Cardiac MRI in Pediatric Patients with Congenital Heart Disease: Comparison at 1.5T and at 3.0T

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ABSTRACT

Background: Despite the theoretical advantages of higher field strength, the widespread adoption of cardiac MRI at 3.0T has been slow, largely due to the increased sensitivity of SSFP cine to off-resonance artifact. Furthermore, to the best of our knowledge, there have been no published reports on the use of 3.0T for imaging in pediatric congenital heart disease (CHD). We sought to assess the feasibility of cardiac MRI in pediatric patients with CHD at 3.0T and to compare the technical and diagnostic performance with an age-matched and clinically comparable control group at 1.5 T.

Materials and Methods: Forty-six pediatric patients with suspected or known CHD were referred for clinical cardiac MRI evaluation. Twenty-three underwent imaging at 1.5T (age range 1 day to 7.8 years old, mean 28.7 ± 33 months) and twenty-three underwent imaging at 3.0T (age range 3 days to 8 years old, mean 47.8 ± 31.4 months). SSFP cine imaging, time-resolved magnetic resonance angiography (TR-MRA), and high resolution contrast-enhanced MRA (CE-MRA) were performed routinely. Two readers independently evaluated the data sets for overall image quality, thoraco-abdominal vessel and cardiac chamber definition, and presence of artifacts. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) from both data sets were calculated.

Results: 95% of SSFP cine images at 3T were rated as good or excellent image quality with 73% having mild and 24% having moderate artifacts (k = 0.07). SNR of myocardium at 3T and 1.5T were 45.0 ± 22.3 and 19.0 ± 6.3 ($P < 0.01$), respectively. CNR between myocardium and blood pool at 3T and 1.5T were 25.7 ± 20.0 and 7.8 ± 5.2 ($P < 0.01$). 100% of Arterial and 100% of venous phase CE-MRA images were considered good or excellent quality (k = 1). Cardiac chamber definition was considered good or excellent in 95% of arterial and venous phase CE-MRA images (k = 0.08). 100% of Arterial and venous phase CE-MRA images showed good or excellent definition of the thoraco-abdominal vessels (k=0.08). SNR of the aorta and PA were 31.7 ± 10.9 vs 18.0 ± 9.2 at 3T and 24.3 ± 11.9 vs 23.2 ± 10.6 at 1.5T ($P<0.01$), respectively. CNR between the aorta and muscle was 25.2 ± 10.4 at 3T vs 18.4 ± 9.8 at 1.5T. CNR between the PA and lung field was 19.6 ± 11.6 at 3T and 17.9 ± 10.0 at 1.5T ($P < 0.01$). TR-MRA maximum enhancement factor at the aorta and PA was 2.3 ± 1.9 vs 3.2 ± 2.1 at 3.0T and 1.7 ± 0.8 vs. 2.5 ± 1.6 at 1.5T ($P < 0.01$). On average, both readers scored cine SSFP images higher at 1.5T and CEMRA images higher at 3.0T. However, overall diagnostic performance was high at both field strengths.

Conclusions: Cardiac MRI of pediatric patients with CHD and vascular abnormalities at 3.0T is feasible. Relative to 1.5T, SNR and CNR are both improved at higher field strength and higher resolution CEMRA is achievable. Whereas SSFP artifacts at 3.0T are more prevalent, they rarely render cine imaging non-diagnostic. Both field strengths can be used successfully for cardiac and vascular imaging. The decision as to which to use is weighted by local availability and the relative requirement for detailed vascular vs intra-cardiac imaging.