In vivo detection of deoxymyoglobin in skeletal muscle by 1H-MRS at 7T

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INTRODUCTION

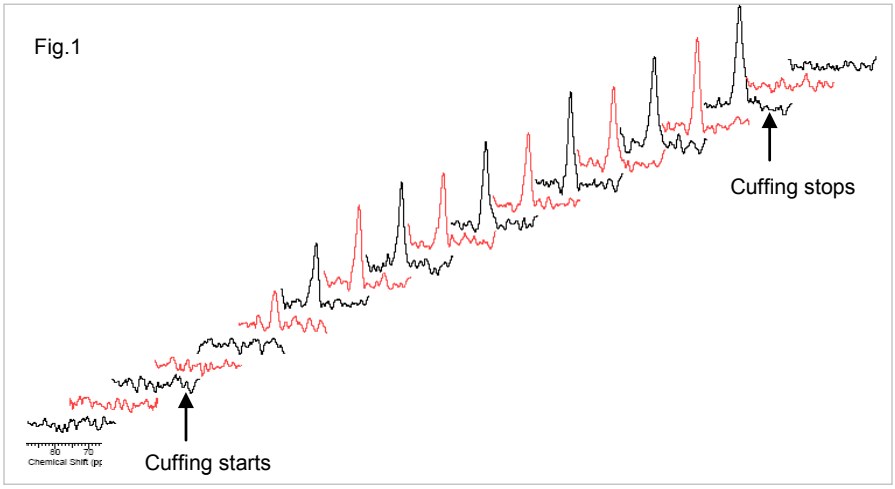
Proton magnetic resonance spectroscopy (^{1}H-MRS) of deoxymyoglobin (deoxy-Mb) provides a noninvasive method to monitor intracellular oxygen tension and is therefore an important means to investigate oxidative metabolism in health and disease. It has been shown at lower field strength that while inducing ischemia using a pressure cuff, deoxy-Mb signal builds up and levels off within 6 min (1). In principle, high field ^{1}H-MRS improves the signal-to-noise ratio and spectral resolution. These are two major advantages for performing spectroscopy in ultra-high fields. However, deoxy-Mb is a paramagnetic molecule, and paramagnetic susceptibility effects cause line broadening linearly with field strength therefore causing a decrease in MR signal intensity. The objective of this pilot study was to investigate the feasibility to detect the deoxy-Mb signal in skeletal muscle using ^{1}H-MRS in a 7 Tesla magnet.

METHODS

^{1}H-MRS of deoxy-Mb in calf muscle was performed in three healthy volunteers ages 42-46 during cuff ischemia. Spectra were acquired on a whole-body 7T scanner (Achieva, Philips Medical Systems, Cleveland, OH, USA) using a single-loop linear T/R surface coil with 10-cm diameter. The FASTMAP algorithm was used for a 2nd-order shimming. Non-selective fid-based acquisition with TR = 36 ms was used. Excitation was achieved with a 550-ms Gaussian RF pulse, truncated to 0.1%, centered at 75 ppm. The selectivity of the pulse allowed the spectra to be acquired without the need of water suppression. Acquisition with bandwidth of 8 kHz, 128 points per fid, and 1024 averages resulted in temporal resolution of 1 min. Signal acquisition was initiated 3 min before the start of cuffing, continued for 8-18 min while cuffing was applied, and was terminated 3 min after the release of the cuff. The left leg of the subject was cuffed just above the knee with pressure of 160-240 mmHg. The acquired data was zero-filled to 1024 points, line broadened by a 150 Hz filter, Fourier transformed, 0-order phase corrected and baseline corrected.

RESULTS AND DISCUSSION

Figure 1 shows the time course of the deoxy-Mb signal observed in a female subject after inducing ischemia with 160 mmHg cuff pressure for 6 min, continued at 180 mmHg for 18 min. The deoxy-Mb signal was detected after 3 min of ischemia, increased continuously until a plateau was reached, and recovered within 1-2 min upon release of the pressure cuff. In two additional male subjects increased cuff pressure of 200-240 mmHg was applied from the beginning. The build up of deoxy-Mb was visible already at 1 min with an earlier plateau after 6 min.



Further deoxy-Mb studies will be required to determine the reliability and reproducibility of measurements at rest, during exercise and ischemia. Signal-to-noise ratio improvement may be achieved using volume transversal electromagnetic RF coils with larger muscle coverage, and spatial resolution might be increased by the use of more than one receive coil.

In conclusion, the current study clearly demonstrates the feasibility of measuring deoxy-Mb in skeletal muscle using ^{1}H-MRS at 7T.

REFERENCE

(1) Wang ZY, Noyszewski EA, Leigh JS Jr. In vivo MRS measurement of deoxymyoglobin in human forearms. *Magn Reson Med* 1990;14:562-7.