PULMONARY CEMENT EMBOLISM AFTER PERCUTANEOUS VERTEBROPLASTY AND TRANSPEDICULAR SCREW FIXATION WITH BONE CEMENT: POTENTIAL RISK FACTORS

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Objective. To analyze cases of pulmonary cement embolism and to determine possible causes of the complication.
Material and Methods. A heterogeneous group of 49 patients was retrospectively analyzed. Vertebroplasty was prescribed to the patients for restoration of vertebral support ability after osteoporotic compression fractures and hemangiomas, and as an auxiliary manipulation for transpedicular fixation of the osteoporotic spine. Thoracic computed tomography was performed and pulmonary cement embolism was revealed in the early or late postoperative periods.
Results. Pulmonary cement embolism was revealed in 7 (14 %) patients, two of them presented with massive pulmonary cement embolism. In one case it was caused by excessive injection of cement, and in the other - by anomalous anastomosis. In one case, the vertebroplasty was cancelled taking into account the results of venospodilography.
Conclusion. Attempts of maximum filling of the vertebral body and inadequate assessment of intertrabecular space volume, as well as anomalous anastomoses between the major blood vessels may cause clinically significant massive pulmonary embolism. Venospondylography performed before vertebroplasty may reveal the features of venous drainage of the vertebral body, which are the risk factors for massive cement embolism.
Key Words: pulmonary cement embolism, vertebroplasty, computed tomography, transpedicular fixation.

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Percutaneous vertebroplasty was first performed in 1984 and currently is widely used to treat patients with pathologic fractures, benign and malignant neoplasms of the spine [3, 6, 10].
Vertebroplasty is also used as an auxiliary manipulation for bone augmentation if pedicle screws fixation is planned on osteoporotic spine. One of the most dangerous complications of percutaneous vertebroplasty is pulmonary cement embolism, which in majority of cases proceeds asymptomatically [3, 10, 11, 15]. At the same time, there have been recorded cases of cement embolism complicated by pulmonary infarction, hypercapnia, and cardiac failure, all of those listed required surgical intervention, e.g. embolectomy or even segmental pulmonary resection [5, 15].

At present, it is established that injection of cement into vena cava, azygous vein or hemiazygous vein is a proven risk factor of the cement embolism, but this predictor can be assessed retrospectively only when surgical intervention is already completed [10]. Anatomy of pulmonary and systemic circulation under normal and pathological conditions was given a nuanced assessment in the middle of the XX century in which auxiliary anastomoses between pulmonary and systemic circulation, cardiac veins and principle veins basins of systemic circulation were detailed [12, 16]. Literature data suggest that vascular anomalies represent potential risk factors for cement embolism during vertebroplasty.
The objective of the present study is to analyze cement embolism cases and identify possible reasons for this complication.

Material and Methods

A retrospective analysis was performed for the heterogenous group of 49 patients. Vertebroplasty was used both for treatment of the main pathology and as an auxiliary manipulation in stabilizing spinal surgery.
In 8 patients, vertebroplasty preceded transpedicular fixation because of osteoporosis, in 6 patients vertebroplasty was performed to restore vertebral load-bearing capacity because of hemangioma, in 34 – because of a sustained pain caused by low energy fracture of vertebrae caused by osteoporosis and surgeon decided to cancel vertebro-

plasty taking into account the results of venospondylography.

Mean age of patients accounted for 65.69 (range: 52 to 78; standard deviation – 7.75). The enrolled cohort included 36 (73 %) women and 13 (27 %) men.

In the study, no exclusion criteria were set on vertebroplasty procedure indication including the amount of injected cement and localization of pathology. The same type of high-viscosity methylmethacrylate cement was used for surgical interventions. Vertebroplasty procedures were performed under local anesthesia and intravenous sedation, general anesthesia was used if pedicle screws fixation was applied. In all cases vertebroplasty was performed under fluoroscopic guidance. The standard technique was employed: a needle was introduced into the anterior third of the vertebral body via transpedicular approach and then bone cement was injected. Bilateral approach was applied when vertebroplasty was used as an auxiliary manipulation for bone augmentation in transpedicular fixation, in all other cases the intervention was made via unilateral approach.

Immediately after the procedure or in the delayed period, computed tomography without contrast enhancement was performed for all patients to register cases attributing to pulmonary cement embolism. Cement emboli were localized inside pulmonary arteries, branching correspondingly, with CT-evaluated density of more than 500 Hounsfield units.

Results

Pulmonary cement embolism was detected in 7 (14 %) patients. Notably, in 5 of them the complication was found occasionally as far as no symptomatic manifestations were found. Thoracalgia was registered in 2 patients, and chest computed tomography in those cases revealed a massive pulmonary cement embolism (with several branches of pulmonary artery involved and multiple cement emboli). The common ground between those two cases is that surgical intervention was performed on the thoracic spine. In one case the most likely cause of the cement embolism was excessive injection of bone cement. Fig. 1 clearly demonstrates that bone cement fills intertrabecular space of the vertebra entirely, with methyl-methacrylate extravasations into spinal canal and segmental vessels. As a result, massive pulmonary embolism was detected (Fig. 2) with cement emboli presenting in first-order pulmonary arteries as well (Fig. 3).

In the second case, vertebroplasty was performed to increase vertebral load-bearing capacity during transpedicular fixation for unstable compression fracture of the T6 vertebra. Before fixation, vertebroplasty via bipedicular approach was applied for bone augmentation at the extreme fixation points. During the procedure no episodes of acute cardiac failure were recorded, hemodynamics remained stable. Fig. 4 provides CT-reconstructed image of the final result of the surgery. Control computed tomography revealed massive pulmonary embolism (Fig. 5), however the specific feature of this case was the cement drain into the auxiliary anastomosis shunting blood from vena cava via the system of pulmonary veins (Fig. 6).

The case when venospondylography results led to the decision against vertebroplasty should be demonstrated individually.

Surgery was planned because of hemangioma of the T7 vertebra with aggressive growth confirmed by computed tomography. Lateral extrapedicular approach was used to introduce needle into a vertebral body, then contrast substance "Omnipaque" was injected. Fluorogram demonstrated opaque enhanced azygous vein, cardiac veins, coronary sinus and auxiliary anastomosis between azygous vein and the system of coronary veins (Fig. 7). Because of the risk of cement drain into the revealed anastomosis and the considerable threat of complication, it was decided to cancel the procedure.

Discussion

Pulmonary cement embolism is a frequent complication of percutaneous vertebroplasty. According to several sources [10, 15], its frequency varies from 2.1 to 26.0 % out of the performed surgical interventions. Among those, cases with cement embolism following transpedicular screw fixation with bone cement have been described [1]. In the majority of cases pulmonary embolism was asymptomatic, however, with a broaden indication of the technique and the increase in the amount of surgical interventions performed each year, a rise in rate of clinically significant complications is reported [10, 17]. Symptoms may vary from a chest discomfort and dyspnea to acute distress syndrome and pulmonary infarction. In addition to that, cases of fatal pulmonary embolism have been registered [15]. It has been proved that methyl methacrylate emboli are not thrombogenic, but may lead to cardiac puncture and cardiac tamponade [2, 3]. Small cement emboli remain inert with time and do not cause any significant reaction of the surrounding tissues. In this regard, if the complication proceeds asymptomatically, the long-term follow-up controlled by computed tomography is not recommended [17]. It is evident that only massive

Fig. 1
Excessive injection of bone cement according to control CT data

cement embolism represents a significant hazard, so it is required to analyze factors which can be promotive of this complication.

Our results demonstrate that inadequate assessment of intertrabecular space volume may lead to an excessive injection of the bone cement that will drain through the venobasilar system to vena cava through the segmental veins. It should be noted that vertebroplasty results are not dose-dependent [14]. Thus, pathologic fractures require filling with cement of 24–25 % intertrabecular space [14]. In other words, filling of the entire space of the vertebral body is not reasonable and associated with a high risk of complications.

Venous circulatory system was investigated in the middle of the XX century and it has been found that not only normal but also anomalous variations such as cavopulmonary shunts and auxiliary anastomoses between venous trunks might be present in some cases. In patients with pathologic conditions such as cardiac deficiency and pulmonary hypertension auxiliary collateral vessels between vena cava system and pulmonary circulation can be active [4, 7–9, 12, 16]. These auxiliary vessels can play a significant role in the development of the cement embolism, that is evident from the results of our observations. Thus, control computed tomography revealed cement-enhanced venous shunt between systemic circulation and pulmonary circulation. Currently, the performance of venospondylography before vertebroplasty is met with a mixed attitude among surgeons. A part of researchers is assured that venospondylography allows one to predict only one-fourth of complications related to cement extravasation outside the vertebral body [13]. At the same time, contrast medium injection facilitates the identification of individual features of venous circulation such as anomalies and auxiliary anastomoses. Therefore, patients prone to a higher risk of complications can be determined, which will give the opportunity to take preventive measures.

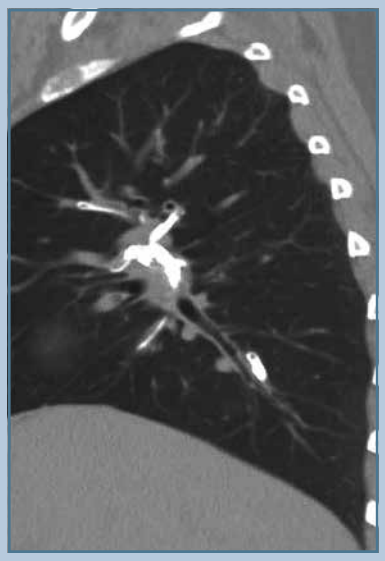

Fig. 2
Massive multiple cement embolism revealed in control CT scans

Fig. 3
Cement embolus in primary pulmonary arteries

Fig. 4
CT-reconstructed image of the results of transpedicular screw fixation with bone cement

Conclusion

Pulmonary cement embolism is a frequent complication of percutaneous vertebroplasty, its frequency reaches up to 14 % of all observations. Attempts of maximum filling of the vertebral body and inadequate assessment of intertrabecular space volume, as well as anomalous anastomoses between the major blood vessels may cause clinically significant massive pulmonary embolism. Venospondylography performed before vertebroplasty may reveal the specific features of venous drainage of the vertebral body associated with the increased risk of massive cement embolism.

Fig. 5
CT-reconstructed image of massive pulmonary embolism

Fig. 6
Cement-enhanced venous shunt between the system of superior vena cava and pulmonary arteries

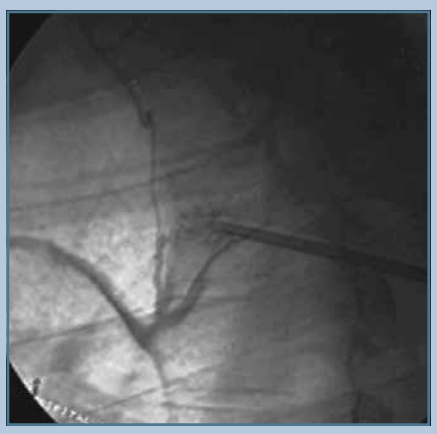

Fig. 7
Venospondilography: an anastomosis between azygous vein and coronary veins opaque enhanced

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