Free Breathing Time Resolved Contrast Enhanced-MRA using SENSE in Pediatric Patients

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Introduction

Unlike in adults, three-dimensional contrast enhanced MRA (CE-MRA) [1] is not as widely used in pediatric patients, despite the obvious need for a non-invasive pediatric vascular imaging tool. The main reasons include: (a) breathholding that is often necessary for a high- quality CE-MRA acquisition is not suitable for infants and children; (b) higher spatial resolution required to visualize small structures demands more acquisition time; (c) faster circulation time in pediatric patients makes the duration of the first pass of the bolus even more transient complicating arterial-venous separation;(d) smaller volume of contrast that can be used in pediatric patients prohibits the luxury of a test bolus. Conventional methods to shorten CE-MRA acquisitions often entail compromises in the acquired spatial resolution. In this regard, sensitivity encoding (SENSE) has been shown to be an effective method to accelerate the acquisition speed without compromising spatial resolution [2-3]. This may be specifically applicable for CE-MRA, where the loss of signal-to-noise ratio (SNR) involved in acquiring SENSE data can be partially offset by the intrinsic increase in SNR associated with contrast enhancement. We used SENSE to obtain free breathing, time resolved, 3D CE-MRA data-sets at a temporal resolution of 5-10 seconds in 11 pediatric patients to image the vessels of the thorax and abdomen.

Methods

All studies were done on a 1.5 T Philips scanner with a software patch (CPR6). Eleven pediatric patients (median age: 3 years; range: 18 days to 19 years) were imaged with a 3D-T1 weighted FFE sequence: TR/TE/flip = 5.1 msec/1.2 msec/40 deg.; 212-228x256 matrix (in-plane) over a FOV of 300-500 mm depending on size of patients; 35-50, 1.9-5 mm thick slices acquired (reconstructed as 0.95-2.5 mm thick); SENSE acceleration factor of 2.0 was used to reduce in-plane phase encoding FOV so that 4-8 3D volumes were acquired at a temporal resolution of 5.5-10 sec. The acquisition and contrast (0.2 mmol/kg of Gd-DTPA)injection were started simultaneously. Data were collected during free breathing with a standard four-element phased-array coil and reconstructed on the scanner console. To analyze the data quantitatively, arterial to venous signal ratio (AVR) was computed for each dynamic. Because SENSE reconstruction relies on the spatially varying coil sensitivity functions, the noise is non-uniform across the image [2-3]. Thus, to avoid any bias that may be introduced by this non-uniform noise, the arterial and venous regions-of-interest (ROI) were chosen to be next to each other on the same slice.

Results

SENSE acquisition, reconstruction and diagnostic evaluation was successfully performed in all cases. Maximum intensity projections from the 3D CE-MRA data are shown in Fig. 1-2. The 3D volume that had the highest AVR was identified as the the peak arterial volume and the AVR of the temporally adjoining volumes were identified as pre, and post-arterial volumes. The AVR of the pre, peak and post arterial volumes were 1.0+/-0.8, 7.0+/-3.5, and 1.7+/-1.1 respectively [Fig. 3].

Discussion

SENSE allows rapid sampling of the contrast concentration curve without compromising spatial resolution [4]. Note the significantly reduced AVR in the post-arterial volume indicating a rapid dilution of the contrast in the pediatric body following first pass. So, a 3D acquisition without SENSE that takes twice as long (to maintain the same spatial resolution) would collect k-space data when the contrast concentration is rapidly varying and could result in blurring [5,6]. Conclusion: Time resolved 3D CE-MRA with SENSE allows angiographic evaluation of thoraco-abdominal vessels in pediatric patients without the need for breath-holding.

References

1. Prince et al., JMRI 1993;3:877-81; 2. Pruessmann KP et al., MRM 1999;42,952-62; 3. Weiger, et al., JMRI 2000;12:871-7; 4. Korosec et al., MRM 1996:36:345-51; 5. Maki, et al., JMRI 1996;6:642-51; 6. Wilman et al., MRM 1998;40:24-35.

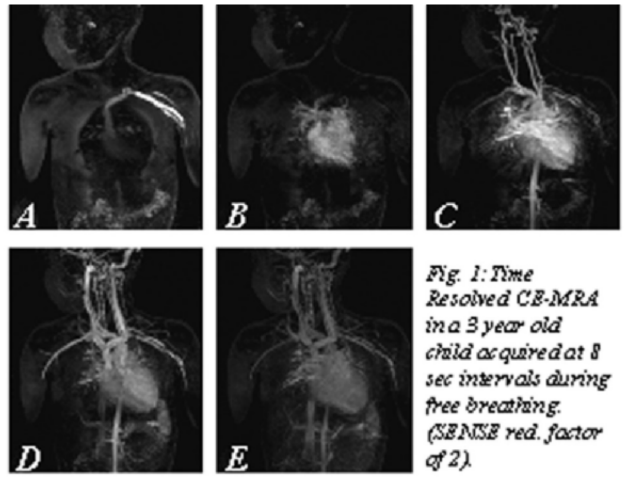

Fig. 1: Note clear separation of arterial and venous phases

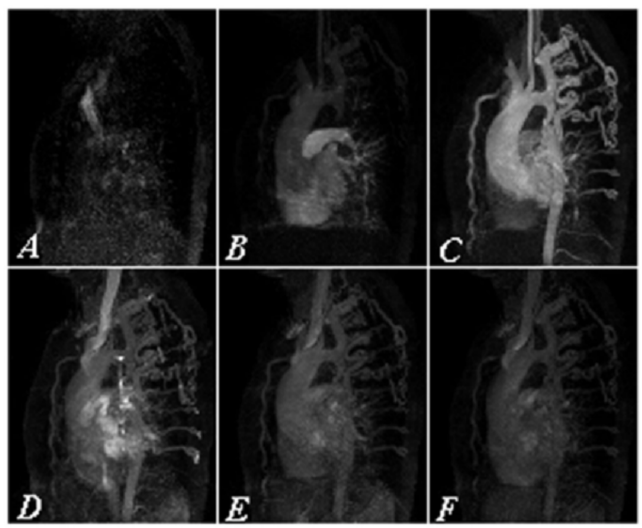

Fig. 2: Free breathing time resolved (8.2 sec each) CE-MRA depicting aortic coarctation with collaterals(C)

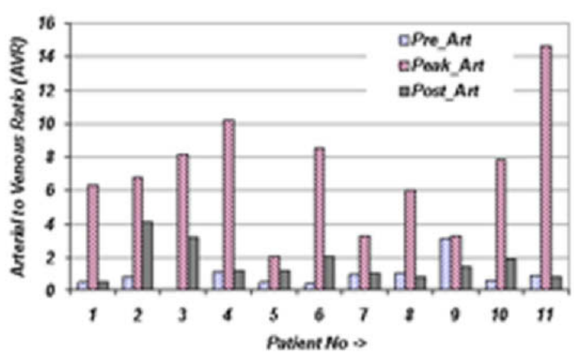

Fig. 3: AVR of pre, peak, and post arterial volumes in patients