Podium Presentation Abstracts

ACS 2026 Surgeons and Engineers: A Dialogue on Surgical Simulation

O-01

Research In-Progress

Immersive Simulation of Congenital Heart Disease: Patient-Specific Augmented Reality Model Development for Apple Vision Pro

Christopher Ibarra, MD; Alex D. Contreras, MD; Rebecca Barnes, MBS; Tommaso Cambiaghi, MD; Austin Ryan. Shelton, MBE; Alan B. Lusmden, MD, ChB, FACS; and Andrea G. Quarti, MD, PhD

Houston Methodist Hospital, Houston, TX; The Bookout Center, Houston, TX

Introduction: Spatial understanding in adult congenital heart disease (ACHD) remains a significant hurdle in surgical education and preoperative strategy. To reimagine how complex cardiac anatomy is taught and understood, we developed a high-fidelity, patient-specific augmented reality (AR) model optimized for the Apple Vision Pro. The immersive platform leverages advanced image processing and real-time visualization to transform cardiac learning into a fully interactive 3D experience.

Methods: In partnership with an ACHD cardiac surgeon, a representative CTA dataset was selected and imported into Mimics Medical Software (Materialise) for segmentation. Hollow cardiac structures were digitally generated by subtracting intravascular blood volume, then sculpted and refined in ZBrush to preserve micro-anatomical detail. The finalized model was exported in Universal Scene Description (.USDZ) format and uploaded into a custom Apple Vision Pro application built with SwiftUI and RealityKit. The interactive AR interface enabled intuitive control through hand and eye tracking, with features including dynamic transparency, structural layering, and real-time manipulation of cardiac structures in immersive 3D space

Preliminary Results: Forty-three participants engaged with the AR model and rated spatial understanding using a 5-point Likert scale. The Apple Vision Pro interface scored an average of 4.96, outperforming traditional imaging 3.6. Notably, 93% of users reported improved clarity of intracardiac relationships. High-performance rendering ensured seamless interaction, with consistent tracking and fluid motion. Qualitative feedback emphasized the model's realism, ease of use, and the unique ability to internalize complex congenital anatomy through immersive exploration.

Next Steps: Ongoing development focuses on integrating multi-user functionality, dynamic pathophysiology animation, and haptic response technology. A structured outcomes framework is in development to measure long-term impacts on knowledge retention and surgical decision-making, setting the stage for the next frontier in congenital cardiac education.