High Resolution 3D MR Plaque Detection in the Thoracic Aorta in 45 Acute Stroke Patients at 3Tesla

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Introduction: Transesophageal echocardiography (TEE) is the current reference standard for the detection of cardiac high risk sources of cerebral embolism such as aortic plaques ≥4 mm and aortic thrombi [1]. In patients with brain ischemia these pathologies are by far the most frequent high risk sources detected by TEE [2]. Although complication rate during TEE is low, the procedure is semi-invasive and limited by artifacts and insonation angles. Therefore, assessment of plaques especially in the proximal ascending aorta and the aortic arch, the origin of the brain supplying great arteries, is often not reliable. Previous MRI studies suffered from incomplete coverage of the aortic segment of interest and plaque analysis was limited by the spatial resolution and breath-hold capabilities of the examined patients [3]. We hypothesized, that 3D MRI at 3T would be equivalent or even superior to TEE in detecting aortic pathologies due to the advantage of improved visualization of proximal aortic segments and detailed retrospective data evaluation..

Methods: 65 patients with acute ischemic stroke were included and underwent both TEE and MRI examination. Readers of TEE findings were blinded to MRI and vice versa. All examinations were performed on a 3T MRI system (TRIO, Siemens Medical Solutions, Germany). Prior to plaque imaging, ECG-gated 2D CINE gradient echo imaging normal to the ascending aorta was performed in end-expiration to individually determine the temporal window within the cardiac cycle with the least vessel motion. High spatial resolution plaque imaging was then performed using a T1-weighted rf-spoiled and fat saturated 3D gradient echo sequence covering the ascending aorta, aortic arch and proximal descending aorta with near-isotropic spatial resolution of ($0.8x1.1x1.1mm^3$). To permit data acquisition during free breathing and to minimize artifacts respiration control based on dynamically adapted navigator gating with respiration drift correction was implemented into the GRE sequence. In the presence of aortic plaques ≥3 mm time-resolved contrast enhanced 3D MR angiography (tr-CE-MRA) was performed. Imaging parameters included parallel imaging (GRAPPA, acceleration factor = 4) in combination with view sharing along the temporal domain (TREAT, elliptical centric view ordering, double update rate of central k-space) resulting in a reconstructed voxel size of 1.3x1.9x1.5-1.8 mm^3 and an effective temporal update rate of 2.7-3.0 s. To assess the effect of contrast agent on vessel wall and plaque representation, high spatial resolution 3D plaque characterization was repeated after contrast agent administration (see also figure 1). For future evaluation of hemodynamic alterations associated with aortic plaque flow sensitive 4D MRI of the entire thoracic aorta was also performed.

Results: Exemplary results for thrombus and plaque characterization using MRI versus TEE are illustrated in figure 2. Data of 45 patients analyzed to date are presented. 95 aortic plaques ≥4 mm and two aortic thrombi were identified by MRI clearly exceeding the number of high-risk aortic plaques (n=48 aortic plaques ≥4 mm, n=1 aortic thrombus).detected by TEE. Correlation of MRI and TEE with regard to maximal aortic wall thickness in the ascending and descending aorta were r= 0.33 and r=0.36, p<0.005. Correlation of findings in the aortic arch were not applicable due to the low number of wall segments assessable in TEE. By use of contrast-enhanced MR angiography and multi-contrast MRI, aortic dissection and a mobile dissection membrane visualized by CINE-sequence were detected by MRI in 2 patients as confirmed by TEE (not shown). Also, multi-contrast MRI imaging in combination with additional time-resolved (CINE) imaging sequences allowed for the detection of a descending aortic thrombus in one patient (see also Figure 3). Furthermore, one mobile thrombus of the aortic arch not detected by TEE could be clearly identified by MRI.

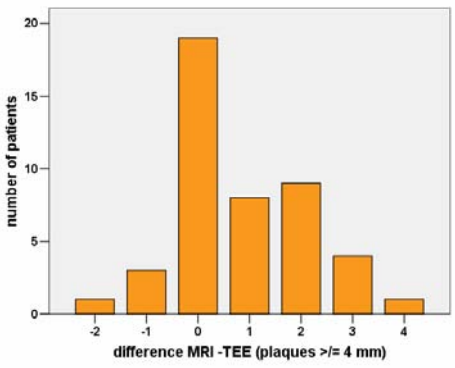

Figure 2: Differences between MRI and TEE with regard to the absolute number of plaques ≥4 mm detected in each patient are shown. The total number of patients analysed was 45. Negative values mean that a higher number of plaques was detected by TEE, positive values indicate higher numbers of plaques were found in MRI examination.
Although a high correlation was found for ~half of the patients, overall, MRI detected significantly more aortic plaques ≥4 mm than TEE.

Discussion: Our results demonstrate the feasibility of this MRI protocol for the reliable detection of high-risk aortic plaques in 45 acute stroke patients. The higher number of plaques ≥4 mm detected by MRI in comparison to TEE is most probably attributable to the improved visualization of the ascending aorta and the aortic arch by MRI. Furthermore, an overestimation of plaque thickness by MRI can also be assumed due to the measurement of wall thickness including the adventitial layer by this technique in contrast to TEE. The detection of an aortic arch thrombus by MRI overlooked by TEE in one patient underlines the clinical potential of MRI to improve secondary prevention in stroke patients by increasing diagnostic accuracy of aortic pathologies. Apart from atherosclerotic embolic sources MRI proved to reliably detect further high-risk pathologies such as aortic dissection. Due to the improved visualization of the ascending aorta and the aortic arch and the 3D nature of MRI data this technique might have the potential to provide more information concerning aortic pathologies than TEE. Both the comparison of TEE and MRI, the improvement of spatial resolution and correlation of local hemodynamics with plaque location are future aims of this ongoing study.

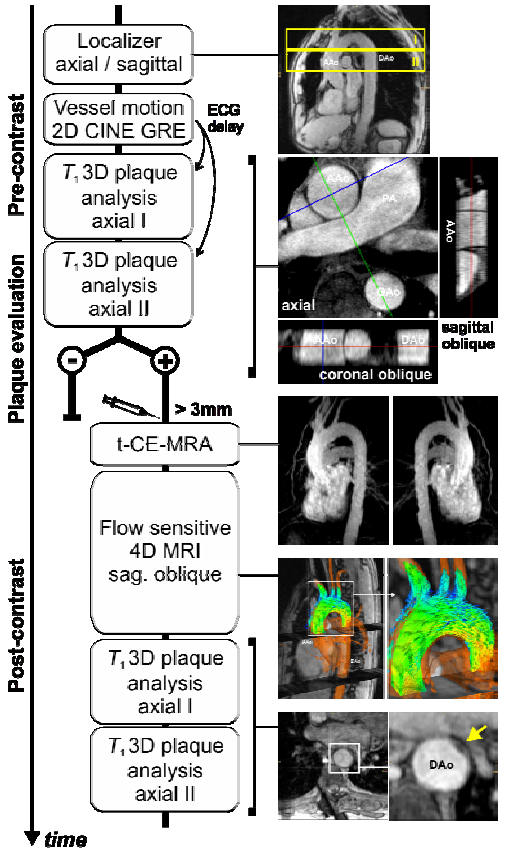

Figure 1: MR plaque evaluation in the thoracic aorta. Note that plaque evaluation is started while the second 3D volume is still measured. Contrast agent (CA) injection in case of detection of plaque ≥3 mm is indicated by the injection symbol. AAo: ascending aorta, DAo: descending aorta, Ao: aorta, PA: pulmonary artery.

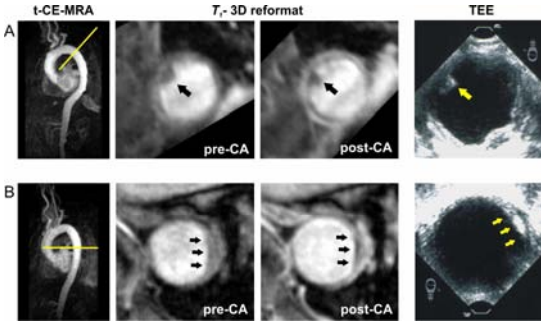

Figure 3: **A**, Results from patient with a hypointense structure protruding into the lumen of the proximal descending aorta. The corresponding TEE image demonstrates a superimposed, echolucent component identified as an aortic thrombus measuring ≥8 mm in length (yellow arrow). **B**, Plaque in the descending aorta with homogeneous appearance on pre-contrast T1 images. After contrast application a hypointense, central core becomes visible which corresponds to the echogenic core seen on TEE (yellow arrows).

References: [1] Reynolds HR, et al. Curr Opin Cardiol. 2003;18:340-345. [2] Harloff A, et al. Stroke. 2006;37:859-864. [3] Fayad ZA, et al. Circulation. 2000;101:2503-2509.