Preoperative Assessment of High-Risk Aortic Plaque by Magnetization-Prepared Rapid Acquisition with Gradient-Echo Imaging in a Patient with Total Arch Replacement

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We present a case of a 70-year-old male who underwent surgical repair of an aortic arch aneurysm. Preoperative assessment of high-risk aortic plaque was performed using magnetization-prepared rapid acquisition with gradient-echo (MPRAGE) imaging. This preoperative image was compared with a histological analysis of plaque specimens from the aortic arch and neck vessels. A high signal intensity on MPRAGE images coincided with intraplaque hemorrhage. MPRAGE, which could detect a fragile plaque in the aorta, could be a powerful modality to prevent intraoperative stroke during cardiovascular surgery.

Keywords: aortic plaque, preoperative care, magnetic resonance imaging

Case Report

A 70-year-old male was referred to us for the surgical treatment of an aortic arch aneurysm. His medical history included hypertension and post-surgical status of graft replacements of the descending and abdominal aorta for atherosclerotic aneurysms. Contrast-enhanced CT revealed a distal aortic arch aneurysm that was 55 mm in diameter. Furthermore, it revealed an irregular spiculated shape of the aortic wall, a so-called “shaggy aorta,” that was located in the aortic arch and descending aorta (Fig. 1).

Preoperative magnetic resonance imaging (MRI) of the carotid artery and aorta using MPRAGE revealed thick plaques with high signal intensity that were peculiarly located at the lesser curvature of the aortic arch and orifices of neck vessels (Fig. 2A). There was no evidence of high-risk plaque in the ascending aorta (Fig. 2B).

The operation was performed through a partial median sternotomy. Cardiopulmonary bypass was established with bicaval venous drainage and ascending aortic cannulation. The aortic arch was opened under moderate deep hypothermia and selective cerebral perfusion. The vulnerable and soft plaques were diffusely placed at the aortic arch with a focus on the lesser curvature side and the orifices of the neck vessel. These areas coincided with the areas of high-signal intensity that was observed in MPRAGE images. After cautious removal of the mobile plaque, total arch replacement using a 20-mm Gelweave graft (Vascutek-Terumo, Japan) with four branches was performed. The patient’s postoperative course was uneventful. Macroscopic histological specimens revealed that the ascending aorta and the greater curvature of the aortic arch revealed only slight atherosclerotic change; however, the lesser curvature...
of the aortic arch and cervical branches were in advanced atherosclerosis (Fig. 2C). Moreover, the microscopic histological specimens of the lesser curvature of the aortic arch and cervical branch walls revealed the presence of large areas of lipid pools without an overlying fibrous cap and inflammatory cell infiltration and intraplaque hemorrhage (Fig. 2D). These areas almost coincide with the areas of high-signal intensity observed in MPRAGE images.

Discussion and Conclusion
An aortic arch surgery, which requires hypothermia and circulatory arrest, is still an invasive intervention. The surgical outcome of aortic arch surgery is gradually improving; however, ischemic stroke is a devastating complication after this procedure.

The incidence of perioperative brain infarction in patients undergoing aortic surgery has been reported to be 5%–15%.3,4

Contrast-enhanced CT has been routinely used to evaluate the atherosclerotic changes of the aorta. Although CT appears to be helpful in measuring the thickness of aortic atheroma and determining the location of calcification and ulceration, it is difficult to detect a high-risk plaque, which is composed of liquid components. Thus far, the assessment of plaque characteristics and identification of potentially high-risk plaque may be crucial for minimizing perioperative embolic stroke events. Carotid ultrasonography (US) is another modality used in evaluating high-risk plaques. However, Watanabe et al.5 reported that vessel wall MRI might have the potential to diagnose an at-risk soft plaque predominantly composed of liquid components more accurately than color Doppler US. Additionally, both transesophageal echocardiography (TEE) and intraoperative direct aortic US were useful methods for diagnosing plaque, although these methods have some limitations. They are as follows: (i) a knowledgeable and experienced operator is required to prevent an outbreak of passing over; (ii) acoustic shadow due to calcification; (iii) because of the interposition of the trachea between the esophagus and great vessels, TEE visualization of the proximal aortic arch and innominate artery is always fraught with difficulty.

Recently, improved detection of high-risk plaque has been accomplished using MRI scans, including MPRAGE and magnetic resonance direct thrombus imaging, which is a T1-weighted MRI method and highlights an intraplaque hemorrhage as a high-intensity signal. Several previous studies have demonstrated the association between intraplaque components that have high-signal intensity and recent ipsilateral ischemic cerebrovascular events.2,7

Using knowledge gained from several recent studies, we performed aortic MR imaging using MPRAGE as an additional evaluation prior to surgical intervention for aortic aneurysms in a case of shaggy aorta. In this patient, the preoperative MPRAGE images revealed that there was no evidence of intraplaque hemorrhage at the ascending aorta and allowed us to safely select the cannulation site. Furthermore, MPRAGE image revealed that thick plaques with high-signal intensity were located at the aortic arch and orifices of neck vessels. Thus, we could safely perform the cervical arterial cannulations required for the selective cerebral perfusion after removing the mobile plaque.

As mentioned above, preoperative evaluation with MPRAGE has the potential to contribute to a highly safe operation and to contribute to the development of the operative strategy. Additionally, MPRAGE does not require radiation exposure and contrast medium, which will be helpful for chronic kidney disease in patients with atherosclerotic aortic disease.

Longitudinal studies with larger subject populations are required to clarify whether MPRAGE hyperintense signals identify vulnerable aortic plaques and indicate elevated risk of cerebral ischemic events.

We reported a case of an aortic arch aneurysm in which MPRAGE was used for the preoperative assessment of high-risk aortic plaques. MPRAGE enabled us to determine a fragile plaque in the aorta, and thus, it could be a powerful modality to prevent the intraoperative stroke during cardiovascular surgery.

Disclosure Statement
All authors have no conflicts of interest.
Preoperative Assessment of Aortic Plaque by MPRAGE


Author Contributions

Data collection: YS
Writing: YS
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

References


Fig. 2  MPRAGE images and corresponding pathological findings of the aortic walls and carotid arteries. (A) High-intensity plaque: T1-weighted MR images obtained using MPRAGE demonstrate that the plaque shows hyperintensity at the lesser curvature of the aortic arch and orifices of the innominate artery (white arrows). The corresponding CT image revealed thick atheromatous plaques at the same positions (Fig. 1 right upper image and red ring). (B) Non high-intensity plaque: There were no areas of hyperintense signal at the ascending aorta (black arrows). However, enhanced CT findings revealed thick atheromatous plaques on the posterior wall of the ascending aorta (Fig. 1 right lower image and red ring). (C) Macroscopic histological specimens revealed that the ascending aorta showed only slight atherosclerotic change (black arrows), but the lesser curvature of aortic arch and the cervical branches were in advanced atherosclerosis (maximum thickness of these plaques was 5.5 mm). (D) Microscopic histological specimens of the aortic arch wall showed large lipid pools (black arrows) without an overlying fibrous cap, the presence of inflammatory cell infiltration and intraplaque hemorrhage, and that these areas almost coincide with the areas of high signal intensity in MPRAGE images (Masson’s trichrome, ×10). MPRAGE: magnetization-prepared rapid acquisition with gradient-echo; MRI: magnetic resonance imaging; CT: computed tomography