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Echocardiographic Assessment of Right Ventricular Volumes: A Comparison of Different Techniques in Children after Surgical Repair for Tetralogy of Fallot

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Background: Different echocardiographic techniques are available for assessing right ventricular (RV) volumes but their clinical validity has not been well established. We tested the feasibility, reproducibility and accuracy of 3 different echocardiographic techniques compared to MRI to measure RV volumes and ejection fraction (EF) in patients after tetralogy of Fallot (TOF) repair.
Methods: Forty patients (age 13±2.9 y) after TOF repair were studied using 3D volume acquisition analysis (3D) (Tomtec, Germany), 2D echo with knowledge based 3D reconstruction (KBR) (Ventripoint, USA) and the 4 chamber area (4C area) method. Parameters analyzed were end diastolic volume (EDV), end systolic volume (ESV) and EF. Ultrasound images were acquired using a Vivid 7 scanner (GE Ultrasound, USA). In 20 patients echocardiography was performed immediately after cardiac MRI. Intra and inter-observer as well as inter-technique variability was assessed using Pearson correlation analysis (R), coefficient of variance (COV) and Bland-Altman analysis.
Results: Feasibility was 90% for 3D, 97.5% for KBR and 100% for 4C area method. Intra- and inter-observer variability were good for both KBR and 3D echo while more variability was observed for the 4C method (e.g. EDV R 0.997, 0.995 and 0.985; COV 3.2, 3.8 and 5.4; bias 1.1±7.6, -2.2±8.8 and 4.3±12.5 respectively). The results for intertechnique variability are summarized in the table. Compared to MRI volumes KBR underestimated EDV by around 4% with narrow limits of agreement, while the 3D method underestimated EDV by around 10% with slightly wider limits of agreement. The 4C area method overestimated the volumes by around 10% with poor agreement. For the ESV, the inter-technique variability of KBR and 3D was slightly higher, with higher coefficients of variation and wider limits of agreement.
Conclusions: Current echocardiographic techniques to assess RV volumes are highly feasible in a pediatric population of TOF patients with the highest feasibility for 2D echo methods. KBR was shown to be the most accurate technique when compared to MRI with a small bias and relatively narrow limits of agreement. This study shows that echocardiography is approaching the reproducibility and accuracy of MRI-based RV volume quantification.

Inter-method variability	N	Correlation coefficient	Coefficient of variance	Mean bias ± SD	p
KBR versus MRI	20				
EDV		.992	4.1	-4.8 ± 9.8	.04
ESV		.974	7.6	-8 ± 10.1	.002
EF		.896	7	2.1 ± 3.2	.007
3D versus MRI	19				
EDV		.983	6.2	-10.1 ± 14.4	.006
ESV		.962	9.4	-4.9 ± 12.5	.1
EF		.760	10.9	-0.4 ± 4.7	.7
4C area versus MRI	20				
EDV		.967	7.8	9.7 ± 19.5	.037