How and why to measure foot perfusion during endo treatments and when is the angiosome concept helpful, when not?

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No Disclosures

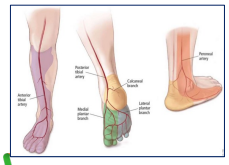
Tissue perfusion in CLI

- Ideal test for foot perfusion should be:
  - inexpensive
  - readily available
  - reproducible
  - improve the clinician's ability to predict outcomes
  - provide perfusion data specific to the area of the foot with a wound
- Improving the ability to evaluate foot perfusion would benefit patients with CLI by
  - assisting with the etiology of a non-healing wound
  - identifying patients with poor perfusion in the angiosome of interest who might benefit from revascularization
  - identifying patients with seemingly adequate perfusion who may not require revascularization
  - selecting a target vessel for revascularization
  - providing insight when revascularization is sufficient
  - facilitating surveillance for patency

Mills JL, Shishehbor MH, Tadaksahi EA, et al. Perfusion assessment in critical limb ischemia: Principles for under- standing and the development of evidence and evaluation of devices: A scientific statement from the American Heart Association. Circulation 2019; 140: e657–e672.

Angiosomes of the lower extremity

Angiosome is an anatomical concept, defined as the blood supply from a main secondary or distributing artery to a specific tissue area.

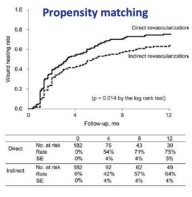


- 6 angiosomes originate from the 3 main source arteries and their branches in the foot and ankle
- Each angiosome is linked with very small vessels, i.e., choke vessels that allow a given angiosome to provide blood flow to an adjacent angiosome if the latter's source artery is damaged

Shishehbor MH, et al. Circ Cardiovasc Interv. 2014;7:642-644

The angiosome-oriented revascularization for CLI patients without concurrent wound infection and DM

After propensity matching of characteristics, analysis showed better wound healing in the DR group than in IR group.

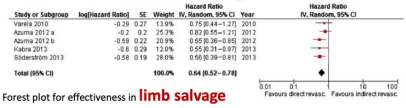


- Wound healing speed was significantly faster in less severe condition of CLI (non-DM and non wound infection)
- All CLI should be primarily considered for direct revascularization if lesions are technically feasible.

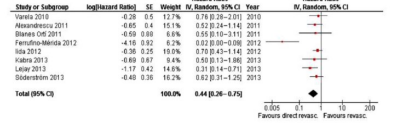
Iida O, et al. J Endovasc Ther. 2014;21:607-615

Meta-analysis of Angiosome concept

Forest plot for effectiveness in **wound healing**



Forest plot for effectiveness in **limb salvage**



Biancari F. Eur J Vasc Endovasc Surg. 2014;47:517-522

Main criticism for angiosome concept

- Angiosome has multiple definitions that makes comparisons between studies difficult
- Angiosomes were designed as dynamic concept to be applied to non-vascular patients
- The foot vascular anatomy is seriously affected in CLI. The regional vascular foot perfusion cannot be statically schematized
- Diffuse distal vascular lesions prevent the DR of the injured angiosome in more than a half of the revascularization procedures and patent foot medium-sized collateral vessels (arterial-arterial connections) could be the only way to achieve ulcer local blood perfusion

Tissue perfusion_Imaging techniques

Transcutaneous oximetry (TcPO2)

measures oxygen diffusion from the capillary beds to the epidermal layer of the skin

Sensor-containing electrode placed on the skin, warms the surrounding skin leading to local hyperthermia, measures the partial pressure of oxygen in the underlying tissue

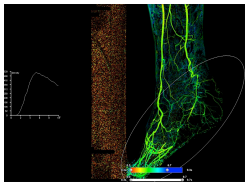
Benefit

- Can be predictive of wound healing
- Identify individuals with nonhealing ischemic wounds who may benefit from hyperbaric oxygen therapy (HBOT)
- Noninvasive, bedside tool with no radiation exposure

Limitation

- Mechanism of action (skin perfusion): barriers to diffusion can lead to falsely low TcPO2 values

Tissue perfusion_Imaging EVT



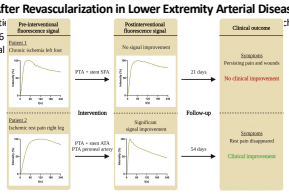
Two-dimensional angiographic perfusion. Right: Color map of the foot generated from a standard catheter-based angiogram. Left: Time density curve representing the time to peak contrast density in the foot. The average time to peak contrast density for this patient was 4.0 seconds

Tissue perfusion_Imaging EVT

Indocyanine green angiography

Near-Infrared Fluorescence Imaging With Indocyanine Green to Predict Clinical Outcome After Revascularization in Lower Extremity Arterial Disease

- 72 patie chemia) including40 endovascular- and 36
- Clinical

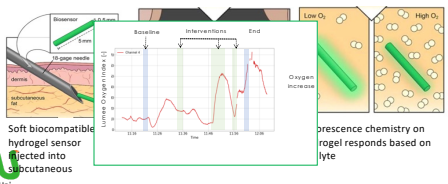


Targe-Fl et al. Angiology 2021; Vol. 00(1) 1–9

Tissue perfusion_Imaging EVT

Oxygen Microsensors

- injectable oxygen microsensors to directly monitor oxygen in the subcutaneous tissue in vivo



Soft biocompatible hydrogel sensor jected into subcutaneous

rescence chemistry on rogel responds based on lyte

Tissue perfusion_Imaging EVT

Oxygen Microsensors

Available evidence/3 studies

- Healthy volunteer study provided validation of the ability of oxygen microsensors to reliably detect changes in tissue oxygen confirmed by TcPO2, with data over 3 months after sensor injection [1]
- FIH/ 10 CLI- patients average tissue oxygen in the affected foot increased after EVR [2]
- Post-market Registry study (OMNIA): Increases in oxygen levels assessed during endovascular revascularization procedures were associated with wound healing 3 months following the procedure [3,4]

Benefit

- Sensitivity to both arterial insufficiency and microvascular impairment (eg diabetics)
- Treatment planning and long-term monitoring
- Prediction of wound healing

Limitation

- Limited data available

1 Jäckle SC, Schneider PA, Klitzman B, et al. Microvasc Res 2018; 124: 6–18. 2 Montero-Baker MF, Au-Yeung KY, Wisniewski NA, et al. J Vasc Surg 2015; 61: 1521–1528 e1. 3 Bendmann M. Interventional course (LINC), Leipzig, Germany, 2019

Tissue perfusion_EVT

- Angiosome concept is helpful but shows limitations
- Tissue perfusion (modern methods) seem promising
- But ideal "assessment tool" has not been identified yet

Tissue perfusion _EVT _ Limitations to overcome

WOUNDOSOME Concept: Concept of the preferred target artery pathway (TAP)

- Interventionalists should identify a preferred primary target path through the least-diseased (or most suitable) crural artery, sharing some similarity with the surgical principle of bypassing to the highest quality vessel providing runoff to the foot
- directly assess in-line arterial flow to the tissue loss territory
- Existing literature focusing on CLTI patients with tissue loss has consistently indicated that the presence of direct arterial flow to the wound is associated with superior outcomes in terms of limb salvage and wound healing

Tissue perfusion _EVT _ Limitations to overcome

Assessing the Woundosome

- To perform a comprehensive evaluation of the small-caliber below-the-knee (BTK) outflow arteries, the preferred method is super-selective Digital Subtraction Angiography (DSA)
- Necessary to conduct anteroposterior (dorso-plantar) and lateral angiograms of the foot to fully delineate perfusion to the ischemic penumbra

Patrone L et al; J Endovasc Ther; 2024 Mar 25:15266028241231745.

Thank you for your attention