

# Effect of cementing on pulmonary arterial pressure in vertebroplasty: A comparison of two techniques

Journal of Orthopaedic Surgery  
28(1) 1–5

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DOI: 10.1177/2309499019897659  
journals.sagepub.com/home/osj



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## Abstract

**Background:** Increase in intraosseous pressure and displacement of bone marrow contents leading to fat embolism and hypotension during cement injection in vertebroplasty (VP). We aimed to compare the effect of low and high viscosity cements during VP on pulmonary arterial pressure (PAP) with different cannula. **Materials and Methods:** Fifty-two patients having multilevel VP due to osteoporotic vertebral compression fractures were randomly treated either by a high viscosity cement (group A,  $n = 27$  patients) and 2.8 mm cannula or a low viscosity cement (group B,  $n = 25$  patients) injected through 4.2 mm cannula. PAP was measured by standard echocardiography and blood D-dimer values were recorded preoperatively, 24 h and third day after operation. **Results:** Mean age was 69 (62–87) years in group A and 70 (64–88) years in group B, and sex and comorbidities were similar. Average number of augmented levels was 5.4 in group A and 5.7 in group B. Preoperative mean PAP was 33 mm/Hg in group A, elevated to 41 mm/Hg on first day, and decreased to 36 mm/Hg on third day. The mean PAP in group B was 35 mm/Hg preoperatively, 51 mm/Hg on first day and 46 mm/Hg on third day ( $p < 0.05$ ). The average blood D-dimer values in group A increased from 2.1  $\mu\text{g/mL}$  to 2.3  $\mu\text{g/mL}$  and in group B from 2.2  $\mu\text{g/mL}$  to 4.2  $\mu\text{g/mL}$ . **Conclusion:** The finding of this study showed that high viscosity cement injected through a narrower cannula results in lesser PAP increase and D-dimer levels when compared to low viscosity cement injected through a wider cannula. Higher PAP and D-dimer level may show possible thromboembolism. This finding may give spine surgeons to reconsider their choice of cement type and cannula size.

## Keywords

high viscosity cement, low viscosity, thromboembolism, vertebra compression, vertebroplasty

Date received: 11 February 2018; Received revised 2 December 2019; accepted: 4 December 2019

## Introduction

Percutaneous vertebroplasty (VP) is the injection of polymethyl methacrylate into a weakened or osteoporotic compression fractured vertebra under fluoroscopy to give pain relief and mechanical strengthening of the vertebral body. It is also used in traumatic pure vertebral compression fractures (VCFs), multiple myeloma metastatic tumors, and symptomatic hemangioma.<sup>1</sup> The main purpose of VP is pain relief and the strengthening of the vertebrae bones weakened by disease. It is increasingly accepted as one of the options in the management of intractable back pain due to VCFs.<sup>2,3</sup> Most studies have shown substantial

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pain relief and increased mobility during the 72 h after VP in up to 90% of patients.<sup>1,4-6</sup> It is an efficient treatment but not free of complications. The main complication of VP is due to cement leaks, fat or thromboembolism, inaccurate needle placement, pain exacerbation, infection, hematoma, and bleeding. Other less seen complications are advert cement reaction, anaphylaxis, pedicle fracture, adjacent organs injury, and epidural hematoma.<sup>7-10</sup> Cement leaks into the adjacent structures may be seen in 41% of routine cases. These leaks are generally small and are usually asymptomatic. The symptoms are regardless of the location and amount of the leak.<sup>11</sup> Approximately 2% of the observed leaks are pulmonary emboli. These reported incidences of pulmonary cement embolism are not reliable because most of them are asymptomatic and more leaks are detected by computed tomography (CT).<sup>12-14</sup> In addition to unwanted cement leakage, pulmonary fat embolism also occurs as a result of the displacement of intraosseous bone marrow into the bone vessels. Bone marrow particles cause microembolization of the arterioles and capillaries of the lung resulting in an increase in pulmonary arterial pressure (PAP). In healthy lungs, small embolies can be tolerated. Multiple embolies or large cement emboli can cause a pulmonary infarct and may lead to pulmonary compromise or even death. The acute consequences of fat embolism may be hypotension, cardiac arrest, and, in serious cases, sudden death.<sup>15-17</sup>

The aim of this study is to show that use of high viscosity cement with narrower cannula may decrease the risk of pulmonary fat emboli when compared to low viscosity cement with wider cannula.

## Materials and methods

Fifty-two patients having multilevel VP (more than three levels) were included in this study. All of the PV were for osteoporotic compression fractures. Traumatic compression fractures were excluded from the study. We also exclude patients with pulmonary and cardiovascular diseases. The main complaint was back pain in fracture area with or without motion. All the procedures were done under local plus sedation anesthesia. All of the procedures were performed using anterior-posterior and lateral fluoroscopy. The procedure was done by one surgeon and cement injection performed manually. The VP procedure was performed by the same surgeon. The mean delivery time was the same for both groups. There were no statistically differences between two groups according to delivery time. The mean delivery of cements to vertebral body was 10 (8-12) s. PAPs were measured by standard echocardiography (supine position) and blood D-dimer values were recorded preoperatively, 24 h and 3 days after the procedure in all patients. Vertebral fractures were randomly treated either by a high viscosity cement (Osteopal plus radiopaque bone cement) (group A,  $n = 27$  patients) and 2.8 mm outer diameter (Kyphone bone filler Medtronic F04B) cannula

or a low viscosity cement (Osteopal V Radiopaque bone cement) (group B,  $n = 25$  patients) injected through 4.2 mm (outer diameter) as wider cannula (Kyphon F05A Medtronic). The randomization was made by the patients entering to the hospital. First patient was included in group A and the second patient was included in group B; 3 mL cement for thoracic vertebra and 4 mL cement for lumbar vertebra averagely were used in our clinic. The target was to fix the fracture and full the vertebra body.

## Statistical analysis

Descriptive analyses were performed to provide information on general characteristics of the study population. Kolmogorov-Smirnov test was used to evaluate whether the distribution of variables were normal (because of the distributions of age, PAP, and D-dimer values have not normal logarithmic transformed data were used). Two independent sample  $t$  test was used to compare the age, PAP, and D-dimer values between A and B groups. Paired sample  $t$  test was used to compare the D-dimer values between preoperative and postoperative terms. Repeated measures one-way analysis of variance (ANOVA) was used to compare the PAP among three periods. For post-operative comparisons between the pairs of follow-up periods Bonferroni test was used. Repeated measures two-way ANOVA test was used to analyze the alterations of the PAP values between A and B groups. The continuous variables were presented as the mean  $\pm$  standard deviation. Categorical variables were compared by  $\chi^2$  test. Categorical variables were presented as a count and percentage. The value of  $p < 0.05$  was considered significant. Analyses were performed using commercial software (IBM SPSS Statistics, Version 23.0. IBM Corporation, Armonk, New York, USA).

It is a prospective randomize study. The randomization was made by the patients entering the hospital. First patient was included in group A and the second patient was included in group B.

## Results

The mean age was 69 (range 62-87) in group A and 70 (range 64-88) in group B. Sex and the presence of comorbidities was similar in both groups. Average number of levels augmented was 5.4 in group A and 5.7 in group B. All of the fractures were new fractures. The VP procedure was also performed for one upper and one lower segment of new fractures. There are no statistically significant differences for the patient characteristics between two groups. Also, there are no statistical differences between two groups according to cementing levels (Table 1).

Preoperative mean PAP in group A was 33 mm/Hg and elevated to 41 mm/Hg on first postoperative day and decreased to 36 mm/Hg on third postoperative day. On the other hand, the mean PAP in group B was 35 mm/Hg preoperatively, 51 mm/Hg on the first postoperative day, and

**Table 1.** Patient characteristics of the study sample.

		Group A (n = 27)	Group B (n = 25)	p Value
Age		69 ± 5.22	70 ± 4.75	0.435
Gender	Female	17 (63)	16 (64)	1.000
	Male	10 (37)	9 (36)	
Cement leakage	1	3 (11.1)	4 (16)	0.698
	2	24 (88.9)	21 (84)	
Levels of cementation	4	2 (7.4)	5 (20)	0.056
	5	12 (44.4)	6 (24)	
	6	12 (44.4)	7 (28)	
	7	1 (3.7)	5 (20)	
	8	0 (0)	2 (8)	

**Table 2.** Comparisons of the pulmonary arterial pressures and D-dimer values between two groups and periods.

		Group A (n = 27)	Group B (n = 25)	p Value <sup>a</sup>
PAP	Pre-operative	33 ± 9.39	35 ± 6.39	0.231
	First postoperative	41 ± 8.73	51 ± 7.05	<0.001
	Second postoperative	36 ± 8.74	46 ± 5.32	<0.001
	p Value <sup>b</sup>	<0.001 <sup>d</sup>	<0.001 <sup>d</sup>	
	p Value <sup>c</sup>		<0.001	
D-Dimer	Preoperative	2.1 ± 0.79	2.2 ± 0.43	0.265
	Postoperative	2.3 ± 0.77	4.2 ± 0.63	<0.001
	p Value <sup>b</sup>	<0.001	<0.001	
	p Value <sup>c</sup>		<0.001	

PAP: pulmonary arterial pressure.

<sup>a</sup>Test results of the comparisons between group A and B.

<sup>b</sup>Test results of the comparisons between periods.

<sup>c</sup>Test results of the comparisons between groups A and B according to alterations of the periods.

<sup>d</sup>There were statistically significant differences among all pairwise comparisons of periods.

46 mm/Hg on the third postoperative day ( $p < 0.05$ ) (Table 2). The average blood D-dimer values in group A increased from 2.1 µg/mL to 2.3 µg/mL and in group B increased from 2.2 µg/mL to 4.2 µg/mL ( $p < 0.05$ ) (Table 2). Test results of the comparisons between groups A and B according to alterations of the periods were statistically significantly different. The average of PAP and D-dimer values was significantly high in group B.

## Discussion

VP is increasingly used for pain relief in patients with osteoporotic compression fractures. PV showed pain relief in 80–90% of patients treated.<sup>14,18</sup> It was first described by Gilbert and Deramond in 1984 for symptomatic vertebral hemangiomas.<sup>18</sup> Most of the complications are related to the cement leakage area, which may result in radiculopathy, spinal cord compression, and pulmonary embolism (PE).<sup>1,3</sup> An acute PE is a cardiovascular emergency with high morbidity and mortality.<sup>19</sup> If the occlusion affects more than 30–50% of the pulmonary arterial bed, PE becomes hemodynamically relevant with increased systolic PAP.<sup>19</sup> Patients with suspected PE often have no diagnostic lung scans and may present in circumstances where lung scanning is unavailable. Levels of D-dimer a fibrin-specific

product are increased in patients with acute thrombosis; this may simplify the diagnosis of PE.<sup>20</sup> PE causes a sustained increase in the PAP and thus will lead to a cardio-pulmonary failure.<sup>21</sup>

In our study, we measure PAP and plasma D-dimer to determine PE. The D-dimer level in plasma is a marker of fibrinolysis and elevated in the presence of acute venous thromboembolism as well as in other clinical conditions. D-Dimer blood tests have high sensitivity and have been proven a safe test to rule out PE in outcome studies.<sup>22</sup>

Most of the VCFs have fracture in the vertebral anterior wall, which increases the risk of cement leakage. Although most of these cement leakages remain asymptomatic, leakage is reported up to 91.9% in severe VCFs after PVP.<sup>23</sup>

Three major factors may influence the cement flow into and out of the vertebral body: bone and fracture-related parameters, injection methods, and properties of cement. Although fracture morphology is impossible to control and the method of injection has been standardized, the properties of cement may be manipulated to ultimately decrease the rate of leakage of cement. The PVP using high viscosity bone cement can provide the same clinical outcome and fewer complications compared with PVP using low viscosity bone cement.<sup>24</sup> In our study, the cement leakage was 13.63% in group A and 20% in group B. All of them were

asymptomatic. The cement leakage rate was similar in both groups but the PAP and D-dimer values were higher in group B than group A. It may be due to slow filling of vertebral body with narrow cannula and high viscosity cement in group A.

There are some articles comparing high viscosity cement to low viscosity cement, most of them claim that high viscosity cement has less cement complications.<sup>25</sup>

Some other authors claim that cement thickness and timing of delivery are key in controlling the intervertebral cement filling and physician may want to explore the use of low- or high-viscous cement for different fractures. The thickness of the cement has no significant impact on the intervertebral pressure.<sup>26</sup> They also mention the importance of delivery of cement into vertebral body. In our study, we used high viscosity cement with a narrower cannula that allows slow delivery and slow filling of vertebral body, which may decrease intervertebral pressure and prevent fat embolism.

Loeffel et al.<sup>27</sup> showed that there are no significant differences between injections performed at 0.05 and 0.15 mL/s. The speed of injection can matter in terms of leak prevention, as slower material flow leaves more time to counteract extravasations. Since thick cement is less likely to leak but demands for rising injection pressure with curing, a balance between viscosity and the speed of injection has to be established. In our study, we used narrower cannula and high viscosity cement to make material flow slow for preventing fat embolism and cement leakage.

## Limitation

CT scan could be obtained postoperatively for the patients with high PAP to support the evidence. A second study with different categories of groups and larger patients number (the high viscosity cement with wider cannula and low viscosity cement with narrower cannula) will make clear decision for the thinner or wider and higher or lower viscosity. Another limitation of our study is the randomization and the small number of the patients included in the study.

## Conclusion

The finding of this study showed that high viscosity cement injected through a narrower cannula results in lesser PAP increase and D-dimer levels when compared to low viscosity cement injected through a wider cannula. Higher PAP and D-dimer level may show possible thromboembolism. This finding may give spine surgeons to reconsider their choice of cement type and cannula size.

## Compliance with ethical standards

Ethical approval was obtained from local ethical committee.

## Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## Informed consent

Informed consent was obtained from all individual participants included in the study.

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