Does a 100% oxygen gas challenge affect renal blood flow, as measured using Arterial Spin Labelling?

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Introduction

Oxygen-enhanced MRI (OE-MRI) has been used in various studies to investigate oxygenation in arterial blood, brain, abdominal organs and tumours by measuring a signal change or T_1 change upon the breathing of 100 % O_2 [1-4]. However, some studies have shown that vasoconstriction may occur when breathing high percentage oxygen gas [5, 6], which may confound the interpretation of the OE-MRI signal. However, a study using arterial spin labelling (ASL) in the brain showed no significant change in flow when accounting for a change in blood T_1 [7]. The aim of this study was to investigate the effect of a 100% O_2 gas challenge on renal blood flow using ASL, including accounting for the effect of blood T_1 changes on ASL quantification, in order to assess evidence for changes in blood flow.

Methods

Acquisition: 10 young healthy volunteers were recruited and informed consent was obtained. Scans were carried out on a 1.5T Philips Intera system (*Philips Medical Systems, Best, NL*). Two different protocols were used. For 4 subjects the protocol was as follows: our standard OE-MRI protocol with T_1 mapping (IR-HASTE, 8 inversion times, NSA=5), plus a shortened ASL sequence (STAR labelling, 3 delay times, up to 40 averages). This was carried out once whilst the subject breathed medical air and then again after the breathing gas was switched to 100% O_2. This separation of T_1 mapping and ASL caused additional difficulty for registration, so for 6 subjects an extended ASL only protocol (STAR labelling, 8 delay times) was carried out before and during the gas challenge and the ASL control images were used for a calculation of T_1. A single imaging slice was used with a coronal oblique orientation along the long axis of the kidneys, with a field of view of 400 mm x 400 mm and a matrix size of 128 x 128.

Analysis: Images were registered using a model-driven technique in combination with FLIRT (FSL [8]), where a target image was created synthetically for each inversion or delay time using unregistered T_1 and M_0 maps [9]. Images were then registered to these targets using the rigid body algorithm in FLIRT. T_1, M_0, flow and bolus arrival time maps were created from the registered data using code written in Matlab (*R2010a, The MathWorks, Natick, MA, USA*), using the calculated T_1 maps to provide tissue T_1 values, and using literature values for the blood T_1 during air and oxygen breathing [1]. Flow maps were also calculated using an identical assumed T_1 value for blood for both breathing gases, a method commonly used in the ASL literature. Regions of interest were created for the cortex of each kidney using a variable threshold on each subject's T_1 maps for air breathing and some manual editing.

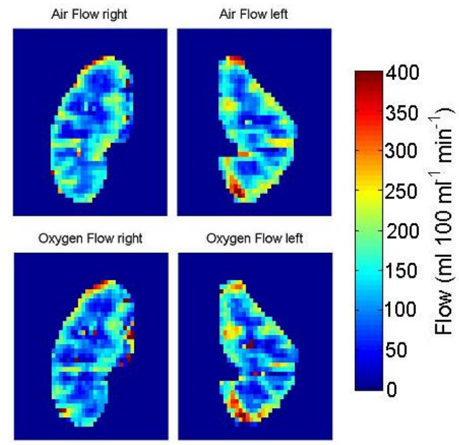

Figure 1: Maps showing blood flow during the breathing of air and 100% oxygen for a single subject.

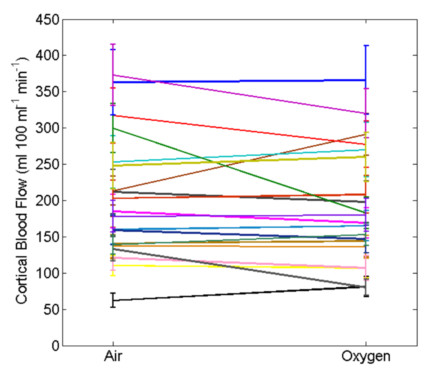

Figure 2: A plot showing mean flow values, with standard deviation, in the renal cortex for both kidneys of all subjects, during the breathing of air and 100% oxygen.

Results

Figure 1 shows example flow maps on air and on 100 % O_2. Flow values for air and oxygen breathing for the renal cortices of each subject are shown in Fig. 2. There were changes in flow in both directions within individual subjects but these were smaller than the differences seen between subjects. Across all subjects, mean cortical blood flow was 200 ± 83 ml 100 ml^{-1} min^{-1} during air breathing and 192 ± 78 ml 100 ml^{-1} min^{-1} during oxygen breathing. A two-tailed paired t-test showed no significant difference in these flow values ($p=0.1585$). However, by using an identical *assumed* T_1 value for blood for both breathing gases, there was an apparent significant (and misleading) reduction in flow values from 200 ± 83 to 169 ± 70 ml 100 ml^{-1} min^{-1} ($p=0.0011$).

Discussion

It appears that a 100% oxygen gas challenge does not have a measurable consistent effect on renal blood flow, contrary to expectations from some of the literature. This is a useful finding for those working on OE-MRI, as we can be more certain that signal changes are due to oxygenation-related T_1 changes, rather than any flow changes. We also demonstrate that it is important to consider possible tissue or blood T_1 changes when using ASL to measure the effect of oxygen.

References

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