Metabolic changes after surgical clipping and endovascular embolisation of intracranial aneurysms - MR spectroscopy study

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Authors: E. Tarasów¹, J. Walecki², J. Kochanowicz¹, A. #ukasiewicz¹, B. Kubas¹, J. Brzozowska¹, Z. Mariak¹,¹ Bia#ystok/PL, ²Warsaw/PL
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Purpose

The aim of the work was to evaluate metabolic changes of the brain in patients after clipping or endovascular embolisation of intracranial aneurysms, after subarachnoid haemorrhage, long after aneurysm obliteration.
Methods and Materials

The study was conducted in a group of 36 patients, 13 men and 23 women (mean age of 52.5±8.3 years) with intracranial aneurysms, with a history of subarachnoid haemorrhage, who underwent a procedure of aneurysm clipping (n=23) or endovascular embolisation with detachable coils (n=13). Imaging examinations and MRI spectroscopy were carried out within 28-44 months from the procedure (35±5 months).

The patients were divided into 3 groups, depending on aneurysm location: group I - patients with aneurysm of the anterior communicating artery complex (anterior artery - ACA and anterior communicating artery - ACoA), group II - patients with aneurysms of the internal carotid artery (ICA) and the middle cerebral artery (MCA), and group III - patients with posterior circulatory aneurysms (basilar artery- BA and posterior arteries - PA). The control group was composed of 20 healthy volunteers, 8 men and 12 women, in a similar age range as the patients from the study group (mean age of 50.4±5.6 years; P>0.05).

All patients underwent a physical examination before the procedure. It was based on the Glasgow Coma Scale (GCS) [1] and Hunt-Hess scale (H-H) [2]. The evaluation of surgery results was carried out on the basis of the Glasgow Outcome Scale (GOS) [3].

MRI examinations were carried out with a Picker Eclipse 1.5T system with the use of a coil designed for head examinations. MR spectroscopy was performed using PRESS sequence (point resolved spatially localised spectroscopy), with the use of the following sequence parameters: TE of 35 ms, TR of 15000 ms, number of repetitions (nex) 192. Voxels measuring 8 cm³ (2×2×2 cm) were located symmetrically in both frontal areas, above the frontal horns of the lateral ventricles, with the superior and medial frontal gyrus included in the measurement area. Voxels included brain structures that remained unchanged on MRI, i.e. white matter mainly, and cerebral cortex to a lesser degree.

In the assessment of the spectra, we included signals of N-acetylaspartate (NAA), creatine (Cr), choline (Cho), myo-inositol (ml), and glutamate/glutamine complex (Glx). The ratios of these chemical components were analysed with respect to the creatine level (NAA/Cr, NAA/Cho, Cho/Cr, ml/Cr, Glx/Cr).

The statistical analysis involved Mann-Whitney U test and Pearson's chi-square test, with significance level amounting to P<0.05.
Results

A mean GOS score in the whole study group amounted to 4.75±0.5 (median of 5 points) and was similar in both groups: after clipping (4.74±0.45; P>0.05) and after embolisation (4.77±0.6; P>0.05). Table 1 showed the results of physical examinations including aneurysm location and the applied method of embolisation. Scores were similar for all the groups, both before the procedure and postoperatively. The difference was not statistically significant.

Figure 1 showed mean ratios of the examined metabolites in the study group and in the control group. In the study group, there was only a slight, statistically insignificant decrease of the NAA/Cr ratio, and a slight increase in the ml/Cr ratio. Cho/Cr and Glx/cr ratios were close to the results of the control group. Similar results were obtained in the comparison of the results of MRS examination in patients with clipped and in patients with embolised aneurysms (Figure 2).

Figure 3 showed mean metabolite ratios depending on aneurysm location and with regard to the control group. No significant differences of metabolite ratios were found between the evaluated groups and in comparison to the control group. Only in group I, i.e. in patients with aneurysms of the ACoA complex, there was a statistically significant decrease in the NAA/Cr ratio (P<0.05) with regard to other study groups and the control group. No significant differences were found in the evaluated metabolite ratios for specific study groups (formed on the basis of aneurysm location and the applied method of obliteration). There were no significant correlations between the clinical status and metabolite ratios, neither in the whole study group, nor in any of the subgroups. When comparing the results of MR spectroscopy in the II group with respect to aneurysm lateralisation, no significant differences were found in the evaluated metabolite ratios in the frontal lobe on the aneurysm side, and in the contralateral hemisphere.
**Table I. Clinical evaluation of the study group of patients, including aneurysm location and type of procedure**

<table>
<thead>
<tr>
<th></th>
<th>Clipping (n=23)</th>
<th>Embolisation (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GCS (Pts)</td>
<td>H-H (Grade I/II/III)</td>
</tr>
<tr>
<td>Group I (n=11)</td>
<td>14.6±0.8</td>
<td>5/2/0</td>
</tr>
<tr>
<td>Group II (n=21)</td>
<td>14.2±1.6</td>
<td>8/6/1</td>
</tr>
<tr>
<td>Group III (n=4)</td>
<td>15.0±0.0</td>
<td>1/0/0</td>
</tr>
</tbody>
</table>

**Fig. 0:** Table I.

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**Fig. 0:** Figure 1. Metabolite ratios in patients after aneurysm obliteration and in the control group.

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**Fig. 0:** Figure 2. Metabolite ratios in patients after surgical clipping and after endovascular embolisation, in comparison to the control group.

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**Fig. 0:** Figure 3. Metabolite ratios depending on aneurysm location, with regard to the control group.

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Conclusion

1. Surgical clipping and endovascular embolisation of aneurysms of the ICA, MCA and of the posterior cerebral arterial circle do not lead to significant changes in metabolite levels in the frontal lobes on MR spectroscopy at long term follow-up.

2. In patients after obliteration of aneurysms of the ACoA complex, metabolic disturbances are found in morphologically unchanged frontal lobes, after 2-4 years following surgery. These disturbances are indicative of neuronal damage (dysfunction).
References


