NIRS Educational Module

Neuro NICU
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December 2014
Outline

• What is NIRS and how does it work?
• Potential Applications of NIRS in the NICU
  – Prematurity and PDA
  – Prematurity and NEC/ SIP
  – Prematurity and IVH
  – CHD
  – Meconium Aspiration/PPHN
  – HIE
• Troubleshooting NIRS
What is NIRS?

Continuous, real-time, non-invasive bedside monitor of regional tissue oxygenation (rSO2)

- Validated with jugular venous saturations
- FDA approved for use in infants (including those <2.5 kg)
How does NIRS work?

(a) Placement of sensor on neonate's forehead with light source and detector.

(b) Light passes from light source to detector after passage through scalp, skull, and brain tissue.

(c) Partial absorption of light by oxygenated and deoxygenated hemoglobin in underlying tissue

(d) No heat generated
What are NIRS values?

Tissue oxygen saturation ($rSO_2$) reflects a ratio of arterial and venous blood (25%:75%)
Average NIRS values

- Cerebral rSO$_2$: 78±8% DOL1 term infants
- Renal rSO$_2$: 92±5%
- Mesenteric rSO$_2$: 70±12%

- Preterm infants with lower average values
- Absolute number not as important as trend over time
Critical Cerebral NIRS Values

• Poorly defined in infants

• Pathology studies in hypoxic piglets
  – $rSO_2$ 30-40% with neuronal mitochondrial injury and fragmentation in hippocampus (Hou, et al. *Physiol Meas*, 2007)

• Clinical studies from patients with cyanotic CHD

• LPCH guidelines:
  – Notify provider if cerebral $rSO_2$ persistently <50%
Two-site NIRS

– Monitor cerebral and somatic oxygenation simultaneously (renal or mesenteric)
– Splanchnic & renal blood flow extremely sensitive to cardiac output (less autoregulation than brain)
– Renal rSO$_2$ typically 15-20% higher than brain
– Circulatory impairment reduces somatic saturation first. Earlier indication of hemodynamic compromise
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Is a PDA Significant?

Together with clinical and echocardiographic findings, NIRS measures may help to determine the hemodynamic significance of a PDA.
Is a PDA Significant?

**Significant PDA:** Renal sats significantly depressed at baseline with extreme variability

**Non-significant or closed PDA:** Renal sats higher with less variability
Is a PDA Significant?

• Example #1: 24 week preterm infant
  – 18 days of age found to have a large PDA with left to right shunting
  – Clinically with poor UOP, rising Cr, pulmonary edema, significant ventilator support
  – Cerebral sats 25-45%, Renal sats 15-50% (of note, the monitor does not register <15%)
  – Indicator of poor cerebral/systemic perfusion
  – Decision made for PDA ligation
Is a PDA Significant?

• Example #2: 11d old, 26 week infant
  – Sm-mod PDA by ECHO, bidirectional shunting
  – Infant with adequate UOP, stable Cr, tolerating trophic feeds, on CPAP support
  – Renal sats mainly 70s, with minimal variability. Cerebral sats mid-80’s.
  – Reassuring NIRS tracing further evidence supporting conservative PDA management
Prematurity: NEC/SIP

• Example #3: 25 week preterm infant
  – Intestinal perforation requiring surgery
  – Notable drop in mesenteric saturation on day of perforation (️ early gut ischemia)
Prematurity and IVH

Example #4: Same infant post-operatively-
• Cerebral sats 55-65%, then decreased to low 40’s,
• Prompted HUS revealing bilateral grade 3/4 IVH

A sudden change in cerebral saturation may be concerning for altered perfusion to brain/ risk of IVH
NIRS in pre-operative cardiac patients

• High risk for CNS injury pre-operatively
  – Chromosomal anomalies/ brain dysgenesis
  – Acquired hypoxic-ischemic injury
    • Ductal dependent lesions with diastolic run-off compromising brain and other end-organ perfusion
    • Increased risk of emboli after balloon atrial septostomy in TGA
  • Ongoing systemic inflammation
  • Altered cerebral autoregulation (esp in preterm infants)
What can NIRS tell us in CHD patients?

- Indirect measure of Qp:Qs (balance between pulmonary and systemic blood flow)
  - Regardless of systemic O$_2$sat values, cerebral and somatic oxygenation may be inadequate

- Cerebral oxygenation
  - Poor end organ perfusion may require interventions to increase systemic blood flow or consider need for earlier surgery

- Splanchnic oxygenation
  - May provide reassurance for initiation of feeds or evidence to keep npo
Interventions amenable to NIRS monitoring in cardiac patients

• Ventilator changes
• Changes in PGE dose
• Rashkind or valvuloplasty procedures
• Initiation of subatmospheric oxygen to improve Qp:Qs
NIRS use in CHD patients

• Consider ordering NIRS placement (cerebral and renal) in all patients with CHD at risk for poor systemic perfusion
  – Especially in infants with left-sided obstructive lesions (HLHS, Coarctation, AS, IAA), TGA, Ebstein’s, or others where concerns about Qp:Qs
• Example #5:
  – Term infant with TGA
  – Systemic sats stable 80-90’s
  – Cerebral sats 50% with dips to low 30%, Renal sats 45-55%
  – Concern for inadequate cerebral blood flow
  – Call made to surgeons/anesthesia
  – Decision made to go to OR sooner than originally planned
NIRS and Pre-ECMO patients

• PPHN/ Meconium Aspiration
  – Optimize both systemic oxygenation AND cerebral oxygenation.
  – Effect of hypocarbia: decreased cerebral perfusion, vasoconstriction in the brain
NIRS use in HIE


NIRS use in HIE

- Example #6: Term infant with HIE and Cooling
  - Cerebral sats 90-95%, Renal sats ~75%

High rSO2 seems good, however, when it is too high it represents a failure of O2 extraction
Infant had moderate to severe brain injury by MRI and initial burst suppression by aEEG
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Trouble-shooting NIRS Use

– What to do with low values?
  • Is infant hypotensive?
  • Is infant anemic?
  • Is infant hypocarbic (poor cerebral perfusion)?
  • Consider reducing cerebral metabolic rate (sedation, control hyperthermia)
  • For cardiac patients: Do values correlate with other indicators of poor systemic perfusion (i.e. high lactate levels, prolonged cap refill time/ cold extremities, decreased UOP)
    – Consider interventions to improve Qp:Qs (i.e. PEEP, subatmospheric oxygen, increased Hct, change in PGE dosing, earlier surgical intervention)
Trouble-shooting NIRS Use

– What to do if not picking up a reading?
  • Check sensor adherence
  • Check connections
  • Too much ambient light? (phototherapy?)

– Skin integrity-- especially in preemies
  • Check sensor site every 24h and change sensor at least every 4 days
  • Avoid direct pressure over sensor
  • Slow and gentle removal
  • Time and date the sensor when placed