Effect of Patient Orientation on Cardiac ^{31}P-MRS

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Introduction:

^{31}P magnetic resonance spectroscopy is an established technique for in vivo measurement of high-energy metabolites to allow the assessment of tissue energy metabolism and function[1]. In order to maximize phosphorus signal, cardiac studies have usually been performed with subjects in the prone position, lying on top of the RF coil. It is assumed that in this position there is greater signal to noise ratio due to the compression of chest wall tissue between the coil and heart, as well as minimal respiratory motion. The primary drawback of prone-acquired spectra is that it is uncomfortable and not well tolerated by many patients for the relatively long scan durations. In this study we have measured the signal to noise differences between patient orientations to evaluate the data accuracy in the supine position relative to the prone position.

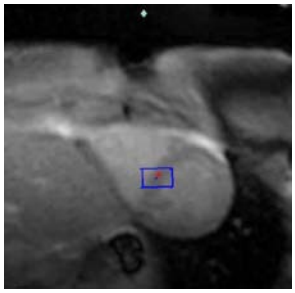

Figure 1 – Region of interest in the ventricular septum.

Methods:

Subjects: ^{31}P cardiac spectra were acquired in ten normal healthy subjects, five male and five female, age 24-48 years, BMI 25 ± 5 kg/m^2. Subjects were scanned twice in succession - either prone then supine or supine then prone. In prone position the RF coil was on the scanner bed underneath the chest, centered on the heart; in supine position the coil rested obliquely on top of the chest, centered at a similar position.

Measurements: Spectra were obtained on a Siemens 1.5T clinical system using a standard ECG-gated acquisition weighted chemical shift imaging (CSI) protocol. Cardiac-centered spectra were acquired along a grid oriented on a short-axis image stack. Spectroscopy duration was 26+/-5 minutes in both positions.

Processing: Homebuilt software written in Matlab was used to locate reference points and determine the RF coil's orientation in space. A voxel was chosen using the mid-ventricular short axis image, and a point selected on that image at the center of the anterior-posterior axis of the cardiac septum (Figure 1). Spectra were processed in jMRUI with DC correction, baseline fitting, zero filling, and AMARES fitting for calculation of 11 peaks[3] (PCr, gamma-ATP doublet, alpha-ATP doublet, beta-ATP triplet, PDE, and two 2,3-DPG – Figure 2). Signal amplitudes were corrected based on literature values of the metabolite T1s and the calculated flip angle[2], as well as for blood contamination[1]. Signal to noise ratio (SNR) was calculated as the sum of the amplitudes of the corrected peaks divided by the standard deviation of the residue signal.

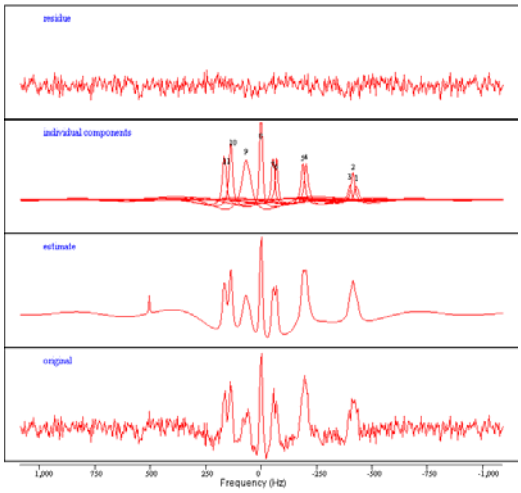

Figure 2 – Typical supine spectrum with AMARES fit.

Results:

There was no statistically significant difference between prone and supine scans in their SNR, PCr/ATP ratio, or distance between the center of the coil and the mid-septal voxel (see Results Table). The TR, which was dictated by ECG R-R interval, was longer in supine position due to slower heart rate. There also appeared to be a slight increase in the PCr signal from supine-acquired spectra, and corresponding increase in PCr/ATP ratio, though the difference was not significant.

Results Table

	Prone	Supine	Sig
SNR	151.20	159.13	p=.487
(StDev)	(33.78)	(29.23)	
PCr/ATP	1.91	2.22	p=.062
(StDev)	(0.45)	(0.23)	
Dist. in cm	12.26	12.97	p=.320
(StDev)	(0.57)	(2.23)	
TR in sec	1.02	1.06	
(StDev)	(0.18)	(0.14)	p=.039*

* Statistically significant difference (p<.05) for Student's two-tailed paired t-test

Discussion:

The close agreement of data obtained in prone and supine position indicates that the loss of signal in the supine position is not significant. We did not see the expected increase in distance between the coil and voxel in supine position or corresponding decrease in SNR. We believe this is due to the oblique coil orientation possible in supine position. Future studies would be needed to evaluate the effect of possibly greater respiratory motion in the supine position on cardiac spectra. The only significant difference between orientations, a longer TR value for supine scans, indicates a lower heart rate in the supine position due either to greater patient comfort or modified cardiac physiology.

Conclusions:

Cardiac ^{31}P spectra acquired with patients in the supine position are comparable to those acquired in the prone position. Use of supine positioning may allow a greater range of patients to tolerate the scan duration required for a clinical cardiac spectroscopy CSI, or allow for longer scan times to increase SNR.

References:

1 Neubauer, S et al. Circulation 1992 86:1810-1818

2 Bottomley, PA et al. Magnetic Resonance in Medicine 1994 32:137-141

3 Vanhamme, L et al. Journal of Magnetic Resonance 1997 129:35-40