Use of oxygen challenge to assess myocardial oxygenation: A potential tool to image oxygen metabolism.

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Introduction:

Non-invasive assessment of oxygen metabolism has so far been limited to the use of exogenous contrast and/or radiation through complex and expensive techniques such as ^{15}O-PET or ^{17}O-MRI. Recently, a few groups have tried to image myocardial oxygenation using proton MRI and pharmacological challenges (1, 2, 3). We hereby proposed a method based on the Oxygen challenge technique (4) providing an easy, cheap and safe assessment of myocardial oxidative metabolism**.**

Methods:

All animal studies were carried out according to the guidelines laid out in the Animals Scientific Procedures Act under a project license from the UK Home Office and approved by the local ethical review panel of the Imperial College London.

Three male Wistar rats aged 7-8 weeks were anesthetised with ~1.5 % isoflurane in a 1.5 l/min mixture of O_2/N_2O (30/70) and placed supine in a purpose build cradle. Physiological monitoring was performed via subdermal ECG needle electrodes and a respiratory balloon (SA Instruments, Stony Brook, NY, USA) for heart rate and respiration monitoring, respectively. Body temperature was monitored via a rectal probe and maintained at 37°C using a heated-air system (SA Instruments). MRI was performed using a 4.7 T DirectDrive Varian MRI system (Palo Alto, CA) with 40 G/cm gradients and a 72mm volume, (quadrature) RF coil. Data acquisition was performed with dual, cardiac and respiration gating under steady state condition other parameters were; 4 Averages; 1mm slice thickness; FOV=56mm x 56mm; and a 256 x 256 pixel matrix. T2* maps were calculated from a series of eight 2D gradient echo (FLASH) acquisitions record during diastole with varying echo times from 1 to 20 ms. The delay between R wave and the excitation pulse was adjusted at each echo time to assure that images were acquired at the same point in the cardiac cycle. Measurements were performed while animals were breathing 30% oxygen followed by the same measurement while breathing 100% oxygen. Blood samples were also taken under both conditions. Images were reconstructed and processed offline using in-house software written in MATLAB to produce T2*maps.

Results:

The inhalation of 100% oxygen induced an increased of the arterial pO_2 from 133 ± 25mmHg to 423 ± 41mmHg. This increase of the blood oxygen reserve lead to an increase of the T2* values not only in the myocardium (T2* = 14.4 ± 3.2 ms and 16.2 ± 4.1 ms under 30% or 100% inhalation of oxygen respectively) but also in skeletal muscle and spinal cord (Fig1).

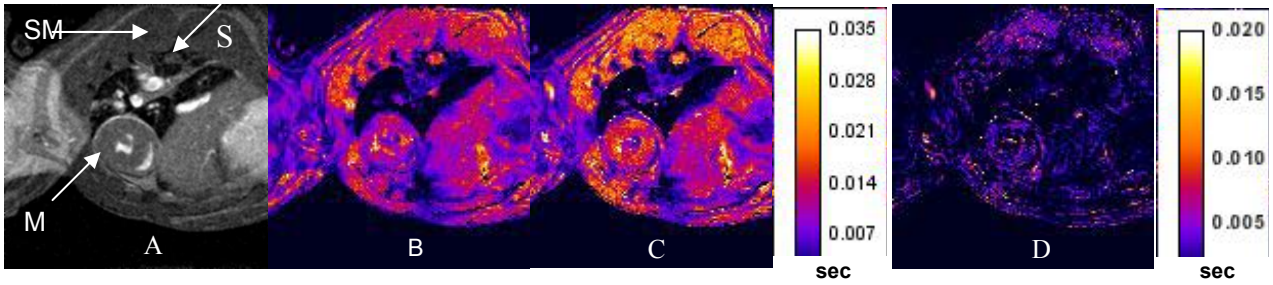

Fig1. Anatomical image (A) and T2* maps across the same imaging plane acquired under 30% (B) and 100% oxygen (C), and difference between C and B (D).
SM –skeletal muscle; M-myocardium; S- spinal cord.

Discussion and Conclusions

This study shows that tissue oxygenation can be evaluated with T2* contrast using an oxygen challenge. The absence of T2* changes in the arterial blood (left ventricle) suggest the origin of this effect to not emanate from variation of blood oxygen concentration but mainly from the binding to deoxyhemoglobin in the metabolically active tissue as suggested by Santosh et al (4). Indeed, highly metabolically active tissue, such as myocardium, spinal cord and skeletal muscle, elicit the greatest changes of T2* values. This pilot study confirms the feasibility of using T2* mapping to image Oxygen metabolism and represent an easy alternative to the already existing methods with real potential for clinical assessment of aerobic metabolism.

References.

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