NICU Guideline: NIRS Monitoring

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Background: The use of near infrared spectroscopy (NIRS) to monitor regional tissue oxygenation in neonates was first introduced clinically in the 1980s. The mechanism behind the technology has been well described in previous reviews. NIRS provides clinicians an estimate of local tissue oxygen utilization by assessing post-capillary oxygenation. Multiple factors may affect NIRS values, but the two main determinants are tissue perfusion and tissue oxygen utilization. In the neonatal intensive care unit (NICU), the principal end-organ clinically monitored with NIRS has been the brain, however, multiple other tissues have been evaluated in neonatal research studies including the kidney, splanchnic circulation, and peripheral muscles.

NIRS provides regional hemoglobin oxygenation status using a technique like pulse oximetry (SpO_2). Both forms of monitoring take advantage of differential absorption spectra between oxygenated and deoxygenated hemoglobin to visible light in the near-infrared range. However, NIRS expresses full tissue hemoglobin oxygenation without subtraction of non-pulsatile data. Thus, NIRS represents the regional oxygenated to total hemoglobin ratio (rSO2) for the combined arterial, capillary, and venous hemoglobin sources underlying a given sensor. Anatomically, at any given time, the blood contained within an individual tissue segment exists in a generally accepted vascular distribution of approximately 20% arterial, 75% venous, and 5% capillary. Ultimately, the difference is then expressed as a ratio for real time trending:

[(oxyhemoglobin/oxyhemoglobin+deoxyhemoglobin) ×100]

In general, there are two approaches to NIRS monitoring in the NICU setting. Disease- or event-specific monitoring, referred to as “responsive” monitoring, is defined as goal-oriented use of NIRS for specific clinical or bedside purposes. The second approach, referred to as “routine” monitoring, concerns the continuous use of NIRS in a framework like current bedside cardiopulmonary vital sign monitoring practices. This guideline will introduce both approaches.

Logistics of Monitoring:

Order in Epic (search NIRS)

- Providers should place order specifying the following:
  - Which sites should be monitored (Cerebral, Renal, Mesenteric)
- Order will include recommended alarm settings by gestational age
  - If other alarms are wanted, should be added in comments

Charting in Epic

- Record site specific value every 1 hour in NIRS flowsheet

Sensors

- Document time and date on each sensor with marker when placing on skin
- Change sensor every 5 days or sooner if necessary

Skin Care

	< 34 weeks’ PMA	**≥ 34 weeks’ PMA**
Mepitel	Yes	Not necessary or PRN for skin breakdown
Movement of sensors	Yes – every **6** hours	Yes – every **24** hours

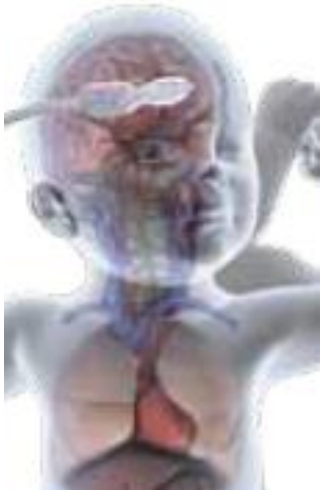
Approved at Clinical Guidelines on 10/31/2022
Implemented at Meriter on 02/01/2023

**Consider a new sensor when soiled or not working.

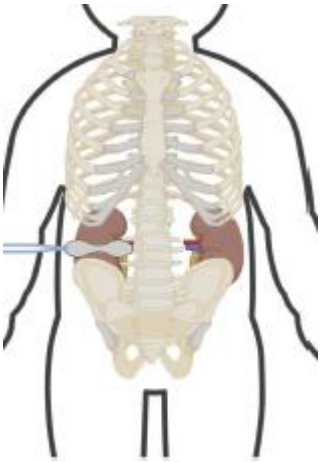
Sensor Location

Organ Monitored	**Location** (may need to be modified slightly by patient)
Cerebral	Above the eyebrow and below the hairline. Ideally either right or left of midline.
Renal	Above the iliac crest and below the last rib, horizontally placed with light emitting tip closest to the spine but not over the bone.
Mesenteric	Below the umbilicus with light emitting tip closest to midline.

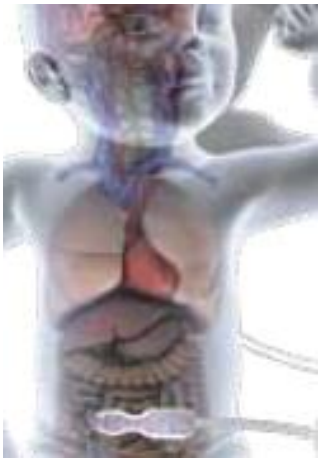
Cerebral



Renal



Mesenteric



Alarms

- The order will include where to set the lower and upper limit of the alarms based on normative values for the gestational and chronological age of the baby
- Nurses should notify a provider if values are outside of the ordered saturation range for more than 30 minutes despite measures noted in the 'Troubleshooting' section below.
- If a baby is persistently outside of the desired range despite interventions, a provider can order for the alarm to be reduced or raised to a new level versus being silenced to avoid alarm fatigue. Determining whether to keep the alarm outside of the normal limits or silenced should be re-addressed daily.

Alarms for > 37 week GA

Organ Monitored	**Suggested Upper Limit**	**Suggested Lower Limit**
Cerebral	85	55
Renal	90	60
Mesenteric	70	30

Alarms for < 37 week GA (preterm)

Organ Monitored	**Suggested Upper Limit**	**Suggested Lower Limit**
Cerebral	85	50
Renal	90	50
Mesenteric	70	30

Monitoring Starting at Admission: Cerebral and Renal

1. Preterm neonates <32 weeks
    a. Start monitoring at 24 hours after birth or sooner if skin allows
    b. Stop monitoring if the following conditions are met:
        i. Off IV nutrition and medications
        ii. On fully fortified feedings
        iii. No hemodynamically significant PDA clinically noted
2. Neonates with Neonatal Encephalopathy undergoing therapeutic hypothermia
    a. Start monitoring on admission to NICU
    b. Stop monitoring prior to brain MRI on Day 4 or 5
3. Neonates evaluated for Congenital Heart Disease
    a. Start monitoring on admission to NICU
    b. Stop monitoring after discussion with Pediatric Cardiology

Event Specific Monitoring: Cerebral and Renal

1. Neonates requiring vasopressor support
    a. Start monitoring when starting vasopressor support
    b. Stop monitoring when off vasopressor support
2. Neonates receiving blood transfusions
    a. Start monitoring 1 hour prior to transfusion
    b. Stop monitoring after first feed post transfusion
3. Neonates meeting Baby NINJA requirements (≥3 nephrotoxic medication within 24 hours or ≥4 calendar days of an intravenous [IV] aminoglycoside)
    a. Start monitoring when requirements met
    b. Continue monitoring until Baby NINJA monitoring is complete (off NTX meds)
4. Neonates with seizures
    a. Start monitoring when vEEG placed
    b. Stop monitoring when vEEG removed

Troubleshooting:

Sensors/Readings

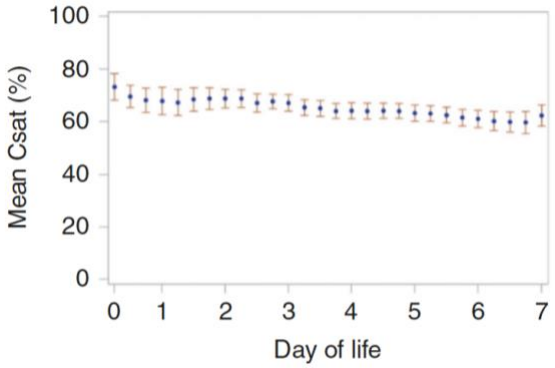
- Make sure probe has complete contact with the skin while ensuring there is no pressure above the sensor.
- Check the cable and sensor connections.
- If the connections are tight and still not providing a reading, try a new sensor/cable.
- If rSO2 readings are not consistent or are not displaying:
    - Check for light interference and consider covering the sensor
    - If the sensor is placed over adipose tissue or edema greater than three (3) cm the light will not reach the tissue bed. Remove or move the sensor to another location.
    - If readings are constant without variability, this requires an evaluation of the location.

Machine

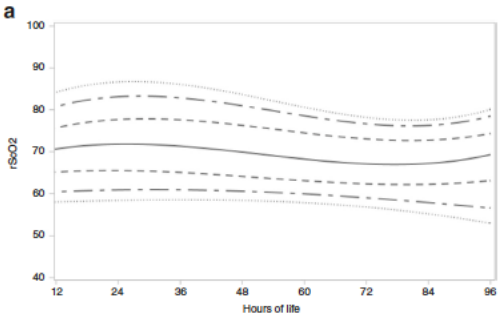
- When turning on the machine, make sure there is always a flash drive inserted at the back of the monitor and the date/time on the machine are correct
- Enter patient MRN as the patient ID

Reference Ranges – (note: most of these saturation values are seen in the first week of age)

Cerebral

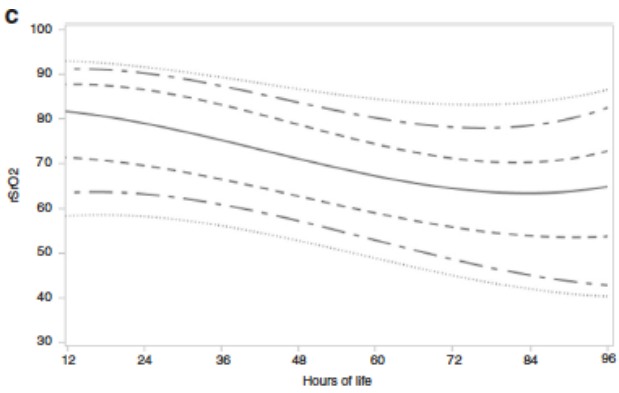


Mean + 95% Confidence intervals – Chock et al 2022

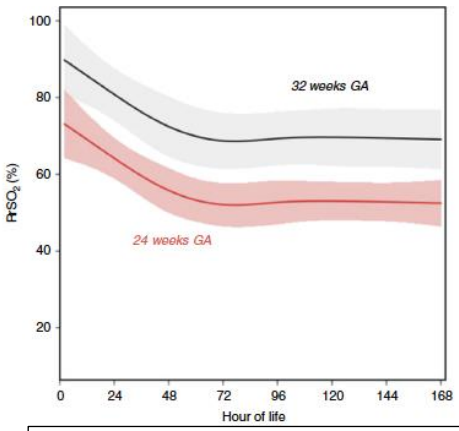


Solid line 50th%, dashed 25/75%, dash-dot 10/90% – Hoffman et al 2022

Renal

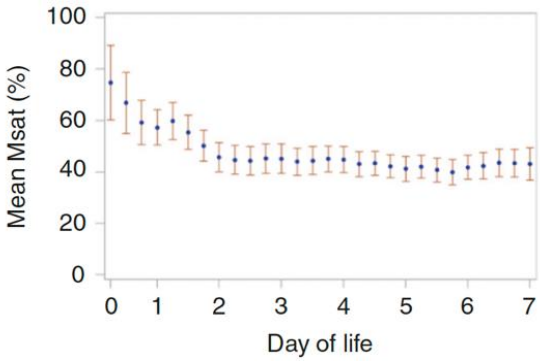


Solid line 50th%, dashed 25/75%, dash-dot 10/90% – Hoffman et al 2022

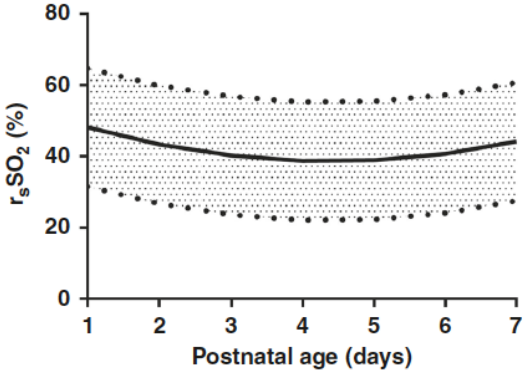


Mean + 95% Confidence intervals – Harer et al 2022

Mesenteric



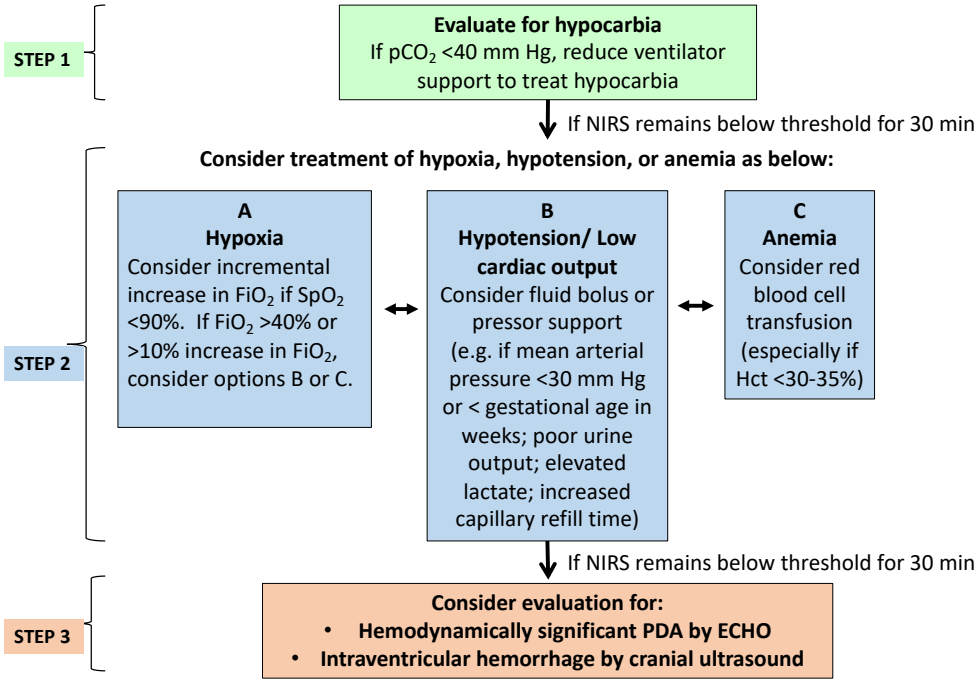
Mean + 95% Confidence intervals – Chock et al 2022



Mean +/- 1 SD – van der Heide et al 2022

Suggested Evaluation when out of 'Reference Range' for 30-60 minutes after 'Troubleshooting' has occurred

Cerebral



Renal