See Article page 135.

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Commentary: Is 3-dimensional printing the panacea for preoperative surgical planning of complex congenital heart disease?

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CENTRAL MESSAGE

3D-printed heart models add significant value to preoperative planning and simulation of surgery in patients with congenital heart disease.

In this issue of the *Journal*, Hussein and colleagues[1] from Toronto present 2 fascinating cases demonstrating the practical utility of 3-dimensional (3D)-printed heart models in the presurgical planning and simulation of patients with Raghib syndrome. In this relatively rare congenital anomaly in which there is a left superior vena cava draining into an unroofed coronary sinus, the authors analyze 4 options of baffling the deoxygenated left superior vena cava blood to the right atrium. Ultimately, they settle on an intracardiac baffle along the roof of the left atrium. As such, the 3D-printed model simulations gave the group a precise execution plan that was thought to provide the best flow dynamics and minimize intraoperative decision-making. Given this, should preoperative 3D printing become the standard of care for complex congenital cardiac repairs and, furthermore, is this technology sufficient for planning the most operative time-efficient and optimal hemodynamic repair?

Compelling data suggest that preoperative surgical planning with 3D-printed hearts of complex congenital heart disease offers clinical benefit. Zhao and colleagues[2] analyzed 25 patients who had complex double-outlet right ventricle. Of those, 8 patients were in the 3D-printed group and 17 patients were in the non–3D-printed group. Although not statistically significant, the 3D-printed group had shorter cardiopulmonary bypass times and shorter aortic crossclamp times. However, statistical significance was achieved in shorter mechanical ventilation times and shorter intensive care unit stays for the 3D-printed group. Another retrospective study, by Ryan and colleagues,[3] analyzed 928 operative cases between 2012 and 2014 in which 164 were associated with 3D-printed hearts. When compared with the non–3D-printed group, the 3D-printed group had shorter mean operative times and lower 30-day readmission and mortality rates, but again without statistical significance. However, this study provided impetus for the current 3DHEART multi-institutional randomized, single-blind clinical trial evaluating the use of 3D print technology in preoperative planning for pediatric heart surgery.

There is no doubt that 3D print technology is being used effectively for congenital heart preoperative planning, as Yoo and colleagues demonstrate, but they also aptly point out that this technology by itself is unable to assess the results of a repair in a dynamic setting. For example, they choose the intracardiac baffle along the roof of the left atrium because of visual assessments, but what if they had quantifiable computational fluid dynamics models to validate this approach, which would be further validated in a 3D-print reconstruction? Siallagan and colleagues[4] demonstrated this when they used computational fluid dynamics to show that a bifurcated Fontan conduit optimizes hepatic flow distribution and reduces power loss in a patient and then used 3D printing to geometrically construct the computationally optimal graft for in vitro validation. Perhaps it is a combination of preoperative planning

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Disclosures: The author reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

Received for publication Dec 23, 2019; revisions received Dec 23, 2019; accepted for publication Jan 3, 2020; available ahead of print Feb 21, 2020.

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JTCVS Techniques 2020;2:143-4

2666-2507

https://doi.org/10.1016/j.xjtc.2020.01.025

technologies that will get us to the most efficient and optimal congenital reconstructions, but 3D printing has certainly started to make an impact.

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