A new dedicated coil setup for in vivo measurement of intramyocellular lipids by 1H-MRS

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Introduction

Insulin resistance is a common characteristic in metabolic disorders such as type 2 diabetes. As an important marker for insulin resistance, the skeletal muscle triglycerides have been discussed [1]. The assessment of such triglyceride by localized ^{1}H-MRS has been shown to become a potential invaluable tool for the characterisation of new drugs for treatment of this disorder [2,3]. More recent approaches for the treatment of both diabetes and obesity directly addresses the fat metabolism in muscle by application of certain metabolic agonists. Therefore, a precise and reliable monitoring of fat metabolism in skeletal muscle is mandatory. In muscle we find two types of lipids characterized by the location their respective reservoirs, i.e., extramyocellular lipids (EMCL) and intramyocellular lipids (IMCL). While EMCL is stored as interstitial adipocyte triglycerides, IMCL accumulates as droplets in the cytoplasm of muscle cells. While EMCL is metabolically relatively inert, IMCL stores are built up, mobilized, and used within several hours.
Since muscles are a highly anisotropic environment, it is important to orientate the muscle fibres along the axis of the magnetic field to obtain fully featured MR spectra. Therefore, a coil setup must support easy positioning and yield a flat RF-profile, which is difficult to achieve by standard surface coils. In our study, we present a dedicated coil setup exhibiting non-standard design allowing for an easy positioning of the rat's leg and for the measurement of IMCL-content with a high signal-to-noise ratio.

Methods

The coil setup consists of two inductively coupled surface coils, which form a cage around the lower leg of the rat. Each of the two coupled coils is built as a modified Helmholtz coil with two loops, which together generated a homogenously excited image (Fig. 1). The whole coil setup is anatomically shaped to closely fit around the rat's leg. The leg of the rat is fixed with a specially designed setup that allows for a very reproducible positioning. Single voxel MR spectra were acquired using a PRESS sequence with following parameters: TR 2000 ms, TE 20 ms, voxel size 1.5 x 1.5 x 3 mm. Voxels were positioned using a T_1-weigthed pilot scan (Fig. 1). MR spectra were analyzed using the LCModel software package [4]

Fig. 1: Horizontal (left) and axial (right) T_1-weigthed MR images of a rat's lower leg.

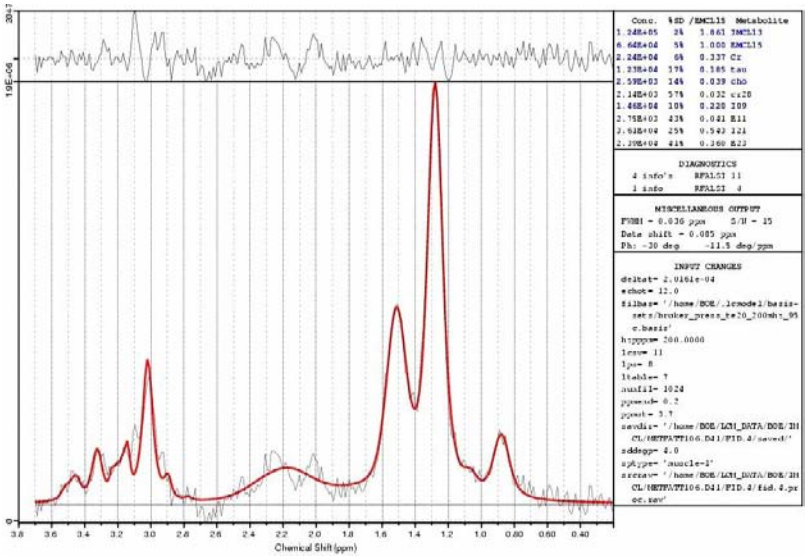

Fig 2: In vivo MR spectrum of tibialis muscle

Results

A typical spectrum acquired with the coil setup in the tibialis muscle of a rat is shown in Fig. 2. Compared to a surface coil an SNR increase by a factor of two was measured. Furthermore, a homogeneous excitation profile was generated, which can easily be appreciated from Fig. 1.
The fixation setup for the rat leg allows for reproducible measurements. Furthermore, the setup avoids extra pressure on the muscles and potential deformations (see Fig. 1 for reference).
In spectral analysis, LCModel provides a unbiased approach and allows for an on-line analysis of spectra.

References

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