Accuracy of MR Oximetry after Resuscitation with a Hemoglobin-Based Oxygen Carrier

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Introduction:

Recent advances in biotechnology produced a class of artificial blood substitutes based on polymerized, hemoglobin-based oxygen carrier (HBOC). These substances overcome many difficulties encountered in conventional allogeneic blood transfusion. While they have the potentials for life-saving treatments in anemia and acute hemorrhage, their effects on tissue oxygenation, especially in human subjects, are relatively unknown [1].

We have previously shown that MR oximetry can accurately measure oxygen saturation of native venous blood [2]. While this technique was originally developed for intracellular hemoglobin [3], we hypothesize that it applies to blood resuscitated with an extracellular HBOC. We tested this hypothesis in a HBOC-resuscitated rabbit model, where oxygen saturation in the inferior vena cava (IVC) measured with MR oximetry was validated against a catheter-drawn blood sample measured with ex-vivo oximetry.

Material and Methods:

Ten New Zealand white rabbits (weight range, 2.5-3.2 kg) underwent 12 hours of fasting. Each animal was anesthetized and mechanically ventilated. A venous catheter was placed in the IVC. Once hemodynamically stable, 20% of blood volume was withdrawn and replaced by 10 ml/kg of bovine hemoglobin glutamer, HBOC-200 (Oxyglobin®; Biopure, Cambridge, MA), dosage per manufacturer’s recommendation.

Each animal underwent MR imaging of the IVC using established MR oximetry protocol [2]. The imaging plane was chosen just beyond the venous catheter tip. T2 value of blood in the IVC was calculated, and oxygen saturation was inferred from ex-vivo calibration. Separately, 2 ml of blood was withdrawn from the venous catheter and its oxygen saturation measured with a clinical reflectance oximeter. This established the gold standard. Data were compared using paired Student t-test and linear regression analysis.

Results:

After blood withdrawal, the animals exhibited hemodynamic changes typical of acute hemorrhage, with an increase in heart rate (HR), a decrease in mean arterial pressure (MAP), and a decrease in peripheral oxygen saturation (Figure 1). After HBOC-resuscitation, there was an excessive increase in mean arterial pressure beyond baseline, suggestive of peripheral vasoconstriction, and a decrease in heart rate likely a result of baroreceptor reflex.

Figure 2 plotted the MR oximetry data against the gold-standard. There was no statistical difference (p > 0.1). The slope of the regression line was 0.98 while the correlation was 0.99, suggesting excellent agreement.

Discussion:

Our experiment indirectly demonstrated a side-effect of HBOC, peripheral vasoconstriction, also shown in other published results [1]. It has been speculated that this effect, by restricting oxygen delivery, can be deleterious to tissue oxygen saturation. By evaluating blood oxygen saturation non-invasively, MR oximetry may help answer this important question, especially in human patients. As a first step, we confirmed that MR oximetry is accurate after resuscitation with an extracellular HBOC.

References:


![Figure 1, Hemodynamic Data](image1)

![Figure 2, MR Oximetry Accuracy](image2)