CHAPTER 13

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# Vascular Disease and Venous Thromboembolism

## CHAPTER OUTLINE



## ABBREVIATIONS

| | |
|---|---|
| ABI | Ankle-brachial index |
| ACE | Angiotensin converting enzyme |
| ALI | Acute limb ischemia |
| ARAS | Atherosclerotic renal artery stenosis |
| ARB | Angiotensin II receptor blocker |
| ASA | Aspirin |
| CAS | Carotid artery stenting |
| CCB | Calcium channel blocker |
| CEA | Carotid endarterectomy |
| CKD | Chronic kidney disease |
| CLI | Critical limb ischemia |
| CTA | Computed tomographic angiography |
| CV | Cardiovascular |
| DP | Dorsalis pedis |
| DM | Diabetes mellitus |
| DVT | Deep venous thrombosis |
| FMD | Fibromuscular dysplasia |
| HTN | Hypertension |
| LIMA | Left internal mammary artery |
| MI | Myocardial infarction |
| MRA | Magnetic resonance angiography |
| MRI | Magnetic resonance imaging |
| NSTEMI | Non-ST-elevation myocardial infarction |
| PAD | Peripheral artery disease |
| PE | Pulmonary embolism |
| PT | Posterior tibial |
| RBBB | Right bundle branch block |
| RVSP | Right ventricular systolic pressure |
| TBI | Toe-brachial index |

# PERIPHERAL ARTERY DISEASE (PAD)

## Prevalence

- ~4% in patients over age 40
  - Increases with age and cardiovascular (CV) risk factors
  - ~15–30% in patients over age 70
- CV Implications [1]
  - Roughly 50% of PAD patients will have coronary artery disease (CAD)
  - CV events are more common than ischemic limb events
  - Ankle-brachial index (ABI) < 0.7 = risk of myocardial infarction (MI) is 20% at 5 years (double the highest-risk Framingham group)
  - ABI 0.7–0.09 = risk of MI is 10% at 5 years
- Patients at risk for PAD (All of the below risk groups have pre-test probabilities of over 15% and should be screened for PAD):

  Table 13-1 Groups with high PAD prevalence

## Presentation—Fig. 13-1

- Symptoms
  - Typical claudication—cramping calf pain exacerbated by exertion and relieved by rest; symptoms suggestive of femoral or popliteal disease
  - Atypical claudication—exertional hip, thigh or buttock pain; impotence; symptoms suggestive of aortoiliac artery disease

**TABLE 13-1**

GROUPS WITH HIGH PAD PREVALENCE

| |
|---|
| Known atherosclerotic coronary, carotid, or renal artery disease |
| Age > 70 |
| Age > 50 with DM or smoking |
| Age < 50 with DM and an additional risk factor (smoking, hypertension, hyperlipidemia) |
| Abnormal LE pulse examination |
| Exertional leg symptoms |

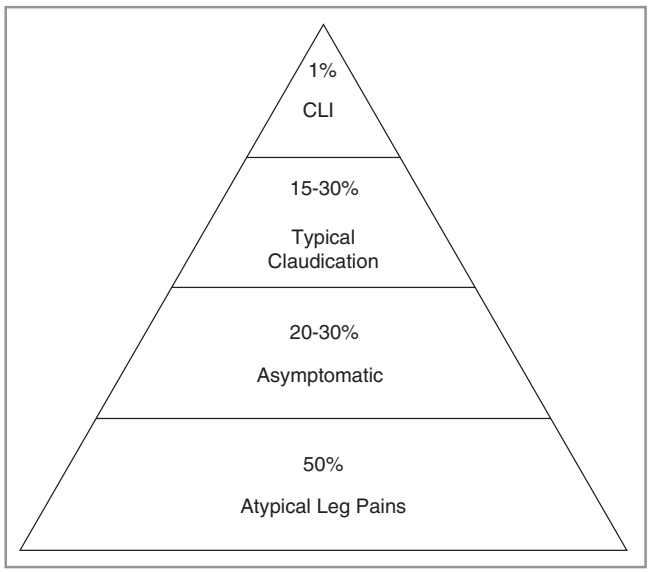


**FIGURE 13-1**

Presentation of PAD

- Critical limb ischemia (CLI)—pain at rest in the foot, non-healing ulcer, gangrene
- Acute limb ischemia (ALI)—sudden (<2 weeks) development of pain, pulselessness, pallor, coolness, and weakness [2]; severity classified into three categories:
  - I—Viable (not immediately threatened)
    - no muscle weakness or sensory loss; + arterial/venous doppler signals
  - II—Threatened
    - Mild-moderate weakness or sensory loss; absent arterial but + venous doppler signal
  - III—Irreversible
    - Major tissue loss or nerve damage is inevitable
    - Severe muscle loss/paralysis, severe sensory loss/anesthesia, both arterial and venous signals absent

- Physical examination
  - Poor peripheral pulses (femoral, popliteal, pedal)
  - Femoral artery bruit on auscultation
  - Elevation pallor (foot develops pallor when raised)
  - Dependent rubor (foot slowly becomes red when returned to the ground)
  - Poor capillary refill (>3 s)
  - Ulcerations on the toes, intertriginous spaces, borders of the feet

# Testing

$$\text{ABI} = \frac{\text{Ankle systolic blood pressure}\left(\text{highest of the DP / PT pressures}\right)}{\text{Brachial artery systolic pressure}\left(\text{highest of the right / left arm pressures}\right)}$$

- ABI Interpretation
  - 1.40: uninterpretable/incompressible
  - 1.00–1.39: normal
  - 0.91–0.99: borderline
  - 0.71–0.90: mild PAD
  - 0.41–0.70: moderate PAD
  - <0.40: severe PAD
- Exercise ABI can be performed for patients with typical claudication symptoms in whom resting ABI values are normal or borderline
- Uninterpretable ABI due to incompressible vessels secondary to Mockenburg's medial artery calcification.
  - This is more common in diabetic and elderly populations.
- Toe brachial index (TBI) can be used in the setting of uninterpretable or incompressible ABI.
  - TBI <0.7 is sensitive for dx of PAD

Table 13-2 Diagnostic Tests for PAD Evaluation

**TABLE 13-2**

DIAGNOSTIC TESTS FOR PAD EVALUATION

| | PROS | CONS |
|---|---|---|
| ABI | Non-invasive, fastest, office-based | No clarity regarding level of disease |
| Segmental pressures with pulse volume recordings | Non-invasive, rapid, no contrast | Does not clarify anatomic details |
| Arterial ultrasound | Non-invasive, no contrast | Operator-dependent, may not be able to image suprainguinal and/or infrapopliteal vessels, time consuming |
| CTA | Non-invasive | IV contrast, radiation, difficult to interpret in the setting of heavy vascular calcification |
| MRA | Non-invasive | Gadolinium, expensive, may overestimate stenosis severity |
| Digital subtraction angiography (DSA) | Best quality anatomic information, option for concurrent therapeutic procedure | Invasive, IV contrast, technical expertise necessary |

## Medical Management of PAD [3]

- Treat DM to glycohemoglobin <7%
- Daily Foot Care and Regular Podiatry Appointments
- Smoking Cessation
- Lipid Lowering Therapies—Statins decrease CV events and may improve leg functioning (i.e.: pain-free walking distance)
- Treatment of hypertension to guideline derived goals.
  - ACE-inhibitors may improve leg functioning
  - Beta-blockers are NOT harmful
- Anti-platelet therapy
  - Aspirin or clopidogrel should be used in all patients
    - CAPRIE trial showed a 24% decrease in CV outcomes for PAD patients treated with clopidogrel rather than aspirin [4]
    - CHARISMA study showed no decrease in CV outcomes from combining clopidogrel plus aspirin in patients with PAD [5]
    - EUCLID trial showed no significant benefit in reducing CV outcomes with the use of ticagrelor instead of clopidogrel in patients with symptomatic PAD [6]
- Coumadin—Coumadin is not recommended in addition to anti-platelet therapy for PAD [7]
  - The role of novel oral anticoagulants (NOAC) in addition to antiplatelet therapy for patients with PAD has not been well established [8]
- Symptomatic Medical Therapy
  - Supervised exercise rehabilitation improves pain-free walking distance.
  - Increased daily activity leads to decreased mortality
  - 3–6 months of cilostazol is recommended (contraindicated in patients with heart failure)

## Interventional Therapy

- Contraindications
  - Lack of symptoms
  - Lack of pressure gradient across an angiographic stenosis

- Endovascular revascularization
  - Indicated if life or work-limiting symptoms exist despite the trial of medical and exercise therapy
  - Primary stenting should not be performed in the femoropopliteal segments (i.e.: use stents for failure of angioplasty or atherectomy techniques)
    - Drug-coated balloon technology appears to provide durable results for patients with femoropopliteal disease [9]
- Surgical revascularization
  - Indicated if life or work-limiting symptoms exist after a trial of medical and exercise therapy and if not a good anatomic candidate for endovascular approach
  - Autogenous vein grafts are preferred to prosthetic grafts for lower extremity bypass due to improved long-term patency
- Special topic: Critical Limb Ischemia (CLI)
  - Revascularization is indicated to provide symptom relief and promote wound healing
  - Goal is to restore "straight-line" blood flow to the foot whenever possible
    - Both the suprainguinal and infrainguinal segments may need to be treated during the same session to achieve this goal
    - "angiosome" concept describes the foot in terms of compartments that receive dedicated arterial supply
      - Wounds located within a specific angiosome are more likely to heal if arterial supply to that angiosome is restored
  - Open repair and endovascular repair of the lower extremities had equivalent results in the BASIL trial [10]
- Special topic: Acute Limb Ischemia (ALI)
  - Treatment is based on ALI category at presentation
    - Category I (not immediately threatened)
- Urgent revascularization (6–24 h) + parenteral anticoagulation
    - Category II (threatened limb)
- Emergent revascularization (within 6 h) + parenteral anticoagulation
    - Category III (irreversible)
- Primary amputation
  - Seek consultation from an expert vascular interventionalist or surgeon
  - The decision between open surgical and endovascular treatment is influenced by the likelihood of the technical success and the rapidity of revascularization with each strategy.
    - Catheter directed lysis may be preferred with recent occlusions, synthetic graft thrombosis and stent thrombosis [2]

# RENOVASCULAR DISEASE

## Atherosclerotic Renal Artery Stenosis (ARAS)

- Prevalence
  - Approaches 10% in consecutive patients undergoing cardiac catheterization
  - May be up to 20% in patients with a history of diabetes mellitus and hypertension
  - Risk factors for ARAS are the same as those for development of coronary artery disease

- Presentation
  - Resistant hypertension
  - Worsening renal function with addition of ACEi/ARB (most common in bilateral disease)
  - Acute pulmonary edema (in bilateral disease)
- Physical exam
  - Severe hypertension
  - Abdominal or flank bruits
  - Signs of volume overload (in bilateral disease)
- Imaging Studies
  - Doppler ultrasound—low cost, non-invasive, no iodinated contrast but sensitivity is highly operator-dependent
  - CTA—usually provides good anatomical information, requires iodinated contrast, limited in cases of heavy calcification
  - MRA—newer gadolinium-free protocols provide excellent anatomical information without risk of nephrogenic fibrosing systemic sclerosis
  - Angiography—invasive but provides best anatomic information with opportunities for true hemodynamic assessment and intervention when necessary
- Treatment
  - Aggressive medical management of hypertension with goal of normotension—often requires three or more agents
    - ACEi/ARB—first line targets RAAS pathway, but may worsen renal function in bilateral disease requiring discontinuation
      - CCB—another first line agent which is safe to use in bilateral disease
    - Thiazide/loop diuretics—second line agents to manage sodium retention
    - Beta-blockers, clonidine, vasodilators, etc. as necessary
  - Treatment of risk factors is imperative to limit disease progression and prevent adverse cardiovascular outcomes
    - Aspirin, lipid-lowering therapy, smoking cessation, diabetes control
  - Routine revascularization should not be performed for angiographically detected stenoses
  - Consider revascularization in selected clinical circumstances
    - Bilateral high-grade stenoses with heart failure out of proportion to systolic function or cardiac ischemic burden
    - High-grade stenosis with resistant hypertension (>3 maximally dosed antihypertensive meds including a diuretic)
  - Randomized trials thus far negative for benefit of stenting in ARAS but all heavily criticized
    - DRASTIC study was underpowered, angioplasty alone used, high-crossover rate, non-severe lesions treated [11]
    - STAR trial was underpowered, non-severe lesions treated, high complication rate [12]
    - ASTRAL suffered from selection bias, non-severe lesions treated, high complication rate [13]
    - CORAL trial [14]
      - Randomized 947 patients with RAS (>80% or >60% + 20 mmHg trans-lesional gradient) to PTA with stenting vs. medical therapy alone

- Primary outcome was composite of major adverse cardiac and renal events
- Major exclusion criteria: FMD, chronic kidney disease from causes other than ischemic nephropathy, serum creatinine >4 mg/dL, renal size <7 cm
- At baseline: average number of anti-HTN medications 2.1, average SBP 150 mmHg, average eGFR 58 mL/min/$m^2$ in both groups
- Outcome: no significant difference in clinical outcomes between the two groups at 43 months follow up
- Criticisms:
  - Trial enrolled patients with non-severe lesions, half of all patients with CKD 2 or less, BP at enrollment not markedly elevated with only two medications on board

## Fibromuscular Dysplasia (FMD)

- Fibromuscular dysplasia is a syndrome caused by diffuse proliferation of vascular smooth muscle cells, leading to random stenoses in multiple vascular beds.
  - Up to 5% of all renovascular disease may be due to FMD
  - Typical patient is young and female
  - Other vascular territories may be affected (i.e.: carotid, lower extremity, mesenteric)
    - Must rule out intracerebral aneurysm
      - Present in 11.8% of all patients enrolled in the US FMD registry [15]
      - Treat with catheter-based embolization
    - Important to screen patients with FMD in one distribution for disease involvement of other vascular beds
      - Imaging modalities: CT or MR angiography
- Diagnosis
  - Doppler ultrasonography may suggest presence of stenosis, however, angiography is characteristic, with typical beads-on-a-string appearance (Fig. 13-2)
- Treatment
  - Aggressive medical treatment of hypertension often requiring multiple agents with ACEi/ARB as first-line therapy (similar to ARAS)
  - In cases of resistant hypertension, treatment with angioplasty (primary stenting is not required) can provide durable results

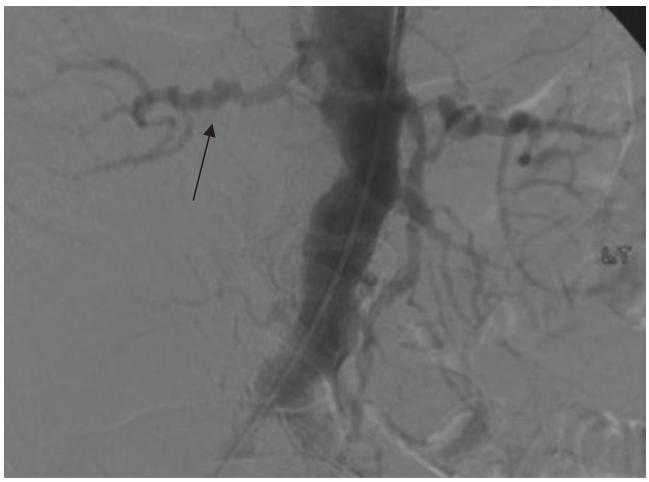

**FIGURE 13-2**

DSA of renal artery FMD with typical beads-on-a-string appearance (arrow) (Courtesy: Weinberg I, www.angiologist.com)

## SUBCLAVIAN ARTERY DISEASE

- Symptoms
  - Most often asymptomatic
  - Arm claudication, described as fatigue > ischemic symptoms
  - Vertebral steal syndrome—developing symptoms of vertebrobasilar insufficiency with exercise using ipsilateral arm
  - Subclavian steal syndrome in patient with prior internal mammary bypass graft
    - May also lead to myocardial ischemia as a result of coronary steal
- Diagnosis
  - Arm systolic blood pressure differential greater than 15 mm Hg should raise suspicion
  - Doppler ultrasonography
  - Angiography (invasive or non-invasive)
- Treatment
  - Selected indications for revascularization
    - Vertebral steal syndrome
    - Coronary steal syndrome in a patient with a LIMA graft
    - Arm Claudication
  - Revascularization: stenting (preferred strategy) vs. carotid-subclavian bypass

## CAROTID ARTERY DISEASE

- Symptomatic Disease—Transient ischemic attack or stroke within 6 months
  - Endarterectomy (CEA) or Stenting (CAS) for angiographic lesions greater than 50% or those judged to be greater than 70% on non-invasive testing
    - SAPPHIRE trial: CAS is non-inferior to CEA in symptomatic patients who are high risk for surgery [16]
  - No intervention on patients with stenoses less than 50%
  - Proceed early to revascularization (<2 weeks) after TIA/stroke
- Asymptomatic Disease
  - Controversy exists regarding medical management vs. revascularization
  - Can consider revascularization in stenoses >70% if low risk of procedure-related complications and long-term expected survival
    - Octagenerians have high procedural risk with both CEA and CAS
- CREST trial: No difference in stroke/MI/death for CAS vs. CEA in broad group of patients [17].
  - Slightly increased risk of minor stroke with CAS.
  - Slightly increased risk of NSTEMI with CEA.
- ACT-1 trial: CAS with embolic protection was non-inferior to CEA in asymptomatic patients with stenosis severity 70–99% by US or angiography [18]
  - Study employed distal embolic protection devices
  - Recent development of proximal embolic protection devices may be even more effective in procedure-related stroke prevention

- CREST-2 trial (ongoing): two parallel trials comparing revascularization strategies (surgical/endovascular) vs. contemporary medical therapy [19]
  - Carotid endarterectomy vs. medical therapy
  - Cartoid artery stenting vs. medical therapy
  - Contemporary studies evaluating management of carotid artery stenosis mostly focused on comparing surgery vs. carotid artery stenting (without inclusion of a medical therapy only arm)
    - No recent study compared revascularization to contemporary medical therapy

# MESENTERIC VASCULAR DISEASE

- Prevalence
  - Angiographic stenosis may be present in over half of patients with known systemic atherosclerosis
  - Causes
    - Atherosclerosis—etiology in >90% of cases
    - Median arcuate ligament syndrome (compression of celiac artery or SMA by median arcuate ligament)
    - FMD
    - Vasculitis
  - Angiographic stenoses may not be associated with symptoms
    - Significant disease in two vessels often necessary to provoke symptoms due to rich collateral networks in the gut
  - IMA stenosis/occlusion usually well tolerated due to hypogastric, meandering mesenteric, and Marginal artery of Drummond collaterals
- Presentation
  - Symptoms of chronic mesenteric ischemia: post-prandial abdominal pain (intestinal angina), "food fear", weight loss
- Diagnosis
  - Non-invasive testing: Doppler ultrasonography, CTA, MRA
- Treatment
  - Percutaneous stenting is a viable treatment strategy in patients with atherosclerotic disease and no evidence of an arterial compression syndrome (such as median arcuate ligament syndrome)
- Acute mesenteric ischemia
  - Often due to thromboembolism or hypotension with insufficiency at watershed territories
  - Usually a surgical emergency requiring urgent laparotomy
  - Adjunctive endovascular techniques are sometimes used

# DEEP VENOUS THROMBOSIS (DVT)

## Incidence

- 1–2 per 1000 patient years
- Incidence increases 10-fold after age 50

## Anatomy

- Proximal DVT: involving iliac, femoral, popliteal veins
- Distal DVT: involving calf veins

## Risk Factors

- Malignancy
- Pregnancy
- Prior DVT
- Oral contraceptives
- May-Thurner syndrome (left common iliac vein compression by the right common iliac artery)
- Virchow's triad
  - Hypercoagulability
  - Stasis
  - Endothelial injury

## Presentation

- Painful, swollen lower extremity
- Upper extremity DVT (<10% of all DVT) are usually associated with indwelling catheters or pacemaker/defibrillators

## Diagnosis (Table 13-3)

Figure 13-3

## Treatment

- Provoked proximal DVT: 3–6 months anti-coagulation (INR = 2–3 with warfarin)
- Unprovoked proximal DVT receives 6 months to indefinite anti-coagulation

**TABLE 13-3**

WELL'S SCORE FOR DVT DIAGNOSIS

| CLINICAL FEATURE | SCORE |
|---|---|
| Active cancer (treatment ongoing or within 6 months or palliative) | 1 |
| Paralysis, paresis or recent plaster immobilization of the lower extremities | 1 |
| Recent bedridden for more than 3 days or major surgery within 4 weeks | 1 |
| Localized tenderness along the distribution of the deep venous system | 1 |
| Entire leg swollen | 1 |
| Calf swelling by more than 3 cm when compared with the asymptomatic leg (measured 10 cm below the tibial tuberosity) | 1 |
| Pitting edema (greater in the symptomatic leg) | 1 |
| Collateral superficial veins (non-varicose) | 1 |
| Alternative diagnosis as likely as or greater than that of DVT | −2 |

Courtesy: Well et al. [20]
Interpretation: High probability >3; Moderate probability 1−2; Low probability <0

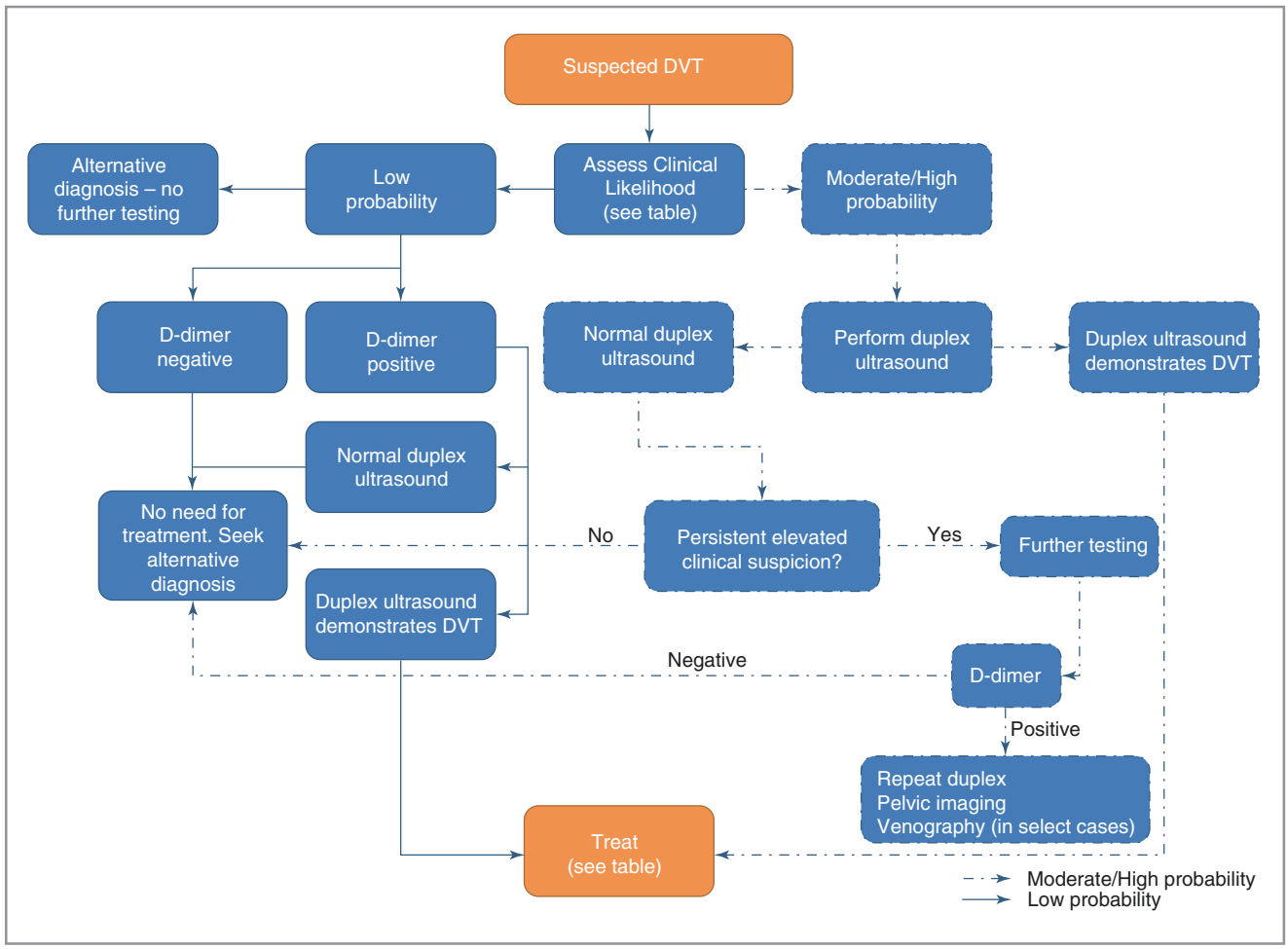


**FIGURE 13-3**

Diagnostic algorithm for DVT (Courtesy: Weinberg I, Jaff, M, Venous Thromboembolism, Springer's Textbook of Cardiovascular Intervention in press) [21]

  - LMWH preferred in patients with malignancy
  - Catheter-directed lysis may reduce the severity of post-thrombotic syndrome in ilio-femoral DVT [22]
  - Do not use CDT for femoropopliteal DVT

- Calf DVT: typically 3 months anti-coagulation for symptomatic pts vs. no anti-coagulation and serial ultrasonography (4–6 ultrasounds over 2–4 weeks) to monitor for proximal extension,
- Superficial venous thrombosis: non-steroidal anti-inflammatory drugs and warm compresses.
  - Consider anti-coagulation for proximal clot (i.e.: near saphenofemoral junction).
- Catheter-Associated DVT: remove catheter, anti-coagulation for 3 months or less

## Complications

- Post-thrombotic syndrome (PTS)
  - Persistent long-term swelling in the lower extremity that may be associated with skin changes (stasis dermatitis)
  - Leg may feel fatigued, heavy and weak
  - Is a common consequence of proximal iliofemoral DVT
  - Prevention
  - Consider early catheter-directed lysis for newly diagnosed iliofemoral DVT
  - Use 20–40 mm Hg graduated compression stockings for long term prevention of venous insufficiency and PTS
  - Treatment
  - Compression therapy
  - Angioplasty/stenting of proximal occluded deep veins
  - Rarely open surgical bypass procedures
- Phlegmasia Dolens
  - Massive thrombosis of a limb with patent collaterals (phlegmasia alba dolens) or obstructed collaterals with resultant compartment syndrome, arterial compromise and venous gangrene (phlegmasia cerulea dolens)
  - Risk factors include post-operative states, malignancy, hypercoaguability, and May-Thurner Syndrome
  - Mortality rates are up to 25% with PE causing at least 1/3 of deaths and amputations are common
  - Presents as pain, swelling, and cyanosis of the affected limb
  - Treatment includes leg elevation, anticoagulation, catheter-directed thrombolysis, and open surgical thrombectomy

# PULMONARY EMBOLISM (PE)

## Incidence

- 400,000–600,000 annual causes in the US

## Risk Factors Are Identical to DVT

(see section “Anatomy”)

## Presentation

- Sudden onset of pleuritic chest pain
- Dyspnea
- Cough
- Hemoptysis
- Tachycardia ± hypotension

## Diagnosis

- History—assess for risk factors and presenting symptoms above
- Physical exam—tachypnea, tachycardia, hypoxia, accentuated P2 component of S2, RV heave
- Electrocardiogram—sinus tachycardia, RBBB, anterior precordial repolarization abnormalities

**TABLE 13-4**

WELL'S SCORE FOR PE DIAGNOSIS

| CLINICAL FEATURE | SCORE |
|---|---|
| Clinical signs and symptoms of DVT (minimum of leg swelling and pain with palpation of the deep veins) | 3 |
| An alternative diagnosis is less likely than PE | 3 |
| Heart rate greater than 100 | 1.5 |
| Immobilization or surgery in the previous four weeks | 1.5 |
| Previous DVT/PE | 1.5 |
| Hemoptysis | 1 |
| Malignancy (on treatment, treated in the last 6 months or palliative) | 1 |

Courtesy: Wells et al. [23]
Interpretation: High probability >6; Moderate probability >2 and <6; Low probability <2. If the D-dimer is negative a cutoff point of 4 points or less makes a PE unlikely

- D-dimer—highly sensitive but poorly specific test that is useful to rule out DVT
- Chest radiography—most commonly unremarkable, may see Westermark sign (oligemic focus distal to PE) or Hampton's hump (wedge-shaped consolidation representing infarction)
- Echocardiography—increased RVSP, right ventricular dilation and hypokinesis, interventricular septal flattening
- Well's criteria (Table 13-4)
  - For moderate or high probability proceed to CT angiogram or ventilation/perfusion (V/Q) scan

## Treatment

- Immediate parenteral anticoagulation
  - Transition to long-term agents (warfarin vs. LMWH/fondaparinux)
    - Provoked PE (status post trauma, prolonged immobilization, or recent surgery) should be treated for a minimum of 3 months
    - Unprovoked PE should be treated for 6–12 months with treatment extension considered
    - Second unprovoked PE is an indication for lifelong anti-coagulation
- IVC filter for select indications
  - VTE with contraindication to anticoagulation
  - Recurrent VTE despite adequate anti-coagulation

# HIGH RISK PE

- Submassive PE
  - Systolic BP ≥90 mmHg but with presence of at least one of the following:
    - RV dilation on Echocardiography (RV/LV ratio ≥1.0) [24]
    - Elevation of cardiac troponin I
    - Elevation of brain natriuretic peptide
- Massive PE
  - Systolic BP <90 mmHg
  - Need for vasopressor support

  - Cardiac arrest
    - Patients may have signs of systemic hypoperfusion (i.e. confusion, reduced urinary output, cool extremities, elevated lactic acid levels)
  - International Cooperative Pulmonary Embolism Registry showed a 4.5% incidence and greater than 50% 90-day mortality [25]
- Diagnostic studies
  - Massive PE sometimes associated with acute RV strain pattern on ECG ("S1Q3T3")
  - Transthoracic echocardiography reveals akinesia of the RV free wall with apical sparing (McConnell's sign)
- Treatment
  - Consider consulting a multidisciplinary PE response team (PERT) to discuss various treatment options [26]
  - Consider peripheral IV or catheter-directed thrombolysis
    - Absolute contraindications to thrombolysis are:
      - active internal bleeding or severe coagulopathy
      - cerebrovascular event, neurosurgical procedure, cerebral trauma in the past 3 months
      - history of hemorrhagic stroke
      - active intracranial malignancy
      - aortic dissection
    - Consider surgical or catheter-based embolectomy strategies for those not eligible for thrombolysis.
    - In cases of refractory hypotension or cardiac arrest, consider emergent mechanical circulatory support with ECMO or isolated percutaneous RVAD

## QUESTIONS AND ANSWERS

1. A 44 year old woman with a history of hypertension presents to the Emergency Room with complaints of severe headaches for several days. Her outpatient medication list includes amlodipine 10 mg daily, lisinopril 40 mg daily, and hydrochlorothiazide 25 mg daily. Vital signs revealed blood pressure of 185/95 and a heart rate of 78. Examination is significant for an abdominal bruit and bilateral carotid bruits. A CT (head) does not show any signs of intracranial hemorrhage. The treatment most likely to benefit this patient is:
   a. Addition of metoprolol XL 50 mg daily to her regimen
   b. Surgical revascularization of her carotid arteries
   c. Angiography and balloon angioplasty of the renal arteries
   d. Carotid angiography with consideration of stent placement
   e. Angiography and stenting of the renal arteries

   1. Answer c. The patient's demographic information, resistant hypertension, and abdominal/carotid bruits should raise suspicion for fibromuscular dysplasia.

   Given resistant hypertension on three medications including a diuretic, renal angiography with angioplasty is indicated in this case. In FMD, stent placement is often unnecessary as good long-term results have been noted with angioplasty alone. There is no clear indication to intervene on her carotid arteries given her absence of neurologic symptoms currently. Addition of metoprolol XL to her regimen is unlikely to normalize her blood pressure.

2. A 56 year old man with a history of tobacco use, hypertension, and diabetes presents to you with complaints of right calf pain after walking two blocks. His medication regimen includes aspirin, cilostazol, ramipril, atenolol, and metformin. He has been advised to walk daily and, for 6 months, he has adhered to a regimen of 30–45 min of walking on a treadmill at his house but has to stop frequently due to right calf pain. He had a recent CTA that revealed a focal 3 cm high-grade 80% stenosis of the right external iliac artery. The next most appropriate step in management is:
   a. Addition of clopidogrel 75 mg daily to his regimen
   b. Addition of warfarin to his regimen with goal INR = 2–3.
   c. Discontinuation of atenolol.
   d. Percutaneous right external iliac artery revascularization.
   e. Continue current regimen including daily walking program with follow-up in 6 months.

   2. Answer d. The patient is on optimal medical therapy and a structured walking program. He continues to have life-limiting symptoms despite this so endovascular revascularization of

the right external iliac artery is indicated.Neither dual antiplatelet therapy nor warfarin have been shown to have benefit in this clinical circumstance. There is no need to discontinue his beta-blocker.

3. A 75 year old patient is hospitalized with a hip fracture. Their past medical history is notable for hypertension, colon cancer treated with hemi-colectomy 2 months prior to presentation, and diabetes mellitus. Their medications include metoprolol, lisinopril, metformin, and aspirin. On hospital day 2, the patient undergoes an open reduction and internal fixation of the hip, which is uneventful. On hospital day three, however, the leg contralateral to the surgical repair is edematous, painful, and indurated.

   A venous thrombosis of the proximal femoral venous system is identified using Doppler ultrasound and systemic anticoagulation is begun.

   All of the following are true EXCEPT

   a. Treatment should last for 3–6 months at a minimum
   b. The development of post-thrombotic syndrome may be minimized with the use of graduated compression stockings after anticoagulation is begun
   c. Placement of a permanent filter for the inferior vena cava will reduce the risk of complications in this patient
   d. Painful venous plethora of the leg should be treated as a vascular emergency
   e. Thrombosis of the left leg may be due to a congenital anomaly of the venous drainage of the limb.

   3. Answer c. Vena cava filters have very specific indications for patients with venous thrombosis, and should be removed as soon as the risk period has passed. Permanent implantation of filters is ineffective in reducing the long term VTE risk, and also may increase the risk for filter-relatedcomplications.

   All other statements are true: anticoagulation, though individualized for each patient, should continue a minimum of 3 months, and probably longer. Compression stockings may reduce the risk for painful edema of the limb after resolution of the DVT, while phlegmasia cerulea dolens is a vascular emergency, due to risk of venous gangrene. Lastly, the May-Thurner anomaly is a congenital compressive syndrome of the left-sided iliac vein, which increases the risk for spontaneous and recurrent venous thrombosis of this vessel.

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