Correlation of renal tissue oxygenation to venous, arterial, and capillary blood gas oxygen saturation in preterm neonates

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Background

- Near-infrared spectroscopy (NIRS) is a noninvasive technology that can measure the amount of oxygen in tissue beds and is being increasingly utilized to measure Renal regional Saturation of Oxygen ($RrSO_2$) in preterm neonates.
- It is commonly believed that organ tissue oxygen distribution is approximately 75% venous, 20% arterial, and 5% capillary.
- A properly placed umbilical vein catheter (UVC) may be used to estimate $RrSO_2$ due to the proximity to the renal vein.
- Previous adult and pediatric studies have observed a significant correlation between $RrSO_2$ and oxygen saturation from catheterized renal vein blood gas specimens.[1]

Objective

To correlate $RrSO_2$ in preterm neonates to venous oxygen saturation (SvO_2), arterial oxygen saturation (SaO_2), and capillary oxygen saturation (ScO_2) obtained from UVCs, umbilical artery catheters (UACs), and capillary heel stick specimens, respectively.

Methods

- This was a secondary analysis of a prospective $RrSO_2$ monitoring study in preterm neonates (GA<32 weeks).[2]
- INVOS NIRS sensors applied over kidney until day 7 of age.
- Inclusion criteria: Blood gas obtained during period of $RrSO_2$ monitoring.
- Exclusion criteria: Improper UVC placement (UVC not located at inferior vena cava/right atrium junction on x-ray).
- Average $RrSO_2$ values calculated for the exact minute at the time of the blood draw.
- $RrSO_2$ compared to O_2 saturation of each blood gas specimen using the non-parametric Mann Whitney U-Test and Spearman correlation coefficient.

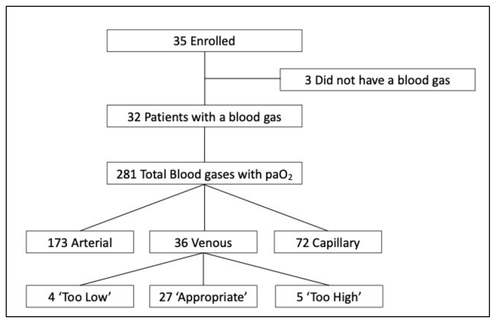

Figure 1. Procedure for data organization and analysis. 35 patients were enrolled in the study. 3 did not have blood gas values associated with the time of NIRS monitoring. The blood gas values of the remaining 32 patients were analyzed. 27 venous blood oxygen values were obtained from proper UVC placement. These 27 venous blood oxygen values were the values analyzed in calculations of summary statistics and tests of correlation.

Demographics	Patients (n=32)
Gestational age, weeks (Median, IQR)	28.7 (26.1-30.0)
Birth weight, grams (Median, IQR)	1075 (777.5-1356.3)
Male sex, N (%)	17 (53.0%)
Small for gestational age, N (%)	6 (18.8%)

Categorical data presented as number (percentage) and continuous data presented as median (interquartile range)

Table 1. Characteristics of the 32 neonates who had blood gas values associated with the period of NIRS monitoring. Median and IQR values reported for gestational age and birth weight. Numbers and associated percentages of participants that were of the male sex and small for gestational age.

In this small pilot secondary NIRS study in preterm neonates, renal tissue oxygenation correlates with both arterial and capillary oxygen saturation while no correlation is observed between central venous

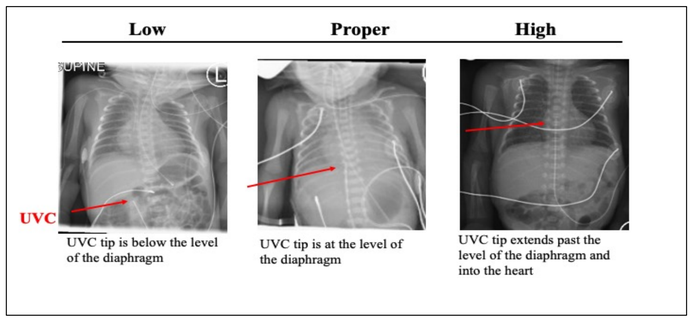

Figure 2. Categories for distinguishing the placement of the umbilical vein catheter (UVC). Low lying refers to a UVC below the level of the diaphragm. Proper UVC placement refers to a UVC at the level of the diaphragm. High placement of the UVC entails a UVC that is above the level of the diaphragm.

Citations

1. Tholén M, Ricksten SE, Lannemyr L. Renal Near-Infrared Spectroscopy for Assessment of Renal Oxygenation in Adults Undergoing Cardiac Surgery: A Method Validation Study. *J Cardiothorac Vasc Anesth.* 2020 Dec;34(12):3300-3305. doi: 10.1053/j.jvca.2020.04.044. Epub 2020 May 15. PMID: 32532694.
2. Harer MW, Adegboro CO, Richard LJ, McAdams RM. Non-invasive continuous renal tissue oxygenation monitoring to identify preterm neonates at risk for acute kidney injury. Pediatr Nephrol. 2021 Jan 3. doi: 10.1007/s00467-020-04855-2. Epub ahead of print. PMID: 33389091.

Results

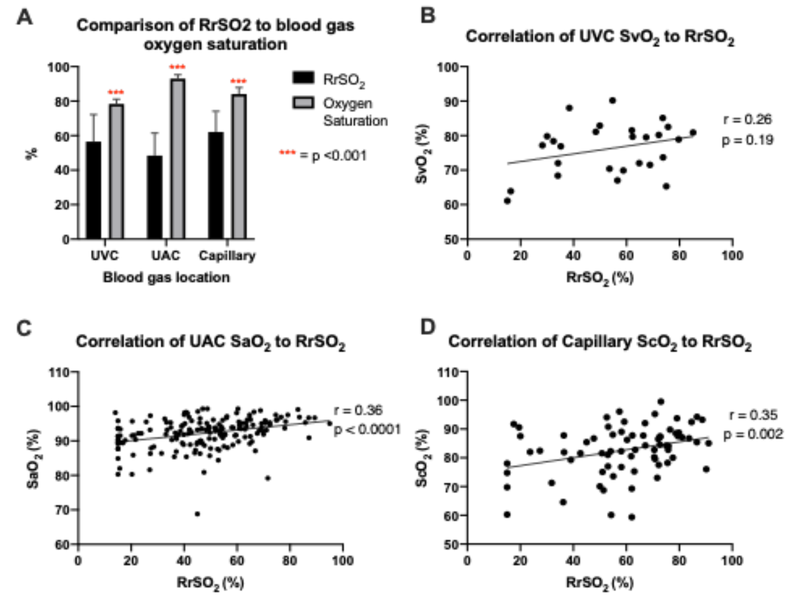

Figure 3. Comparison plots and Spearman correlation plots of $RrSO_2$ to oxygen saturation by site of blood draw. In figure A, the median $RrSO_2$ values were compared to the median oxygen saturation values from each blood draw site. Figures B-D are Spearman correlation plots that illustrate the correlation of oxygen saturation of each blood draw site to $RrSO_2$ values. Figure B is the correlation plot of UVC SvO_2 against the $RrSO_2$ values. Only the UVC PaO_2 of properly placed UVC are included in the plot. Figure C is the correlation plot of UAC SaO_2 against the associated $RrSO_2$ values. Figure D is the correlation plot of capillary ScO_2 against the corresponding $RrSO_2$ values.

Conclusions

1. This is the first study to examine the correlation between renal tissue oxygenation and blood oxygen saturation in preterm neonates.
2. Renal tissue oxygen saturation values are lower than blood oxygen saturations.
3. Renal tissue oxygen saturation correlates significantly with arterial and capillary oxygen saturation.
4. The findings of this study did not support the hypothesis that renal tissue oxygen saturation is significantly correlated with UVC blood oxygen levels; this finding may be due to the small UVC sample size.

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