CONTRAST-ENHANCED MR ANGIOGRAPHY (CE MRA) IN THE STUDY OF THE CAROTID STENOSIS: COMPARISON WITH DIGITAL SUBTRACTION ANGIOGRAPHY (DSA)

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Summary

Purpose
To determine sensitivity, specificity and diagnostic accuracy of contrast-enhanced magnetic resonance angiography (CE MRA) compared to digital subtraction angiography (DSA) in the study of carotid stenosis.

Methods and material
We studied 23 patients with suspected cerebro-vascular insufficiency by carotid stenosis. Diagnostic examinations by means of CE MRA and DSA were carried out within 24 hours of each other. A 1.5 T superconductive magnet (Signa - General Electric) was used for CE MRA. This technique was performed using a fast spoiled gradient echo recalled (SPGR) sequence acquired in coronal plane 13 sec after injection of contrast medium. Imaging parameters were: TR/TE/FA 8 msec/1 msec/60°, matrix 256 x 128, 1 excitation, FOV 18 x 13 cm, 28 slices per slab, slice thickness of 1 mm, acquisition time of 32 sec. The post-processing was performed using maximum intensity projection (MIP) and targeted MIP. For DSA examinations a Politron 1000 VR unit (Siemens) was used.

Results
In the identification and quantification of lesions, CE MRA showed values of 100 %. In particular, in comparison to DSA, CE MRA was accurate in diagnosing all true negative and positive cases. The location of stenosis evaluated with CE MRA agreed in all cases with DSA.

Conclusion
In our experience CE MRA proved to be a very valuable technique in diagnosing carotid stenosis, showing the same diagnostic accuracy as DSA. In this way CE MRA appears to be a substantial alternative technique to conventional MRA and other non-invasive diagnostic methods.

Key words: carotid arteries, stenosis and occlusion, contrast-enhanced magnetic resonance angiography (CE MRA), comparative studies.

Résumé

Angiographie par résonance magnétique rehaussée par injection de contraste pour l’étude des sténoses carotidiennes : comparaison avec l’angiographie numérique soustraite

Objectif
L’objectif de cette étude a été de déterminer la sensibilité, la spécificité et la précision diagnostique de l’angiographie par résonance magnétique avec rehaussement par injection de contraste (CE MRA) par rapport à l’angiographie numérique soustraite (DSA) pour l’étude des sténoses carotidiennes.

Méthodes
Vingt-trois patients avec une suspicion d’insuffisance circulatoire cérébrale par sténose carotidienne ont été étudiés. L’exploration diagnostique a comporté une CE MRA et une DSA dans les 24 heures. Un aimant supraconducteur (Signa -
INTRODUCTION

Magnetic resonance angiography (MRA) imaging of the carotid artery is considered one of the most important non-invasive methods [1, 5]. However, in the carotid stenosis the main limits of « conventional » MRA are the overestimation and, rarely, the underestimation of the lesions [6, 9]. Recently, a new MRA technique has been optimised; this technique consists in the use of a fast T1 sequence and a bolus of contrast medium [10, 13].

The aim of this study was to assess the sensitivity, specificity and diagnostic accuracy of CE MRA versus digital subtraction angiography (DSA), assumed as gold standard, in the evaluation of patients with clinical signs of cerebro-vascular insufficiency (CVI).

METHODS AND MATERIAL

From May to September 1997, 23 patients (14 males and 9 females, age range 63-73 years) with clinical signs of CVI (amaurosis fugax, repeated carotid ischemic attacks) who had been referred to our institute for DSA were consecutively included in this study, after giving their informed written consent. Diagnostic procedures were carried out within 24 hours of each other. Nine of these patients underwent thromboendarterectomy (TEA). CE MRA was performed using a 1.5T superconductive magnet (Signa - General Electric, Milwaukee, WI) and anterior neck coil. To calculate the delay time from contrast medium injection to the beginnings of the sequence it is necessary to perform a pre-test sequence after the injection of a small quantity (1 cc.) of contrast medium. For this a single slice 2D fast SPGR (Spoiled Gradient Echo Recalled) sequence, acquired in 1 sec, is repeated until an optimal contrast enhanced image is reached. In our experience we found a mean delay time of 13 sec. Then a 3D fast SPGR sequence was acquired in the coronal plane using the following parameters: TR/FA 10 msec/60°, TE minimum (the shortest possible TE time for the given prescription), matrix 256×128, slice thickness 1 mm, FOV 24 cm., acquisition time 32 sec. A double dose (0.2 mmol/Kg) of Gd-DTPA (Omniscan, Nycomed) was injected in the antecubital vein with a flow-rate of 1.5 ml/sec, using an automatic injector (Spectris-Medrad). Post-processing was performed using Maximum Intensity Projection (MIP) for the visualisation of the entire course of carotid arteries, and targeted MIP to visualise only a user-specified subvolume (carotid bifurcation) of the volume image. The images were rotated in the Z-axis from -45° to +45° with 15° steps, in order to reduce confusing vessels overlap. DSA, assumed as gold standard, was performed with a Siemens Politon 1000 VR unit. After selective common carotid artery catheterization, obtained by right transfemoral artery puncture, non ionic iodine contrast medium was injected at 4 ml/sec flow-rate (8 ml total volume) or 5 ml/sec (10 ml total volume) and two different projections (the oblique anterior left and right ones) were taken. CE MRA and DSA angiograms were evaluated by two different radiologists: one assessed CE MRA images, while the other evaluated DSA findings. They graded the severity of the stenosis according to the NASCET method as gold standard, in the evaluation of patients with clinical signs of cerebro-vascular insufficiency (CVI).
RESULTS

DSA provided 46 diagnostic judgements: 22 were negatives and 24 positives for carotid stenosis. Among the positive cases 3 were class II, 9 class III, 9 class IV and 3 class V. In all cases CE MRA provided diagnostic judgements without artefacts. When compared to DSA, CE MRA was accurate in diagnosing all true negative and true positive cases. The location of stenosis evaluated with CE MRA agreed with DSA in all of the cases. In particular, the assessment of the degree of stenosis with CE MRA and DSA was concordant in all cases, without neither overestimation nor underestimation of the stenosis (figures 1-3). CE MRA characterization of the lesions provided a correct diagnosis in 3 patients submitted to TEA with ulcerated plaques (figures 2-3); in the other 6 patients, 2 with calcified plaques and 4 with thrombosed or mixed plaques, CE MRA did not provide a correct diagnosis.

DISCUSSION AND CONCLUSION

Carotid stenosis is the main cause of the cerebrovascular strokes; DSA is usually considered the gold standard in the clinical investigation of the carotid disease [5]. The non-invasive techniques (Color-Doppler sonography, CT-angiography and MRA) [15-17] could replace DSA in the study of the patients with clinical signs of cerebrovascular insufficiency. In the late 80’s much work regarding MRA and carotid stenosis was reported in the scientific literature [1-8]. Conventional MRA techniques were compared with DSA in order to assess their diagnostic accuracy in diagnosing carotid stenosis and in grading their severity. The technical evolution of the sequences has led to an improvement in the diagnostic accuracy of conventional MRA. In a recent work we reported diagnostic accuracy values of 98 %, 92 %, 95 % for 3D TOF, 2D TOF and 3D PC, respectively [9]. Recently, the development of CE

Fig. 1. — DSA (a) and gadolinium-enhanced MRA (b, c): complete occlusion of the proximal right internal carotid artery (a, b) and mild stenosis (1-29 %) of the left carotid bifurcation (a, c). The vascular imaging is similar in both methods.
MRA has offered new diagnostic perspectives and, among all anatomical sites, neck vessels were the first anatomical area to be studied [10-13]. Unlike conventional MRA, the complete lack of overestimation and underestimation of the grade of the stenosis of CE MRA is determined by the use of a contrast medium. In shortening T1 time of the blood, Gd-DTPA resolves all limits created by the saturation of slow flow spins and/or turbulent spins. However some difficulties may relate to mathematical algorithms. MIP is the most widely accepted method for post-processing but it is not perfect: it can introduce artefacts and potentially lead to underestimation of vessel caliper. Nevertheless in our experience we observed a strict concordance between DSA and CE MRA in identifying and grading the stenosis (figures 1-2-3).

In considering both diagnosis and characterization, in our experience CE MRA allowed to detect and correctly diagnose ulcerated plaques, presenting semiologic findings similar to DSA (figures 2-3). On the contrary, with CE MRA, as well as with conventional MRA, important limits in diagnosing calcified or thrombotic plaques are still present.

MR is unable to visualize and detect the calcified aspect of the plaque where MRA is unable to identify its thrombotic component. In order to characterize the plaque, Spin Echo T1 and T2 sequences are necessary but they could only detect thrombotic plaque [15]. On the contrary CE MRA utilizes T1 sequences with reduction of signal of the stationary tissues and, therefore, of the thrombotic component. In the future this limit could be overtaken with the use of ultra Fast T1 and T2 weighted MRA sequences.

Besides improved diagnostic accuracy, another advantage of CE MRA is the overall visualization of the epiaortic vessels, from the aortic arch to intracranial vasculature, in a coronal plane. This important characteristic permits to detect in the same acquisition time, lesions localized in different vascular districts (tandem lesions). Tandem lesions are not visualized in the same angiogram with conventional MRA and this represents one of the major drawbacks of the technique.

A n important problem of CE MRA is the choice of the optimal delay time of injection of contrast medium. The pre-test Fast 2D sequence with preliminary bolus of contrast medium may be helpful to identify the correct delay time. Unfortunately, even if the correct delay time has been chosen, the relatively long acquisition time of Fast 3D sequence (more than 30 seconds) may visualize venous vessels overlapping carotid arteries.

Recent introduction of softwares that permit the automatic choice of correct delay time and the use of ultrafast 3D sequences may represent the definitive answer to this problem, but these solutions are still not diffused and they are not available on all magnets. However, the use of targeted MIP post-processing and the different degree of contrast enhancement between venous and arterial vessels usually permit to distinguish carotid arteries from jugular veins.

Our preliminary experience seems to suggest that the use of contrast medium improves diagnostic reliability of MRA in the study of steno-occlusive pathologies of the neck vessels.

REFERENCES

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Fig. 3. — DSA (a) moderate stenosis of both proximal internal carotid arteries; and gadolinium-enhanced MRA (b) a simple plaque is present on the left side while the plaque is ulcerated on the right side.

Fig. 3. — Angiographie numérique soustraite (a) et angiographie par résonance magnétique avec rehaussement par injection de contraste (b) : plaque simple du côté gauche et plaque ulcérée du côté droit.


