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Implementation of interactive mixed reality display of three-dimensional echocardiography during percutaneous structural interventions

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Background. Three-dimensional (3D) echocardiographic data acquired from transesophageal (TEE) window are commonly used in planning and during percutaneous structural cardiac interventions (PSCI).
Purpose. We hypothesized that innovative, interactive mixed reality display can be integrated with procedural PSCI workflow to improve perception and interpretation of 3D data representing cardiac anatomy.
Methods. 3D TEE datasets were acquired before, during and after the completion of PSCI in 8 patients (occluders: 2 atrial appendage, 2 patent foramen ovale and 3 atrial septal implantations and percutaneous mitral commissurotomy). 30 Carthesian DICOM files were used to test the feasibility of mixed reality with commercially available head-mounted device (overlying hologram of 3D TEE data onto real-world view) as display for the interventional or imaging operator. Dedicated software was used for files conversion and 3D rendering of data to display device (in 1 case real-time Wi-Fi streaming from echocardiograph) and spatial manipulation of hologram during PSCI. Custom viewer was used to perform volume rendering and adjustment (cropping, transparency and shading control).
Results. Pre- and intraprocedural 3D TEE was performed in all 8 patients (5 women, age 40-83). Thirty selected 3DTEE datasets were successfully transferred and displayed in mixed reality head-mounted device as a holographic image overlying the real world view. The analysis was performed both before and during the procedure and compared with flatscreen 2-D display of the echocardiograph. In one case, real-time data transfer was successfully implemented during mitral balloon commissurotomy. The quality of visualization was judged as good without diagnostic content loss in all (100%) datasets. Both target structures and additional anatomical details were clearly presented including fenestrations of atrial septal defect, prominent Eustachian valve and earlier cardiac implants. Volume rendered views were touchlessly manipulated and displayed with a selection of intensity windows, transfer functions, and filters. Detail display was judged comparable to current 2-D volume-rendering on commercial workstations and touchless user interface - comfortable for optimization of views during PSCI.
Conclusions. Mixed reality display using a commercially available head-mounted device can be successfully integrated with preparation and execution of PSCI. The benefits of this solution include touchless image control and unobstructed real world viewing facilitating intraprocedural use, thus showing superiority over virtual or enhanced reality solutions. Expected progress includes integration of color flow data and optimization of real-time streaming option.