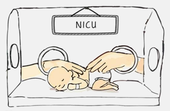
Comparison of Cerebral blood flow and Cerebral oxygenation Measured non-invasively in extremely premature infants



How are they related?
Could brain injury play a role?



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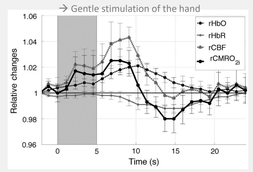
Athinoula A. Martinos Center For Biomedical Imaging

Alyssa Martin, Sarah Lee, Katie Hannon, Tina Steele, Deborah Cuddyer, Emily M. Herzberg, Terrie Inder, Maria Angela Franceschini and Mohamed El-Dib

BACKGROUND

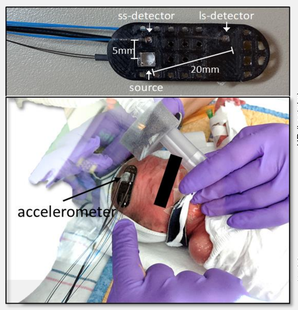
The temporal relationship between cerebral blood flow (CBF) and cerebral oxygenation (rSO2) are often studied and modeled in adults and animals, but not enough studies are performed in extremely premature infants, a population that is vulnerable to brain injuries, such as germinal matrix/intraventricular hemorrhage (GM/IVH) due to unstable, immature regulation of cerebral hemodynamics.

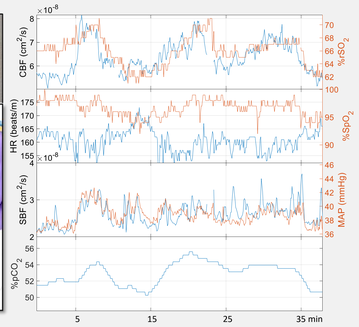
Often, cerebral oximetry serves as surrogate CBF → Right showing close association between CBF and cerebral oxygenation in preterm infants, but with different time constants and magnitudes



METHOD

1. Start **diffuse correlation spectroscopy (DCS)** measurements within 48 hours of life; Acquire cerebral NIRS rSO2, EKG, SpO2, ABP and tcPCO2 (→resampled to 33-sec data rate)
2. Compute daily average Spearman's rank correlation (R) using 10-min sliding window (→Find the association with GM/IVH)



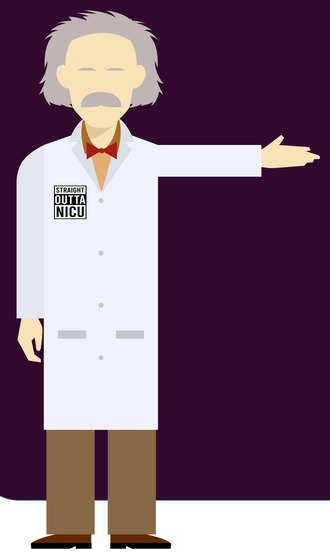


RESULTS & DISCUSSION

(43 daily measurements in 20 extreme preemies <28 weeks GA)

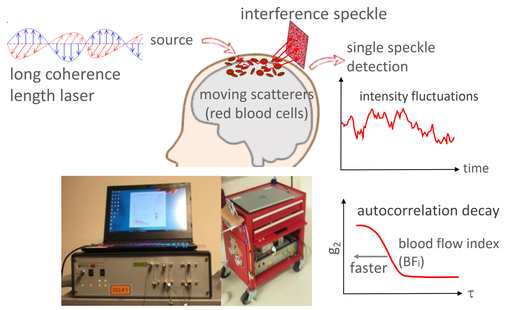
- Some correlation between DCS blood flow and NIRS rSO2
  - Perfusion vs. oxygenation
- We hoped that rSO2 can help further explain impaired cerebral autoregulation (CAR) in IVH,
  - BUT, we did not find it helpful
- Work-in-progress: Characterization of Cerebral Perfusion and Utilization (CPU) via input-output systems modeling
- SpO2 showed good & tight correlation with rSO2

→ Buckley, E.M., Parthasarathy, A.B., Grant, P.E., Yodh, A.G., Franceschini, M.A., 2014. Diffuse correlation spectroscopy for measurement of cerebral blood flow: future prospects. Neurophotonics 1, 011009.



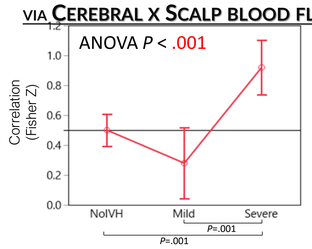
Did you want Cerebral Perfusion, or Oxygenation, or BOTH?

WE MEASURED CEREBRAL BLOOD FLOW (CBF) IN EXTREMELY PREMATURE INFANTS USING DIFFUSE CORRELATION SPECTROSCOPY (DCS)



WE PREVIOUSLY SHOWED: A GREATER INDEX OF IMPAIRED CEREBRAL AUTOREGULATION (CAR)

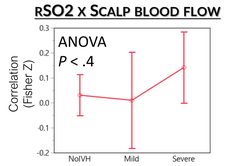
RISC: AVERAGE CROSS-CORRELATION VIA CEREBRAL X SCALP BLOOD FLOW



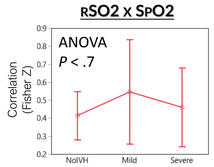
- Also a significant influence from Birth Weight (*P*=.037)
- But, INVOS rSO2 as a covariate didn't help further explain impaired CAR and IVH in our population

BUT, NO SIGNIFICANT INDICATION OF IMPAIRED CAR USING RSO2 INSTEAD

RSO2 X SCALP BLOOD FLOW

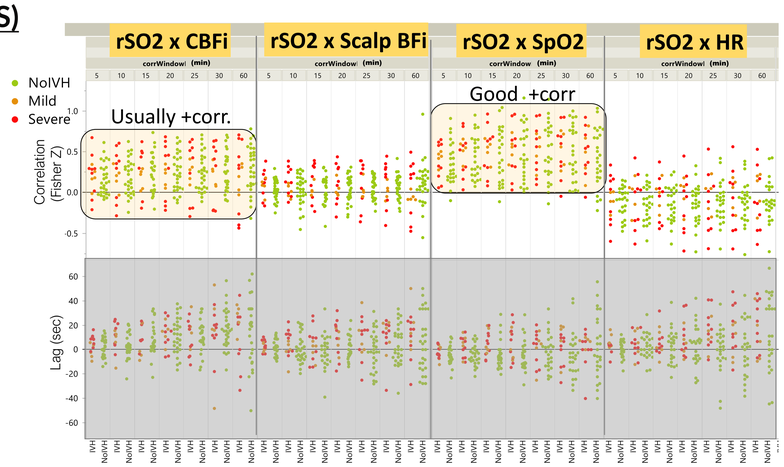


RSO2 X SPO2



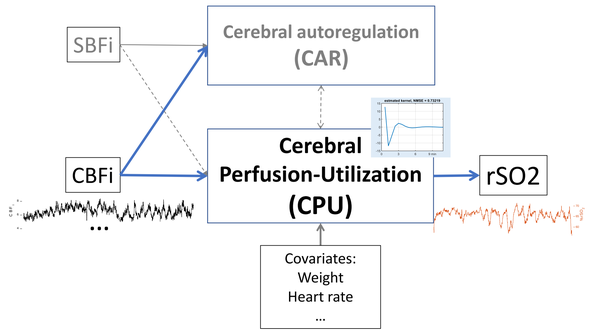
- Indicated that rSO2 information can comprise of different combinatory activities from blood flow and metabolism
- Interesting influence of birth-weight into CAR

DCS CBF AND NIRS OXYGENATION (RSO2) USUALLY SHOWED A POSITIVE CORRELATION



- The lag time may not represent meaningful temporal relationships between the two physiological parameters, as we have slow sampling rate and the time drifting in each device

CAN CEREBRAL PERFUSION AND UTILIZATION (CPU) BE A MARKER OF BRAIN INJURY IN PRETERM INFANTS?

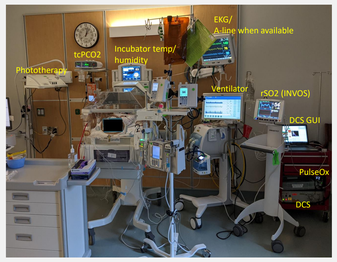


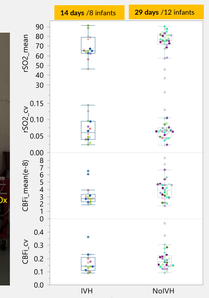
$$y(k) = \sum_{m_1=1}^{M_1} h_1(m_1)x_1(k-m_1) + \sum_{m_2=1}^{M_2} h_2(m_2)x_2(k-m_2) + v$$

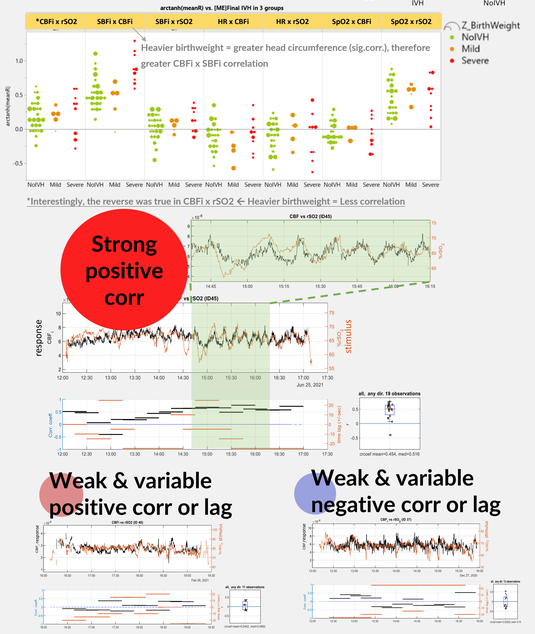
- Linear-time-invariant dynamic system was assumed
  - *M*: Memory of the system (up to 30min)
  - *h*: System impulse response = Cerebral Perfusion-Utilization (CPU)
  - *x*: Input; y: Output signal; *v*: Residual of the model
- Work-in-progress
  - A group averaged CPUs by the IVH outcome
  - Correcting the long signal gaps rejected due to excessive motion
  - Use high-rate data for the input signal, DCS CBFi

Variables	IVH[&] (N=8)	No IVH (N=12)	P-Val
Gestational age (weeks)	26 ± 2	26 ± 1	.8
Birth weight (g)	799 ±206	861 ±202	.5
Time of IVH (HoL*)	74 ± 64	-	-
Apgar at 1 min (Median [25-75th])	3 [1-5]	5 [4-7]	.03 [x]
Apgar at 5 min (Median [25-75th])	6 [4-6]	7 [6-8]	**.01** [x]

[&] IVH grade IV (N=5), II (N=3); [x] Wilcoxon Exact Test
*HoL: Hours of Life, IVH found by head ultrasound





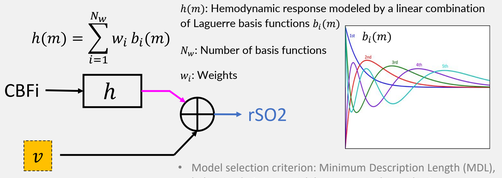


$$h(m) = \sum_{i=1}^{N_w} w_i\, b_i(m)$$

$h(m)$: Hemodynamic response modeled by a linear combination of Laguerre basis functions $b_i(m)$

N_w: Number of basis functions

w_i: Weights

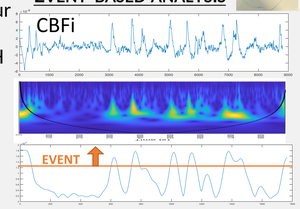


- Model selection criterion: Minimum Description Length (MDL), balancing between model accuracy and complexity

LIMITATIONS & FUTURE WORK

- 33-second resolution by our cerebral oximeter may not show characteristics of IVH
- Event-based Analysis instead of the whole day average
- We can add additional inputs to the model to adjust for their influences, such as scalp blood flow

EVENT-BASED ANALYSIS



- Chances of events
- CAR and CPU at the events

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