Development of a Multi-Wavelength Spatial Domain Cerebral Oximeter for Pediatrics.

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Introduction: Detection of cerebral hypoxia-ischemia in infants remains problematic, as current monitors are impractical, insensitive, or nonspecific. Near infrared spectroscopy (NIRS) is capable of detecting cerebral hypoxia-ischemia at the bedside, although uncertainties persist about the accuracy of commercially available devices. Our study was designed to develop and test a new multi-wavelength spatial domain NIRS device in a piglet cerebral hypoxia-ischemia model.

Methods: The Institutional Review Committee approved the study. The prototype NIRS device consists of main unit connected to an optical probe housing photodiode detectors 2-4 cm from a 3 wavelength light emitting diode. An algorithm was derived from a Beer-Lambert spatial domain construct. Piglets were anesthetized with fentanyl (10μg/kg/hr infusion) and midazolam (0.1mg/kg/hr). Arterial and sagittal sinus saturation (SaO_2 , SsO_2) was determined by co-oximetry. The algorithm was tested in 8 piglets subjected randomly to varying conditions of hypoventilation, hypoxia (low inspired oxygen concentration), and ischemia (carotid occlusion). Arterial blood gases, SaO_2 and SsO_2 were recorded at each condition. Mean cerebral saturation (SmO_2) was $SmO_2=0.85SsO_2 + 0.15SaO_2$ based on a 15:85 arterial:venous brain blood ratio. NIRS cerebral saturation (ScO_2) was evaluated relative to SmO_2 by bias, precision, slope, intercept, and correlation coefficient.

Results: We found a linear relationship ($ScO_2 = 0.72\ SmO_2 +14$) with good correlation ($r^2=0.84$). The bias and precision were 0% and 10%, respectively (Figure).

Discussion: This prototype NIRS device uses inexpensive, robust, clinically friendly technology similar to pulse-oximetry. The bias and precision is similar to other clinical devices such as pulse-oximetry, although accuracy remains intact over a wide saturation range. The multiwavelength spatial domain approach appears to improve accuracy. Clinical studies are underway.

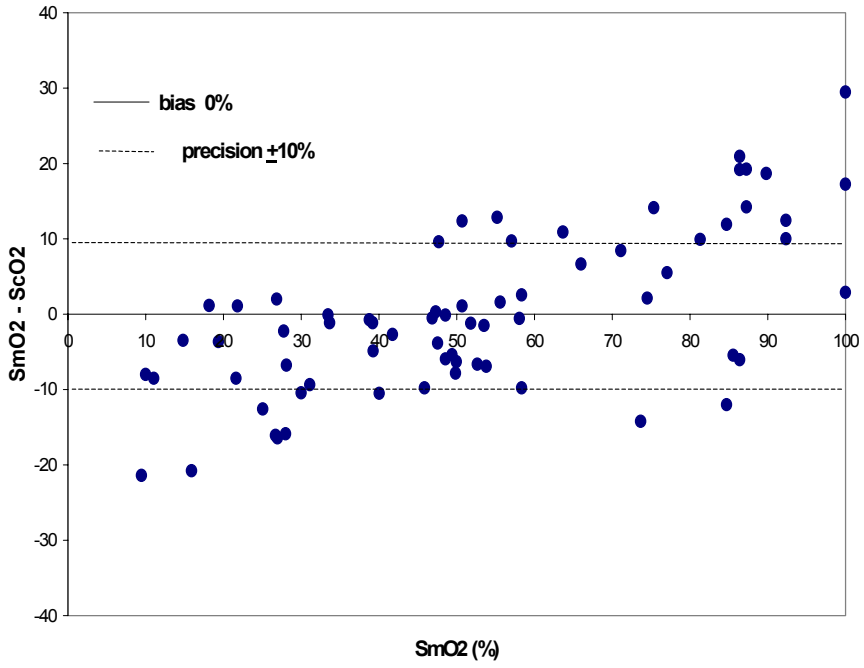

Figure: Comparison of NIRS and arterial/venous oxygen saturation ratio

ScO_2 refers to cerebral oxygen saturation as measured with NIRS, SmO_2 refers to mean cerebral oxygen saturation, a 15:85 ratio of arterial and sagital sinus venous oxygen saturation