Clinical experience of Large FOV Accelerated Time-Resolved 3D Contrast-Enhanced MR Angiography at 3T in 105 Patients

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Purpose: To evaluate large FOV time-resolved 3D MR-angiography at 3T with high spatial resolution and temporal update rate based on accelerated parallel imaging and to test whether image quality and artifact level allow for diagnostic image quality in clinical routine.

Methods: 105 consecutive patients underwent time-resolved 3D contrast-enhanced MR-angiography [1] on a 3T system (Magnetom TRIO, Siemens, Erlangen, Germany) of the thoracic aorta and supra-aortic branches (n=78) or craniocervical arteries (n=27) [2]. Imaging consisted of accelerated 3D rf-spoiled gradient echo sequences combining parallel imaging (GRAPPA) with an acceleration factor of four [3], partial Fourier acquisition along phase and slice encoding direction, and view sharing (TREAT) [4, 5]. 20-30 T1 weighted (T1w) 3D data volumes were acquired consecutively with a temporal update rate of 2.5-3.3s, a FOV of 280-400 x 300-400 mm², and spatial resolution of (1.68-2.53 x 0.94-1.74 x 1.5-1.9) mm³. CE-MRA was performed using intravenous gadolinium contrast agent (Gadobenate dimeglumine, Gd-BOPTA chelate, Multihance, ALTANA Pharma, Konstanz, Germany, molar concentration 0.5M, single dose = 0.1 mmol/kg body weight, injection rate = 3 - 4ml/s) administered after the second data volume. Additionally, standard axial breath-held 3D gradient echo imaging (VIBE) sequences (TE/TR = 1,8/4,4ms, flip angle = 13°, spatial resolution = 1.1 x 1.4 x 2.5mm³) were performed afterwards.

Data analysis and quantification: Data volumes representing the arterial and venous contrast phases were independently evaluated by 2 experienced radiologists by grading of image quality and artifact level on a 0-3 scale. Results were averaged between both readers and calculated for arteries, veins, and artefacts with a total imaging score: 0 – 0.75 = poor, 0.76 – 1.5 = moderate, 1.51 – 2.2 = good, 2.21 – 3 = excellent. Further, SNR and CNR analysis were performed on a subset of 30 datasets for different arteries, veins and soft tissues (see Fig. 1 and 2). To account for spatially varying, g-factor dependent, noise levels in parallel imaging [6], SNR was calculated by averaging and subtracting the last two time frames and by dividing the mean value in a ROI of the averaged image by the standard deviation in the same ROI in the subtracted image. Relative CNR values were calculated as $(SNR_A\text{-}SNR_B/SNR_B)x100$.

Results: Time-resolved MR-angiography was successfully performed in all subjects without the need for contrast agent bolus timing. Excellent arterial (average score = 2.39 ± 0.73) and good venous (average score = 2.17 ± 0.78) diagnostic image quality and little image degrading due to artifacts (average score = 2.65 ± 0.50) were confirmed by both independent readers (agreement in 71,0 %). In 44 patients vascular pathologies were independently identified in the arterial phases and confirmed on the axial VIBE images. Also, in 65% of the pathologies alternative diagnostics (DSA, CT) were available to confirm the diagnosis. In nineteen examinations temporal resolution and depiction of contrast agent dynamics provided additional information about pathology (e.g. figures 3 and 4). In SNR and relative CNR quantifications, next to good SNR and CNR values, large standard deviations (SD) were encountered (see Fig. 1 and 2).

Discussion: Without further necessity for additional bolus timing, time-resolved 3D contrast-enhanced MR-angiography with high acceleration factors demonstrated excellent diagnostic image quality in large FOV neurovascular and thoracic imaging. Large FOV imaging implies that diagnostic accuracy such as in imaging of the carotid bifurcation was not within the scope of this study. Rather, an easy to apply tool to gather information on angiographic data with every injection of contrast agent was tested.

The large SD in SNR and CNR quantifications is subject to further analysis especially with respect to the different coils and coil design. To further strengthen this promising application of contrast-enhanced MR-angiography future studies may include the evaluation of optimal trade-offs between spatial and temporal resolution for different pathologies.

References: [1] Korosec FR, MRM 1996;36:345-51; [2] Frydrychowicz A, Magn Reson Mater Phys 2006;19:187-95; [3] Griswold MA, MRM 2002;47:1202-10; [4] Wilman AH, Radiol 1997;205:137-46; [5] Fink C, Eur Radiol 2005;15:2070-4; [6] Pruessmann KP, MRM 1999;42:954-62

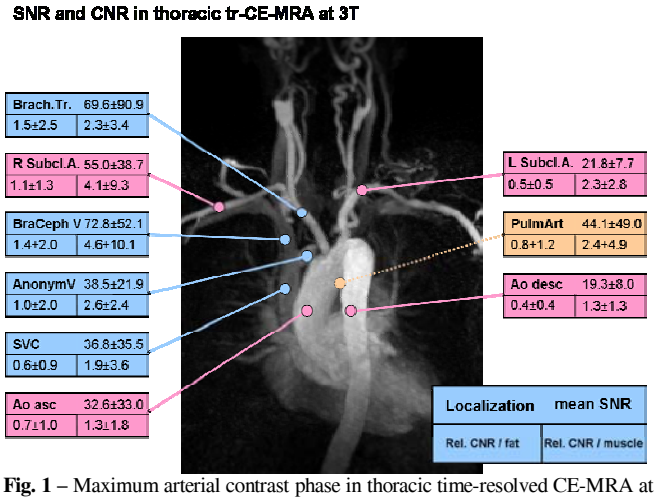

Fig. 1 – Maximum arterial contrast phase in thoracic time-resolved CE-MRA at 3T for the display of mean SNR, CNR vs. fat, and CNR vs. muscle. Brach.Tr. = brachiocephalic trunk, R Subcl. A. = right subclavian artery, BraCeph V = brachiocephalic vein, AnonymV = innominate vein, SVC = superior cava vein, Ao asc = ascending aorta, L subcl.A = left subclavian artery, PulmArt = pulmonary artery, Ao desc = descending aorta

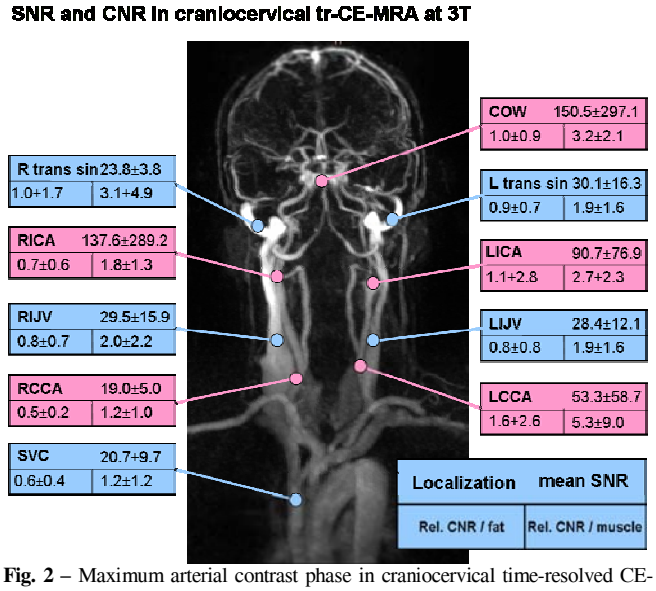

Fig. 2 – Maximum arterial contrast phase in craniocervical time-resolved CE-MRA at 3T for the display of mean SNR, CNR vs. fat, and CNR vs. muscle. R/L trans sin. = reight or left transverse sinus, R/LICA = right or left internal carotid artery, R/LIJV = right or left internal jugular vein, R/LCCA = right or left common carotid artery, SVC = superior cava vein.

Fig. 3:

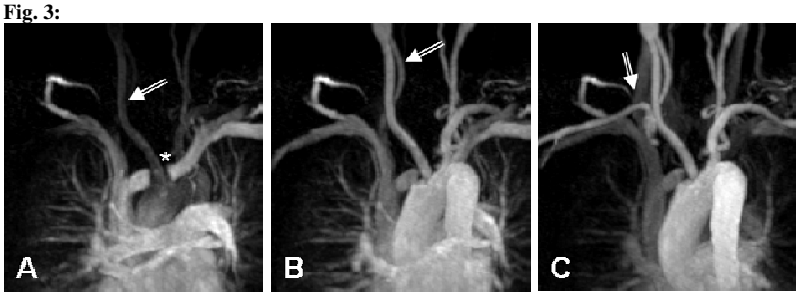

Fig. 3 – Coronal thoracic time-resolved CE-MRA at 3T in a patient with a bypass from the ascending aorta to the right carotid bulb due to occlusion of the proximal right brachiocephalic trunk. The temporal update rate allows to discriminate the contrast media delivery from the bypass to the bulb, backwards to the brachiocephalic trunk and from there to the right subclavian artery (open white arrows).

Fig. 4:

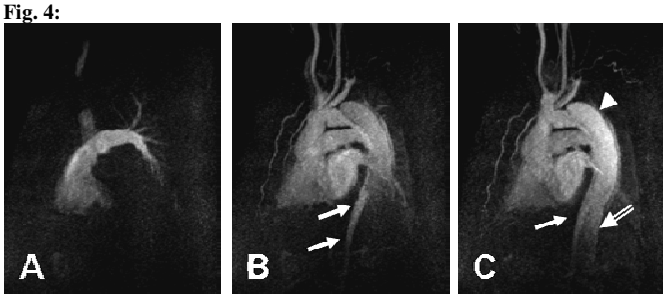

Fig. 4 – Sagittal thoracic time-resolved CE-MRA at 3T in a patient with aortic dissection Type-A after ascending aortic graft. Clearly, the early filling of the true lumen and the complete filling of the aneurysmatic false lumen can be appreciated.