Peripheral Artery Disease, Acute Limb Ischemia, and Gangrene in the Hospital Setting

Peripheral artery disease (PAD), acute limb ischemia (ALI), and gangrene are vascular conditions that can lead to significant morbidity and mortality if not managed promptly in the hospital setting. This pamphlet provides students with a guide to diagnose, evaluate, and manage these conditions, with clinical scenarios to apply the knowledge.

Clinical Presentation

Peripheral Artery Disease (PAD):

- Symptoms:
  - Intermittent claudication (leg pain with walking, relieved by rest),
  - rest pain (severe, nocturnal, in advanced disease), non-healing ulcers, hair loss, cool/dry skin.
- Exam:
  - Diminished pulses (femoral, popliteal, dorsalis pedis, posterior tibial), pallor on elevation, dependent rubor, muscle atrophy, delayed capillary refill (>2 sec).
- Risk Factors:
  - Smoking, diabetes, hypertension, hyperlipidemia, age >60, family history of cardiovascular disease.

Acute Limb Ischemia (ALI):

- Symptoms:
  - **Sudden onset of the "6 Ps":** Pain, Pallor, Pulselessness, Paresthesia, Paralysis, Poikilothermia (cold limb); symptoms progress within hours.
- Exam:
  - Absent pulses, pale/cyanotic limb, sensory loss (numbness), motor deficits (weakness/paralysis), cool skin.
- Classification (Rutherford):
  - **I:** Viable (no sensory/motor loss, audible Doppler signals).
  - **IIa:** Marginally threatened (mild sensory loss, inaudible arterial Doppler, audible venous).

- **IIb:** Immediately threatened (sensory/motor loss, inaudible Doppler).
- **III:** Irreversible (profound paralysis, rigor, no Doppler signals).

- Causes:
  - Thrombosis (60%, often in PAD), embolism (30%, e.g., AF, mural thrombus), trauma, dissection.

Gangrene:

- Symptoms:
  - Tissue necrosis, black/gray discoloration, foul odor, pain (early, later insensate), systemic symptoms (fever, sepsis if wet gangrene).
- Types:
  - **Dry Gangrene:** Mummified tissue, slow progression, often in PAD (toes, feet).
  - **Wet Gangrene:** Moist, infected tissue, rapid progression, often post-ALI or trauma.
  - **Gas Gangrene:** Clostridium perfringens, crepitus, gas on imaging, rapid systemic toxicity.
- Exam:
  - Black/gray tissue (dry), moist/purulent tissue (wet), crepitus (gas), surrounding erythema, systemic signs (fever, tachycardia).

Diagnosis

Initial Assessment:

- History:
  - Symptom onset (gradual in PAD, sudden in ALI), risk factors (smoking, diabetes, AF), trauma, prior vascular procedures, systemic symptoms (fever, sepsis).
- Physical Exam:
  - Assess pulses (femoral, popliteal, dorsalis pedis, posterior tibial), skin (pallor, rubor, necrosis), sensory/motor function, signs of infection (erythema, warmth, purulence).

Labs:

- CBC:
  - Leukocytosis (infection, wet gangrene), anemia (chronic disease, PAD), thrombocytopenia (sepsis, DIC in ALI/gangrene).

- CMP:
  - **Glucose:** Elevated in diabetes (PAD risk), monitor for DKA/HHS in ALI/gangrene.
  - **Creatinine:** Elevated Cr (hypoperfusion, AKI in ALI), monitor for contrast-induced nephropathy post-imaging.
  - **Electrolytes:** Hyperkalemia (K >5.5 mEq/L, tissue necrosis in gangrene), lactic acidosis (lactate >2 mmol/L, ischemia).
- Coagulation:
  - **PT/INR:** Elevated in AF (source of embolism), anticoagulation (warfarin, DOACs).
  - **D-dimer:** Elevated in ALI (thrombosis/embolism), less specific in gangrene.
- Inflammatory Markers:
  - **CRP/ESR:** Elevated in infection (wet/gas gangrene), PAD (chronic inflammation).
  - **Procalcitonin:** Elevated in wet/gas gangrene (bacterial infection).
- Blood Cultures:
  - If fever, systemic toxicity (wet/gas gangrene, sepsis).
- Creatine Kinase (CK):
  - Elevated in ALI/gangrene (muscle necrosis, rhabdomyolysis risk).

Imaging:

- Ankle-Brachial Index (ABI):
  - **PAD:** ABI <0.9 (mild 0.7-0.9, moderate 0.4-0.7, severe <0.4); ABI >1.3 suggests non-compressible vessels (calcification, diabetes).
  - **ALI:** Not diagnostic (Doppler signals often absent), but baseline ABI useful for chronic PAD assessment.
- Duplex Ultrasound:
  - **PAD:** Identifies stenosis, occlusion, flow velocity; non-invasive, first-line.
  - **ALI:** Detects occlusion, thrombus; confirms absent flow in distal vessels.
- CT Angiography (CTA):
  - **PAD:** Visualizes stenosis, occlusion, collateral circulation; preferred for planning intervention.
  - **ALI:** Identifies site of occlusion (e.g., popliteal artery thrombus), extent of ischemia.
  - **Gangrene:** Soft tissue edema, gas (gas gangrene), extent of necrosis.
- Magnetic Resonance Angiography (MRA):
  - Alternative to CTA if contrast contraindicated (e.g., renal failure); similar findings.

- Conventional Angiography:
  - Gold standard for PAD/ALI; diagnostic and therapeutic (e.g., thrombolysis, stenting).
- X-ray:
  - Gas gangrene (subcutaneous gas), osteomyelitis (if gangrene-related infection).

Clinical Features and Diagnosis Table

Condition	Clinical Features	Diagnostic Tools	Key Findings
PAD	Claudication, rest pain, ulcers	ABI, Duplex US, CTA	ABI <0.9, stenosis on imaging.
ALI	6 Ps (Pain, Pallor, Pulselessness)	Duplex US, CTA, angiography	Absent pulses, occlusion on imaging.
Dry Gangrene	Black/gray tissue, mummified	ABI, CTA, X-ray	ABI <0.4, no gas, chronic ischemia.
Wet/Gas Gangrene	Moist tissue, crepitus, sepsis	CT, X-ray, tissue culture	Gas on imaging, polymicrobial culture.

Interventions, Treatment, and Overall Management

General Principles:

o Stabilize: ABCs (airway, breathing, circulation), IV access, telemetry, oxygen if SpO2 <90%.

o Restore perfusion: Urgent in ALI, elective in PAD, manage infection in gangrene.

o Prevent progression: Risk factor modification, wound care, infection control.

Peripheral Artery Disease (PAD):

- Medical Therapy:
  - **Antiplatelets:** Aspirin 81 mg PO daily or clopidogrel 75 mg PO daily (reduces cardiovascular events).
  - **Statins:** Atorvastatin 40-80 mg PO daily (target LDL <70 mg/dL, stabilizes plaques).
  - **Cilostazol:** 100 mg PO BID (for claudication, improves walking distance; avoid in heart failure) – for symptom management
- **Risk Factor Control:** Smoking cessation extremely important, BP control (target <130/80 mmHg), glycemic control (HbA1c <7% in diabetes).

- Revascularization:
  - **Endovascular:** Angioplasty, stenting (e.g., iliac, femoral artery) for claudication not responding to medical therapy (Rutherford 3) or critical limb ischemia (Rutherford 4-6).
  - **Surgical:** Bypass grafting (e.g., femoropopliteal bypass) for extensive disease or failed endovascular therapy.
- Wound Care: Debridement of ulcers, compression therapy, offloading (e.g., diabetic foot).

Acute Limb Ischemia (ALI):

- Urgent Revascularization:
  - **Rutherford I/IIa:** Catheter-directed thrombolysis (e.g., alteplase 0.5-1 mg/h intra-arterial x 12-24h) or thrombectomy (endovascular or surgical).
  - **Rutherford IIb:** Emergent surgical thrombectomy or bypass (within 6h to salvage limb).
  - **Rutherford III:** Amputation (irreversible ischemia, rigor, no Doppler signals).
- Anticoagulation:
  - **Heparin:** 80 units/kg IV bolus, then 18 units/kg/h infusion (target aPTT 60-80 sec); prevents clot propagation.
  - **Transition:** Warfarin (INR 2-3) or DOAC (e.g., rivaroxaban 15 mg PO BID x 21 days, then 20 mg daily) for 3-6 months if embolic source (e.g., AF).
- Supportive Care:
  - **IV Fluids:** NS 1-2 L IV bolus (hypovolemia, rhabdomyolysis risk), then 100 mL/h.
  - **Pain Control:** Morphine 2-5 mg IV q4-6h PRN (severe ischemic pain).
  - **Monitor:** CK (rhabdomyolysis), Cr (AKI), lactate (ischemia severity).

Gangrene:

- Dry Gangrene:
  - **Revascularization:** If viable tissue remains (endovascular or surgical, as in PAD).
  - **Amputation:** If non-viable tissue (e.g., toe, forefoot amputation), after optimizing perfusion.
  - **Wound Care:** Keep dry, avoid infection, auto-amputation possible in small areas (e.g., toes).

- Wet/Gas Gangrene:
  - **Surgical Debridement:** Emergent (within 6h), extensive removal of necrotic tissue, repeat q24-48h until clean margins.
- Antibiotics:
  - **Wet:** Vancomycin 15 mg/kg IV q12h (MRSA) + piperacillin-tazobactam 4.5 g IV q6h (polymicrobial); alternative: Linezolid 600 mg IV q12h (if vancomycin contraindicated, e.g., allergy, renal impairment, or MRSA resistance).
  - **Gas:** Penicillin G 4 million units IV q4h + clindamycin 900 mg IV q8h (C. perfringens).
- Supportive Care:
  - IV fluids (NS 2 L bolus, then 100 mL/h), pressors (norepinephrine 0.01-0.5 mcg/kg/min if shock), ICU admission.

Overall Management:

o Multidisciplinary Approach: Vascular surgery (revascularization, amputation), infectious disease (wet/gas gangrene), wound care team, physical therapy (rehabilitation).

o Risk Factor Modification: Smoking cessation, glycemic control, BP/lipid management, antiplatelets (as above).

o Follow-Up: Regular vascular checks (ABI, Duplex US), wound care, patient education on foot care (diabetes).

Treatment and Management Table

Condition	Interventions	Medical Therapy	Supportive Care
PAD	Angioplasty, stenting, bypass	Aspirin 81 mg PO daily, atorvastatin 80 mg PO daily	Smoking cessation, wound care, exercise.
ALI	Thrombolysis, thrombectomy, bypass	Heparin 80 units/kg IV bolus, then 18 units/kg/h	IV fluids, pain control, monitor CK.
Dry Gangrene	Revascularization, amputation	Antiplatelets, statins	Keep dry, wound care, optimize perfusion.
Wet/Gas Gangrene	Debridement, amputation	Vancomycin 15 mg/kg IV q12h (or Linezolid 600 mg IV q12h) + pip-tazo, penicillin + clindamycin	IV fluids, pressors, ICU admission.

Key Pearls

- **PAD:** ABI <0.9 diagnostic; treat with antiplatelets, statins, cilostazol; revascularization for critical limb ischemia (rest pain, ulcers).
- **ALI:** 6 Ps = emergency; Rutherford IIb requires surgery within 6h; heparin for all, thrombolysis for I/IIa, amputation for III.
- **Gangrene:** Dry (chronic ischemia, auto-amputation possible); wet/gas (surgical emergency, debridement + antibiotics, including linezolid as alternative to vancomycin).
- **Imaging:** Duplex US first-line for PAD/ALI; CTA for detailed anatomy; X-ray/CT for gas gangrene.
- **Revascularization:** Endovascular for PAD (claudication, Rutherford 3); surgical for ALI (Rutherford IIb, extensive disease).
- **Multidisciplinary:** Vascular surgery for revascularization, ID for wet/gas gangrene (consider linezolid for MRSA coverage), wound care team for ulcers/gangrene.
- **Monitor:** CK (rhabdomyolysis in ALI/gangrene), lactate (ischemia severity), renal function (contrast nephropathy risk, adjust linezolid if needed).

References

• **UpToDate:** “Peripheral Artery Disease: Diagnosis and Management” (2025).

• **NEJM:** “Acute Limb Ischemia: A Review” (2024).

• **J Vasc Surg:** “Management of Gangrene in Peripheral Artery Disease” (2023).

• **Circulation:** “Diagnosis and Treatment of Critical Limb Ischemia” (2024).

Clinical Scenarios

Case 1: A 65-Year-Old Male with Leg Pain

- **Presentation:** A 65-year-old male with smoking history (40 pack-years), diabetes, and HTN presents with calf pain when walking 1 block, relieved by rest, for 6 months. Exam: BP 150/90 mmHg, HR 80 bpm, diminished DP/PT pulses, cool feet, hair loss on legs.
- **Labs:** HgbA1c 8.5%, LDL 120 mg/dL, Cr 1.0 mg/dL.
- **Imaging:** ABI 0.6 (moderate PAD), Duplex US shows 70% stenosis in superficial femoral artery.
- **Diagnosis:** Peripheral Artery Disease (Rutherford 3, Moderate) → Claudication, diminished pulses, ABI 0.6.

- **Management:** Aspirin 81 mg PO daily, atorvastatin 80 mg PO daily, cilostazol 100 mg PO BID. Smoking cessation counseling. BP control (lisinopril 10 mg PO daily, target <130/80 mmHg). Vascular surgery consult for endovascular intervention (angioplasty/stenting). Supervised exercise program (30 min walking, 3x/week). Monitor ABI, LDL, and HgbA1c.

Case 2: A 72-Year-Old Female with Sudden Leg Pain

• **Presentation:** A 72-year-old female with AF (on warfarin) presents with sudden right leg pain, numbness, and weakness for 3 hours. Exam: BP 110/70 mmHg, HR 90 bpm, irregularly irregular pulse, absent DP/PT pulses, pale/cyanotic right foot, sensory loss, mild motor weakness.

• **Labs:** INR 2.5, Cr 1.2 mg/dL, lactate 3.0 mmol/L, CK 500 U/L.

• **Imaging:** CTA shows acute occlusion of right popliteal artery.

• **Diagnosis:** Acute Limb Ischemia (Rutherford IIb, Embolic) → 6 Ps, absent pulses, AF history, CTA occlusion.

• **Management:** Heparin 80 units/kg IV bolus, then 18 units/kg/h infusion. Emergent vascular surgery consult for thrombectomy (within 6h). NS 2 L IV bolus (hypovolemia). Morphine 2 mg IV q4h PRN (pain). Monitor CK (rhabdomyolysis), lactate, and renal function. Post-op: Continue warfarin (INR 2-3), echo to confirm embolic source (AF).

Case 3: A 58-Year-Old Male with Foot Necrosis

• **Presentation:** A 58-year-old male with PAD, diabetes, and recent trauma presents with black toes on his left foot, foul odor, and fever for 2 days. Exam: BP 100/60 mmHg, HR 110 bpm, Temp 39°C, black/gray toes, surrounding erythema, purulent discharge, crepitus.

• **Labs:** WBC 18,000/µL, lactate 4.0 mmol/L, Cr 1.8 mg/dL, CK 800 U/L, tissue culture: polymicrobial (S. aureus, anaerobes).

• **Imaging:** X-ray shows subcutaneous gas, ABI 0.3.

• **Diagnosis:** Wet Gangrene (Post-Trauma, Polymicrobial) → Black tissue, purulence, crepitus, systemic toxicity.

• **Management:** Emergent surgical consult for debridement (within 6h). Linezolid 600 mg IV q12h (patient has vancomycin allergy) + piperacillin-tazobactam 4.5 g IV q6h + clindamycin 900 mg IV q8h. NS 2 L IV bolus, norepinephrine 0.01 mcg/kg/min (shock). ICU admission. Vascular surgery consult for revascularization (post-debridement). Monitor lactate, renal function, and cultures. Amputation if non-salvageable tissue.