Assessment of TOF- and CE- MRA in the Visualisation of Small Cerebral Vessel-Structures at 3.0 T

U. Wiesspeiner[1], R. Stollberger[2], K. Leber[3], and F. Ebner[1]

[1]Neuroradiology, Medical University of Graz, Graz, Austria, [2]MR Physics, Medical University of Graz, Graz, Austria, [3]Neurosurgery, Medical University of Graz, Graz, Austria

Introduction

Good delineation of cerebral vessels, up to arteries being in the third divisional generation (diameter of 1.4-0.8mm) [1], is essential in the diagnosis of specific vascular diseases, as for instance vasculitis, stenoses or vascular malformations. The purpose of this study was to prospectively evaluate the benefit of TOF 3D and CE-MRA sequences, just as different types of contrast media application [3,4] in the visualisation of first and third order vessels, using a 3.0 T unit. Data analysis included quantitative analysing methods to assess signal intensity [SI] and signal-to-noise ratio [SNR], in addition to common visual grading systems [2,4,5].

Methods

121 patients (29 men, 92 women) underwent MRA of the cranial vessels at 3.0-T (Magnetom-Trio, Siemens Medical), using a twelve channel head array coil. TOF 3D imaging protocol: TR/TE/α: 22/3,68/18°; voxel-size: 0,7x0,5x0,7; slice thickness: 0.65mm interpolated; FOV: 200x200mm; Matrix: 202x384; TA: 04:19 min. As CE-MRA a first pass FLASH 3D sequence was used: TR/TE/α: 3,74/1,49/20°; voxel-size=0,8x0,6x0,7; Slice thickness: 0.7i mm; FOV: 220x280 mm; Matrix: 281x448; GRAPPA, Accel.Factor:2; TA: 00:22 min. Contrast agent (Gadobenate Dimeglumine, MultiHance®) was administered using a power-injector (Medrad®, Solaris). All study-participants underwent a non-contrast 3D TOF MRA followed by either a low-dose (3ml) TOF MRA under steady state conditions or a bolus-timed CE-MRA (0.1 mmol/Kg/BW; 2,5ml/s) and a subsequent full dose TOF MRA (image acquisition in the steady state of the contrast agent applied in the CE-MRA). For quantitative evaluation, signal intensities (SI) of first and third order vessels (diameter: 0,8-1,4mm) were acquired, placing a freehanded region of interest (ROI) around the vessels and extracting the average of the highest 3% of pixel values by a dedicated house-made software, whereby the signal of vessels could specifically be differentiated from those of the surrounding tissue. As in the TOF 3D scan a circular polarised coil mode was used and neither parallel acquisition technique nor image normalising was performed, a simple method to obtain SNR could be applied. SNR= $(2-\pi/2)^{0.5}$x (mean SI_{vessel}/ SD_{air}) [6,7]. For the CE-MRA sequence utilising GRAPPA reconstruction (PI-factor 2) and the array mode of the head coil, the noncentral chi distribution of the noise in the background [8] and the g-factor of GRAPPA reconstruction were considered by baseline image subtraction and application of a calibration factor, obtained from a phantom study. The noise within the ROI was than estimated dividing the standard deviation [SD] of the noise in the artefact free background by the calibration factor: SNR= 0.3x$\sqrt{2}$x(mean SI_{vessel}/ $SD_{1\text{-}2\ air}$). Visually, MRA images were graded on source images and maximum intensity projections, according to depiction of small vessels, diagnostic image quality and presence or absence of artefacts.

Results

Statistical equivalence testing (Classical Confidence Interval and Schuirmann-TOST analysis) of the quantitative results could claim equivalence, within the specified bound of 10%, for the non-contrast compared to the low-dose TOF scan, but not for the full-dose scan. CE-MRA presented significantly higher signal intensities at lower SNR levels [Tab.1]. In the visual assessment, all sequences proofed adequate delineation of the analysed vessels, only full-dose TOF MRA suffered from severe venous overlay.

Internal Carotid Artery (Segment 7)				
mean	**TOF n[1]**	**TOF l.d.[2]**	**TOF f.d.[3]**	**CE-MRA**
SI	459 +/-81	466 +/-79	520 +/-81	1184 +/-332
SNR	55 +/-12,7	56 +/-11,7	59 +/-9,6	42 +/-13,1
Third order vessels (Segment M2-M3)				
mean	**TOF n[1]**	**TOF l.d.[2]**	**TOF f.d.[3]**	**CE-MRA**
SI	339 +/-60	344 +/-68	372 +/-50	694 +/-216
SNR	40 +/-7,4	41+/-9,1	43 +/-6,9	24 +/-7,5

Table 1: Signal intensities and SNR's of non-contrast (1), low dose (2) full dose (3) TOF and CE-MRA scans.

Discussion

The excellences of the TOF 3D sequence were the dispensability of contrast media due to the higher inflow effects at 3.0T, high spatial resolution and SNR values, allowing the detection of vascular structures up to 1-2mm, as well as the possibility to examine the cerebral vascular system from the posterior inferior cerebellar artery [PICA] to the insular branches of the middle cerebral artery, within a reasonable time. A weak point of this sequence occurs at the application to patients with aneurysms. Large aneurysms or remnants are underestimated or simply not seen, because of saturation effects, owing to turbulent and slow flowing blood. In this case the CE-MRA adds indispensable information of the real situation, so that despite of the lower SNR, the rather small viewable region and the relatively low spatial resolution, this sequence is needed as problem focussed examination, to further evaluate regions with questionable abnormalities.

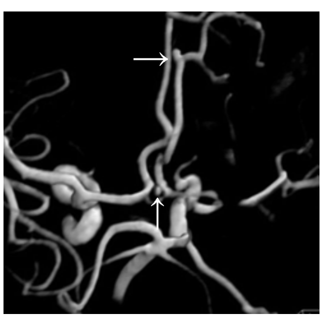

Figure 1: TOF MRA, Volume-rendering reconstruction: depiction of an anterior communicating and a pericallosal artery aneurysm (each 2mm in diameter)

References

[1] Anderhuber F, Weiglein A, Pucher RK, Acta Anat (Basel). 1989;136(1):42-8. **[2]** Willinek WA et al., Radiology. 2003 Dec;229(3):913-20; **[3]** Ozsarlak O, Van Goethem JW, Maes M, Parizel PM, Neuroradiology. 2004 Dec;46(12):955-72; **[4]** Majoie CB et al., AJNR Am J Neuroradiol. 2005 Jun-Jul;26(6):1349-56. **[5]** Pierot L et al, AJNR Am J Neuroradiol. 2006 Apr;27(4):744-9; **[6]** Kaufman L, Kramer DM, Crooks LE, Ortendahl DA, Radiology. 1989 Oct;173(1):265-7; **[7]** Firbank MJ, Coulthard A, Harrison RM, Williams ED; Phys Med Biol. 1999 Dec;44(12):N261-4. **[8]** Constantinides CD, Atalar E, McVeigh ER.; Magn Reson Med. 1997 Nov;38(5):852-7. Erratum in: Magn Reson Med. 2004 Jul;52(1):219.