Understanding Microvascular Health in Diabetes

Emerging technologies support better outcomes.

BY WINDY COLE, DPM

Introduction

Diabetes is a chronic condition affecting millions of individuals worldwide, posing numerous health challenges, particularly in relation to vascular health.[1] One of the most alarming aspects of diabetes is the increased risk of lower extremity amputations due to impaired circulation and nerve damage. Additionally, uncontrolled diabetes can lead to other serious issues, including peripheral artery disease and ulcers.[2]

Recognizing and prioritizing vascular health in diabetic patients is crucial for the prevention of serious complications. Conducting regular assessments of lower extremity vascular health not only allows for early identification of potential issues but also ensures timely and effective interventions. Additionally, maintaining vascular integrity greatly enhances patient management, significantly improving clinical outcomes and the overall quality of life for individuals with diabetes.[3] This article will delve into exciting emerging technologies that can support clinicians in their assessment of vascular health in diabetic patients. Our goal is to raise awareness and advocate proactive measures so that healthcare providers can profoundly impact on the lives of those living with diabetes.

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The Vascular Risk in Diabetes

Diabetes mellitus is associated with a myriad of complications, including peripheral artery disease (PAD), which can lead to severe outcomes such as ulcers, infections, and ultimately amputations.[4] Studies have shown that assessing the vascular health of patients can help mitigate some of these risks.[5] Throughout the last decade, clinicians and researchers have gained a better understanding of the pathophysiologic processes leading to the impairment of microcirculation in the diabetic foot.[6]

Historically, poor microcirculation seen in the diabetic foot has been blamed on the calcifications of the small vessel. More recently, endothelial dysfunction, along with derangements in numerous biochemical pathways, has been implicated as the primary causes of microcirculation impairment.[7] Additionally, reduction or absence of the nerve-axon reflex renders the neuropathic diabetic foot functionally ischemic and leads to the inability of the autonomic nervous system to mount a vasodilatory response under conditions of stress, such as injury or infection, thus making the diabetic foot functionally ischemic even in the presence of satisfactory blood flow under normal conditions.[8] Furthermore, these changes appear to be directly related to the presence and severity of diabetic neuropathy.[9] Alterations in diabetic microcirculation may precipitate the formation of diabetic foot ulcers and lead to poor wound healing commonly observed in diabetes.[10]

Near-infrared spectroscopy (NIRS) is a validated technology that has been successfully used to evaluate functional tissue oxygen saturation in the management of diabetic foot ulceration.[11] One such commercially available NIRS device is the SnapshotNIR (Kent Imaging, Calgary, AB, Canada). The non-contact SnapshotNIR is hand-held, mobile, and offers repeatable immediate images that can be used to determine site-specific quantifiable levels of tissue oxygenation. This diagnostic tool utilizes differing optical signals based on the proportion of oxygenated hemoglobin found within the tissue capillary bed.[12] The

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New Concepts and Studies

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images obtained allow clinicians to get a better idea of microcirculation and functional blood flow to the wound as well as the surrounding tissues.

Exploring Microcirculation: A Study Overview

To further investigate the complexities of microcirculation in diabetic patients, a recent study utilized NIRS to compare microcirculatory responses in two groups: those with diabetes and diabetic neuropathy and those without diabetes. The primary goal was to demonstrate the impaired microcirculatory stress response in the diabetic neuropathic foot. In a controlled environment, researchers exposed both groups to various stresses, such as heat, cold, and elevation, while capturing NIRS images. The study aimed to uncover significant physiological differences between the two cohorts, ultimately validating NIRS as a reliable tool for clinical assessments.

Methods

This Institutional Review Board (IRB) approved a study aimed to assess the microcirculatory stress response in diabetic and non-diabetic feet utilizing near-infrared imaging. The primary objective was to determine whether the microcirculatory stress response is compromised in diabetic neuropathic feet. The secondary objective was to evaluate the clinical utility of NIRS, specifically the SnapShotNIR system from Kent Imaging, to identify changes within the microcirculatory system of the foot.

The participant cohorts comprised individuals diagnosed with diabetes and confirmed diabetic peripheral neuropathy (DPN) as well as individuals without diabetes. Patients with diabetes completed a two-page Michigan Neuropathy Screening Instrument (MNSI) and underwent the Semmes-Weinstein Monofilament test to validate the presence of DPN.

Each group included 10 participants, and following a comprehensive informed consent process, each individual was screened according to the study's inclusion and exclusion criteria. A total of 22 subjects were screened for eligibility; however, two subjects were excluded due to Ankle-Brachial Index (ABI) readings that fell outside the defined inclusion criteria, categorizing them as screen failures.

Subsequent to the screening process, demographic data were collected from the remaining participants, en-

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NIRS Images Examples of a Patient without Diabetes and DPN (Figures 1-5)

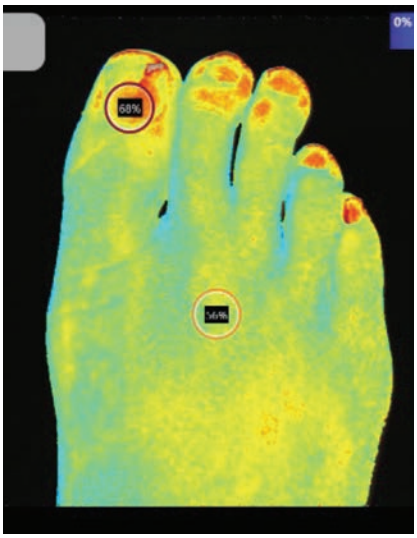

Figure 1: Non-Diabetic Patient Baseline

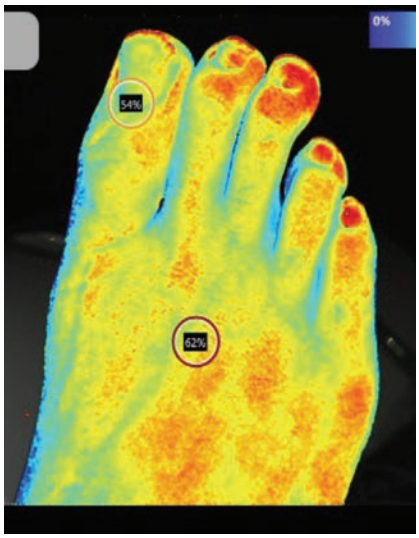

Figure 2: Non-Diabetic Patient After Elevation

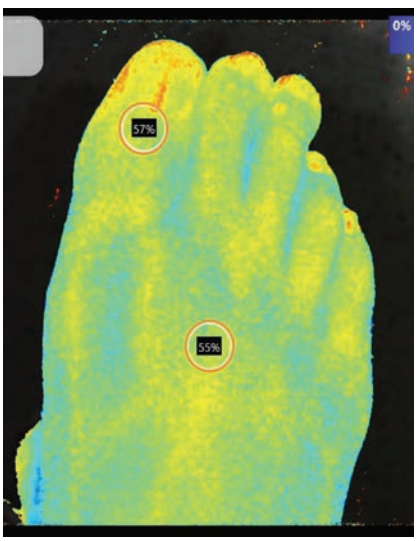

Figure 3: Non-Diabetic Patient After Dependency

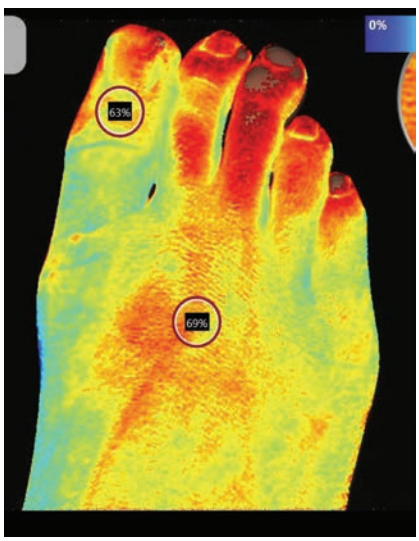

Figure 4: Non-Diabetic After Heat

Figure 5: Non-Diabetic After Cold

compassing age, gender, race, ethnicity, tobacco use, Fitzpatrick Skin Type Score, and pertinent medical history. Baseline NIRS images were obtained from both the dorsum and plantar regions of the right foot while participants were in a supine position, prior to the application of the intended stressors. To ensure consistency throughout the study, researchers designated the right foot as the index limb for all participants, thereby standardizing measurements and facilitating accurate comparisons across the subjects involved.

Testing (Figures 1-10)

Participants had their right foot subjected to various stresses (heat, cold, elevation, and dependency) for 5 minutes in a controlled setting. After each test, NIRS imaging was performed on the top and bottom of the foot.

Limb Elevation: A team member raised the leg to a 45-degree angle, supporting the limb gently with a slightly bent knee. This position was held for 5 minutes, during which up to 4 NIRS images were captured.

Interestingly, the data revealed that changes in foot positioning may impact tissue oxygenation significantly.

Limb Dependency: The leg was allowed to hang freely over the edge of the treatment chair, creating a 90-degree angle at the knee. This position was maintained for 5 minutes, with up to 4 NIRS images taken.

Heat: An electric heating pad (on high) was wrapped around the foot for 5 minutes, and up to 4 NIRS images were recorded afterward.

Cold: A cold therapy compress was wrapped around the foot for 5 minutes, followed by taking up to 4 NIRS images.

The Significance of Study Findings

The findings from this study are illuminating (Figure 11). They demonstrate that elevation leads to a notably decreased oxygenation in the plantar region of the foot in individuals with DPN compared to non-diabetics. This decline in tissue oxygenation can reflect underlying vascular impairments, emphasizing the importance of continuous monitoring and assessment strategies in diabetic patients. Although the study did not yield statistically significant results to distinguish between

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NIRS Image Examples of a Patient with Diabetes and DPN (Figures 6-10)

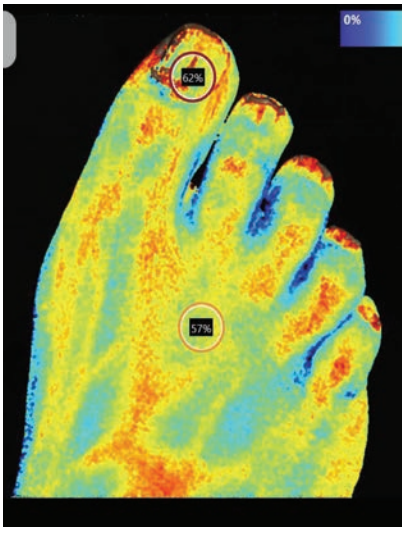

Figure 6: DPN Patient Baseline

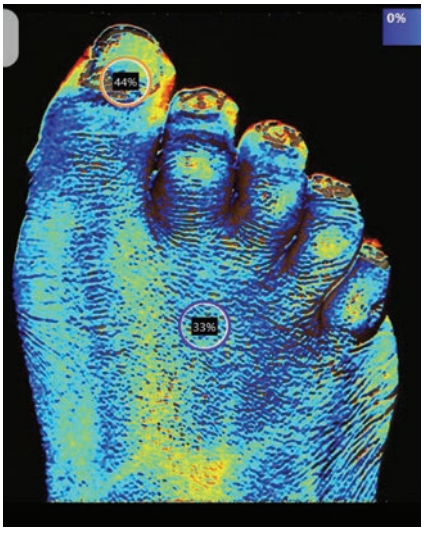

Figure 7: DPN Patient After Elevation

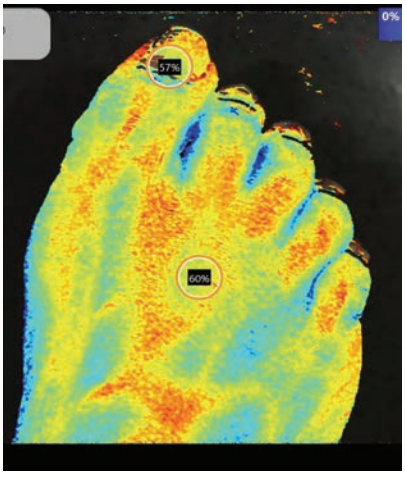

Figure 8: DPN Patient After Dependency

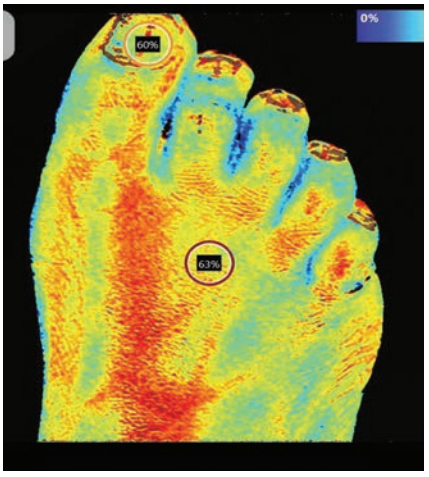

Figure 9: DPN Patient After

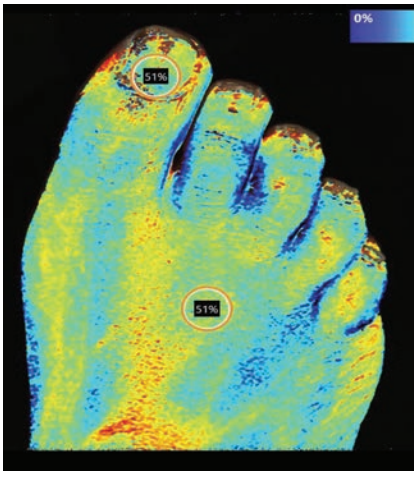

Figure 10: DPN Patient After Cold

the two groups, observed trends indicate profound differences that could influence management strategies for diabetic populations. This highlights the necessity of utilizing tailored interventions that consider individual patient statuses.

Elevation and StO2 Values

Interestingly, the data revealed that changes in foot positioning may impact tissue oxygenation significantly. The observed reduction in StO2 values—a measure of tissue oxygen saturation—in patients with neuropathy upon elevation indicates a vulnerability that demands attention. Healthcare providers should be mindful of these changes and integrate them into care strategies, especially considering that individuals with DPN may be at greater risk of compromised blood flow.

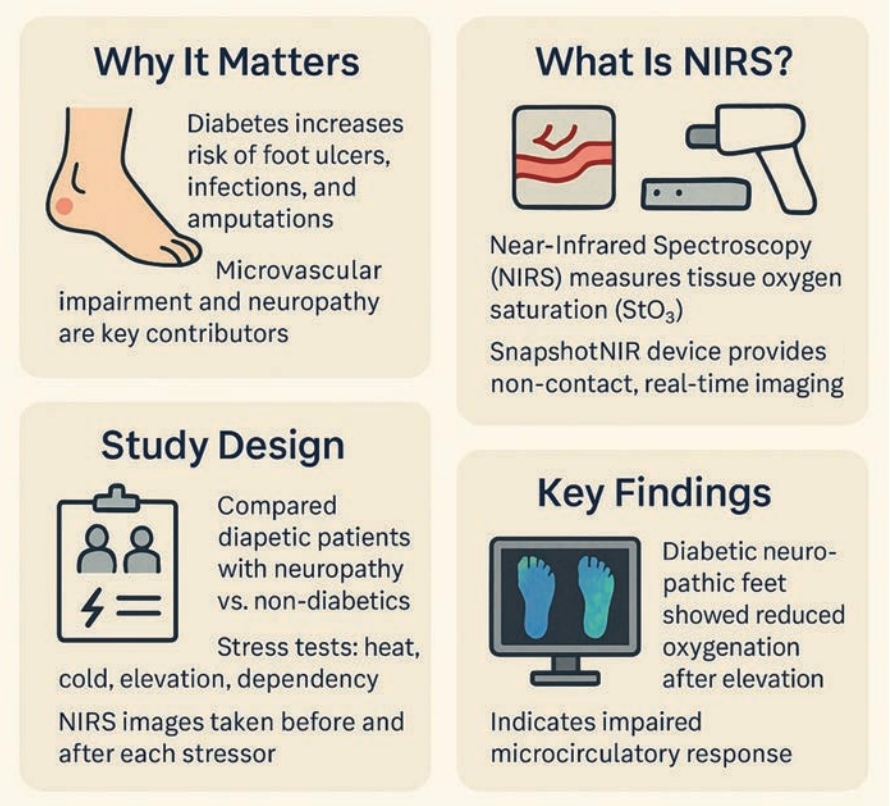

Figure 11: Infographic summarizing the study's findings

Personalized Care Through Vascular Assessments

Prioritizing vascular health assessments can enable healthcare practitioners to categorize patients based on their risk of complications. This categorization allows for personalized treatment strategies that address the specific needs of each patient. For instance, those identified as high risk may require closer monitoring and aggressive interventions, which can include lifestyle modifications, improved foot care practices, and better glycemic control.[1] Moreover, vascular assessments can serve as a valuable educational tool, informing patients about necessary healthcare practices.[13] Regular follow-up assessments allow healthcare professionals to monitor disease progression, evaluate treatment effectiveness, and make necessary adjustments to care plans.[14]

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Early Detection of Peripheral Artery Disease

Peripheral artery disease (PAD) is one of the most serious vascular complications faced by diabetic patients. Conducting routine vascular assessments is essential in identifying early signs of PAD, which can help prevent severe consequences such as limb ischemia.[15] The risks associated with undetected PAD are substantial, potentially leading to amputations.[16] A thorough diabetic foot assessment is critical in screening for limb perfusion and recognizing early signs of vascular disease.[17] The integration of these assessments within routine diabetes care can significantly improve the outcomes for those living with the condition, ultimately enhancing their quality of life.[18]

The Challenge of Non-Invasive Vascular Studies

While non-invasive vascular studies (NIVS) provide several methodologies for conducting assessments, challenges persist. Often, results from standard NIVS can be misleading in diabetic patients.[19] For instance, individuals with diabetic peripheral neuropathy may exhibit what seems to be adequate blood flow, but underlying vascular issues may remain undetected.[20] The complications of autonomic neuropathy cannot be overlooked; they play a critical role in the development of microvascular disease by impairing blood flow regulation.[21] This impaired regulation can lead to functional ischemia, where tissues do not receive adequate oxygen, heightening the risk of diabetes-related complications.[22]

Future Directions in Diabetic Care

The study not only sheds light on the complexities of diabetes management and the implications of vascu-

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lar assessments but also points toward a pressing need for further research. Larger, more diverse sample sizes will allow for a better understanding of microcirculatory changes and how they relate to diabetic complications.[23] By continuing to explore NIRS technology and its application in clinical practice, future studies can refine vascular assessment methods, leading to improved diagnostic tools that inform better treatment modalities for diabetic patients.[24]

Conclusion: A Call to Action

In summary, the importance of lower extremity vascular assessments in diabetes management cannot be overstated. Integrating these assessments into standard care practices is crucial for proactive diabetes management, allowing for early detection of vascular complications and personalized treatment strategies. Enhanced awareness and understanding of the vascular aspect of diabetes will not only improve patient outcomes but significantly elevate their quality of life. Healthcare practitioners must prioritize these assessments, ensuring that patients receive the comprehensive care they deserve. The future of diabetes management should embrace innovation, education, and rigorous assessment protocols to combat the devastating impact of vascular complications in those living with this chronic condition. **PM**

Enhanced awareness and understanding of the vascular aspect of diabetes will not only improve patient outcomes but significantly elevate their quality of life.

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