it is plausible the appropriate measures taken by us could have potentially prevented a major devastating cement extravasation and pulmonary embolism, judging by the fact that the backward flow of the cement was probably created by the increased intravenous pressure. Therefore, we can theorize that this effect could have prevented a major thromboembolic problem. ❑

CONCLUSIONS

In conclusion, the implementation of proper surgical and anesthetic techniques may reduce, but not eliminate, the risk of cement leakage and embolic complications. The significance of manipulating intrathoracic and intra-abdominal pressure during balloon inflation and cement insertion is the only practical measure to minimize intraoperative cardiorespiratory events. The surgeon should remain vigilant during the phase of cement insertion under fluoroscopy control as the best preventive measure. ❑

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