

Background

Ultrasound imaging is used for visualization of soft tissue structures and vascular flow. It can be useful for monitoring blood perfusion and tumor angiogenesis.

Microbubble Enhanced Ultrasound

Advances microbubble-enhanced US enabled better visualization of microvascular networks using microbubble contrast agents, usually 3um in diameter as they rapidly contract and expand in response to ultrasound waves.

Ultrasound Localization Microscopy

ULM achieves super-resolution imaging by tracking individual microbubbles over time. In turn helping map out complex vascular and perfusion patterns.

Vascular Flow Phantoms

Models made from tissue mimicking materials are used to validate imaging performance; however, they need to replicate physiological features for accurate representation.

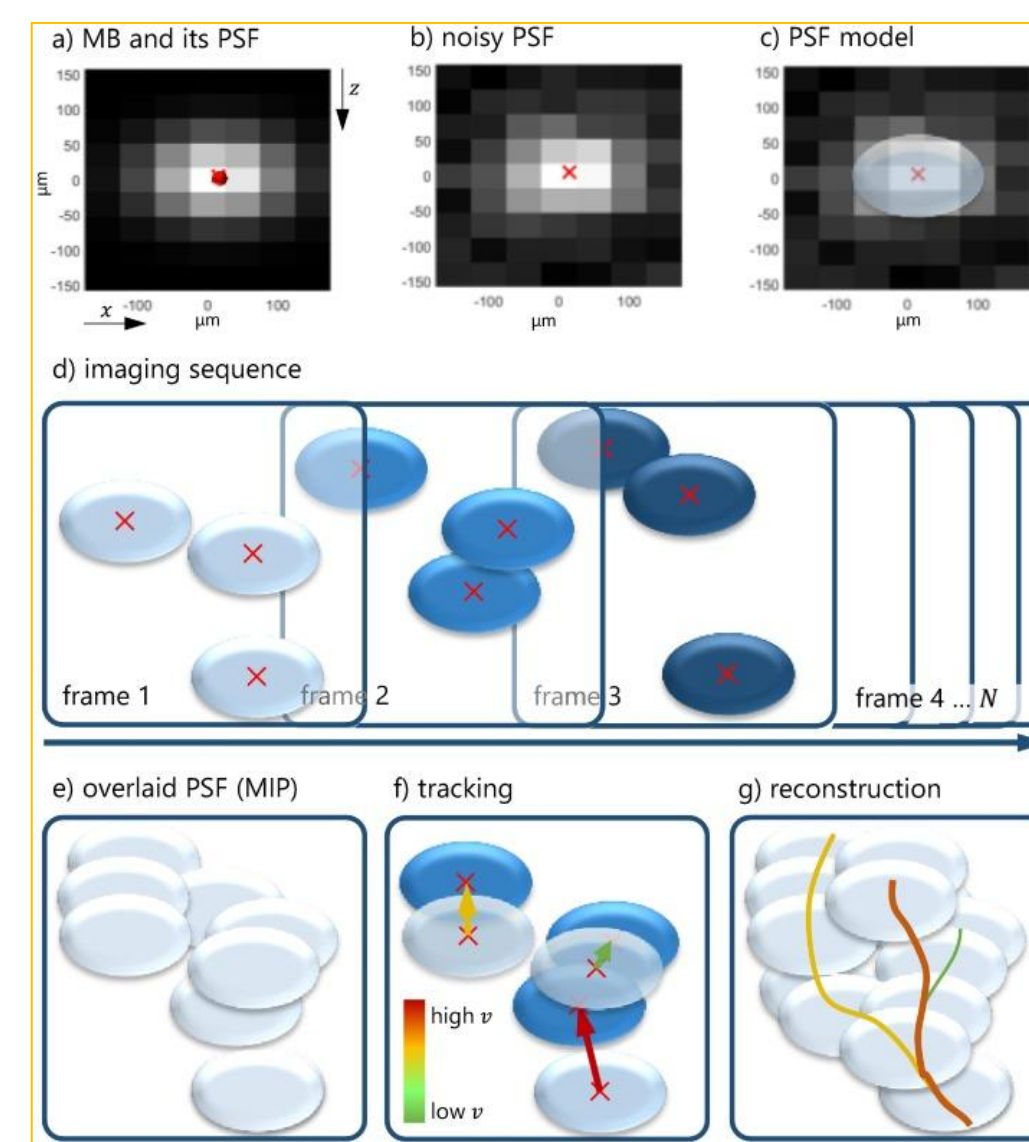


Fig.1 Basic Concept of ULM

Needs + Proposed Solution

Problem Statement: Advanced High-resolution US methods can provide valuable information about microvascular structure and functional biomarkers related to cancer pathogenesis. Yet these techniques are not widely implemented in clinical practice due to workflow and validation barriers.

Objectives:

Develop vascular flow phantoms that enable evaluation of ultrasound imaging techniques for perfusion and vascular characterization.

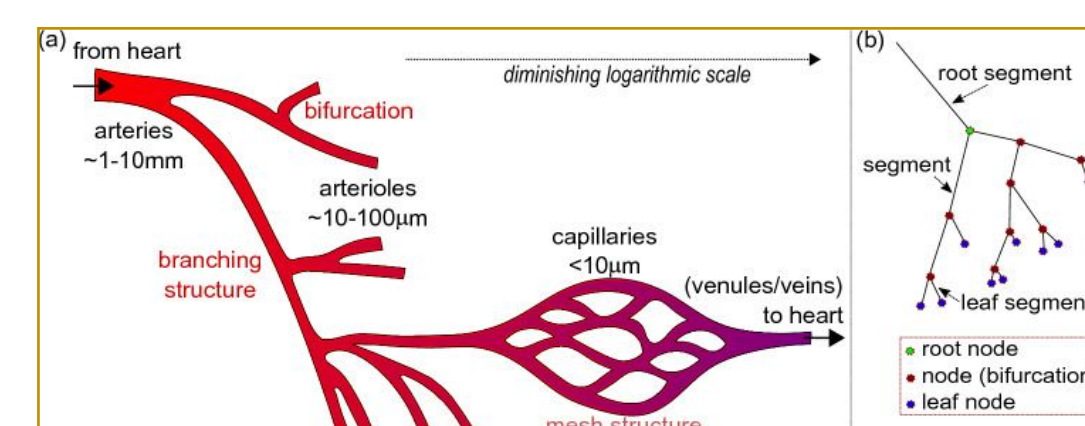


Fig.2 Scale of Vascular Structure in the body

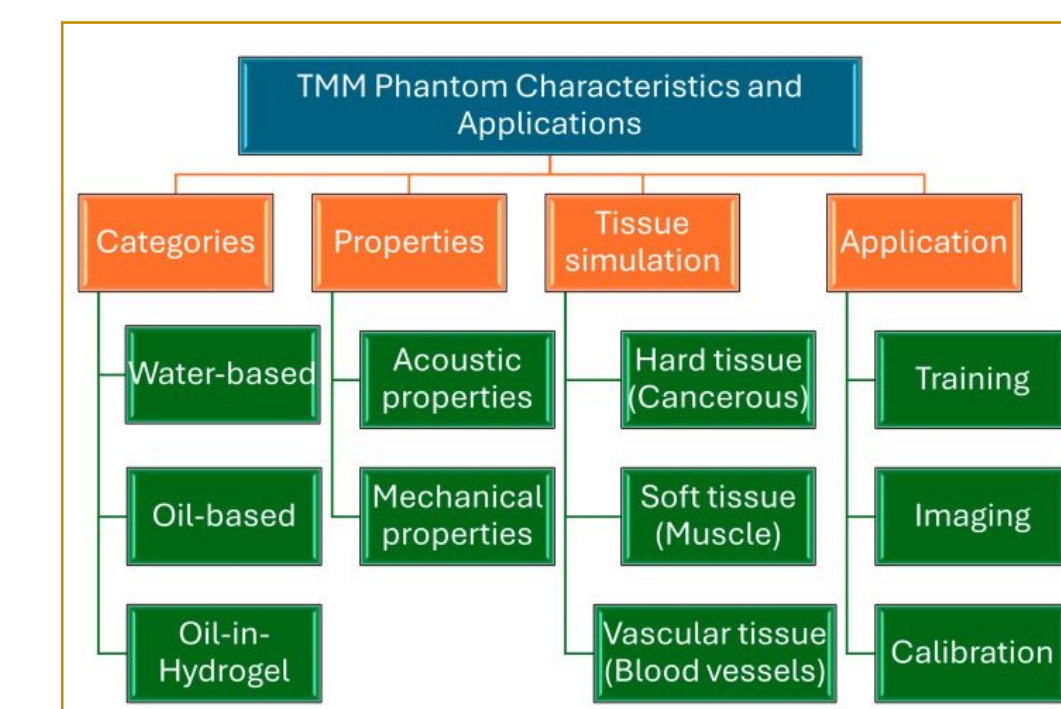


Fig.3 Material Considerations for Ultrasound

- 1 Replicate physiologically relevant vascular structures
- 2 Use ultrasound transparent tissue mimicking materials
- 3 Construct perfusable channels

Experimental Design

Experimental Design

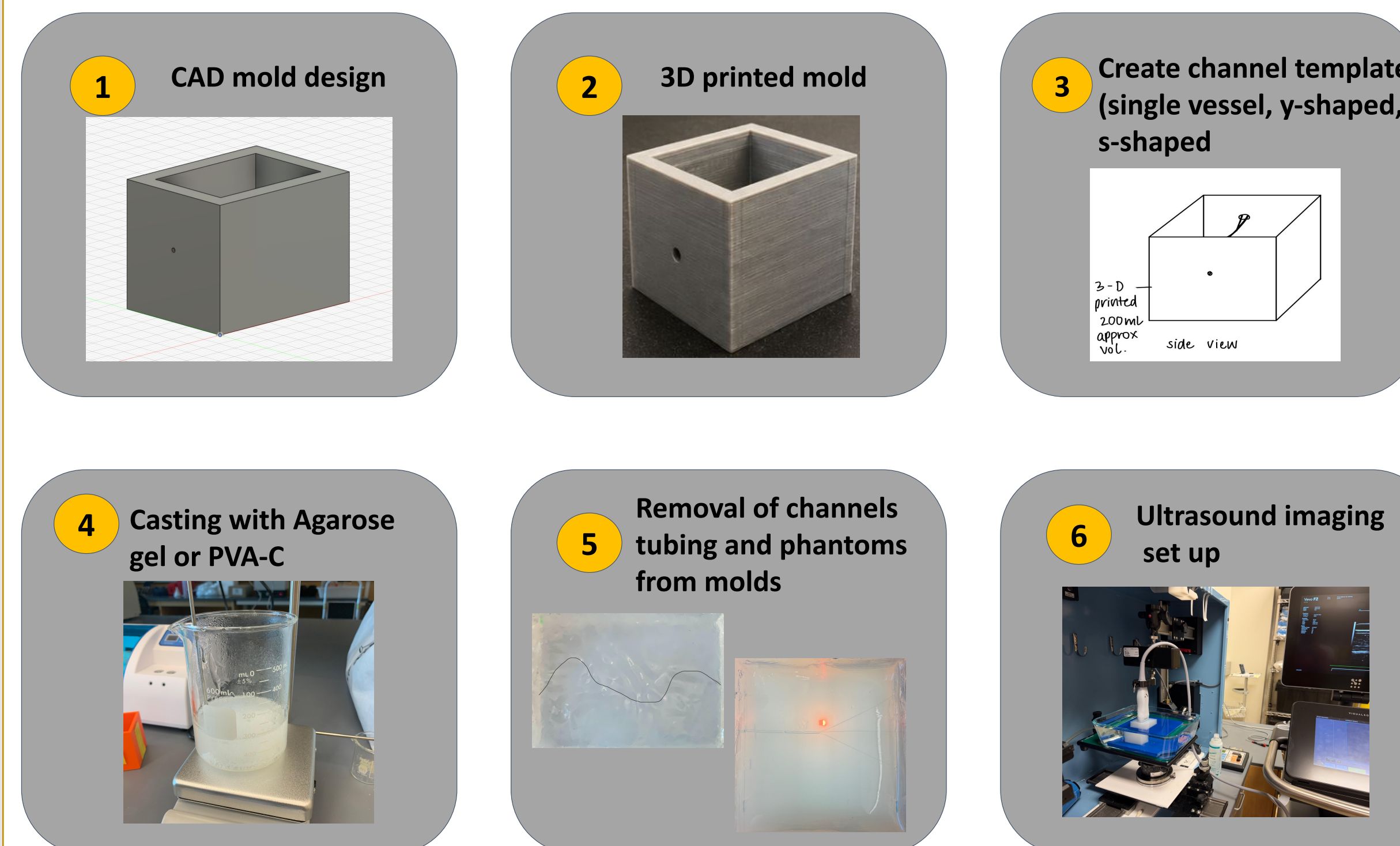
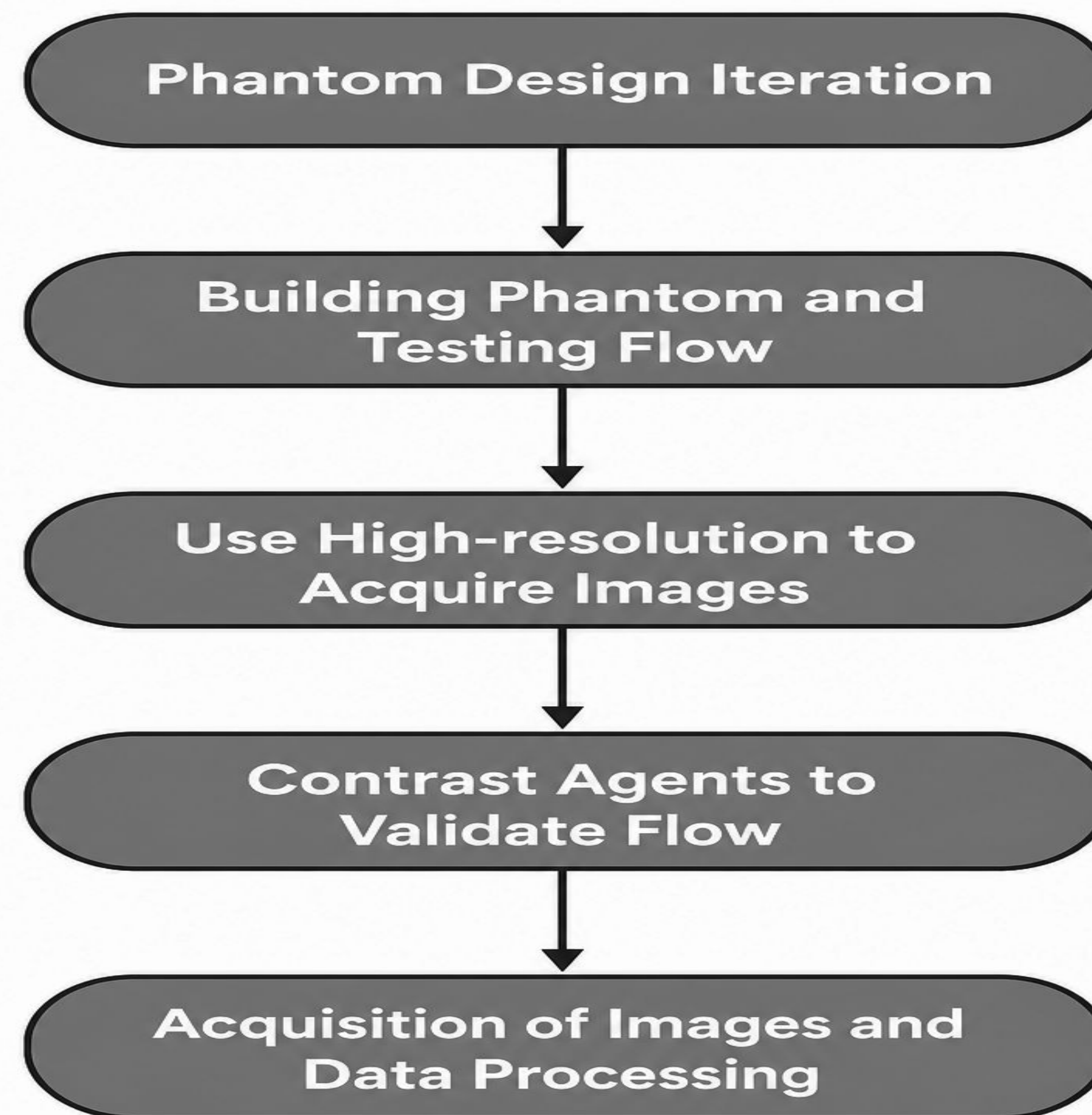
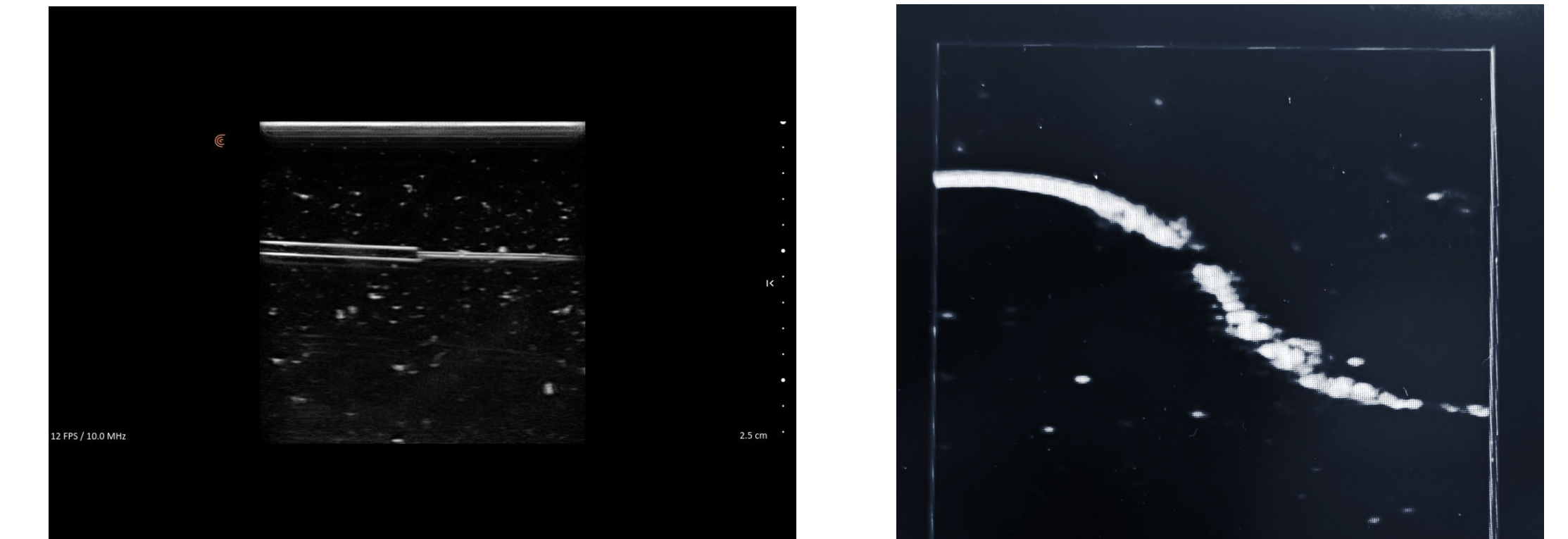


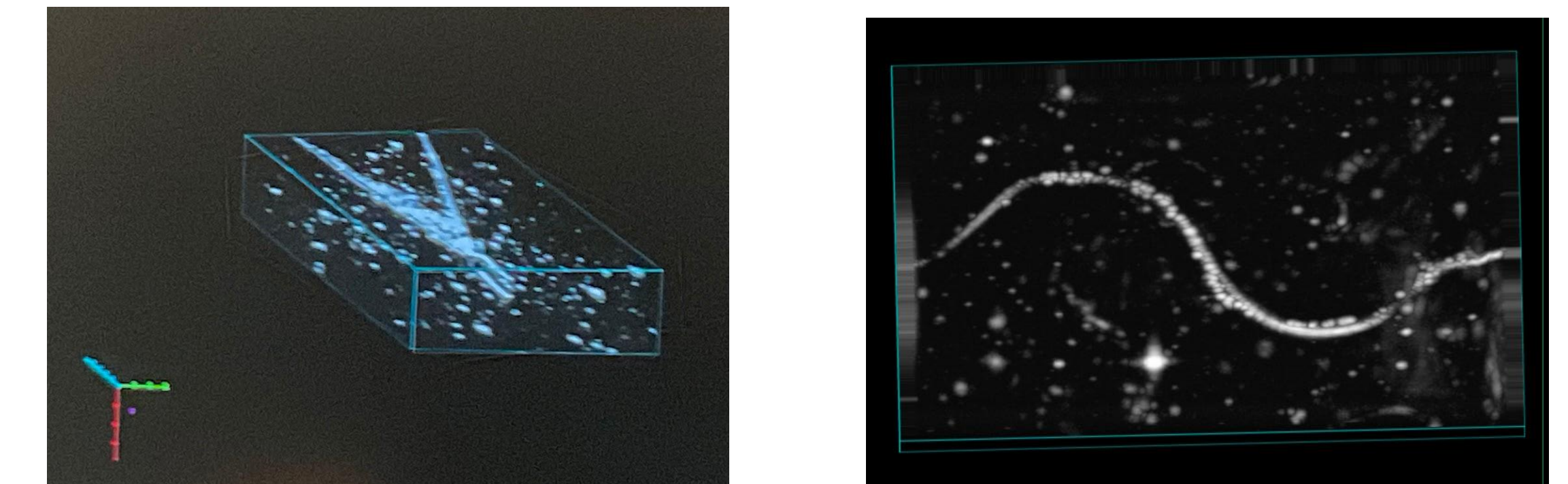
Figure 4. Experimental workflow for fabrication and ultrasound imaging of a perfusable PVA-C vascular phantom. (1) CAD design of the phantom mold geometry, (2) 3D printed PLA mold fabrication, (3) insertion of a sacrificial channel template to form the vascular pathway, (4) casting of the PVA-C tissue-mimicking material, (5) removal of the sacrificial template to generate a hollow perfusable channel, and (6) ultrasound setting used for imaging.

Expected Outcomes

B-Mode Images using Clarius L-20 probe



3-D rendering of vasculature using Vevo F2 29x probe



(a) Y-shaped structure

(a) S-shaped structure

Conclusions + Future Directions

- Images acquired from fabricated phantoms successfully represent the vascular structure and size of channels represents physiological scale.
- At this stage, noise reduction of images and optimization of phantom fabrication process is needed.
- Increasing tortuosity, and quantization and localization of microbubbles will help replicate physiological features of tumor angiogenesis
- Future scope lies in introducing cells to phantoms to test conjugated microbubbles for molecular ultrasound.

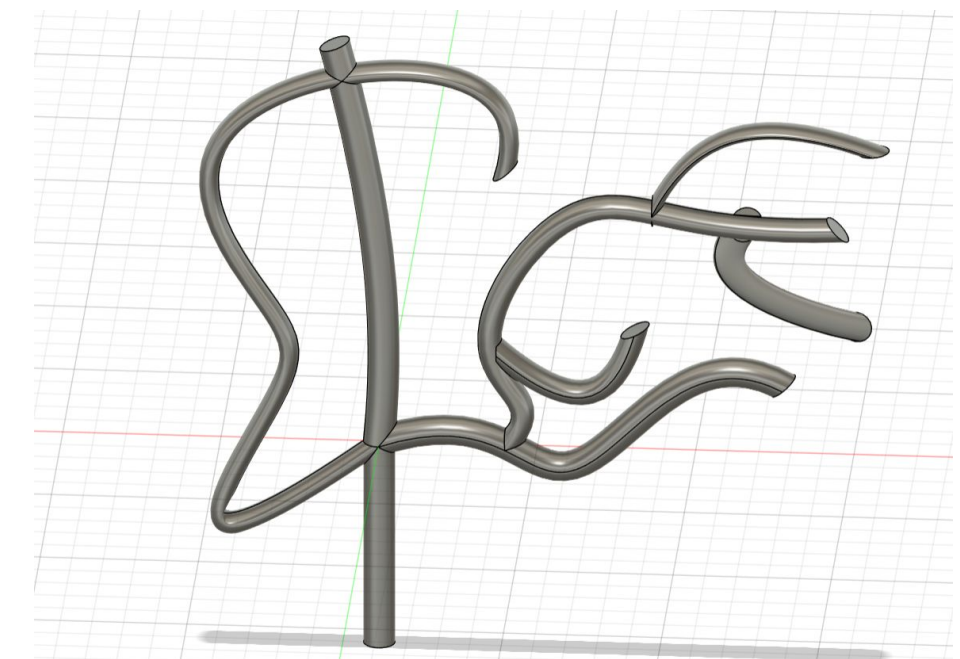


Fig. 5 CAD design of high tortuosity phantom

Acknowledgements

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Link to references:

