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Free breathing high temporal resolution time resolved contrast enhanced MRA (4D MRA) at high heart rates using keyhole SENSE CENTRA in congenital heart disease

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Introduction

In children with CHD, achieving adequate separation of right-sided, left-sided, and venous structures using conventional CEMRA is hampered by high heart rates and the fast circulation. The need for visualizing small structures prolongs the acquisition time, and necessitates intubation and breath-holding to reduce motion induced blurring.

Purpose

To investigate the feasibility of a free-breathing time resolved CEMRA (trCEMRA) acquisition that is suitable for children with high heart rates using a keyhole approach combined with parallel imaging.

Methods

18 patients age range 0-10 years (12/18 were </= 5 years), were imaged under intravenous sedation for the following CHD indications: aorta or aortic arch morphology (8/18), branch pulmonary arteries (7/18), systemic veins (4/18), pulmonary veins (3/18), and systemic arteries (1/18). Heart rates ranged from 76-160 (mean 102 bpm). A free-breathing trCEMRA sequence was used with the following acquisition parameters: TR 4-5.5 ms, TE 1.2-1.6 ms, flip angle 35-45°, CENTRA k-space filling, acquired voxel size 1-1.3 × 1.1.3 × 2-2.8 mm^3, reconstructed voxel size 0.65-1 × 0.65-1 × 1-1.4 mm^3, number of dynamics 9-17, key-hole percentage 25-38%, two-dimensional SENSE factor 2 × 1-2 × 2, gadolinium dose 0.2 mmol/kg, and injection rate 1-3 cc/second. The number of phase encoding steps was adjusted so that the dynamic scan time was synchronized with the duration of the respiratory cycle. Respiratory rates ranged from 16-32/min. Dynamic times for the 3D MRA ranged from 1.9 to 3.6 seconds.

The quality of the MRA was graded by a subjective scale from 1-5 (1 = excellent, no limitations; 2 = good, minor limitations; 3 = moderate, moderate limitations; 4 = poor, major limitations but still of diagnostic quality; 5 = non-diagnostic).

Results

All except 2 studies were graded 1-2. 2 studies were graded 3. All studies were considered diagnostic. Adequate temporal separation of right-sided (where applicable), left-sided, and systemic venous phases of first pass contrast enhancement was achieved in all cases. Two studies had blurring of vessel margins related to motion. One study had suboptimal contrast intensity on all dynamics due to a slow rate of contrast injection by hand. Comparison with 3D SSFP non-contrast angiographic sequence, CTA or catheterization was available in 14 cases. There was one diagnostic discrepancy.

Conclusion

Respiratory synchronized trCEMRA technique that uses a combination of SENSE, key-hole, and centric data acquisition provides good quality 4D MRA images capable of temporally resolving the contrast bolus passage in

neonates, infants and children with high heart rates during free breathing.