ACS 2025 Surgeons and Engineers: A Dialogue on Surgical Simulation Meeting

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Challenges in Surgical Education

Efficacy of Midlevel Fidelity Arteriovenous Fistula Complication Simulator: Development of a Hybrid Synthetic and Biologic Material Based Simulator for AV Fistula Procedure and AV Fistulaplasty.

Shawn Moore, EdD; Matthew Black, MD; Margaret Romine, MD; David Black Leeser, MD, FACS; Carlos Marroquin, MD, FACS; and Carl Eugene Haisch, MD, FACS

East Carolina University: Brody School of Medicine, Greenville, NC

Background: Surgical simulators are essential tools in residency programs, though they differ in realism and cost. Low fidelity simulators are inexpensive but lack realistic anatomy, while high fidelity simulators offer greater realism but are costly. Midlevel fidelity simulators strike a balance, providing more realistic anatomy and clinical functionality at a low to moderate cost. These simulators have been shown to boost residents' self-confidence, competency, and proficiency in performing surgical procedures.

Current Challenges: Faculty attendings and residents require simulators that are both realistic and cost effective. These tools must replicate human tissue properties like elasticity, texture, and color, using synthetic and alternative biological materials. Additionally, it is crucial for trainees to engage with abnormal anatomy and complications in a safe, controlled environment before operating on real patients.

Need of Innovation: To allow faculty attendings to practice and teach residents in making sound surgical decisions and hone operative skills when encountering certain complications, we have developed two simulators for AV Fistula practice; 1) a routine arteriovenous fistula and 2) an arteriovenous fistula aneurysm complication. Both simulators were developed using a PLA or ASA 3D printed human arm as the base for radiocephalic and/or brachiocephalic fistula housings. These models have incorporated silicone and hydrogel soft tissue structures (skin, hypodermis, fascia, muscle, etc.), synthetic adhesions, and other supportive tissues. The arterial and venous vessels are commercial collagen vascular graft material to provide the most realistic anatomy possible for the primary step in these procedures. Survey responses regarding authenticity and utility are provided by faculty attendings and residents. In addition, survey responses from residents are compared to feedback on procedural performance by faculty attending surgeons via EPA data using cross tabulations. This identifies potential relationships between satisfaction levels and actual performance outcomes, providing insights into the effectiveness of the simulators.