Hôpital de Montréal pour enfants
Centre universitaire de santé McGill

Montreal Children's Hospital
McGill University Health Centre

Clinical MCH-NICU Guideline

MCH NICU – Near Infrared Spectroscopy (NIRS) in the NICU

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Population eligible for monitoring

Population A: Hypoxic ischemic encephalopathy undergoing therapeutic hypothermia.

Population B: All newborns with a congenital heart defect detected antenatal or post-natal:
Newborns (32 weeks and more of gestational age) with any of the above cardiac diagnosis:

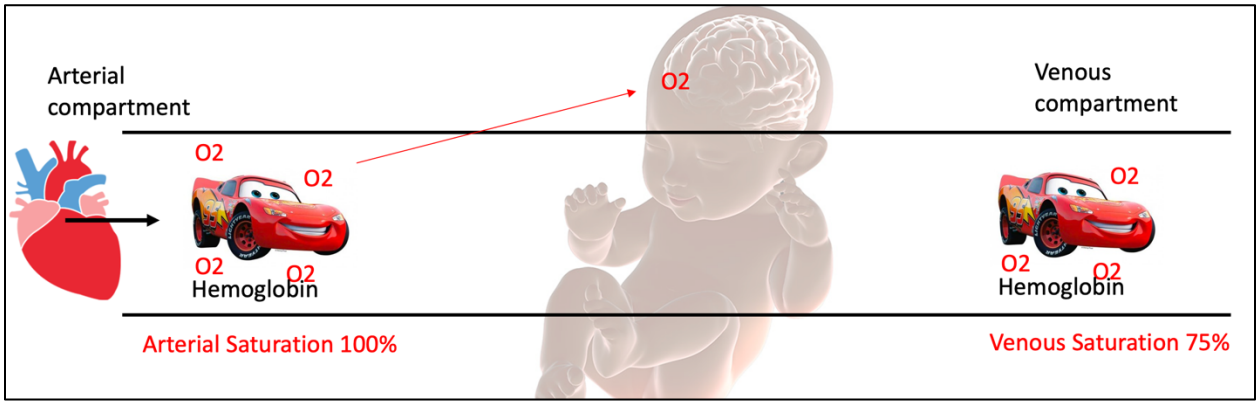
- Congenital Heart Defect requiring prostaglandin (PGE) infusion (ductal-dependent for systemic flow, pulmonary flow or mixing). This may include:
  - Hypoplastic left heart syndrome
  - Tricuspid Atresia
  - Ebstein anomaly
  - Severe Pulmonary or Aortic stenosis
  - Truncus arteriosus
  - Pulmonary Atresia (with or without intact septum)
  - Single ventricular physiology
- Coarctation of the aorta (with or without PGE)
- Total anomalous pulmonary venous return
- Severe variants of Tetralogy of Fallot that can lead to neonatal instability (MAPCAS, Absent Pulmonary Valve or severe pulmonary stenosis requiring PGE).

Population C: At the request of the medical treating team to monitor perfusion

Principles of NIRS:

Near-infrared spectroscopy (NIRS) monitors regional tissue oxygenation

- **Estimates venous-weighted % of oxygen saturation in the monitored tissue**
- Oxygen saturation in a vein depends on how much oxygen is delivered in the arterial side, and how much is extracted. The whole process can be affected by many physiological factors.
- Trends in time are important and inform on perfusion and oxygen delivery
- Cerebral (Csat – pre-ductal), Renal (Rsat – post-ductal) saturations
- Regional O2 sat dependent on multiple factor: local perfusion, systemic oxygenation, CO2, local extraction (metabolic rate), and concentration/type of Hgb.



If regional saturation is <50 or >85%:

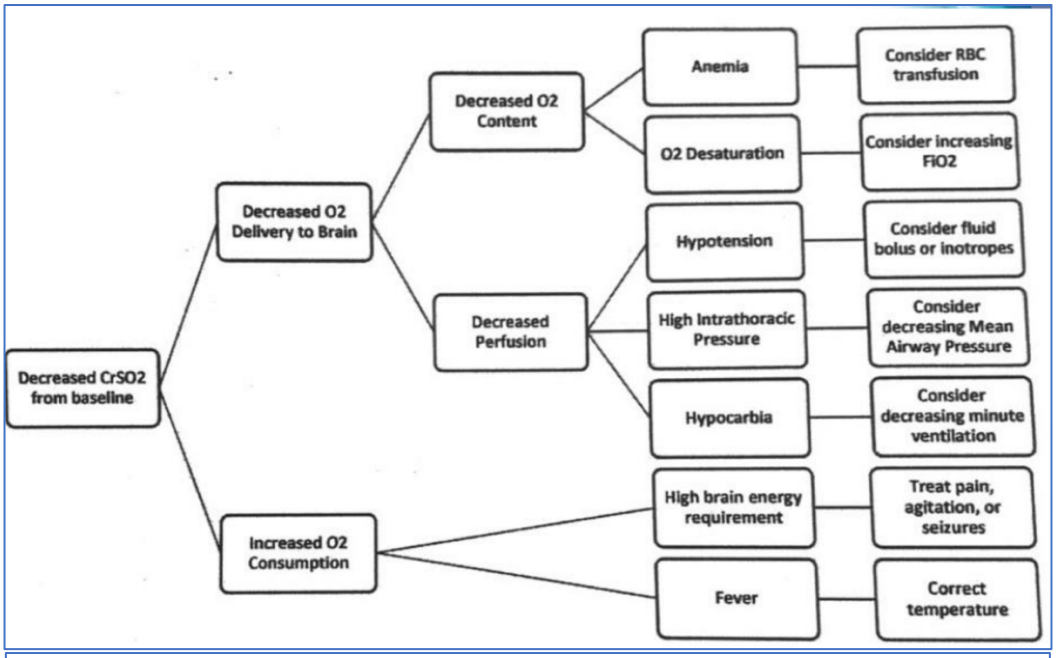
- How is the SpO2 (arterial saturation)? Too low vs Too high? Is the infant hypoxic or with supranormal oxygen saturation?

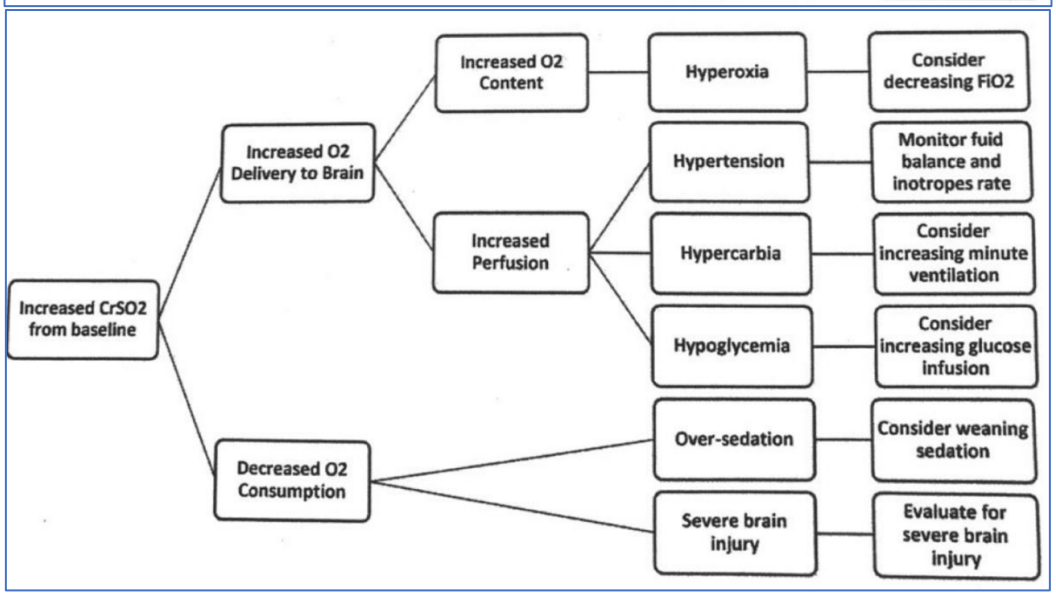
- How is blood pressure / heart rate / refill / urine output / pulses trending over time?
- What is the hemoglobin / hematocrit? Is the infant anemic?
- What is the pCO2 (if too low - hypocarbic: vasoconstriction and if too high - hypercarbic: vasodilation)

Regional saturation is dropping or low (<50%)	
Blood flow is decreasing	Cardiac output is impaired? Heart function impaired? Verify blood pressure, pulses, consider echocardiography? Drop in systolic or mean blood pressure?
	Ductal or diastolic steal effect? Drop in diastolic blood pressure?
	Vasoconstriction? Verify pCO2, pH which can alter vascular tone (Low pCO2 and/or high pH).
	Vascular integrity has been jeopardized? Clot (disseminated intravascular coagulation?), vascular injury, bleeding (IVH)?
	If ductal dependent systemic perfusion – is the ductus closing? Verify pulses.
Is the metabolic demand increasing in the monitored tissue?	Underlying muscle twitching consuming oxygen?
	Seizure?
	Metabolic derangement such as hypoglycemia?
	Sepsis with increasing metabolic demand?
Oxygen delivery is impaired	Oxygenation (arterial) not adequate? (Low SpO2)
	Is hemoglobin dropping? Bleeding? Anemia?
	Underlying blood loss such as IVH?
	Dyshemoglobinemia (methemoglobinemia – oxygen dissociation anomaly)
Artefact	Underlying structure (hematoma, muscle/skin oxygen consumption – fasciculations)

Regional saturation is too high (>85%)	
The underlying organ is injured?	Brain activity is decreased profoundly – sedation (oversedated?), anti-seizure medication, severe HIE? Intrauterine growth restriction?
	Significant acute kidney injury? Consider measuring creatinine and monitor urine output.
	Some septic episode may be associated with mitochondrial dysfunction and the use of O2 is inadequate – associated with lactic acidosis.
Vasodilation	Secondary to hypercarbia? Vasodilation secondary to certain medications?
Oxygen in arterial compartment is too high	SpO2 too high – consider weaning FiO2
Metabolic derangement	Hypoglycemia (profound) can be associated with a high regional saturation (not enough glucose delivery for aerobic metabolism)

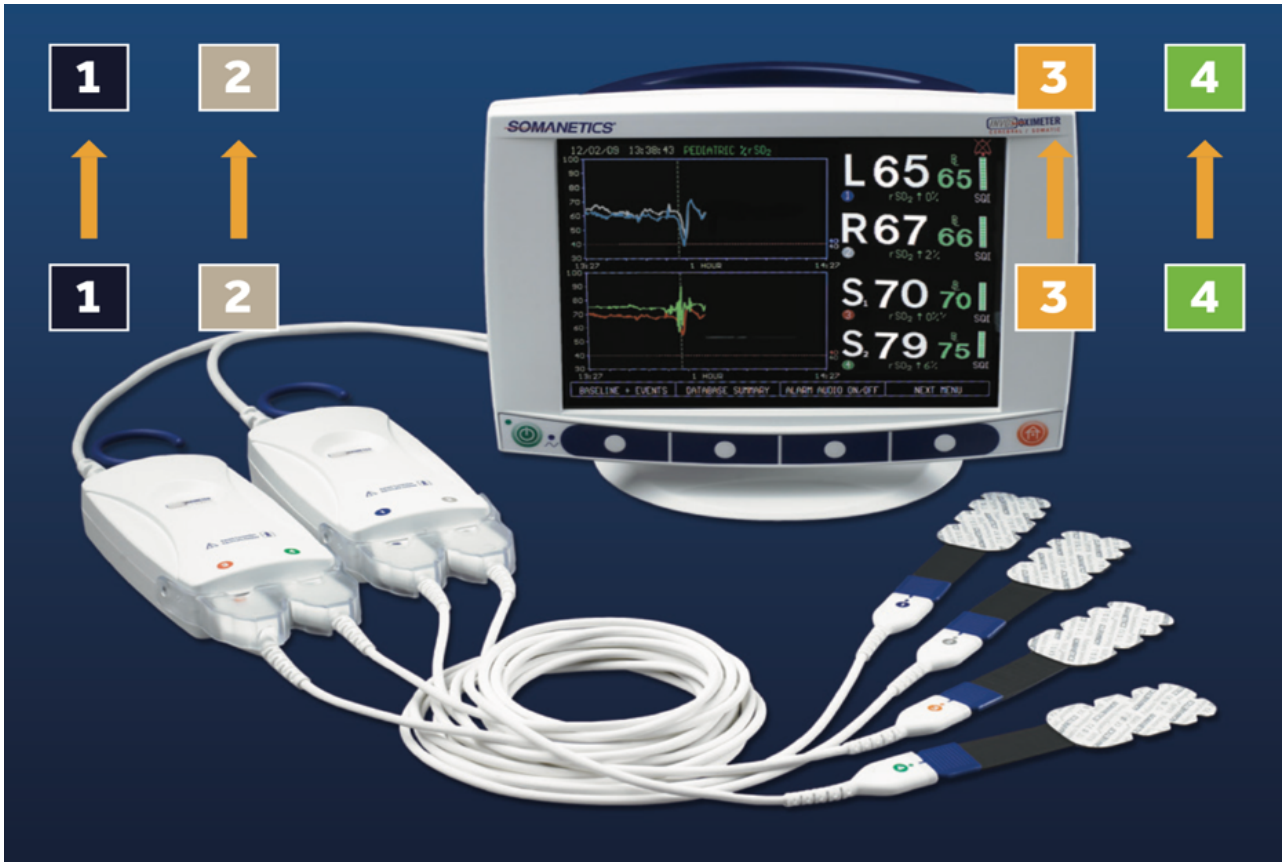
Quick reminder if Csat < 50?
1) Is patient hypoxic? 2) Is patient hypotensive / in shock? 3) Is patient anemic? 4) Is patient hypocarbic (cerebral vasoconstriction)? 5) Is the metabolic rate altered (seizure, agitation, fever) 6) Any other underlying conditions: a. Severe IVH b. Ductal Steal c. Congenital heart defect with altered systemic perfusion





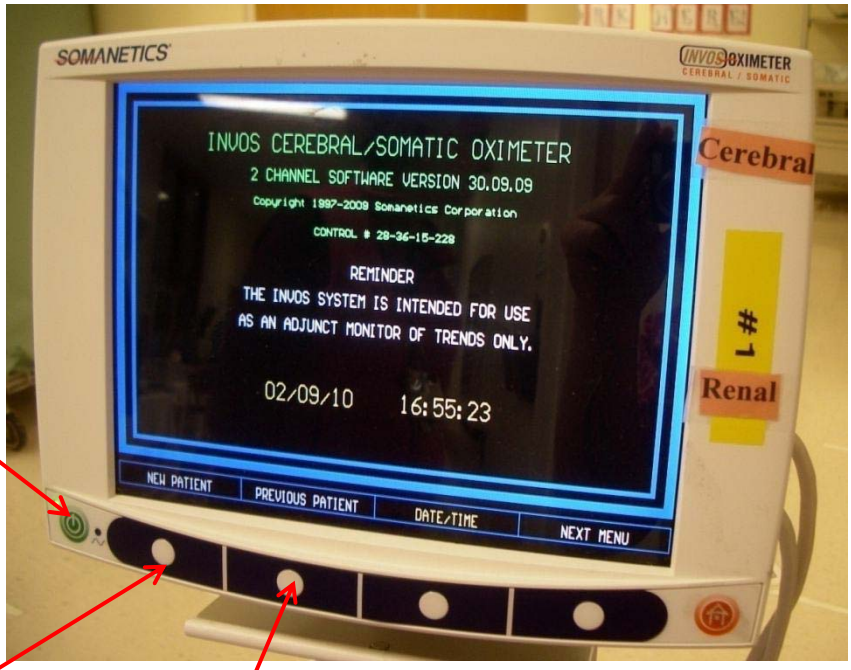
Starting the NIRS monitor

1. Turn on the switch located behind the unit.
2. Press the “ON” button located in front.
3. Press ‘‘New patient ‘‘
4. Enter the patient MRN Number
5. Press ‘‘Next’’
6. Press ‘‘Done’’
7. Connect the sensors.
8. Wait until you see a value on the screen.
9. Press ‘‘Baseline Menu’’.
10. Press ‘‘Set Baseline’’.
11. Look at the screen to make sure all basic info are displayed.
12. ‘Press ‘‘Alarm On/Off ‘‘to turn off all alarms.



Plug machine into outlet

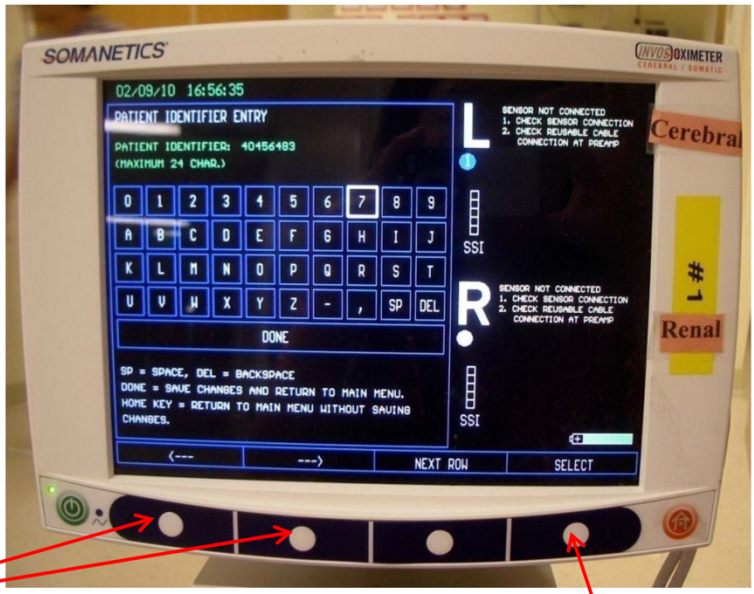
Turn on machine



Power button

Select NEW PATIENT or PREVIOUS PATIENT

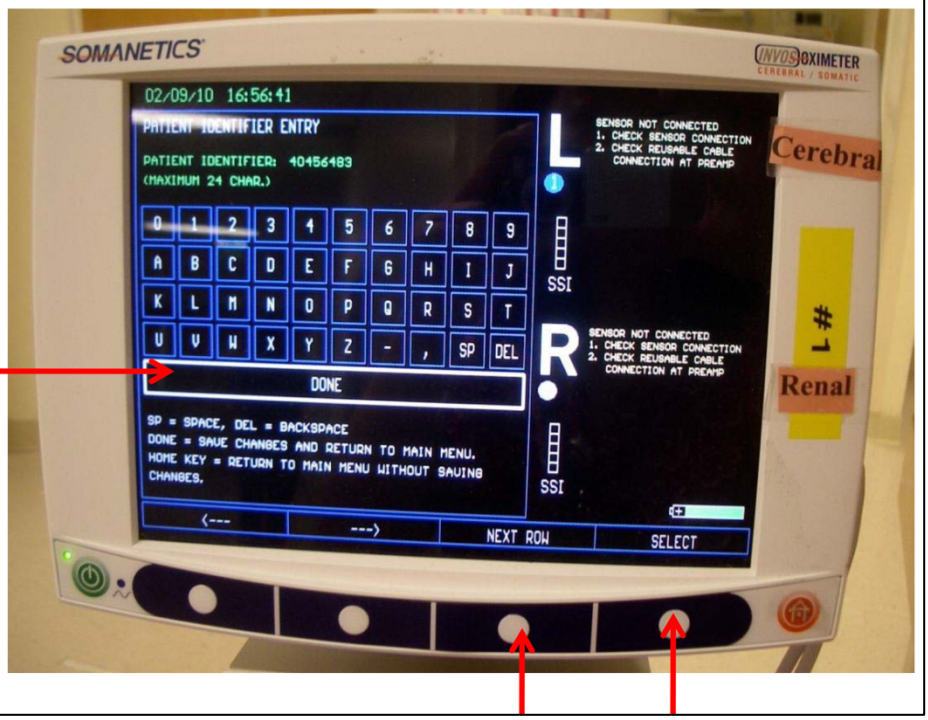
If new patient type in medical record #



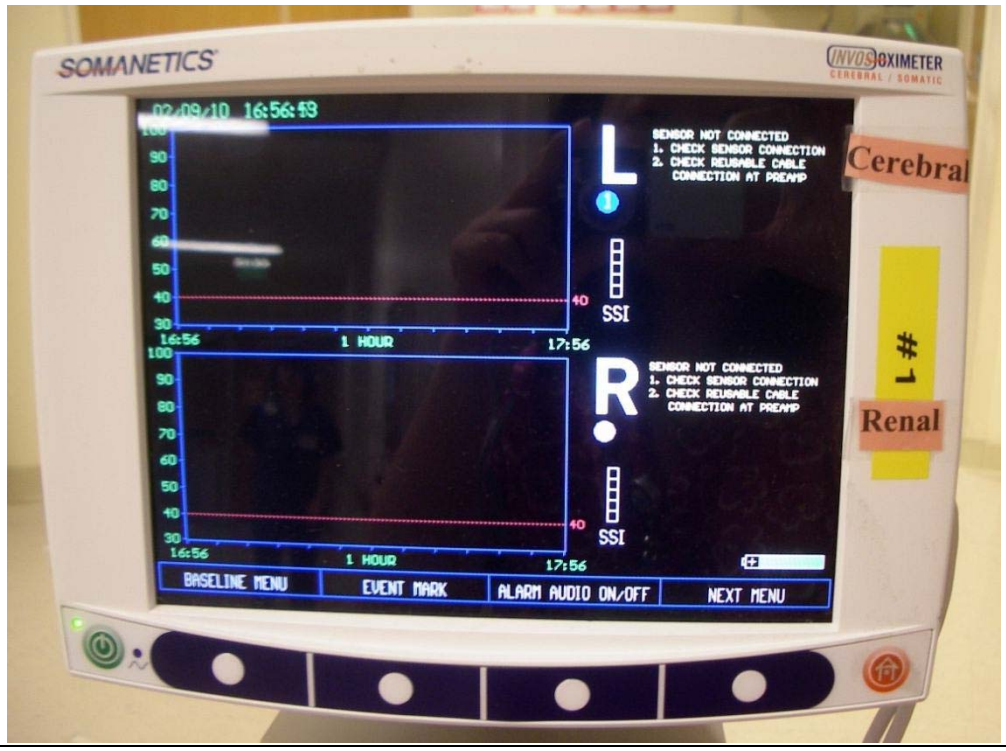
These arrow will allow you to scroll through the numbers

SELECT button when you scroll to the correct number

Once the medical record # is complete, press NEXT ROW to get to DONE. Press SELECT

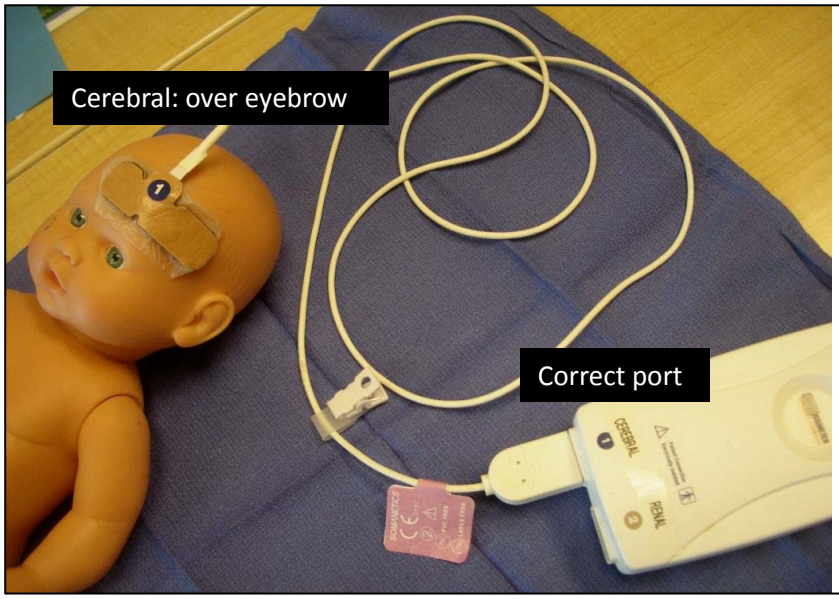


Which brings up this screen – you're ready for monitoring



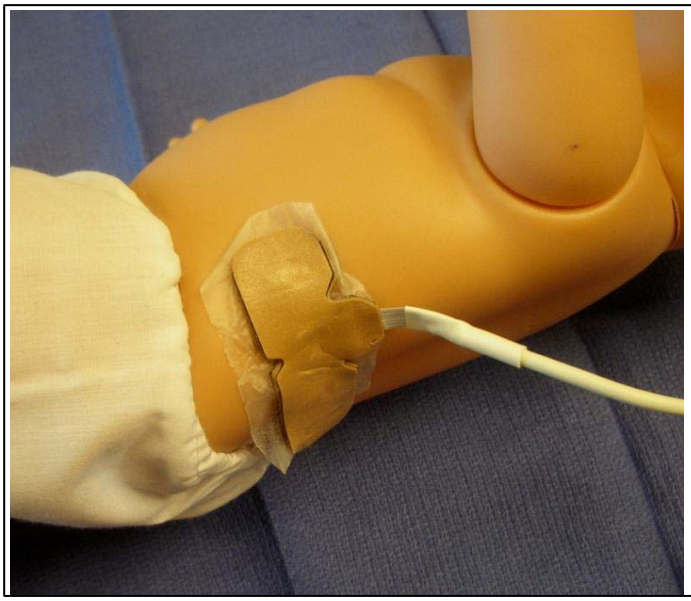
Sensor placement

1. Patient preparation: To achieve optimum adhesion, the skin must be gently cleaned (with water) and dry (dry skin with a gauze pad and warm the sensors in your hands to ease placement). You may secure the sensor with Mepitac.



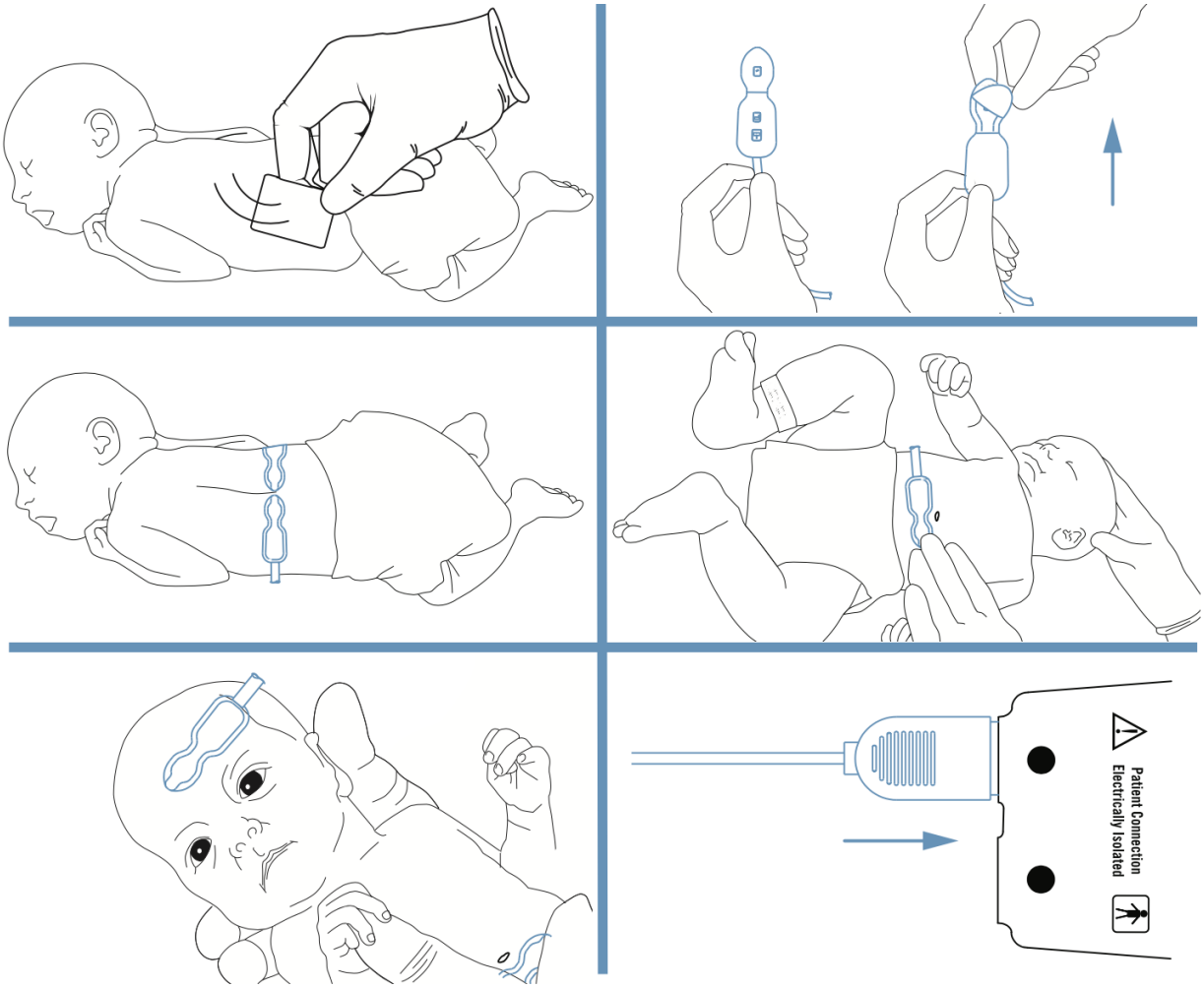
Cerebral placement: over the right or left eyebrow. Make sure you plug into correct port on the box

2. Place the cerebral sensor (parieto-frontal position) and connect to preamplifier 1 (corresponding to L on the monitor) - Apply sensors by smoothing it to skin from center outward. Secure with Mepitac.



Somatic sensor over flank

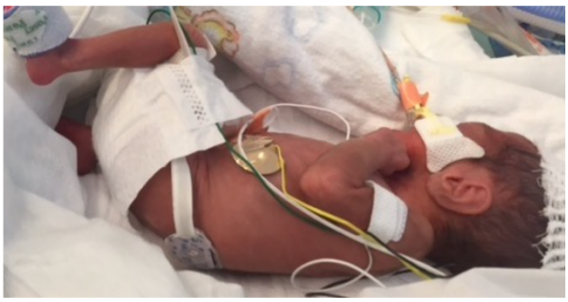
3. Place the somatic sensor pad on the posterior flank (T10-L2) on the right or left side and connect to preamplifier 2 (corresponding to R in the monitor). Secure with Mepitac.



Cerebral

Renal/Flank

Cerebral sensor on right or left side of forehead



Renal sensor on posterior flank below costal margin and above iliac crest (T10-L2)

Manipulation during monitoring

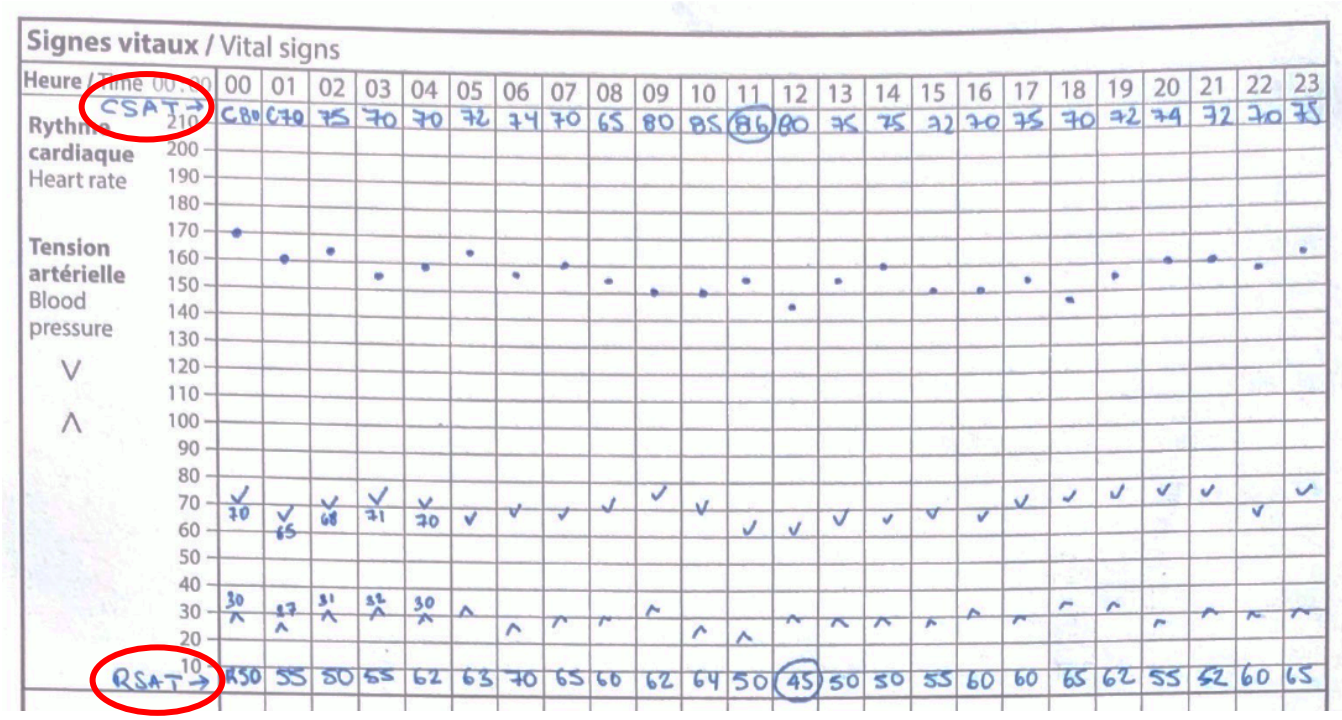
The patients can be held or manipulated, secure the sensor cable to a fixed object to avoid strain on the sensor-to-skin interface. Having the NIRS sensor is not a contraindication for skin-to-skin care. In certain situations, the sensor may be removed during the time of Kangaroo care if it is felt to be in the way of the skin-to-skin session, but to be re-installed after skin to skin care. No need to close the monitor or unplug the sensors, just reapply the sensors.

Skin integrity

- Every 12 hours remove and massage the skin underneath the pad and reapply (be sure sensor is properly re-sealed to skin to avoid light. Ensure to resecure with Mepitac the sensors.
- Do not power off the monitor or disconnect the sensors from the monitor at any time (Skin to Skin care or MRI for an example * not MRI compatible), or the study ID and the settings would have to be re-entered. Simply reapply the sensors once the patient is back if the sensors properly re-seals to the skin (sensors are expensive).

Charting:

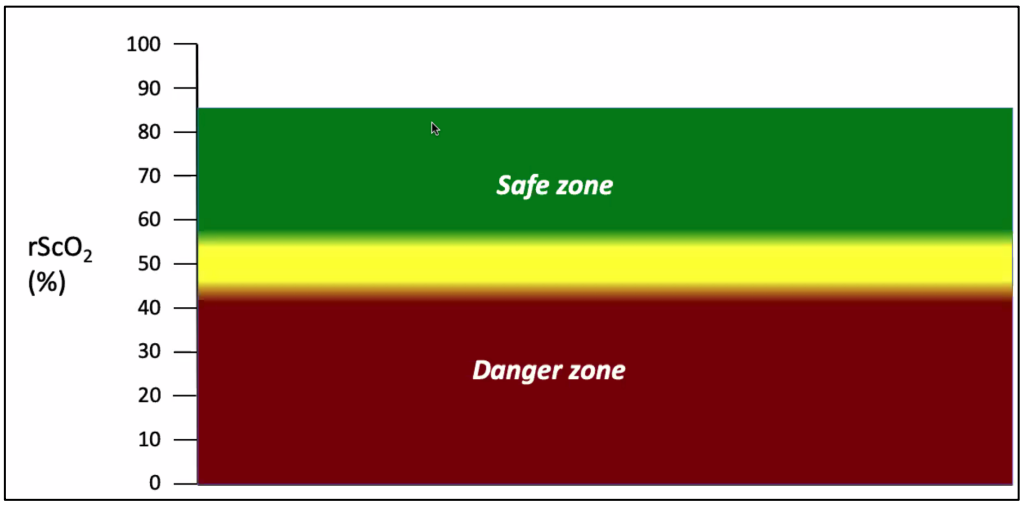
- Chart rSO2 Saturations on patient record hourly for both Cerebral and Renal Saturations
- Document skin assessment at each 24 hours in nursing notes
- Write date & time applied and when change due on patient label attached to sensor cable.



Alerting the medical team:

- **If Regional Saturation (Cerebral or Renal) < 50 % sustained or > 85% sustained** - notify medical team (make sure sensor is in place & adequate signal strength)
- **Alert team if a drop of >20% from baseline** in either Cerebral or Renal saturation after checking for adequate sensor placement.

- Typical Cerebral saturation is between 60-80%, assuming that the arterial saturation (oxygen delivery to organ) is 90% and more. Typically, Renal saturation is higher than the cerebral saturation (since the brain consumes more oxygen than the kidney). This is however often not the case in the context of an opened ductus because of the ductal steal effect.



Troubleshooting:

- If Cerebral or Renal saturation <50%, make sure the sensor is in place and that there is adequate signal strength – secure sensor with Mepitac if getting off if less adhesive
- Avoid placing sensor over thick fatty deposits, hair, bony protuberances, sinus cavities, superior sagittal sinus, nevi, hematoma, anomalies (arterio-venous malformation), broken skin. This may cause inaccurate readings.
- If trouble with the cerebral sensor(s) – secure with Mepitac. Can also secure with a newborn hat or cpap hat. Avoid having too puch pressure on the sensor to prevent sensor pressure sore and ensure monitoring of the underlying skin q12hours. When placing back sensor, try to move slightly to avoid always covering the exact same area.
- If "excessive light" warning occurs, cover the sensor lightly with a cloth to block out the ambient light (more common when under phototherapy). Phototherapy is not a contra-indication for NIRS monitoring.

Removal of NIRS monitoring:

- Sensors should be kept until day 7 in CHD newborns (or until going for intervention)
- Sensors should be kept until at least rewarming is complete in HIE newborns undergoing therapeutic hypothermia (same timing as aEEG removal)
- Sensor may be used up to 7 days
- Sensors are discarded after use and INVOS monitor/cable wiped down with the wipes and stored in Therapeutic Hypothermia storage closet.
- If sensor still very adhesive: Remove sensors slowly & gently with Medisol Adhesive remover OR Unplug Sensor and place a warm moist cloth over sensor for 10 minutes to loosen adhesive.