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High-resolution imaging of complex aortic plaques in ischemic stroke patients using 3.0 Tesla MRI with VISTA

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Complex aortic plaques (CAP) in the thoracic aorta are considered a recurrent risk factor of ischemic stroke in association with instability [1]. Magnetic resonance (MR) plaque imaging of CAP in the thoracic aorta, using black blood imaging by the conventional double inversion recovery (DIR) method has not been challenging due to motion artifacts from cardiac pulsation. This study tried to evaluate the quality of CAP using MR plaque imaging with a new method. The present study was a prospective study and the participants were selected involving acute ischemic stroke patients admitted to Tokai University Hospital between October 2013 and September 2014. Written informed consent was obtained from all patients. This study was approved by the Tokai University Ethics Committee (13R-118).

Ten acute ischemic stroke patients where aortic arch plaque was detected with transesophageal echocardiography (TEE) were recruited (age median, 76 years [interquartile range (IQR), 65–80 years], 5 were women [50%]). All recruited patients were classified as stroke of other determined etiology based on the diagnosis of clinical subtype made by an experienced neurologist according to the Trial of Org 10172 in the Acute Stroke Treatment classification [2].

Regarding vessel wall analysis of the aorta with plaque imaging, evaluation revealed CAP using MR imaging (MRI) and TEE. MRI was performed using 3.0 Tesla MRI (Achieva 3.0T®; Philips Healthcare, Andover, MA, USA). All cases underwent T1 black blood imaging by a new sequence of volume isotropic TSE acquisition (VISTA) [3]. We measured the consecutive thoracic aorta on the coronal view by synchronizing with heartbeats of the maximal systolic phase to reduce flow artifacts. Upon imaging, the scan time/parameters were standardized across all patients. Aortic vessel wall were verified and results were compared with TEE findings. TEE was performed using ARTIDA (TOSIBA, Japan) with a 5 MHz, multiplane probe. Aortic plaques were evaluated from the ascending aorta to the aortic arch. Evaluation included plaques in the short axial view for maximal plaque thickness, low echoic lesion, mobility, and ulcerative lesion. An ulcerative lesion was defined as the presence of surface defects showing a depth of over 2.0 mm.

Based on the MRI findings, patients were divided into the following two groups: positive or negative findings of high signal resolution along the vessel wall, following the previous reports (Fig. 1) [3, 4]. Evaluation included correlations with age, sex, atherosclerotic risk factors (hypertension, diabetes mellitus, and dyslipidemia), inflammatory marker (high sensitivity C-reactive protein [hs-CRP]), and high the Calcification in the Aortic Arch, Age, Multiple Infarction (CAM) score (≥ 3) [5].

High signal resolution was detected along the thoracic aorta wall in 5 patients (positive group). Age, sex, and atherosclerotic risk factors were not significantly different between the positive group and negative group. Low echoic lesion (4 [80%] vs. 1 [20%], respectively, $p = 0.06$) and ulcerated/mobile lesion (2 [20%] vs. 0 [0%], respectively) of TEE were detected at a higher frequency in the positive group compared to the negative group, which is in agreement with the high signal resolution. The median plaque thickness was not significantly different between the positive and negative group (5 [4–6; IQR] vs. 4 [3–6], respectively). Hs-CRP was also significantly higher in the positive group than in

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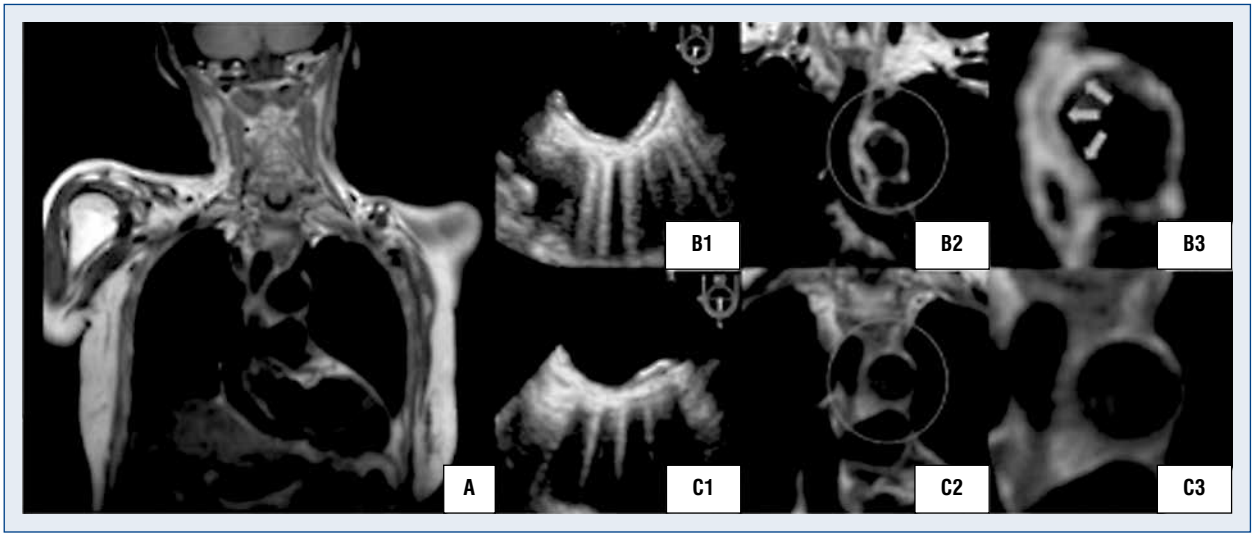

Figure 1. Magnetic resonance plaque imaging of the thoracic aorta (MRI system, Ingenia 3.0T; coil, ds Torso coil; field of view, 340 × 310; matrix, 224 × 256; number of slices, 50; slice thickness, 3 mm; repetition time/echo time, 1 beat/17, SENSE factor, 2.5; TSE factor, 21); **A.** The consecutive thoracic aorta image on the coronal view synchronized with heartbeats; **B1, B2, B3.** A patient with high signal resolution along the aortic arch vessel wall matched with plaque lesion of transesophageal echocardiography (TEE) findings; **C1, C2, C3.** A patient with non-high signal resolution along aortic arch vessel does not reflect plaque lesions with TEE findings.

the negative group (32638 ng/mL vs. 3500 ng/mL, respectively, $p < 0.05$). High CAM score (≥ 3 mm) patients also had a higher frequency in the positive group compared to the negative group (4 [80%] vs. 1 [20%], respectively, $p = 0.06$).

Complex aortic plaques were evaluated with T1- and T2-weighted MRI in a previous study [6]. Here, success was obtained detecting CAP on the thoracic aorta wall clearly using a novel MR plaque imaging method. In this study, the following results were assessed: correlation of high signal resolution along the vessel wall with hs-CRP and the frequent tendency of CAP and high CAM score in the high signal lesion positive group. The high value of hs-CRP in the positive group might reflect inflammatory change focused on the plaque lesions [7]. The high frequency of CAP and high CAM score were also evidence of an association of CAP and high signal resolution along the thoracic aorta on MRI. Based on the results, high signal resolution along the thoracic aorta wall was considered to reflect lipid-rich plaque [4]. The qualitative improvement of CAP by anti-platelet therapy and lipid-lowering therapy might allow for evaluation by this method.

In the conventional DIR method, imaging range and the length of the imaging time were assessed as a disadvantage and limitation, because blood suppression weakened the image cross-section and respective blood vessels. VISTA was proposed as a novel method to overcome this disadvantage [3]. Also, the addition of synchronizing with heartbeats to further reduce flow artifacts from cardiac pulsation was utilized in this study.

In conclusion, MR plaque imaging using the VISTA method with heartbeat synchronization appears to be superior to the conventional method to detect CAP, offering advantages such as higher time resolution, lower motion artifacts, and shorter scanning time. This method may enhance the evaluation of CAP in addition to TEE as a minimally invasive test.

Conflict of interest: None declared

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