MR Spectroscopy in Different Regions of the Spinal Cord and in Spinal Cord Tumors

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Introduction

Proton MR spectroscopy (MRS) shows a great potential to non-invasively add valuable diagnostic information in the evaluation of spinal cord lesions, just as has been shown in the brain. However MRS of the spinal cord is particularly challenging due to the small voxel sizes, field inhomogeneities, and physiologic motion. Cooke et al. [1] have demonstrated that good quality spectra can be obtained and quantified in the healthy cervical spinal cord at 2T. They concluded that the best placement for the MRS voxel is above the level of the interface of the C2/C3 vertebral bodies. In this work we show spectra acquired at 3T from a primary cord tumor located in the cervical spinal cord. Furthermore, as cord lesions are not restricted to the cervical regions, we also explored the feasibility of MRS in lower parts of the spinal cord, especially near the intumescentia lumbosacralis.

Materials & Methods

Single voxel spectroscopy was performed in the pons, the medulla oblongata, at different levels of the cervical spinal cord and close to the intumescentia lumbosacralis (near the lower end of the spinal cord) in healthy volunteers to compare the achievable spectral quality along the spinal cord. Furthermore, a patient with a primary tumor of the cervical spinal cord was measured with MRS. All volunteers and the patient gave written informed consent prior to participating in the study. Measurements were carried out on a 3T Philips whole body system (Philips Medical Systems, Best, The Netherlands), either with a transmit/receive head coil or with a dedicated spine coil. PRESS localization with voxel sizes ranging from 0.8 ml (lower cord) up to 4 ml (cervical cord) was used. ECG triggering was applied to improve the linewidth of the peaks as recommended in [1], and the number of averages ranged between 512 and 1024. Further acquisition parameters included: TR ≥ 850 ms and TE = 33 ms (Fig.1a-c), 43 ms (Fig.1e), 60 ms (Fig.1d and 2b), depending on the coil used, or 288 ms for lactate detection (Fig.2c). Water peaks were shimmed to approximately 10 Hz. In some cases outer volume suppression slabs were positioned around the PRESS volume, with a gap of 3-5 mm. Postprocessing of the spectra included exponential and Gaussian filtering as well as zero order phase correction.

Results

Figure 1 shows spectra acquired in the brain stem and in different locations of the spinal cord. From top to bottom spectra originate from the pons (Fig.1a), the medulla oblongata (Fig.1b), the cervical spinal cord at the level of the C1/C2 vertebral bodies (Fig.1c) and at the level of the C3/C4 vertebral bodies (Fig.1d), and finally from the intumescentia lumbosacralis (Fig.1e). While obtaining a good shim was straightforward in the upper regions of the spinal cord, very small voxel sizes had to be used to obtain sufficiently narrow peak linewidths in lower regions. In return, more averages were needed in the lower spinal cord. The spectra show a clearly decreasing quality in terms of signal to noise ratio and linewidth along the spinal cord. However some metabolites such as NAA, the combined peaks of creatine and choline as well lipids are still distinguishable even in the lowest voxel (Fig.1e).

The MRS exam in the spinal cord tumor was comparable to the measurement shown in Fig.1d, both in terms of acquisition parameters (TE) and voxel placement (Fig.2a). Whereas choline and creatine peaks show similar amplitudes and NAA is clearly the highest peak in Fig. 1d, the spectrum from the tumorous tissue (Fig.2b) corresponds more to the spectral patterns typically seen in high grade brain tumors. Metabolite levels were generally lower than in healthy tissue, with low NAA level, high choline level, and increased lactate and lipid levels. Peaks at 3.6 ppm may be attributed to myo-inositol in both spectra and elevated inositol levels could be possible in the tumorous voxel. While signal to noise becomes too low for the detection of most metabolites at TE = 288 ms in the pathological volume of interest, lactate and some lipid can still be discerned (Fig.2c).

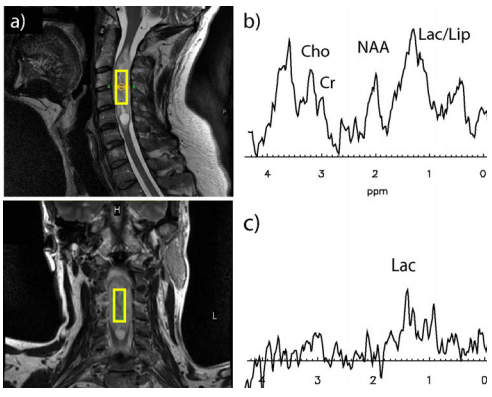

Figure 2: *Voxel placement and spectra acquired from a primary spinal cord tumor with TE = 60 ms (2b) and TE = 288 ms (2c).*

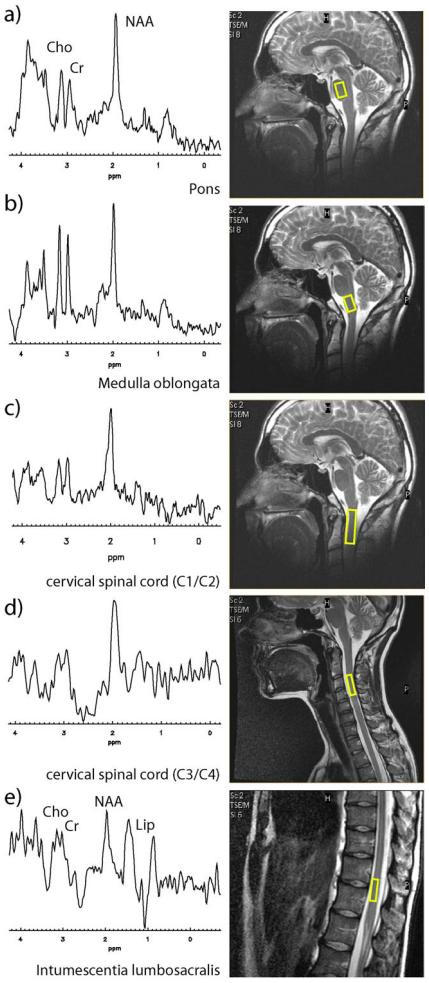

Figure 1: *Voxel placement and spectra acquired in healthy volunteers in different regions of the brain stem and the spinal cord.*

Discussion

We have shown that MRS of the spinal cord is possible both in the healthy spinal cord as well as in a cervical spinal cord tumor. Spectral quality is limited by low sensitivity due to small voxel sizes and inhomogeneities along the cord. However the spectra from the spinal cord tumor show similar information content as spectra from brain tumors.

According to Cooke et al. [1] the inhomogeneities arise mainly from susceptibility differences between vertebral spinous processes and connective tissue. In our experience the problem of inhomogeneities and poor sensitivity increases massively in lower parts of the spinal cord. For example, voxel length in the intumescence had to be limited to 20 mm to obtain sufficiently narrow peak linewidths for peak discrimination. In return such small voxels require more than 15 minutes of signal averaging. Some differences in spectral quality of the different spinal cord regions may also be attributed to the different coils used, as the transmit/receive head coil clearly achieves a more homogenous excitation and therefore higher sensitivities. Therefore specialized coils might help to acquire signal from even smaller voxels and achieve better spectral quality in lower spinal cord regions in the future.

References:

[1] Cooke F.J. et al., MRM 51:1122-1128, 2004.