Small Diameter Vascular Graft Elasticity Measurement in Response to Pulsatile Pressure

The Challenge:

Measure Wall Distention of Vascular Grafts in Response to Pulsatile Pressure

Background

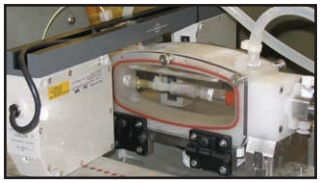
There is currently a large demand for small diameter (< 5 mm) vascular grafts to replace diseased arteries of the coronary and peripheral vasculature. Particularly vascular grafts developed from synthetic scaffolds (e.g., polyurethane, polyglycolic acid) do not have tissue-like compliance and elasticity. Therefore, measuring the elasticity of the vascular wall of graft materials is essential for predicting their success and patency in vivo.

Meeting the Challenge

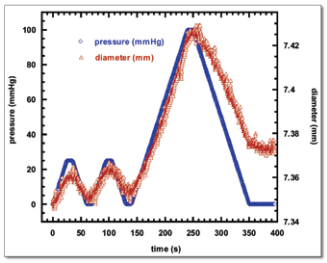
Bose ESG has developed the BioDynamic® test instrument for the simultaneous characterization and mechanical stimulation of orthopaedic and cardiovascular tissues and biomaterials. This system can accommodate vascular grafts in a biological environment and measure wall distension and elasticity under pulsatile flow and pressure conditions using a laser micrometer. Gel-Del Technologies, Inc. (St. Paul, MN) contacted Bose ESG for the elasticity measurements of their composite vascular graft biomaterial.

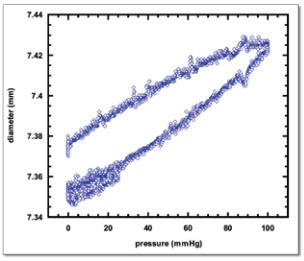
Experimental Setup and Tests

Vascular graft distension with increasing pressure was evaluated in a single axis TestBench configuration with a vascular BioDynamic chamber using a laser micrometer. The graft material used (Gel-Del Technologies, Inc., St. Paul, MN) is composed of proteins and polymers fabricated to mimic the viscoelastic properties of native blood vessels.

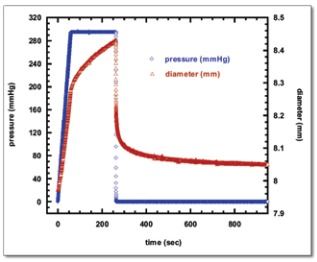


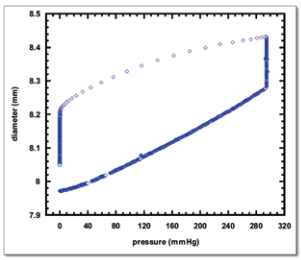
Tube clamps were used to secure the grafts (3 mm inner diameter and 30 mm long) on hose barb fittings in the BioDynamic chamber. A laser micrometer was placed over the chamber with the laser beam penetrating the transparent chamber doors and measuring outer diameter (OD) changes with pressure and time. The sample was loaded under pressure control with two cycles of a sinusoidal pressure waveform from 0 to 25 mmHg, followed by a cycle of pressure increase to 100 mmHg. The diameter response followed the pressure changes very closely throughout the test.





A linear pressure ramp was also applied to the sample from 0 to 295 mmHg. While the pressure was held constant, the vascular graft OD continued to increase with time until the pressure was returned to zero.





After each pressure loading cycle, the sample OD did not return to its initial value within the time frame of the test, indicating potential creep behavior.

Summary

Preliminary results with vascular grafts show that the BioDynamic test instrument is a powerful tool for the evaluation of critical mechanical properties pertaining to arterial substitutes. The data obtained confirmed the biphasic composition of the specimen that is composed of a protein-rich material and synthetic polymers. The results indicate that this prototype vascular graft material may not possess all the elastic properties required in vivo. The vascular BioDynamic test instrument equipped with a laser micrometer can precisely measure wall elasticity in response to pulsatile flow that can be accurately prescribed to mimic physiologic hemodynamics.

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