Title: Confirmation of a broadband NIRS method for measuring oxygen saturation as a simplistic quantitative tool

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Structured Abstract:

Introduction Brain injury during preterm infancy can result in serious cognitive, motor and behavioural disabilities; as such, reliable monitoring of cerebral health in the neonatal intensive care unit (NICU) is a sought-after practice. Current standards of care rely on global measurements of arterial oxygen saturation (SaO2) to indicate respiratory performance; however, this is an insensitive marker of cerebral health. Near-infrared spectroscopy (NIRS) is ideal for neonatal neuromonitoring because it is non-invasive, extremely safe, and can measure cerebral oxygen saturation (ScO2) due to the oxygen-dependent absorption property of hemoglobin. The main limitation with measuring ScO2 accurately is separating the effects of light absorption from the much greater effects of light scattering. The gold standard for this is time-resolved (TR) NIRS, which uses temporal information of light propagation through tissue to characterize light absorption and scattering. However, TR systems are complex and expensive. A simpler alternative is broadband NIRS (B-NIRS), which utilizes the different wavelength-dependencies of scatter and absorption to separate their effects. This technique requires a broadband light source and a spectrometer to collect reflectance data across the NIR spectrum. The aim of this study was to investigate the ability of B-NIRS to quantify optical properties and determine ScO2 under different physiological conditions in comparison to TR-NIRS measurements.

Methods: A piglet model of hypoxia was used to compare broadband and TR-NIRS measures of ScO2. The fraction of inspired oxygen was decreased from 60% to moderate hypoxia (16% O2) in 8 steps. Arterial partial pressure of oxygen (PaO2) and SaO2 were measured at each step. Optical fibers directed light from the halogen source to the animal's head and collected reflected light that was send to the spectrometer. Spectra acquired at each level of oxygenation were used to calculate the changing hemoglobin concentrations and in turn ScO2. For comparison, TR-NIRS was used to measure changes in ScO2 by acquiring reflectance data at 670 and 760 nm.

Results: Across three animals, average PaO2 and SaO2 decreased from 200 ± 50 to 26 ±5 mmHg and 100 to 33%, respectively. Oxy and deoxyhemoglobin concentrations were quantified at each step and the resulting ScO2 values dropped from 76 ± 8% at normoxia to 19 ± 9% at the lowest inspired O2 fraction. This trend of deceasing ScO2 was confirmed by TR-NIRS.

Conclusion: Preliminary data show that broadband NIRS has the capability to quantify cerebral oxygen saturation at the bedside for patients in the NICU. Considering this is a simple, inexpensive but quantitative NIRS approach, it should enhance the clinical use of NIRS for neuromonitoring. Studies are ongoing to better assess the agreement between StO2 measurements from B-NIRS and TR-NIRS techniques.