TIME-RESOLVED MR ANGIOGRAPHY FOR THE DETECTION OF STENOSES AND OCCLUSIONS OF CENTRAL VEINS

C. Y. Kim[1], R. A. Mirza[1], J. A. Bryant[1], E. Whiting[1], D. DeLong[1], C. E. Spritzer[1], and E. M. Merkle[1]

[1]Dept of Radiology, Duke University Medical Center, Durham, NC, United States

Background:

MR is becoming increasingly popular as a noninvasive means for evaluating the central venous system for stenoses and occlusions, particularly in patients with long term indwelling central venous catheters and end stage renal disease. MR evaluation of the central veins has been reported to be highly sensitive and specific in the detection of stenoses and occlusions when compared to conventional venography[1]. However, the optimal MR sequences for evaluation of the central veins have not yet been clearly identified in the literature. The time-resolved echo-shared angiographic technique (TREAT) allows visualization of the progression of contrast through the veins at rapid 3-4 second intervals, allowing one to assess the real-time dynamics of venous flow. The purpose of this study is to assess the utility of TREAT sequences for the detection of stenoses and occlusions of the central veins, as an adjunct sequence or replacement for the conventionally utilized contrast enhanced high-resolution images.

Materials & Methods:

During an 8 month period, a total of 27 patients (11 males and 15 females, mean age = 45 ± 14 years) underwent MR angiography of the central veins at 1.5T (n = 10, Magnetom Symphony or Avanto, Siemens Medical Solutions, Germany) or 3.0T (n = 17, Magnetom Tim Trio). The sequence protocol consisted of time-resolved images which were acquired in a coronal orientation with a temporal resolution of 3-4 seconds for a total of 60 seconds during shallow breathing. This sequence commenced five seconds after the initiation of the first contrast administration (10mL Gd-DTPA at 2mL/sec followed by 20 mL of saline at 2mL/sec). Following a second administration of contrast (40mL Gd-DTPA at 2mL/sec followed by 20 mL of saline at 2mL/sec), breath-hold MRA images were obtained in a coronal orientation with at least 3 time points for each patient. Study interpretation was performed by six radiologists of varying levels of experience (two senior level faculty readers with specialized training in MRI, two fellows in abdominal imaging, and two residents in radiology).

The central venous system of the chest was divided into 7 venous segments, composed of the left and right internal jugular veins, subclavian veins, brachiocephalic veins, and SVC, comprising a total of 189 venous segments. The datasets were anonymized and divided into three sessions: Maximum intensity projection TREAT images only, high-resolution datasets only, and both. Each reader recorded the side of contrast injection and time to complete the interpretation of each study and scored each venous segment for the degree of stenosis along with their level of confidence. Stenoses were graded as none to mild (<50%), moderate to severe (50-95%), occluded or nearly occluded (95-100%), or not visualized well enough to rate. The level of confidence was graded on a numerical scale from 1-4, with 4 being the most confident. The true degree of stenosis for each segment was determined by any available conventional angiographic studies, surgical notes, and if none available, by a consensus read by the two senior radiologists.

Findings:

Of the 189 venous segments imaged, 49 had significant a stenosis or occlusion. The pertinent data is compiled in the table below. The average time for study interpretation was not statistically changed by the addition of TREAT images to the high-resolution datasets. The side of contrast injection was correctly inferred in 86% of studies when the TREAT images were available, compared to only 32% with high resolution images alone ($p<0.001$). The sensitivity and specificity for the detection of diseased venous segments (stenotic or occluded) were not significantly changed by adding TREAT images to high resolution images. However, for the faculty readers, the addition of TREAT images resulted in a statistically significant increase in specificity for detecting venous occlusions. The addition of TREAT images also resulted in a significantly higher degree of confidence compared to high resolution images alone ($p=0.003$). TREAT images as a stand-alone technique demonstrated poor sensitivity and specificity in the assessment of the central veins (0.45 and 0.56 respectively).

	1. TREAT	2. High res	3. both	p-value between 2 & 3
Mean reading time (mins)	3.0	3.4	3.3	0.28
Correct side of injection	86%	32%	83%	<0.001
Sensitivity for stenosis / occlusion	0.45	0.79	0.78	0.72
Sensitivity for occlusion	0.37	0.62	0.60	0.9
Specificity for stenosis / occlusion	0.56	0.84	0.84	0.63
Specificity for occlusion	0.72	0.96	0.97	0.13
Specificity for occlusion: Faculty readers only	0.74	0.96	0.99	0.03
Mean confidence level	2.6	3.4	3.5	0.003

Conclusions:

The addition of the TREAT images to the traditionally utilized high-resolution images did not significantly change the average reading time for each study or the sensitivity or specificity for the detection of stenoses. However, there was a statistically significant improvement in the detection of occlusions for faculty readers, likely due to improved visualization of collaterals compared to the high-resolution images alone. Furthermore, there was a statistically significant increase in reader confidence and ability to determine the side of contrast injection for all readers. The TREAT images as a stand-alone technique were inadequate for the assessment of central veins. Based on these results, we have added a time resolved MR angiography sequence to our standard central venous MRA protocol. We send only the maximum intensity images (usually 18 images) of the various TREAT series to our PACS system, which appears negligible in terms of storage space. In addition, the additional scan time of less than two minutes appears to be outweighed by the statistically significant improvement in reader confidence, specificity for detecting occlusions, and correct inference of the injection side.

References:

1. Thornton MJ, Ryan R, Varghese JC et al. “A three-dimensional gadolinium-enhanced MR venography technique for imaging central veins.” AJR 1999 173:999-1003.