3D Contrast-Enhanced MR Angiography in Occlusive Disease of the Central Thoracic Veins

K. Nael[1], M. Krishnam[1], S. Ruehm[1], G. Laub[2], and J. Finn[1]

[1]Radiological Sciences, David Geffen School of Medicine at UCLA, Los Angeles, CA, United States, [2]Radiological Sciences, Siemens, Los Angeles, CA, United States

Objective: Multi-channel MR scanners have greatly improved the performance of MR angiographic protocols in terms of speed, coverage, signal-to-noise, resolution or a combination of all **(1, 2)**. The purpose of this study was to evaluate the feasibility and clinical usefulness of 3D CE-MR angiography encompassing both high spatial resolution and functional angiographic protocols over a large field of view; specifically to evaluate the central thoracic veins and their entire course of inflow and outflow in patients with suspected central venous occlusive disease.

Materials and Methods: Ten patients (7F, 19-66 y/o) with suspected central venous disease underwent a CE-MRA protocol including both time-resolved and high spatial resolution acquisitions on a 32-channel 1.5T whole-body MR scanner (Magnetom Avanto, Siemens Medical Solutions). For signal reception a combination of 24 coil elements were used to cover a maximum field of view of 500 mm encompassing the chest, neck and abdomen. After intravenous injection of 6ml gadolinium (Berlex Laboratories) at 4ml/s, time-resolved 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: 10mm; slab thickness: 140 mm). Applying temporal echo-sharing with 3 k-space segments of equal size **(3)**, and generalized autocalibrating partially parallel acquisitions (GRAPPA) **(4)** with an acceleration factor of 2 in the phase encoding direction, breath-hold 3D datasets were acquired with a temporal resolution of 1.5s, and in-plane spatial resolution of 1.3 x 1.3 mm, for a total of 15 sequential measurements. Subsequently high spatial resolution CE-MRA was performed during a 20s breath-hold with acquired isotropic voxel dimension of 1 x 1 x 1.1 mm^3 after IV injection of 0.1 mmol/kg of contrast at 1.5ml/s, using a GRE sequence (TR/TE: 2.8/1.1ms, FA: 25°, BW: 610 Hz/pixels, FOV: 500 x 375mm; matrix: 512 x 330, 124 slices with 1.1 mm thickness, and GRAPPA x 3). Full-thickness collapsed maximum intensity projections from the CE-MRA were reconstructed, and evaluated independently by 2 radiologists. MRA results were correlated with the findings at digital subtraction angiography (DSA) and intermodality agreement for determination of categorized segmental disease was evaluated.

Results: Abnormal findings included 8 venous stenoses and 12 venous occlusions were detected on MR angiograms and were confirmed by DSA with excellent intermodality agreement ($\kappa = 1$). In 3 patients who had complete SVC occlusion, time resolved MRA mapped the sequential filling of the collateral circulation (**fig**), a sequence not apparent on the non-time-resolved images. Overall, MR angiography findings helped determine the anatomical and dynamic status of upper extremity and central thoracic veins in all patients.

Conclusion: The described protocol provides comprehensive evaluation of central thoracic venous-occlusive disease with high diagnostic accuracy in comparison with DSA. By combining time resolved imaging and steady state imaging over a large field of view, it is possible to clarify the sequence of filling of patent segments and collateral pathways, providing important complementary anatomical and dynamic information.

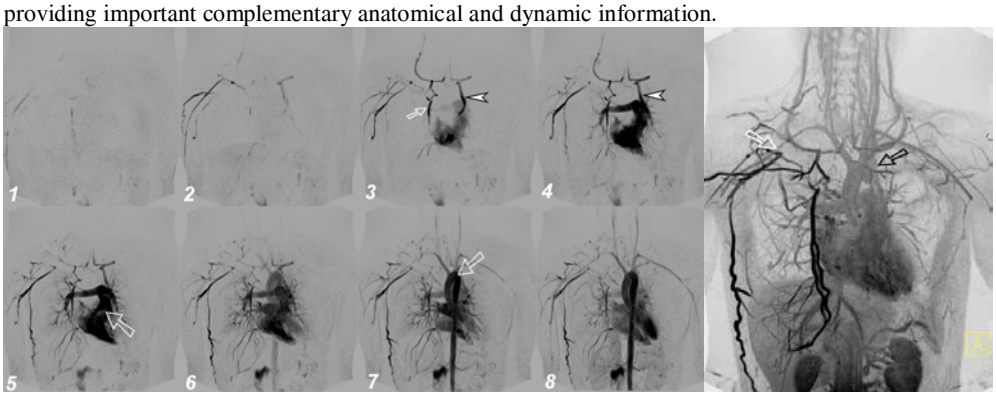

Figure (A) Coronal MIP images from time-resolved CE-MRA: a 500mm FOV enabled depiction of the entire thoracic and upper extremity veins with 1.5s temporal resolution following injection of only 6ml contrast. Due to occlusion of the right subclavian vein, right innominate vein and SVC, contrast fills the Azygos vein (arrow in 3) and left SVC (arrowhead in 3 & 4), which then drains to right atrium. This follows by pulmonary (arrow in 5) and systemic circulation (arrow in 7). High spatial resolution MRA **(B)** shows occlusion of the right subclavian vein (white arrow in B), right innominate vein, and SVC in addition to a widely patent left SVC (black arrow in B).

References:

1. Hardy, C.J., R.D. Darrow, M. Saranathan, R.O. Giaquinto, Y. Zhu, C.L. Dumoulin, et al., Large field-of-view real-time MRI with a 32-channel system. Magn Reson Med, 2004. 52(4): p. 878-84.

2. Zhu, Y., C.J. Hardy, D.K. Sodickson, R.O. Giaquinto, C.L. Dumoulin, G. Kenwood, et al., Highly parallel volumetric imaging with a 32-element RF coil array. Magn Reson Med, 2004. 52(4): p. 869-77.

3. Korosec, F.R., R. Frayne, T.M. Grist, and C.A. Mistretta, Time-resolved contrast-enhanced 3D MR angiography. Magn Reson Med, 1996. 36(3): p. 345-51.

4. Griswold, M.A., P.M. Jakob, R.M. Heidemann, M. Nittka, V. Jellus, J. Wang, et al., Generalized autocalibrating partially parallel acquisitions (GRAPPA). Magn Reson Med, 2002. 47(6): p. 1202-10.