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Research paper

Elasticity and viscoelasticity of embolization microspheres

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ABSTRACT

The present study investigates the mechanical properties of three embolization microspheres (E-ms): tris-acryl gelatin microspheres (TG-ms), acrylamido polyvinyl alcohol microspheres (APVA-ms), and polyphosphazene-coated polymethylmethacrylate microspheres (PP-PMMA-ms). Compression and relaxation tests were performed on monolayers of particles and their Young's moduli and relaxation half times (RHTs) were determined. The elasticity of E-ms was evaluated by applying Hertz theory with the assumptions of incompressibility and a Poisson's ratio of 0.5. The Young's moduli of TG-ms, APVA-ms, and PP-PMMA-ms were 39.6 ± 5.05 kPa, 18.8±4.00 kPa, and 13.6±1.98 kPa, respectively. The RHTs of TG-ms, APVA-ms, and PP-PMMA-ms were 52.3 ± 5.56 s, 59.1 ± 8.16 s, and 31.0 ± 7.01 s, respectively. TG-ms have a high rigidity and deform slightly under a sustained compression since they have a high elasticity. PP-PMMA-ms are soft and deform a lot under sustained compression. They are more viscous than the other two microspheres. APVA-ms have intermediate material properties, having the same low rigidity as PP-PMMA-ms and being more elastic than TG-ms.

1. Introduction

For 30 years, nonspherical polyvinyl alcohol (PVA) particles have been widely used to perform embolization. However, they are difficult to calibrate, they form aggregates and their behavior is unpredictable during embolization, which makes it difficult to perform targeted embolization (Derdeyn et al., 1995; Barr et al., 1998).

Embolization microspheres (E-ms) have drastically altered embolization since radiologists can match the diameter of E-ms to the size of the vessels to be occluded, enabling accurate targeting (Laurent et al., 1996; Derdeyn et al., 1997).

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