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Maximal Systolic Acceleration and Near-Infrared Fluorescence Imaging With Indocyanine Green as Predictors for Successful Lower Extremity Revascularization

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Abstract

Background: Patients with lower extremity arterial disease (LEAD) frequently require revascularization procedures. Currently used diagnostic methods are insufficient in predicting successful outcomes and focus on macrovascular rather than microvascular state. Several promising modalities to increase diagnostic accuracy are emerging, including maximal systolic acceleration (ACC_{max}), measured by duplex ultrasound (DUS). For the assessment of tissue perfusion, near-infrared fluorescence (NIR) imaging using indocyanine green (ICG) demonstrates promising results. This study aims to identify the usefulness of combining these two methods for macrovascular and microvascular perfusion assessment to predict successful clinical outcomes.

Methods: A retrospective study was performed collecting preinterventional and postinterventional DUS and ICG NIR fluorescence imaging measurements from LEAD patients undergoing revascularization. The correlation between the preinterventional and postinterventional perfusion parameters, described as the delta (Δ) ACC_{max} and ΔICG NIR fluorescence parameters, were analyzed. Improvements in perfusion parameters were compared to clinical outcomes, defined as improvement in pain-free walking distance, freedom from rest pain, or tendency toward wound and ulcer healing.

Results: A total of 38 patients (42 limbs) were included. ACC_{max} and ICG NIR fluorescence perfusion parameters improved significantly after revascularization ($p<0.001$). Patients with a poor clinical outcome had a significantly lower improvement of both parameters after revascularization ($p<0.001$–0.016). Lack of correlation was found between the delta of ACC_{max} and ICG NIR fluorescence imaging. Multiple non-congruent improvements of macrovascular parameters (ACC_{max}) and perfusion (ICG NIR fluorescence) were seen within patients. However, for all patients with a successful clinical outcome, at least one parameter improved.

Conclusion: Combining ACC_{max} and ICG NIR fluorescence imaging revealed improvement in at least one parameter within all patients with a successful clinical outcome. This study highlights the potential of assessing both the macrovascular state and tissue perfusion following lower extremity revascularization, as both appear to reflect different aspects of vascularization.

Clinical Impact

Numerous techniques have been developed to assess tissue perfusion to predict clinical outcomes following revascularization in patients with peripheral artery disease. However, none are widely implemented in clinical practice. This study emphasized the importance of employing multiple modalities from different perspectives for more accurate prediction. By focusing on both the macrovascular state and tissue perfusion, clinicians can better guide themselves in their treatment strategies.

Keywords

peripheral artery disease, chronic limb ischemia, duplex ultrasound, maximal systolic acceleration, near-infrared fluorescence imaging, indocyanine green

Introduction

Lower extremity arterial disease (LEAD) is characterized by decreased perfusion, mostly due to atherosclerotic plaques. It is estimated that over 230 million people worldwide are affected by LEAD and this number is expected to increase.[1,2] The most severe form, known as chronic limb-threatening ischemia (CLTI), carries a 5-year mortality risk of 60%.[3] These patients typically require revascularization procedures to preserve limb function. Despite successful revascularization, high reintervention rates persist due to post-operative occlusions and the multilevel disease patterns of CLTI patients.[3,4] Currently, the prediction of clinical outcome following revascularization remains inadequate using existing modalities and mainly focuses on assessment of the macrovasculature instead of perfusion[5] Combining assessment of the macrovascular state with perfusion after revascularization could be a promising method to better guide physicians in their treatment decisions by initiating or preventing reinterventions and amputations more promptly.[6]

The maximal systolic acceleration (ACC_{max}) is a new emerging bedside test that corresponds to macrovascular flow proximal to the measurement point.[7–9] ACC_{max} is measured through duplex ultrasonography (DUS) and has shown excellent diagnostic accuracy to detect and rule out LEAD, independent of patients prone to medial arterial calcification[8] ACC_{max} seems to be a reliable diagnostic modality and can provide insights into the severity of a stenosis, yet only depicts macrovascular state.[10,11] Especially in LEAD patients with impaired wound healing or diabetes mellitus, a combined assessment of the microvascular status could be very helpful for physicians.[12]

To assess tissue perfusion, near-infrared (NIR) fluorescence imaging with indocyanine green (ICG) can be used. ICG is a fluorescent dye that binds to plasma protein albumin after intravenous injection and provides visualization and quantification of perfusion when recorded with a specialized NIR camera.[13] Studies have shown that NIR fluorescence imaging has the potential to predict clinical outcomes after revascularization procedures using the extracted inflow and outflow perfusion parameters.[14,15]

This study aims to identify the usefulness of combining two emerging methods for macrovascular and microvascular assessment to predict successful outcomes after revascularization. Therefore, the primary objective of this study is to investigate whether there is a correlation between ACC_{max} and ICG NIR fluorescence or if they independently assess different aspects of vascularization. It is hypothesized that ACC_{max} corresponds with macrovascular flow and that ICG NIR fluorescence imaging assesses perfusion. A secondary objective is to analyze how combining the two modalities, ultimately leads to an improved prediction of clinical outcome after revascularization.

Materials and Methods

This retrospective cohort study was performed between February 2019 and December 2023 in a single academic hospital. Patients were included if they underwent a technically successful revascularization procedure and had complementary preinterventional and postinterventional DUS and ICG NIR fluorescence imaging measurements. Successful clinical outcome was defined, as in a previous study, depending on Fontaine's classification of the limb, by either improvement of pain-free walking, reduction of rest pain, or tendency toward wound and ulcer healing assessed by the treating physician.[15] Follow-up was performed according to the revascularization protocol in the outpatient clinic within 6 weeks measurement. Patients included before implementation of ICG NIR fluorescence as the standard of care gave written informed consent. All patients provided permission for data usage.

ICG NIR Fluorescence Measurement

Indocyanine green NIR fluorescence measurements were performed before the revascularization and within 5 days after the intervention, according to previously described methods.[15] During ICG NIR fluorescence imaging, patients were taken into a room that could be cleared of ambient light, where a bolus of ICG (Verdye) 0.1 mg/kg was administered intravenously in the cubital vein. Subsequently, the NIR fluorescence intensity change over time was recorded for 5 min by the Quest Spectrum 2.0 (Quest Medical Imaging, Middenmeer, the Netherlands), which was aimed perpendicular to the dorsum of the feet at a distance of 50 cm. This system uses a visible light engine and an NIR light source (700–820 nm). All videos were recorded using fixed camera settings.

DUS Measurement

ACC_{max} values were measured by DUS and calculated at the maximal slope of the upstroke (expressed in m/s^2). A detailed description can be found in previous literature.[8] Patients with

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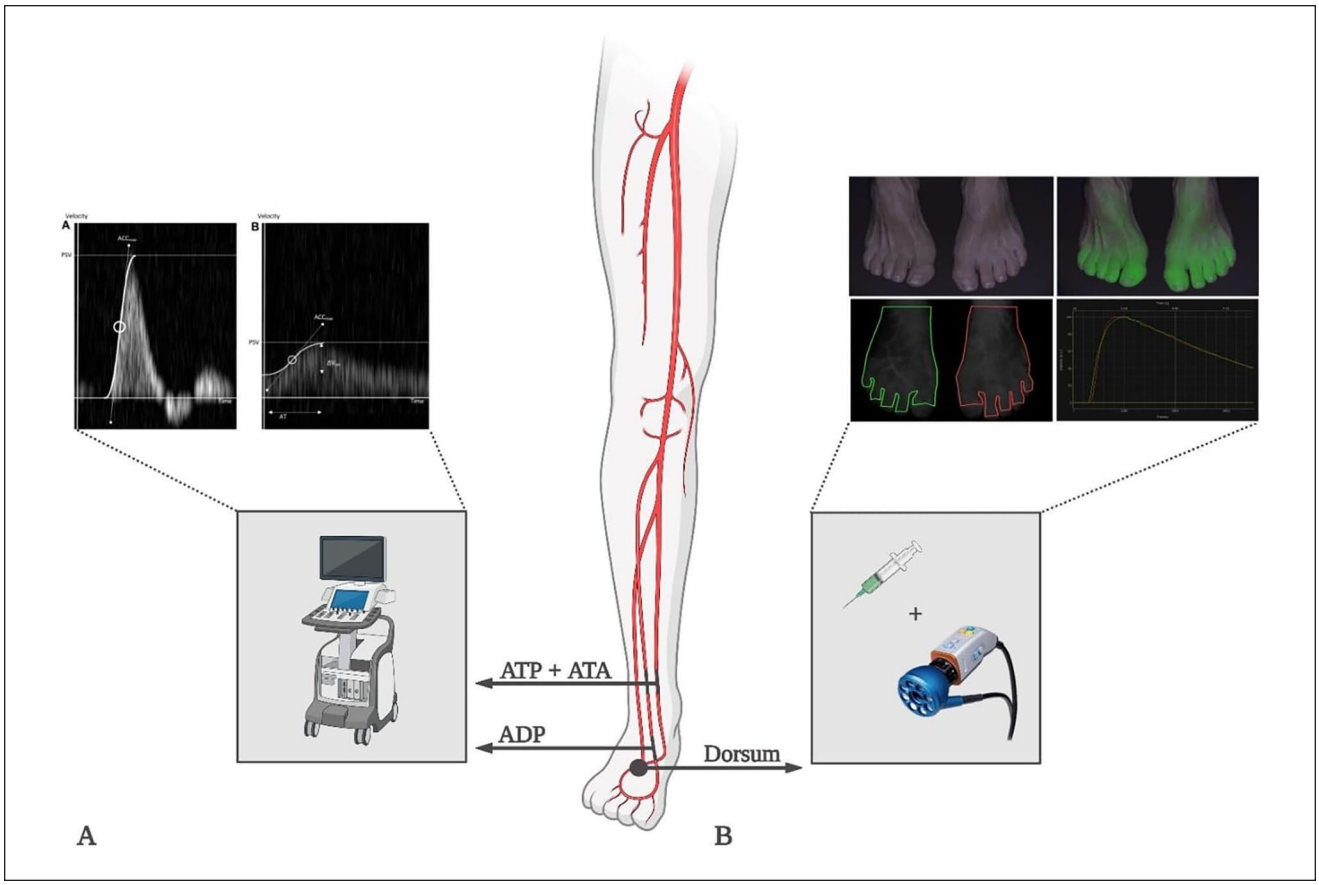

Figure 1. Schematic overview of the two techniques and their corresponding location of measurement. (A) Duplex ultrasound with maximal systolic acceleration was visually measured and calculated as the maximal slope of the upstroke of a Doppler wave. [10] (B) Near-infrared fluorescence with indocyanine green measurement of two feet, including two drawn regions of interest and corresponding time-intensity curves. Abbreviations: ATA, arteria tibialis anterior; ATP, arteria tibialis posterior; ADP, arteria dorsalis pedis.

preinterventional and postinterventional measurements of the arteria tibialis posterior (ATP), arteria tibialis anterior (ATA), or arteria dorsalis pedis (ADP) were included. When measurements in multiple arteries were available, the artery demonstrating the greatest improvement was selected. Patients with a preinterventional ACC_{max} longer than 6 months prior to the revascularization or post-interventional ACC_{max} longer than 3 months after the revascularization were excluded. Patients who displayed a newly formed stenosis on the post-interventional duplex were excluded as well. The DUS measurements were performed by the same sonographer, using the Siemens Acuson Sequoia Ultrasound System. Figure 1 gives a schematic overview of both techniques and their corresponding location of measurement.

Data Analysis

Quantification of ICG NIR fluorescence data was performed using Quest Research Framework (Quest Medical Imaging, Middenmeer, the Netherlands). The entire dorsum of the foot was selected as a region of interest, from which time-intensity curves were extracted. The parameters normalized max ingress slope (Normalized slope in %/s) and time to maximum intensity (T_{max} in s) were extracted from these curves for further analysis, as these inflow parameters are most reliable in clinical settings.[16,17] Statistical analyses were conducted using IBM SPSS Statistics 25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Versions 25.0 Armonk, NY, USA; IBM Corp.). Preinterventional and postinterventional parameters were compared using the Wilcoxon signed-rank test. Delta (Δ) ACC_{max}, ΔNormalized slope, and ΔT_{max} were correlated using the Spearman's rank correlation coefficient (Spearman's ρ). Subgroup differences were analyzed using the Mann–Whitney U test and the Kruskall–Wallis test. p-Values <0.05 were considered statistically significant. Based on clinical outcome, 2×2 tables were generated, aligning improvement or no improvement of ACC_{max} and ICG NIR fluorescence parameters to

Table 1. Patient and Revascularization Characteristics.

	Total (n=38, limbs = 42)
Age (mean, SD)	68.5±8.2
Sex (male/female)	22/16
BMI (mean, SD)	26.45±4.1
Diabetes (limbs, %)	15 (35.7)
Hypertension (limbs, %)	26 (61.9)
History of smoking (limbs, %)	37 (88.1)
Active smoking (limbs, %)	12 (28.6)
eGFR 30–60 mL/min/1.73 m^2 (limbs, %)	5 (11.9)
Successful clinical outcome (limbs, %)	37 (88.1)
Fontaine classification (limbs, %)	
2A	1 (2.4)
2B	21 (50.0)
3	11 (26.2)
4	9 (21.4)
Intervention (limbs, %)	
Bypass	9 (21.4)
PTA	23 (54.8)
TEA	10 (23.8)
Level of revascularization (limbs, %)	
Aortoiliac	16 (38.1)
Femoral/popliteal	22 (52.4)
Crural	4 (9.5)
Assessed artery in duplex (limbs, %)	
ATA	14 (33.3)
ATP	25 (59.5)
ADP	3 (7.1)

Abbreviations: SD, standard deviation; BMI, body mass index; eGFR, estimated glomerular filtration rate; PTA, percutaneous transluminal angioplasty; TEA, thromboendarterectomy; ATA, arteria tibialis anterior; ATP, arteria tibialis posterior; ADP, arteria dorsalis pedis.

each other. Improvement was defined by an increase of >1.5 $m/s^2$of ACC_{max}, >2 s of T_{max}, and >0.2%/s of Normalized slope by consensus of the authors.

Results

Patient Characteristics

Thirty-eight patients were included with a mean age of 68.5 (±8.2) years, and 58% (n=22) were male (Table 1). Reported comorbidities include hypertension (60%), diabetes (33%), and kidney failure (12%). Of all patients, 88% had a history of smoking, of which 29% were active smokers. A successful clinical outcome was seen in 37 limbs (88%). Most limbs (n=21) were classified as Fontaine stage 2B, corresponding to Rutherford (RF) stage 3. One limb was stage 2A (RF 2), 11 limbs were Fontaine stage 3 (RF4), and 9 limbs were classified as Fontaine stage 4 (RF 5/6). Endovascular revascularization was performed in 23 limbs (55%), whereas surgical treatment (bypass or thrombendarteriectomy of the common femoral artery or infrarenal aorta) was conducted in 9 (21%) and 10 (24%) patients, respectively. Sixteen limbs (38%) were revascularized at the aortoiliac level, 22 (52%) limbs were treated at a femoral-popliteal level, and four limbs (10%) were treated at a crural level. The ATA was assessed by ACC_{max} in 14 (33%) instances; subsequently, the ATP and ADP were assessed in 25 (60%) and 3 (7%) instances, respectively.

Intervention

Preinterventional and postinterventional delta's of ACC_{max} and ICG NIR fluorescence imaging are displayed in Table 2. Normalized slope increased from a median of 2.7 %/s (1.8–4.2) to 5.8 %/s (3.8–7.8). Time to maximum intensity (T_{max}) increased from a median of 102.2 s (60.2–151.9) to 38.8 s (20.3–66.0). Median ACC_{max} improved from 1.6 m/s^2 (0.6–3.2) to 9.3 m/s^2 (4.1–10.8).

Correlation

Scatterplots of absolute ΔACC_{max}, ΔNormalized slope, and ΔT_{max} were generated. ACC_{max} and ICG NIR fluorescence parameters did not exhibit equivalent improvement as no significant correlations between change in macrovascular ACC_{max} and microvascular ICG NIR fluorescence parameters were observed (Figure 2).

Clinical Outcomes

Table 3. presents the median delta's of ACC_{max} and ICG NIR fluorescence parameters within specific subgroups. In patients with an unsuccessful clinical outcome, all three parameters exhibited a significantly lower delta after revascularization. Based on Fontaine classification, ΔT_{max} significantly differed, indicating that CTLI patients classified as Fontaine 4 experienced less improvement of perfusion after revascularization. No significant differences between diabetics and non-diabetics were observed.

Figure 3 shows improvement or no improvement of ACC_{max} against either Normalized slope or T_{max}. Among patients with an increase in both ACCmax and normalized slope (n=27), all eventually experienced a successful clinical outcome. Within this group, zero patients showed no improvement in both parameters, whereas ten patients showed improvement in only one parameter. Similar results were observed when examining the parameter T_{max}. Among patients with a poor clinical outcome, three cases exhibited no improvement in both ACC_{max} and Normalized slope, while two patients exhibited improvement in one parameter.

Table 2. Preinterventional and Postinterventional ICG NIR Fluorescence Parameters and ACC_{max} With Absolute Improvement.

	Preinterventional (median, quartiles)	Postinterventional (median, quartiles)	Delta (median, quartiles)	*p*
Normalized slope	2.7 (1.8/4.2)	5.8 (3.8/7.8)	2.2 (0.3/4.4)	<0.001
T_{max}	102.2 (60.2/151.9)	38.8 (20.3/66.0)	−45.0 (−93.5/5.4)	<0.001
ACC_{max}	1.6 (0.6/3.2)	9.3 (3.7/10.8)	5.3 (1.3/8.9)	<0.001

Abbreviations: T_{max}, time to maximum intensity; ACC_{max}, maximal systolic acceleration.

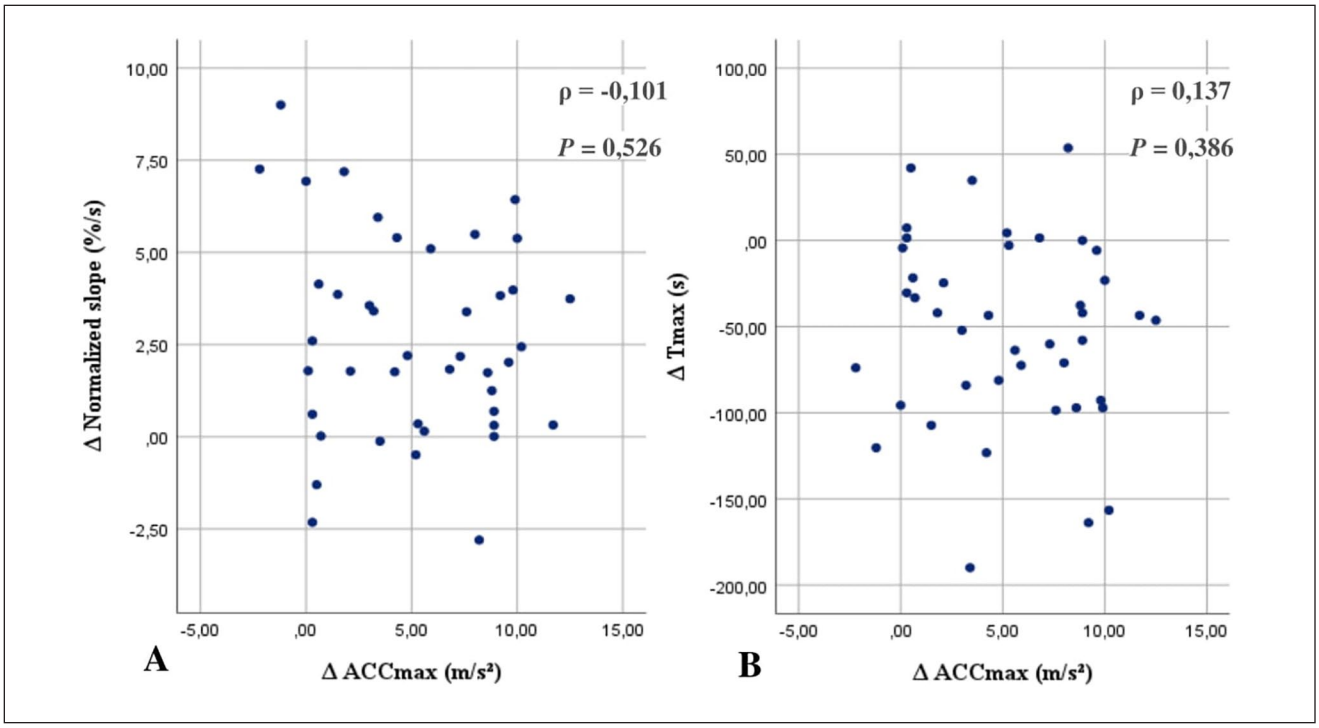

Figure 2. Scatterplot of change in normalized slope against change in ACCmax with associated correlation coefficient (A), scatterplot Of change in T_{max} against change in ACCmax with associated correlation coefficient (B). Abbreviations: ACC_{max}, maximal systolic acceleration Spearman's correlation coefficient. T_{max}, time to maximum intensity; A, deltas; ρ, Spearman's correlation coefficient.

Discussion

This study was designed to identify the usefulness of combining ACC_{max} and ICG NIR fluorescence imaging to predict successful outcome after revascularization of the lower extremity. For all patients with a successful clinical outcome at least one parameter improved. Complementary use of these two modalities can give optimal information to predict clinical outcomes after revascularization.

ICG NIR fluorescence has been used extensively for various indications, including perfusion assessment in oncologic, reconstructive, and vascular surgery.[13] ICG has long been recognized for its ability to bind to plasma proteins following intravenous administration, making it feasible for perfusion assessment.[18–20] Recently, the focus has shifted to quantification of this fluorescence signal, which results in an objective and reproducible evaluation of tissue perfusion.[19]

This is the first study to describe the relationship between quantified ICG NIR fluorescence and ACC_{max} measured with DUS in patients with LEAD and linking this to clinical outcomes. Previously, poor correlation has been observed between the microvascular oxygenation parameter StO_2 and the macrovascular ankle-brachial index.[21–23] Geskin et al.[24] compared acceleration time, measured by DUS, of the medial and lateral tarsal artery to near-infrared spectroscopy. Similar to our findings, no significant correlations were observed between differences of microvascular and macrovascular assessment following revascularization. The efficacy of ICG NIR fluorescence as a quality control measure post-revascularization and as a predictive value on

Table 3. Delta's of ICG NIR Fluorescence Imaging and ACC_{max} in Patients Based on Clinical Outcome, Fontaine Classification and Presence of Diabetes.

	Clinical outcome			Fontaine classification				Diabetes		
Parameter	Successful (n=37)	Unsuccessful (n=5)	*p*	2b (n=21)	3 (n=11)	4 (n=9)	*p*	Diabetes (n=15)	No diabetes (n=27)	*p*
ΔNormalized slope	2.6 (1.5/5.2)	−0.12 (−1.8/0.32)	<0.001	2.2 (0.2/4.5)	3.7 (0.6/6.9)	1.8 (−0.5/4.2)	0.308	2.0 (0.35/3.6)	2.2 (0.3/5.4)	0.646
ΔT_{max}	−58.0 (−96.4/−24.0)	7.3 (−16.0/38.4)	<0.001	−60.2 (−97.2/−31.9)	−71.1 (−98.6/−42.1)	−5.8 (−30.5/4.4)	0.021	−42 (−84.1/−4.4)	−58 (−97.2/−21.8)	0.503
ΔACC_{max}	5.9 (2.6/8.9)	0.5 (0.3/2.1)	0.016	5.2 (3.2/8.9)	1.8 (0.3/8.0)	8.2 (0.45/9.7)	0.478	3 (0.3/7.6)	6.8 (3.4/8.9)	0.064

Abbreviations: T_{max}, time to maximum intensity; ACC_{max}, maximal systolic acceleration.

Figure 3. 2 × 2 tables of improvement of ACC_{max} and ICG NIRF parameters (Normalized slope and T_{max}) in patients with a good or bad clinical outcome. Abbreviations: ACC_{max}, maximal systolic acceleration; Norm. slope, Normalized slope; T_{max}, time to maximum intensity.

clinical outcome has already been demonstrated in previous studies.[14,15,25–28] DUS is already recommended by current guidelines as standard surveillance after endovascular interventions for detection of newly formed in-stent stenoses.[29] As these guidelines on follow-up after surgical or endovascular revascularizations do not include ICG NIR fluorescence or any type of (microvascular) perfusion assessment, considerable prognostic advantages can be obtained in the future.[30]

Non-congruent improvements in ACC_{max} and ICG NIR fluorescence, seen in multiple patients, show that an enhanced macrovascular state following revascularization does not necessarily result in improved tissue perfusion and vice versa (Figure 3). However, in the clinical improvement group, all patients showed improvement of at least one parameter. This suggests that observing lack of improvement of both ACC_{max} and ICG NIR fluorescence, a more rapid evaluation of the patient might be necessary. Adding ICG NIR fluorescence imaging to standard monitoring after revascularization enables more accurate identification of patients without improved perfusion. This is particularly crucial in patients with CLTI, as early identification of those with unimproved perfusion can significantly aid in preventing reinterventions or amputations. ICG NIR fluorescence

imaging appears to more directly reflect the endpoint in CLTI patients, which in this case is actual wound perfusion. Patients with a poor clinical outcomes showed significantly less improvement in both ACC_{max} and ICG NIR fluorescence parameters (Table 3). However, more interestingly, Fontaine stage 4 patients in this cohort demonstrated less improvement of the T_{max} compared to Fontaine stage 2b and 3, which is consistent with findings from a previous study.[31]

The poor correlation between the delta of ACC_{max} and ICG NIR fluorescence imaging suggests that both modalities evaluate different aspects of vascularization. However, this lack of correlation could be attributed to several other factors. It is important to note that significant changes in perfusion may take several weeks to become noticeable.[32,33] Current study design involves conducting a second NIR fluorescence imaging measurement shortly after the intervention, which may not allow enough time for changes in perfusion to manifest. Additionally, diabetes mellitus could potentially lead to disparities in microvascular and macrovascular statuses. However, it does not appear to be the primary factor behind the poor correlation observed in this cohort, as no significant differences in improvement are seen between diabetic and non-diabetic individuals (Table 3). The absence of significant differences among these individuals may be attributed to the small sample size. Considering that diabetes mellitus is a known contributor to microvascular disease, different changes in perfusion patterns after revascularization are expected. Improved tissue perfusion measured by ICG NIR fluorescence imaging without enhancement of macrovascular flow, as depicted by ACC_{max} is not in line with expectations. This discrepancy can be most logically explained by the likelihood that inline flow was not attained through the analyzed artery. As improvement in foot perfusion might have taken place through an alternative pathway, such as collateral vessels or through another crural vessel.

It appears that ACC_{max} and ICG NIR fluorescence both reflect different aspects of vascularization and combining both modalities could provide more prognostic insight into macrovascular and microvascular pathology. However, these findings should be interpreted with caution, due to the retrospective nature of the study, patient heterogeneity, and variations in the timing of ACC_{max} measurements. Nevertheless, the heterogeneous presentation observed is typical for PAD patients, and the underlying pathophysiology is consistent across all patients. Furthermore, although various revascularization techniques were employed, they all share the common objective of augmenting blood flow to the lower extremities.

Future studies should focus on simultaneous ACC_{max} and ICG NIR fluorescence imaging measurements in CLTI patients, as this group stands to benefit most from such combined assessment. This exploratory study is an important first step toward more comprehensive research into predicting successful revascularization by employing multiple modalities from a different perspective. Prospective studies are necessary to establish the utility of combining these two promising modalities and translate these findings into clinical care. Ultimately, this could result in intra-operative assessments involving both preinterventional and postinterventional measurements of the macrovascular state and actual tissue perfusion to evaluate the effectiveness of treatment. If necessary, immediate adjustments could be facilitated to deviate from a "wait-and-see" approach by revascularizing more extensively or deciding to amputate more promptly.

Conclusion

Combining ACC_{max} and ICG NIR fluorescence imaging revealed improvement in at least one parameter within all patients with a successful clinical outcome. This study highlights the potential of assessing both the macrovascular state and tissue perfusion following lower extremity revascularization, as both appear to reflect different aspects of vascularization.

Declaration of Conflicting Interests

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References

1. Aday AW, Matsushita K. Epidemiology of peripheral artery disease and polyvascular disease. *Circ Res*. 2021;128(12):1818–1832. doi:10.1161/circresaha.121.318535.
2. Song P, Rudan D, Zhu Y, et al. Global, regional, and national prevalence and risk factors for peripheral artery disease in 2015: an updated systematic review and analysis. *Lancet Glob Health*. 2019;7(8):e1020–e1030. doi:10.1016/s2214-109x(19)30255-4.
3. Ventoruzzo G, Mazzitelli G, Ruzzi U, et al. Limb salvage and survival in chronic limb-threatening ischemia: the need for

a fast-track team-based approach. *J Clin Med*. 2023;12(18). doi:10.3390/jcm12186081.
4. Parvar SL, Ngo L, Dawson J, et al. Long-term outcomes following endovascular and surgical revascularization for peripheral artery disease: a propensity score-matched analysis. *Eur Heart J*. 2021;43(1):32–40. doi:10.1093/eurheartj/ehab116.
5. Schreuder SM, Hendrix YMGA, Reekers JA, et al. Predictive parameters for clinical outcome in patients with critical limb ischemia who underwent percutaneous transluminal angioplasty (PTA): a systematic review. *Cardiovasc Intervent Radiol*. 2018;41(1):1–20. doi:10.1007/s00270-017-1796-9.
6. Misra S, Shishehbor MH, Takahashi EA, et al. Perfusion assessment in critical limb ischemia: principles for understanding and the development of evidence and evaluation of devices: a scientific statement from the American heart association. *Circulation*. 2019;140(12):e657–e672. doi:10.1161/cir.0000000000000708.
7. Brouwers JJWM, Willems SA, Goncalves LN, et al. Reliability of bedside tests for diagnosing peripheral arterial disease in patients prone to medial arterial calcification: a systematic review. *Eclinicalmedicine*. 2022;50:101532. doi:10.1016/j.eclinm.2022.101532.
8. Willems SA, Dolfing SG, van Wissen RC, et al. Diagnostic accuracy of the maximal systolic acceleration to detect peripheral arterial disease. *J Vasc Surg*. 2024;79(2):405–411. doi:10.1016/j.jvs.2023.10.049.
9. Brouwers JJWM, Jiang JFY, Feld RT, et al. A new Doppler-derived parameter to quantify internal carotid artery stenosis: maximal systolic acceleration. *Ann Vasc Surg*. 2022;81:202–210. doi:10.1016/j.avsg.2021.09.056.
10. Brouwers JJWM, van Doorn LP, van Wissen RC, et al. Using maximal systolic acceleration to diagnose and assess the severity of peripheral artery disease in a flow model study. *J Vasc Surg*. 2020;71(1):242–249. doi:10.1016/j.jvs.2019.01.088.
11. Brouwers JJWM, van Doorn LP, Pronk L, et al. Doppler ultrasonography derived maximal systolic acceleration: value determination with artificially induced stenosis. *Vasc Endovascular Surg*. 2022;56(5):472–479. doi:10.1177/15385744221076269.
12. Beckman JA, Duncan MS, Damrauer SM, et al. Microvascular disease, peripheral artery disease, and amputation. *Circulation*. 2019;140(6):449–458. doi:10.1161/circulationaha.119.040672.
13. van den Hoven P, Ooms S, van Manen L, et al. A systematic review of the use of near-infrared fluorescence imaging in patients with peripheral artery disease. *J Vasc Surg*. 2019;70(1):286–297. doi:10.1016/j.jvs.2018.11.023.
14. Van den Hoven P S, Weller F, Van De Bent M, et al. Near-infrared fluorescence imaging with indocyanine green for quantification of changes in tissue perfusion following revascularization. *Vascular*. 2022;30(5):867–873. doi:10.1177/17085381211032826.
15. Tange FP, van den Hoven P, van Schaik J, et al. Near-infrared fluorescence imaging with indocyanine green to predict clinical outcome after revascularization in lower extremity arterial disease. *Angiology*. 2023:33197231186096. doi:10.1177/00033197231186096.
16. Van Den Hoven P, Tange F, Van Der Valk J, et al. Normalization of time-intensity curves for quantification of foot perfusion using near-infrared fluorescence imaging with indocyanine green. *J Endovasc Ther*. 2023;30(3):364–371. doi:10.1177/15266028221081085.
17. Lütken CD, Achiam MP, Osterkamp J, et al. Quantification of fluorescence angiography: toward a reliable intraoperative assessment of tissue perfusion—a narrative review. *Langenbecks Arch Surg*. 2021;406(2):251–259. doi:10.1007/s00423-020-01966-0.
18. Landsman ML, Kwant G, Mook GA, et al. Light-absorbing properties, stability, and spectral stabilization of indocyanine green. *J Appl Physiol*. 1976;40(4):575–583. doi:10.1152/jappl.1976.40.4.575.
19. Van Den Hoven P, Osterkamp J, Nerup N, et al. Quantitative perfusion assessment using indocyanine green during surgery—current applications and recommendations for future use. *Langenbecks Arch Surg*. 2023;408(1):67. doi:10.1007/s00423-023-02780-0.
20. Pang HY, Chen XL, Song XH, et al. Indocyanine green fluorescence angiography prevents anastomotic leakage in rectal cancer surgery: a systematic review and meta-analysis. *Langenbecks Arch Surg*. 2021;406(2):261–271. doi:10.1007/s00423-020-02077-6.
21. Grambow E, Dau M, Sandkühler NA, et al. Evaluation of peripheral artery disease with the TIVITA® tissue hyperspectral imaging camera system. *Clin Hemorheol Microcirc*. 2019;73(1):3–17. doi:10.3233/ch-199215.
22. Grambow E, Sandkühler NA, Groß J, et al. Evaluation of hyperspectral imaging for follow-up assessment after revascularization in peripheral artery disease. *J Clin Med*. 2022;11(3):758. doi:10.3390/jcm11030758.
23. Boezeman RP, Becx BP, van den Heuvel DA, et al. Monitoring of foot oxygenation with near-infrared spectroscopy in patients with critical limb ischemia undergoing percutaneous transluminal angioplasty: a pilot study. *Eur J Vasc Endovasc Surg*. 2016;52(5):650–656. doi:10.1016/j.ejvs.2016.07.020.
24. Geskin G, Mulock MD, Tomko NL, et al. Effects of lower limb revascularization on the microcirculation of the foot: a retrospective cohort study. *Diagnostics (Basel)*. 2022;12(6):1320. doi:10.3390/diagnostics12061320.
25. Braun JD, Trinidad-Hernandez M, Perry D, et al. Early quantitative evaluation of indocyanine green angiography in patients with critical limb ischemia. *J Vasc Surg*. 2013;57(5):1213–1218. doi:10.1016/j.jvs.2012.10.113.
26. Igari K, Kudo T, Toyofuku T, et al. Quantitative evaluation of the outcomes of revascularization procedures for peripheral arterial disease using indocyanine green angiography. *Eur J Vasc Endovasc Surg*. 2013;46(4):460–465. doi:10.1016/j.ejvs.2013.07.016.
27. Settembre N, Kauhanen P, Albäck A, et al. Quality control of the foot revascularization using indocyanine green fluorescence imaging. *World J Surg*. 2017;41(7):1919–1926. doi:10.1007/s00268-017-3950-6.
28. Colvard B, Itoga NK, Hitchner E, et al. SPY technology as an adjunctive measure for lower extremity perfusion. *J Vasc Surg*. 2016;64(1):195–201. doi:10.1016/j.jvs.2016.01.039
29. Gerhard-Herman MD, Gornik HL, Barrett C, et al. 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: executive

summary: a report of the American college of cardiology/American heart association task force on clinical practice guidelines. *Circulation*. 2017;135(12):e686–e725. doi:10.1161/cir.0000000000000470.
30. Zierler RE, Jordan WD, Lal BK, et al. The society for vascular surgery practice guidelines on follow-up after vascular surgery arterial procedures. *J Vasc Surg*. 2018;68(1):256–284. doi:10.1016/j.jvs.2018.04.018.
31. Van Den Hoven P, Goncalves LN, Quax PHA, et al. Perfusion patterns in patients with chronic limb-threatening ischemia versus control patients using near-infrared fluorescence imaging with indocyanine green. *Biomedicines*. 2021;9(10):1417. doi:10.3390/biomedicines9101417.
32. Normahani P, Khosravi S, Sounderajah V, et al. The effect of lower limb revascularization on flow, perfusion, and systemic endothelial function: a systematic review. *Angiology*. 2021;72(3):210–220. doi:10.1177/0003319720969543.
33. Borozan PG, Schuler JJ, Spigos DG, et al. Long-term hemodynamic evaluation of lower extremity percutaneous transluminal angioplasty. *J Vasc Surg*. 1985;2(6):785–793.