OBJECTIVES

• Learn the protocols to perform successful upper and lower extremity venous examinations
• Become familiar with the roles of compression ultrasound, color Doppler and spectral Doppler ultrasound in making the diagnosis of venous thrombosis.
• Understand the differences between acute and chronic thrombosis and management of thrombus by location.

VENOUS THROMBOEMBOLISM (VTE)

• A common problem, affects 70/100,000 patients annually*
• DVT affects 1,1000 and is 90% assoc with PE**
• PE causes 25,000 deaths/yr (NCHS 2006)**
• US testing for extremity DVT currently the primary diagnostic method

Reference:
*Fraser JD, Anderson DR. Radiology 1999 211:9-24

Cancer Patients

• Cancer population increases incidence of VTE -1.6% or greater (nearly double the general population)
• Greater in patients with metastatic disease (3:1000) (lymphoma, lung, colorectal)
• Hypercoagulable
• Catheter related thromboses

Clinical Importance of DVT

• Focal morbidity
  – Pain and swelling of affected limb
• Risk of pulmonary embolism
  – Of patients with PE, 70% have asymptomatic DVT
  – If thrombus from lower extremity and small (i.e., from calf vessels), embolus usually asymptomatic
  – Only 5% of patients with symptomatic DVT have isolated calf thrombosis, of these approximately 30% will extend into thigh and/or popliteal veins.

Incidence of venous thromboembolism and its effect on survival among patients with various cancers – shows that of patients with PE, 70% have asymptomatic DVT
Clinical Importance of DVT

- Chronic Problem
- Recurrent disease in 20%
  - 45% same leg
  - 36% other leg
  - 19% PE
- Post phlebitic syndrome: Potential valve damage and development of chronic pain and swelling (29% at 8 yrs.)*

References:
*Prandoni et al Annals of Internal Medicine 1 Jul 96 125:1-7

WHICH LOWER LEG VESSELS MAY HARBOUR “DEEP VEIN THROMBOSIS”?

- Iliac, common femoral, (s) femoral and profunda femoral, popliteal and paired deep calf veins (anterior and posterior tibial and peroneal)
- Muscular veins including gastrocnemius and soleus plus unnamed tributaries.
- Distal 5 cm of the greater saphenous vein ( clot in this location is treated as DVT).

- Up to Date 2014
- Kearon et al Chest 2012; 141:e419S.
- American College of Chest Physicians

From Rumack, et al, Diagnostic Ultrasound, 3rd Ed

TYPICAL LEG PROTOCOL

- Transverse compression every cm
  - Common femoral vein (CFV) including saphenous junction to tibioperoneal trunk. Include femoral vein and profunda femoral vein
  - Transverse compression imaging every cm of paired calf veins.
- Longitudinal color imaging popliteal through CFV
- Spectral waveforms in the bilateral common femoral veins.
- Iliac color and waveforms if indicated by CFV

NORMAL ANATOMY

New terminology is the “femoral vein”
Many clinicians ignored the diagnosis of potentially lethal deep vein thrombosis, mistakenly believing this vessel to be superficial.

From Rumack, et al, Diagnostic Ultrasound, 3rd Edition

Calf Veins

- Scan paired veins with graded compression. Identify the adjacent artery as needed.
- Tibioperoneal trunk is the confluence of peroneal and posterior tibial veins prior to the anterior tibial confluence
- Scan calf veins in their entirety. Scanning from ankle to knee is often easier than knee to ankle.

POSTERIOR TIBIAL VEINS
DVT?

• Gastrocnemius veins
  – paired with accompanying artery within the muscle.
  – enter the popliteal vein.

Muscular Calf Veins are also Deep Veins

Muscular Calf Veins are also Deep Veins

Soleal sinuses
  – deeper in the calf muscles adjacent to the tibia, no artery.
  – empty into the posterior tibial or peroneal veins.

Normal Variants

• Duplicated segments of femoral and popliteal veins are common: at least 20% and 30% respectively in normal populations.
• The incidence of FV duplication is higher in patients with femoral DVT, rising to 38%.
• Triplicated segments are also possible.
• Unnamed muscular branches may occur.

DVT Pitfalls

Patent FV?

Duplicated FV, posterior one has extensive clot.

TRIPLICATED FV
LEDVT Compression Technique

- High frequency linear array (5 MHz or greater)
- Grey Scale
  - Use transverse compression across the vessel
  - Compress every centimeter from the common femoral vein (including the saphenous junction) to the popliteal trifurcation.
  - Continue in calf through all paired veins.
- Vein walls should coapt completely.

LEDVT Compression Technique

- Use hand behind the medial thigh to aid compression of the FV in the adductor canal.
- Scan the groin and proximal thigh anteriorly, the mid thigh medially and the distal thigh, upper popliteal fossa posteriorly.
- Elevate head of patient to increase distension
- Have the patient dangle his/her legs over the side of the bed to improve calf vein distension.

Making the Diagnosis

- Noncompressible segment in gray scale
- Clot expands the lumen
- Clot displaces flow in the lumen

ANECHOIC ACUTE THROMBUS
Diagnosis?

Isolated thigh DVT. Don't ignore a segment.

Normal or Abnormal?

Don't forget the profunda femoral vein!

DVT or SVT?

DVT or SVT?

Report as positive for DVT. The greater saphenous vein is treated as a deep vein in its cephalad portion. 70% of patients with proximal SVT in the greater saphenous will progress into the common femoral vein if not anticoagulated. Chengalis DL, Bendick PJ, Glover JL et al: Progression of superficial venous thrombosis to deep vein thrombosis. J Vasc Surg 1996;24:745-749.

58 yo male with left leg swelling

Therapy?

Clot within 2cm of the GSV/CVF jx is significant. Sover et al, JUM 1997; Cronan, US Clin 2011-2012: AICCP clot within 2 cm is significant.

• American College of Chest Physicians issued new guidelines in February 2012, recommending anticoagulation for patients with SVT who are at increased risk for venous thromboembolism (SVT>5cm, proximity to deep veins <5cm, positive medical risk factors). Positive medical risk factors include prior clots, cancer, surgery, thrombophilia, estrogen therapy or prolonged travel. Fondaparinux 2.5mg daily or enoxaparin 40 mg daily for a period of 4 weeks is recommended. If DVT is present, the patient should be fully anticoagulated.

• Ligation of the great or small saphenous vein may be considered for patients in whom anticoagulation is contraindicated. Otherwise, surgery for SVT was found to be associated with a higher risk for thromboembolism.
Post laser ablation
Therapy needed?

Color Flow Doppler: Useful to find deep compressed veins in extremities with swelling.
Augmentation with calf squeeze or Valsalva release useful to increase flow, not diagnostically helpful (1)
Color Doppler alone is 96% accurate for diagnosis of proximal DVT when complete compression cannot be performed (2)

References:
1. Lockhart et al. Augmentation in lower extremity DVT, AJR 2005 184:419
2. Lewis et al. Diagnosis of acute DVT of the lower extremities: prospective evaluation of color flow Doppler versus venography Radiology, 1994;192:651-655

Color Flow in non-compressible patient with contractures

Leg swelling post gastrectomy
Calf clot detection: grayscale and color

SHOW PROXIMAL EXTENT

Color Technique: Pitfalls

Blooming artifact: color extends posterior to the wall of the vein.
Always check your color imaging in the axial plane to avoid missing partial thrombus.

Sequential 5mm CT images at time of initial US shows a 1.5cm (in length) CFV thrombus. Corresponding US at repeat exam correlates exactly with CT. Covering the entire region of interest is critical and more operator dependent with US.

US Spectral Doppler
- Spectral Doppler waveform: Required in bilateral common femoral veins per ICAVL* Accreditation Requirement - 2000 Standards.
- Monotonous ipsilateral waveform indicates more proximal disease, either intrinsic or extrinsic. Bilateral abnormality indicates IVC or retroperitoneal pathology, or bilateral disease.


Normal CFV Spectral Waveforms

Diagnosis?

Pregnant with uterine compression
Unilateral Monophasic Waveform

Significance of M. Waveform
- 40% iliac DVT
- 20% Extrinsic compression (tumor/other)
- 5% narrow/scar
- 35% unknown

MONOPHASIC WAVEFORMS: A FIVE YEAR RETROSPECTIVE REVIEW

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<th>Number</th>
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<tr>
<td>Number of patients</td>
<td>2963</td>
</tr>
<tr>
<td>No. of cases with monophasic wave form</td>
<td>124</td>
</tr>
<tr>
<td>No. of cases with CT or MR correlation</td>
<td>106</td>
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<tr>
<td>DVT involving iliac veins</td>
<td>47 (38%)</td>
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<tr>
<td>Extrinsic compression</td>
<td>26 (21%)</td>
</tr>
<tr>
<td>Intrinsic narrowing</td>
<td>6 (5%)</td>
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<tr>
<td>No explanation</td>
<td>45 (36%)</td>
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37 y.o. female; one week of right leg swelling
Deborah J. Rubens, MD  
**ULTRASOUND SCANNING FOR DEEP VENOUS THROMBOSIS**

**Monophasic Waveform**
- Vessel narrowed
- Adjacent mass

**Dx: Compression by Lymphoma**

**Upper Extremity DVT**

**UEDVT: Same as LEDVT?**
- 4% of all DVT
- Primary (rare)
  - effort related
  - hypercoagulable
- Secondary (common)
  - central and peripheral venous catheters and pacemakers. (up to 25% of patients with lines)
- PE in 12-36% same mortality as LEDVT.
  - 6% in primary UEDVT, 13% high risk/hypercoagulable, 17% catheter induced.

**What is the Clinical Presentation?**
- Pain, swelling, erythema, or mild cyanosis
- Dilated superficial veins
- Palpable cord
- Neck or shoulder discomfort
- Facial swelling (SVC syndrome)
- Less than 50% of symptomatic patients have documented DVT.
- Only 60% of patients with UEDVT have clinical symptoms.

**US Diagnosis of UEDVT**
- Compression the mainstay for IJ, basilic, brachial, axillary and distal subclavian veins.
- Color flow essential for proximal subclavian and brachiocephalic veins. Absent flow abnormal.
- Spectral Doppler documents normal variability with respiration and cardiac pulsation. Spectral Doppler alone insensitive due to collaterals.

**Accuracy of UEDVT US**
- Large range of sensitivity (56-100%)
- Specificity high (94-100%)
- Prospective study compared to venography yields specificity and sensitivity of 82% (Baarslag)
  - Incompressability most specific
  - Incomplete filling on color Doppler next
  - Spectral waveform analysis only 50% specific
Normal Anatomy

Cephalic and basilic are superficial veins
Deep veins

SUBCLAVIAN VEIN: COLOR TO SEE THROMBUS

Normal UEDVT Compression Examination

Normal Doppler

DVT?

UE PICC LINE DVT?

Grayscale makes the diagnosis
LUE Swelling PICC line clot?

Additional thrombus in right IJ. Examine both IJ's.

Left arm swelling DVT?

- Are there branches of the axillary vein?
- What vessel is this?
- History: prior a-v fistula
- Dx: thrombus in enlarged cephalic vein

Chronic DVT

- Characterized by focal or diffuse wall thickening
- Size of vein is diminished
- Thrombus echogenicity also increases over time.
- Calcifications indicate chronic nature
- May see webs or scars

Initial examination

5 months later

Acute vs Chronic DVT

CHRONIC DVT: WEBS AND WALL THICKENING

Chronic Clot
Main US Diagnostic Pitfalls

- Technically inadequate examinations due to patient obesity, tense, swollen limbs may limit compressibility, leading to false positive diagnoses.
- Duplicated segments (20-30% of normal population)—if only one thrombosed, it may be missed as the other is normal.
- Nomenclature—remember muscular calf veins are DVT's and distal saphenous veins are treated as though they were DVT's.

DVT Color Doppler Pitfall

The popliteal vein is completely thrombosed, but the superficial collateral adjacent to it may be mistaken for the popliteal. Note the abnormal distance of the collateral from the artery, indicating it is not the native vessel.

Leg Swelling-DVT?

POST OP THIGH SARCOMA

Initial exam with diffuse leg pain. Sonographer noted no DVT. What is missing?

POST OP SARCOMA

The calf veins should be paired. Previous day’s exam only showed one vein. Repeat focused exam of the peroneal veins shows one vein has a focal thrombus. Don’t omit the gray scale compression exam.

43 yo male, arm swelling s/p shoulder dislocation/relocation

Diagnosis?
Deborah J. Rubens, MD
ULTRASOUND SCANNING FOR DEEP VENOUS THROMBOSIS

**Patient anticoagulated**

**Pain, swelling increase**

- Collection has doubled
- Slow flow in normal axillary vein
- Dx: HEMATOMA, patient treated unnecessarily
- Pearl: No normal axillary vein is 3cm

**53 yo F with leg pain**

- Smooth borders
- Minimal flow
- Anatomy critical-
- Consider further imaging as needed

**Schwannoma**

- Smooth
- T2 bright
- Homogeneously enhancing
- Contiguous with the nerve

**50 yo F with arm redness and swelling, r/o DVT**

- Action: Image with another modality

**Liposarcoma**

- For primary MSK tumors
- Bx only after consult with ortho oncology
- Bx may seed overlying tissues and alter primary resection

**52 yo F s/p right leg surgery 2 mo ago with persistent pain**

- Is this a postoperative fluid collection?
52 yo F s/p right leg surgery 2 mo ago with persistent pain

- Needs higher frequency for better sensitivity
- Confirm with spectral Doppler
- Melanoma recurrence

Proving Solid Masses

- Maintain high index of suspicion in patient with hx of malignancy
- Spectral Doppler confirmed flow essential
- Absent flow
  – Improper Doppler settings/technique, be sure to optimize
  – Necrotic lesion
- Image with another modality or use US contrast if available (off label)

Role of Serial Ultrasound

- Previously recommended at 1 week in all patients
- Safe to withhold anticoagulants with normal initial examination and serial ultrasound*
- Follow up unnecessary without persistent symptoms** ***
- With symptoms, follow up should be encouraged.

CONCLUSION:

- Overall, US is highly accurate for assessment of LEDVT and UEDVT
- Grayscale ultrasound is central to diagnosis.
- Color Doppler can be used to facilitate the grayscale examination, and where compression cannot be performed, especially UE exam
- Spectral Doppler is required in the bilateral common femoral veins to assess for proximal obstruction and in the upper extremity for central evaluation.

CONCLUSION

- Beware of duplicated systems and collaterals which may be confusing and lead to false negative diagnoses.
- Be sure to image where it hurts, especially in the calf, in order not to miss muscular thrombosis, or other causes of patient symptoms.
- A technically adequate negative DVT exam in the leg does not require follow up in the absence of persistent symptoms, unless the patient is high risk (i.e. hypercoagulable, oncology pts).

Thank you