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IMAGES IN INTERVENTION

# Successful Catheter Treatment Using Pre-Operative 3D Organ Model Simulation for Atrial Septal Defect With Dextrocardia and Interrupted Inferior Vena Cava to the Superior Vena Cava

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A 31-year-old male patient with a history of situs inversus, dextrocardia, and interrupted inferior vena cava (IVC) with azygous continuation referred to our hospital (**Figure 1A**). Transesophageal echocardiography revealed a 9 mm × 16 mm atrial septal defect (ASD) with continuous left-to-right shunting with small aortic rim and the defect surface of the septum primum is different from that of the septum secundum, which indicates malalignment (**Figure 1B**). To perform catheter intervention for a patient with such a complicated anatomy, pre-operative simulation using a 3-dimensional (3D) organ model (Cross Effect Inc., Kyoto, Japan) was constructed by computed tomography (CT) imaging (**Figure 1C**). A 21-mm Occlutech ASD Occluder Figulla Flex2 (Occlutech GmbH, Jena, Germany) was selected in accordance with the defect size as seen on pre-procedural transesophageal echocardiography and CT.

To perform this catheter intervention, we used a 12-F FlexCath Advance Steerable Sheath for cryoablation (Medtronic, Minneapolis, Minnesota) via a left jugular venous approach. Subsequently, an in vitro trial occlusion was performed successfully in the elastic rubber model for pre-operative evaluation (**Figures 1D and 1E**). In the real clinical procedure, the device was deployed successfully. Post-operative CT showed perfect positioning of the device (**Figure 1F**, Online Video 1).

To the best of our knowledge, this is the first application of 3D organ model with transcatheter closure of an ASD with IVC interruption and situs inversus and dextrocardia. Congenital absence of the intrahepatic segment of the IVC is a congenital anomaly found in 0.1% to 0.6% of the general population and in approximately 1% to 3% of patients with congenital heart disease (1,2). This patient has situs inversus, and the position of the defect is located in the anteroposterior direction. Although successful transcatheter closure has been reported in ASD with interrupted IVC by using an 8.5-F steerable sheath for ablation via the transjugular approach (3), it is still difficult to predict successful closure. A personalized heart model can be produced using 3D printing, which assists with the pre-operative evaluation of ASD (4). Pre-operative simulation using a 3D organ model can predict successful catheter treatment and decrease related complications.

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From the Department of Cardiovascular Medicine, Graduate School of Medicine, Kyoto University, Kyoto, Japan. Dr. Kimura has served as an advisory board member for Cordis Cardiology, Abbott Vascular, and Terumo. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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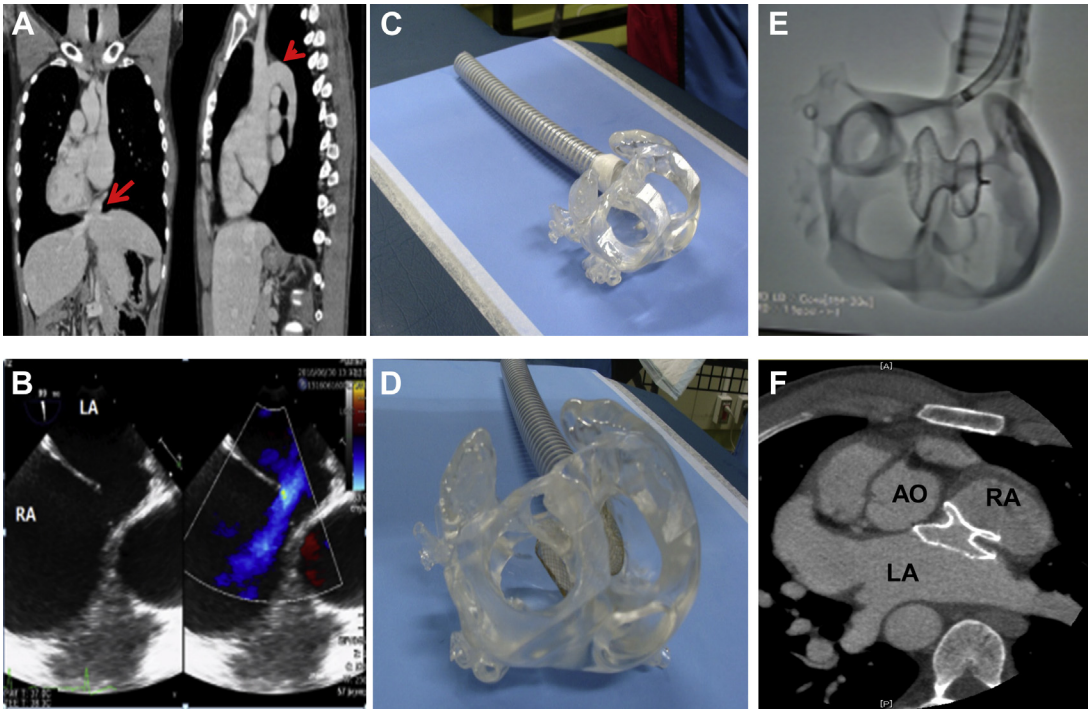
**FIGURE 1 Pre-Operative and Post-Operative Images and 3D Organ Model Simulation for Atrial Septal Defect With Situs Inversus, Dextrocardia, and Inferior Vena Cava Interruption**




**(A)** Computed tomography shows no hepatic segment of the inferior vena cava **(arrow)** and an interrupted inferior vena cava with azygous continuation to the superior vena cava **(arrowhead)**. **(B)** Echocardiograph shows 9 mm × 16 mm atrial septal defect with continuous left-to-right shunting and small aortic rim. **(C)** A personalized 3-dimensional (3D) organ model based on computed tomography imaging was constructed. **(D)** A 21-mm Figulla Flex II (Occlutech GmbH, Jena, Germany) was implanted in the 3D organ model in accordance with the defect size seen on the transesophageal echocardiography. **(E)** Perspective image of an implanted device through a 12-F sheath and placed with stability. **(F)** Post-operative computed tomography showed good positioning of device and implanted A-shaped to the aorta (AO) (Online Video 1). LA = left atrium; RA = right atrium.

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**KEY WORDS** 3-dimensional organ model, ASD, dextrocardia, IVC interruption

**APPENDIX** For a supplemental video, please see the online version of this paper.