Investigations of the high-energy phosphate cardiac metabolism in dilated cardiomyopathy (DCM) by using 31P-MRS

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Purpose:

^{31}P-MRS offers the possibility to evaluate non-invasively high-energy phosphates in the myocardium of heart patients. The heart muscle is one of the largest energy consumer per unit of tissue mass and its efficiency is affected essentially by disturbances of energy supplying processes. Phosphocreatine (PCr) levels in patients with cardiomyopathy may be reduced due to metabolic alterations of cell organelles, myocytolysis and/or progressive fibrosis. These processes can cause progressive dilation of the left ventricle. ^{31}P-MRS of cardiomyopathy in animal models [1] and biopsies of patients with DCM [2] have indicated reduced cardiac high-energy phosphates. However, reported findings about the PCr/ATP ratio in DCM were not able to consistently verify this decrease [3]. The aim of this study was to investigate if the concentration of high-energy phosphates correlates with the left ventricular ejection fraction (LVEF), which is known as a mortality predictor, and to assess whether high-energy phosphate concentration changes may serve as a potential prognostic factor.

Methods and Materials:

The study group consisted of 25 patients with dilated cardiomyopathy including 15 patients with severe DCM (NYHA III or IV, LVEF<30%, mean age 50.0±12.1 years), 10 patients without severe symptoms (NYHA I,II, LVEF>30%, 50.6±10.5 years) as well as 20 healthy controls (mean age 35.2±10.7 years). Diagnosis was based on past physical examination, echocardiography and cardiac catheterization (normal coronaries, reduced LVEF). ^{31}P-MR-spectra were obtained with a 1.5 T clinical whole-body scanner using a surface coil (300 mm × 300 mm). A 100 mm thick, transverse slice was investigated by ECG-gated chemical shift imaging (matrix: 8 × 8; TR/TD/TE/α=600ms/250ms/3ms/90°). The measured voxel size was $40 \times 40 \times 100$ mm^3 and was interpolated by reconstruction to $20 \times 20 \times 100$ mm^3. The correct voxel position was validated by sagittal, coronal and transverse images. Spectral analysis was performed by automatic fitting of a spectral model function to the original spectra using the scanner software (Luise, Siemens Medical, VB33A). Corrections for T1-saturation and partial volume effects of blood were made.

Results

Spectra of patients with severe DCM and patients with moderate DCM without severe symptoms showed different relations between PCr and adenosine triphosphate (ATP). In patients with severe (LEVF<30%, p<0.001) and in patients with mild DCM (LEVF>30%, p=0.024) the PCr/γ-ATP ratios were significantly reduced compared to healthy controls (Tab. 1). The PCr/γ-ATP ratios of all investigated 25 DCM patients indicate a correlation to the LEVF values with a Person coefficient r=0.64 (p<0.001).

Conclusions

The observed differences in the PCr/γ-ATP ratio between patients with DCM and healthy controls indicate that spectroscopic detectable changes in the metabolism of high energy phosphates occur. The observed correlation between PCr/γ-ATP ratios and LEVF indicates that these changes correlate with the clinical severity of the disease. The results suggest that spectroscopic estimations of the PCr/γ-ATP ratio are of substantial importance as a clinical predictor for the outcome.

References

[1] Markiewicz W *et al*. Circ Res 59:597-604 1986
[2] Ingwall JS *et al*. N Engl J Med 313:1050-4 1985
[3] Bottomley PA *et al*. Radiology 191:593-612 1994

Tab. 1

Comparison of the PCr/ γ-ATP ratios between controls and patients with severe and moderate DCM.

	DCM sev.	DCM mod.	controls	P (Mann-Whitney-Test) sev.-contr.	mod.-contr.
PCr/ γ-ATP (SD)	1.19 (0.34)	1.53(0.35)	2.0(0.22)	<0.001	0.024

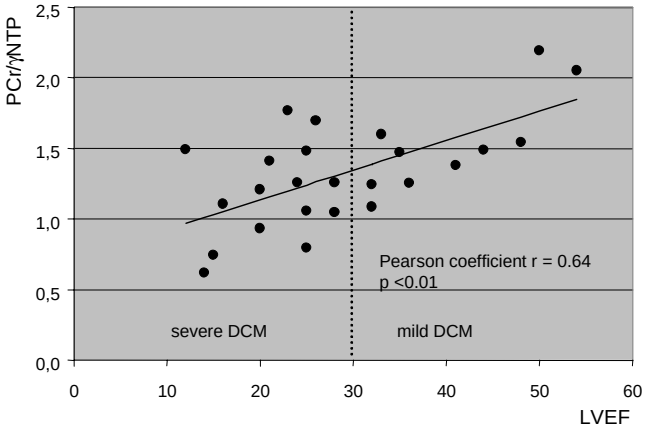

Fig. 1: Correlation between PCr/γ-ATP ratios and LVEF values in patients with mild and severe DCM.

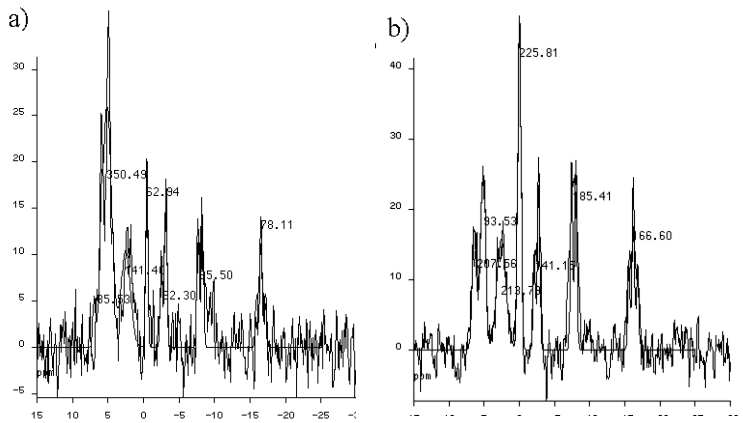

Fig. 2: Representative spectra of a patient with severe DCM (LVEF = 25%) (a) and a healthy control (b).