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Commentary: Preoperative planning using 3-dimensional printed models: Static versus dynamic

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CENTRAL MESSAGE

3D printing is valuable tool planning complex heart surgery. However, current technology is limited by the static nature of those models that might not accurately simulate in vivo dynamic conditions.

In the current issue of the *Journal*, Hussein and colleagues[1] from the Hospital for Sick Children in Toronto report 2 children with a rare congenital cardiac anomaly, Raghib syndrome (unroofed coronary sinus defect with persistent left superior vena cava). In both patients, they obtained high-resolution cross-sectional images and subsequently created 3-dimensional (3D)-printed models to better understand the morphology of these defects and also simulate various operative approaches with the aim to select the optimal surgical choice. They used Agilus clear resin (Stratasys Ltd, Eden Prairie, Minn) to print these models and that soft material allowed them to reproduce the different surgeries and actually suture a patch and perform various anastomoses on those models. Based on that, they chose intra-atrial baffle for both patients, who did well following surgery and had satisfactory echocardiographic results.

3D printing is an exciting technology that is being increasingly used in medicine, including pediatric cardiac surgery. The main application so far has been in the preoperative planning of congenital heart disease. The Toronto group, led by Shi-Joon Yoo, has been one of the pioneering programs adopting this enthusing technology in children with congenital heart disease for education and surgical planning.[2,3] The current submission from the same group is another contribution to our knowledge of the utility of this evolving skill. Undoubtedly, 3D printing enhances our understanding of anatomy in complex intracardiac defects and has been helpful determining suitability for biventricular repair, surgery type, and the need for additional procedures in various settings in our field.[2–6] Nonetheless, this 3D-printing expertise is currently restricted by several factors that limit our ability to accurately mimic the environment that the heart and extracardiac structures will be exposed to in reality. When using 3D printing to plan extracardiac repair, the current equipment might not be able to take into account the effect of distortion or compression by adjacent cardiac and extracardiac structures, chest wall, or existing devices. In addition, when using 3D printing to plan complicated intracardiac repair, this simulation does not allow for assessment of the repair in a dynamic setting. A patch that is used for intracardiac baffling might bulge based on several factors (preload and afterload, pressure differential at both ends of the patch, valvular insufficiency or obstruction, etc), and that bulge might cause inflow or outflow obstruction with consequent hemodynamic changes that can contribute to development of residual lesions affecting satisfactory repair. Moreover, the ability to duplicate the results operatively might be occasionally compromised by difficult exposure, valve chordae, conduction system, and of course technical imperfections

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(anastomotic structures, stiff patch, etc). Therefore, although valuable and stimulating, the current limitations of 3D printing in our field should motivate us to explore ways to develop dynamic models that would better mimic the in vivo milieu and further enhance our ability to identify the optimal surgical approach. Ex vivo dynamic testing of artificial valves and devices has been done by industry for decades and might be one way to enhance this system; combination with other advanced methodologies such as computational flow dynamics might also be beneficial; and most importantly further improvements in detailed imaging and print material properties might allow us in the near future to perform preoperative dynamic testing and assess flow in the simulated repaired models.

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