Validation of a 3D Printed Neck Model for Simulated Ultrasound-Guided Internal Jugular Central Venous Cannulation

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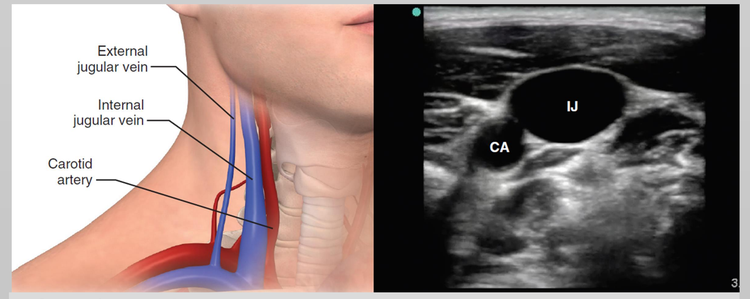
INTRODUCTION

- Nurse anesthetists use central venous catheters to provide intravenous access for administering medications and for specialized monitoring of certain high-risk anesthesia patients
- The internal jugular (IJ) vein in the neck is one of the most common sites for central venous catheter insertion
- Neck anatomy is complex and multiple vital structures are near the insertion site
- With traditional landmark techniques, the complication rate for student practitioners placing central lines is a high as 7.8%
- Ultrasound-guided technique allows for continuous visualization of needle placement, which can reduce complications to as low as 1.9%



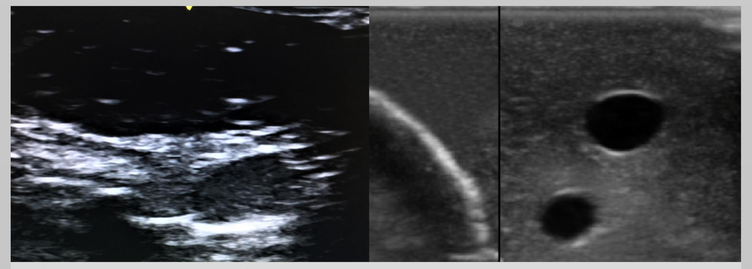
Left: Neck Vascular Anatomy
Right: Ultrasound Image of Neck Anatomy

PURPOSE

- Simulation training is beneficial for learning ultrasound-guided central line insertion, but commercial simulation models are often cost-prohibitive
- Because of lack of access to affordable training models, students often have limited high fidelity simulated training experiences prior to practicing on a live patient
- The combination of 3D printed molds and silicone elastomer can be used to create anatomically accurate medical models that are easily reproducible with a low cost of production
- The purpose of this project was to demonstrate that a self-developed 3D print and silicone training model can provide an equivalent experience to a commercial model for ultrasound-guided central line insertion training

METHODS

- After IRB approval, 19 student participants were recruited from the Union University Nurse Anesthesia class of 2021
- Two pre-draped central line insertion stations were set up, one with the self-developed model, another with a BluePhantom Internal Jugular manikin
- In addition to the pre-draped model, each station contained a central line insertion kit and a GE LogiQ ultrasound machine
- Students performed blinded ultrasound-guided central line insertions on each model
- Students were then asked to fill out an anonymous evaluation rating both models on realism of palpation and appearance, ultrasound picture, feel during needle insertion, overall realism, and usefulness as a training tool.
- Student ratings of each model were compared using paired sample t-tests

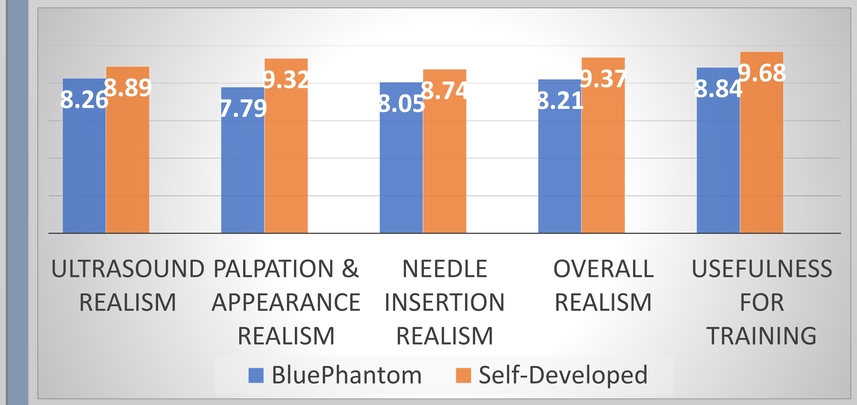


Left: Ultrasound image of the self-developed model
Right: Ultrasound image of the BluePhantom Internal Jugular manikin

RESULTS

- Both models scored highly on student evaluations
- The self developed model achieved higher mean scores than the BluePhantom model on all evaluation items
- A statistically significant difference to a p-value <0.05 was found for realism of palpation and appearance and overall realism

Paired Sample T-Test	Mean	Std. Deviation	t	df	Sig. (2-tailed)
Ultrasound Realism	.632	2.733	1.007	18	.327
Palpation & Appearance Realism	1.526	2.836	2.436	18	.031
Needle Insertion Realism	.684	1.701	1.753	18	.097
Overall Realism	1.158	1.979	2.550	18	.020
Usefulness for Training	.842	1.979	1.854	18	.080



DISCUSSION

- The total material cost for the self-developed neck model was less than $200, compared with a retail cost of $1,599 for the Blue Phantom Internal Jugular manikin
- 3D print designs can be posted as open-source plans and reproduced anywhere with a 3D printer

Limitations:

- The model was evaluated by student practitioners with varying levels of experience, rather than experienced anesthesia providers

Conclusions:

- The self-developed model was non-inferior to the BluePhantom training manikin in this evaluation
- 3D print and silicone elastomer ultrasound phantoms represent a feasible low-cost alternative to commercial ultrasound phantoms for anesthesia skills training

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