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TITLE: Walk-through fetal heart simulation of in utero operation using virtual reality enhanced four-dimensional (4D) echocardiography and 3D MRI

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ABSTRACT BODY:

Objectives: Some fetal conditions, such as isolated severe pulmonary stenosis and pulmonary atresia, if untreated pranatally, will result in fetal intracardial death or significant morbidity. If promptly treated in utero, babies affected would not only survive but could also live with near-normal life. Maternal/intrauterine surgery is a highly risky procedure, requiring sophisticated training and planning.

Methods: 3D body models were formed from 3D fetal MRI datasets. 4D fetal echo datasets were segmented to create 4D cardiac models. Atrio-pulmonary valve (PaV) was reconstructed using the models and post-maternal data. After combining the models into a single VR system, a simulation of pulmonary valve stenosis was performed using a virtual catheter.

Results: Work in progress has shown it is feasible for the catheter to walk through various cardiovascular structures. The catheter can enter from the inferior vena cava (IVC) into the right heart, till reaching the right ventricle outflow tract (RVOT). After confirming appropriate location, the catheter can "puncture" the atrio-pulmonary PaV, and get into the narrow but patent pulmonary artery (PA). A retrograde salve can also be simulated from the descending aorta through the ductus arteriosus into the PA, then through the atrio-pulmonary valve into the RVOT.

Conclusions: Using quality multi-modal 3D/4D imaging and VR, it is possible to simulate in utero cardiac procedures. The next stage of development will be to provide the physiological sensation of maneuvering the catheter through a rapidly beating heart. This technique has broad applicability and can be developed for training of other fetal interventionalists, e.g., treatment of aortic stenosis or transcatheter surgery for aortic bicus.

Additional details

KEYWORDS: Fetal heart, 3D/4D, Virtual reality, Magnetic resonance imaging.

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