Time-resolved MR Angiography in Evaluation and Mapping of Central Thoracic Veno-occlusive Disease

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Introduction: Advances in fast imaging tools such as parallel acquisition (1) and sparse k-space sampling methods such as time-resolved angiography with interleaved stochastic trajectories (TWIST) (2, 3), have the potential to improve the performance of time-resolved MR angiography (TR-MRA). Another potential advantage of TR-MRA is the requirement for substantially less gadolinium in comparison to conventional MRA. In light of recent reports regarding the implication of gadolinium-based contrast agents as a causative factor in the development of nephrogenic systemic fibrosis (4), it seems logical to minimize the amount of gadolinium administered, particularly in high risk population of patient with central venous disease many of whom with underlying renal disease.

Purpose: The purpose of our study was to evaluate the feasibility and diagnostic performance of a 3D TR-MRA protocol in evaluation of central thoracic venous occlusive disease and comparison with conventional MRA and catheter angiography.

Materials and Methods: Twenty patients (8F, age range: 19-74 y/o) with suspected central venous disease were examined by a CE-MRA protocol including both time-resolved and conventional MRA acquisitions on a 32-channel 1.5T whole-body MR scanner (Magnetom Avanto, Siemens Medical Solutions). A combination of 24 coil elements was used to cover a maximum field of view of 500 mm over the entire thorax and upper extremities. After intravenous injection of 6ml gadolinium at 2ml/s, TR-MRA was implemented in the coronal plane, using a 3D fast GRE sequence (TR/TE: 2/0.9 ms; FA: 20°; BW: 1000 Hz/pixels, FOV: 500 x 458 mm, matrix: 384 x 342, slice thickness: 7mm; slab thickness: 140 mm). Generalized autocalibrating partially parallel acquisitions (GRAPPA) (1) with an acceleration factor of 2 in phase encoding direction was employed, as was TWIST, a recent view-sharing technique, which undersamples the periphery of k-space depending on the radial distance of the center of k-space (2). By combination of GRAPPA and TWIST, the resulting 3D datasets were acquired with a temporal resolution of 1.5 seconds per frame for a total of 20 sequential measurements. Subsequently after IV injection of 0.2 mmol/kg of contrast, conventional CE-MRA was performed during a 20s breath-hold with acquired voxel dimension of 1 x 1 x 1.1 mm3 using a GRE sequence (TR/TE: 2.8/1.1ms; FA: 25°; BW: 5610 Hz/pixels, FOV: 500 x 375mm; matrix: 512 x 330, 124 slices with 1.1 mm thickness, and GRAPPA x 3). Time-resolved and conventional MRA images were evaluated in separate reading sessions by two independent radiologists for image quality/level of confidence and degree of veno-occlusive disease. The interobserver/intermodality agreements were evaluated and sensitivity and specificity were calculated using catheter angiography as standard of reference.

Results: TR-MRA were resulted in diagnostic image quality without significant difference in comparison with conventional MRA. Thirty one segmental disease were identified including 5 segments with <70% stenosis, 12 segments with 70-99% stenosis, and 14 segmental occlusions. Interobserver agreement was good for TR-MRA (κ = 0.62; 95% CI: 0.42; 0.83) and excellent for conventional CE-MRA (κ = 0.84; 95% CI: 0.65; 0.98). Kappa% coefficient of good intermodality agreement (κ = 0.96; 95% CI: 0.62; 0.76) between TR-MRA and conventional CE-MRA. When compared to catheter angiography, the sensitivity and specificity for diagnosis of significant stenosis (≥70%) were 87.5% and 68% for TR-MRA and 90% and 90% for conventional CE-MRA respectively. In five patients both TR-MRA and conventional CE-MRA were negative. In 4 patients with occlusion of superior vena cava, TR-MRA mapped the sequential filling of the collateral circulation, a sequence not apparent on conventional MRA images.

Conclusion: Described 3D TR-MRA protocol over a large field of view provides comprehensive assessment of central venous occlusive disease anatomy, collateralization and hemodynamics. Having a high comparable sensitivity, and need for only a small gadolinium dose, TR-MRA has the potential to be used as an initial and screening diagnostic tool, obviating the need for conventional MRA and higher contrast dose in normal or near-normal examination. However, due to its relatively lower specificity, adjunct use of conventional CE-MRA is still required for accurate grading of venous occlusive disease.

References:

Figure. Coronal MIP images from TR-MRA (6ml gadolinium) show sequential filling of the central thoracic veins with temporal resolution of 1.5s. Using a 500 mm filed of view allows for comprehensive evaluation of the entire thoracic and upper extremity arterial and venous system in a single station acquisition. Note high-grade focal stenosis of the superior vena cava (arrows in frame 4 & 5), the presence of arterio-venous fistula with aneurysmal venous dilatation in the right upper arm (arrowheads in frame 9 & 10), and complete occlusion of the right subclavian vein (arrows in frame 13 & 14).