[PR1-107] Detection of pain in children by a bedside device: funtional near infrared spectroscopy (fNIRS)

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INTRODUCTION

At present there are no objective tools to measure pain in children. A device to monitor pain may improve its diagnosis and therapy. Functional MRI (fMRI) has been used to map brain regions associated with painful stimulation. fMRI reveals the frontal cortex as essential to the emotional elaboration of pain (1). fNIRS is a non-invasive, bedside technology that relies on the transparency of biological tissues to near infrared light (700-900 nm) where oxy- and deoxy-hemoglobin (HbO2, Hb) display distinct absorption spectra(2). It can also generate images of the cortex using an optical probe. We conducted a study to investigate the ability of fNIRS to detect and image painful stimulation from the frontal cortex in anesthetized children.

METHODS

After IRB approval, we enrolled 12 patients (12-18 y/o) admitted for idiopathic scoliosis surgery in which the electrical current of the neuromonitoring (NM) served as the painful stimulus. The fNIRS (BioPac Inc) probe, placed on the patient’s forehead, contained 4 LED (760, 805, 830 nm) and 4 detectors in a matrix construct, activated in various combinations to generate an image. The protocol followed 3 phases during steady state propofol anesthesia. Phase 1: after NM needle insertion, baseline fNIRS was obtained. Phase 2 had low and high stimulation sequences. Low stim: ulnar nerve was stimulated (10-15 mAmps) for 15 sec with 30 sec recovery. Next, High Stim: ulnar nerve stimulation was increased (25-30 mAmps) for 15 sec with 30 sec recovery. Phase 3: 2 min after fentanyl 2 µg/Kg IV, low stim sequence was performed. Changes in frontal cortex HbO2, Hb and HbT (HbO2 + Hb) from baseline for low stim, high stim, and low stim + fentanyl were analyzed by paired t-tests.

RESULTS

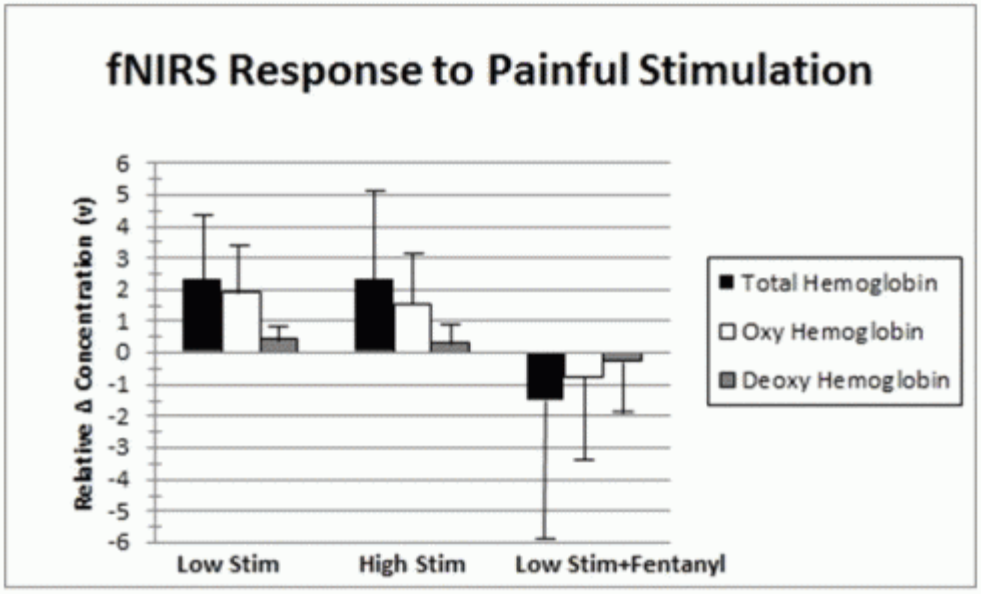
Of 12 patients, 4 did not complete the protocol (equipment fail 3, protocol violation 1). In all 8 patients completing the protocol, HbO2, Hb and HbT increased significantly after low and high stimulation (fig. 1). The increase in HbO2 and HbT was significantly greater than Hb. There was no difference in HbO2, Hb, or HbT between low and high stimulation. HbO2, Hb, and HbT did not increase with stimulation after fentanyl. The frontal cortex increase in HbO2, Hb, and HbT occurred ipsilateral to the painfully stimulated ulnar nerve (fig. 2).

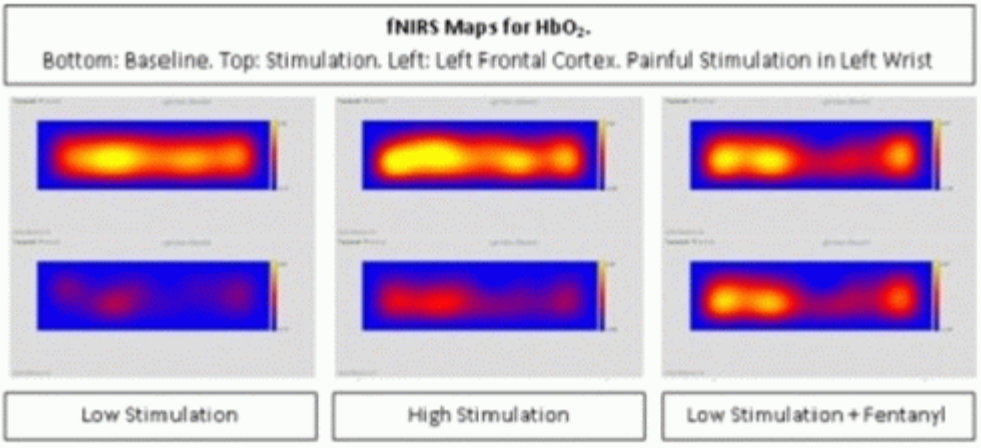
CONCLUSION

We observed that electrically induced ulnar painful stimuli increased HbO2, Hb, and HbT in the ipsilateral frontal cortex by fNIRS. These observations correspond to increased cerebral blood volume and oxygenation by fMRI bold signal to pain in adults. That fNIRS is monitoring pain is suggested by the increase being blocked by fentanyl and the increase occurring ipsilateral to the pain; non-pain somatosensory activation is contralateral. As a relatively inexpensive bedside device, fNIRS might be developed into a monitor of pain in children.

(1) Wiech K. J Neurosci 2006, 26(44), 11501-509

(2) Lu C. J Neurosci Methods 2010, 186, 242-249


fNIRS Response to Painful Stimulation
Relative Δ Concentration (v)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
Low Stim
High Stim
Low Stim+Fentanyl
Total Hemoglobin
Oxy Hemoglobin
Deoxy Hemoglobin


fNIRS Maps for HbO_2.
Bottom: Baseline. Top: Stimulation. Left: Left Frontal Cortex. Painful Stimulation in Left Wrist
Low Stimulation
High Stimulation
Low Stimulation + Fentanyl