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ORIGINAL ARTICLE

Overestimation of moderate carotid stenosis assessed by both Doppler US and contrast enhanced 3D-MR angiography in the CARMEDAS study

Surestimation des sténoses carotidiennes modérées évaluées par l'association Doppler + ARM-3D gadolinium dans l'étude Carmedas

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KEYWORDS
Angiography;
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Summary
Purpose. — To evaluate the agreement and diagnostic accuracy of Contrast enhanced magnetic resonance angiography (CE-MRA), Doppler ultrasound (DUS) and Digital subtraction angiography (DSA) in the assessment of carotid stenosis.
Methods. — DUS, CE-MRA and DSA were performed in 56 patients included in the *Carotide-angiographie par résonance magnétique-échographie-doppler-angioscanner* (CARMEDAS)

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Magnetic resonance (MR) contrast enhancement;
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US

multicenter study with a carotid stenosis $\geq$ 50%. Three readers evaluated stenoses on CE-MRA and DSA (NASCET criteria). Velocities criteria were used for stenosis estimation on DUS.
Results. — CE-MRA had a sensitivity and specificity of 96—98% and 66—83% respectively for carotid stenoses $\geq$ 50% and a sensitivity and specificity of 94% and 76—84% respectively for carotid stenoses $\geq$ 70%. The interobserver agreement of CE-MRA was excellent, except for moderate stenoses (50—69%). DUS had a sensitivity and specificity of 88 and 75% respectively for carotid stenoses $\geq$ 50% and a sensitivity and specificity of 83 and 86% respectively for carotid stenoses $\geq$ 70%. Combined concordant CE-MRA and DUS had a sensitivity and specificity of 100 and 85—90% respectively for carotid stenoses $\geq$ 50% and a sensitivity and specificity of 96—100% and 80—87% respectively for carotid stenoses $\geq$ 70%. The positive predictive value of the association CE-MRA and DUS for carotid stenoses $\geq$ 70% is calculated between 77 and 82% while the negative predictive value is calculated between 97 and 100%. CE-MRA and DUS have concordant findings in 63—72%, and the overestimations cases were recorded only for carotid stenosis $\leq$ 69%.
Conclusion. — Combined DUS—CE-MRA is excellent for evaluation of severe stenosis but remains debatable in moderate stenosis (50—69%) due to the risk of overestimations.

Introduction

Three randomised trials defined the indications for endarterectomy in patients with extracranial carotid arteries stenoses [1—3], but a recent meta-analysis has suggested that surgical treatment does not seem to be as effective as medical treatment is in the prevention of stroke associated with asymptomatic severe carotid stenosis [4]. Recent studies highlighted the high accuracy of Contrast-enhanced magnetic resonance angiography (CE-MRA) for measuring carotid stenosis [5—7]. However, these studies reported a significant rate of false positive results. Thus, numerous patients could suffer from a risk of an overestimation of a 50—69% stenoses and consequently undergo inappropriate surgery.

Moreover, according to another meta-analysis [8], more data are required to determine the accuracy of noninvasive carotid imaging in moderate stenosis.

In this work, based on the *Carotide-angiographie par résonance magnétique-échographie-doppler-angioscanner* (CARMEDAS) prospective multicenter study [9,10], we evaluate Doppler Ultrasound (DUS) and CE-MRA compared with Digital substraction angiography (DSA) for diagnosing carotid stenosis in symptomatic and asymptomatic patients.

Materials and methods

Study population

Two hundred and six patients suspected of having a carotid artery stenosis of 50% or greater on DUS, were enrolled in the CARMEDAS multicenter study between 2001 and 2003. Patients who had contraindications to MRA and/or to the administration of iodine contrast media were not included in this study. Among 206 patients, one group of 56 patients (15 women, 41 men, mean age 71 years, age range 45—85 years) had undergone within 15 days a DUS, a CE-MRA and a selective DSA. Results of the other group of patients (150) of the CARMEDAS study who underwent DUS, CE-MRA and Computed tomography angiography (CTA) instead of DSA, were analysed in previous papers [9,10]. Written informed consent was obtained from all patients. The study was approved by a medical ethics committee.

Imaging

DUS examinations were performed according to the Society of Radiologists in Ultrasound (SRU) criteria [11] and included measurements of peak systolic velocity (PSV), end-diastolic velocity (EDV), of the ratio of the Internal carotid artery (ICA)/common carotid artery velocities (ICA/CCA PSV ratio).

For CE-MRA, a coronal 3D gradient echo elliptic-centric acquisition was used before and after intravenous injection of Gadolinium chelate. CE-MRA parameters were optimised in each center with parameter ranges as follows: TR 3.9—7.8 ms, TE 1.4—2.1 ms, flip angle 25—30°, acquisition time 23—44 s. The maximal voxel size was 0.781 mm^3. The volume of gadolinium was 0.2 ml/kg bw and the flow rate was 2—3 ml/s. The 3D source images and the Maximum-intensity projections (MIP) algorithm were used to show extracranial vessels with multiple angles of view.

DSA were performed using the Seldinger technique with catheterization of both common carotid arteries (2D DSA in 47 patients, 3D DSA in nine patients). Vertebral arteries were not studied during these exams, to be as least invasive as possible. For 2D DSA, two orthogonal views were required for evaluation of the carotid artery stenosis and a third incidence was performed if needed. Two orthogonal studies were performed in addition on the skull to screen for cerebral vascular abnormality. A non-ionic iodine contrast medium was used as the contrast agent. All the patients have been admitted in a neurologic unit the day of the DSA exam and left the hospital the day after.

Image analysis

The analysis included the carotid artery suspected of having a stenosis and the opposite side. DUS data were provided by