Fast brain spectroscopic imaging fits routine clinical use

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User experiences

The Department of Radiology at University Hospitals Leuven (Belgium) performs some MR brain spectroscopy exams each week with Achieva 3.0T TX. It provides valuable information in cases such as metabolic and mitochondrial disorders, and offers information for differential diagnosis between recurrent brain tumor and brain tissue changes resulting from radio-, chemo- or immunotherapy, as well as assessment of abscesses.

Applying SENSE in two directions has allowed the Leuven team to dramatically shorten the scan time of MR spectroscopic imaging (MRSI) in the brain to about three and a half minutes without loss of spectral or spatial resolution, while maintaining sufficient SNR. “These shorter scan times make it practical to include MR spectroscopy in routine brain MR exams,” says Philippe Damaerel, MD, PhD. “It adds only 5-10 minutes to the patient’s exam and provides clinically relevant information. We now routinely use 2D MRSI, and also single-voxel MR spectroscopy in cases where quantification is important.” The advantage of 2D-MRSI over single-voxel data lies in the extra information of obtaining the spatial distribution of metabolites in the brain by acquiring a whole grid of spectra with similar clinically acceptable scan times.

Leuven speeds up spectroscopy with SENSE

“Using the 8-channel head coil we acquire a 2D SENSE-PRESS MRSI with a field of view of 16 x 16 cm², and a volume of interest of 8 x 8 x 1 cm³. A typical acquisition voxel is 1 x 1 cm², reconstructed to 0.5 x 0.5 cm², with slice thickness 1 cm. TR/TE is 2000/35 ms,” explains Uwe Himmelreich, PhD. “With SENSE factor 2.0 x 1.8 the scan time is reduced to 3:34 minutes.”

“Long TE spectroscopy is mainly used to assess changes in metabolite ratios NAA/Cho, NAA/Cr, and Cho/Cr. In addition, metabolites that indicate anaerobic metabolism (lactate) or are indicative for abscesses (acetate, succinate) can also be identified in long TE spectroscopy,” says Dr. Himmelreich. “Short TE spectroscopy is used for the assessment of lipids and other
“MR spectroscopy adds 5-10 minutes to the brain exam and provides clinically relevant information.”

**Lymphoma**

74-year-old with visual impairment. Ophthalmological examinations were normal. MR of the brain demonstrated a contrast-enhancing lesion in the left occipital lobe. Possible diagnosis is a primary brain tumor (glioblastoma or anaplastic astrocytoma), solitary metastasis or lymphoma. MR Spectroscopy showed extremely elevated choline (indicative for high cellularity), and remarkable lipid peaks (membrane breakdown and necrosis). NAA and Cho were not identifiable. These findings are suggestive of an intracranial lymphoma, rather than a high grade primary tumor or a metastasis. This is of particular interest, as the three entities require different therapeutic strategies.

Clinical Cases are provided by Sofie Van Cauter, MD, University Hospitals Leuven.
User experiences

**Metabolites visible in brain MR spectroscopy (mM range)**

<table>
<thead>
<tr>
<th>Metabolite</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipids</td>
<td>Lip</td>
<td>Breakdown product from cells, present in necrosis, inflammation</td>
</tr>
<tr>
<td>Lactate</td>
<td>Lac</td>
<td>Product of anaerobic metabolism, present in stroke, lactacidosis, aggressive tumor, cysts</td>
</tr>
<tr>
<td>N-acetyl aspartate</td>
<td>NAA</td>
<td>Present in healthy neurons, axons, dendrites</td>
</tr>
<tr>
<td>Creatine/Phosphocreatine</td>
<td>Cr/PCr</td>
<td>Energy marker, relatively stable concentration in brain</td>
</tr>
<tr>
<td>Choline</td>
<td>Cho</td>
<td>Building block of cell membranes, brain myelin, is increased in tumor, MS</td>
</tr>
<tr>
<td>Myoinositol</td>
<td>mI</td>
<td>Sugar, osmolite, present near cell damage, so in tumor, MS, hepatic encephalopathy</td>
</tr>
</tbody>
</table>

Metabolite changes such as myoinositol, glutamate/glutamine (Glu/Gln) and other amino acids, but also for the assessment of NAA, choline (Cho) and total creatine (Cr+PCr) if time does not permit the acquisition of two MR spectra with different TE.

Dr. Demaerel adds, “The ability to look at these changes is extremely important, and could really make a difference in diagnosis. The availability of SENSE allows us to reduce the scan times of MRSI so that it can be easily added to standard exams.”

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**Glioblastoma**

A 65-year-old woman was admitted to the hospital after a first epileptic seizure. Conventional MR shows a large contrast-enhancing heterogeneous lesion in the left parietal lobe. MR Spectroscopy in the enhancing portion of the lesion shows an elevated Cho/NAA ratio as could be expected in rapidly proliferating tumoral tissue with neuronal loss. The MR spectrum in the peri-lesion edema shows elevated choline, suggestive of infiltrating tumor. Tumor infiltration is a characteristic of a glioblastoma multiforme. As the edematous regions in metastases are purely vasogenic, increased choline is not expected.

The differentiation between a solitary metastasis and a glioblastoma can possibly be made by the spectroscopic features in the peritumoral edema rather than the spectra from enhancing tumoral tissue.
Four-day-old neonate with intractable seizures. Transcranial ultrasound showed a hypoplasia of the corpus callosum. Blood and spinal fluid had slightly elevated glycine. Anatomical MR images confirmed the tic corpus callosum. No other structural anomalies are seen. Spectroscopy was performed with three different TEs (35 ms, 144 ms and 288 ms). In the short TE spectrum a clearly elevated peak is seen at 3.6 ppm, which corresponds to myoinositol and/or glycine. Myoinositol has a short T2 and is therefore not visible at longer TE’s. The peak is visible at TE 144 and TE 288 and can therefore be assigned to glycine. In physiological circumstances, glycine is present in non-detectable amounts in the human brain. Due to an inherent disorder in the glycine metabolism in this patient, glycine accumulates in the body. Excess glycine in the brain and the organs results in serious medical problems, including encephalopathy.