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IMAGING VIGNETTE

3D Printing in Complex Congenital Heart Disease

Across a Spectrum of Age, Pathology, and Imaging Techniques

Shafkat Anwar, MD,[a] Gautam K. Singh, MD,[a] Justin Varughese, MS,[a] Hoang Nguyen, MD,[a] Joseph J. Billadello, MD,[b] Elizabeth F. Sheybani, MD,[c] Pamela K. Woodard, MD,[c] Peter Manning, MD,[d] Pirooz Eghtesady, MD, PhD[d]

WE APPLIED 3-DIMENSIONAL (3D) PRINTING IN PATIENTS WITH CONGENITAL HEART DISEASE TO precisely visualize complex anatomy, plan surgical procedures, and teach trainees and patients. Cases presented range from infants to adults with congenital heart disease. A variety of pathologies are shown, including intracardiac defects, vascular malformations, and airway abnormalities (**Figures 1 to 4**, Online Videos 1, 2, 3, 4, 5, 6, 7, 8, 9, 10). Data for 3D printing were derived from cardiac magnetic resonance imaging or computed tomographic angiography. Cardiac magnetic resonance was performed on a 1.5-T scanner with a 3D respiratory navigated inversion recovery fast low angle shot sequence after administration of blood-pool gadolinium contrast, gadofosveset trisodium (Ablavar, Lantheus Medical Imaging, North Billerica, Massachusetts). Contrast-enhanced cardiac computed tomography was performed on a 128-slice dual-source computed tomographic scanner using high-pitch spiral mode. Segmentation, post-processing, and 3D printing were performed in collaboration with 3D Systems-Healthcare (Golden, Colorado) and were printed on a ProJet 660 color jet printer. Models for the cases that went to surgery were found to be accurate via direct observation in the operating room.

From the [a]Division of Cardiology, Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri; [b]Division of Cardiovascular Medicine, Department of Internal Medicine, Washington University School of Medicine, St. Louis, Missouri; [c]Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis, Missouri; and the [d]Division of Cardiothoracic Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, Missouri. Dr. Woodard has received research support from Bayer and Astellas; and funding from the National Institutes of Health. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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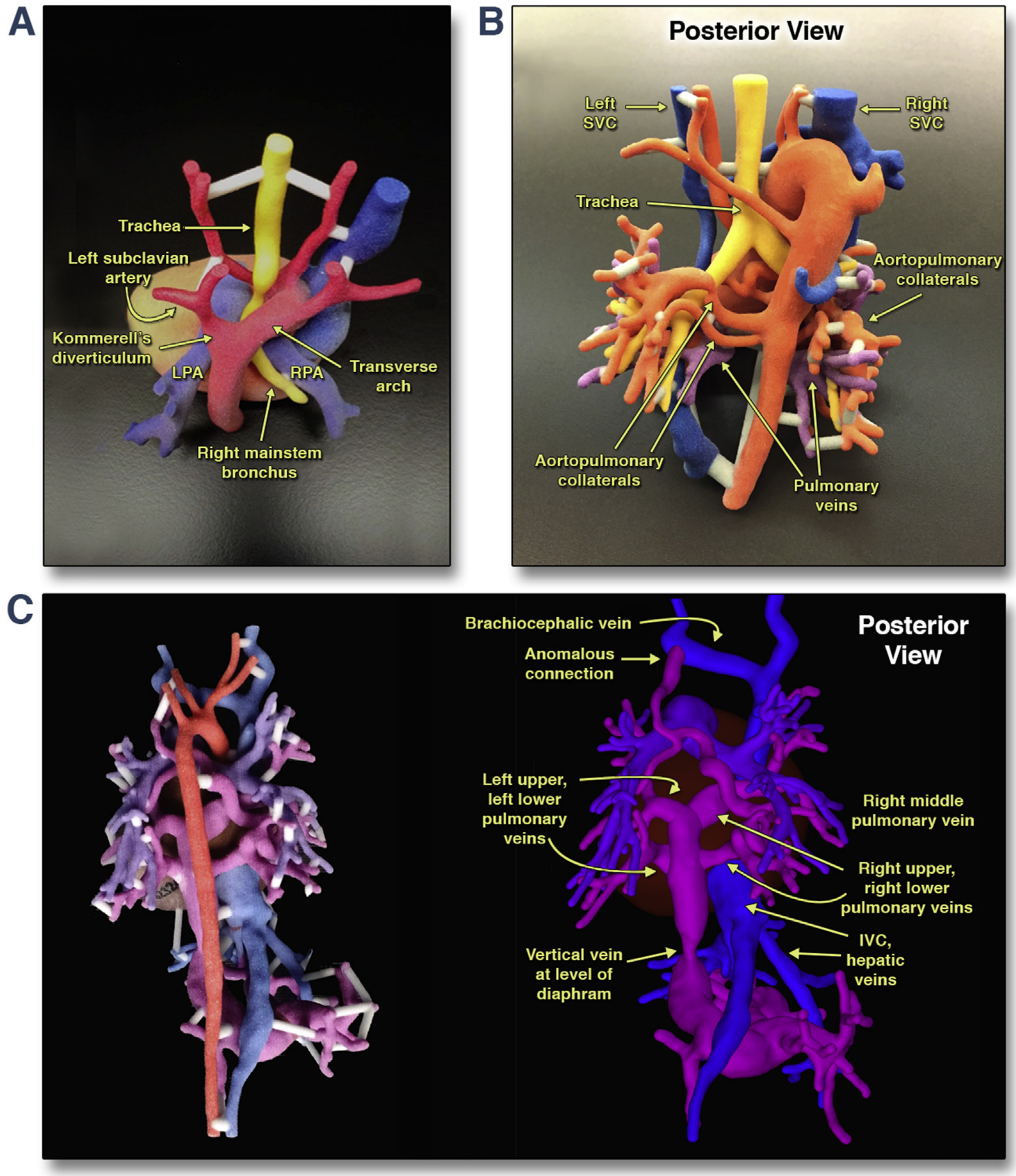
FIGURE 1 3D Models of Complex Vascular Anomalies



(A) Fifteen-month-old (7.4 kg) male patient with a vascular ring. The 3-dimensional (3D) model printed from the magnetic resonance angiogram (Online Video 1) showed a "circumflex" distal arch (not Kommerell diverticulum or aberrant left subclavian artery) compressing the esophagus and trachea posteriorly, and the model enabled precise surgical planning. **(B)** Ten-month-old (6.2 kg) female patient with tetralogy of Fallot, pulmonary atresia, and major aortopulmonary collaterals. 3D printing from computed tomographic angiography (Online Video 2) was performed for surgical planning and showed spatial relationships among the aorta, aortopulmonary collateral arteries, pulmonary veins, and airways that enabled detailed pre-operative surgical planning. **(C)** Fifteen-day-old (2.3 kg) male patient with respiratory distress. Computed tomographic angiography showed mixed total anomalous pulmonary venous return. The 3D model printed for teaching purposes showed right- and left-sided pulmonary veins connecting to a vertical vein that descended below the diaphragm (Online Video 3). A right middle pulmonary vein ascended superiorly to form a separate connection with the left brachiocephalic vein. IVC = inferior vena cava; LPA = left pulmonary artery; RPA = right pulmonary artery; SVC = superior vena cava.