1T magnetic resonance imaging in the diagnosis of giant cell arteritis: comparison with ultrasonography and physical examination of temporal arteries

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Received on February 18, 2008; accepted in revised form on April 6, 2008.

Clin Exp Rheumatol 2008; 26 (Suppl. 49): S76-S80.

Key words: Temporal arteritis, magnetic resonance imaging, duplex ultrasonography, temporal artery inspection, temporal artery biopsy.

Competing interests: none declared.

ABSTRACT

Objective. *To assess the usefulness of 1T magnetic resonance imaging (MRI) of temporal arteries and to compare 1T MRI with duplex ultrasonography (US) and physical examination of temporal arteries for the diagnosis of giant cell arteritis (GCA) in patients with suspected GCA.*

Method. *The superficial temporal arteries of 20 consecutive patients with a suspected diagnosis of GCA were examined using a 1T MRI scanner. Fat-saturated multislice T1-weighted spin-echo images were acquired perpendicularly to the orientation of the vessel. In all cases, MRI results were compared to US and temporal artery examination findings. Temporal artery biopsies were performed in all patients.*

Results. *Mural contrast enhancement of the temporal arteries on MRI had a sensitivity of only 33.3% and a specificity of 87.5% for the diagnosis of biopsy-proven GCA. Compared with the diagnosis of GCA by the American College of Rheumatology criteria, MRI had a sensitivity and specificity of 27.2% and 88.9%, respectively. Temporal artery abnormalities on physical examination and the presence of a hypoechoic halo on US had a higher sensitivity (66.7% and 77.7%, respectively) and a higher specificity (100% for both) compared to MRI findings.*

Conclusion. *1T MRI is not useful for the diagnosis of GCA because of its low sensitivity. US and physical examination of temporal arteries had a better diagnostic accuracy. However, our data does not exclude a diagnostic role for higher-resolution MRI.*

Introduction

The diagnosis of giant cells arteritis (GCA) is usually confirmed by the positive result of temporal artery biopsy (1-3). However, non-invasive imaging techniques such as color duplex sonography and high-resolution magnetic resonance imaging (MRI) have been shown to be of diagnostic utility for GCA (4-10). Both these techniques are able to visualize the inflammation of temporal arteries. A recent meta-analysis has confirmed that the evidence on ultrasonography of a hypoechoic halo around the lumen of the temporal arteries is a specific sign for GCA diagnosis; however, its sensitivity is significantly lower (6). Recently, Bley *et al*. demonstrated that the presence of bright enhancement on high-resolution contrast-enhanced MRI of the temporal artery was a sign of mural inflammation which correlated well with the histological evidence of GCA and with the fulfillment of the American College of Rheumatology (ACR) criteria for GCA (7, 8).

The presence of temporal artery abnormalities (tenderness on palpation or decreased or absent pulsation) is one of the criteria included in the 1990 ACR criteria for the classification of GCA (11). Previous studies have shown the value of temporal artery examination in predicting a positive temporal artery biopsy result (12, 13).

ACR criteria are often used by clinicians for the diagnosis of GCA, although their diagnostic utility remains controversial (14).

In our study, we aimed to assess the usefulness of temporal artery MRI for the diagnosis of GCA in a prospective cohort of patients with suspected GCA diagnosed over a 12-month period. We used a 1T MRI scanner, which is the equipment available in our Hospital. We also compared the diagnostic accuracy of 1T MRI with that of ultrasonography and that of physical examination

of temporal arteries. Temporal artery biopsy and ACR 1990 criteria for the classification of GCA were the reference standards.

Methods

From April 2005 until April 2006, 20 consecutive patients with suspected GCA were seen in the Department of Rheumatology of Reggio Emilia Hospital, Reggio Emilia, Italy.

The study protocol was reviewed and approved by the Ethics and Research Committees of Reggio Emilia Hospital. Before entering the study, each patient was informed of the nature and purpose of the study and provided informed consent.

All patients had a suspected diagnosis of GCA and received a careful physical examination of the temporal arteries. Right and left common superficial temporal arteries with their parietal and frontal rami were examined for the presence or absence of tenderness on palpation and decreased or absent pulsation by the same Rheumatologist.

On the second day, the patients had ultrasonographic evaluations performed by one experienced ultrasonographer who was blinded to the clinical diagnosis. Simultaneous color Doppler and duplex ultrasonography were performed using a 5 to 12 MHz linear probe (ATL HDI 5000, ATL Ultrasound, Bothell, WA, USA) along the course of the common superficial temporal arteries and their branches and occipital arteries bilaterally. These vessels were examined as thoroughly as possible in a longitudinal and transverse plane to evaluate whether a halo was present around the lumen. A halo was defined as a hypoechoic region surrounding the perfused lumen of the temporal arteries or branches for a discrete region.

After that, MRI was performed on a 1.0-T scanner (T10-NT, Philips) using a surface coil (Sense-Flex-M). Fat-saturated multislice un-enhanced T1-weighted spin-echo sequences were acquired perpendicularly to the orientation of the superficial temporal artery of both sides (TR/TE, 550/15; field of view, 200 x 200 mm^2 ; in-plane-resolution, 0.78 mm x 0.78 mm; acquisition matrix, 256 x 256; number of excitations, 3). Twenty slices with a thickness of 3.5/0.3 mm, covered a distance of 72,2 mm. Fat-saturated multislice T1-weighted spin-echo images with the same parameters were acquired after venous injection of 0.1 mmol of gadobenate dimeglumine (MultiHance®, Bracco) per kilogram of body weight.

We decided to use the contrast agent Gadobenate dimeglumine (Multihance®, Bracco, Milan, Italy) because of its superior contrast enhancement perform-

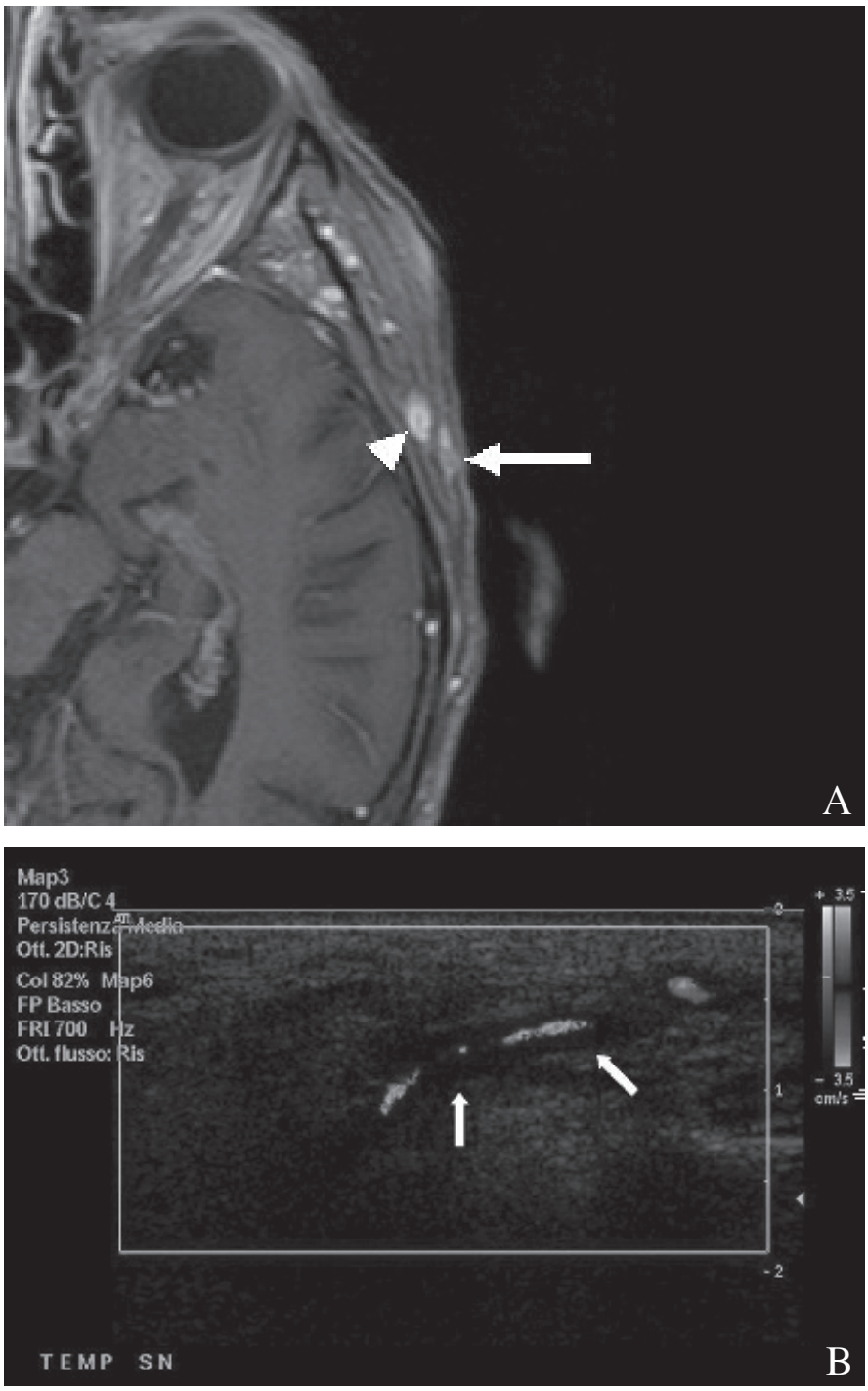

Fig. 1. An 85-year-old GCA female with giant cell arteritis. Panel **A**. A fat-saturated multislice enhanced T1-weighted spin-echo sequence (TR /TE, 550/15) acquired perpendicularly to the orientation of the superficial temporal artery shows contrast enhancement of thickened vessel wall -consistent with vessel inflammation (white arrow). Please note the presence of contrast media in the adjacent temporal vein (white arrowhead). Panel **B**. A color Doppler longitudinal scan shows a hypoechoic (black) halo (white arrows) around the lumen of the superficial frontal temporal artery.

Table I. Demographic and clinical features of the 20 patients enrolled in the study.

Sex (male/female), n/n (%/%)	5/15 (25/75)
Age at onset of disease, mean ± SD years	72±7
Headache with no history, n (%)	13 (65)
Abnormalities of temporal arteries, n (%)*	8 (40)
Scalp tenderness, n (%)	5 (25)
Jaw claudication, n (%)	7 (35)
Visual manifestations, n (%)	6 (30)
Visual loss, n (%)	0 (0)
Systemic symptoms and/or signs, n (%)†	7 (35)
Polymyalgia rheumatica, n (%)	9 (45)
ESR at diagnosis, mean ± SD mm/hour	53±29
CRP at diagnosis, mean ± SD mg/dl	3.2±3

*Tenderness on palpation and/or decreases or absent pulsations.
†Fever, anorexia and weight loss.

Table II. Magnetic resonance imaging and ultrasonography findings and temporal artery abnormalities for the diagnosis of giant cell arteritis.

Finding	Sensitivity n/n (%)	Specificity n/n (%)	Negative predictive value n/n (%)	Positive predictive value n/n (%)
American College of Rheumatology criteria				
Mural contrast enhancement	3/11 (27.2)	8/9 (88.9)	8/16 (50)	3/4 (75)
Halo	9/11 (81.8)	9/9 (100)	9/11 (81.8)	9/9 (100)
Temporal artery abnormalities	8/11 (72.7)	9/9 (100)	9/12 (75)	8/8 (100)
Biopsy-proven giant cell arteritis				
Mural contrast enhancement	3/9 (33.3)	7/8 (87.5)	7/13 (53.8)	3/4 (75)
Halo	7/9 (77.7)	8/8 (100)	8/10 (80)	7/7 (100)
Temporal artery abnormalities	6/9 (66.7)	8/8 (100)	8/11 (72.7)	6/6 (100)

N.B.: Two patients fulfilling the ACR criteria and one patient not fulfilling the criteria had a non-contributory temporal artery biopsy, because no arterial tissue was sampled.

ance compared with gadopentetate, which is due to the markedly greater T1 relaxivity in blood of this agent (15).

MRI was performed before biopsy of the temporal artery. The scan time of each fat saturated T1-weighted spin-echo sequence was 5.39 minutes (temporal arteries total scan time, 11.18 minutes). The images were evaluated facing fat-saturated un-enhanced T1-weighted spin-echo sequences with enhanced T1-weighted spin-echo ones using a last-generation Picture Archiving and Communication System (PACS) (Kodak) in order to minimize possible errors in the evaluation of the images. A Radiologist with 8 years of experience interpreted all the images; he used enlarged images for the vessel evaluation. Both the radiologist and the ultrasonographist were blinded to the clinical data.

Arteries were considered to be inflamed in the presence of the following parameters: prominent or strong contrast enhancement of the vessel wall and/or of the perivascular space.

Temporal artery biopsy was the last step. It was performed in all patients on the third day at the site targeted by the ultrasonographer, usually where the halo (if present) was seen. The Pathologist who read the biopsies had no knowledge of the clinical, ultrasonographic or MRI findings.

None of the patients had been treated with corticosteroids before physical examination of temporal arteries, MRI, ultrasonography and temporal artery biopsy. The final diagnosis of GCA or other disorder was made after the histologic findings from the temporal artery biopsy became available and the clinical course was assessed.

We calculated sensitivities, specificities, positive predictive values (PPVs) and negative predictive values (NPVs).

Results

All 20 eligible patients were enrolled in the study. Table I shows the patients' characteristics. In 9 of these patients, the diagnosis was confirmed by a positive temporal artery biopsy. Two of these 9 patients had a moderate inflammatory infiltrate prevalently involving the vasa vasorum with some extension to the adventitia or periadventitial vascular areas. The other vessel layers were not affected by the inflammation. 11 (including all 9 patients with positive biopsy results) of the 20 patients met the 1990 ACR criteria for GCA (11). Two patients fulfilling the ACR criteria had a non-contributory temporal artery biopsy because no arterial tissue was sampled. In the remaining 9 patients who did not meet the ACR criteria, a final diagnosis other than GCA was made after diagnostic procedures were completed and the follow-up period had ended. Of these patients, 8 had negative biopsy results, while in one patient temporal artery biopsy showed no arterial tissue. The median follow-up period for all patients was 18 months (range: 13 to 22 months), and the median length of biopsy specimens was 0.8 cm (range 0.4 to 1.5 cm).

Temporal artery abnormalities on clinical examination

Of the 9 patients with biopsy-proven GCA, 6 had temporal artery abnormalities (tenderness on palpation or decreased or absent pulsation), while none of the patients with a negative biopsy had temporal artery abnormalities. 8 of the 11 patients who met the ACR criteria for GCA had anormalities of the temporal arteries versus none of the patients who did not meet the criteria.

Ultrasonographic evidence of a halo

Of the 9 patients with histological evidence of GCA, 7 had a hypoechoic halo around the lumen of the temporal arteries. The halo was not present in the patients who had negative biopsy results. Of the 11 patients who met the ACR criteria, 9 had evidence of a halo, while the halo was absent in the patients who did not meet the criteria.

Magnetic resonance imaging evidence of mural contrast enhancement

Of the 9 patients with histological evidence of GCA, 3 had evidence of prominent or strong mural enhancement revealing the presence of temporal artery inflammation.

Prominent mural enhancement was also present in one of the patients who had negative biopsy results. Three of the 11 patients who satisfied the ACR criteria for GCA had prominent or strong mural enhancement versus one of the patients who did not meet the criteria.

Diagnostic accuracy of magnetic resonance imaging evidence of mural contrast enhancement, of ultrasonographic evidence of a halo and of physical examination for temporal artery abnormalities

Table II shows the sensitivities, specificities, PPVs and NPVs for mural contrast enhancement on MRI, for ultrasonographic evidence of a halo and for temporal artery abnormalities on clinical examination for the diagnosis of GCA. The sensitivity of mural contrast enhancement was low for the diagnosis of GCA both when temporal artery biopsy and the ACR criteria were used as reference standard. However, the specificity was much higher (87.5% and 88.9%, respectively). Positive predictive values for mural contrast enhancement was higher than NPVs.

The sensitivities of ultrasonographic halo and of clinical temporal artery abnormalities for the diagnosis of GCA were much higher than the sensitivity of mural contrast enhancement on MRI. The specificities and PPVs were 100% for both US and physical examination, while NPVs were lower.

Three patients had evidence of mural contrast enhancement on MRI and of halo sign on US. Two of these 3 patients also had temporal artery abnormalities. The fourth patient with mural inflammation on MRI had negative US and temporal artery inspection.

This patient was referred to our institution with a suspected diagnosis of GCA for a 4-month history of new-onset headache. Other signs/symptoms of GCA and/or polymyalgia rheumatica were not present. Erythrocyte sedimentation rate (by the Westergren method) and C-reactive protein values were normal (19 mm/hour and 0.08 mg/dl, respectively). Temporal artery biopsy was negative and ACR criteria were not satisfied. The patient was not treated with corticosteroids and at the 5-month followup visit he reported spontaneous amelioration of his headache. At this visit, ESR was 26 mm/hour and CRP was 0.14 mg/dl.

Seven patients with a halo had temporal artery abnormalities, 2 patients had a halo in absence of temporal artery abnormalities, and one patient had temporal artery abnormalities without a halo.

Relationship between pathological, magnetic resonance imaging, ultrasonography and temporal artery examination findings

Two of the 9 patients with positive temporal artery biopsy had evidence of a moderate inflammatory infiltrate which prevalently involved the vasa vasorum. One of these patients had a negative MRI, while ultrasonography and physical examination of temporal arteries were suggestive of GCA. The second patients had negative findings on MRI, ultrasonography and physical examination.

Discussion

The primary objective of our study was to assess the usefulness of MRI in the diagnosis of GCA. We used a 1T MRI scanner which is the MRI system available in our hospital. We found that MRI evidence of prominent or strong mural contrast enhancement of the vessel wall and\or of the perivascular space had a sensitivity of only 27% compared with the diagnosis of GCA by the ACR criteria. The NPV of this finding was 50%. Therefore, the absence of mural contrast enhancement on MRI did not rule out the possibility of having GCA. However, as shown by Bley *et al*., this MRI finding was specific to GCA (8). The presence of mural enhancement had a specificity of 89%.

The low sensitivity observed in our study is probably related to the low resolution of the MRI equipment used.

In our study the major limitation of the MR acquisition protocol was the low in-plane-resolution of 0.78 mm x 0.78 mm (which was due to the field strength of 1T). This circumscribed the detection of the vessel wall of the superficial temporal artery to one or even part of one pixel. We did not apply a larger matrix in order not to compromise the signal-to-noise ratio.

The results of studies using higher-resolution MRI with 1.5 or 3 T scanners support this explanation. In the first study, Bley *et al*. using high-resolution contrast-enhanced 1.5 MRI showed only one false negative patient when MRI findings of mural inflammation were compared with the diagnosis obtained using ACR criteria (7). In the second study Bley *et al*. used a 3T high-field MRI scanner to examine superficial cranial arteries of 21 patients with suspected GCA (8). Compared with the diagnosis of GCA by the ACR criteria, MRI had a sensitivity of 88.9%, while compared with temporal artery biopsy findings of GCA the sensitivity was 100%.

Corticosteroid therapy decreases MRI signs of mural inflammation (16), therefore performing temporal artery MRI after the beginning of corticosteroids may potentially increase the number of false negative MRI results. However, in all our patients corticosteroids were started after MRI was performed.

The second objective of our study was to compare the diagnostic accuracy of MRI with that of ultrasonography and of physical examination of temporal arteries for the diagnosis of GCA. The presence of abnormal temporal arteries on clinical examination increased the probability of a positive temporal artery biopsy result, while the absence of any abnormality reduced the chance of having GCA (12, 13, 17). We selected temporal artery tenderness on palpation or decreased or absent pulsation because these abnormalities in the 1990 ACR classification criteria for GCA separated patients with a diagnosis of GCA from controls without GCA better than any other criterion (11). In our study the diagnostic accuracy of ultrasonography and of physical examination were substantially better than that of 1T MRI. Compared with temporal artery biopsy findings of GCA, the sensitivity of a positive halo sign on US and of temporal abnormalities were

77.7% and 66.7% respectively, while the sensitivity of mural enhancement on MRI was only 33.3%. The specificity of the halo sign and of temporal artery abnormalities was very high (100%). A recent meta-analysis showed an overall sensitivity of 69% and an overall specificity of 82% for the halo sign compared to temporal artery biopsy (6). The diagnostic performance of the halo sign in this study is better compared to that observed in the meta-analysis and in a previous study from our group (5). This may reflect the improvement of the skills and experience of the ultrasonographist and the higher technical quality of the ultrasound equipment used in this study.

Furthermore, as we observed in our previous study (5), in most patients with GCA the presence of a positive halo sign was associated with evidence of temporal artery abnormalities at inspection.

A negative finding on temporal artery biopsy does not exclude the presence of GCA. Therefore, we used 2 reference standards: findings of the biopsy alone and use of the ACR criteria for GCA.

Our study has several limitations: our cohort of patients was small and mainly consisted of patients who were referred to us because of clinical suspicion of GCA. Therefore, the results of the study may not be generalized to patients in the community. However, this referral bias is difficult to avoid in studies of rare medical conditions, such as GCA.

Finally, we have used sequences that were acquired perpendicularly to the orientation of the vessel. To improve the diagnostic accuracy of 1T MRI examination we have planned to use also coronal sequences.

In conclusion, our study shows that 1T MRI is not useful in the diagnosis of GCA because of its low sensitivity and low NPV in detecting mural inflammatory signs. A positive halo sign on US and the abnormalities of temporal arteries at inspection had a better sensitivity and specificity. However, our data does not exclude a possible future diagnostic role for higher-resolution MRI, which has been reported as having a high sensitivity and specificity in detecting mural inflammation in cranial arteries.

References

1. SALVARANI C, CANTINI F, BOIARDI L, HUNDER GG: Polymyalgia rheumatica and giant-cell arteritis. *N Engl J Med* 2002; 347: 261-71.
2. JENNETTE JC, FALK RJ: The role of pathology in the diagnosis of systemic vasculitis. *Clin Exp Rheumatol* 2007; 25 (Suppl. 44): S52-S56.
3. WARRINGTON KJ, MATTESON EL: Management guidelines and outcome measures in giant cell arteritis (GCA). *Clin Exp Rheumatol* 2007; 25 (Suppl. 47): 137-41.
4. SCHMIDT WA, KRAFT HE, VORPAHL K, VOLKER L, GROMNICA-IHLE EJ: Color duplex ultrasonography in the diagnosis of temporal arteritis. *N Engl J Med* 1997; 337: 1336-42.
5. SALVARANI C, SILINGARDI M, GHIRARDUZZI A *et al.*: Is duplex ultrasonography useful for the diagnosis of giant-cell arteritis? *Ann Intern Med* 2002; 137: 232-8.
6. KARASSA FB, MATSAGAS MI, SCHMIDT WA, IOANNIDIS JP: Meta-analysis: test performance of ultrasonography for giant-cell arteritis. *Ann Intern Med* 2005; 142: 359-69.
7. BLEY TA, WIEBEN O, UHL M, THIEL J, SCHMIDT D, LANGER M: High-resolution MRI in giant cell arteritis: imaging of the wall of the superficial temporal artery. *AJR Am J Roentgenol* 2005; 184: 283-7.
8. BLEY TA, WEIBEN O, UHL M *et al.*: Assessment of the cranial involvement pattern of giant cell arteritis with 3T magnetic resonance imaging. *Arthritis Rheum* 2005; 52: 2470-7.
9. BLEY TA: Imaging studies in the diagnosis of large vessel vasculitis. *Clin Exp Rheumatol* 2007; 25 (Suppl. 44): 60-1.
10. DASGUPTA B, HASSAN N: Giant cell arteritis: recent advances and guidelines for management. *Clin Exp Rheumatol* 2007; 25 (Suppl. 44): S62-S65.
11. HUNDER GG, BLOCH DA, MICHEL BA *et al.*: The American College of Rheumatology 1990 criteria for the classification of giant cell arteritis. *Arthritis Rheum* 1990; 33: 1122-8.
12. GABRIEL SE, O'FALLON WM, ACHKAR AA, LIE JT, HUNDER GG: The use of clinical characteristics to predict the results of temporal artery biopsy among patients with suspected giant cell arteritis. *J Rheumatol* 1995; 22: 93-6.
13. RODRIGUEZ-VALVERDE V, SARABIA JM, GONZALEZ-GAY MA *et al.*: Risk factors and predictive models of giant cell arteritis in polymyalgia rheumatica. *Am J Med* 1997; 102: 331-6.
14. RAO JK, ALLEN NB, PINCUS T: Limitations of the 1990 American College of Rheumatology classification criteria in the diagnosis of vasculitis. *Ann Intern Med* 1998; 129: 345-52.
15. MARAVILLA KR, MALDJIAN JA, SCHMALFUSS IM *et al.*: Contrast enhancement of central nervous system lesions: multicenter intraindividual crossover comparative study of two MR contrast agents. *Radiology* 2006; 240: 389-400.
16. BLEY TA, WIEBEN O, LEUPOLD J, UHL M: Images in cardiovascular medicine. Magnetic resonance imaging findings. *Circulation* 2005; 111: e260.
17. SMETANA GW, SHMERLING RH: Does this patient have temporal arteritis? *JAMA* 2002; 287: 92-101.