A Comparison of 31P Concentration Measurements Using CSI and RARE MRI

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Introduction

The phosphorus-31 chemical shift imaging and (^{31}P-CSI) and rapid acquisition with relaxation enhancement (^{31}P-RARE) methods have both been used to assess the ^{31}P metabolism in the muscles of the diabetic foot (1, 2). It has been shown that the concentrations of inorganic phosphate (Pi) and phosphocreatine (PCr) can be determined from ^{31}P-RARE images, which can be acquired with higher spatial and temporal resolution than ^{31}P-CSI images (3). We have measured the correlation between the average Pi and PCr concentrations across an axial view of the diabetic and normal foot as measured by ^{31}P-RARE data and by ^{31}P-CSI data.

Methods

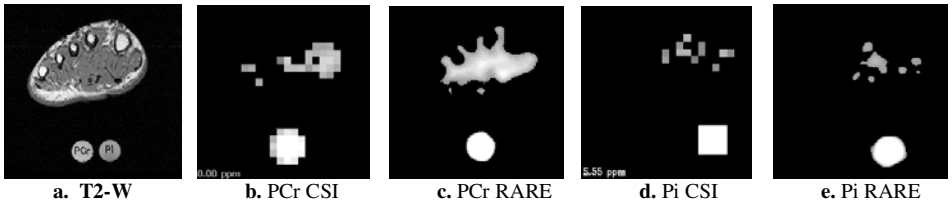
Twelve diabetic patients and seven normal subjects were studied. All data acquisition was performed on a 3T whole body scanner (GE Medical Systems, Milwaukee, WI). The subjects were positioned supine with one foot placed into a dual-tuned ^{1}H/^{31}P quadrature birdcage RF coil. Two tubes containing 75 mM concentrations of Pi and PCr were placed under the plantar aspect of the foot. All images were acquired in the axial plane through the metatarsal heads. A ^{1}H T2-weighted anatomical image was acquired. One spectrally selective ^{31}P-RARE scan was performed with the center frequency set to that of Pi and another with the center frequency set to that of PCr (TR = 12 S, ETL = 32, 10 averages). The spatial resolution of the ^{31}P-RARE images was 0.47 X 0.47 X 2.5 cm and each spectrally selective image was acquired in 4 minutes. A pulse-and-acquire ^{31}P CSI scan was then performed with a spatial resolution of 1.0 X 1.0 X 2.5 cm (TR = 4 S, 2 averages) and a scan time of 34 minutes. Pi and PCr images were created from the areas under the Pi and PCr peaks of the CSI data. Average Pi and PCr concentrations across the axial view of the foot were calculated from the CSI and RARE images as previously described (3). The correlation between the concentrations calculated using the two methods was tested using a Pearson correlation analysis.

Results

The higher spatial resolution of the ^{31}P-RARE image acquisitions resulted in improved visualization of the morphology of the foot muscle tissue and geometry of the ^{31}P reference tubes compared to the ^{31}P-CSI images (Figure 1). A strong correlation was observed between the Pi ($r = 0.94$, $P < 0.0001$) and PCr ($r = 0.95$, $P < 0.0001$) concentrations as measured by the intensities of the ^{31}P-CSI and ^{31}P-RARE images and reference tubes (3). These data are plotted in Figure 2.

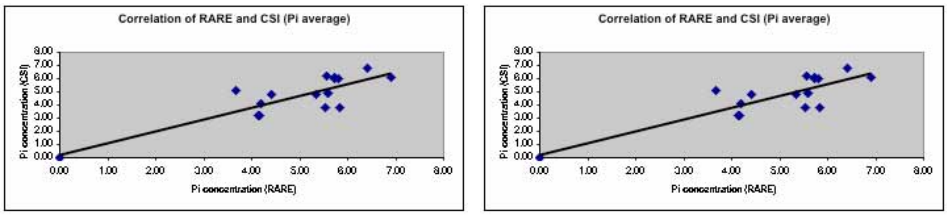
Discussion

We have demonstrated that ^{31}P-RARE MRI provides the same global functional information (i.e. average ^{31}P concentrations) as ^{31}P-CSI MR spectroscopy. Previous studies have shown that the improved spatial resolution that is possible with ^{31}P-RARE MRI allows the detection of local areas of ischemia that are present in the diabetic foot that are not detectable by ^{31}P-CSI within a scan time that is tolerable by a human subject (1, 2). The large voxels that are necessary when prescribing ^{31}P-CSI scans may result in an averaging of the ^{31}P metabolites over larger regions, resulting in the occultation of focal areas of ischemia. ^{31}P-RARE provides the same functional information related to the ^{31}P concentrations as ^{31}P-CSI with improved spatial resolution and shorter scan times.



a. T2-W **b.** PCr CSI **c.** PCr RARE **d.** Pi CSI **e.** Pi RARE

Figure 1. Axial T2-Weighted (T2-W), ^{31}P-CSI and ^{31}P-RARE images acquired from the foot a diabetic patient.



a. **b.**

Figure 2. Correlation plots of RARE vs CSI average concentration measurements of Pi (a.) and PCr (b.).

References

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