Estimation of Blood Oxygenation using Quantitative Susceptibility Mapping

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Target audience: Researchers interested in quantitative susceptibility mapping and tissue oxygen consumption quantification.

Purpose: Quantitative susceptibility mapping quantifies tissue iron and exogenous contrast agents [1]. It is further possible to utilize this technique to quantify tissue oxygen consumption by measuring flow and susceptibility differences between oxygenated arterial and deoxygenated venous blood. In the current abstract we present results of an in-vivo study demonstrating dependence of venous blood susceptibility on the level of blood oxygenation.

Methods: Forearms of five healthy volunteers were scanned at 1.5T (Signa HDx, GE) using a fully flow compensated GRE sequence (FA 15, matrix size 256x256x26, FOV 14cm, slice thickness 2mm, 62.5kHz BW, TE_1=3.3ms, ΔTE=3.3ms, 5 echoes). After the baseline acquisition, supra-arterial pressure was applied on the upper arm using a standard pressure cuff for 7 minutes. During this period, QSM data were acquired repeatedly, 50 seconds per scan), with simultaneous readings from a finger pulse oximeter. For each time point, field maps were estimated using a water/fat separation algorithm [2] and then processed with nonlinear MEDI [3]. As a final step, volumetric averages of the interosseous vein susceptibility were calculated and compared to the finger pulse oximeter data.

Results: Fig. 1 shows a sequence of reconstructed susceptibility maps with changes in vein susceptibility over time clearly visible. Fig. 2 shows the comparison of QSM vs. pulse oximetry.

Discussion: This research may find applications in diagnosis of ischemia and arteriovenous shunts and the assessment of muscle metabolic properties. Less burdensome stresses (e.g., squeeze-and-hold or pharmacologic) might be possible, but require additional study.

Conclusion: In the current study we present results of a pilot study on changes of venous blood susceptibility in an extremity under physiological stress. Our data demonstrate the linear dependence between venous susceptibility and blood oximetry readings.

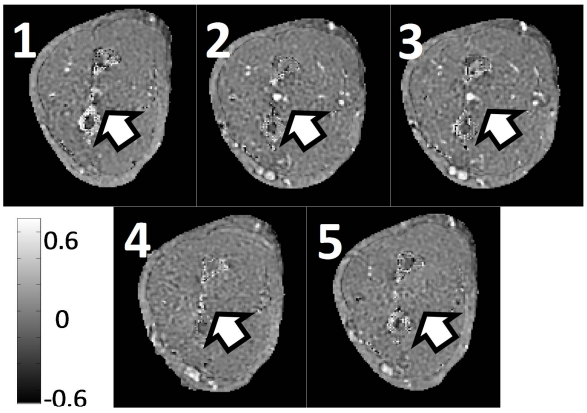

Fig.1 Reconstructed susceptibility maps for base scan (1), scan with applied cuff (2,3), and after the pressure release (4,5)

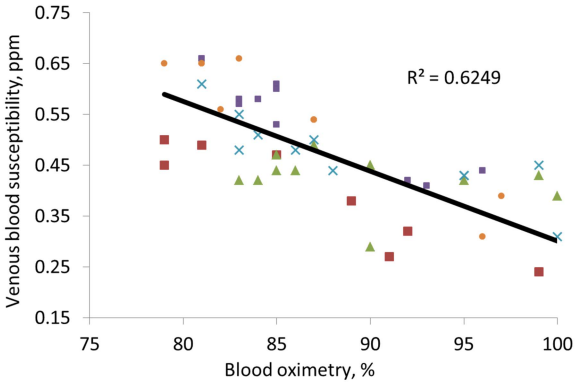

Fig.2 Linear regression of the venous blood susceptibility over corresponding oximetry reading for 5 subjects. Different legends represent different subjects.

References: [1] Chen W et al, Radiology, 2014 Feb;270(2):496-505. doi:10.1148/radiol.13122640, [2] Dong J et al, IEEE Trans Med Imaging. 2014 Oct 8, [3] Liu T et al, Magn Reson Med. 2013 Feb;69(2):467-76. doi:10.1002/mrm.24272