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Imaging

Asymptomatic carotid artery plaques: use of magnetic resonance imaging to characterize vulnerable plaques in 6 cases

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Abstract

Background: Echography is a convenient and noninvasive method of characterizing carotid artery plaques. However, recent reports suggest that multisequential MR imaging may yield better data regarding the instability of asymptomatic carotid artery plaques. Therefore, the goal of the present study was to show the useful information for asymptomatic carotid artery plaque.

Methods: A total of 6 patients (5 men, 1 woman; age range, 62-76 years; mean age, 69.2 years) with carotid artery plaques, which were detected during medical check-up using carotid MR angiography and/or echography, underwent MR imaging. Two-dimensional TOF MR angiography, T1WI, and fat-suppressed, cardiac-gated, black-blood proton density image, and T2WI were obtained with a 1.5-T MR imager. All plaques underwent carotid endarterectomy and histological examination.

Results: The MR imaging demonstrated high signals in at least one modality in 4 of 7 plaques. In the remaining 3 patients, MR imaging detected partial-high signals, which corresponded to histologically confirmed partial lipid core or hemorrhagic components in the fibrous tissues The TOF MR imaging showed 2 cases of thin fibrous caps, and MR imaging also showed a large mural thrombus in 1 patient.

Conclusions: Magnetic resonance imaging was useful in characterizing factors associated with plaque instability in patients with asymptomatic carotid artery plaques and may help guide therapeutic strategies for asymptomatic carotid artery plaques.

Keywords: Asymptomatic carotid artery plaque; Magnetic resonance imaging

1. Introduction

The efficacy and limitation of carotid endarterectomy or intravascular surgery for asymptomatic carotid artery plaque have been discussed [20,23]. Indications for surgical management of carotid artery plaques include significant carotid artery stenosis or plaque ulceration. Current methods to characterize these events include DSA, echography, and a clinical history of transient ischemic events [20]. However, there is no highly reliable and noninvasive method of characterizing the stability of carotid artery plaques [11,20,22].

Most MR imaging modalities are performed as a form of MR angiography for carotid artery plaques [1,4,6,11,14,18,24,25]. Recent studies suggest that multisequential MR imaging may be a useful modality in characterizing the stability of carotid artery plaques [2,3,5,6,7,10,13,16,17,19,21,26-29]. Therefore, the goal of the present study was to show the unsuspected vulnerability of asymptomatic carotid artery plaques.

2. Patients and methods

From 6 different patients (Table 1), 7 asymptomatic carotid artery plaques were examined. The subjects consis-

Abbreviations: ACAS, Asymptomatic Carotid Atherosclerosis Study; DSA, digital subtraction angiography; ETL, echo train length; FSE, fast-spin echo; MR, magnetic resonance; MRI, magnetic resonance image; NASCET, North American Symptomatic Carotid Endarterectomy Trial; NEX, number of excitations; PD, proton density-weighted image; T1WI, T1-weighted image; T2WI, T2-weighted image; TE, echo time; TOF, time-of-flight; TR, repetition time.

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ted of 5 male and 1 female patients (age range, 62-76 years; mean age, 69.2 years). One patient had contralateral carotid artery occlusion, and the remaining 5 patients had contralateral carotid artery stenosis. All patients were referred to our department from an affiliate medical center or clinic after cerebrovascular check-up using carotid MR angiography or echography. After admission, patients were studied using a 3-in phased-array surface coil in a 1.5-T scanner (Signa CV/i; GE Medical Systems) (mean time interval, 14 days relative to surgery). A standardized protocol was used to obtain 4 different imaging sequences of the carotid artery in the transverse plane comprising (1) 2-dimensional TOF MR angiography, (2) T1WI, (3) PD, and (4) T2WI.

The parameters for the imaging were as follows: TOF—TR/TE 50/4.2 ms, flip angle 45°, field-of-view 13 cm, matrix size 256 × 128 using a zero-fill interpolation technique, slice thickness 2.5 mm, and NEX 1; T1WI—2-dimensional FSE, TR/TE 800/11 ms, and ETL 4; PD/T2WI—FSE, black-blood (double-inversion recovery), TR 2 heart beats (1400-2000 ms, depending on heart rate), effective TE 20 ms for PD and 80 ms for T2WI, ETL 16. Fat suppression was used for T1WI, PD, and T2WI. The in-plane resolution was 0.5 mm. The longitudinal coverage of each artery was 40 mm (16 slices) for T1WI, PD, and T2WI, and 80 mm (32 slices) for TOF. Gadolinium enhancement was performed in 2 cases (cases 3 and 4). The NASCET criteria (70%–99%; mean, 85.6%) were indicated for DSA images in all plaques [5,26]. According to the ACAS trial, these plaques were suspected as high-risk plaques, then carotid endarterectomy was performed under general anesthesia and operative microscope by a single senior surgeon (I.N) [20].

Written informed consent was obtained from all patients. Did the institutional review board approve the protocols?

3. Results

All patients did not suffer any neurological complications during the peri- and postoperative period. High-intensity signals were characterized in 3 plaques on TOF (cases 2, 5, and 6), 4 on T1WI (cases 1, 2, 5, and 6), 3 on PD (cases 1, 5, and 6), and 3 on T2WI (cases 1, 2, and 5). Furthermore, partial-high signals were detected in 3 plaques from 2 patients (cases 3 and 4). Magnetic resonance with contrast medium enhanced the peripheral part of the plaque (case 3, data not shown). Magnetic resonance imaging could not visualize plaque ulcerations, which were actually detected by DSA (cases 1, 3, and 4). A low signal band on TOF corresponded to findings of a fibrous cap on histopathological examination. In fact, one of these 4 plaques had ruptured (case 4), and another plaque showed a thinning fibrous cap (case 1).

Table 2
Signal intensity of the plaque

	TOF	T1WI	PD	T2WI
Lipid/ Necrotic core	Isointense to slightly hyperintense	Hyperintense	Hyperintense	Hyperintense
Hemorrhage	Hyperintense	Hyperintense iso	Heterogeneous	Hyperintense
Fibrous cap	Hypointense band	Isointense to slightly hyperintense	Isointense to slightly hyperintense	Isointense to slightly hyperintense
Calcification	Hypointense	Hypointense	Very hypointense	Very hypointense
Fibrosis	Hypointense to isointense	Isointense to slightly hyperintense	Isointense to slightly hyperintense	Isointense to slightly hyperintense

Thus, 3 plaques were suspected to be hematoma-rich (cases 2, 5, and 6), 3 were fibrous (cases 3 and 4), and 1 was lipid-rich (case 1) according to the classification described in Table 2.

Intraoperative findings revealed that 2 plaques had lipid a core (cases 2 and 6), 2 had intraplaque hemorrhage (cases 1 and 5), and 1 had organized mural thrombus on the fibrous plaque (case 4). Histopathological examination confirmed that the main component of plaque was fibrous tissues, but intraplaque hemorrhage or lipid/necrotic core was obviously detected in all specimens as detected by plaque MRI. The organized mural thrombus of case 4 confused preoperative diagnosis by isointensity signal, which had been thought as fibrous component (Fig. 1).

4. Discussion

The present study demonstrated that MR imaging can characterize asymptomatic carotid artery plaques with intra-

Table 1
Summary of cases

Case no.	Age/Sex	Side	TDF	T1WI	PD	T2WI	Ulcer[a]	Fibrous cap[b]	Calcification	Appearance predicted by MRI	Appearance found at surgery	Pathology
1	74/Male	Left	Iso	High	High	High	+	Thin	+	Hematoma	Hematoma	Fiber, hematoma
2	69/Male	Right	High	High	Iso	Iso/High	–	Thick	+	Lipid	Lipid/Hematoma	Fiber, lipid hematoma
3	74/Male	Right	–	Iso	Iso	Iso	+	Thick	–	Fibrous tissue	Fibrous tissue	Fiber, lipid
		Left	–	Iso	Iso	Iso	–	Thick	–	Fibrous tissue	Fibrous tissue	Fiber, lipid
4	62/Female	Left	Iso	Iso	Iso	Iso	+	Thin/ Rupture	+	Fibrous tissue	Mural thrombus fibrous tissue	Fiber, lipid
5	76/Male	Right	High	High	Iso/High	High	–	Thick	++	Hematoma	Hematoma	Hematoma, fiber
6	60/Male	Left	High	High	High	Iso	–	Thick	++	Hematoma	Fiber/Lipid	Fiber, hematoma, lipid

[a] Confirmed by DSA.
[b] Confirmed by histological examination.