Correlation and fusion of perfusion and spectroscopic MR imaging for the characterisation of brain tumors

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Objectives:

For biopsy as well as for radiation therapy planning preoperative classification and detection of the most aggressive area of brain tumors are essential. We investigated whether a combination of spectroscopic and perfusion imaging is useful to preoperatively characterize intracranial tumors and if the regions of highest values correspond.

Materials and Methods:

Until now we investigated 12 patients with brain tumors (Fig. 1). Besides T2- and T1-weighted morphologic images T2*- weighted MR perfusion in the same slice position and 2D- proton MR spectroscopic imaging was performed (Fig. 2). For calculating the blood volume maps, the data were loaded into the programme DPTools® by Denis Duceureux, which in addition allows for transferring regions of interest (ROI) from morphologic images onto the perfusion maps (Fig. 5). For evaluation of the spectroscopic data we used the software Syngo® implemented on our MR-scanner (Fig. 6).

As ROI we defined the macroscopic apparent part of the tumor e.g. the enhancing area (ROI 1) (Fig. 3) and the surrounding area hyperintense on T2 images (ROI 2) (Fig. 4) and compared it to normal appearing white matter (ROI 3). Spectroscopic voxels with artifacts from bone or necrosis were excluded.

For lack of absolute concentrations relative regional Cho/NAA ratios (rCho/NAA ratio) and relative regional cerebral blood volume (rCBV) were used.

We also assessed match or mismatch of the areas of highest perfusion and Cho/NAA ratio.

Results:

Perfusion imaging was evaluable in all cases. In 2 glioblastoma some spectra in the tumor were disturbed due to intratumoral bleeding and necrosis. As these spectra were ignored for evaluation, all patients showed raised Cho/NAA ratio in ROI1.

rCBV in the glioma III, in 3 glioblastomas and in the meningioma was highly elevated.

In the meningioma in both parameters increase was strictly limited to ROI 1, whereas in ROI 2 of the malignant gliomas Cho/NAA ratio was elevated.

Lymphomas showed no or only slight elevation of rCBV in ROI 1 and non in ROI 2. Low grade astrocytomas neither had increase of rCBV in ROI 1 nor in ROI 2, however as they do in Lymphomas spectra revealed raised Cho/NAA ratio in ROI 1 and in 1 case again in ROI 2.

Gliomatosis cerebri didn’t show hyperperfusion but increased Cho/NAA ratio in either of the ROIs. In 6 of 9 tumors, in which areas of highest rCBV and Cho/NAA within the lesion were definable, perfusion and spectroscopy displayed the same location.

Conclusion:

Perfusion and 2D proton MR spectroscopic imaging are able to visualize characteristics of tumors such as vascular proliferation and infiltration

Not all of our patients demonstrate good local correlation of regions with highest values:

CBV helps to reveal areas with high density of vessels defining vital parts of tumors. That in gliomas represents a higher malignancy (e.g. Fig. 8). But CBV fails to detect poorly vascularized lesions (Fig. 7).

Cho/NAA ratio is a reliable instrument for locating neoplastic lesions (Fig. 11). But in some cases elevation of Cho/NAA ratio persists in necrotic regions (Fig. 10). For that we suggest to combine conventional MR-imaging with MR-perfusion- and -spectroscopy as a useful tool for preoperative characterisation of brain tumors as well as for biopsy and radiation therapy planning.

Results have to be confirmed with larger numbers of patients which is in progress.

Patients and MR-Imaging (Fig. 1 and 2):

<table>
<thead>
<tr>
<th>tumor</th>
<th>patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>glioma III</td>
<td>2</td>
</tr>
<tr>
<td>glioblastoma</td>
<td>9</td>
</tr>
<tr>
<td>gliomatosis</td>
<td>1</td>
</tr>
<tr>
<td>meningioma</td>
<td>1</td>
</tr>
</tbody>
</table>

sequence T2-TSE 2D multivoxel spectroscopy T1-SE T2* perfusion (grey-EPI)

TE, TR (ms) 131 ms/460 ms 1000 ms/105 ms 17 ms/665 ms 2000 ms/60 ms

matrix 256 x 256, FOV 256 160 x 160, FOV 160 mm 256 x 256, FOV 256 128 x 128, FOV 256 mm

measurement 20 slices 8 slices 20 slices 25 repetitive averages 20 slices

slice thickness 4 mm without gap 6 mm without gap 3 mm without gap 2 mm without gap

pulldown 0.1 mm, slice, 1.5 m/s 0.1 mm, slice, 5 m/s

scanner 1.5 T whole body MR scanner (Siemens Magnetresonantr, Erlangen, Germany)

Analysis (Fig. 3 - 6):

Results (Fig. 7 - 11):

Fig. 11: Regional values of cerebral blood volume and Cho/NAA ratio relative to normal appearing white matter. In addition match or mismatch of the areas of highest values of both parameters are on display. Tumors, in which no region of highest CBV was evaluable were marked with ‘\n’.