Vascular and Endovascular surgery training using 3D printed models

I. Specific educational aims:

Over the past few decades, imaging in vascular surgery has evolved from 2D images to 3D-rendered computed tomography (CT) scans and magnetic resonance angiography (MRA) imaging.[1] This has enhanced the preoperative planning process as well as provided patients with the abilities to visualize their pathologies and planned interventions and may prove beneficial for medical student education. However, many of the tools used for training during undergraduate medical education relies heavily on textbooks and software that may only have 2D capabilities. Additionally, as some learner preferences are kinesthetic, this may negatively impact the learning experience. Additive manufacturing, or 3D printing, may provide a potential solution as it is a technology that has been used to develop models derived from medical imaging for purposes such as training and custom prosthetics.[2] The goal of this project is to develop an advanced vascular model for medical student instruction, focusing on simulation-based endovascular training and depicting vascular pathologies such as abdominal aortic aneurysms and carotid artery stenosis. Prior studies have shown the advantage of simulation-based training to improve management and critical assessment skills as well as acquiring technical skills training that are transferrable to the operating room.[1–3]

Our project seeks to address rigorous approaches to scholarship and innovation. Our primary educational outcomes would include the following:

I. Enhance medical students' understanding of vascular anatomy,
II. Provide instruction on safe, ultrasound guided intravascular access, and
III. Explain open and teach simulation-based endovascular techniques for surgical repair of commonly encountered vascular pathologies.

Secondary educational outcomes would include early exposure to surgery and translation of skills learned to other medical and surgical specialties, increased involvement in Vascular Surgery Interest Group (VSIG), and entrance into vascular surgery or specialties utilizing endovascular techniques. Additionally, the findings of and models developed in this study can be used to train residents and fellows in General Surgery, Vascular Surgery, and Cardiothoracic Surgery, as well as Cardiology.

II. Project rationale:

Endovascular strategies are employed in several specialties, such as vascular surgery and neurosurgery. In vascular surgery, endovascular techniques have continued to evolve, reducing the frequency of open surgical repairs. The knowledge and quality gaps to be addressed by this project include increasing medical students' understanding of the principles of endovascular surgery and vascular anatomy of common vascular pathologies. The knowledge and skills attained from this skills session is applicable to other specialties such as cardiology, cardiac surgery, and neurosurgery. Other fundamental skills such as safe intravascular access using Seldinger technique also has uses in other fields including, but not limited to, General Surgery, Pulmonology, Gastroenterology, and Interventional Radiology. We hypothesize that instruction using a 3D anatomical model of vascular pathologies will aid in students' understanding of vascular anatomy and endovascular surgical interventions, thereby enhancing the surgical clerkship framework and igniting interest in surgical subspecialties like vascular surgery.

3D printed models have been developed and used in cardiac surgery, neurosurgery, and craniomaxillofacial surgery for preoperative planning and simulation-based training.[3] A previous study explored the use of a 3D printed aorta for endovascular simulation training and demonstrated feasibility of using such models for training purposes.[4] Our project would also explore the feasibility of implementing such models for undergraduate medical education training as well as begin to explore validity evidence for its continued use.

III. Approach:

In collaboration with Vascular Surgery faculty, abdominal aortic aneurysm, carotid artery stenosis, and peripheral artery disease imaging will be identified in conjunction with Surgery Clerkship course objectives. After identification of these common pathologies, vascular 3D reconstruction images will be reviewed for development of model prototypes. After development of prototypes, the models will be evaluated by residents and faculty for realism and potential areas of improvement. These models will then be integrated into the Surgery Core Clerkship curriculum during the vascular surgery session. Iterative feedback and cycling will be used during model development and curriculum integration to enhance the educational experience and achievement of educational aims.

IV. Timeline and plan for implementation:

The timeline and plan for implementation would be divided into two phases: Vascular Model Development and Curriculum Development. For the Vascular Model Development phase, during October 2021, identification of model types and locations would commence. Between November 2021 to January 2022, the model prototypes would be developed and then deployed for testing in February 2022. The Curriculum Development phase would include expanding the vascular surgery module curriculum to include these models (October-December 2021) and implementation of this curriculum beginning February 2022.

V. Anticipated work product:

3D-printed vascular models of carotid artery stenosis, abdominal aortic aneurysm, and lower extremity arterial occlusive disease will be created. These models will function as both models of vascular pathologies and simulation-based endovascular trainers.

VI. Evaluation plan:

Medical students during the Surgery Clerkship will complete survey-based feedback to evaluate the efficacy and utility of the vascular models. Surveys will be conducted before and after model implementation, as well as pre/post-session surveys that will assess their understanding of vascular anatomy, endovascular management strategies, and endovascular technical skills. In addition, iterative cycling will be used to improve the course with continued post-implementation feedback.

VII. Dissemination of results:

The findings of this study will be presented during the Teaching and Mentoring Academy conference, as well as be submitted for presentation at outside conferences and to MedEd portal.

Appendix

References

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3. Ganguli, A. *et al.* 3D printing for preoperative planning and surgical training: a review. *Biomed Microdevices* **20**, 65 (2018).
4. Mafeld, S. *et al.* Three-dimensional (3D) printed endovascular simulation models: a feasibility study. *Ann. Transl. Med.* **5**, 42–42 (2017).