Increased Volume of Coverage for Abdominal Contrast-Enhanced MRA with 2D Autocalibrating Parallel Imaging: Initial Experience at 3.0T

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INTRODUCTION: Three-dimensional contrast-enhanced MR angiography (3D CE-MRA) has become widely accepted for the noninvasive evaluation of the intra-abdominal vasculature. Data acquisition must occur within a single breath hold, typically 20-30 seconds. With current technology the volume of coverage that can be obtained within the time constraints of a single breath hold is limited. As a result, only a subset of the intraabdominal vessels is visualized with conventional techniques. With the advent of parallel imaging methods[1,2], greatly accelerated acquisitions now offer the opportunity to increase the volume of coverage[3], while maintaining image quality. The purpose of this work is to combine a previously described 2D parallel imaging method (Autocalibrating Reconstruction for Cartesian sampling - ARC)[4,5] with 3D CE-MRA for complete abdominal coverage within a breath hold.

MATERIALS AND METHODS: With institutional review board approval, 6 healthy volunteer subjects and 8 consecutive patients were imaged on a 3.0T system (Signa EXCITE HDx TwinSpeed; v14; GE Healthcare, Waukesha, WI) after providing written informed consent. For the 6 volunteers, an intraindividual comparison study was performed. Each volunteer received two 0.15mmol/kg injections of gadobenate dimeglumine (MultiHance, Bracco Diagnostics, Inc., Princeton, NJ) separated by 90 minutes to allow urinary excretion of contrast. 3 volunteers underwent the MRA exam accelerated with parallel imaging first; the other 3 underwent the conventional non-accelerated MRA exam first. Both techniques utilized sampling of a full echo with minimum echo time. Prior to evaluating this technique on a series of patients, further technical developments included the implementation of a fractional echo with minimum echo time. Parameters are reported in Table 1. For 2D-ARC scans, the RF excited a sagittal slab to eliminate L/R phase wrap from arms or peripheral anatomy, however images were reconstructed in coronal sections. Field of view, matrix size (after correction for rectangular-FOV fraction), and spatial resolution are reported S/I x L/R x A/P. Images were reviewed independently in randomized order by 2 radiologists experienced in vascular imaging on a PACS workstation (Horizon RadStation, v11.0, McKesson Medical Imaging Group, Richmond, BC). Image quality was rated on a five-point scale (4 = excellent, 3 = good, 2 = fair, 1 = poor, 0 = non-diagnostic) at the abdominal aorta, the celiac trunk, the superior mesenteric artery, the proximal and segmental renal arteries, the proper hepatic artery and its branches, and the bilateral common iliac arteries. Scores are reported as medians.

Table 1: Pulse Sequence Parameters

Exam Type	Volunteer	Volunteer	Patient
Parallel Imaging	None	2D-ARC	2D-ARC
Excitation Slab	Obl. Cor.	Sagittal	Sagittal
TR (msec)	4.6	4.5	3.4
TE (msec)	1.9	1.9	1.1
Flip Angle (degrees)	32	32	25
Bandwidth (kHz)	62.5	62.5	83.3
Field of View (cm)	34 x 25.5 x 9.7	34 x 33.6 x 25.5	34 x 30 x 27.2
Matrix Size (after pFOV)	256 x 144 x 54	256 x 224 x 168	256 x 200 x 180
Spatial Resolution (mm)	1.3 x 1.8 x 1.8	1.3 x 1.5 x 1.5	1.3 x 1.5 x 1.5
Scan Duration (sec)	28	27	28

RESULTS: Amongst the 6 volunteer exams, a total of 71 vessel segments were evaluated. A score of 2 or higher was considered to be diagnostic.

Table 2: Median Image Quality Scores

	6 Volunteers				8 Patients	
	Reader 1		Reader 2		Reader 1	Reader 2
	2D-ARC	Standard	2D-ARC	Standard	2D-ARC	2D-ARC
All Segments	3	3	3	3	3	3
Proximal Renal	3	4	3	3	3	4
Segmental Renal	3	3	3	3	2	2
Proper Hepatic	2	0	3	1	3	3

Reader 1 rated 66/71 (93%) and 59/71 (83%) of segments to be diagnostic for the 2D-ARC accelerated and conventional sequence respectively. Meanwhile, Reader 2 rated 70/71 (99%, 2D-ARC) and 67/71 (94%, conventional) of the evaluated segments diagnostic. Scores were higher for the proper hepatic artery as it was often not included in the imaging volume with the standard oblique coronal slab acquisition.

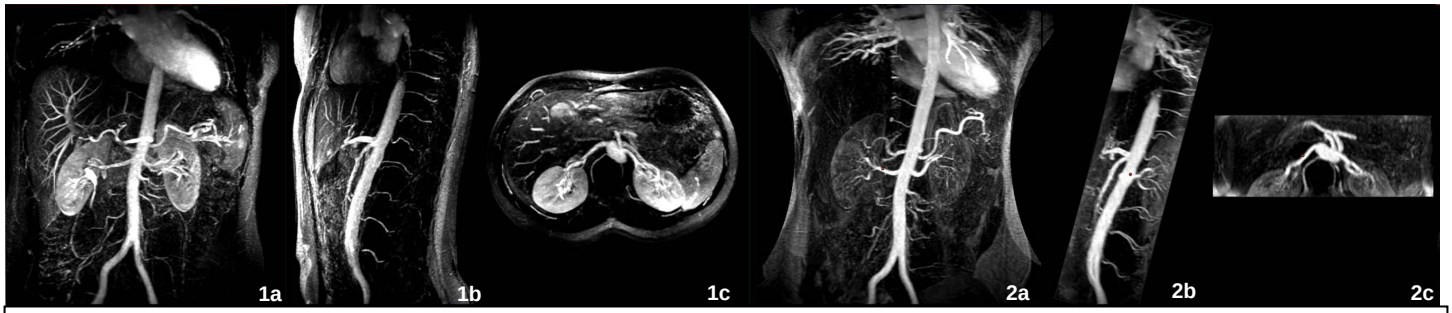

Figure 1: 3.5x increase in coverage, 30% reduction in voxel size, and similar image quality in the same scan time. Coronal (a), sagittal (b), and axial (c) 3D CE-MRA with 2D ARC. **Figure 2**: Corresponding coronal (a), sagittal (b), and axial (c) images in the same volunteer without parallel imaging

CONCLUSIONS: In this study, we find that the subjective image quality of these two methods was essentially equivalent. However, the 2D-ARC accelerated sequence provided a 3.5 fold increase in imaging volume, allowing coverage of the entire abdomen with a 30% reduction in voxel size in the same acquisition time. Such an increase in coverage improves the ease of prescription and allows improved visualization of the branches of the celiac and superior mesenteric vessels. Results in 8 patients demonstrated high quality, diagnostic contrast enhanced MR angiograms as rated by the two board certified radiologists.

REFERENCES:

1. Pruessmann KP, et al. Magn Reson Med. 1999 Nov;42(5):952-62.
2. Griswold MA, et al. Magn Reson Med. 2002 Jun;47(6):1202-10.
3. Fenchel M, et al. Invest Radiol. 2006 Sep;41(9):697-703.
4. Beatty et al. p.1749. Proceedings of the ISMRM, 2007.
5. Brau et al. p.2462. Proceedings of the ISMRM, 2006.