BOLD MRI for assessment of tissue supply during reactive hyperemia in diabetic patients with severe peripheral arterial occlusive disease

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BACKGROUND: Diabetes mellitus is a worldwide public health problem. The number of people with diabetes worldwide was 135.3 million in 1995, and is estimated to increase up to 221 million in 2010[1]. Micro and macroangiopathy lead to wound healing impairment in most of diabetic foot patients. The malnutrition of the lower limbs can be further analyzed with intraarterial digital subtraction angiography, sonographic techniques, transcutaneous partial oxygen pressure measurements and laser doppler perfusion measurements. Recently, blood-oxygen level-dependent (BOLD) magnetic resonance imaging proved to be a promising tool for assessment of substrate supply where the BOLD signal is assumed to primarily reflect the degree of blood oxygenation in the tissue[2,3].

OBJECTIVE: In this study, the applicability of the BOLD technique to demonstrate tissue perfusion supply during postischemic reactive hyperemia in diabetic patients with peripheral arterial occlusive disease (PAOD) was evaluated.

METHOD: BOLD effect was registrated with a T_2^*-weighted 3D PRESTO echo-planar sequence (factor 9; 1.8x1.8x6 mm; TR/TE/flip=32/39/7; 10 slices; temporal resolution 2.9 s) on the lower calf muscle of (A) 17 PAOD-patients (stage III, IV due to Fontaine, 65.7 ± 6.2 [53-75] y., 14 males) with diabetes mellitus type II and (B) 4 healthy volunteers (32.4 ± 8.8 [23-44] y., 2 males). BOLD data were acquired continously for 15 minutes including transient reactive hyperemia, which was induced by a 4.5 minutes cuff compression (see fig.). Measurements were repeated 2-3 times in group B to determine reproducibility. Maximum and slope of the hyperemic response (max_{HR}, $slope_{HR}$), time-to-maximum (t_{max}), recovery-time ($t_{recovery}$), time-of-latency ($t_{latency}$) and the curve fitting parameters b and t of the applied sigmoidal function ($f= a_o exp[-\{a_1 t\}b]+a_2$) were evaluated.

RESULTS: Transient hyperemic response was higher for healthy volunteers (20.2 ± 3.8%) compared to 4.5 ± 4.3% found in diabetic PAOD-patients. Regarding the slope of the regression line, 0.38 ± 0.33 [units/s] and 1.35 ± 0.18 [units/s] were found for group A and B, respectively, indicating a reduced hyperemic response in patients. Reproducibility was ±16 % and ±13 % for reactive hyperemia and slope, respectively. $t_{latency}$ was prolonged in only 3/17 patients. t_{max} increased from 34 ± 2 s (B) to 151 ± 126 s (A). Curve fitting was only successful in group B.

CONCLUSION: BOLD technique is a reproducible method in measuring microcirculation.

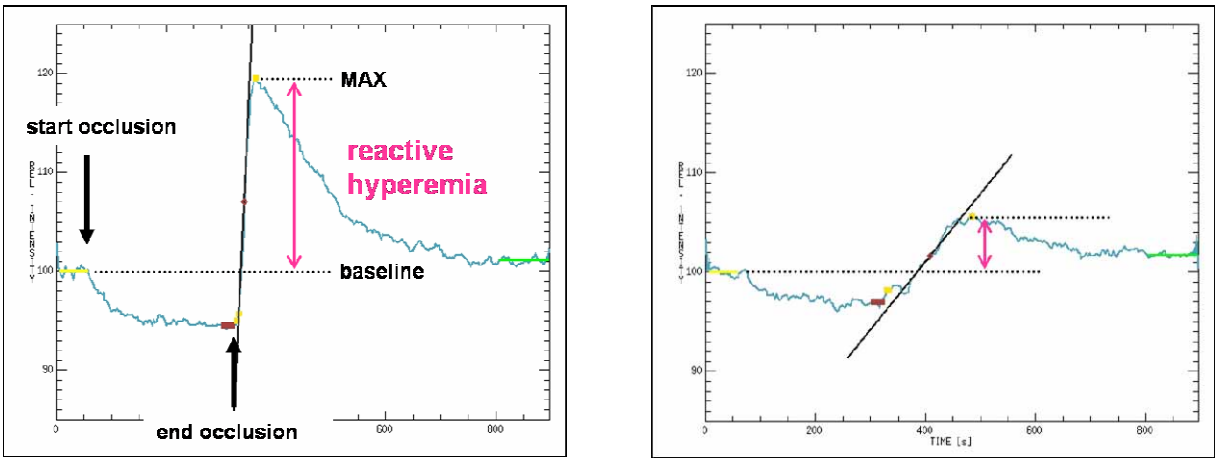

Figure: Postocclusive reactive hyperemia. Normalized signal-time-curves of a volunteer (left) and a PAOD-patient (right).

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