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Determination of oxygen relaxivity in oxygen nanobubbles at 3 and 7 Tesla

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Abstract:

Objective Oxygen-loaded nanobubbles have shown potential for reducing tumour hypoxia and improving treatment outcomes, however, it remains difficult to noninvasively measure the changes in partial pressure of oxygen (PO_2) in vivo. The linear relationship between PO_2 and longitudinal relaxation rate (R_1) has been used to noninvasively infer PO_2 in vitreous and cerebrospinal fluid, and therefore, this experiment aimed to investigate whether R_1 is a suitable measurement to study oxygen delivery from such oxygen carriers.

Methods T_1 mapping was used to measure R_1 in phantoms containing nanobubbles with varied PO_2 to measure the relaxivity of oxygen (r_{10x}) in the phantoms at 7 and 3 T. These measurements were used to estimate the limit of detection (LOD) in two experimental settings: preclinical 7 T and clinical 3 T MRI.

Results The r_{10x} in the nanobubble solution was 0.00057 and 0.000235 s⁻¹/mmHg, corresponding to a LOD of 111 and 103 mmHg with 95% confidence at 7 and 3 T, respectively.

Conclusion This suggests that T_1 mapping could provide a noninvasive method of measuring a > 100 mmHg oxygen delivery from therapeutic nanobubbles.

Keywords: quantitative MRI, MRI relaxometry, oxygen, hypoxia