Diagnostic Impact of Aortic MRI at 3Tesla in Patients with Acute Cryptogenic Stroke

A. Harloff[1], P. Dudler[1], A. Frydrychowicz[2], C. Strecker[1], A. L. Stroh[3], A. Geibel[3], A. Hetzel[1], C. Weiller[1], J. Hennig[2], and M. Markl[2]

[1]Neurology and Clinical Neurophysiology, Albert-Ludwigs Universität, Freiburg, Germany, [2]Diagnostic Radiology, Medical Physics, Albert-Ludwigs Universität, Freiburg, Germany, [3]Cardiology and Angiology, Albert-Ludwigs Universität, Freiburg, Germany

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: 74 patients with acute ischemic stroke were included and underwent both TEE and MRI examination. After performance of TEE and routine diagnostics stroke etiology was classified according to a modified TOAST classification. Readers of TEE findings were blinded to MRI and vice versa. All MRI examinations were performed on a 3T system (TRIO, Siemens, Erlangen, 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 both additional 2D CINE, 2D T2 imaging and time-resolved contrast enhanced 3D MR angiography (tr-CE-MRA) were performed. Imaging parameters of angiography 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.

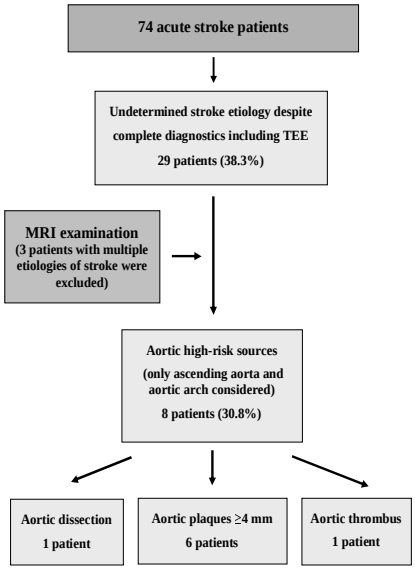

Figure 1: Distribution of stroke subtypes within the study population according to the TOAST criteria and additional findings of MRI in patients with stroke of undetermined etiology.

Results: Differences in maximum aortic wall thickness (AWT) for TEE and MRI were not statistically significant for all aortic segments. The overall number of high-risk plaques detected by MRI (n=74) was substantially higher compared to TEE (n=47). Most noticeably, MRI identified aortic high-risk pathologies in 8/26 (30.8%) patients with cryptogenic stroke after standard diagnostics including TEE (n=2: dissection or thrombus; n=6: plaques ≥4 mm, see Figure 1). By use of contrast-enhanced MR angiography and multi-contrast MRI, reliable plaque detection could be performed in all aortic segments as exemplary illustrated in figure 3. 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. Furthermore, one mobile thrombus of the aortic arch not detected by TEE could be clearly identified by MRI. Differences of MRI and TEE measurements are given in the Bland and Altman plot in figure 2: Results show limited agreement of MRI and TEE measurements in direct comparison. The mean and SD of the difference were small, whereas the differences between MRI and TEE were relatively wide in comparison to the mean, with difference increasing with the mean of maximum aortic wall thickness. However, >94% of the differences were within the limits of agreement and there was no indication of a systematic error.

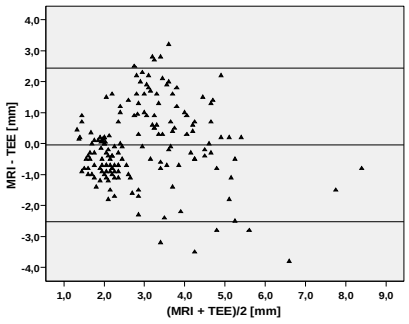

Figure 2: Bland-Altman plot of maximum plaque thickness by TEE and MRI from matched cross-sectional aortic plaque images of the ascending aorta, the aortic arch and the descending aorta for all segments assessable by both TEE and MRI (n=167). Mean of difference was -0.05 mm, SD of difference was 1.27 mm, and limits of agreements were mean - 1.96 x SD = -2.53 mm and mean + 1.96 x SD = 2.44 mm.

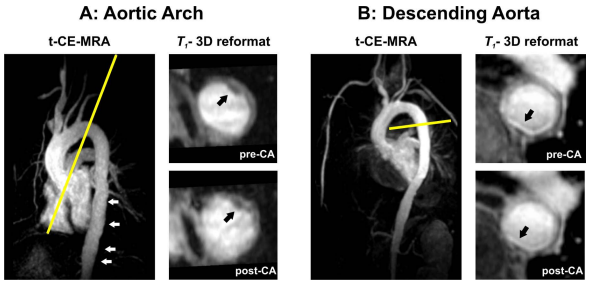

Figure 3: MRI result from two patients with plaques (black arrows) in the aortic arch and proximal descending aorta. Image planes (T1-3D reformat) within the acquired axial 3D data volumes were reformatted normal to the aorta at the sites of the plaques. Note the improved visualization of central hypointense cores of the plaques on B following contrast agent administration (post-CA). In A, note that, large protruding atheroma of the posterior wall results in a fractured appearance of the descending aorta in the MR angiography image (t-CE-MRA, white arrows).

Discussion: In our study, plaque detection in the thoracic aorta using high spatial resolution 3D MRI at 3T was successfully demonstrated in 74 acute stroke patients in direct comparison to TEE. Although the agreement between MRI and TEE using Bland-Altman analysis was poor, further evaluation suggests that MRI may be more reliable than TEE for the detection of high-risk aortic diseases in stroke patients: The number of high-risk plaques found by MRI was significantly higher compared to TEE. Most noticeably, additional aortic high-risk sources of brain ischemia were detected by MRI in almost 30% of patients with stroke of undetermined etiology after routine diagnostics including TEE. The significance of these additional MRI findings was confirmed by the high number of embolic strokes in this subgroup. Thus, our findings suggest that high-field 3D MRI may increase diagnostic accuracy for the detection of aortic high-risk pathologies especially in patients with cryptogenic stroke.

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.