Neuro Quiz 36
Cerebral Oximetry

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On behalf of the education Committee of the SNACC
Learning Objectives

- What is the NIRS monitor
- Why should we monitor NIRS
- How do we trouble shoot low numbers
- How does it compare with other monitors
- What principle does it work on
- What numbers should we target
- What are the setbacks associated with it
- Do we have robust evidence that it improves outcomes
1. Which of the following about cerebral oximetry (near infra red spectroscopy) is true?

A. Cerebral O2 saturation measured by NIRS is normally 90-100
B. It is a measurement of arterial oximetry in the brain
C. A non-invasive measurement of regional cerebral oxygenation
D. It is accurate when there is extravascular blood
The above statement is false. When the sensors are placed on the forehead about 1.5–2 cm above the eyebrows, then the rSO2 (regional cerebral oxygen saturation) will be estimating cerebral oxygen supply/demand in the frontal cortex, an area of the brain which is most prone to hypoxaemia, the so-called ‘watershed’ area which is supplied by the anterior and middle cerebral arteries and a value of around 70% is seen in normal volunteers.

B. It is a measurement of arterial oximetry in the brain

This is false. There is no ‘pulsatility’ in the signal obtained unlike a pulse oximeter, so it is estimating cerebral tissue rSO₂.
C. A non-invasive measurement of regional cerebral oxygenation

This is true. While brain tissue oxygen tension monitoring is a focal and invasive monitor, cerebral oximetry is non-invasive global monitor of regional cerebral perfusion.
D. It is accurate when there is extravascular blood

Presence of extravascular blood (intra cranial hematoma, cerebral edema or subarachnoid blood) or air might invalidate some of the assumptions upon which commercial cerebral oximeter algorithms are based. This could limit the usefulness of NIRS in these settings.
2. Which of the following is true regarding cerebral oximetry (NIRS)?

A. Its mechanism of measurement is based on Doppler principle
B. The two sensors that come with the NIRS should be placed on the side to be measured
C. One sensor serves as the light emitting diode and the other serves as the light receiver
D. Hyperventilation will lead to decrease in NIRS value
A. Its mechanism of measurement is based on Doppler principle

This is false. The mechanism of measurement is based on a modified Beer Lambert’s law similar to pulse oximeters. This law describes the relation of attenuation of light to the properties of the material that the light is passing through”. The equation is modified to account for scattering of light that can occur. Differences in the absorption spectrum of de-oxy - Hb and oxy- Hb can be detected based on differential absorption at multiple wavelengths.

A recent addition is the ultrasound technology to the NIRS technology. Ultrasound tagging of the NIRS signal utilizing Doppler effect is being done producing a new generation of cerebral oximeters which is supposed to be able to more accurately measure cerebral blood flow and tissue saturation. This still needs to be validated however.
B. The two sensors that come with the NIRS should be placed on the side to be measured

This is false. The two sensors should be placed bilaterally one on each side of the forehead. If practical, the sensors should be positioned above each eye with the long axis parallel to the intra-aural line and the superior optode edge adjacent to the hairline. Consistent positioning in this manner minimizes inter- and intra subject baseline rSO2 variation and avoids the potentially confounding effects of the frontal sinus on light scattering. Repeated optode use is not recommended because the accumulation of epidermal debris on the adhesive surface may have unpredictable effects on extracranial photon scattering.
C. One sensor serves as the light emitting diode and the other serves as the light receiver

This is false. There is one light emitting diode and two receivers on each sensor.
D. Hyperventilation will lead to decrease in NIRS value

This is true. Cerebral arteries in the healthy brain are exquisitely sensitive to hydrogen ion shifts and CO2 change. CO2 accumulation results in arteriolar vasodilation and attendant rSO2 increase. Hyperventilation on the other hand would lead to a decrease in rSO2 values.
3. Regarding the use of NIRS in carotid endarterectomy, which of the following is true?

A. **NIRS** has high positive predictive (PPV) value and low NPV for neurologic complications
B. NIRS value cannot be increased by changing FIO2
C. EEG monitoring would more likely lead to a decision of shunt placement than NIRS monitoring.
D. NIRS is useful to predict cerebral hyperemia after revascularization.
Measurement of cerebral oxygenation during carotid endarterectomy (CEA) appears to be a major indication for its use since the occurrence of stroke is an important contributor to postoperative morbidity and mortality. However, its value is disputed because of its low positive predictive value (33%) and higher negative predictive value (97%) making the above statement false. Hence, if the NIRS values decline during CEA, it is not necessary that the patient will have a stroke. On the other hand, if a patient does not have a drop in value, there is a high likelihood that this patient will not have a stroke.

B. NIRS value cannot be increased by changing FIO2

This is false. Any decline in regional cerebral oxygenation gives warning of potential cerebral ischemia and neurologic events and may be reversible by raising MAP and CO and by increasing inspired oxygen concentration.

C. EEG monitoring would more likely lead to a decision of shunt placement than NIRS monitoring.

The above statement is false and the opposite is true. This is based on a study which looked at 74 patients undergoing CEA and compared EEG versus NIRS to guide shunt placement. The study concluded that the decision on shunting would have increased 20% if NIRS was used when compared to the EEG. Thus, many centers use rScO2 monitoring to guide cardiovascular management of the patient to maintain rScO2 rather than as a direct indication for shunt placement. As a result of these controversies, cerebral oximetry is still not established as an essential monitor for CEA.

D. NIRS is useful to predict cerebral hyperemia after revascularization.

This is true. The vast majority of clinical rSO2 studies have focussed on brain injury from hypoperfusion and oxygen debt. However, cerebral hyperperfusion manifested by hyperoxia is also potentially injurious. An increase in NIRS values after CEA could indicate this complication. A pathologically persistent (i.e., >24 hr) hyperemia may produce vasogenic edema and a cerebral hyperfusion syndrome characterized by migraine symptoms, delirium, focal neurodeficit and seizures. The syndrome may develop with “normal” blood pressure and may be undetectable by tomographic brain imaging. Ogasawara et al. (2003) found the incidence of SPECT-confirmed pathologic post-endarterectomy hyper perfusion to be 12%. These authors showed cerebral oximetry to have 100% sensitivity and specificity in detecting this hyperperfusion.

4. The following statements regarding potential applications of NIRS from existing studies are true except

A. Goal directed optimization of cerebral oxygenation has proven benefit in cardiac surgery
B. NIRS may play a useful role in vasospasm detection after a subarachnoid hemorrhage
C. There is a correlation between cerebral tissue oxygenation and jugular bulb venous saturation in patients with traumatic brain injury
D. There is insufficient evidence for NIRS monitoring to reduce short term POCD after non-cardiac surgery.

Go to Q 5
A. Goal directed optimization of cerebral oxygenation has proven benefit in cardiac surgery

This statement is false. A recent systematic review and meta-analysis tested the hypothesis that goal-directed optimization of cerebral oxygenation during cardiac surgery results in reductions in cerebral injury (neurocognitive function and serum biomarkers), injury to other organs like heart and brain, transfusion rates, mortality. The results of this review did not support the hypothesis that NIRS based algorithms have clinical benefits in cardiac surgery.

Effects of cerebral near-infrared spectroscopy on the outcome of patients undergoing cardiac surgery: a systematic review of randomised trials. Serraino GF, Murphy GJ. BMJ Open. 2017 Sep 7;7(9) PMID: 28882917
B. NIRS may play a useful role in vasospasm detection after a subarachnoid hemorrhage.

This is true. Early detection of vasospasm is essential for the prevention of neurologic deficits in subarachnoid hemorrhage (SAH). A study compared time resolved NIRS (TR-NIRS) with transcranial doppler and demonstrated that it had high sensitivity to detect vasospasm (a). Another study demonstrated that NIRS may have a useful role in the detection of cerebral desaturation secondary to vasospasm in neuroendovascular procedures (b).


C. There is a correlation between cerebral tissue oxygenation and jugular bulb venous saturation in patients with traumatic brain injury

The above statement is true. A recent study utilized a monitor which uses NIRS coupled with ultrasound to measure regional cerebral tissue oxygenation in patients with severe traumatic brain injury (TBI) and compared this to invasive jugular venous bulb oxygen saturation which is invasive. They found that these two measurements correlate.

D. There is insufficient evidence for NIRS monitoring to reduce short term POCD after non-cardiac surgery.

A recent Cochrane data base review assessed the effects of peri-operative cerebral NIRS monitoring on the detection of cerebral desaturation events, neurologic and non-neurologic outcomes in the perioperative setting. Based on 6 studies with 962 participants, there was moderate quality evidence that cerebral oxygenation monitoring probably does not decrease the occurrence of POCD at one week after surgery. The results of ongoing studies are awaited to draw better conclusions.

5. Which of the following is true regarding trouble shooting an abnormal NIRS value

A. **Unilateral drop in NIRS in cardiac surgery should first be corrected by increasing MAP**
B. **Red cell transfusion can increase NIRS values in the face of ongoing blood loss.**
C. **Hyperthermia increases the NIRS values**
D. **Bilateral decrease in NIRS values warrants an decrease in mean arterial pressure**
A. Unilateral drop in NIRS in cardiac surgery should first be corrected by increasing MAP

This is false. When the value of rSO2 decrease, mechanical obstruction to cerebral blood flow should be ruled out first. Aortic cannula malposition in cardiac procedures should be sought. Usually this manifests as a unilateral decline in NIRS values.
B. Red cell transfusion can increase NIRS values in the face of ongoing blood loss.

Hemoglobin is a key element in oxygen transport. When there is ongoing blood loss a decrease in hemoglobin can be associated with drop in NIRS values. In this situation, RBC transfusion can help to increase cerebral oxygenation.

ALGORITHM TO TROUBLE SHOOT LOW NIRS
Decrease of NIRS by 20%

Verify head position
Check if bilateral or unilateral

MAP—if Low etiology?Rx
Systemic saturation
Check PaCO2 if Low correct
Hb—if Low correct
Cardiac function and SV02

Unilateral?
Cardiac surgery?—check SVC cannula
CEA—? shunting

High CMR02?
Antiepileptic medication
? hypothermia


Back to Q 5
Back to Q 1
C. Hyperthermia increases the NIRS values

Hyperthermia increases the CMRO2 and decreases rSO2 values. To decrease CMRO2, strategies like propofol/thiopental, hypothermia and anti epileptic medication in case of seizures should be kept in mind.
D. Bilateral decrease in NIRS values should prompt a decrease in mean arterial pressure

This is false. NIRS values decrease when mean arterial pressure is lowered particularly when auto regulation is impaired in patients with low cerebrovascular reserve. One of the most common interventions in the treatment of brain desaturation is to maintain the cerebral perfusion pressure by increasing the MAP and optimizing cardiac output.