Abstract

Advanced ultrasound techniques such as contrast-enhanced ultrasound (CEUS), Ultrasound Localization Microscopy (ULM), and molecular ultrasound can provide quantitative information about microvascular structure, perfusion, and targeted biomarkers relevant to cancer imaging. However, translation of these methods into broader research and clinical use remains limited by the lack of realistic, reproducible vascular phantoms for validation and workflow development. This project addresses that need through the design and fabrication of ultrasound-compatible vascular phantoms with embedded flow channels that support microbubble perfusion.

The final design solution consists of a workflow-based prototype including complex 3D-printed vascular phantoms with distinct branching and tortuous architectures, and contrast-enhanced ultrasound imaging using microbubbles and systems such as the Clarius and Vevo F2. Early iterations demonstrated the feasibility of fabricating perfusable channels and imaging microbubble flow, while later iterations improved anatomical relevance and structural complexity. Although quantitative validation of the final phantom is still ongoing, the project establishes a practical platform for evaluating perfusion behavior, contrast transport, and future ULM and molecular ultrasound applications. Continued work should focus on final fabrication optimization, quantitative comparison of perfusion metrics between phantom structures, and implementation of programmable acquisition sequences through VADA.