Biomechanical Insights into Venous Disease and Emerging Treatments

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Chronic Venous Insufficiency

Prevalence
Affects up to 10-35% of Americans

Deep Venous Disease
Persistent Reflux/Hypertension → Inflammation, endothelial dysfunction, etc.

Needs
Translational Animal Models (Science & Therapy)
Emerging Treatment: Prosthetic Valves

Animal Model
Greyhound tricuspid injury (8 wks) to induce reflux/HTN (reflux fraction of 23.1±4.2% and 7.1±0.3–>23.0±2.1 mmHg peak pressure; common iliac)

Growth and Remodeling
Remodeling of Microstructure

Histological and merged SHG/TPEG images of the common iliac venous wall for control and experimental veins. Histological section of an experimental (A) and control (B) canine common iliac vein. C: Merged SHG/TPEG image of an experimental (C) and control (D) canine common iliac vein.

Remodeling of Collagen and Elastin

Collagen and elastin in control and experimental common iliac venous tissue. Left) Percent of collagen and elastin areas within the venous wall of control and experimental common iliac veins using MPM. Right) Collagen-to-elastin ratio. Figures show grouped average for n = 6 dogs.

Uniform Stress Hypothesis?

No load state wall thickness and Circumferential stress at different states. Left) Total wall thickness and intimal-medial thickness at the no load state in control and experimental canine common iliac veins. Right) Circumferential stress for control pressure (Control; 7 mmHg), pressure-overload (Control; 20 mmHg) immediately after injury and chronic hypertensive pressure (8 weeks; 20 mmHg) in canine common iliac vein. * p < 0.05 vs. Control; 20 mmHg

Emerging Treatment?

Prosthetic Venous Valves

Synthetic
  Urethane, Pellethane, Polymers

Biological
  Autologous, allografts, xenograft, manufactured

Failure modes
  Thrombosis, Leaflet Remodeling: Design, material selection
Conclusions

Canine model of CVI provides both scientific understanding of venous disease as well as translational model for assessment of potential therapies.

Growth and remodeling of veins under reflux/HTN show increased vein stiffness, wall thickness, and collagen-to-elastin ratio.

A potential prosthetic venous valve shows early (4 wks) pre-clinical promise but requires longer implant durations prior to FIM.