MR angiography of the supraaortic arteries: a methodical update

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INTRODUCTION:

Although contrast-enhanced (CE) MR angiography has widely replaced catheter angiography for diagnosis of the supraaortic arteries there still remained some problems concerning diagnostic reliability – mainly at the origins of the neck vessels and the intracranial part of the internal carotid arteries. The aim of our study was to evaluate diagnostic reliability of three different state-of-the-art MR angiographic techniques performed on modern 1.5 T scanners with optimal coil configuration. Therefore, 36 MRAs of the supraaortic arteries were selected from three different institutes – 12 examinations per site.

METHODS:

All MR angiograms were acquired at 1.5 T using scanners with identical hardware configuration (Magnetom Symphony TIM, Siemens, 30 mT/m; head, neck, and spine array coil elements for signal detection). Three different MRA strategies were compared selecting 12 consecutive patients with suspected atherosclerotic disease of the supraaortic arteries for each technique from three different sites. From each site that strategy was selected which is well established and used for clinical routine. Technique 1 uses a fluoroscopic triggering with an acquisition time of 21 s, whereas a preceeding testbolus is applied in technique 2 and 3 for correct timing of the CE sequence (acquisition time: 22 s or 14 s), further details are given in table 1. Parallel imaging was employed for all techniques.

	technique 1	technique 2	technique 3
k-space ordering	elliptic centric	linear	linear
timing method	fluoroscopically triggered	testbolus	testbolus
breathhold command	no	yes	yes
TR / TE / flip angle	3.65 ms / 1.28 ms / 30°	3.78 ms / 1.54 ms / 35°	3.37 ms / 1.22 ms / 30°
voxel size	1.1 x 0.7 x 0.8 mm^3	1.2 x 0.6 x 0.8 mm^3	1.0 x 0.8 x 0.8 mm^3
acquisition time	21 s	22 s	14 s
contrast agent	25 ml Gd-DTPA	0.2 ml/kg BW Gd-BOPTA	25 ml Gd-DTPA

Table 1:
Three different MRA techniques for the supraaortic arteries

36 maximum intensity projections (MIPs) were calculated over a range of 360° for all angiograms and evaluated by an experienced neuroradiologist blinded to the imaging technique and to clinical findings. Overall image quality was judged on a scale from 1 to 5 (1: excellent, 2: good, 3: satisfactory, 4: moderate, 5: poor). Venous suppression for the extra- and intracranial vessels, delineation (image sharpness) of the aortic arch, and diagnostic reliability in evaluating different anatomical regions were assessed on a scale from 1 to 4: excellent (1); good, only minimal restrictions (2); some restrictions, but still sufficient for diagnosis (3); non-diagnostic (4). Means and standard deviations were calculated for all criteria.

RESULTS:

All techniques gave similar results with only minor differences, details for mean and standard deviation are given in table 2.

	technique 1	technique 2	technique 3
overall image quality	2.25 ± 0.87	1.83 ± 0.58	1.75 ± 0.87
venous suppression: extracranial	1.50 ± 0.52	1.33 ± 0.49	1.08 ± 0.29
venous suppression: intracranial	2.00 ± 0.60	1.83 ± 0.39	1.75 ± 0.45
image sharpness: aortic arch	2.00 ± 0.60	1.67 ± 0.65	1.50 ± 0.52
diagnostic reliability: innominate artery (origin)	1.58 ± 0.79	1.33 ± 0.49	1.17 ± 0.39
diagnostic reliability: subclavian artery (origin)	1.58 ± 0.79	1.36 ± 0.51	1.17 ± 0.39
diagnostic reliability: common carotid artery (origin)	1.54 ± 0.66	1.42 ± 0.65	1.21 ± 0.51
diagnostic reliability: vertebral artery (origin)	1.42 ± 0.78	1.35 ± 0.57	1.45 ± 0.91
diagnostic reliability: basilar artery	1.17 ± 0.39	1.00 ± 0.00	1.00 ± 0.00
diagnostic reliability: internal carotid artery (bifurcation)	1.05 ± 0.23	1.00 ± 0.00	1.08 ± 0.28
diagnostic reliability: internal carotid artery (skull base)	1.00 ± 0.00	1.00 ± 0.00	1.04 ± 0.20
diagnostic reliability: internal carotid artery (siphon)	1.00 ± 0.00	1.14 ± 0.35	1.04 ± 0.20

Table 2:
Visual evaluation of three different MRA techniques: means and standard deviations of 12 MRA examinations for each technique

Overall image quality was excellent or good in a total of 26 of 36 examinations, 10 were graded as satisfactory (technique 1: 6 angiograms, technique 2: 1, technique 3: 3). Venous overlap for the intracranial vessels resulted in some problems in 2 examinations (technique 1: grade 3). Delineation of the aortic arch was somewhat reduced (grade 3) in 3 angiograms (technique 1: 2, technique 2: 1). Diagnostic reliability of the origin of the innominate as well as of the left subclavian artery was restricted, but still possible in 2 patients using technique 1, respectively. Diagnostic reliability of the origins of the common carotid arteries was somewhat restricted in a total of 5 of 36 vessels (technique 1: 2, technique 2: 2, technique 3: 1). Assessment of the origin of the vertebral arteries was judged as excellent or good in 67 of 72 vessels, 1 vessel was graded as non-diagnostic using technique 1 and 2 vessels (in one patient) using technique 3. Diagnostic reliability of the internal carotid artery at the bifurcation, near the skull base and in the siphon, of the vertebral arteries in all segments above the origin as well as of the basilar artery was regarded to be good or even excellent for all vessels.

DISCUSSION AND CONCLUSION:

Using state-of-the-art equipment at 1.5 T for MRA of the supraaortic arteries yields good diagnostic reliability even in more critical regions. The combination of head, neck and spine array coils results in high signal-to-noise ratios (SNR) and allows for the application of parallel imaging. We found no relevant differences using three different techniques – although timing and contrast regime differed among these techniques. High spatial resolution with sufficient SNR – which was very similar for all sequences – seems to be an important prerequisite for this result. Venous suppression was a little bit more effective in MRA techniques with testbolus than in the fluoroscopically triggered technique. Overall image quality, delineation of the aortic arch as well as diagnostic reliabilty at the origins of the supraaortic arteries was slightly reduced in the fluoroscopically triggered technique. This result, however, might be mainly caused by motion artifacts of the aortic arch. Acquisition during breathhold – at least at the beginning of the measurement – would therefore be advantageous. A breathhold duration of 14 s or even of 22 s – as it was used for the techniques with preceeding testbolus – seemed to be acceptable for most patients.