

Near Infrared Spectroscopy: a technique for non-invasive assessment of perfusion in the lower extremity: to Stratify Severity of Peripheral Arterial Disease

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INTRODUCTION

Peripheral arterial disease (PAD) and its severe form, chronic limb-threatening ischemia, are associated with high morbidity and limb loss. While validated for screening and diagnosis, current diagnostic tools such as ankle-brachial index (ABI), duplex ultrasound, Computed Tomographic Angiography (CTA) and transcutaneous partial pressure of oxygen measurement provide limited insight into microvascular perfusion and fail to predict wound healing reliably. Near-infrared spectroscopy (NIRS) offers a non-invasive approach to assess tissue oxygenation, and may improve diagnosis and prognostication in PAD.

METHODS

This is a prospective observational study using NIRS imaging (SnapshotNIR, Kent Imaging Inc., Calgary, Canada) to evaluate perfusion in patients with PAD of varying severity. Thirty subjects were enrolled with three exclusions due to poor image quality and lack of correlative ABI data, 28 patients were analyzed in groups: 10 asymptomatic (normal ABI), 9 with intermittent claudication (ABI 0.50–0.85), and 9 with ischemia (ABI ≤ 0.49). Plantar and dorsal foot images were captured and four NIRS-derived parameters were generated from consistent regions in each patient; oxyhemoglobin (HbO), deoxyhemoglobin (Hb), total hemoglobin (HbTot), and tissue oxygen saturation (StO₂).

Multivariate analysis of variance (MANOVA) tested global group differences, followed by univariate ANOVA and post-hoc comparisons. All statistical analyses were performed using SPSS software.

RESULTS

MANOVA revealed significant multivariate differences across the groups of varying PAD severity (Wilk's Lambda = 0.089, $p = 0.015$). Univariate analyses showed that plantar sites, particularly the great toe, and between the first–second digits, exhibited significant differences between groups for all four NIRS parameters. The ischemic group demonstrated markedly lower HbO, HbTot, and StO₂, and higher Hb compared to other groups. Dorsal surface measurements were largely non-discriminatory.

Figure 1: Estimated Marginal Means of NIRS Parameters for the Plantar surface of the Great Toe with 95% Confidence Interval

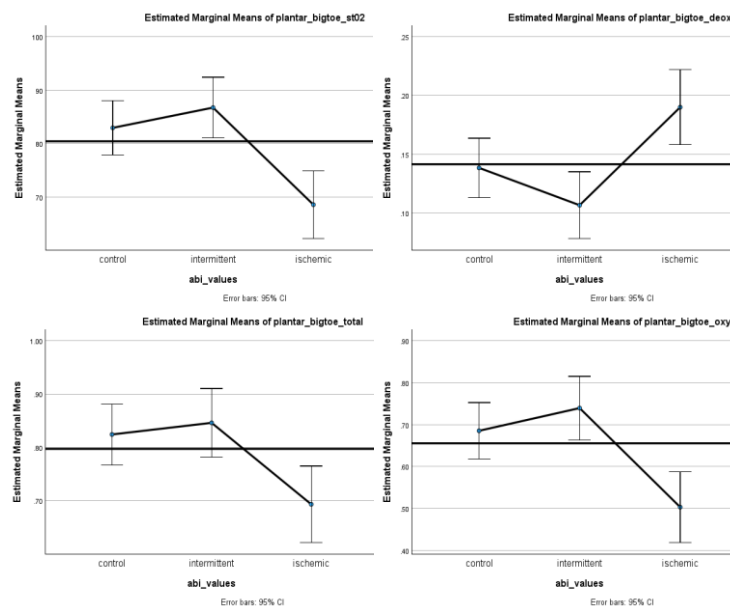
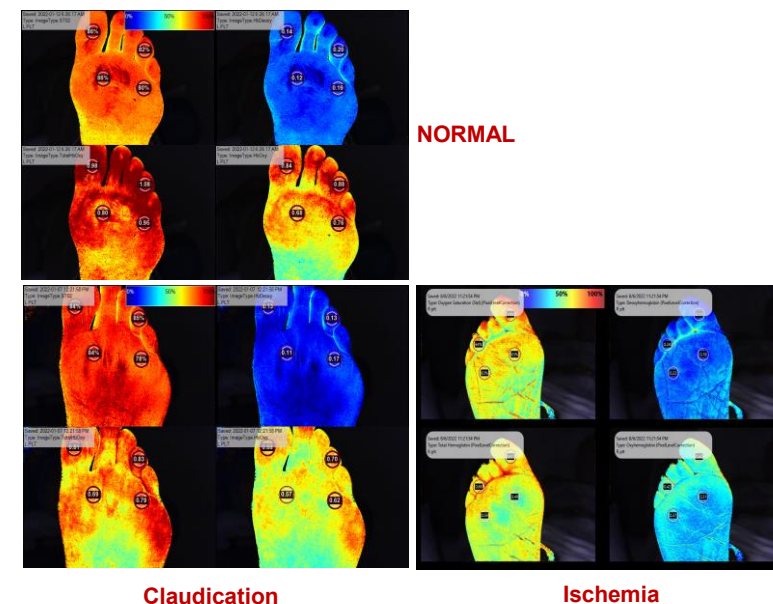


Figure 2: Sample NIRS images for study groups



CONCLUSION

Near-infrared hyperspectral imaging (NIRS) was able to differentiate normal patients and claudicants from those with ischemia by perfusion status of the foot. Claudication was not statistically different from normal subjects with respect to NIRS parameters. Plantar surface measurements were more significant than those of the dorsal surface. Near-infrared light may have advantages as compared to other wavelengths for spectral imaging of perfusion. In conclusion, near-infrared hyperspectral imaging shows promise as a rapid, non-invasive tool for stratifying PAD severity. Future trials will be important to further define methodology and investigate the ability to predict wound healing.