Venous Duplex
Above and Below The Diaphragm

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Diagnostic Approach to Acute Deep Venous Thrombosis

- More than 1 million patients seek medical care per year for leg pain and/or swelling.
- Approximately 20% of these are diagnosed with DVT.

VTE

Until 1990’s VTE (DVT) was considered primarily as a complication of hospitalization for major surgery (or associated with late stage of terminal illness)
Venous Thromboembolism (VTE)

- The precise number of people affected by DVT/PE is unknown, although as many as 900,000 people could be affected (1 to 2 per 1,000) each year in the United States.

- Estimates suggest that 60,000-100,000 Americans die of DVT/PE (also called venous thromboembolism).
  - 10 to 30% of people will die within one month of diagnosis.
  - Sudden death is the first symptom in about one-quarter (25%) of people who have a PE.

- Among people who have had a DVT, one-half will have long-term complications (post-thrombotic syndrome) such as swelling, pain, discoloration, and scaling in the affected limb.

- One-third (about 33%) of people with DVT/PE will have a recurrence within 10 years.

- Approximately 5 to 8% of the U.S. population has one of several genetic risk factors, also known as inherited thrombophilias in which a genetic defect can be identified that increases the risk for thrombosis.
DVT

Pre-Test Probability Assessment of Outpatients with Clinical Suspicion of DVT

- Acute Limb Swelling - involved extremity 2 cm or greater difference in circumference
- Documented previous history of DVT
- Malignancy
- Recent surgery
- Hypercoagulable state

DVT

Clinical Assessment of Outpatients with Suspicion of DVT:

• 438 Outpatients
  – 153 had acute swelling with 2 cm circumference difference
  – 65 (42%) were positive for DVT by Venous Duplex Ultrasonography

DVT

Clinical Assessment of Outpatients with Suspicion of DVT:

- 99 outpatients with at least one risk factor, but without >2 cm circumference difference
- 38 (37%) were positive for DVT by Venous Duplex Ultrasonography
Clinical Assessment of Outpatients with Suspicion of DVT:

• 137 outpatients with no acute swelling and no risk factors for DVT

• 134 (98%) had no DVT by Venous Duplex Ultrasonography

DVT

Clinical Assessment of Outpatients with Suspicion of DVT:

• 31 outpatients seen with cellulitis, none had DVT

• 44 outpatients with chronic swelling > 4 wks
  – 1 acute DVT
  – 2 chronic DVT

DVT

Clinical Assessment of Outpatients with Suspicion of DVT:

- Conditions found to have no association with DVT
  - Obesity (10%)
  - Cellulitis (0%)
  - Knee pain/swelling (0%)
  - Calf pain without swelling (5%)

## DVT Risk Factors

<table>
<thead>
<tr>
<th># of Risk Factors</th>
<th>Rate of DVT</th>
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<tbody>
<tr>
<td>0</td>
<td>11%</td>
</tr>
<tr>
<td>1</td>
<td>24%</td>
</tr>
<tr>
<td>2</td>
<td>36%</td>
</tr>
<tr>
<td>3</td>
<td>50%</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
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**Modified Well's Criteria**

**History:**

**Clinical Parameters:**
- Active Cancer (treatment ongoing or within 6 months)
- Paralysis, paresis, recent plaster immobilization of lower extremity
- Recently bedridden for >3 days/major surgery within 4 weeks
- Localized tenderness along distribution of deep venous system
- Calf swelling > or = to 2 cm compared to asymptomatic leg
- Collateral superficial veins (non-varicose)
- Alternative diagnosis as likely or greater than that of DVT (2 pts)
- Long plane/car trip
- Medical intensive care patient
- PMH of unprovoked DVT

D-Dimer result (positive or negative)

Pre-test Probability: High (3 or >) Intermediate (1 – 2) Low (0 – 0)

Venous Duplex Findings

- Right Leg: Negative
- Left Leg: Positive
- Bilateral
- Contralateral CFV (Patent ?)
- Acute
- Chronic

Indeterminate age

Additional comments: ____________________________________________________
Deep Venous Thrombosis

- Multitude of causes
- Trauma, Hypercoagulability, Stasis
- When DVT is noted there is a cause!
- Idiopathic Bilateral DVT is a concern for underlying cancer
Right Popliteal Vein
Right Popliteal Vein
M-SMI Hold
Is Residual DVT a common risk factor?
Recurrent DVT

Residual Venous Thrombosis as a Predictive Factor of Recurrent DVT.


• 313 patients with DVT entered the study and received anticoagulation for 6 months
Recurrent DVT

Results of follow-up venous duplex studies:

No residual thrombosis

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<tr>
<td>6 months</td>
<td>38.8</td>
</tr>
<tr>
<td>12 months</td>
<td>58.1</td>
</tr>
<tr>
<td>24 months</td>
<td>68.3</td>
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</tbody>
</table>
Recurrent DVT

**Residual venous thrombosis is important risk factor for recurrent DVT**

- **Overall, 58 recurrent episodes (18.5% of study group)**
- **41 recurrent episodes occurred in patients with abnormal duplex findings (71% of recurrences)**
Recurrent DVT

**UNC REX Healthcare Position:**

We recommend to our referring doctors to have a follow-up venous duplex prior to stopping Coumadin or any of the new anticoagulation agents.
WHAT IS YOUR DIAGNOSIS?
129 cm/s
Popliteal Vein
3 Minutes Later
Popliteal Vein Contrast
WHAT IS YOUR DIAGNOSIS?
D-Dimer: Use, Misuse, Strengths, Weaknesses and Basic Clinical Understanding

- D-Dimer is a blood test
- The basic theory behind D-Dimer is that when DVT is present, there is spontaneous lysis of the thrombosis and the D-Dimer (FSP’s) is produced
- Several types of D-Dimer tests are available
- The most popular are Latex Agglutination, Enzyme Linked Immunosorbent Assays (ELISA) and Whole Blood Agglutination Assay (SimpliRed).
Lower Extremity Venous Anatomy
Deep Venous Anatomy

Deep System
- EIV
- CFV
- Profunda Femoral Vein
- Femoral Vein
- Popliteal Vein
- Tibial Veins
  - Posterior, Anterior and Peroneal
- Gastroc Veins
  - Soleal Veins

Superficial System
- GSV
- Accessory Veins
  - AAGSV
  - PAGSV
- Thigh Circumflex Veins
  - Anterior and/or Posterior
- Tributary Veins
- SSV
- Perforators
- ISV-intersaphenous variations
**Deep Venous Anatomy**

- **CFV**
  - May or may not have valves
    - 1-2 Valves typical
    - GSV confluences with the CFV at the SFJ
      - Superior Epigastric vein also confluences at the SFJ
- **FV (superficial femoral vein)**
  - 3-4 Valves
  - May be duplicated or triplicated in segments
    - Thigh perforators confluence with FV
      - Lateral thigh perforators may confluence elsewhere
Deep Venous Anatomy Continued

- **Popliteal Vein**
  - 2-3 valves
  - **Multitude of confluences happen in the popliteal**
    - Gastroc vein confluence, sometimes confluence with SSV
    - SSV confluence via the Saphenopopliteal Junction, as mentioned above the gastroc and SSV in some cases will confluence and then dump to popliteal.

- **Tibial Vessels**
  - Multiple valves present, usually double digits in each of the paired veins
    - Most common source of refluxing perforators arise from PTV

- **Gastrocnemius and Soleal Veins are not studied much in relation to venous insufficiency**
  - This doesn’t mean ignore them!
INTERCOSTALS VEIN
PROMINENT
Inguinal Region
Common Iliac Veins
Contrast

Common Iliac Veins

MRI
Collaterals Adjacent To Abdominal Aorta
Collaterals Adjacent To Abdominal Aorta
What am I?
Oblique and Transverse
3 seconds Reflux
Complete Venous Examination should include deep veins of the calf

- Transverse compression
- Augmented color flow and secondary imaging
- Color and Power Doppler can't hide isolated thrombosis
- Newer technology circumvent thrombosis
- How much time does these maneuvers take?
- 15-30 minutes?
Calf Veins

Posterior Tibial and Peroneal Veins
Normal Venous Spectra

Spontaneous and Phasic
Color And Spectral Phasic Flow
Abnormal Venous Spectra

- Gross Tricuspid regurgitation
- Deep Venous Reflux
- Continuous

Arterio-Venous Fistula
- Ventilator
- Fatty Emboli
Underlying Cardiac Issues

• **Most Typical Findings Can Include:**
Acute vs Chronic
Heterogeneity

- **Acute Thrombi = Acoustically homogeneous**
- **Chronic Thrombi = Acoustically heterogeneous**

Although this criterion is used by many laboratories no investigations have been performed to confirm accuracy.
Pathological Thrombus Comparison

Surface of Thrombus

Acute: Smooth

Chronic: Irregular

**No investigations have been performed to confirm accuracy**
Acute vs Chronic

- Treatment strategies
- Potential for VTE
- 15% indeterminate cases post-phlebitic
- **Acute thrombus may be non occlusive have a floating type “appearance”**
- Thrombus becomes adherent to vessel wall within one week
Acute vs Chronic

- **Acute thrombi are composed of red cells and fibrin**
- **As thrombus ages red cells break down and are replaced by fibrin mesh**
- **Chronic thrombus are covered in endothelium**
- **Vessel contraction vs. dilation**
Criteria For Acute DVT

- **Occlusive**
  - Implies no outflow
- **Non-occlusive**
  - Flow around thrombosis
- **Isolated**
  - Common femoral only
  - Popliteal only
  - Implies separate processes
- **Extensive**
  - Implies continuous process
  - Extensive LLE DVT (entire leg)
### Criteria for Acute DVT

<table>
<thead>
<tr>
<th>Primary Diagnostic</th>
<th>Secondary Diagnostic</th>
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<tbody>
<tr>
<td>Non-compressibility</td>
<td>Echoluent thrombus</td>
</tr>
<tr>
<td>Venous distention</td>
<td></td>
</tr>
<tr>
<td>Absence of Spectral Doppler</td>
<td></td>
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<tr>
<td>Loss of Flow Phasicity, response to Valsalva or Augmentation</td>
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**Non-compressibility is the most reliable sign of acute DVT.**

*Acute thrombus may be anechoic.*

*Intraluminal echoes may represent a false-positive test.*
Acute Deep Venous Thrombosis

- Two times the size of the accompanying artery
Initial Venous Duplex Exam
1-27-16
Venous Duplex 2-1-16
Comparison of Augmentation
What is your differential diagnosis?

- Missed DVT previous exam?
- Patient was on anticoagulation.....
- Dig into history, patient has been diagnosed with metastatic CA
  - *When patients have an acute underlying cancer, all bets are off and one can fail anticoagulation*
  - *This was an acute deep venous thrombosis that was not missed*
Venous Duplex......

- **Expect the Unexpected**
- **“You ain’t Not looking where it hurts”**
- **Standard protocol**
- **Finish your exam 1\textsuperscript{st}**........
- **Sometimes you can’t explain everything**
- **Pre Test probability**
Images are Not Always Illusions or Artifacts
Grayscale Pitfalls

• **Watch your gain**
  
  **Under or over gain settings can play tricks or cause a misdiagnosis**

• **Not all intraluminal echoes represent DVT**

• **Echo characteristics are important**
Grayscale Pitfalls
Upper Extremity Venous Anatomy
A Quick Look at Upper Extremity Hemodynamics
Venous Doppler Signal

- **Spontaneous**: flow is present without augmentation maneuvers.

- **Pulsatility**: pulsatile signals in jugular, brachiocephalic, and subclavian veins because of proximity to heart.

- **Respiratory phasicity**: flow velocity changes with respiration.

- **Augmentation**: flow velocity increases with distal limb compression.
Upper Extremity Venous Anatomy

- Upper vs Lower
- More cardiac pulsatility in the upper extremity (normal)
- Direction of flow
- Contralateral comparison
Right IJV
SAME PATIENT 4 MINUTES LATER
Upper Extremity Contrast

7:11 AM (Initial)

7:15 AM
Hydrostatic Pressure

- Patient in Erect Position
- Patient in Supine Position

RT IJV
ERECT POSITIONAL FLOW DYNAMIC CHANGES

RT IJ SUPINE
Hydrostatic Pressure

Patient Erect

Patient Supine

RT IJV

Erect Positional Flow Dynamic Changes
Pay Attention to your patient's position

Is your patient sitting up in a chair?
Is your patient supine?
Is your patient reverse Trendelenburg?
Axillary-Subclavian Venous Thrombosis

- Rare event - 2% of all DVT
- Primary and Secondary thrombosis
  - **Primary**
    - Classic Paget-Schroetter Syndrome
    - Spontaneous thrombosis in otherwise healthy individuals
    - Young, male smokers
    - Right upper extremity predominance
  - **Secondary**
    - Central venous catheterization
Where Is The Level of Disease?
LEFT AND RIGHT COMPARISON
Life Cereal
Rouleaux Flow

- What is it?
- What causes this?
- What does it mean?
- Is this a normal finding?
- What does Rex (UNC Healthcare) do?
- When does an ALARM go off?
- Should we anticoagulate?
The RBC Aggregates are large enough to interact with the insonating beam manifesting as echos and are more likely to occur in areas of slow flow. Typically the first manifestation is in the sinus behind the cusps of the venous valves.
What is it?

• **Blood flow is anechoic because the red cells are too small to reflect the incoming sound wave**

• **Certain conditions may cause the (RBC) to stick to each other termed rouleaux formation**

• **Stacks of red blood cells which form because of the unique discoid shape.**

• **The flat surface of the discoid (RBC) give them a large surface area to stick to each other forming Rouleaux**
• **Stacks of red blood cells which form because of the unique discoid shape**

• **The Flat surface of the discoid (RBC) give them a large surface area to stick to each other forming Rouleaux**
What typically causes this formation?

- Infection
  - Acute Hepatitis
  - Tuberculosis
  - Bacterial
- Connective Tissue Disorders
  - Systemic Lupus
  - Polymyalgia Rheumatica
  - Rheumatoid Arthritis
  - Temporal Arteritis
  - Systemic Sclerosis
What typically causes this formation?

- Malignancy
- Polycythemia Vera
Underlying Conditions which cause Rouleaux Formation

- Others
  - Sarcoidosis
  - Renal disease
  - Drug fever
  - Cirrhosis
  - Physiologic increases in fibrinogen
  - Pregnancy
Many causes associated with Rouleaux formation are also associated with deep venous thrombosis.
Why are we seeing this more often?

- Technologic advances in B-mode imaging
  - Compound imaging
  - Harmonics
  - Having a high bandwidth transducers
Is This A Normal or Abnormal Finding?

- Rouleaux flow is controversial
- Many experts differ on opinions
- We feel the most benign form of rouleaux is seen third trimester pregnancy
- With pregnancy phasic flow may still be seen in venous flow
- Color flow in our opinion provides minimal information
- This is seen today with increased frequency due to advances in technology
What do we do?

- Pre test probability of DVT (Wells Criteria)
- D-Dimer results (emphasis on negative)
- Exclude benign Rouleaux flow if there is proximal deep venous thrombosis

**Provocative measures**

- Heel raises 30 seconds recheck
- Manual deep calf compressions on non ambulatory patients
- Did all Rouleaux clear?
- If pre test probability is high a F/U exam in 24-48hrs
VALVES AND AUGMENTATION

Rouleaux behind Valve cusp

Provocative maneuvers

Left Popliteal Vein

Right Popliteal Vein
When does an Alarm go off?

- **Rouleaux flow does not clear with provocative measures**
- **Presence of continuous flow with loss of spontaneity**
- **Difficulty in compression despite proper patient positioning of CFV and proximal FV**
- **High pre test probability**
Next Step

- **MUST IMAGE PELVIC VEINS**
- **IF VENOUS IMAGING IS INADEQUATE SECONDARY IMAGING SUCH AS CT WITH CONTRAST OR STANDARD VENOGRAPHY**
Let’s look at a couple examples...
Bilateral CFV

Right CFV

Left CFV
Right External Iliac Vein — Right CFV
One Final Technical Note
Compression

• Make a mental note of the force involved in each compression of the CFVs
• Many times with proximal obstruction the force involves to complete compression the adjacent arterial vessels will be altered
• Always before contralateral compression and spectral analysis
• Apples to Apples
Standard Causes

IVC Filter Occlusion

Proximal Obstruction
Summary

• Rouleaux flow is a controversial topic
• Very little published data
• Constant improvement of technology makes issue more difficult
• Complete clearing of Rouleaux with provocative measures excludes deep venous thrombosis
• Contralateral waveform analysis is mandatory
• If pre test probability is high a F/U exam in 24-48hrs
• Always be cognizant of pre test probability of DVT
1982
QUESTIONS...
Thank You!!

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