ANIMAL MODEL VALIDATION OF THE CAS NEONATAL NIRS SYSTEM, INCLUDING EFFECTS OF EXTRACEREBRAL INTERFERENCE

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Introduction - Near-infrared spectroscopy (NIRS) is non-invasive optical based technique to continuously monitor brain and other tissue oxygenation. We have developed a 3λ-CW neonatal NIRS system to determine absolute mixed venous tissue oxygen saturation (SnO_2) based on a differential wavelength variation of the Modified Beer-Lambert Law. Our neonatal NIRS system is currently being validated on a neonate pig animal model as well as human neonates. Similar to humans, the pig cerebral and extracerebral vascular systems are generally similar with insignificant collateral exchange for most individuals. We performed fluoroscopy imaging on the cerebral vasculature of larger pigs to verify this.

Methods: Several tests were developed to evaluate the neonatal NIRS system: 1) Correlation of NIRS brain SnO_2 to sagittal sinus ($SssO_2$) and arterial (SaO_2) oxygen saturation with the scalp removed during selective hypoxia; 2) Correlation of SnO_2 to $SssO_2$ and SaO_2 with the extracerebral tissues intact during selective hypoxia; and 3) Quantitatively evaluate the extracerebral interference to brain SnO_2 determination under extreme conditions by selective bilateral external carotid artery (ECA) occlusion. The neonatal NIRS probe (optode separation 25 mm) was carefully placed across the piglet forehead, just behind the eyes to maximally sample brain tissue. The total extracerebral tissue thickness (scalp + skull) under the NIRS probe for Yorkshire piglets weighting 3-11 kg ranged from 4 to 7 mm thick.

Results: The correlation of NIRS SnO_2 vs. mixed venous oxygen saturation ($SmvO_2$) from $SssO_2$ and SaO_2 for 6 piglets with scalp removed (Figure 1b) and 6 piglets with intact scalp (Figure 1a) are shown below. As expected, there is increased scattering observed with the intact scalp study, likely due to extracerebral interference. The average ± SD of the decrease of NIRS SnO_2 due to bilateral ECA occlusion was 9.0 ± 3.1 (6 piglets, 12 ECA occlusion events).

Conclusion: In routine neonatal NIRS monitoring, extracerebral interference is probably not clinically significant, since the change in SnO_2 is expected to be much less than the observed results from bilateral ECA occlusion. Study supported by NIH NINDS grant # R44NS39723.

Figure 1: