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Optimising the accuracy and reproducibility of aortic root measurements from cardiac MRI data

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Introduction

Paediatric aortopathy is assessed increasingly with MRI, because 3D data is acquired without ionising radiation, which is advantageous for serial assessment. However, the accuracy and repeatability of aortic measurements are limited because no consistency exists regarding measurement positions and technique

Purpose

To investigate the best possible reproducibility of paediatric aortic measurements, using different MR sequences and post-processing, with a single, experienced observer

Methods

An observational study of 20 consecutive children, (age 11, +/- 5.5 years) undergoing MRI for aortic root and arch assessment. None had undergone intervention. Imaging used standard true FISP cine sequences and an isotropic, respiratory-navigated, ECG-gated, 3D multi-slab SSFP sequence (allowing reformatting in any 3D-plane). A single, experienced observer measured the maximum diameter from cine images of the LV outflow tract (diastolic phase) and the 3D dataset (diastolic phase), at three aortic root levels and at the diaphragmatic aorta, twice, with one week between measurements. 3D data measurements used true cross-sectional planning, and included planimetered area. Aortic sinus diameter was measured from commissure-to-opposing-cusp (Figure 1). The difference between 2D cine and 3D diameters, and intra-observer variability were compared using Bland-Altman variability analysis

Results

Though measured in the same phase of the cardiac cycle, 2D cine diameters were smaller than 3D true-cross-sectional diameters (3.6-8.9%). There was no systematic variation with aortic size (Figure 2). The average intra-observer variability at sinus level for 3D data was 1% for diameter, and 5% for area. The variability for 2D cine measurements was 10%. In this best case scenario of repeated measurements, for paediatric aortic roots approximately 30 mm in diameter, a change in aortic sinus diameter would have to exceed 3 mm on 3D data and 6 mm on 2D cine data to be sure the change did not result from measurement variability (Table 1)

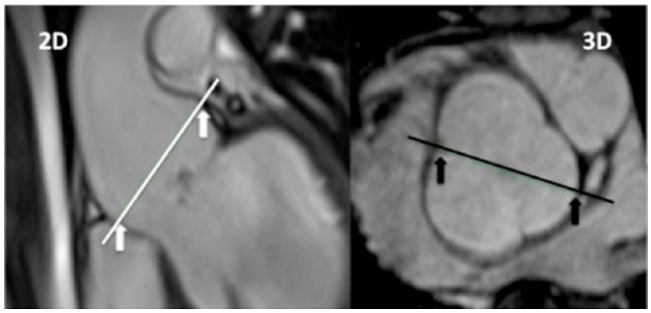

Figure 1
Illustration of 2D and 3D aortic sinus measurement planes in the same patient (42.2 mm and 44.6 mm, respectively), measuring from the arrows and from commissure-to-cusp on the 3D data.

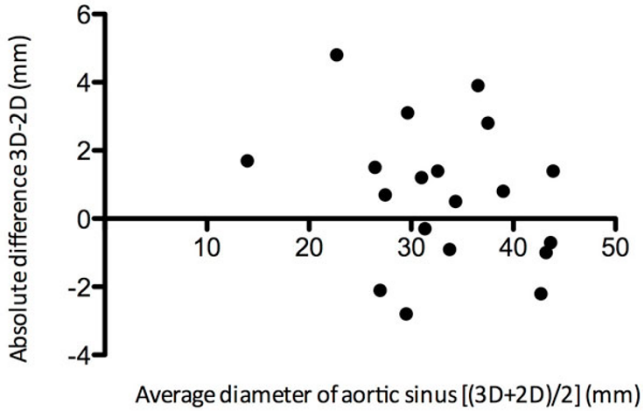

Figure 2
Variability of 2D and 3D aortic sinus measurement planes in the same patient (42.2 mm and 44.6 mm, respectively), measuring from the arrows and from commissure-to-cusp on the 3D data.

Conclusion

In paediatric ascending aortopathy, even with a single, experienced observer measuring the same raw data and using consistent measurement technique, there is considerable error associated with assessment of aortic root size, comparing different techniques and repeat measurements. Our results indicate that even with optimal 3D imaging and systematic post-processing, there is clinically important variability. This would be compounded further by interobserver variability, inconsistent slice planning on 2D cine imaging, varying leaflet configuration, asymmetric dilatation and patient growth. Therefore, accurate and clinically valid serial assessment of paediatric aortopathy crucially requires standardisation of scanning and post-processing techniques. This data highlights the issues and suggests appropriate measurement parameters.

Maximum aortic diameter at sinus level is cusp-to-commisure.

Aortopathies: Marfan syndrome (6), Loeys-Dietz syndrome (1), Turner syndrome (2), bicuspid aortic valve (4), and other connective tissue disease (7).

Table 1: Bland-Altman analyses of aortic size measurements obtained by different techniques and from different MRI sequences in paediatric aortopathy (N = 20).

				REPRODUCIBILITY OF REPEAT 3D MEASUREMENTS (one week in between)		
	MAXIMUM DIAMETER		DIFFERENCE between 3D PERPENDICULAR and 2D CINE	MAXIMUM DIAMETER		PLANIMETRIC AREA
AORTIC LEVEL	2D CINE IMAGING mm [SD]	3D SSFP IMAGING mm [SD]	Mean difference % [95%CI]	Mean difference mm [95%CI]	Mean difference % [95%CI]	Mean difference % [95%CI]
Hinge	23.8 [5.1]	26.1 [5.5]	9.1 [-23.4;47.7]	0.3 [-3.6;3.1]	1.0 [-16.7;13.2]	5.6 [-10.6;11.6]
Sinus	32.7 [8.0]	33.7 [8.1]	2.9 [-11.7;17.2]	0.1 [-2.2;2.1]	1.2 [-8.5;10.9]	5.0 [-10.8;8.9]
Sinutubular	24.4 [7.7]	27.2 [8.2]	11.2 [-3.9;16.3]	-0.2 [-3.4;3.0]	-0.9 [-12.6;10.7]	-1.4 [-18.2;15.4]