Relative Tissue Oxygenation Changes are More Reliable than Clinical Exam or Temperature Changes for Detecting Early Tissue Ischemia

Elizabeth M. Polfer MD, Jennifer M. Sabino MD, Isaac C. Fleming CCRC,
Kenneth R. Means Jr. MD

The Curtis National Hand Center

Introduction

The clinical effect of not recognizing ischemia in post-traumatic and post-operative free flap tissue can be devastating. In a prior study, it was demonstrated that increased skin pigmentation results in a significant difference in the ability for board certified plastic and orthopaedic hand surgeons to clinically assess an ischemic limb with a physical exam alone (92.9% for Caucasians versus 23.3% for African Americans). Given the aforementioned difficulty with clinical exam on patients with increased skin pigmentation, we chose to compare two non-invasive methods to determine if they are able to detect compromise regardless of skin pigmentation. We hypothesized that there are non-invasive adjuvants to physical exam to better assess ischemia regardless of skin pigmentation.

Methods

A prospective study of healthy controls exposed to limb ischemia was conducted to determine if adjuvants to physical exam are reliable methods to determine ischemia regardless of skin pigmentation. The subjects were classified based on skin pigmentation using a defined skin type assessment tool(Fitzpatrick Scale), a visual color scale(Von Luschan), and self-description of race. Ischemia was induced by tourniquet insufflation to 250mmHg. A surface temperature probe and a near-infrared spectroscopy(NIRS) monitor were placed on the skin in the PIA skin territory. The readings from both monitors were taken at baseline and every 15 seconds thereafter until 10 minutes.

ID	Fitzpatrick Score	Von Luschan	Race	Starting O2	Ending O2	Change	Starting Temp	Ending Temp	Change in Temp
1	3	12	C	85	67	18	31.5	31.0	-0.5
2	4	15	C	81	56	25	32	32	0
3	3	16	C	72	49	23	31.5	31.5	0
4	4	24	H	76	56	20	32.2	32.2	0
5	4	24	H	75	61	14	32	32.5	+0.5
6	4	27	AA	66	48	18	32	32	0
7	4	29	AA	76	51	25	31.5	31.5	0
8	4	29	AA	81	65	16	31.5	31.0	-0.5
9	5	29	AA	78	62	16	33	33	0

Table 1: Results; C – Caucasian, H – Hispanic, AA – African American

Results

We enrolled 9 subjects, 2 Hispanics, 3 Caucasians, and 4 African-Americans. We found a consistently reliable decrease in the tissue oxygenation using NIRS in all patients regardless of skin pigmentation. On average, there was a decrease of 19.4% in tissue oxygenation(range 14%-25%) using NIRS with the starting oxygenation at 76.6%(range 66%-85%) and ending oxygenation at 57.2%(range 48%-67%). There was no such decrease in the temperature readings. There was no significant difference in the change in NIRS tissue oxygenation or temperature between patients when patients were grouped into Fitzpatrick less than and equal to or greater than 3 or less than and equal to or greater than Fitzpatrick 4($p>0.05$). There was also no significant difference seen in patients with Von Luschan scores less than and equal to or greater than 20($p>0.05$).

Conclusions

It has been demonstrated that clinical exam is not sufficient in detecting tissue ischemia in patients with increased skin pigmentation. Our study suggests that near-infrared spectroscopy should be strongly considered in patients with increased skin pigmentation when evaluating tissue for ischemia as a non-invasive method of monitoring.

*This study was funded by the Raymond M. Curtis Research Foundation, The Curtis National Hand Center, Baltimore, MD.
*The views expressed in this presentation are those of the author(s) and do not reflect the official policy of the Department of the Army, Department of Defense, or U.S. Government