P9. Biodesign: Redesigning the Treatment of Heart Failure

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PURPOSE

Volume overload is a common consequence of heart failure and accounts for more than 900,000 admissions each year. Excess fluid accumulates in the interstitium and can lead to pulmonary edema, causing shortness of breath and potentially respiratory arrest. Despite widely used therapeutics, 90% of patients re-admit with the same symptoms within 6 months. Our group is studying the effects of lymphatic access and drainage as a way to influence interstitial fluid balance. Here we present a novel method of reconstructing vascular and lymphatic anatomy to develop a benchtop model of the lymphatico-venous confluence.

MATERIALS AND METHODS

Manual segmentation (Analyze 10.0, AnalyzeDirect, Inc.) was performed on high resolution axial computed tomography (CT) of the neck and chest anonymized from patient data at Stanford Hospital. The confluence of the internal jugular (IJ), subclavian, and innominate veins was isolated, followed by identification and segmentation of smaller branching veins and the thoracic duct terminus. Three dimensional reconstruction (Solidworks 18.0, Dassault Systems SolidWorks Corp.) was used to produce stereolithographic models of the venous confluence and thoracic duct. Next, compliant resin models were cast from a novel elastic polymer (SynDaver Labs, Inc.) and integrated into a benchtop perfusion model (Masterflex L/S, Cole Parmer, Inc.).

RESULTS

Compliant models of the lymphatico-venous junction were successfully constructed from actual patient data through stepwise segmentation and reconstruction. Dimensional accuracy was preserved throughout the reconstruction process (subclavian vein diameter = 12.9 mm, our model: 13.5 mm; IJ vein diameter = 17.4 mm, our model: 13.1 mm, innominate vein diameter = 17.0 mm, our model: 19.9; model diameters calculated by taking the average of the major and minor diameters). Using a variable speed perfusion system, physiological venous flow rates can be recreated in a benchtop model.

CONCLUSION

Here we demonstrate a highly accurate method for reconstructing the lymphatico-venous junction in a benchtop model. As a valuable tool in our on-going research, this model will be used to study flow and pressure patterns around the thoracic duct outlet and the performance of novel catheter-based interventions to control duct output.

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