Ultrasound – Deep Vein Arterialization Post-Op Graft Surveillance

PURPOSE:
To survey the LimFlow graft including arterial inflow and venous outflow for continued viability and "stealing branches" of the arterialized vein.

SCOPE:
Applies to Ultrasound LimFlow Graft evaluation and TBI studies requested to be performed as part of routine post-operative follow-up and surveillance:

- UT Southwestern William P. Clements Jr. University Hospital and Clinics, Imaging Services (UTSW Radiology)

ORDERABLE:

- US VEIN MAPPING LOWER EXTREMITY PRE-SURGICAL
- US DOPPLER ARTERIAL LOWER EXTREMITY LEFT/RIGHT
- US ANKLE BRACHIAL ARTERIAL INDICES (ABI)

CHARGEABLE:

- 93926 (Unilateral Lower Extremity Arterial Duplex)
- 93971 (Unilateral Lower Extremity Venous Duplex)
- 93922 (ABI)
    - For unilateral TBI evaluation due to amputation, Add "RT" or "LT as a modifier in "Charges".

INDICATIONS:

- Post-operative surveillance of the LimFlow graft and inflow and outflow vasculature.
- May be referred to as DVA or LimFlow Graft

CONTRAINDICATIONS:

- No absolute contraindications
- Evaluation of graft may not be possible within the first 24-48 hours post-op due to post-surgical air and limited visibility of graft. If surgeon requests evaluation during this time period, evaluate what you can see.

EQUIPMENT:

- Commercial duplex Doppler ultrasound system
    - Preferably a linear array transducer that allows for appropriate resolution of anatomy (frequency range of 9 mHz or greater), capable of duplex imaging. Sector or curvilinear transducers may be required for appropriate penetration in patients with edema or large body habitus
    - A hockey stick probe may be used for plantar vein evaluation
- Vasculab physiologic testing system
    - 4-8 MHz continuous wave transducer

PATIENT PREPARATION:

- Patient should be placed in a supine position.

EXAMINATION:

GENERAL GUIDELINES:

- The duplex examination will be unilateral unless otherwise indicated.
- A complete examination includes evaluation of the entire course of the accessible portions of each vessel and graft.
- Variations in technique must be documented.

EXAM INITIATION:

- Introduce yourself to the patient/family.
- Verify patient identity using patient name and DOB.
- Explain test.
- Obtain patient history including symptoms.
- Enter and store data page.
- Patient should be placed in a supine position.

TECHNICAL CONSIDERATIONS:

- Equipment gain and display settings will be optimized while imaging vessels with respect to depth, dynamic range, and focal zones.
- Proximal and distal refer to the relative distance from the attached end of the limb (proximal PTV/PTA is closer to knee, and distal is closer to foot; Prox GSV is below knee, distal GSVis at ankle).

- TBI Considerations
  - TBI should be obtained bilaterally.
  - Required on all patients unless patient has a TMA – transmetatarsal amputation.
  - If 1st digit is amputated, obtain next neighboring digit TBI. It is not required to obtain same digit bilaterally (ie. If Rt 1st digit is amputated, obtain Rt 2nd digit and Lt 1st digit). Add "Rt" or "Lt" modifier in End Navigator charges.

- Arterial Duplex Considerations
  - Follow the guidelines established in the "US Arterial Duplex Lower Extremity" protocol to evaluate for native arterial inflow arterial stenosis.
  - Angle must be 60® and steered parallel to vessel walls.

- TADV Graft Considerations
  - LimFlow graft will be labeled "TADV Graft" (Transcatheter arterialization of deep veins).
  - Flow volumes will be obtained at multiple levels.
  - Do not obtain a volume flow at a stenosis. Instead, obtain pre-, at-, and post- stenosis PSV and EDV.
  - Any flow volume < 75 ml/min needs surgical attention!
  - Any flow volume > 400 ml/min suggests there may be stealing branches. Evaluate carefully!
    - If a stealing branch is suspected, evaluate flow volume prox and distal to branch. If there is a >100 ml/min from prox to distal, this is a functional stealing branch.

DOCUMENTATION:

1. Arterial Inflow Evaluation

1	Common Femoral Artery (CFA)	Long, with and without color
2	Common Femoral Artery (CFA)	Long, spectral Doppler w/ PSV, EDV
3	Profunda Femoris Artery (PFA)	Long, with and without color
4	Profunda Femoris Artery (PFA)	Long, spectral Doppler w/ PSV, EDV
5	Superficial Femoral Artery (SFA), PROX	Long, with and without color
6	Superficial Femoral Artery (SFA), PROX	Long, spectral Doppler w/ PSV, EDV
7	Superficial Femoral Artery (SFA), MID	Long, with and without color
8	Superficial Femoral Artery (SFA), MID	Long, spectral Doppler w/ PSV, EDV
9	Superficial Femoral Artery (SFA), DIST	Long, with and without color
10	Superficial Femoral Artery (SFA), DIST	Long, spectral Doppler w/ PSV, EDV
11	Popliteal Artery (Pop A), PROX	Long, with and without color
12	Popliteal Artery (Pop A), PROX	Long, spectral Doppler w/ PSV, EDV
13	Popliteal Artery (Pop A), DIST	Long, with and without color
14	Popliteal Artery (Pop A), DIST	Long, spectral Doppler w/ PSV, EDV
15	Posterior Tibial Artery (PTA), DIST	Long, with and without color
16	Posterior Tibial Artery (PTA), DIST	Long, spectral Doppler w/ PSV, EDV
17	Peroneal Artery (Pero A), DIST	Long, with and without color
18	Peroneal Artery (Pero A), DIST	Long, spectral Doppler w/ PSV, EDV
19	Anterior Tibial Artery (ATA), DIST	Long, with and without color
20	Anterior Tibial Artery (ATA), DIST	Long, spectral Doppler w/ PSV, EDV

2. TADV Graft Evaluation

1	Inflow/Native Artery, Prox to stent	Long, with and without color
2	Inflow/Native Artery, Prox to stent	Long, spectral Doppler w/ PSV, EDV
3	Inflow/Native Artery, Prox to stent	Long, Flow Volume
4	TADV Crossing Stent	Long, with and without color
5	TADV Crossing Stent	Long, spectral Doppler w/ PSV, EDV
6	TADV Crossing Stent	Long, Flow Volume
7	TADV Graft, PROX	Long, with and without color
8	TADV Graft, PROX	Long, spectral Doppler w/ PSV, EDV
9	TADV Graft, PROX	Long, Flow Volume
10	TADV Graft, MID	Long, with and without color
11	TADV Graft, MID	Long, spectral Doppler w/ PSV, EDV
12	TADV Graft, MID	Long, Flow Volume
13	TADV Graft, DIST	Long, with and without color
14	TADV Graft, DIST	Long, spectral Doppler w/ PSV, EDV
15	TADV Graft, DIST	Long, Flow Volume
16	Outflow in Arterialized vein, 2 cm below TADV Graft	Long, with and without color
17	Outflow in Arterialized vein, 2 cm below TADV Graft	Long, spectral Doppler w/ PSV, EDV
18	Outflow in Arterialized vein, 2 cm below TADV Graft	Long, Flow Volume
19	Lateral Plantar Vein (LPV), PROX	Long, with and without color
20	Lateral Plantar Vein (LPV), PROX	Long, spectral Doppler w/ PSV, EDV
21	Lateral Plantar Vein (LPV), PROX	Long, Flow Volume
22	Lateral Plantar Vein (LPV), DIST	Long, with and without color
23	Lateral Plantar Vein (LPV), DIST	Long, spectral Doppler w/ PSV, EDV
24	Lateral Plantar Vein (LPV), DIST	Long, Flow Volume
*Evaluate for any LPV branches from the stent end at the prox foot to distal foot. If visualized, obtain VF Proximal to and Distal to the branch **Evaluate for any stenosis within the stent and in the outflow pedal vein		

- If you identify a stenosis (obvious narrowing on grayscale, PSV > 180 cm/sec, focal spectral broadening/turbulent flow), you will need to document the following:
  - At the site of stenosis
    - Grayscale lumen diameter
    - Doppler waveform
    - Peak Systolic Velocity (PSV)
  - At a site 2 cm proximal to the stenosis (or relatively normal segment of proximal vessel)
    - Grayscale diameter
    - Doppler waveform
    - PSV

3. Venous Return Evaluation

1	Posterior Tibial Vein (PTV) (parallel, unstented vein), DIST	Long, with and without color
2	Posterior Tibial Vein (PTV) (parallel, unstented vein), DIST	Long, spectral Doppler w/ PSV, EDV
3	Anterior Tibial Vein (ATV), DIST	Long, with and without color
20	Anterior Tibial Vein (ATV), DIST	Long, spectral Doppler w/ PSV, EDV
4	Greater Saphenous Vein (GSV), DIST at ankle	Long, with and without color
5	Greater Saphenous Vein (GSV), DIST at ankle	Long, spectral Doppler w/ PSV, EDV
6	Medial Marginal Vein (MMV)	Long, with and without color
7	Medial Marginal Vein (MMV)	Long, spectral Doppler w/ PSV, EDV

4. TBI Evaluation (Toe-brachial Index)
   Obtain bilateral TBI

   - Save data page(s)

PROCESSING:

- Review examination data
- Export all images to PACS
- Note any study limitations

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- Fitzpatrick S, Dunlap E, Nagarsheth KH. Utilization of Deep Vein Arterialization for Limb Salvage. *Journal for Vascular Ultrasound*. Published online October 6, 2023. doi:https://doi.org/10.1177/15443167231202502
- Clair DG, Mustapha JA, Shishehbor MH, et al. PROMISE I early feasibility study of the LimFlow System for percutaneous deep vein arterialization in no-option chronic limb-threatening ischemia 12-month results. *Journal of Vascular Surgery*. Published online May 18, 2021. doi:https://doi.org/10.1016/j.jvs.2021.04.057

DIAGNOSTIC CRITERIA:

- Ideal VF range is 100-300 ml/min

Table 15 Diagnostic criteria for peripheral arterial diameter reduction

	Diameter reduction	Waveform	Spectral broadening	PSV distal/PSV proximal
Normal	0	Triphasic	Absent	+++ No change
Mild	1%-19%	Triphasic	Present	< 2:1
Moderate	20%-49%	Biphasic	Present	< 2:1
Severe	50%-99%	Monophasic	Present	> 2:1*

PSV, Peak systolic velocity.
*>4:1 Suggests >75% stenosis, >7:1 suggests > 90% stenosis.

Table 17 Diagnostic criteria for vein graft lesions using peak systolic velocity

- Minimal stenosis <20% with PSV ratio < 1.4 and < 125 cm/s
- Moderate stenosis of 20% to 50% with PSV ratio 1.5 to 2.4 and a PSV <180 cm/s
- Severe stenosis 50% to 75% with PSV ratio 2.5 to 4 and a PSV >180 cm/s
- High-grade stenosis > 75% with PSV ratio > 4 and PSV > 300 cm/s

PSV, Peak systolic velocity.

Table 18 Interpretation criteria for arterial stenosis after percutaneous revascularization

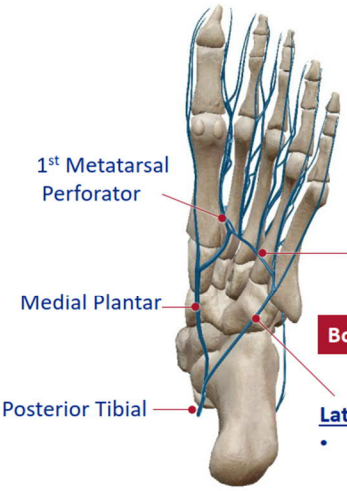
- PSV >180 cm/s
- PSV ratios >2 indicate significant stenosis
- Changes in waveform shape and velocity measurements on serial examinations warrant close interval follow-up

PSV, Peak systolic velocity.

APPENDIX:

Pedal Venous Anatomy: Overview

Plantar Veins



Bottom view of left foot

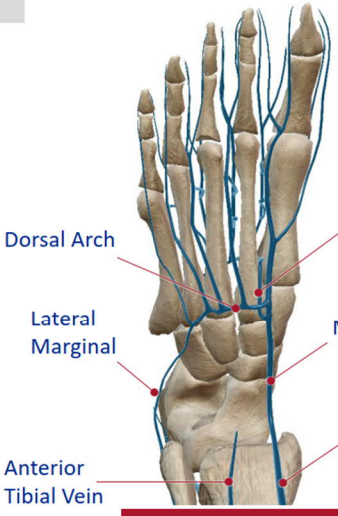
VEINS TO KNOW

1. Lateral Plantar
2. Medial Plantar
3. Posterior Tibial
4. Lateral Marginal
5. Dorsal Venous Arch
6. Medial Marginal
7. Greater Saphenous

Lateral Plantar Vein

- Paired system

Dorsal Veins



Top view of left foot

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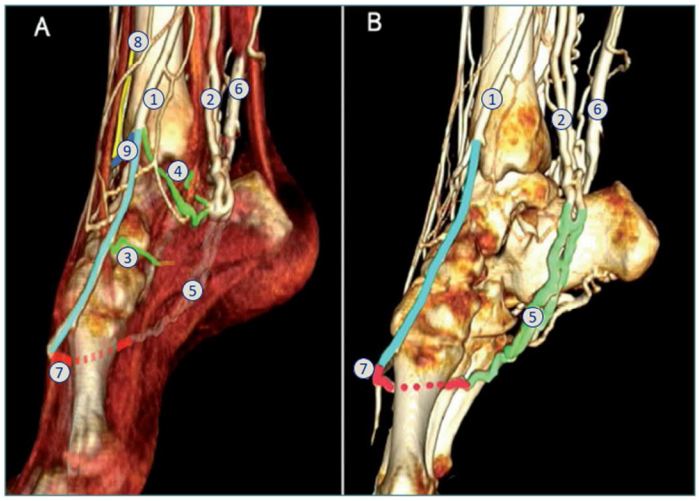
Pedal Venous Anatomy: Arterialized Circuit

1. Great saphenous vein
2. Posterior tibial veins
3. Navicular perforator vein
4. Inframalleolar perforator vein
5. Lateral plantar veins
6. Small saphenous vein
7. Perforator vein of the first inter-metatarsal space
8. Anterior tibial vein
9. Dorsal perforator to the anterior tibial vein



Uhl JF, Vuolo M, Gillot, C. Anatomy of foot and ankle perforator veins. Phlebolymphology. 2017;24(2):105-112.

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Volume Flow Rate: **Correct Example**

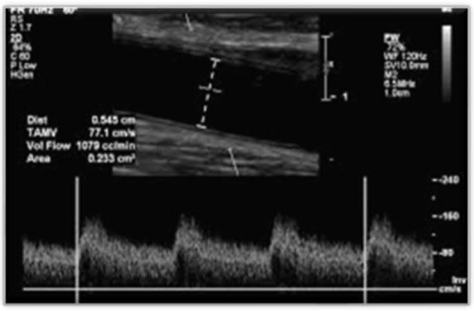
Proper technique is critical

Doppler angle at 60°

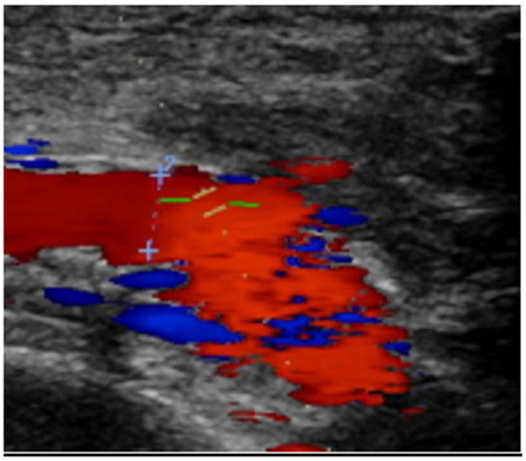
Accurate diameter measurement (color off)

Sample volume widened to encompass entire vessel lumen

TAMV averaged over several cardiac cycles



Incorrect Examples:



Why:

1. Sample gate is not wide enough for the entire vessel.
2. Doppler sample not centered in the vessel.
3. AP measurement is not accurate/perpendicular to the angle.
4. AP measurement is not taken at the same spot the Doppler is.

Why:

1. Sample gate is too small.
2. AP measurement is not a true AP measurement / obliqued.
3. Doppler angle is not parallel to the vessel wall.

CHANGE HISTORY:

STATUS	NAME & TITLE	DATE	BRIEF SUMMARY
Submission	Skye Smola, US Technical Supervisor	11/27/2023	Submitted
Approval	Dr. Girish Kumar	12/22/2023	Approved
Review			Reviewed
Revisions			