

5th International Conference on Pediatrics and Neonatal Care

July 21-22, 2026 | Vienna, Austria



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Comparison of 4D-flow and 2D-phase contrast cardiac MRI for assessment of pulmonary flow in patients with repaired tetralogy of Fallot after transcatheter pulmonary valve replacement

Individuals with repaired tetralogy of Fallot (rToF) often suffer from pulmonary regurgitation (PR) leading to chronic right ventricular overload, necessitating transcatheter pulmonary valve replacement (TPVR). Cardiac MR (CMR) is considered the reference for post-procedural assessment of residual PR and ventricular function. However, conventional 2D phase contrast flow measurements do not always accurately characterize hemodynamics in the pulmonary artery (PA) and right ventricle (RV). This study compares the accuracy of 4D-flow CMR to 2D CMR in measuring pulmonary artery flow metrics as they correlated to ventricular volumetry and function in post-TPVR patients. Twenty post-TPVR rToF patients who underwent both 2D- and 4D-flow CMR on a 1.5T scanner were included, with 2D-flow measured at the valve level. Two blinded observers measured 4D-flow at the pulmonary vein (PV) and main pulmonary artery (MPA), and we analyzed correlations between 2D and 4D flow derived pulmonary net flow (PNF), forward flow (FF) and pulmonary regurgitant fraction (PRF) to aortic net flow (ANF), RV volume and ejection fraction (EF). 4D-derived PNF had the strongest correlation ($r = 0.81$) to ANF out of the measured metrics, while 4D-derived PRF showed a stronger correlation with RV end-diastolic volume RVEDVi compared to 2D flow ($r = 0.72$, $p < 0.01$). There were significant differences in pulmonary valve PNF between 2D and 4D flow measurements in 4 cases. Inter-rater reliability was excellent for 4D-flow derived measurements at the PV and MPA (ICC:0.91-0.96). This study demonstrates that in patients with rTOF who have underwent TPVR, 4D-flow CMR may be superior to conventional 2D phase-contrast techniques for evaluation of pulmonary valve and main pulmonary artery flow metrics.

Keywords: tetralogy of Fallot, transcatheter pulmonary valve replacement, 4D flow MRI, cardiac MRI, congenital heart disease

Biography

I am currently division chief for the pediatric and emergency radiology division of the Department of Radiology at Taichung Veterans General Hospital, while also holding a teaching position at the department of Medical Imaging and Radiological Sciences at the Central Taiwan University of Science and Technology. My primary interests are cardiac MR imaging of congenital heart diseases, CT imaging of the heart and coronary arteries, as well as neurological imaging in children and adults.