Cardiac Stress P-31 MRS at 3T for Type-I Diabetes Mellitus Patients

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Introduction

Experimental studies have demonstrated left ventricular dysfunction and have suggested a microvascular disease involving the myocardium among type-I diabetes mellitus (DM) [1]. Traditional studies like stress electrocardiography, stress echocardiography and radionuclide perfusion imaging have been disappointing for detecting microvascular dysfunction. Previously, it has been shown that cardiac P-31 MRS allows for the determination of cardiac muscle ischemia by depletion of the PCr/ATP ratio during stress in patients with coronary stenosis [2], or with microvascular disease [3]. In this study, we have investigated the effects of handgrip stress on cardiac bioenergetics using P-31 MRS to determine myocardial microvascular ischemia with type-I DM patients.

Methods

Patients: Patients with type-I diabetes of greater than 10 years duration, who are younger and have a lesser incidence of large vessel coronary artery disease were selected from a large registry of over 2000 diabetic subjects. Patients were excluded if they had signs or symptoms of epicardial coronary artery disease (CAD) or overt renal disease. A comprehensive history, physical examination and metabolic panel were collected on all study subjects. All subjects underwent a thorough retinal examination. A total of 89 subjects were enrolled in the study and 29 underwent 31P MRS study with hand grip stress. Mean age was 28±8 years and 11 were males (36%). All were Latino, duration of diabetes was 14.8±4 years, body mass index was 29.7± 6.1, hemoglobin A1C was 9.7±2.1, total cholesterol was 181±37 gm/dl, and triglyceride was 110±6.1 gm/dl. Microalbuminuria and diabetic retinopathy was present in 12.5%, and in 31% of the patients, respectively.

31P MRS: The P-31 MRS was done at 3T (Signa, GE, Milwaukee) primarily using the depth resolved surface coil spectroscopy (DRESS) [4] with transceive surface coil. During stress, mild level stress applied using home built digital handgrip stressor.
Coil: A laterally elongated quadrature surface coil (transceiver mode), or single-turn linear coil was used as we previously reported [5]. The 31P acquisition with quadrature coil pair yielded better signal-to-noise ratio with minimized contamination from the liver. However, a larger circular linear coil (10cm in dia.) shows higher sensitivity for deeper slices (>6 cm). The coil was placed as the homogeneous B1 field (Figure 1) was overlaid on the anterior left ventricle and septum. The Beekley MR-spots (Bristol, CT) were placed in three distinct areas in order to correctly align the coil during proton scout imaging. *MRI/MRS:* The subjects were scanned (supine, head first) with scout imaging using 2D FIESTA followed by B_o shimming by PRESS voxel. For MRS, 31P signals were obtained from the 15mm-thick double-oblique DRESS slice which covered anterior left ventricle and septum (3 R-R TR, 128 avg, 5kHz). Three sets of 31P spectra were obtained: rest, stress and recovery (Figure 2). During the stress acquisition, the subject was asked to press the handgrip by 30% of maximum voluntary contraction. *Handgrip stressor*: Digital handgrip stressor was built with McMaster Cu-Be based strain gauge in which the level of the stress was converted to the pressure [Kg-g/m^2]. *Analysis:* P-31 spectra were processed in the time domain using AMARES (MRUI 3.0 package, European Union) followed by T1 and blood corrections.

Results and Discussion

Nine of the 29 subjects (31%) showed a significant drop (> 2 SD [3,6]) in PCr/ATP (mean drop: -31.0±10.3) during handgrip stress. This stress-induced reduction in PCr/ATP is suggestive of myocardial microvascular abnormality. This abnormal response in PCr/ATP probably occurs earlier than retinal or renal involvement. Our findings may indicate that in a subgroup of type-I DM patients, stress 31P MRS can identify abnormal cardiac metabolism that is likely microvascular in origin. A non-invasive 31P cardiac MRS that identifies metabolic abnormality may facilitate the prediction of cardiomyopathy in type-I DM patients.

References

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Acknowledgement

Figure 1. B1 contour plot (left) on the 5 cm-deep slice parallel from the quad coil (right). This type of coil is the best for slice less than 6 cm-thick.
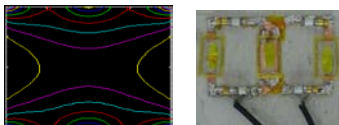

Figure 2. 31P spectra of positive response to handgrip stress: rest(left), stress (middle) and recovery (right). During the stress the PCr level was significantly lowered.
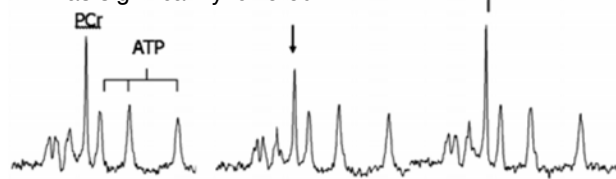
PCr

ATP

Figure 3. Individual changes in PCr/ATP (mean -10.9%) during handgrip stress. Drops >20% (outside of the box) are regarded as significant.