Assessment of Critical Limb Ischemia using MRI

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Background

Critical limb ischaemia (CLI) is a manifestation of peripheral arterial disease (PAD) that describes patients with chronic ischaemic rest pain, or ischaemic skin lesions in the form of ulcers or gangrene[1]. Current treatment approaches differ, in part due to disputes over the best non-invasive method of assessing CLI. We therefore sought to determine whether MRI could provide an non-invasive objective assessment of the degree of ischemia without the use of contrast agents.

Hypothesis/Objective

We examined the use of three MRI maps to depict vascular impairment:
T_2* images, the hypothesis being, that increased amounts of de-oxygenated blood in ischemic patients yields increased amounts of paramagnetic methemoglobin causing faster spin relaxation and a decreased T_2* time (BOLD effect).
T_2 images, hypothesized to depict edemas in chronic ischemic patients. Further, the obtained T_2 map may be used to correct T_2* for water content through the use of T_2'.
T_2' images, hypothesized to be superior to T_2* for depicting methemoglobin content, since this map incorporates both relaxation due to paramagnetic effects and signal increases due to edema.

Methods

The calfs of five patients suffering from chronic ischemia in the legs and three healthy volunteers were scanned using a Philips Intera Achieva 1.5T scanner. A fast gradient echo sequence was used to calculate T_2* maps employing a single cross-sectional slice using eight images with echo times (TE) ranging from 6.9 ms to 83.2 ms, TR of 108.8 ms, flip angle (FA) of 30°, 2 averages, and 0.5x0.5x6 mm^3 voxel size. Additionally T2 maps were calculated using a turbo spin echo sequence using eight images with TE from 10 to 80 ms, TR = 108 ms, 6 averages, and 0.5x0.5x10 mm^3 voxel size.
Post-processing was applied to fit T_2-, and T_2* images (Figure 1) to exponential curves using the free open-source software OSIRIX[2]. Using the 2D Grow Region Confidence algorithm (multiplier: 2.5, num. of iteration: 5, initial radius: 2), the calf muscles were segmented, and the average signal intensity calculated (Figure 2). The average T_2- and T_2* values were extracted and used to calculate the T_2' using the relation:

$$\frac{1}{T_2^*} = \frac{1}{T_2} + \frac{1}{T_2'} \Leftrightarrow T_2' = 1 \Big/ \left(\frac{1}{T_2^*} - \frac{1}{T_2} \right)$$

Results

T_2 values (Figure 3A) differed significantly (P=0.011, CI95=[5.6;29.7]) between patients (T_2=57.4 ± 7.9 ms) and controls (T_2=39.7 ± 3.3 ms). T_2* (Figure 3B)showed no significant difference (P=0.107, CI95=[-1.14;8.91]) between patients (T_2*=33.8 ± 2.6 ms) and controls (T_2*=29.9 ± 3.1 ms). T_2' (Figure 3C) also did not display any insignificant difference (P=0.09, CI95=[-78.56;7.17]) between patients (T_2'=87.6 ± 22.7 ms) and controls (T_2'=123.3 ± 26.4 ms).

Discussion

Initial results did not show any significant differences between severely ischemic patients and normal controls using either T_2* or T_2', indicating the BOLD effect of deoxygenated blood to be too small to measure using the present sample size and settings. However, T_2 values were significantly affected, hypothesized to be the result of edema caused by the severe ischemia.

Conclusion

MRI T_2 maps may prove viable for assessing severely ischemic patients quantifiably.

References

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2. Rosset, A., L. Spadola, and O. Ratib, *OsiriX: An Open-Source Software for Navigating in Multidimensional DICOM Images.* Journal of Digital Imaging, 2004. **17**(3): p. 205-216.

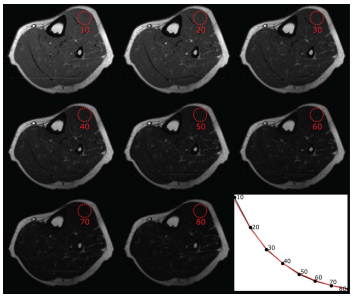

Figure 1: T2 images used to calculate T2 map.

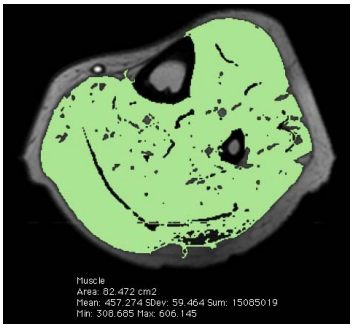

Figure 2: T2 image with segmented muscles.

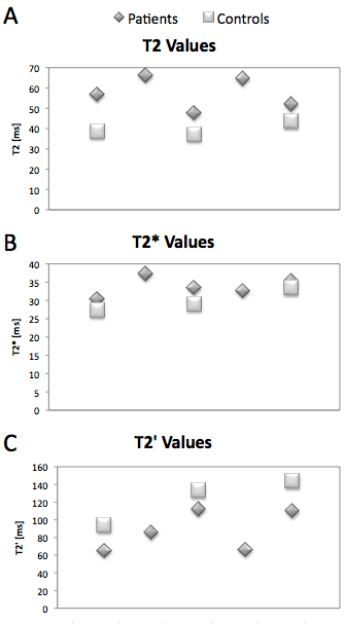

Figure 3: Results