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Commentary: Three-dimensional printing in congenital cardiac surgery: The future is now

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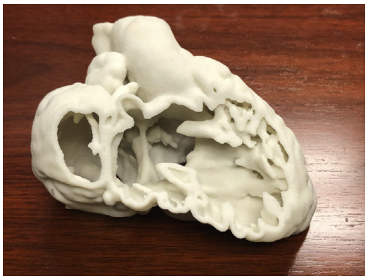

Three-dimensional printed model of double-outlet right ventricle with a noncommitted ventricular septal defect.

CENTRAL MESSAGE

Three-dimensional printing is rapidly evolving and the time to incorporate it into congenital cardiac surgical training has arrived.

The American Board of Thoracic Surgery and the Thoracic Surgery Directors Association understand the importance of incorporating simulation into the training of resident physicians in thoracic surgery.[1,2] Many publications report the benefits of simulation-based training in cardiothoracic surgery residency.[3-5] The opportunities for simulation to be integrated into training keep expanding. Congenital heart disease is often associated with complex and unique spatial relationships that can be difficult to grasp from standard 2-dimensional imaging with echocardiography, computed tomography, or magnetic resonance imaging. Most of the time this would involve 3-dimensional (3D) mental reconstruction of 2-dimensional images. Indeed, the need for this visualization is supported by the fact that all 3 modalities—echocardiography, computed tomography, and magnetic resonance imaging—have evolved to provide 3D imaging. Utilizing 3D printed models for congenital cardiac surgical education represents the holy grail in training residents to perform complex cardiac operations without putting patient lives at risk.

Van Arsdell and colleagues[6] provide their expert opinion on using 3D printing in congenital cardiac surgery. This group has been at the forefront of the push to utilize pliable 3D printed models in the surgical training of congenital cardiac surgery fellows. Three years ago they reported their experience with 81 surgeons or trainees performing procedures such as the arterial switch or Norwood on 3D printed models. The participants agreed that the simulation training was helpful and would consider integrating this into their programs.[7] Van Arsdell and colleagues[6] point out that their congenital cardiac models have been developed and used for training purposes around the world.

There are several points that bear reiterating. First, the models are evolving quickly, going from firm opaque material to pliable clear material. They are also more user friendly from a surgical standpoint. Newer models incorporate atrioventricular valves, an area that in the past has been a detractor for some. Despite the limitations of the models, trainees have all found value in this simulation exercise. Having residents rehearse operations by setting up the procedure, shaping patches, figuring out sewing angles and hand positions, and sorting out the conduct of the operation has to have some worth. This preparedness will undoubtedly be reflected at the time of real-life operations making one question why this has not been made a requirement in all programs. The stakes are too high, results are being scrutinized publicly, and junior surgeons' careers are at risk—the days of learning on a patient are obsolete. Lastly, this technology is moving rapidly and will play a role in bioprinting with personalized cardiac structure construction.[8] Limitations such as cost and time for image segmentation and model production will not be limitations for long.

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It appears that we have at our disposal what we have wanted: The ability to print a 3D model of a congenital cardiac patient's heart. This not only allows for improved patient and physician education, but enables heart teams to review a corrective plan and practice it preoperatively. The future of simulation in congenital cardiac surgery is now. We owe it to our patients to embrace it.

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