Peripheral Arterial Disease Detection Beyond ABIs: Utilizing Near-Infrared Spectroscopy for Non-Invasive Assessment

Laura Swoboda, DNP, APNP, FNP-C, FNP-BC, CWOCN-AP, WOCNF ; Carthage College- Kenosha, WI; Skin Gurus- Milwaukee, WI

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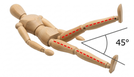
Track: Clinical Research



Purpose: This study aims to elucidate the use of NIRS and thermography for PAD detection and stratification

Introduction: Diagnosing Peripheral Arterial Disease (PAD) is foundational to complex wound management & amputation optimization, yet the often-used Ankle-Brachial Index (ABI) is frequently unreliable due to medial arterial calcification in high-risk populations, leading to unreliable, falsely elevated, or indeterminate results.. Alternative non invasive tests, such as Toe-Brachial Index (TBI) and Transcutaneous Oxygen Monitoring ($TcPO_2$), provide valuable functional data but are often limited by procedural complexity, cost, or time requirements. Near-Infrared Spectroscopy (NIRS) offers a non-contact, rapid method to estimate tissue oxygen saturation StO_2, providing spatially resolved functional measure of perfusion data. This study evaluated the utility of the NIRS + thermography as a complementary tool for detecting compromised circulation indicative of PAD, particularly in cases where ABI results are unreliable or difficult to obtain.

Methods: A scoping review was conducted to identify clinical studies and reviews comparing the diagnostic utility of NIRS for PAD detection and stratification. The review focused on studies evaluating high-risk populations (e.g. diabetes, renal failure) where ABI is often non-diagnostic and utilizing StO_2 to evaluate circulatory reserve. A small, prospective cohort of limbs with indeterminate or high ABIs (>1.3) underwent assessment using NIRS with the MIMOSA Pro (Toronto, CAN), a non-contact device that captured spatial StO_2 heatmaps using visible and NIR LED wavelengths & ABI with the MESI ABPI (Ljubljana, Slovenia) to evaluate the screening potential.

Proposed PAD Screening with NIRS

1. Asymptomatic screening

&

2. Screening in wound patients

(wound as s symptom of PAD until ruled out)

Why Screening for PAD with NIRS

1. Disease identification
2. Referral to treatment
3. Risk stratification for treatment (wounds)
4. Informs expected response profile (wounds)

Key findings:

Provocative maneuver:

45° leg elevation for 60 seconds

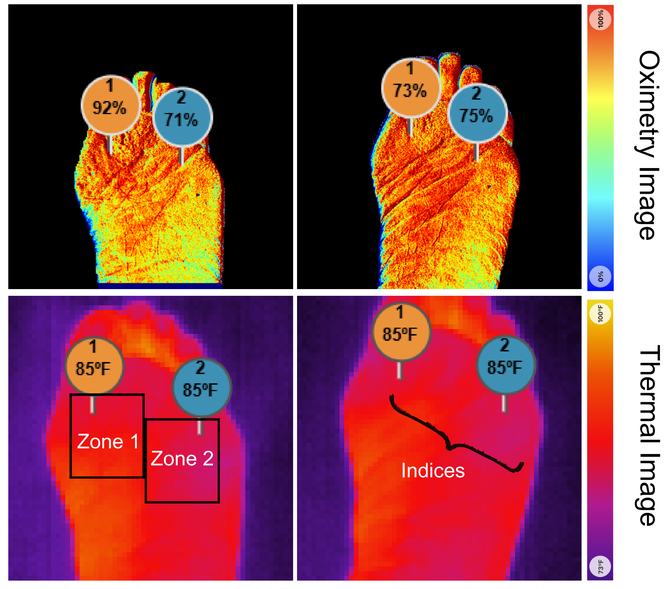
Better Correlation with ABI

Measures the ΔStO_2

Table 1. Considerations for use of NIRS+ in the field

Benefits	Limitations & Considerations
Clinical Utility: Non-invasive, non-contact (reduces contamination), and rapid (<10 mins).	**Hardware**: Limited battery life; cannot image while charging; requires USB-C for charging.
Versatility: Suitable for bedside, facility, or remote home monitoring.	**Connectivity**: Requires stable Wi-Fi for image uploads; must sync prior to field use.
Diagnostic Edge: Unimpacted by calcified vessels where ABI fails; better perfusion detail than thermography.	**Technical**: Lower visual resolution than standard photography; Limitations in collecting/storing other visual light images (e.g. dressings, calluses).
Prevention: Enables bilateral monitoring to prevent new ulcers/PIs.	**Environment**: Requires specific lighting and dry skin (free of creams/oils) for accuracy.
Wireless: Fully portable for point-of-care use.	**Access**: High cost (>15,000 USD); not yet a universal standard for PAD screening.

Improved Accuracy: The technology is designed to work across different skin tones. Limitations across heavily melanated skin continue; however, plantar foot surfaces express ~80-90% less melanin.



Images (above) demonstrating PAD screening location and technique.
Images A and B: multispectral imaging demonstrating dual zone random readings between the 1st and 5th plantar metatarsal phalangeal joints (MTPJ)
Image C: demonstrates dual zone random readings between MTPJs
Image D: an alternative practical index postulated comparing the plantar metatarsal phalangeal spaces in a grouping.

These average readings across the MTPJ space are then compared to an alternative (eg. same space after a provocative maneuver or similar space on the ipsilateral palm).

Results:

The review revealed NIRS-derived metrics (particularly StO_2 recovery time) demonstrated strong correlation with both TBI and StO_2 values in detecting PAD. Studies noted NIRS advantages included non-contact application, speed (minutes vs. up to 90 minutes for $TcPO_2$), and portability. The NIRS heatmaps clearly delineated areas of compromised perfusion that corresponded to known ulceration sites, providing spatially registered functional evidence of ischemia where ABI failed. NIRS has the potential to further visualize ischemic conditions and deterioration of skin and underlying tissue before visible and tactile manifestation of damage. However, evidence supporting NIRS as a sole replacement for established methods remains insufficient, often requiring a provocative maneuver. See **Table 1** for additional considerations including stratification of limitations and benefits.

Discussion: StO_2, especially the delta with provocation, provides a valuable, non-invasive functional assessment of microcirculation, offering similar diagnostic insight with significant practical advantages in terms of speed and contact requirements. Its ability to identify functional compromise in limbs with non-compressible arteries makes it an essential complementary tool for PAD screening in the field. Future directions should focus on establishing standardized protocols and specific StO_2 cut-off values for integration into routine clinical practice, potentially leveraging its speed and portability for broader community screening initiatives in combination with other key PAD risk factors.

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