European Cells and Materials Vol. 10 Suppl. 3, 2005 (page 54) ISSN 1473-2262

High Cement Viscosity Reduces Leakage Risk in Vertebroplasty

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INTRODUCTION: Extravasation of PMMA can lead to pulmonary cement and fat embolisms. To study the leakage phenomena in cadaveric experiments would require a large sample size due to the variability with living tissue. Consequently, the possibility of developing and implementing a physical model may be of interest.

METHODS: A physical leakage model of a vertebra was created to observe the leakage phenomenon due to a range of injection viscosities of bone cement. Open cell aluminum foam blocks with a porosity of 90% were used to model osteoporotic trabecular structure. A thin layer 1.8mm layer of PMMA served as the as a cortical shell. One 4mm diameter passage to the center of the model was used to locate the injection syringe while a second port (2mm diameter) located 10mm from the syringe port and orthogonal functioned as a perforating blood vessel. Four 2mm diameter ports allowed for the desired 3.45kPa internal pressure during injection. Each model was completely filled with a gelatin as a bone marrow stimulant. Blood expander acted as a blood stimulant by flowing through the model. Approximately 20cc of bone cement was injected into each model and a real time value of the cement viscosity was determined by extruding 20cc of cement from the same batch through an identical syringe and recording the extrusion force. The time required to leak was determined when the cement exiting the perforating vessel and cross the path of a photosensitive transducer.

RESULTS: A total of 33 tests were performed and results of interest were the time required to leak for a certain initial injection viscosity, the amount of cement leaked and the distribution of the cement spread within the model. Figure 1 shows cements with viscosities starting around 50Pa·s would leak early around 10 to 20 seconds after injection while higher viscosities around 325Pa·s would leak after 60 seconds. Most importantly, but not shown on either figure, is the fact that bone cements with viscosities greater than 350Pa·s did not leak.

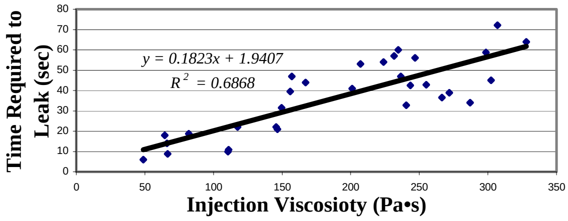

Fig. 1: Time Required to Leak as a Function of Injection Viscosity

Finally, in Figure 2, the distribution of the cement within the leakage model would tend to fall into three categories: high, medium, and low viscosity spreads.

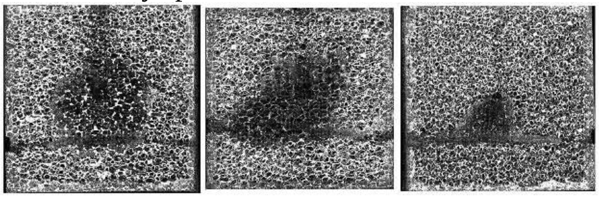

Fig.2: Section views of the leakage model exhibiting three different initial cement viscosities (from left to right: high, medium, low).

DISCUSSION & CONCLUSIONS: The model has shown a strong correlation between cement viscosity and leakage frequency and thus clearly identified bone cement viscosity as a key parameter influencing leakage. More importantly, our model suggests that a critical bone cement viscosity of 350Pa·s results in no leakage and by using this value clinically may reduce the risk of extravasation.

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