Submission ID #: 61533
Scriptwriter Name: Anastasia Gomez
Project Page Link: https://www.jove.com/account/file-uploader?src=18767613

Title: How to Administer Near-Infrared Spectroscopy in Critically Ill Neonates, Infants, and Children

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Author Questionnaire

1. **Microscopy**: Does your protocol involve video microscopy, such as filming a complex dissection or microinjection technique? **No**

2. **Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **No**

3. **Filming location:** Will the filming need to take place in multiple locations? **No**

Current Protocol Length

Number of Steps: 15
Number of Shots: 23

Introduction

1. Introductory Interview Statements

REQUIRED:

1.1. **Frank Münch:** Near infrared spectroscopy helps to monitor regional tissue oxygenation of various organs during cardiopulmonary bypass, ECMO, or critical illness.

1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

1.2. **Nora Bruns:** The main advantage of NIRS is that it is non-invasive and the measurement takes place continuously.

1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

OPTIONAL:

1.3. **Hanna Müller:** Visual demonstration of this technique is critical to point out the correct handling and potential pitfalls of this method, especially for abdominal applications.

1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera.

Introduction of Demonstrator on Camera

1.4. **Hanna Müller:** Demonstrating the procedure will be Frank. He is a perfusionist in the Children's Hospital of the University of Erlangen.

1.4.1. INTERVIEW: Author saying the above.

1.4.2. The named demonstrator(s) looks up from workbench or desk or microscope and acknowledges the camera.

Ethics Title Card

1.5. Procedures involving human subjects are part of the clinical routine at the University Hospital Erlangen and need not be approved by the Institutional Review Board (IRB).

Protocol

2. Preparation and Probe Placement

2.1. Begin by turning on the NIRS device and connecting the preamplifiers **[1]**. Enter the patient's data **[2]** and select the proper probe according to the patient's weight and intended site of use **[3]**. Connect the probe to the preamplifier **[4]**.

2.1.1. Talent turning on the NIRS device and plugging in the preamplifiers.

2.1.2. Talent entering the patient's data.

2.1.3. Talent selecting the probe.

2.1.4. ADDED SHOT: Talent connecting the probe to the preamplifier.

2.2. Make sure that the patient's skin is clean and dry for optimum adhesion. Dry the skin with a swab if necessary, being very careful or omitting cleaning if the skin is vulnerable **[1]**.

2.2.1. Talent drying the skin with a swab.

2.3. After identifying the correct probe position, carefully bend the center of the probe toward the side of the white cover until it starts to come off, then gently peel off the cover without touching the probe's sticky surface **[1]**.

2.3.1. Talent peeling off the cover of the probe.

2.4. Place the sensor on the skin from the center of the probe to the sides, making sure that the edges of the probe are firmly connected to the skin. If the probe disconnects, wrong NIRS values will be obtained **[1]**. *Videographer: This step is important!*

2.4.1. Talent placing the probe on the skin.

2.5. To avoid skin lesions, do not place the probe on very immature or vulnerable skin. If the probe must be placed on vulnerable skin, use a layer of cellophane between the skin and the probe, or leave the cover on **[1]**.

2.5.1. Talent placing the probe onto the skin with the cover left on. Talent fixing the probe with cohesive bandage. NOTE: Filmed in the operating theatre, supplementary video material

3. Selecting the Probe Position

3.1. If the cerebral position is selected, place the NIRS probe in the supra-orbital region on the forehead below the hairline to obtain values from the frontal cortex. Do not place the probe above hair, the frontal sinus, the temporal muscle, nevi, the superior sagittal sinus, intracranial hemorrhages or other anomalies **[1]**. *Videographer: This step is important!*

3.1.1. Talent placing the NIRS probe in the supra-orbital region on the forehead.

3.2. Placement of two probes allows for selective analysis of both hemispheres if the clinical setting requires this. Neighboring probes emit and measure signals alternately to avoid interference **[1]**.

3.2.1. Talent placing a second probe on the forehead.

3.3. If placing the probe in a somatic position, select a position above the region of interest. Avoid fat deposits, hair, and bones. Do not place the probe above nevi, hematoma, and injured skin. Keep in mind that the depth of the NIRS signal is approximately 2.5 centimeters **[1]**.

3.3.1. Doll with markers for possible somatic probe positions.

3.4. To place the probe on the kidney, first locate the kidney via a dorsal sagittal sonogram **[1]**. Make sure that the skin-to-organ-distance does not exceed the maximum depth of the probe **[2]**. *Videographer: This step is difficult!*

3.4.1. Talent checking the kidney location with a sonogram.

3.4.2. Talent placing the probe on the kidney.

3.5. When placing the probe on the intestines, simply place it in the region of interest such as below the umbilicus or in the right or left lower quadrant **[1]**. For liver placement, place the probe exactly above the liver **[2]** and confirm its position by ultrasound, making sure that the liver tissue is at least as deep as the emitted light penetrates **[3]**.

3.5.1. Talent placing the probe on the intestines.

3.5.2. Talent placing the probe above the liver.

3.5.3. Talent identifying the probe location with an ultrasound. NOTE: Please move 3.5.3 before 3.5.2.

3.6. The probe can also be placed on the plantar portion of the foot. Measuring NIRS in the most distant part of the body gives information about peripheral perfusion during hypothermia, in patients with shock, or in any situation where pulse oximetry does not work, such as during cardiopulmonary bypass **[1]**.

3.6.1. Talent placing the probe on the foot.

3.7. Finally, the probe can be placed on a muscle of interest **[1]**.

3.7.1. Talent placing the probe on a muscle.

3.8. Set the baseline 1 to 2 minutes after placing the probe by pushing the corresponding button on the device, which reflects the starting point of the measurement **[1]**. The evolution of tissue perfusion in each monitored area can be observed and interpreted individually by relying on the change from the baseline value **[2]**. *Videographer: This step is important!*

3.8.1. Talent pushing the button to set the baseline.

3.8.2. Baseline displayed on a monitor.

3.9. If the device indicates bad recording quality or the values are implausible, confirm that all previous steps have been taken correctly **[1]**. Check all electrical plug contacts and the preamplifier. If necessary, replace the probe **[2]**. If external light sources are affecting the sensor and they cannot be eliminated, cover the probe **[3]**.
Videographer: This step is important!

3.9.1. Bad recording or implausible value displayed.

3.9.2. Talent checking the wire connections of the probes and the preamplifiers.

3.9.3. Talent covering the probe.

3.10. After ruling out technical problems, check the patient for clinical complications and adjust the treatment to optimize the following parameters **[1]**.

3.10.1. *Video Editor: Show a list of what to check the patient for with the following text in list format.* **TEXT: Check the patient for: ; Arterial blood pressure ; Systemic oxygenation ; pH ; Hemoglobin ; Cerebral blood return (superior vena cava syndrome)* : *in the event of cardiopulmonary bypass**

Results

4. Results: NIRS Monitoring of Tissue Oxygenation

4.1. The measured regional tissue oxygenation value results from the ratio between oxygen supply and consumption. Metabolic characteristics lead to slightly different normal values depending on age and organ **[1]**. Except for the brain, scientifically evaluated reference values exist only for preterm infants and newborns **[2]**.

4.1.1. LAB MEDIA: Table 2.

4.1.2. LAB MEDIA: Table 2. *Video Editor: Emphasize the "Not defined" values in column 3.*

4.2. If the oxygen supply and demand are balanced at physiological values, tissue oxygenation is within normal range. Changes in either cause the regional tissue oxygenation value to fall or rise **[1]**. A typical curve revealing normal cerebral and renal near-infrared spectroscopy, or NIRS, values is displayed here **[2]**.

4.2.1. LAB MEDIA: Figure 2.

4.2.2. LAB MEDIA: Figure 2. *Video Editor: Emphasize the area from the beginning of the plot until 14:25.*

4.3. Clamping the descending aorta causes cerebral perfusion and the corresponding regional tissue oxygenation to rise **[1]**. Another cause of increased cerebral blood flow and elevated cerebral regional tissue oxygenation is hyperdynamic shock in conjunction with high cardiac output **[2]**.

4.3.1. LAB MEDIA: Figure 2.

4.3.2. LAB MEDIA: Figure 3.

4.4. When using two cerebral NIRS probes, values from the right and left sides should be similar **[1]**. Dissonance between the right and left channel can be caused by the sensor's incomplete adhesion or indicate a complication **[2]**.

4.4.1. LAB MEDIA: Figure 4.

4.4.2. LAB MEDIA: Figure 4. *Video Editor: Emphasize where the red star is pointing.*

4.5. During some heart surgeries, the brain is perfused selectively via one carotid artery, making use of intracerebral collaterals to supply the opposite side. Throughout this procedure, dissonance between the two cerebral NIRS channels can help diagnose a dysfunctional circle of Willis **[1]**.

4.5.1. LAB MEDIA: Figure 5.

4.6. NIRS can also help discover a dislocated vena cava superior cannula during cardiopulmonary bypass leading to venous stasis and lowered cerebral oxygen supply **[1]**.

4.6.1. LAB MEDIA: Figure 6.

Conclusion

5. Conclusion Interview Statements

5.1. **Nora Bruns:** The most important thing when administering NIRS to an infant or child is to choose the appropriate position for the probe and place it thoroughly.

5.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera. *Suggested B-roll: 2.4.1.*