VASODILATING IN MR-ANGIOGRAPHY :
A COMPARISON OF TECHNIQUES

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SUMMARY

Purpose: To verify the hypothesis that a drug that causes vasodilatation can contribute to improvement in MRA spatial resolution. To test this hypothesis, a comparison was made between the images obtained using the high resolution time-of-flight (TOF HR 3D) technique and the TOF 3D MTC TONE technique.

Methods: From November 1993 to December 1994, we studied 40 patients, of which 20 patients (16 males and 4 females; average age of 10 years; range from 3 to 20 years) we examined after they had inhaled Isoflurane (experimental group), and 20 patients (16 males and 4 females; average age 9.7 years; range from 3 to 12 years) were examined with standard MRA (control group).

Results: The vasodilator in both HR MRA and MTC TONE MRA permits a better spatial visualization with respect to the clinical routine MRA. On the other hand, it is true that MTC TONE gives better visualization of the small vessels.

Discussion: In our experience, this preliminary study indicates that with respect to routine MR, the spatial resolution is notably increased when Isoflurane is used. The signal-to-noise ratio is increased but, moreover, the ability to visualize small vessels is increased.

Conclusion: The preliminary results obtained in this study indicate that a pharmacological drugs is capable of increasing the vascular detail of MRA images of the intracranial vessels and that continued research this direction is called for.

Key-words: Magnetic Resonance Angiography. Vasodilator groups, Intracranial vessels, Time of flight technique, Magnetic Resonance Angiography-Vasodilator drugs.

RESUMÉ

Vasodilatation au cours de l’angiographie par résonance magnétique : une comparaison des techniques

Objective: Vérifier l’hypothèse selon laquelle l’utilisation d’un médicament vasodilatateur permet d’améliorer la résolution spatiale de l’angiographie par résonance magnétique. Afin de tester cette hypothèse, nous avons comparé les images obtenues en séquence temps de vol à haute résolution (TOF HR 3D) à celles obtenues avec la technique TOF 3D MTC TONE.

Méthodes: De novembre 1993 à décembre 1994, nous avons étudié 40 patients divisés en deux groupes. Le premier groupe de 20 patients (16 hommes et 4 femmes ; âge moyen 10 ans ; extrêmes 3-20 ans) a été examiné après inhalation d’isoflurane (groupe expérimental). Le deuxième groupe de 20 patients (16 hommes et 4 femmes, âge moyen 9,7 ans ; extrêmes 3-12 ans) a été examiné avec la méthode standard d’angiographie par résonance magnétique.

Résultat: Pour la technique HR comme la technique MTC TONE, le vasodilataiteur a permis une amélioration de la visualisation spatiale par rapport à l’angiographie de routine. Une meilleure visualisation des petits vaisseaux a été observée sur les séquences MTC TONE.

Discussion: Cette étude préliminaire a montré que l'utilisation de médicaments vasodilatateurs améliore le détail des images angiographiques par résonance magnétique et souligne l’importance des études dans ce domaine.

Mots clés : Angiographie par résonance magnétique, vasodilatatateurs, vaisseaux intracrâniens, temps de vol, angiographie par résonance magnétique-vasodilatateurs.

INTRODUCTION

The limited spatial resolution capability of magnetic resonance angiography (MRA) in the visualization of small vessels [4, 5] has not created complications for the visualization of the large aortic branches.

This limited capability has, restricted the clinical application of MRA in the study of the smaller peripheral vessels. Indeed, the visualization of small vessels of the intracranial circulation is conditioned...
by several variables: for example, the terminal portion of arterial vessels have a small diameters (M4, P2, A2); the moving spins, during the final part of their run accumulate more than 20 radiofrequency (RF) impulses and are, therefore, saturated [3]; the venous vessels have a particularly slow flow and, consequently, with three-dimensional (3D) techniques, may not give signals. Numerous contributions have been made in the attempt to increase the resolution of MRAs of intracranial vessels. For example: the increase of signal-to-noise ratio of the dedicated coils, the development and implementation of high resolution (HR) technique (512 × 256) [9], the magnetization transfer contrast (MTC) [11], the use of tilted optimized, nonsaturating excitation (TONE) [1], and the use of paramagnetic contrast medium [14]. All of the above mentioned technical improvements have contributed to the continued advances in the quality of the image used in the study of the intracranial circulatory system.

The purpose of this study is to verify the hypothesis that a drug causes vasodilatation can contribute to the improvement in MRA spatial resolution.

A comparison was made between the image obtained with and without administration of Isoflurane using the high resolution time-of-flight (TONE HR3D) technique and the TOF3D MTC TONE technique.

MATERIALS AND METHODS

For this study, Isoflurane, an anesthetic gas, was chosen because of its well-noted effect of increasing the cerebral blood supply as a result of a decrease in vascular resistance due to vasodilatation. In fact the increased agree of anesthetic results a progressive decrease in arterial pressure, the cerebral blow flow increases and the cerebral metabolism decreases. The intracranial blow pressure increase as a result of the cerebral vasodilatation but this effect is corrected by hyperventilation [10].

After a written informed consent in the time period from November 1993 to December 1994, we studied 40 patients, of which 20 patients (16 males and 4 females; average age of 10 years; range from 3 to 20 years) were examined after they had inhaled Isoflurane (experimental group), and 20 patients (16 males and 4 females; average age of 9.7 years; range from 3 to 12 years) were examined with MRA standard (control group).

The twenty patients selected has a control group were enrolled according to a prospective study. The use of a control group was necessary because it was not possible to conduct two examinations for patient, using both methods. All the patients in the experimental group were candidates for examination while under anesthesia. Each patient was assignated to one of the groups using as criteria age and clinical problems (table I).

A 1.5 T superconductive magnet, a dedicated circular polarization coil (head coil), and TOF technique without pre-saturation pulse for the venous flow were used all MRAs. Our protocol called for with two different matrix size.

To evaluate the effects of the vasodilator drug on intracranial vessel MRAs, two sequences were compared, HR FISP3D and FISP3D MTC TONE.

Twenty patients, ten from the control group and ten from the experimental group, were studied with HR FISP3D and FISP3D MTC TONE. Twenty patients, ten from the control group and ten from the experimental group, were studied with FISP3D MTC TONE sequences (TR 40 ms, TE 7 ms, MA 512 × 512). The remaining twenty patients, ten from the control group and ten from the experimental group, were studied with FISP3D MTC TONE sequences (TR 40 ms, TE 8 ms, MA 512 × 256).

The images were acquired on the axial plane and elaborated according to the MIP. The patients in the experimental group were administered a 1:1 mixture of O2 : N2O with increasing concentrations of Isoflurane (from 0.4 % to 0.6 %). The acquisition technique called for the continuous administration of Isoflurane for the entire acquisition time.

The angiograms were rendered anonymous and then given to an expert radiologist along with a multiple choice card that listed all the arterial segments [8,13] of the intracranial circulatory system. The interpretation of the angiogram was expressed on a relative descending scale from 1 to 4 (table II). The card contained an appendix in which the radiologist was asked to list the presence of venous vessels and/or the alterations of the background noise. The results for each card were then reinserted in their original group and the final results were categorized.

<table>
<thead>
<tr>
<th>Diagnostic verdicts</th>
<th>1) Homogeneous hyperintense vessel with well-defined wall and clear background contrast</th>
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</thead>
<tbody>
<tr>
<td>2) Non-homogeneous hyperintense vessel (with signal void) with well-defined wall</td>
<td></td>
</tr>
<tr>
<td>3) Non-homogeneous vessel, with blurred wall and high background noise</td>
<td></td>
</tr>
<tr>
<td>4) Vessel poorly or non-distinguishable</td>
<td></td>
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Diagnostic scale according to score from 1 to 4

<table>
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<tr>
<th>TABLE I. – MRA with Isoflurane versus MRA standard</th>
<th>TABLEau I. – Angiographie par résonance magnétique : isoflurane versus la technique standard</th>
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</thead>
<tbody>
<tr>
<td>MRA Isoflurane</td>
<td>MRA Standard</td>
</tr>
<tr>
<td>3D HR</td>
<td>3D MTC TONE</td>
</tr>
<tr>
<td>Average age</td>
<td>10</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>3</td>
</tr>
<tr>
<td>Cephalalgia</td>
<td>4</td>
</tr>
<tr>
<td>Loss of vision</td>
<td>1</td>
</tr>
<tr>
<td>Edema of the optical papilla</td>
<td>2</td>
</tr>
</tbody>
</table>

Inclusion criteria of the patients studied with MRA standard versus MRA with Isoflurane:

1. 3D HR: Acquisition of volume with High Resolution
2. 3D MTC TONE: Acquisition of volume with magnetization transfer contrast and tilted optimized nonsaturating excitation.

number of poorly or non-visualized blood vessels (table III).

The smaller vessels (table IV) were better visualized in the experimental groups; in particular for the MTC TONE experimental group, the ophthalmic artery was rated “1” 15 times versus 7 for the control, segment A2 was visualized 15 times for the experimental group versus 9 for the control, segment M3 was visualized 16 times for the experimental group versus 11 for the control, segment M4 was visualized 15 times for the experimental group.

Ten Mann-Whitney Test was used for the sum rank of the scale to determine if the results were statistically significant (p < 0.01).

In our protocol we did not perform MRI because we wanted to study the cerebral vasculature.

The angiograms were performed with two different techniques (HR FISP 3D and 3D MTC TONE) but with the same parameters for all patients in order to render the final angiogram as reproducible as possible.

The angiograms were evaluated in second time by the same neuroradiologist to determine if existed an intra-observer difference.

RESULTS

The overall results for the patients analyzed with HR FISP 3D are: 128 ratings of “1” (optimal diagnostic rating) for the experimental group versus 109 for the control group (fig. 1), 31 ratings of “2” for the experimental group versus 37 for the control group, 13 ratings of “3” for the experimental group versus 23 for the control group, and 18 ratings of “4” for the experimental group versus 21 for the control group.

The results for the patients analyzed with 3D MTC TONE are: 149 ratings of “1” (optimal diagnostic rating) for experimental group versus 122 for the control group, 18 ratings of “2” for the experimental group versus 30 for the control group, 11 ratings of “3” for the experimental group versus 18 for the control group, and 12 ratings of “4” for the experimental group versus 20 for the control group.

Analysis of these result using the Mann Whitney Test indicate a statistically significant difference for the ratings “1” and “4”, independent of the MRA technique used. A statistically significant difference was not obtained for the ratings “2” and “3” for both techniques. This confirms that the MRAs for the experimental group rated with the optimal diagnostic rating “2” permit a better visualization of the blood vessels; this situation is inverted go the rating “4” since the control group had a greater
versus 8 for the control (fig. 2), the communicating arteries were visualized 20 times for the experimental group versus 9 for the control, and segment P2 was visualized 20 times for the experimental group versus 12 for the control (fig. 3).

The visualization of the intracranial veins and/or the venous sinuses were reported. On the other hand, the quality of the angiogram was not reported. On the other hand, the quality of the angiogram was non reported to decrease, indicating that the use of Isoflurane did not cause the impregnation of the nasal mucosa and/or choroid plexus. In the comparison between the results of neuroradiologist (intra-observer difference) there was not statistically difference.

DISCUSSION

In 1987 the first reports on the possible applications of MRA for clinical studies of the intracranial vessels appeared. Since then numerous advances have been made in the techniques of acquisition and post-processing. But despite the intrinsic technological advances can contribute to an increase in angiogram quality, and in particular, their spatial resolution. The advantages offered by gadolinium have been demonstrated and it is now used routinely, in particular in the study of arterial-venous malformations, cavernous angiomas, sinus thrombosis, and meningiomas [2, 13].
This preliminary study indicates that with respect to clinical routine MR, the spatial resolution of MRA is notably increased by this external element. The signal-to-noise ratio is increased but, moreover, the ability to visualize small vessels is increased.

The vasodilator in both HR MRA and MTC TONE MRA permits a better spatial visualization with respect to the clinical routine MRA. On the other hand, it is true that MTC TONE gives better visualization of the small vessels [7, 12].

With respect to MRAs obtained with contrast medium, in this preliminary study with a vasodilator, non-arterial structures of importance were not seen. Thus avoiding confusing angiograms; in particular, with respect to gadolinium, the contemporary and/or the choroid plexi are avoided.

Attempts to obtain better MRAs of the intracranial circulatory system with vasodilators have received clinical and experimental support. The principal limit of the use of Isoflurane as the vasodilator agent is that, because it is an anesthetic agent, it is non a plausible routine clinical technique. The results of this preliminary study indicate the usefulness of identifying a pharmacological agent that causes vasodilatation in a target area without causing collateral effects.

Although the different sizes of the matrices used with the two techniques (512 × 512 - 512 × 256).

FISP 3D MTC TONE is resulted more accurate than the HR FISP 3D because the first technique reduces background noise.

CONCLUSION

Since 1989, there have been consistent improvements in the diagnostic potential of MRA. These improvements have been in two different areas: 1. attempts to optimize the parameters and therefore the acquisition techniques [6, 11] and 2. attempts to introduce external agents, contrast medium and/or other agents, capable of improving quality and therefore providing additional diagnostic information.

The preliminary results obtained in this study indicate that a pharmacological drug is capable of increasing the vascular detail of MRQs of the intracranial vessels and that continued research in this direction is called for.

In conclusion, the results of this study and the cerebral vascular effects of this drug suggest its use in endovascular treatment.

REFERENCES