

Coronary MR Angiography in Children During Systole and Diastole Using a Dual Cardiac Phase Scan of the Whole Heart

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Introduction: In children with acquired and congenital heart disease (CHD) the visualization of the course of the coronary arteries is highly desirable for surgical planning and for follow up. Coronary Magnetic Resonance Angiography (CMRA) has been successfully applied in adults and recently also in young children and infants. In children with CHD a whole heart CMR approach is of great clinical advantage, since the anatomy of the heart and the great vessels can be evaluated in addition to the coronary arteries. Usually, a 3D volume is obtained either at end-systole or mid-diastole. However, in children with high heart rates and/or with RR variability it is unclear which phase of the cardiac cycle results in better image quality. Therefore, the simultaneous acquisition of the end-systolic and mid-diastolic phase in conjunction with the whole heart approach allows retrospectively selection of the best image phase for coronary artery visualization [1] without any scan time penalty.

Method: Eight children (age = 6.38 ± 4.27 , height = 116.57 ± 30.77 , weight = 23.57 ± 14.25 , Heart-rate = 85.02 ± 8.59) with CHD were scanned under general anesthesia on a 1.5 T MR system (Achieva, Philips Healthcare). The cardiac rest period for end-systole and mid-diastole was determined from a 2D SSFP cine scan with high temporal resolution (TR/TE = 3.1/1.6 ms, flip angle 60°, slice thickness 6 mm, 60 to 80 cardiac phases). A previously developed free-breathing navigator gated 3D SSFP dual cardiac phase sequence [2] was then applied in sagittal orientation for imaging of the whole heart including the coronary arteries and great vessels (TR/TE = 3.4/1.7 ms, flip angle 90°, 60-120 slice, isotropic resolution of 1-1.5 mm³, temporal resolution of 60-75 ms, SENSE of 2 in AP direction). Data was obtained during end-systole and mid-diastole and the acquisition window of the 3D scan was adapted accordingly to the shortest rest period. Images were then reformatted along the major axes of the left and right coronary artery for both cardiac phases. Vessel length, diameter and sharpness of the visualized coronary arteries (RCA, LM, LAD, LCx) were measured using the "SoapBubble" software. Image quality was assessed by two independent observers. Statistical analysis and Bland Altman plots were used to compare the different data sets.

Results: The dual cardiac phase whole heart scan was applied successfully in all patients. An example of each coronary segment is shown in figure 1. The vessel length (V.L), diameter (V.D), sharpness (V.S), and consensus score for each segment during systole and diastole are shown in Table 1. Bland Altman plots of the systolic versus diastolic data from each coronary segment are shown in figure 2. It was found that on a patient level V.L, V.D, V.S and image quality showed differences either favoring systolic or diastolic image acquisition.

Furthermore, it was also found that the selection of either the systolic or diastolic image varied for different coronary segments within the same patient.

Conclusion: A 3D SSFP dual cardiac phase scan of the whole heart was capable of identifying the origin and proximal course of the coronary arteries in children during either the end-systolic or mid-diastolic rest period of the heart. The ability to show the 3D relationship of the heart, great vessels and coronary arteries, and also the possibility to retrospectively select the optimal rest period of the heart for each coronary artery segment makes this technique a clinically valuable tool for coronary imaging in children.

References. 1. Manke et al JMRI 2001, 2. Uribe et al, Radiology 2008.

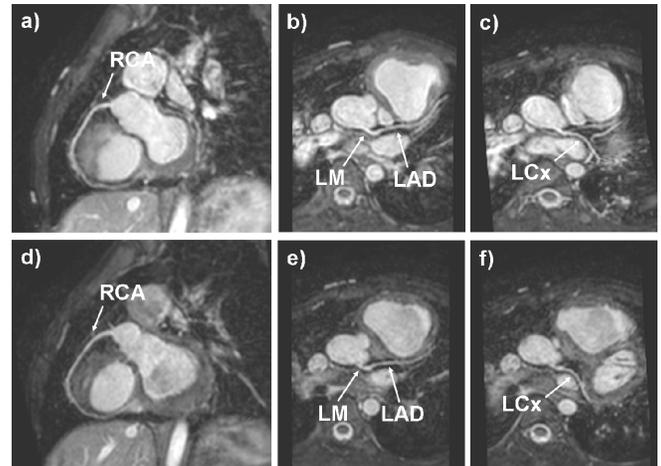


Figure 1. Reformatted images during systole (Top) and diastole (Bottom) of different coronary segments in a 7 year old patient.

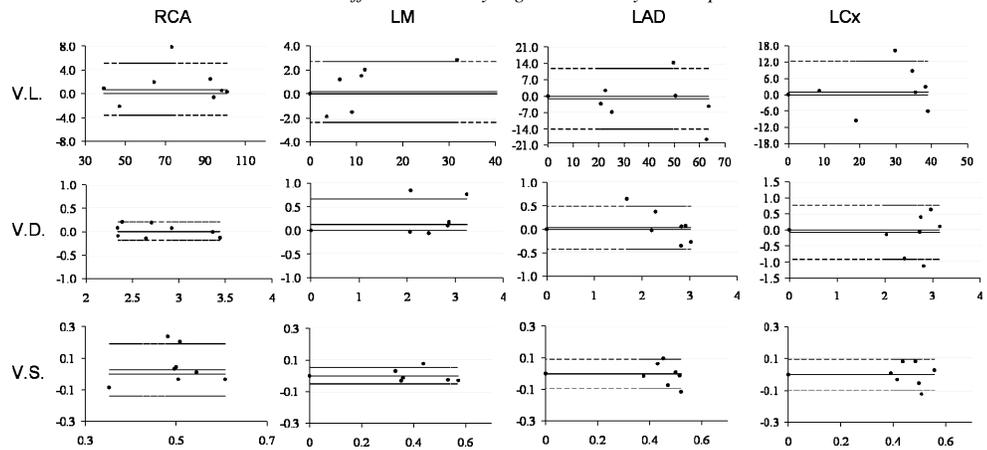


Figure 2. Bland Altman plots of the different coronary segments for Vessel length (V.L), Vessel Diameter (V.D) and Vessel Sharpness (V.S). Vertical axis represents the difference values and horizontal axis the mean values between systole and diastole for the parameters of V.L. or V.D. or V.S.

	RCA		LM		LAD		LCx	
Cardiac phase	Systole	Diastole	Systole	Diastole	Systole	Diastole	Systole	Diastole
Vessel Length	76.94±24.15	75.54±23.96	21.26±31.06	20.93±31.41	41.02±18.44	43.36±20.24	30.35±12.8	28.21±11.48
Vessel Diameter	2.78±0.42	2.76±0.47	2.34±1.15	2.09±1.02	2.58±0.37	2.5±0.64	2.61±0.56	2.77±0.4
Vessel Sharpness	0.52±0.1	0.48±0.09	0.37±0.19	0.37±0.19	0.46±0.05	0.47±0.07	0.47±0.06	0.47±0.07
Quality Score	3.88±0.44	3.19±0.75	3±0.6	2.5±0.53	3±0.6	2.5±0.53	3.14±0.56	3±1