In vivo 1H-MR Spectroscopy of the mouse cervical spinal cord.

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Introduction

In vivo proton magnetic resonance spectroscopy (MRS) is a unique method for non invasive assessment of healthy and pathologic tissue metabolism. Spinal cord (SC) MRS has been reported in human studies [1-4], as well as in rats [5-6], however, no reports have been performed on mice although it should help, in addition to MRI, in the description of the numerous mouse models of SC diseases such as multiple sclerosis and injury. In this work, and as a preliminary step for feasibility and sensitivity studies, we have investigated the possibility of performing single voxel spectroscopy (SVS) on mouse cervical spinal cord.

Materials and Methods

Experiments were performed on anaesthetized C57BL/6J mice, on an 11.75T vertical Bruker system, using a 2-cm diameter transmitting/receiving birdcage coil. Sagittal, coronal and axial gradient-echo images of 0.75-mm thickness were acquired so as to precisely place the voxel of interest and avoid the vertebra structure where large susceptibility effects may alter the spectrum quality. First and 2nd order shims were performed on a (2-mm)^3 voxel using the constructor FASTMAP procedure. The PRESS method was used with the following parameters: TR/TE 2000/12 ms, voxel size 2x1.5x2 mm^3, 1024 points, VAPOR water suppression, 16 ppm spectral width, 1024 averages, acquisition synchronized with breath motion and total acquisition time 34 minutes. Data were processed using an in-house-developed software running under IDL and the AMARES time domain fitting algorithm [7].

Results

Figure 1 shows a typical spectrum that can be obtained from single voxel spectroscopy acquisition. Figure 2 indicates the voxel position. The three major resonances of N-acetyl-aspartate (NAA, 2.02 ppm), creatine (Cr, 3.02 ppm) and choline (Cho, 3.2 ppm) could clearly be identified. The residue curve only contained noise in the area of the fitted resonances (data not shown).

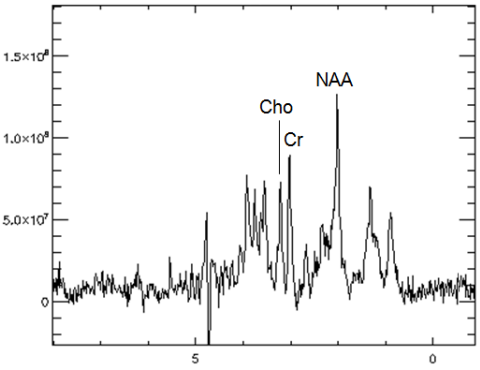

Fig.1 – ^{1}H spectrum of the C3 spinal cord segment derived from the PRESS acquisition. *The peak integral ratios NAA/Cho and NAA/Cr obtained with the AMARES time-domain fit were found equal to 1.83 and 1.38.*

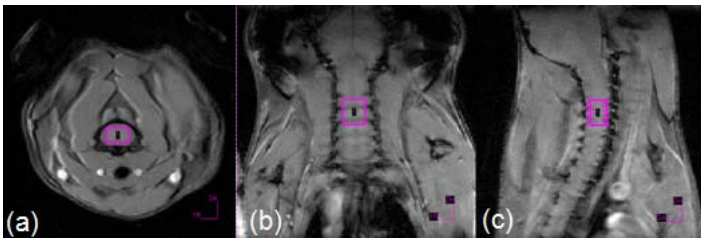

Fig. 2 – Representation of the (2x1.5x2)-mm^3 voxel, on axial (a), coronal (b) and sagittal (c) planes (gradient echo images).

Discussion

The spinal cord diameter (~ 2 mm) limits the voxel size that can be used and thus the available signal to noise ratio (SNR) that can be reached. In this study, experiments were performed with a rectangular VOI of 2x1.5x2 mm^3 (6 µl) that suits the spine size and curvature while avoiding the bony structure. Despite the field strength of our MR system (11.75T), a long acquisition time (34 minutes, 1024 averages) was required to achieve sufficient SNR. This scan time remains nonetheless compatible with pathologic SC examination. MRS protocols including acquisitions at both healthy and pathologic SC locations can be envisaged in less than 90 minutes (including localizer images, FASTMAP and both PRESS acquisitions). To determine whether the technique is sufficiently sensitive and robust to detect metabolic changes indicative of the pathology will be the next step of our study. Further work should also include optimization of the voxel geometry to the shape of the spinal cord and investigation at the lumbar spinal cord level.

Conclusion

This preliminary study demonstrates the feasibility of localized ^{1}H MRS in mouse cervical spinal cord, enabling its application to examine SC pathologies such as multiple sclerosis or SC injury. Combined to anatomic and diffusion MRI, MRS could be a valuable tool that should increase our understanding of the pathogenesis mechanisms and offer new ways to assess and characterize the response to therapeutics and regenerative strategies that need to be tested.

References

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