

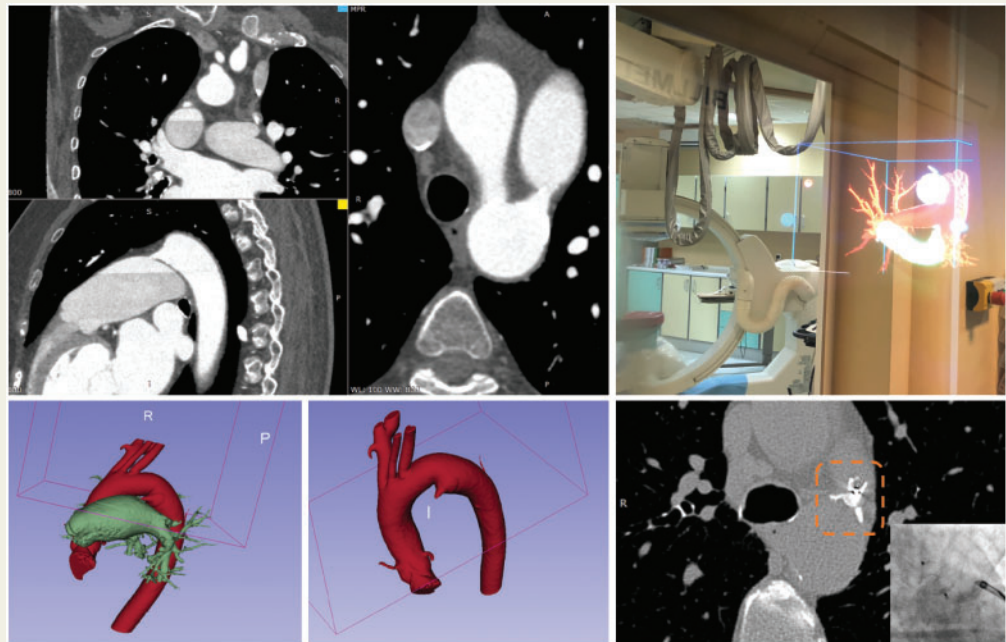
Percutaneous patent ductus arteriosus closure using intraprocedural mixed reality visualization of 3D computed tomography angiography data: first-in-man experience

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3D imaging is widely used to improve understanding of complex anatomy and aid in structural percutaneous cardiac interventions. However, displaying 3D information on standard computer monitors carries inherent limitations. Therefore, we used for the first time, during percutaneous patent ductus arteriosus closure (PDAC), intraprocedural mixed reality display of segmented computed tomography angiography (CTAngio) data. Previously recorded contrast CTAngio of aorta and ductus (4 mm diameter of pulmonary orifice) was



manually segmented and uploaded into 3D DICOM workstation (CarnaLife[®] Holo, MedApp, Kraków, Poland). Commercially available head-mounted device allowing for touchless control was used to display shared 3D holograms during the procedure within cath lab. During PDAC, aortic orifice wiring was assisted by 3D holography, controlled by the imaging specialist, and shared with the operator to produce mixed reality display, overlaying unobstructed real view. Segmented data were visible as a semitransparent spatial hologram positioned in a convenient part of visual field allowing real-world activity by interventionist. Image could be touchlessly controlled (e.g. zoomed, rotated, translated, cropped) by voice commands and hand gestures recognized by the device in real-time. Operator appreciated the use of 3D model recreating spatial relationships as practical to facilitate entry into the ductus orifice.

The procedure was successfully completed using arteriovenous guidewire loop and pulmonary trunk access to implant Amplatzer Duct Occluder II size 6-6.

In conclusion, we demonstrate for the first time the practical use of intraprocedural mixed reality holographic display of 3D CTAngio data, with sterile touchless control of holographic image shared by interventional and imaging team to support percutaneous PDAC. The concept of mixed reality CTAngio display is illustrated on *Panel*.

Panel illustrates the concept of intraprocedural use of mixed reality for interventional occlusion of patent ductus arteriosus (preprocedural visualization of 12 × 4 mm funnel-shaped PDA by CTAngio—top-left, serving as a source for spatial segmentation of aorta/red and pulmonary trunk/green—bottom left). Top right panel simulates the view of the operator wearing HoloLens with hologram overlaying the real-world vision to assist in successful occluder implantation as documented in fluoroscopy and CT angiography (bottom right).