Impact of diffuse peripheral arterial disease (PAD) on high-energy phosphate metabolism in the exercising calf muscle

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Objectives:
Patients with diffuse peripheral arterial disease (PAD) often suffer from atypical leg pain or do not show any symptoms. In case of atypical leg pain, it is difficult to differentiate between ischemic pain during walking or pain caused by degenerative spine disorders. In these patients, the impact of peripheral atherosclerosis on high-energy phosphate (HEP) metabolism in the calf muscle, the most important muscle group for walking, is often unclear.
Purpose:
The purpose of this study was to investigate the HEP metabolism in the calf muscle of patients with diffuse PAD during incremental plantar flexion exercise with the help of time-resolved phosphorus-31 magentic resonance spectroscopy (31P MRS).
Methods:
Using a 1.5 Tesla whole body MR scanner (Magnetom Symphony and Avanto, Siemens, Germany), 20 patients with uni- or bilateral diffuse PAD (63.4 ± 7.8 years) and 24 healthy controls (65.3 ± 8.6 years) underwent serial 31P MRS during exercise increments at 2, 3, 4 and 5 W. The patients had at least one leg with leg pain and were therefore admitted to the outpatient clinic of the Division of Vascular Surgery at our University hospital. All patients received a MR angiography in three levels by using FLASH 3D sequences (field of view of 420 mm, matrix of 384 to 448, TR of 6.2 ms, TE of 2.3 ms, slice thickness of 0.8 to 1.2 mm, slab thickness of 96 to 128 mm and iPAT factor of 2) with moving bed technique and a three-phase gadobenate bolus (20 mL Multihance, Bracco, Italy). For 31P MRS, we used serial free induction decay sequences (TR of 1000 ms, TE of 0.13 ms, flip angle of 90°, 10-15 averages, acquisition time of 10-15 s) with NOE enhancement. The phosphocreatine (PCr) time constants were determined for each exercise increment and recovery. In the patient group, the runoff resistance (ROR) was determined on MR angiograms. Patients with a ROR < 10 were included into this study (Figure 1).
Results:
All patients and all normal controls succeeded the whole exercise protocol. Patients with diffuse PAD showed normal PCr time constants during the increment at 2, 3 and 4 W compared to the helthy controls (Figure 2). In the patient group, the PCr time constants were significantly increased during the last exercise increment at 5 W, whereas the PCr recovery time constants were in the normal range compared to the healthy controls. Furthermore, we detected a signficantly decreased pH in the patient group only at the end of the 2 W increment, but not at the end of the following increments.
Conclusions:
Our findings indicate that diffuse PAD is associated with impaired muscle metabolism depending on the work intensity. Furthermore, it appears to be important to investigate the HEP metabolism during several exercise increments, because a normal PCr recovery rate does not exclude an efficacious PAD.

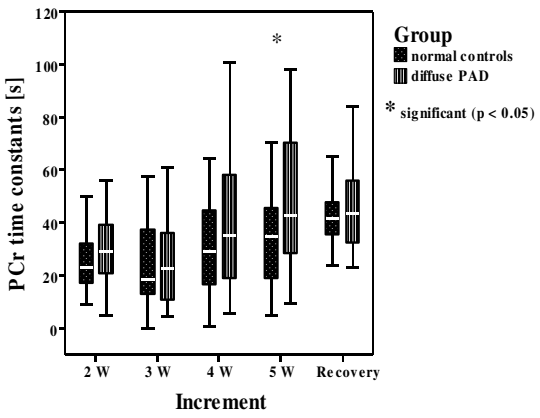

Figure 2: The PCr time constants are presented as boxplots, whereby the errorbars indicate the range, the box limits the quartiles and the white bars the medians.

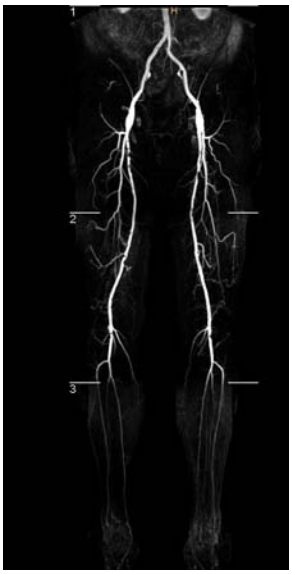

Figure 1: The MR angiogram shows bilateral diffuse PAD with multi-segmental athero-sclerotic lesions. The runoff resistance score is below 10 in each leg.