

MR Imaging of Carotid Plaque: Correlation between Contrast-enhancement and Inflammation at Histopathology

F. Sardanelli^{1,2}, G. D. Papini¹, S. Tritella¹, B. Cotticelli¹, G. Nano³, C. Clemente⁴, and G. Di Leo¹

¹Unit of Radiology, IRCCS Policlinico San Donato, San Donato Milanese, Milan, Italy, ²Medical and Surgical Science, University of Milan School of Medicine, Milan, Italy, ³Unit of Vascular Surgery, IRCCS Policlinico San Donato, San Donato Milanese, Milan, Italy, ⁴Unit of Pathology, Istituto Clinico Sant'Ambrogio, Milan, Italy

Purpose: Ischemic neurological events are more frequently related to carotid plaque instability than to stenosis degree (1). Moreover, a large number of patients with severe carotid artery stenosis are asymptomatic (2). The majority of ruptured plaques contains a lipid rich core covered by a thin cap of fibrous tissue and are infiltrated by macrophages (3). Plaque contrast enhancement in magnetic resonance may be correlated to inflammation. Our aim was to assess the correlation between carotid vessel wall enhancement at MR imaging and plaque inflammation at histopathology.

Methods and materials: IRB approval and written informed consent were obtained. Twenty-eight patients (aged 68±9 years) scheduled for thromboendarterectomy prospectively underwent 1.5-T MR imaging (Sonata, Siemens). Phased array head, neck and cervical spine coils were used in the following protocol:

- 1) unenhanced axial 3D T1-weighted gradient-echo sequence centered on carotid bifurcation;
- 2) standard 3D coronal carotid MR angiography with 0.1 mmol/kg of gadobenate dimeglumine (Gd-BOPTA, MultiHance, Bracco, Italy);
- 3) gradient-echo sequence as in point 1, three minutes after contrast injection.

Images obtained at point 1 were digitally subtracted from those obtained at point 3, as already described (4). On axial native and subtracted images, vessel wall enhancement was assigned a three-point score (0, absent; 1, focal; 2, extended). Stenosis degree was calculated on standard MR angiography according to NASCET criteria. At histopathology, inflammatory cell infiltration was graded using a three-point score (0, absent or minimal; 1, focal; 2, extended), used as a standard of reference. Weighted Cohen k was used. Moreover, the correlation between plaque inflammation at histopathology and stenosis degree was assessed using the Chi-square test.

Results: Six MR studies were discarded due to patient movements. Out of the remaining 22 patients, the vessel wall enhancement was graded as absent in 13, focal in 6, and extended in 3. Inflammatory cell infiltration was graded as absent or minimal in 13, focal in 7, and extended in 2. An example is shown in Figure 1. Weighted Cohen k resulted 0.57 (moderate agreement). The diagnostic performance at dichotomous analysis is reported in Table 1. Considering all the 28 MR angiographies, stenosis degree was moderate in 7 and severe in 21. Stenosis degree did not show any correlation either with inflammatory cell infiltration ($p=1.000$, $n=28$) or with vessel wall enhancement ($p=0.747$, $n=22$).

Conclusion: Carotid vessel wall enhancement using 0.1 mmol/kg of gadobenate dimeglumine is a good marker of plaque inflammation. This finding, not correlated with stenosis degree, could be used as an independent indicator of plaque instability.

References

1. Moody AR, et al. Characterization of complicated carotid plaque with magnetic resonance direct thrombus imaging in patients with cerebral ischemia. *Circulation* 2003;107:3047-3052
2. Mitsumori LM, et al. In vivo accuracy of multisequence MR imaging for identifying unstable fibrous caps in advanced human carotid plaques. *J Magn Reson Imaging* 2003;17:410-420
3. Hatsukami TS, et al. Visualization of fibrous cap thickness and rupture in human atherosclerotic carotid plaque in vivo with high-resolution magnetic resonance imaging. *Circulation* 2000;102:959-964
4. Sardanelli F, et al. Evaluation of carotid vessel wall enhancement with image subtraction after gadobenate dimeglumine-enhanced MR angiography. *Eur J Radiol.* 2008 Apr 3. [Epub ahead of print]

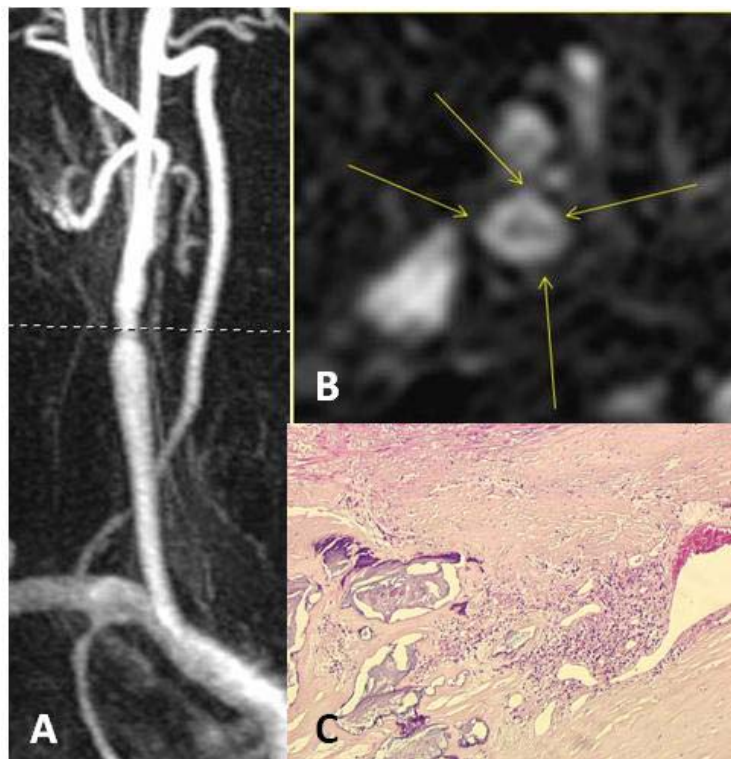


Figure 1. MR angiography showing moderate stenosis of internal carotid artery (A). Vessel wall enhancement scored 2 (arrows in B). Histopathology showing an extended inflammatory cell infiltration (C).

Table 1. Diagnostic performance

		95%CI	
Sensitivity	78%(7/9)	40%	97%
Specificity	85%(11/13)	55%	98%
Accuracy	82%(18/22)	60%	95%
PPV	78%(7/9)	40%	97%
NPV	85%(11/13)	55%	98%

PPV=positive predictive value; NPV=negative predictive value