White paper

Diagnosis, management, and the role of pedal acceleration time: a case report

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Abstract

Peripheral arterial disease (PAD) is characterized by atherosclerotic blockages that reduce blood flow to the extremities, particularly the lower limbs. As PAD progresses, it can lead to chronic limb-threatening ischemia (CLTI), marked by rest pain, non-healing ulcers, and an elevated risk of tissue loss or amputation. Risk factors such as diabetes and smoking further exacerbate the disease, complicating both diagnosis and management.

Traditional diagnostic approaches, including the ankle-brachial index (ABI) and toe-brachial index (TBI), often fail in patients with diabetes and medial wall calcification, where non-compressible vessels result in inaccurate pressure measurements. Similarly, methods such as transcutaneous oxygen saturation and skin perfusion pressure testing can yield unreliable results in the presence of significant tissue damage or large wounds.

Pedal acceleration time (PAT), measured via duplex ultrasound, is a novel diagnostic tool that assesses arterial hemodynamics directly in the pedal arteries. This case report illustrates the utility of PAT in diagnosing and predicting wound healing in a patient with PAD where traditional methods were less effective.

Introduction

Peripheral arterial disease – Overview

PAD is a common circulatory problem caused by atherosclerosis, leading to reduced blood flow to the lower extremities. As it progresses, symptoms such as intermittent claudication (pain triggered by exertion and relieved by rest) worsen and blood flow becomes critically impaired. Advanced PAD leads to CLTI, characterized by rest pain, non-healing ulcers, and gangrene, significantly raising the risk of limb loss [1]. Risk factors for PAD and CLTI include diabetes, smoking, hyperlipidemia, and hypertension. Prompt diagnosis and management of CLTI are essential to prevent tissue loss and improve the chances of wound healing.

Diagnostic challenges

In patients with diabetes or medial wall calcification, traditional diagnostic tools like ABI and TBI may be unreliable due to non-compressible vessels or not obtainable due to wounds or previous digital amputation [2]. Transcutaneous oxygen saturation (TCP02) and skin perfusion pressure (SPP) testing face limitations in cases with large wounds or significant tissue damage where proper placement of testing probes is difficult.

Pedal acceleration time (PAT)

PAT is a novel diagnostic approach using duplex ultrasound to measure the arterial flow hemodynamics of the pedal arteries [3–4]. It provides direct, real-time information on perfusion and hemodynamics, offering a reliable predictor of wound healing in CLTI patients [5]. This case report presents a clinical example that demonstrates the effectiveness of PAT in the diagnosis and management of PAD.

Objective

This case report aims to demonstrate the utility of PAT as a reliable, non-invasive diagnostic tool for assessing perfusion in patients with PAD and CLTI, predicting wound healing outcomes and guiding clinical decision-making.

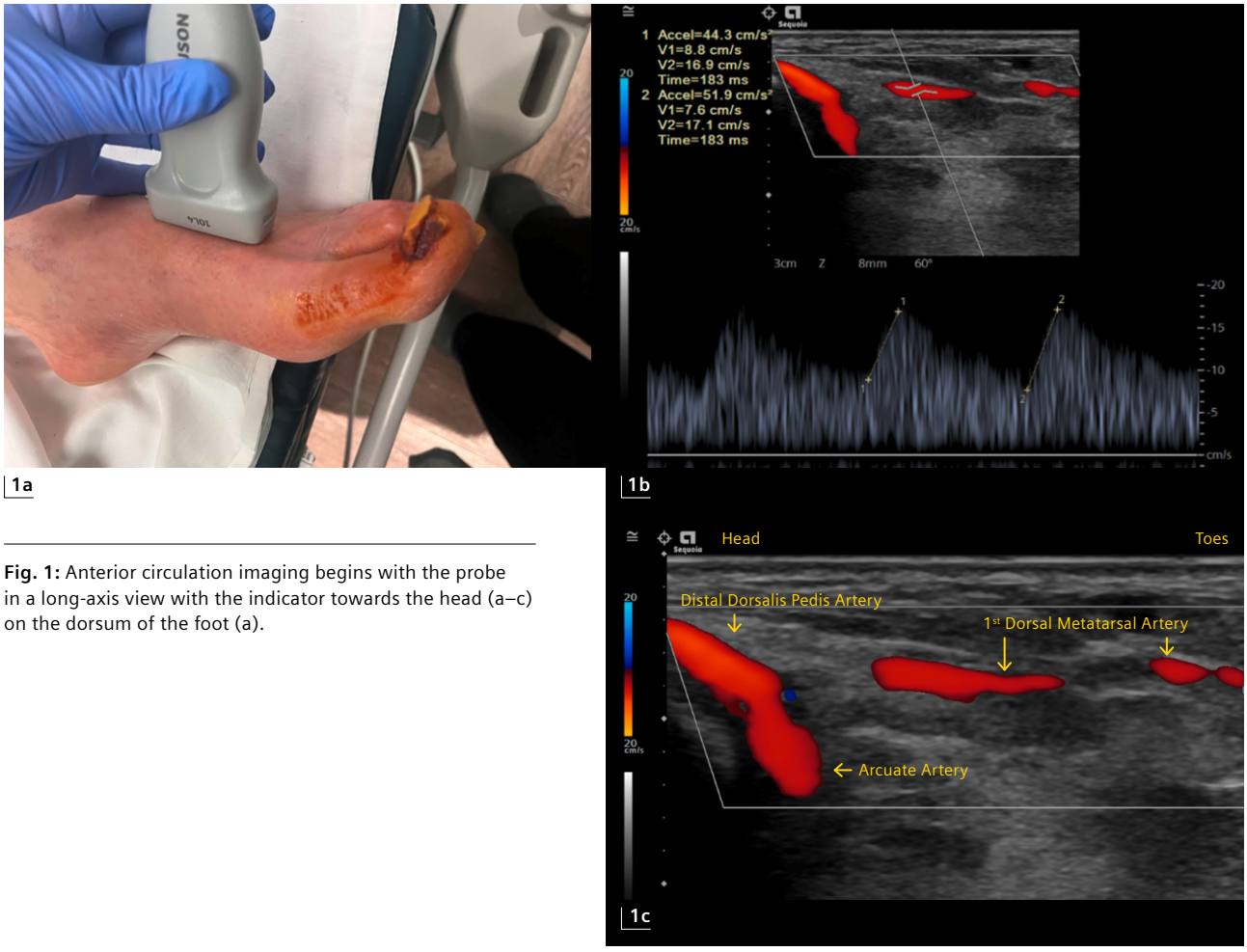


Fig. 1: Anterior circulation imaging begins with the probe in a long-axis view with the indicator towards the head (a–c) on the dorsum of the foot (a).

Image acquisition technique

Utilizing a standard linear probe on the ACUSON Sequoia ultrasound system (Siemens Healthineers, Forchheim, Germany), either the 10L4 or 15L4, is appropriate for pedal arch duplex imaging. Anterior circulation imaging begins with the probe in a long-axis view with the indicator towards the head (Fig. 1).

A pedal acceleration time in the arcuate artery and 1st dorsal metatarsal artery can be acquired providing a spectral Doppler of the anterior circulation. The plantar circulation imaging is obtained in the lateral plantar and medial plantar artery. Obtaining a spectral Doppler waveform in these pedal vessels will be typically lower than the tibial vessels. Optimization of the spectral waveform allows for an accurate manual measurement of the PAT.

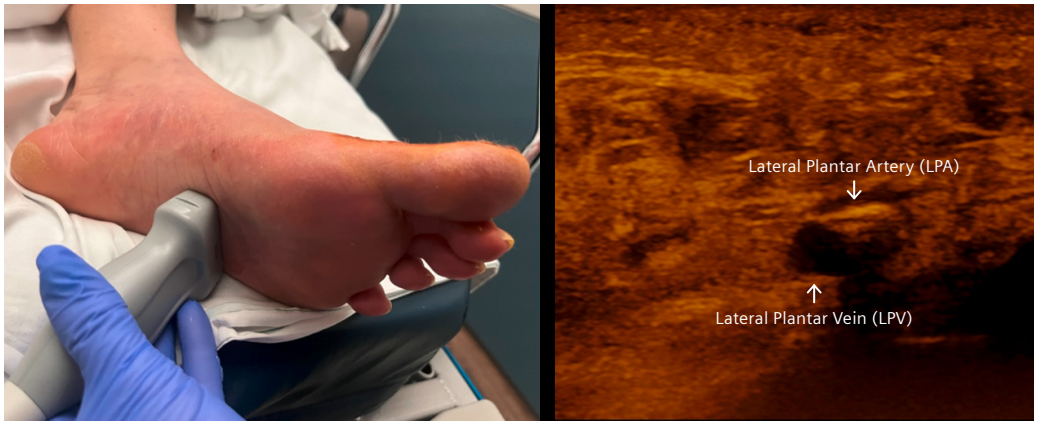


Fig. 2: Plantar circulation imaging begins with the probe in a transverse view in the mid foot.

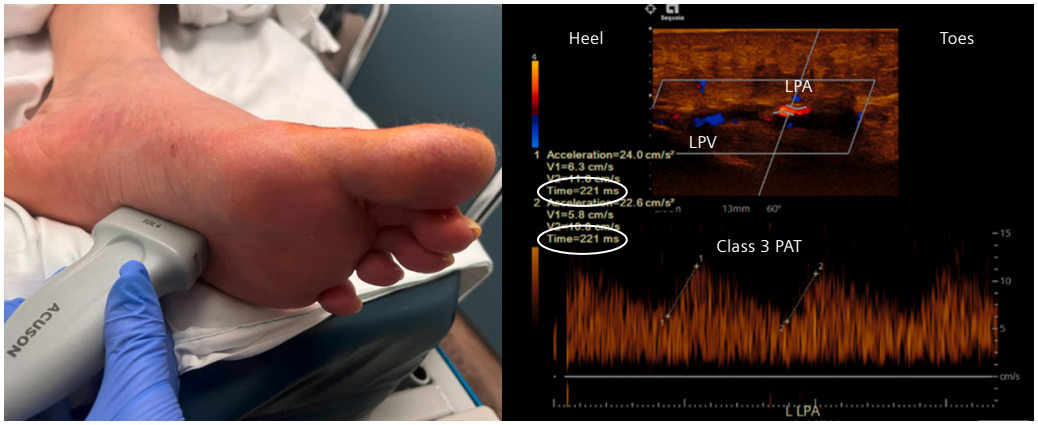
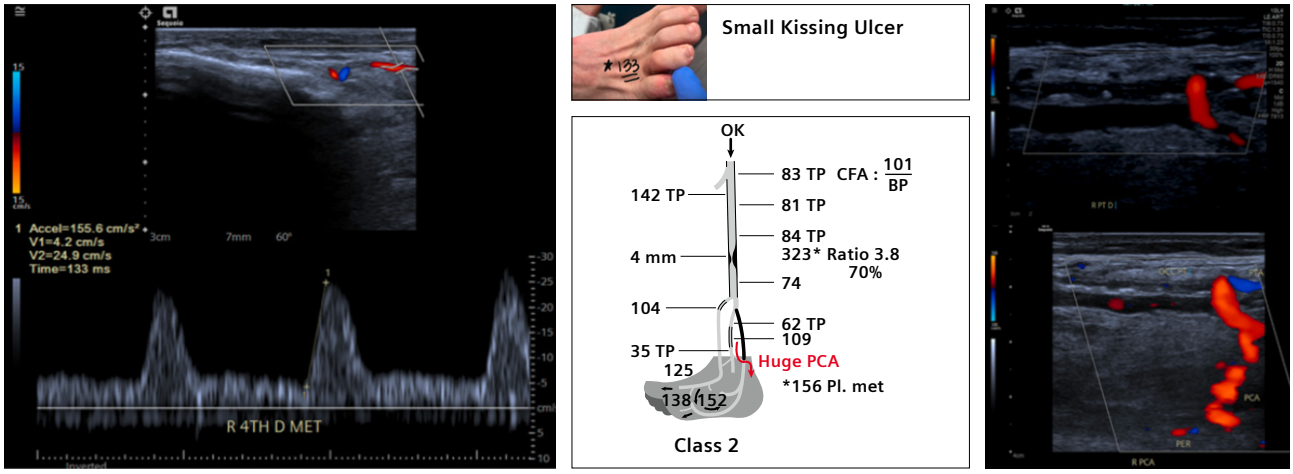


Fig. 3: The probe is turned in a long axis with the indicator of the probe to the heel. PAT can be obtained in the LPA.

Correlation of PAT with degrees of ischemia

	No ischemia class 1	Mild ischemia class 2	Moderate ischemia class 3	Severe ischemia class 4
Clinical symptoms	Asymptomatic	Greater than 2 block claudication	Less than 2 block claudication	CLTI tissue loss; rest pain
PAT	20–120 ms	121–180 ms	181–224 ms	Greater than 225 ms
ABI	1.3–0.9	0.89–0.69	0.68–0.50	0.49–0.00
Toe Pressure	> 30 mmHg		< 30 mmHg	
TCP02	> 44		< 26	

Source: Sommerset J et al. AVS 2019; Pinelo A et al. AVS 2024; Trihan et al. Front Cardiovasc Med 2022



4a 4b

Fig. 4: Initial ultrasound demonstrating Class 2 PAT at the wound bed. Pedal acceleration time (PAT) to the wound bed demonstrates class 2 perfusion (4a). Posterior communicating artery (PCA) well visualized demonstrating indirect perfusion to the plantar arch circulation (4b).

Case presentation

Patient background

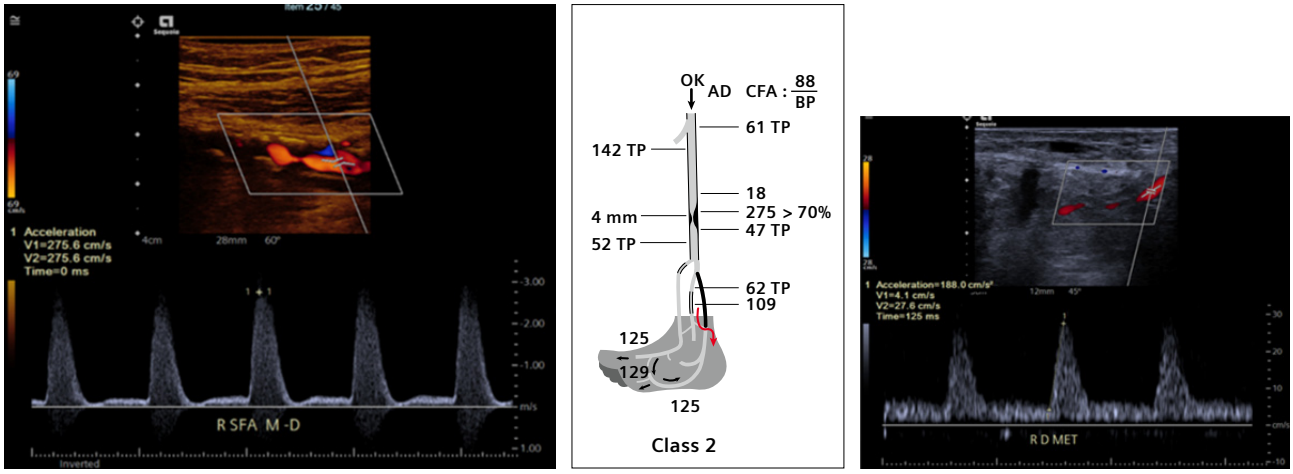
A 50-year-old male presented with right toe kissing ulcers between the 3rd and 4th toes and reported short-distance claudication with pain occurring after walking less than 50 feet. His medical history included poorly controlled diabetes (hemoglobin A1c of 10) and a 20-year history of smoking one pack per day. The patient provided written consent.

Initial assessment

The initial physical exam revealed non-healing ulcers and diminished distal pedal pulses in the right foot (Fig. 4). Duplex ultrasound with PAT was performed, measuring a PAT of 133 ms to the wound bed, consistent with class 2 PAT, suggesting sufficient blood flow for wound healing. Additional findings included:

- Antegrade flow in the arcuate artery with a PAT of 138 ms
- Retrograde flow in the lateral plantar artery with a PAT of 152 ms
- Occlusion of the origin and mid posterior tibial artery (PTA); patent distal PTA with collateral flow from the peroneal artery via the posterior communicating artery
- Widely patent anterior tibial artery (ATA) and peroneal artery (Per)
- High-grade stenosis in the distal superficial femoral artery (SFA) with a 3.8 ratio in the Hunter's canal, indicative of greater than 70% diameter reduction
- Widely patent popliteal artery and tibio-peroneal trunk

Given the sufficient blood flow to the wound bed (class 2 PAT), conservative management was pursued, including wound care optimization, glucose control, smoking cessation, and a strict walking regimen. The patient was scheduled for a follow-up after one month.



5a 5b

Fig. 5: One-month follow-up ultrasound showing class 2 PAT with healed wounds. Greater than 70% stenosis in the superficial femoral artery (5a), and pedal acceleration time (PAT) to the wound bed demonstrating class 2 perfusion (5b).

Management and outcome

One-month follow-up

At the one-month follow-up, the patient had adhered to the prescribed regimen, including smoking cessation and improved wound care. The right toe ulcers were completely healed, confirming that sufficient perfusion, as predicted by class 2 PAT, was present to support wound healing (Fig. 5). However, the patient reported persistent right calf claudication after walking approximately 50 feet, significantly impacting his ability to work as a construction worker.

Six-month follow-up

Despite complete wound healing, the patient's short-distance claudication persisted. A follow-up duplex ultrasound demonstrated an interval change post-exercise PAT, now classified as class 4, indicating a significant hemodynamic stenosis. After failed medical management, an endovascular intervention was planned. Plain old balloon angioplasty (POBA) of the distal SFA lesion was performed, using antegrade access in the ipsilateral common femoral artery. No intervention was performed on the occluded PTA.

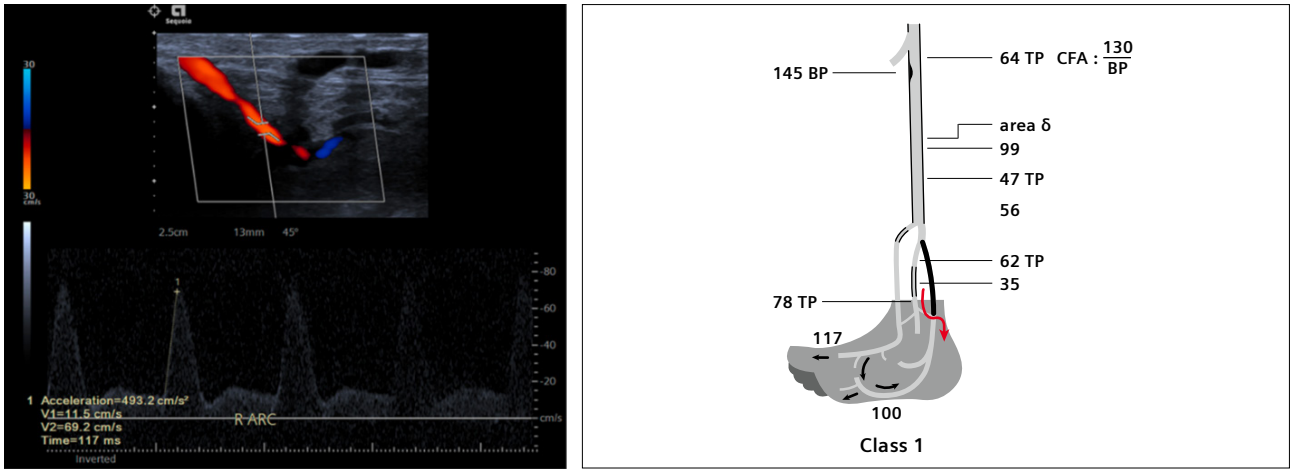


Fig. 6: Postoperative ultrasound demonstrating class 2 PAT following balloon angioplasty. Follow-up post-intervention ultrasound image acquired with the ACUSON Sequoia ultrasound system shows wounds are still healed and no claudication.

Post-intervention outcome

At one-week post operation, the patient reported complete resolution of claudication symptoms, and the previously healed wounds remained in remission (Fig. 6). The successful intervention confirmed that PAT played a crucial role in monitoring disease progression and guiding therapeutic decision-making.

Discussion

This case highlights the critical role of pedal acceleation time (PAT) in diagnosing arterial perfusion and predicting wound healing in CLTI patients. PAT provided real-time, non-invasive insights into the patient's hemodynamic status, enabling the clinician to confidently delay invasive intervention until clinically necessary. By correlating PAT with the patient's wound healing outcomes, this case reinforces the utility of PAT as a reliable predictor in PAD management. Current published literature demonstrates the positive correlation with standard methods, such as transcutaneous oxygen pressure (TCP02) and toe pressures (TP) [6–7]. As such, PAT may be a more efficient and accurate method to assess the perfusion status helping guide the timing of revascularization.

Conclusion

Pedal acceleration time (PAT) has proven to be a valuable diagnostic tool for assessing lower extremity perfusion and predicting wound healing in patients with PAD. By providing precise real-time objective measurements of blood flow hemodynamics, PAT offers critical insights that help clinicians decide when conservative management is sufficient and when revascularization is necessary. This case demonstrates the potential of PAT in optimizing treatment strategies and improving clinical outcomes in patients with PAD and CLTI.

References

[1] Conte, M. S., Bradbury, A. W., Kolh, P., White, J. V, Dick, F., Fitridge, R., ... GVG Writing Group. (2019). Global vascular guidelines on the management of chronic limb-threatening ischemia. Journal of Vascular and Endovascular Surgery, 58(1), S1–S109.

[2] Tehan, P. E., Santos, D., & Chuter, V. H. (2016). A systematic review of the sensitivity and specificity of the toe-brachial index for detecting peripheral artery disease. Vascular Medicine, 21(4), 382-389.

[3] Sommerset, J., Teso, D., Feliciano, B., Vea, Y., Sentman, M., Zimmerman, ... Karmy-Jones, R. (2019). An Innovative Arterial Duplex Examination: A Guide to Evaluate Flow in the Foot Using Pedal Acceleration Time. JVU, 43(1), 11-17.

[4] Sommerset, J., Karmy-Jones, R., Dally, M., Feliciano, B., Vea, Y., & Teso, D. (2019). Plantar Acceleration Time: A Novel Technique to evaluate Flow to the foot. Ann Vasc Surg, 60, 308-314.

[5] Teso, D., Sommerset, J., Dally, M., Feliciano, B., Vea, Y., & Karmy-Jones R. (2021). Pedal Acceleration Time (PAT): A novel predictor of limb salvage. Ann Vasc Surg, 75, 189-193.

[6] Pinelo, A., Loureiro, L., Martins, J., Sommerset, J., Carvalho, R., & Machado, R. (2024). Correlation Between Pedal Acceleration Time and Transcutaneous Oxygen Pressures - A Prognostic Tool for Wound Healing in the Diabetic Foot Population. Ann Vasc Surg, 106, 400-407.

[7] Trihan, J-E., Mahe, G., Croquette, M., Coutant, V., Thollot, C., Guillaumat, J., & Laneelle, D. (2022). Accuracy of Acceleration Time of Distal Arteries to Diagnose Severe Peripheral Arterial Disease. Front Cardiovasc Med, 8(8444354), 1-8.

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