Virtual reality for transcatheter procedure planning in congenital heart disease

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Multimodality imaging has recently become an important tool for interventional cardiology. Three-dimensional (3D) model printing, virtual reality, holography, and 3D image fusion are just a few of the modern possibilities for planning, simulation, and navigation in interventional procedures [1–5].

VMersive (VR-Learning, Poland) is a novel tool that utilizes automatic 3D reconstruction of computed tomography (CT) and magnetic resonance imaging (MRI) studies based on volume rendering, which eliminates the need for manual segmentation. In this system, virtual reality headsets and controllers are used to analyze anatomy and also to simulate the procedure.

The presented male patient had a late diagnosis of persistent ductus arteriosus (PDA) at the age of two years. He underwent catheterization and due to sub-systemic pulmonary pressure and risk of left-to-right device embolization, a double-disc 10 mm Amplatzer muscular VSD occluder was implanted. There was no protrusion of the device to either the pulmonary artery or the descending aorta at that time. Pulmonary hypertension treatment with sildenafil proved to be effective with discontinuation after 2 years. The patient was readmitted at the age of 15 years; he was asymptomatic and had recognized left pulmonary artery (LPA) stenosis on recent echocardiography examinations. Angio-CT confirmed asymmetric arborization of the lungs and complex LPA stenosis with the right-sided disc of the device protruding obliquely into the proximal part of the artery and narrowing it to 5 mm. The diameter of distal LPA was 12 mm. The CT-derived data was uploaded to the VMersive application. With use of different 3D reconstruction profiles, proper visualization of the LPA stenosis from the outside and the inside of the pulmonary artery was possible (Figure 1, Supplementary material, *Videos S1–S4*). Moreover, simulation of LPA stenting was performed, the final size of the stent was selected (13 mm in diameter, 27 mm in length), and angiography projections were planned (LAO 60, Cran 15).

The procedure was guided using both Vessel Navigator fusion imaging (Philips Healthcare, the Netherlands) and standard fluoroscopy. Angiography and interrogation with a 14 mm balloon confirmed the LPA stenosis and proper landing zone at the proximal disc level. Then, a 35 mm XL AndraStent (AndraMed, Reutlingen, Germany) crimped on a 14 mm MaxiLD (Cordis, Florida, US) balloon was implanted with a good result and flow improvement, as the pressure gradient dropped from 17 to 1 mm Hg. The final position of the stent, diameter (13.2 mm), and length (28 mm) corresponded well to the simulation. The procedure and two-month observation were uneventful.

The presented tool gives an additional advantage over standard CT/MRI software by offering the possibility to analyze 3D datasets with a 3D virtual reality headset, which gives an extraordinary sense of space and anatomical details, such as a device protruding obliquely into the pulmonary artery, as in our patient. It is not time-consuming and allows for very precise measurements in different projections. The simulation option is based on overlapping images but does not predict the mechanical response of tissues, thus, balloon interrogation is still useful. However, such a tool can predict stent shortening, which is of great importance.

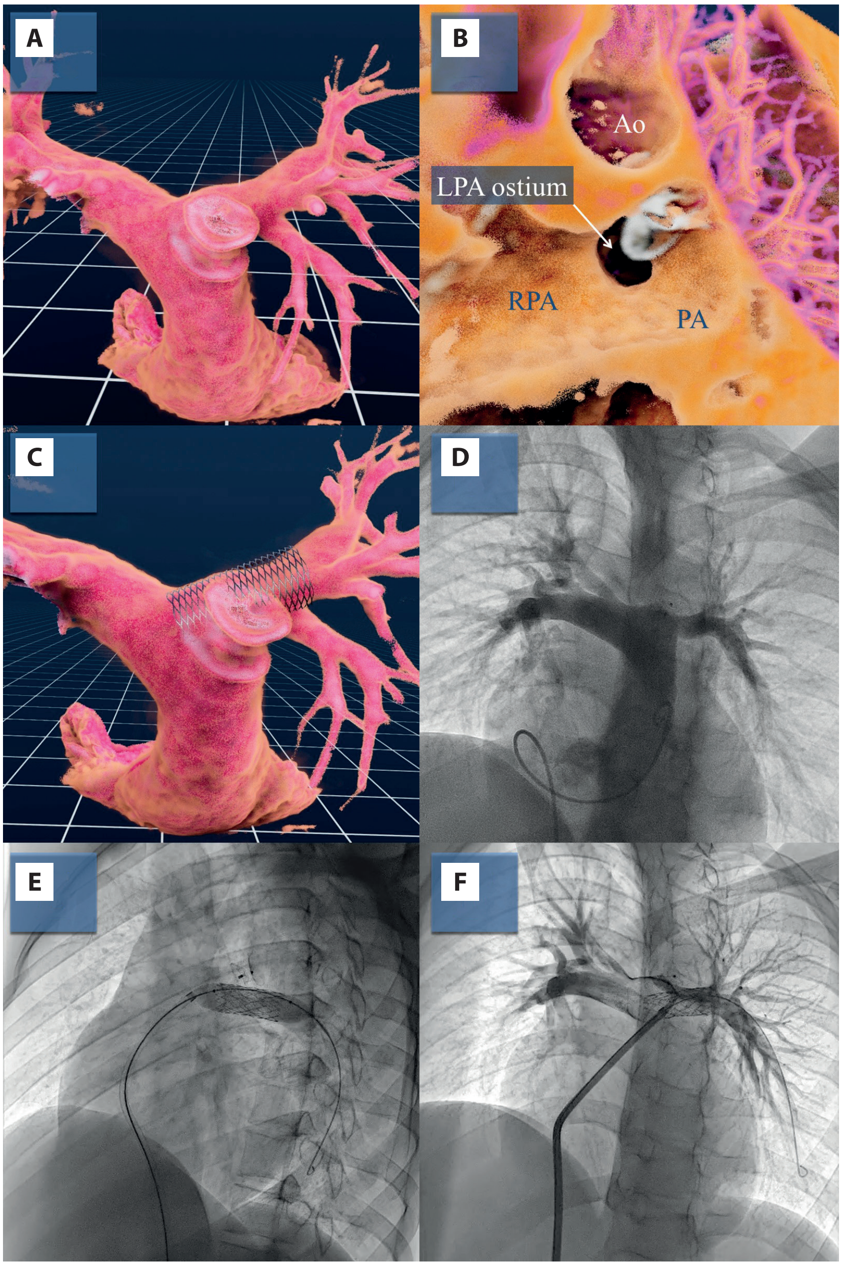

Figure 1. A. 3D model of the right ventricular outflow tract, pulmonary arteries and an Amplatzer muscular VSD occluder protruding into the left pulmonary artery. **B.** 3D reconstruction — view from the inside of the pulmonary artery (PA), narrow left pulmonary artery (LPA) entrance evident (RPA, right pulmonary artery; Ao, aorta, device in white). **C.** Simulation of 13 × 27 mm stent implantation into the narrowing. **D.** Right ventriculography, worse arborization of the left pulmonary artery. **E.** Stent implantation. **F.** Final angiography with the appropriate stent position (projections: **D** and **F** — LAO 30, Cran 30, E — LAO 60, Cran 15)

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

Article information

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