Simultaneous 31P-MR-Spectroscopy and SEMG of the low back muscle – A methodical approach

R. Rzanny[1], J. R. Reichenbach[1], R. Graßme[2], M. Rottenbach[2], H-C. Scholle[2], W. A. Kaiser[1]

[1]Institute of Diagnostic and Interventional Radiology, Friedrich-Schiller-University, Jena, Thüringen, Germany, [2]Motor Research Group, Institute of Pathophysiology, Friedrich-Schiller-University, Jena, Thüringen, Germany

Purpose

^{31}P-MRS and surface electromyography (SEMG) are established methods to investigate muscle fatigue. However, the mechanisms of muscle fatigue are still not well understood in all details. Important information about the impact and the interaction between metabolic (^{31}P-MRS) and electrophysiologic changes (SEMG) during muscle fatigue can be obtained by investigating their temporal correlation simultaneously [1]. However, the signals measured with both methods may be perturbed by distortions and mutual interference caused by the measurement equipment [2]. The aim of this study was to reduce mutual artifacts between the MR and EMG systems to evaluate muscle fatigue simultaneously in volunteers by ^{31}P-MRS and SEMG.

Methods and Materials

Five healthy volunteers (age range 22-26 years) were investigated with ^{31}P-MRS and SEMG in a clinical whole body scanner (1.5 T). Volunteers had to perform an exercise of isometric muscle contraction of the lumbar back muscle which corresponds to a modified Biering-Sörensen test [3]. SEMG and ^{31}P-MRS measurements were performed simultaneously for overall 10 minutes including 150 s resting phase, 150 s muscle activation and 300 s recovering phase. Surface EMG was registered with an MR-compatible EMG-system using a bipolar technique at the level of the lumbar vertebrae L4 and L5. ^{31}P-MRS measurements were performed using chemical shift imaging (TR/TE/α=715ms/16ms/90°) with a double-tuned ^{1}H/^{31}P-surface coil (30 × 30 cm^2). The temporal resolution was 30 s per spectroscopic measurement. The investigated transverse slice (thickness: 100 mm) was positioned in the region of the electrodes. Spectral data were analyzed with the built-in scanner software (Luise, VB33A, Siemens Medical Systems).

Results

Distortions of the EMG signal induced by MR gradient switching could be sufficiently reduced to estimate frequencies and amplitudes from undisturbed EMG signal parts between the gradient pulses (Fig. 1). ^{31}P-MR-spectra indicated no signs of artifacts (Fig. 2) and showed decreased phosphocreatine (PCr) values to approximately 60-80% of the resting state value as well as increased values of anorganic phosphate (Pi) during the working period. These transient changes recovered after releasing the muscle contraction (Fig. 3). In contrast to the observed PCr recovery, however, which started immediately after the termination of muscle contraction (300 s after the start of the paradigm), Pi showed a delayed return to the baseline (330 s after the start). During the working period the EMG measurements showed decreased mean frequencies by about 20% compared to the resting period. The mean amplitudes increased in 2 of 5 cases.

Conclusions

Simultaneous ^{31}P-MRS and SEMG measurements are feasible and typical metabolic and electrophysiologic changes were observed [1, 4]. This approach makes it possible to extract important and reliable parameters and to monitor their temporal changes. Further technical improvements, including optimized surface coils, MR sequences or signal amplification by using proton decoupling may help to improve the data quality, which in turn may add important new information, especially in patients suffering from low back pain.

References

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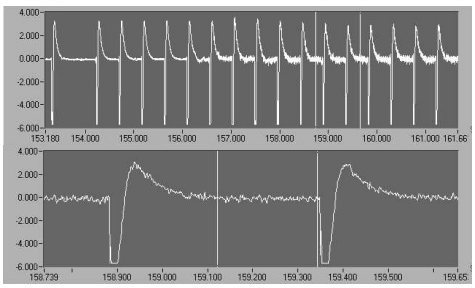

Fig. 1: Typical EMG spectra at the beginning of muscle contraction.

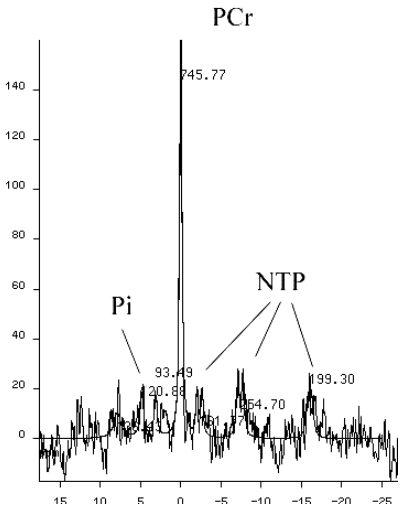

Fig. 2: ^{31}P-MRS during rest.

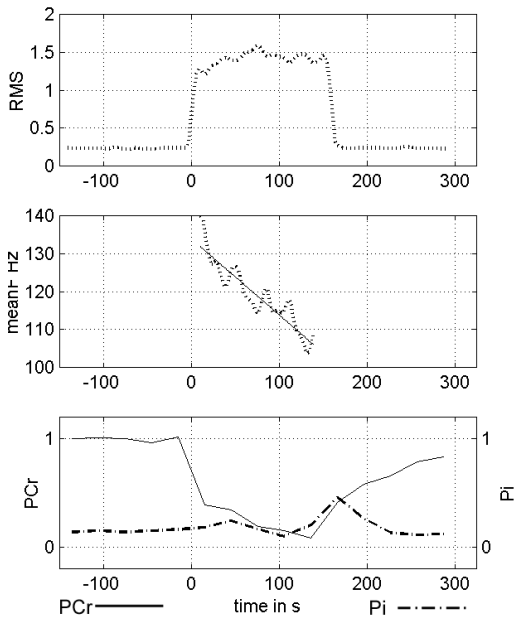

Fig. 3: Comparison of time courses of amplitude (RMS) and frequency of the SEMG signals and changes of the PCr and Pi intensities scaled to their level at rest (mean value of the first 5 time points) for one subject.