

IMAGES IN INTERVENTION

Using Multimaterial 3-Dimensional Printing for Personalized Planning of Complex Structural Heart Disease Intervention



Kent Chak-Yu So, MBChB,^a Yiting Fan, MM,^a Louis Sze, MSc,^b Ka-wai Kwok, PhD,^c Anna Kin-yin Chan, MBChB,^a Gary Shing-Him Cheung, MBBS,^a Alex Pui-Wai Lee, MD^a

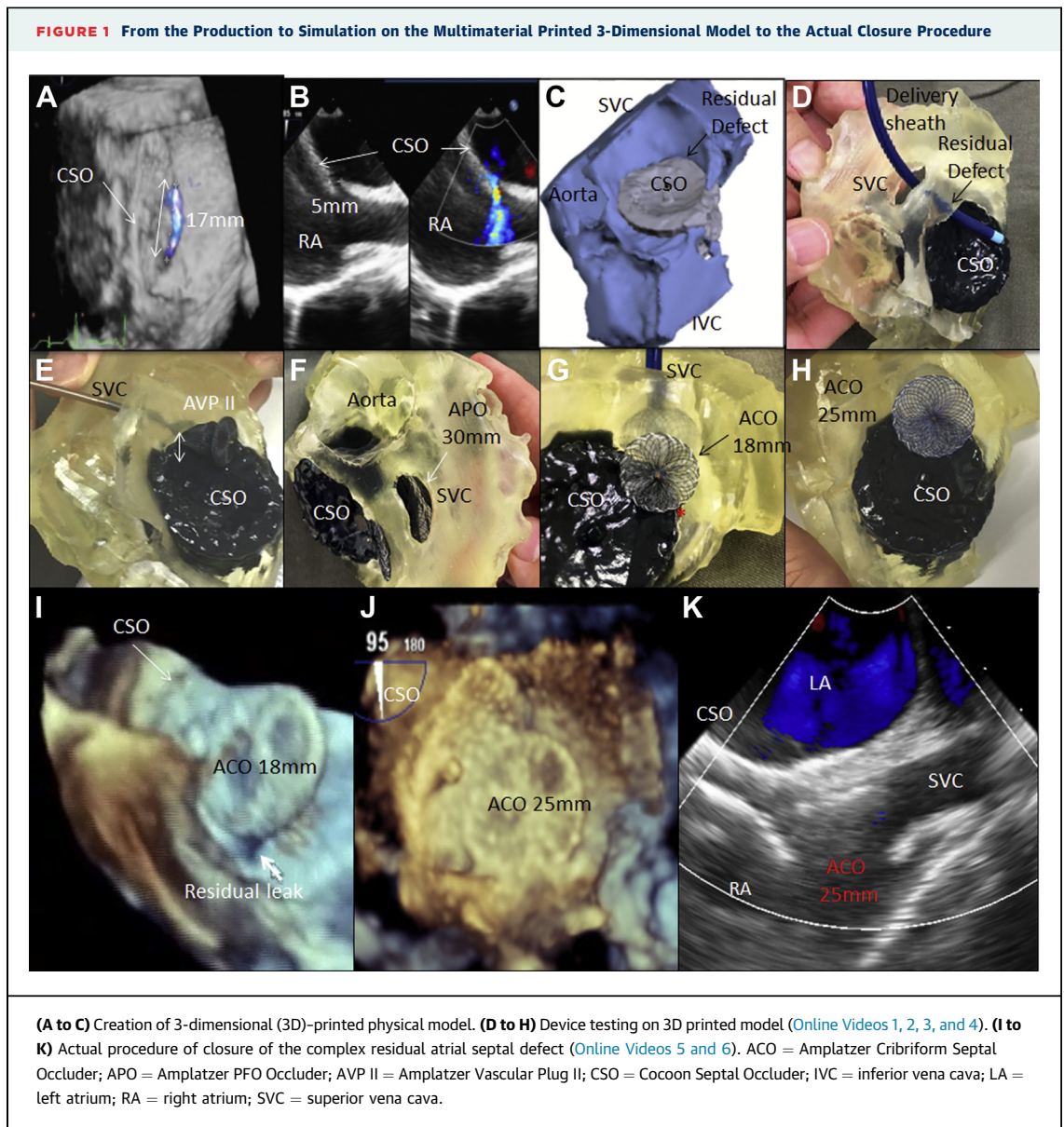
A 56-year-old woman presented with dyspnea 6 months after percutaneous closure of atrial septal defect with a Cocoon Septal Occluder. Transesophageal echocardiography revealed partial device prolapse and recurrent left-to-right interatrial shunt through a crescent-shaped, tunnel-like peridevice defect (17 × 5 mm) (Figures 1A and 1B). Because of the complexity of anatomy, 3-dimensional (3D) printing was used for pre-procedural planning.

A computer model of the structure of interest was segmented from the 3D transesophageal echocardiographic dataset (Mimics, Materialise, Leuven, Belgium), with different colors and rigidity assigned to different segments for preparation of multimaterial 3D printing (Figure 1C). The cardiac structure and the Cocoon Septal Occluder were 3D-printed (J750, Stratasys, Eden Prairie, Minnesota) using rubberlike translucent material (TangoPlus, Stratasys) and rigid black material (VeroBlackPlus, Stratasys), respectively, for texture simulation. The 3D spatial relationship between the superior vena cava and the defect was tangibly appreciated on the 3D-printed model (Figure 1D).

Simulated device closure was conducted on the model. We found that an Amplatzer Vascular Plug II (14 × 10 mm) would excessively dilate the tunnel-shaped defect (Figure 1E, double-sided arrow), the right atrial disc of a 30-mm Amplatzer PFO Occluder would obstruct the superior vena cava (Figure 1F), and an 18-mm Amplatzer Cribriform Septal Occluder would not completely cover the defect (Figure 1G, asterisk). Finally, a 25-mm Amplatzer Cribriform Septal Occluder was optimal for complete defect closure without obstructing the superior vena cava (Figure 1H) (Online Videos 1, 2, 3, and 4). The actual procedure was successfully performed via right internal jugular venous access with a 25-mm Amplatzer Cribriform Septal Occluder device, with excellent agreement with the simulation (Figures 1I to 1K, Online Videos 5 and 6).

The ability to 3D-print parts in multiple materials allows more realistic procedural planning on structures consisting of soft cardiac tissues and rigid implanted prosthesis. This report illustrates the feasibility and advantages of multimaterial 3D printing for pre-procedural planning to guide complex structural heart interventions.

From the ^aDivision of Cardiology, Department of Medicine and Therapeutics, Prince of Wales Hospital, Hong Kong, China; ^bDivision of Biomedical Engineering, Faculty of Engineering, The Chinese University of Hong Kong, Hong Kong, China; and the ^cDepartment of Mechanical Engineering, The University of Hong Kong, Hong Kong, China. This work is partially funded by the General Research Fund of the Hong Kong Research Grant Council (grants 467812 and 27209515). The authors have reported that they have no relationships relevant to the contents of this paper to disclose. Drs. So and Fan contributed equally to this work.



ADDRESS FOR CORRESPONDENCE: Dr. Alex Pui-Wai Lee, 9/F Department of Medicine and Therapeutics, Lui Che Woo Clinical Sciences Building, Prince of Wales Hospital, 30-32 Ngan Shing Street, Shatin, N.T., Hong Kong SAR, China. E-mail: alexpwlee@cuhk.edu.hk.

KEY WORDS 3-dimensional printing, atrial septal defect, personalized medicine

APPENDIX For supplemental videos and their legends, please see the online version of this article.