NC STATE UNIVERSITY

Biaxial Mechanical Properties of Venous Valve Leaflet Tissues

Jiaqi Lu and Hsiao-Ying Shadow Huang
Mechanical and Aerospace Engineering Department, North Carolina State University, Raleigh, NC

Introduction and Background

Current Knowledge

- Incompetence of venous valves plays an important role in chronic venous insufficiency.
- Valvular tissues have stronger mechanical properties than vein wall tissues under uniaxial tensile testing [1].

Current Limitations

- The native loading conditions of venous valves should be multi-axial. However, only uniaxial tensile testing has been reported [1].
- Quantitative information of extracellular matrix components of the valve is not available.

Objectives

- To obtain stress-strain curves and modulus of elasticity of venous valve tissues under biaxial tensile testing.
- Quantitatively analyze collagen concentration of venous valve tissues.

The results will provide information for future tissue engineered venous valve designs, with matching mechanical properties and biochemical components of native venous valve tissues.

Methods

Equibiaxial Tensile Testing

- Bovine jugular venous valve (JV) and saphenous venous valve (SV) specimens were collected.

Collagen Assay

- The specimens were mixed with collagen extraction solution for 120 hours. Collagen concentration of each specimen were analyzed afterwards.

Results

Bovine JV and SV Samples Preparation

- JV (10mm x 10mm) and SV (2mm x 2mm) specimens were immersed in HBSS at 37°C and stretched by a biaxial tester to 60% in both circumferential (cir) and radial (rad) directions.

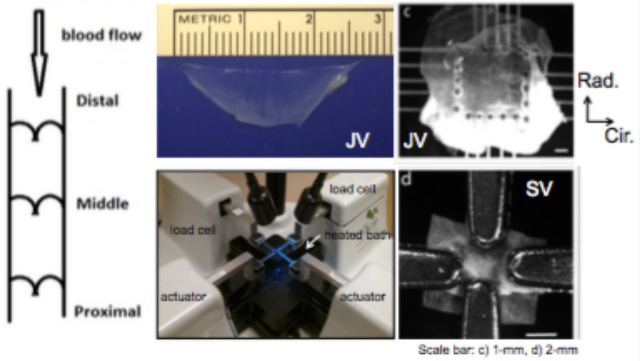


Fig.1 JV stress-strain curves

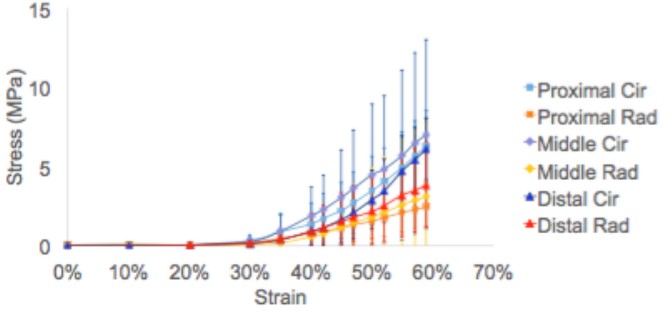
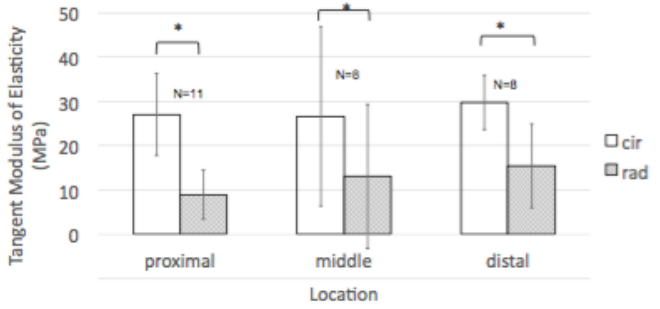


Fig.2 Inter-valvular modulus variability

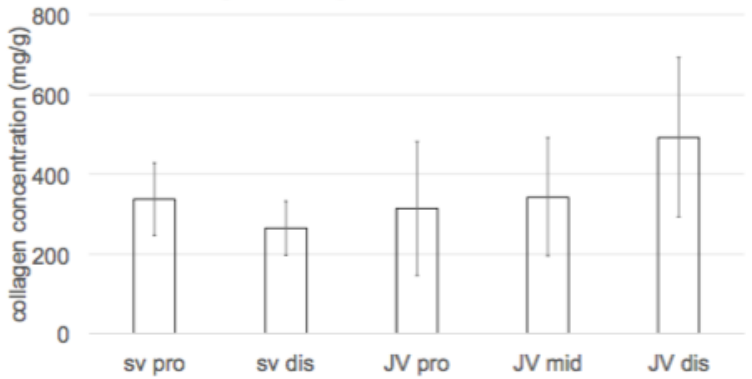


Discussion and Conclusion

Bovine JV and SV Mechanical Properties and Collagen Concentration

- Venous valve leaflet tissues showed anisotropic and nonlinear mechanical properties (Fig.1).
- Tangent moduli of elasticity in the Cir direction of the valve were larger than those in the Rad direction, indicating the leaflet tissues were stiffer in the Cir direction (Fig. 2).
- JV tissues showed an increasing trend in collagen concentration from the proximal end to the distal end, while SV tissues showed a decreasing trend (Fig. 3).

Fig. 3 Collagen concentration



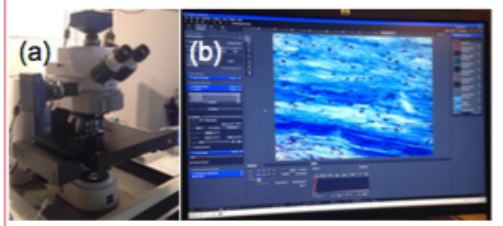


Fig. 4. State-of-art Zeiss Axiophot microscope in the Cellular and Molecular Imaging Facility at NC State.

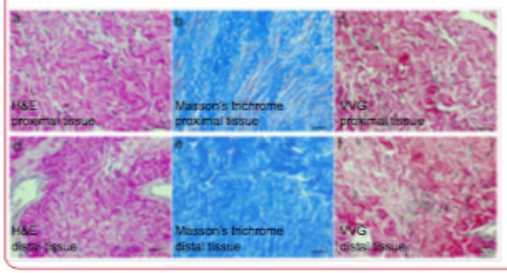


Fig. 5. Histological images of JV tissues under 400x with H&E, Masson's trichrome and VVG stains, (a-c) Proximal tissue (d-f) Distal tissue, scale bars: 50um

[1] J. S. Ackroyd, M. Pattison, and N. L. Browse, *Br. J. Surg.*, vol. 72, no. 2, pp. 117–119, 1985.

nc state ENGINEERING