Assessment of the supra-aortic vessels using time-resolved double-bolus 3D TWIST-MRA

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Introduction

In a routine clinical setting, MR angiography of the supra-aortic vessels is usually performed in CARE bolus technique. Generally, conventional contrast-enhanced MR angiography with CARE bolus technique yields good image quality in patients with stable hemodynamic conditions. However, in a considerable subgroup of patients hemodynamic conditions may change over time and are often unstable. In some cases, due to its subjective nature, it may be difficult to start the measurement at the time of maximal contrast concentration in the aortic arch. CARE bolus techniques necessitate high operator experience and interaction with the control panel.

TWIST is a recently introduced view-sharing time-resolved MR angiography technique that undersamples the periphery of k-space depending on the radial distance of the center of k-space [1, 2], which results in a high temporal resolution. The measurement time will be nevertheless by several seconds, if a high spatial resolution is required. This will lead to a superposition of venous and arterial vessels in some patients, if the contrast agent bolus is applied in an automatic way. Goal of the present work was to implement an automated and therefore robust protocol for the TWIST angiography of the supra-aortic vessels with high spatial resolution and increased likelihood of optimal arterial contrast by double bolus injection.

Materials and Methods

24 patients (10 men, 14 women; age range: 33-52 years, mean age: 43±14 years) who were scheduled for contrast enhanced cerebral MRI underwent a time-resolved angiography. All examinations were performed on a 32-channel 1.5-T whole body MR scanner equipped with a commercially available 8 channel head- and 4 channel neck matrix coils (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany).

Time resolved TWIST-MR angiography was applied in the coronal orientation using a 3D fast gradient-recalled echo (GRE) sequence with the following parameters: TR/TE, 3.37 ms /1.43 ms; Flip angle 25°; bandwidth 660 Hz/pixel; FOV 260 x 260 mm²; image matrix 426 x 448; slice thickness 0.8 mm. Parallel acquisition technique (GRAPPA) with an acceleration factor of 3 was used. By combining GRAPPA and TWIST, the resulting 3D data-sets were acquired with a temporal resolution of 8.4 seconds per frame with a total of 15 sequential measurements.

An electronic MR injection system (Spectris; Medrad, USA) was used for a biphasic injection protocol: 5 ml Gadobutrol (Gadovist; Bayer Schering Pharma, Berlin, Germany) were injected at a flow rate of 3 ml/s at the start of data acquisition. The second injection of 5 ml Gadobutrol was started with an interval of 20 seconds after the first injection automatically. Therefore the second injection started in the middle of the fourth sequential measurement. Each contrast agent application was followed by a saline flush of 20 ml with a flow of 3.0 ml/s.

Post-processing was performed with scanner software (Syngo, Siemens) using subtracted MR angiographic data to allow for reconstruction of multi-planar projection reformats (MPR), and maximum intensity projections (MIP) of TWIST.

Image evaluation was performed by two experienced neuroradiologists in a consensus reading. Image quality of the respective 3D datasets was rated according to a 4-point scale: 0=no arterial enhancement, non diagnostic; 1=minimal arterial enhancement, no confidence in diagnostic content; 2=diagnostic; 3=maximal arterial enhancement, high confidence in diagnosis.

Results

Only in 10 of 24 patients (42 %) sufficient depiction (rating >=2) of the arterial vessels in one time frame was achieved with the first bolus. Regarding the first bolus injection in 12 patients (50%) no clear separation between the venous and arterial vessels was evident. In these cases the second bolus was examined for sufficient arterial enhancement and confident assessment of the arteries. Figure 1 shows a typical result obtained with the second bolus. The venous contamination does not influence the diagnostic value when multi-planar reconstructions are used. Including the data acquired after the second bolus, a sufficient diagnosis (rating >=2, mean 3.5) could be obtained in 22 of 24 patients (92%). Two patients with insufficient results (rating 0 and 1) had an unusual long circulation time due to cardiac diseases.

Discussion

Using time-resolved 3D TWIST-MRA, assessment of the supra-aortic vessels was possible with a high spatial resolution. The new double bolus injection protocol allowed for good separation of arterial vessels at least after one of the two bolus applications. In contrast to conventional single-bolus contrast-enhanced MR angiography or CARE-bolus angiography this separation by time-resolved TWIST-MRA leads to an automated and robust protocol using.

References

1 Lim et al.: Am J Neuroradiol, 2008; 29: 1847-1854
2 Vogt et al.: Joint annual meeting ISMRM-ESMRMB 2007

Figure 1: Truncus bi-caroticus and fenestration of the left vertebral artery (V4 segment) with double-bolus TWIST technique.