Validation of 3D-CEMRA with 2D ARC Acceleration in a Porcine Study

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INTRODUCTION: Contrast enhanced MR angiography (CEMRA) has become widely accepted for the noninvasive evaluation of the intra-abdominal vasculature. Typically, data acquisition is completed within a single breath-hold limiting the total scan time to 15-30s. With traditional CEMRA techniques the volume that can be obtained within that duration is limited. As a result, examinations are typically focused on only a subset of the intra-abdominal vessels (e.g. a coronal slab for renal CEMRA and a sagittal slab for mesenteric CEMRA). With parallel imaging methods,[1-3] greatly accelerated acquisitions now offer the opportunity to increase the volume of coverage (Fig. 1), while maintaining image quality. The purpose of this study was to validate a previously described CEMRA with 2D parallel imaging acceleration (auto-calibrating reconstruction for Cartesian sampling, "ARC")[4-6] for quantifying the severity of renal artery stenosis (RAS) in a pocine model using digital subtraction angiography (DSA) as a gold standard.

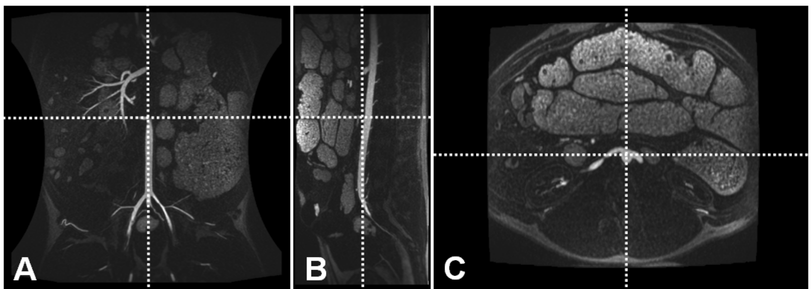

Fig. 1: With 2D ARC parallel imaging, a volumetric CEMRA dataset can be acquired within 16 seconds. Coronal (A), sagittal (B), and axial (C) MPR images.

MATERIALS AND METHODS: Following local Animal Care and Use Committee approval, RAS were created surgically in 12 swine (weight = 36.4±1.8kg). All examinations were performed under general anesthesia. 3D rotational DSA was used as the gold standard for quantification of the degree of stenosis in 8 animals. Projectional DSA was used for comparison in the other 4 animals. Following DSA, each animal was imaged on a clinical 1.5T system (Signa HDx TwinSpeed, GE Healthcare, Waukesha, WI). CEMRA was performed during the hand injection of 0.1mmol/kg (6.8-7.9ml) of gadobenate dimeglumine (MultiHance, Bracco Diagnostics, Inc., Princeton, NJ). Parameters used for the CEMRA include: TR/TE = 3.4/1.1ms, flip angle = 25°, bandwidth = ±83.3kHz, FOV = 34x27cm^2, matrix = 256x224, 184 slices, slice thickness = 1.5mm, for a true acquired spatial resolution of 1.3x1.2x1.5mm^3 which were zero-filled to 0.7x0.7x0.8mm^3. A clinical cardiac phased array coil with 8 elements and a net acceleration factor of 3.67 was used for data acquisition. Total scan time was 16s. CEMRA images were reviewed independently in randomized order by 3 expert cardiovascular radiologists on a PACS workstation. Reviewers graded the severity of the renal artery stenosis on a six-point scale (0=normal; 1=1-24% stenosis; 2=25-49% stenosis; 3=50-74% stenosis; 4=75-99% stenosis; 5=occluded). The severity of renal artery stenosis by CEMRA was compared to quantitative DSA measurements. Reviewers also assessed (A) the number of visible segmental renal artery branch vessels; (B) the overall image quality for the renal arteries, (C) the presence of noise, and (D) the presence of artifacts.

RESULTS: CEMRA was successfully performed in all studies (Figs. 1, 2). The severity of stenosis on the CEMRA images correlated well with that determined by DSA (Pearson correlation coefficient = 0.69, 0.72, and 0.84 for readers 1, 2, and 3, respectively). The mean difference in stenosis severity between CEMRA and DSA was -0.25 (± 0.75) for the three readers. 3rd and 2nd degree renal branch vessel were depicted in 51.4% and 30.6% by CEMRA, respectively. Image quality was rated excellent (4/4) in 86.1%. Artifacts (8.3% of cases) and substantial noise (19.4% of cases) were present on the CEMRA studies, but did not interfere with image interpretation in any of the cases.

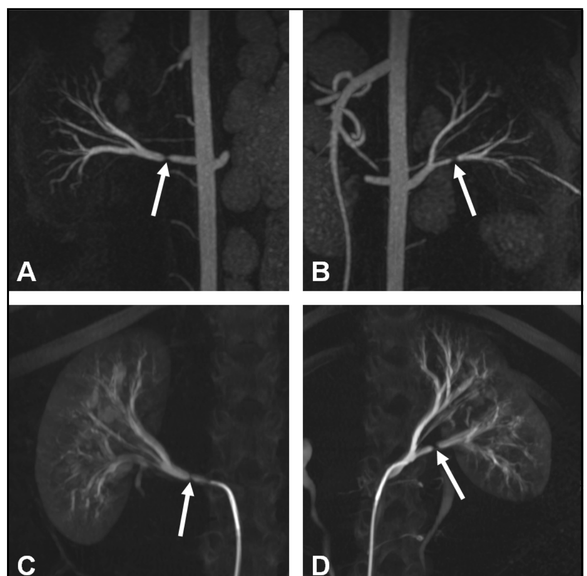

Fig. 2: CEMRA (A, B) and DSA (C, D) of the right (A, C) and left (B, D) renal arteries in a porcine model of renal artery stenosis (RAS). The severity of RAS by CEMRA closely correlates with that determined by the gold standard, DSA.

CONCLUSIONS: Rapid CEMRA with large volumetric coverage using 2D ARC parallel imaging is a highly accurate means of grading renal artery stenosis, compared to DSA. The use of 2D-ARC allows for an approximately 3.7x increase in scan coverage, facilitating acquisitions that cover the entire abdomen with high spatial resolution for all abdominal 3D-CEMRA indications.

REFERENCES: 1. Pruessmann, et al. MRM 1999;42:952. 2. Griswold, et al. MRM 2002; 47:1202. 3. Fenchel, et al. Invest Radiol 2006;41:697; 4. Beatty et al., ISMRM 2007 #1749. 5. Brau et al. ISMRM 2006 #2462. 6. Lum et al. ISMRM 2008 #2865.