1284. Teaching Radial Artery Catheterization using 3D Printing: A Feasibility Study

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INTRODUCTION

- 3D printing has numerous applications in medicine, from clinical planning to creation of unique training models.

- While the use of 3D printing in cases where robust clinical imaging has been well documented, such options are not always available.

- Reconstruction from more readily available imaging modalities such as angiogram offers the capability to extend the uses of 3D printing in both a clinical and teaching aspect.

- Radial artery catheterization is a method of vascular access which is quickly gaining popularity in the field of neurosurgery for procedures such as mechanical thrombectomy and endovascular aneurysm treatment.

- Training for this procedure is often done using industry-provided models, which may be expensive and not customizable for a specific anatomical variation or aspect of the procedure that the resident wishes to focus on.

- In order to better facilitate the learning process for radial artery catheterization, we created a cost-efficient, catheterizable 3D printed model of radial artery anatomy at the cubital fossa.
Because routine imaging of the cubital fossa area only includes 2D angiogram and not CT angiogram or MRI, we were faced with the challenge of reconstructing the 3D vessel using computer-assisted design (CAD).

We took advantage of several tools within a CAD program which allowed the use of the angiogram as an overlay, or template for 3D reconstruction. Thus, we were effectively able to accomplish 2D-guided hybrid segmentation of the 3D vasculature.

Adjustments were made regarding support generation in slicer software in order to maintain luminal patency of the model vasculature.

In addition, various post processing methods were employed to ensure optimal curation and durability for use in catheterization.

Completed models were then printed with a novel elastic photopolymer with biomimetic properties.
Using CAD software, we were able to perform 2-D guided hybrid segmentation of the radial and distal brachial artery.
Initial model introduced problems with luminal patency due to difficulty in modeling a fully cylindrical vessel from a 2D image.
▪ Luminal patency was achieved in follow-up model using manual material removal.

▪ The model was validated for accuracy and catheterizability by the neurosurgeon who performed the initial radial access procedure.

▪ Five neurosurgery residents evaluated the model, ranging from PGY1 to PGY6. The model rated an average of 4.6/5 for anatomical accuracy, 4.4/5 for realism/feel, and 5/5 for ease of handling.

▪ 100% of residents strongly agreed that the model was useful for learning radial artery catheterization and that they would use this model alongside observation to learn radial artery catheterization.

▪ 60% strongly agreed that the model was better than industry-available models.
DISCUSSION

- Total cost of model was $2.73, drastically undercutting industry-available models while maintaining educational value as demonstrated by resident survey.

- While the initial reconstructive process took more time and effort due to difficulty and iterations with the CAD process, future reconstructions are expected to require much less time and effort and perhaps be able to be automated, presenting a unique pipeline for physician education.

- In addition, this type of reconstruction can be applied to several other fields in which CT/MRI is not routinely available.
The most common feedback was that blood flow simulation as well as abnormal radial and brachial anatomies would be valuable additions.

Experimentation was done with a complex brachial loop model, which requires more complication segmentation and modeling due to Z-axis variability and structural stability.

Future studies are aimed at reproducing such anatomical variants which provide rich educational opportunities outside of just the residents and attendings involved in the initial procedure.
METHODS

▪ Translation of arterial angiogram to a 3D model using CAD allows for easy clinical workflow without additional required imaging

▪ Digital processing of 3D model to mimic specific characteristics of vessel anatomy can be done to maintain anatomical accuracy

▪ Use of novel 3D printing materials and techniques to manufacture patient vessel anatomy into a physical object that can be manipulated can be an invaluable tool in education

▪ Seamless integration of model acquisition into the clinical setting is possible with manual or semi-manual segmentation

▪ Integration into neurosurgery resident education to improve catheterization procedure confidence and outcomes can be done

SUMMARY POINTS