COMPARISON OF NEAR INFRARED SPECTROSCOPY VALUES BETWEEN COMPARTMENTS OF THE LOWER EXTREMITIES

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Abstract

BACKGROUND: Lack of reliable objective diagnostic tools for acute compartment syndrome (ACS) has led to liberal use of prophylactic fasciotomies in casualty care. Near infrared spectroscopy (NIRS) noninvasively measures muscle oxygenation and may be useful in diagnosing ACS. We compared NIRS of uninjured subjects using two commercially available devices.

METHODS: NIRS of the anterior (A), lateral (L), deep (D) and superficial (S) posterior compartments of lower extremities of 19 uninjured subjects using the Equanox Regional Oximeter (Nonin, Plymouth, MN) were compared to 19 subjects using the INVOS Cerebral Oximeter (Somanetics, Troy, MI). The relationship between each compartment of contralateral legs was assessed using Pearson correlations. Repeated measures ANOVA was used to test equality of means between compartments of the same leg.

RESULTS: NIRS values of each compartment were well-correlated between legs in both devices (Equanox: r=0.75, 0.78, 0.81, 0.67; INVOS: r=0.83, 0.84, 0.80, 0.76 (A, L, D, S)). When comparing mean NIRS between compartments of the same leg, no significant differences were observed among subjects measured with the Equanox oximeter (Mean [SD]: A=71.0[7.7], L=71.4[6.0] , D=70.9[8.3], S=71.9[7.8]; p=0.93), however mean NIRS values of at least one compartment differed significantly in subjects measured with the INVOS (A=74.7[9.0], L=75.9[9.8], D=84.2[9.7], S=81.2[10.4]; p<0.0001). Tests for device-compartment interaction revealed that differences in mean NIRS values across compartments were dependent on device used (p=0.006).

CONCLUSION: Correlations between compartments of each leg suggests that the contralateral leg may be a valid internal control. This has important implications for monitoring patients with lower extremity injuries. Similarities between compartments of the same leg with Equanox suggests that one compartment of the uninjured leg as a control for all compartments of the injured leg may be possible with the Nonin device only.

Objectives

This study sought to compare NIRS values produced from two commercially-available NIRS devices.

Research Questions:

- Are NIRS values from corresponding compartments of contralateral lower extremities correlated?
- Do mean NIRS values collected from the anterior (A), lateral (L), deep (D) and superficial posterior (S) compartments within the lower extremity differ significantly *from each other*?
- Are these between-compartment differences observed *across devices*?

Methods

- NIRS values were collected from 19 uninjured volunteer participants using the Equanox Regional Oximeter (Nonin Medical, Plymouth, MN). Participants were enrolled from a pool of employees and volunteers at a local medical practice in Athens, Georgia.
- Data were compared to NIRS values collected on 19 uninjured volunteer participants using the INVOS Cerebral Oximeter (Somanetics, Troy, MI). Participants included ambulatory self-care patients who presented to the Landstuhl Regional Medical Center Neurosurgery Clinic (Landstuhl, Germany).
- NIRS sensors were placed over the mid-diaphyseal region of the anterior (A), lateral (L), deep posterior (D), and superficial posterior (SP) compartments of each lower extremity. The anterior compartment was accessed by placing the pad lateral to the anterior tibial ridge. The lateral compartment was measured over the anterior aspect of the fibula on the lateral aspect of the leg. The superficial posterior compartment measurement was made by placing the pad on the posterior aspect of the leg. The deep posterior compartment was measured by placing the sensor just posterior to the medial aspect of the tibia over the flexor digitorum longus. The medial aspect of the tibia was palpated until the posterior border was identified, and the pad was placed so that the light would be directed just posterior to the tibia. By placing the sensor at this point, it is possible to obtain a deep posterior measurement, while limiting the potential interference from the superficial posterior compartment.
- A single representative NIRS value was chosen for each compartment of each lower extremity for statistical comparisons. These summary NIRS values were calculating as the average of NIRS values collected over five minutes of monitoring, once sensors for all compartments were applied and successfully recording data.

Statistical Analyses:

- Pearson correlation coefficients were used to describe the relationship between corresponding compartments of contralateral lower extremities.
- Differences in mean NIRS values between each compartment of the same lower extremity was tested using repeated measures analysis of variance (ANOVA) model for each device (H_0: A=L=S=D). A model testing for device-compartment interaction term was used to test whether between-compartment differences were dependent on the device used.

Results

- NIRS values of each compartment were well-correlated with the corresponding compartment of the contralateral leg (Equanox: r=0.75, 0.78, 0.81, 0.67; INVOS: r=0.83, 0.84, 0.80, 0.76 for the A, L, D, and S compartments, respectively; Figures 1 & 2).
- Mean NIRS values collected from each compartment of the lower extremity did not differ significantly from each other among participants who were tested using the Equanox oximeter (Mean [SD]: A=71.0[7.7], L=71.4[6.0], D=70.9[8.3], S=71.9[7.8]; p=0.93; Table 1).
- Conversely, mean NIRS values of at least one compartment were significantly different among participants collected using the INVOS oximeter (A=74.7[9.0], L=75.9[9.8], D=84.2[9.7], S=81.2[10.4]; p<0.0001; Table 1).
- A model testing for device-compartment interaction, revealed that mean differences in NIRS values between compartments of a single leg were dependent on the device used (p=0.006; Table 1)

Figure 1. Scatterplots showing the relationship between near infrared spectroscopy (NIRS) values of each compartment of contralateral legs, among 19 uninjured subjects measured with the Equanox oximeter.

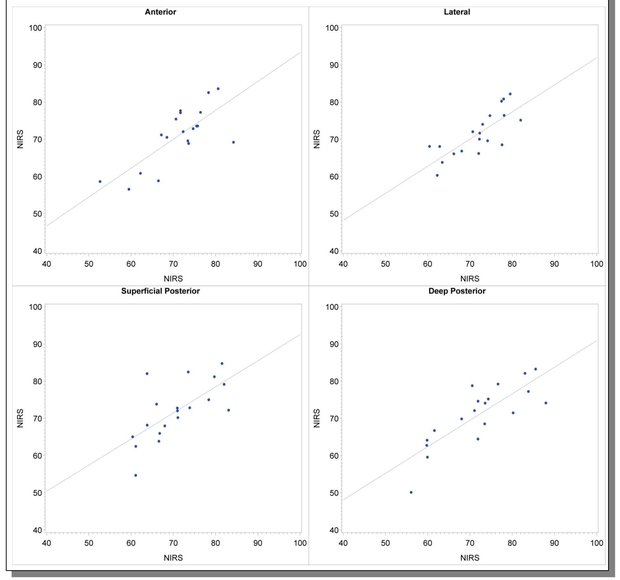

Figure 2. Scatterplots showing the relationship between near infrared spectroscopy (NIRS) values of each compartment of contralateral legs, among 19 uninjured subjects measured with INVOS oximeter

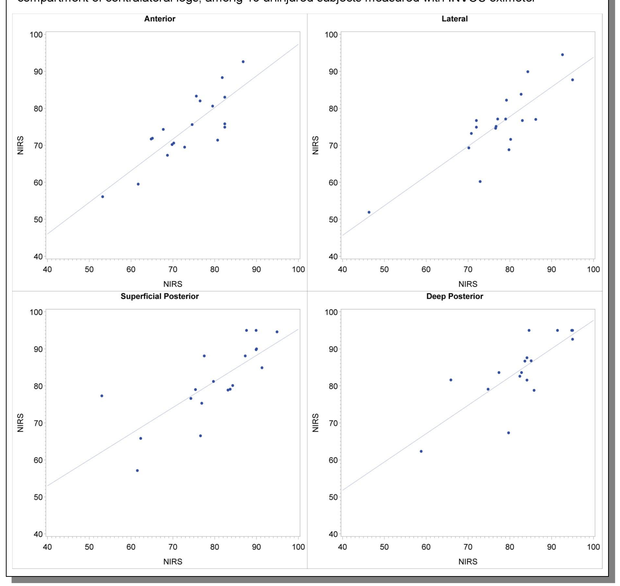

Table 1. Comparison of mean near infrared spectroscopy (NIRS) values of each compartment of the lower extremity, among 38 uninjured subjects using the Equanox and INVOS oximeters

	Equanox (n=19)	INVOS (n=19)
Compartment	Mean (SD)	Mean (SD)
Anterior	71.0 (7.7)	74.7 (9.0)
Lateral	71.4 (6.0)	75.9 (9.8)
Deep Posterior	70.9 (8.3)	84.2 (9.7)
Superficial Posterior	71.9 (7.8)	81.2 (10.4)
p-value*	0.93	< 0.0001
	p for interaction** = 0.006	

Abbreviations: SD, standard deviation

*p-value for repeated measures analysis of variance (ANOVA), testing equality of means across compartments within the leg

**p-value for device-compartment interaction using repeated measures ANOVA

Conclusions

NIRS values collected with both devices demonstrated high correlations between corresponding compartments of contralateral legs (Figures 1 & 2), indicating that the these compartments may serve as a useful internal control for their respective contralateral compartments. This corroborates previous findings using the INVOS device and provides support for the utility of these control compartments among subjects monitored with the Equanox device. Furthermore, a repeated measures ANOVA model testing equality of mean NIRS values between compartments of the same leg found that values collected with the INVOS oximeter were *not* equal across the anterior, lateral, deep and superficial posterior compartments within the same leg (p<0.0001), whereas values collected with the Equanox oximeter did not differ significantly across compartments (p=0.93; Table 1). Tests for interaction indicated that the differences observed between compartments was dependent on the device used (p=0.006; Table 1). This suggests that, among unilaterally injured patients, it may be possible to use a single compartment of the contralateral lower extremity as an internal control when using the Equanox oximeter, which would not be possible using the INVOS oximeter.

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