Effects of Supplemental Oxygen on Cardiovascular Relaxation Parameter Mapping (T1, T2 and T2*)

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Purpose: To determine the effects of supplemental oxygen supplied by nasal cannula or a non-rebreather mask on blood and myocardial MR relaxation time mapping protocols (T1, T2 and T2*).

Introduction: Measurements of cardiovascular MR relaxation times are being increasingly employed in clinical and research protocols for myocardial tissue characterization via native and contrast-enhanced relaxation times or calculated measures such as myocardial partition coefficients and extracellular volume fractions. Clinical applications of T2*, T2 and T1 mapping include the detection of iron overload, myocardial edema and diffuse fibrosis. Extrinsic factors as well as disease can alter relaxation times and cause a shift from normal values without underlying pathology. Oxygen levels are well known to alter blood and tissue relaxation times [1] for example the BOLD effect and MR ventilation imaging [2]. Supplemental oxygen has two main effects on relaxation times 1) in its bound state to hemoglobin and 2) freely dissolved in blood plasma.

Interest in myocardial relaxation time measurements has resulted in mature protocols for their clinical application consisting of dedicated standardized pulse sequences with motion correction (MOCO) and inline parameter calculation provided by MR vendors. Supplemental oxygen is routinely used therapeutically in chronic and acute cardiovascular care and has been studied and used in MR imaging to improve breath-holding. The extent to which blood and myocardial relaxation times measured with current protocols are affected by supplemental oxygen has not been studied.

Methods: Twelve healthy subjects without respiratory or cardiac disease (age: 47.4±5.3 years; 6 male) were studied at 1.5T using vendor relaxation mapping protocols in the four chamber view. Five measurements spaced by 10 minutes were performed with supplemental oxygen supplied by nasal cannula and a non-rebreather mask alternating with room air (M1: Room air, M2: nasal oxygen (2 l/m), M3: Room air, M4: non-rebreather mask (15 l/m), M5: room air). Relaxation mapping was performed using: MOLLI T1 mapping (TR/TE= 2.8/1.2 ms; FA= 18^{o}; 3-(3)-5; 2 inversions, 3 heartbeat rest period; TI start=120 ms; TI increment=120ms; 3 parameter curve fitting); T2 prepared bSSFP T2 mapping (TR/TE= 2.6/1.2ms; FA= 18^{o}; adiabatic T2 prep TEs=0, 25, 55 ms); Dark-blood spoiled multiple gradient-echo T2* mapping (TR/TE= 22.6/(2.9-20.4; ΔTE=2.5; flyback) ms; FA= 35^{o}; BW = 814 Hz/pixel). Regions-of-interest were drawn in septal myocardium and in each chamber of the heart excluding papillary muscles for blood measurements on relaxation maps. Two-way analysis of variance (ANOVA) was used to study changes in relaxation times with supplemental oxygen. A p value<0.05 was used as a threshold of statistical significance.

Results: Study results are displayed in Figures 1 and 2. There was no difference in myocardial relaxation times with supplemental oxygen. Left ventricular and atrial T1 bloodpool relaxation times were significantly reduced using the non-rebreather mask and could be easily visualized in source T1 maps (arrow and Figure 3), p<0.001. There was no detected change in right atrial or ventricular bloodpool T1 times or T2 and T2* times with supplemental oxygen, p>0.05.

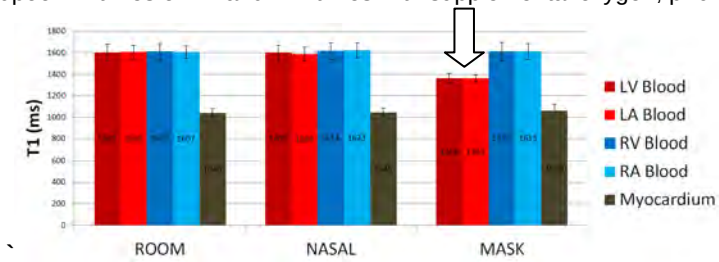

Figure 1: Blood and Myocardial T1 Relaxation Times

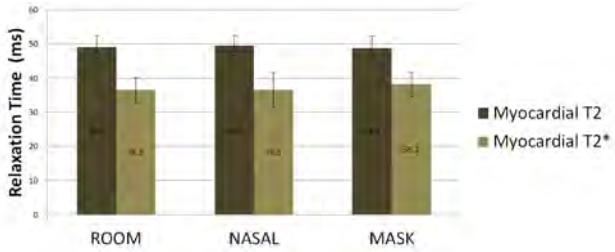

Figure 2: T2 and T2* Myocardial Relaxation times

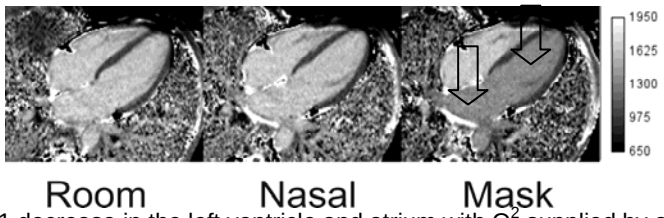

Figure 3: Significant T1 decrease in the left ventricle and atrium with O^2 supplied by a non-rebreather mask.

Conclusion: Use of supplemental oxygen can change measured relaxation values and subsequent derived values. As measured using a well documented MOLLI T1 protocol, there are significant changes in left ventricular and atrial T1 relaxation times with supplemental oxygen supplied by a non-rebreather mask. We did not detect a change when oxygen was supplied by nasal cannula or T2 and T2* measurements. Additionally, myocardial, right atrial and ventricular blood pool T1 relaxation times did not change with supplemental oxygen. If supplemental oxygen is used, one can measure blood relaxation times from the right side of the heart as they are unaffected.

[1] Tadamura E et al. "Effect of oxygen inhalation on relaxation times in various tissues." J Magn Reson Imaging. 1997;7(1):220-5. [2] Edelman RR et al. "Noninvasive assessment of regional ventilation in the human lung using oxygen-enhanced magnetic resonance imaging." Nat Med. 1996; 2(11):1236-9.