

## BOLD MRI of lower extremity muscles : venous insufficiency is affecting BOLD signal

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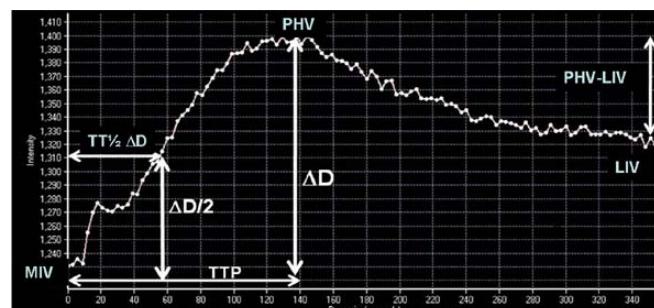
**Purpose:** Was to implement BOLD MR imaging in the demonstration of ischemic state of the lower extremity muscles, by describing additional parameters on T2\* time-intensity curves.

**Methods:** The calves of 25 patients (57.08 years of mean age (20-84 years), 19 male, six female) with findings of arterial occlusive disease of lower extremity and six healthy volunteers (all male, mean age of 28.6 years (ranging between 21-31 years) were scanned on a 3-T MR unit (Achieva, Philips Medical Systems, Best, The Netherlands). Cuff compression induced ischemia paradigm has been used to provoke BOLD signal. A fat-saturated T2\*-weighted multishot multiecho echo planar imaging sequence was used on axial slices with four images, TE ranging from 16 to 107 ms, TR of 3000 ms, flip angle of 90°, field of view of 230 mm x 230 mm and a matrix size of 128 x 80. Post-processing was applied to fit T2\* time-intensity curves on a separate workstation (Dell Precision T5500) via the software Extended MR Workspace 2.6.3.2 (Philips Healthcare, Best, The Netherlands). The parameters calculated were as follows: *i*) minimum ischemic value (MIV), *ii*) peak hyperemic value (PHV), *iii*) time to peak (TTP), *iv*) the difference between MIV and PHV ( $\Delta D$ ), *v*) the elapsed time to half of  $\Delta D$  ( $TT\frac{1}{2} \Delta D$ ), *vi*) last ischemic value (LIV), *vii*) the change in signal intensity over a second during  $TT\frac{1}{2} \Delta D$  (D1), and its percentage to MIV (D1%), and *viii*) the difference between PHV and LIV (Fig.1). Statistical analysis compared patient and normal group with Kruskal-Wallis test. A p value <0.05 was considered as significant. Bonferroni adjusted Mann-Whitney U test for multiple comparisons were done. Pearson and Spearman correlation was used for comparison.

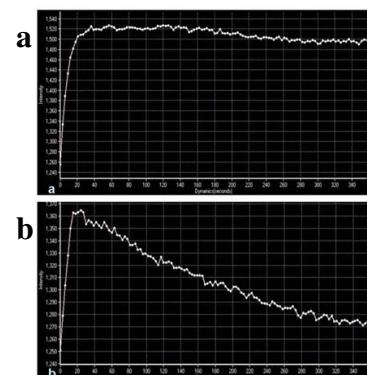
**Results** Statistically significant differences were found. The curve from MIV to the PHV were found to be less steeper in patients group. A negative correlation was found between the ages of the groups and the calculated PHV, MIV, LIV and  $\Delta D$  values which with the increased age, these values were observed to be decreased. When the threshold value for TTP was designated as 40 sec, the sensitivity, specificity, positive predictive and negative predictive values were found as % 83.3, % 92.3, % 90.9 and % 85.7 respectively. As for  $TT\frac{1}{2} \Delta D$ , when the threshold value was set as 20 sec, the sensitivity, specificity, positive predictive and negative predictive values were found as % 50, % 100, % 100 and % 68.4 respectively.

**Discussion:** In the evaluation of stenosis, TTP value is first to be evaluated in such, a TTP value of longer than 40 sec suggest insufficient blood sources to the muscle. In one case having normal arterial Doppler ultrasound examination but also grade IV venous insufficiency, TTP value was longer than normals. This has been postulated owing to the presence of deoxygenated blood in the venous capillary system longer than normals, which may affect the BOLD signal. TTP value with a threshold of 40 sec, can exclude stenosis with a great sensitivity, unless venous insufficiency is excluded. The signal intensity-time curves of this case with venous insufficiency, revealed a plateau, which LIV was found closer to PHV (Fig.2).

**Conclusion:** BOLD MRI is a promising method in displaying the arterial functional state of the muscles, within a short examination time without contrast media administration and ionizing radiation. Patients evaluated with BOLD MRI for the ischemic disease of their lower extremities should also be evaluated for possible venous insufficiencies before their BOLD examination.



**Fig.1.** The parameters evaluated on the T2\* time-intensity curve



**Fig.2.** Time-intensity curve displaying plateau after PHV of a control case with venous insufficiency **(a).** Note the steep decline from PHV to LIV of a control case w/o venous insufficiency **(b).**