Compendium of Critical Limb Ischemia (CLI) in Peripheral Arterial Disease

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Agenda

- Our patient
- Important classifications and pre-imaging evaluation of patient
- Conceptual framework for acute vs. chronic critical limb ischemia (CLI)
- Menu of tests available for evaluation
- Vascular anatomy
- Evaluation and Management of our patients with additional images
- Follow-up s/p bypass surgery
Our patient: history and presentation

Patient A.C. acute on chronic CLI

- 61yo woman presents with worsening pain and erythema of right foot with eschar forming lesion (lesion present for two months)
- PE- D Femoral pulses bilaterally, absent P/DP/PT bilaterally
- PMH- TIIDM, HTN, Obesity, PAD, Smoker.
- PSH- bilateral iliac stents, cardiac cath. with stents, left kidney stent
Peripheral artery disease (PAD)- Stenotic, occlusive, and aneurysmal diseases of the aorta and its branches; primarily caused by atherosclerosis and thromboembolic processes.

DDx. for occlusive arterial disease

- Thromboembolic, inflammatory, or aneurysmal disease
- Atherosclerosis
- Trauma
- Adventitial cysts
- Entrapment syndromes
- Congenital abnormalities
Risk factors for atherosclerosis

- Cigarette smoking
- Diabetes
- Dyslipidemia
- Hypertension
- Hyperhomocysteinemia
Evaluation of CLI prior to imaging

- **H+P** - establish time frame, exercise/rest pain, pain worsens on leg elevation, ulcers, long history of PAD +/- claudication, FHx of AAA, pulses, bruits, skin exam

- **ABI** - resting ABI of <0.4 support diagnosis of CLI (normal is between 0.9-1.2). Change in ABI rest-exercise >15-20% = PAD. Evaluation is limited in stiff arteries
  - **Toe-Brachial index** measures digit perfusion and is more useful than ABI in non-compliant posterior tibial (PT) and anterior tibial (AT) arteries
**CLI Algorithm**

CLI clinically diagnosed (presents with rest pain, non-healing ulcer, or gangrene)
- assess time course

**Acute**
- clinically 5P’s or Blue toe syndrome
- Anticoagulate and categorize

- Viable limb
- Threatened marginally
- Threatened immediately

**Chronic**
- time course > 2 weeks, most often PAD related

- Image to assess treatment options and reduce risk factors for limb loss

- Medical (rare)
  - Antiplatelet + anticoagulant and positioning

- Revascularize
  - Endovascular or Bypass

- Other (currently experimental):
  - Spinal cord stimulation, angiogenic factors

- Medically manage

Revascularize
- Endovascular, Bypass, or Catheter Based Thrombectomy

Imaging

Amputation

Adapted from TASC Pocket Guide to Acute CLI; www.tasc-2-pad.org
DDx framework for acute CLI

1. **Conditions that mimic occlusive disease**-
   - Shock, phlegmasia cerulea dolens, acute compressive neuropathy

2. **Occlusive disease other than acute PAD**-
   - Arterial trauma, Aortic/arterial dissection, Arteritis w/ thrombosis, HIV, spontaneous thrombosis in hypercoagulable state, popliteal adventitial cyst w/ thrombosis, popliteal entrapment with thrombosis, compartment syndrome

3. **Acute PAD**-
   - Thrombosis of atherosclerosed stenotic artery, Thrombosis of arterial bypass graft, Embolism from heart/aneurysm/plaque/critical stenosis upstream, thromboosed aneurysm +/- embolization

Adapted from TASC Pocket Guide to Acute CLI; www.tasc-2-pad.org
Menu of tests for CLI

- Segmental Doppler pressures and Plethysmography
- Duplex Imaging
- Computed Tomography Angiography (CTA)
- Magnetic Resonance Angiography (MRA)
- Contrast Angiography
Noninvasive non-imaging: Segmental Doppler

Advantages
- Segmental Doppler Pressures- assess severity and level of PAD.

Disadvantages
- Seg. Dopp.- inaccurate in stiff arteries; can’t differentiate between occlusion and stenosis

Significant occlusion = > 20mmHg reduction between segments along same leg or as compared to same segment on opposite leg

Localizing (by where reduction in pressure is seen)
- Thigh = aortoiliac or SFA disease
- Calf = distal SFA or popliteal disease
- Ankle = Infrapopliteal disease

TASC Pocket Guide to Management of PAD; www.tasc-2-pad.org³
Noninvasive non-imaging: Plethysmography

Advantages
- Useful in patients with non-compressible vessels

Disadvantages
- Qualitative and not quantitative, also could be inaccurate in low stroke volume

Seg. Dopp. + Plethysmography has a 95% accuracy in identifying and localizing significant occlusions

Stenosis causes a flattening and widening of wave form seen in PAD

TASC Pocket Guide to Management of PAD; www.tasc-2-pad.org
Purpose of imaging in CLI

- Confirmation of diagnosis
- Localization and severity of lesion
- Assessment of hemodynamic requirements for successful revascularization
- Assessment of patient’s endovascular/operative risk

Table adapted from - Norgen L., TASC II Working Group
Non-invasive imaging: Duplex Doppler US

Duplex Doppler US studies include b-mode imaging, pulse wave doppler, continuous wave doppler, and color display doppler.

Advantages

- Differentiates stenosis from occlusion in addition to assessing location and severity.
- Sens. and Spec. for stenosis >50% is 88% and 96%.

Disadvantage

- Takes a long time and dense calcification/proximal stenosis can limit evaluation.
- User and location of vessel dependent. Few centers use it alone for pre-op mapping.

Stenosis → loss of normal triphasic waveform and increased velocities (wave height).

TASC Pocket Guide to Management of PAD; www.tasc-2-pad.org

Systole
Early diastole
Late diastole
Non-invasive imaging: MRA vs. CTA

**MRA**

**Advantages**
- Effectively assesses location and degree of stenosis and selects candidates for intervention
- More accurate for detecting stenosis and pre-op planning than US
- Sens. and Spec. are 95% and 97% for stenosis >50%
- MRA is more accurate in heavily calcified atheromatous arteries (thus MRI better for elderly >84yo, diabetics)

**Disadvantages**
- Costly
- Motion artifact
- Overestimates degree of stenosis
- Loss of signal in arterial segments with metal clips/stents
- Usual MRI contraindications apply
- Small risk of NSF

**CTA**

**Advantages**
- Fast scan times
- Works in those with contraindication to MRA
- Localizes PAD and selects candidates for intervention
- Images soft tissue surrounding vessel
- Sens. and Spec. are 91% and 91% for stenosis >50%

**Disadvantages**
- Requires contrast and ionizing radiation
Invasive Imaging: Contrast Angiography with digital subtraction

Advantages
- Gold standard when revascularization planned

Disadvantages
- Inconsistency between hemodynamic effects and morphology of lesion
- Diffusely diseased arteries difficult to assess for stenosis and collateral contribution
- Associated invasive risks—hematoma, dissection, infection, bleeding
Vascular anatomy of the abdomen
Vascular anatomy of the proximal lower extremities
Vascular anatomy of the distal lower extremities (LE)
Our patient A.C.- CTA with no flow in distal right PT artery

- Clinical diagnosis of ischemic PAD causing non-healing wound
- DDx for foot ulcer divided into arterial, venous, or nerve problem; diagnosis is clinical
- CTA used to assess extent of disease and interventional options
- Pre-op: Duplex Art. US, ECG, Chest x-ray
- Other radiologic considerations: evaluation for osteomyelitis in deep non-healing ulcer of foot

![Rt. LE Sagittal view of C+ CTA Runoff](image)

No flow in distal PT artery
Our patient A.C. - Bilateral LE CTA

Engorgement of collateral vessels
Our patient A.C. - Axial Abdominal CTA

C- CTA axial abdominal view

Renal cyst

Calcified Abdominal Aorta
Our patient A.C.- CTA showing Aortoiliac occlusion

C+ CTA Runoff axial view of abdomen

C+ CTA Runoff frontal view of abdomen and LE

Partial occlusion of Abdominal Aorta with soft plaque

Complete occlusion of Abd. Aorta and proximal Iliacs

Renal cyst
Our patient A.C.- Occluded Lt. Common Iliac artery on CTA

- Occluded left Common Iliac and patent right Common Iliac; both are calcified
- Left Common Iliac beginning to recannulate at this level
Our patient A.C.- Pre-op Arterial Duplex US

- Immediately treated with Heparin
- Patent Left Brachial artery with triphasic waveforms seen on this US
- Patient received axillary-bifem bypass and was discharged from hospital in stable condition
Is this Atheroembolic Disease?

Clinical clues that should prompt further evaluation for embolic source include:

- Recent endovascular manipulation
- Rising Creatinine levels
- Symmetrical acute bilateral limb symptoms
- Livido reticularis
Companion Patient 1: Lt. Atrial thrombus and Popliteal artery embolism on CTA

C+ CTA of thorax axial view

C+ CTA Runoff of lower extremity sagittal view

Thrombus in left atria

Popliteal artery occlusion (non-calcified): source from left atria

Image courtesy of Faisel Khosa, MD BIDMC PACS
Now for other imaging modalities discussed with additional companion patients
Companion patient 2: Rt. Internal Iliac stenosis on MRA

Pt. presented with left foot claudication

MRA with Gadolinium: coronal of Pelvis

- Stenosis of right Internal Iliac
- External Iliac arteries

MRA with Gadolinium: axial view of pelvis

- # Psoas muscle
Companion patient 2: Diffuse PAD of lower extremities on MRA

MRA with Gadolinium: frontal view of distal LEs

MRA with Gadolinium: frontal view of distal left leg

Multiple focal points of stenoses (right AT artery and bilateral PT arteries) with less collateral blood flow to left foot compared to right.
Companion patient 3: Multiple Stenoses of Iliacs on contrast angiography

Pt. presented with left foot claudication

Contrast angiogram: frontal view of pelvis

Contrast angiogram: frontal view of pelvis with digital subtraction (DS)
Companion patient 3: Stenoses of infrainguinal vessels on contrast angiography

Contrast angiogram: frontal view of left hip

- Left External Iliac artery
- Superficial Femoral artery
- Profunda Femoris artery
- Focal stenosis

Contrast angiogram: frontal view of left hip with digital subtraction (DS)
Companion patient 3: Stenoses and collaterals of lower vessels on contrast angiography

- Focal stenosis
- Enlarged collateral feeding into Popliteal artery
- Superficial Femoral artery with adjacent enlarged collateral vessel
Companion patient 3: Endovascular Intervention

F/u: one year later patient required left CF artery to PT artery bypass when he presented with non-healing ulcer on left foot.
**Recommended radiologic f/u for patients post vascular bypass**

### Variant 1: Intrainguinal vein graft, asymptomatic. Screening.

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<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
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**Rating Scale:** 1=Least appropriate, 9=Most appropriate  

### Variant 2: Intrainguinal graft, symptoms of ischemia and/or abnormal ABI.

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<td>See statement regarding contrast in text under &quot;Anticipated Exceptions.&quot;</td>
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Table courtesy of American College of Radiology. ACR Appropriateness Criteria. [www.acr.org](http://www.acr.org)
Take Home points

- A thorough vascular H+P is important for patients suspected of having CLI
- Distinguishing acute vs. chronic CLI is vital for imaging purposes and management
- Effective noninvasive non-imaging techniques to assess PAD in outpatient setting are segmental doppler and plethysmography
- Remember the purpose of imaging is not only to confirm diagnosis but also to map out options for intervention and assess intra-op risk
- MRA and CTA are both commonly used for pre-op mapping currently
- Contrast angiography is still gold standard when revascularization is planned but has many risks
- As occlusion of stents, grafts, and bypass conduits are common post-op surveillance is important in the post-op patient, whether they have symptoms or not
Acknowledgements

- Faisel Khosa, MD
- Adam Jeffers, MD
- Gillian Lieberman, MD
- Maria Levantakakis
References

5. Collins R., Burch J., et al., Duplex ultrasonography, magnetic resonance angiography, and computed tomography angiography for diagnosis and assessment of symptomatic, lower limb peripheral arterial disease; systematic review. BMJ 2007; www.bmj.com; doi 10.1136/bmj.39217.473275.55