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Commentary: It's all about perspective: 3-dimensional visualization and surgical repair planning for complex congenital heart defects

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3-D modeling helps surgeons plan for challenging congenital repairs.

CENTRAL MESSAGE

Three-dimensional preprocedure planning helps surgeons safely tackle challenging repairs for complex congenital heart disease.

No two congenital heart defects are the same, and surgical repair requires a carefully planned, individualized approach. Advances in neonatal echocardiography have enabled early detection and characterization of complex defects, enabling safe delivery and timely intervention. However, conventional imaging is often not robust enough to fully understand spatial relationships in especially complex defects, and 3-dimensional (3D) visualization, whether via 3D printed models or virtual reality, can be instrumental to surgical planning.

Oh and colleagues[1] describe a patient with VACTERL syndrome (vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities) and a unique collection of congenital heart defects, including tetralogy of Fallot, right aortic arch, isolated left subclavian from the patent ductus arteriosus, aortopulmonary window, and hypoplastic right pulmonary artery. Surgical management was further complicated by the patient's extracardiac defects, which included extreme rotation of the heart secondary to a hypoplastic right lung. A multidisciplinary team considered the risks and benefits of partial palliative repairs, including pulmonary artery banding, tetralogy of Fallot repair, and arch repair, versus complete repair. The authors used virtual heart mapping via EchoPixel software (EchoPixel) to visualize relationships between defects in a holographic model, allowing for virtual procedure planning, conceptualization of different repair techniques, and anticipation of challenges or complications. Ultimately, they decided to perform full repair targeting each defect in a single operation. The team successfully completed patent ductus arteriosus ligation, aortopulmonary window repair, relief of right ventricular obstruction via myectomy, VSD closure, and reimplantation of the left subclavian artery. The patient did well following surgical repair.

The ability to manipulate 3D models of a patient's anatomy to precisely plan a surgical approach

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Disclosures: The authors 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 April 15, 2022; accepted for publication April 15, 2022; available ahead of print April 19, 2022.

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JTCVS Techniques 2022;14:196-7
2666-2507

https://doi.org/10.1016/j.xjtc.2022.04.015

emphasizes the role surgical simulation can play in congenital heart surgery, where the stakes are high and the margin for error is low. At our institution, we frequently create flexible 3D-printed models of our most complex heart defects to aid in surgical planning.[2,3] In fact, this approach also has had similar utility in our institution in the less complex, but equally critical anatomy of the ductus arteriosus in planning preoperative stent placement.[4] Szugye and colleagues[5] have described their use of EchoPixel to determine HeartMate III placement in a 15-year-old patient with Fontan circulation with a successful outcome.

Given the vast number of unique defects and procedures within the field of congenital heart surgery, it seems natural that practice makes perfect. Further, given the relationship between institutional case volume and outcomes, patients with rare, complex defects rely on a surgeon's operative experience and ability to adapt to new challenges.[6] When a complex patient comes along, the use of cutting-edge visualization techniques to plan and rehearse can make critical surgeries safer and more efficient. The authors should be commended for their use of EchoPixel technology to set their patient up for a successful repair.

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