CTC
Clinical Seminar
Venous Thromboembolism (VTE)
Agenda

What is a DVT?
Virchow’s Triad & Risk Factors
Methods of DVT Prophylaxis
Diagnosis of DVT
Treatment of DVT
Complications of DVT
A Life-Threatening Medical Condition

• DVT and PE are collectively known as VTE

• Two million people in the U.S. develop VTE annually
  – Nonfatal VTE -- 613,423
  – Fatal VTE -- 296,370

• 2/3 of VTE episodes are related to hospitalization
The Economic Effect

“More people die each year from pulmonary embolism than from motor vehicle accidents, breast cancer or AIDS.”

Costs of hospitalization (2013)

- PE $25,864
- DVT $20,636
- Stroke $14,401
- Acute Myocardial Infarction $11,642
What is a DVT?

• DVT – the formation of a blood clot within a deep vein that may partially or completely block the flow of blood

• Forms in any vein in the body but most commonly in the lower extremities, especially the calf veins (distal DVT)
  - 20% will propagate proximally into the thigh (proximal DVT)

• Most clinically significant PEs originate from proximal DVTs of the leg (popliteal, iliac or femoral veins)
  - 10% die within the first hour
  - PE may be the most common preventable cause of death in the world.
Deep Vein Thrombosis
Anatomy & Physiology

**ARTERIAL SYSTEM**
- Contains muscles layers
- High pressure system
- Carries oxygenated blood from heart to tissues
- Low compliance
- Contains 20% of circulating blood

**VENOUS SYSTEM**
- Thin, elastic vessels return blood to the heart
- Compress and collapse easily
- Low pressure system
- Valves prevent reflux
- Contains 80% of circulating blood
Venous Return

- **Muscle pumping** of the legs (esp. calf region) facilitates blood return to the heart

- **Cardiac output** - pressure at which blood is pumped out of heart

- **Gravity** - elevation above heart level assists venous return

- **Respiratory pump** - diaphragm movements shifts pressure and acts as a pump in pulling venous blood toward heart

- **Pulsations of the arteries** - milking effect on veins alongside them
Calf Muscle Pump

Valves closed

Deep veins under high pressure

(Cullum and Roe, 1996)
Semi-Lunar Valves

Valve Open  Competent Valve  Closed

Incompetent Valve
Virchow’s Triad

Stasis

Vessel Injury

Hypercoagulability

The more risk factors a person has....
the greater the chances of developing a DVT
Blood Clots: Natural Part of the Healing Process

- Clots enable injured tissue to begin to repair itself without excessive blood loss
- Platelets clumping and aggregating at site of injury is normal part of clotting and healing process
- Balance exists between promoting coagulation and retarding coagulation
- Disturbance in equilibrium may occur and mechanism may backfire under “ideal” conditions....

Coagulopathies

Anti-Coagulation

Coagulation
Virchow’s Triad

Stasis

- Surgery longer than 30 min.
  - Muscles ineffective due to anesthesia
  - Veins overfill
  - Over-distended veins may develop micro-tears in the vein wall

- Prolonged Immobility
  - Vein distention and blood pooling in lower extremities
  - Long trips

- Paralysis/Stroke
  - Muscles can’t help move blood

- Obesity / Pregnancy
  - Excess weight in the abdomen prevents venous return
  - In pregnancy, risk of VTE 6x greater (fetus increases pressure on veins in pelvis)

- Edema in lower extremities
  - Excess fluid within the tissues increases pressure against the veins

- Age over 40
  - Loss of muscle tone
Fibrinolytic Shutdown Phenomenon

– Occurs in ALL operative patients to some degree

– Cause uncertain

– Believed to be a stress response to surgery

– Postoperatively, the fibrinolytic activity (body’s natural ability to dissolve blood clots) falls, leaving the patient open to risk of DVT formation

– Begins 30 minutes into surgery and may continue three to four days post-op; has been documented to last up to seven days
Virchow’s Triad

Vessel Injury

• History of DVT or PE
  – 4x more likely to develop a new DVT

• Vessel damage
  – Phlebitis, trauma to vein from bone fractures, IV punctures and vein-irritating IV medications, burns
  – Central venous catheters

• Immobility
  – Over-distention of veins leads to micro-tears in vein wall

• Surgery longer than 30 minutes
  – Lack of movement -> stasis -> micro-tears
  – Surgical trauma

• Age over 40
  – Risk increases with age: nearly doubling with each decade of life after age 40
Virchow’s Triad
Hypercoagulability

• Surgery lasting longer than 30 minutes
  – Anesthesia alters blood chemistry

• Dehydration
  – Thickens circulating blood

• Estrogen Therapy
  – Birth control pills (3 - 6x greater risk)
  – Hormone therapy

• Malignancies - 2x the risk of DVT and 3x the risk of fatal PE as in non-cancer patients undergoing similar procedures

• Inherited clotting disorders
Public Awareness

"If you think I’m going on that and risking deep vein thrombosis you can think again"
<table>
<thead>
<tr>
<th>Patient Group</th>
<th>Risk of DVT (%)</th>
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<tbody>
<tr>
<td>Medical patients</td>
<td>10-20</td>
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<tr>
<td>General surgery</td>
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<td>Major gynecologic surgery</td>
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<td>Neurosurgery</td>
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<td>Stroke</td>
<td>20-50</td>
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<tr>
<td>Hip or knee arthroplasty</td>
<td>40-60</td>
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<td>Hip fracture surgery</td>
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<td>Major trauma</td>
<td>40-80</td>
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<tr>
<td>Spinal cord surgery</td>
<td>60-80</td>
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<tr>
<td>Critical care patients</td>
<td>10-80</td>
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</tbody>
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Obesity and DVT

• Obese patients were 2.5x as likely to have DVT and 2.2x as likely to have PE

• Odds of PE and DVT were more than 5x higher for obese patients younger than 40 than their non-obese peers

• Obese men under age 40 had a tripled risk of DVT

• Obese women under age 40 had the highest risk of DVT – 6x as likely as non-obese women under age 40 to have DVT
Risk Stratification for DVT & PE

**Low Risk**
Uncomplicated minor surgery in patients < 40 years old with no risk factors

**Moderate Risk**
Major surgery in patients > 40 years old with no risk factors

**High Risk**
Major surgery in patients > 40 years old who have additional risk factors

**Very High Risk**
Major surgery in patients > 40 years old plus history of DVT/PE, cancer, major orthopedic surgery, hip fracture, stroke, spinal cord injury or hypercoagulability

(ACCP, 2012)
DVT Facts

- Majority of DVTs are clinically silent

- 50 percent of DVTs start on the operating room table, and the majority will be present within 48 hours of surgery

- DVT risk does not end upon discharge
  - After joint replacement surgery:
    - Highest risk two to five days after surgery
    - 2\textsuperscript{nd} peak occurs 10 days after surgery, after most have been discharged from hospital
    - Extends for at least three months after surgery
Deep Vein Thrombosis Prophylaxis

Chemical Methods

- The use of anticoagulants includes an inherent risk of increased bleeding and various other side effects
- All anticoagulants require frequent blood draws in order to monitor the dosage provided to the patient
- Anticoagulants:
  - Warfarin
  - Low Molecular Weight Heparin
  - Heparin
Deep Vein Thrombosis Prophylaxis

Physical Methods

• Walking
• Vena Cava Filters
• Gradient Stockings
• Intermittent Pneumatic Compression (IPC)
MECHANICAL METHODS
Intermittent Pneumatic Compression

• Introduced over 30 years ago
• Considered as effective as anticoagulants but without side effects
• Addresses all aspects of Virchow’s Triad (stasis, hypercoagulability, and injury)
• Appropriate modality for all patients at risk
  • Low-Moderate Risk -- IPC alone
  • High Risk -- IPC + Anticoagulants
How are Pneumatic Compression Systems Clinically-Proven?

Blood Flow Studies
DVT Outcome Studies
Compliance Studies
Fibrinolytic Studies
How Does IPC Work?

- **Mechanical Effects:**
  - Mimics the action of walking by “squeezing” or compressing the calf, or calf and thigh muscles, thereby enhancing blood flow, reducing stasis

- **Chemical Effects:**
  - Enhances fibrinolytic activity (stimulates fibrinolysis – the body’s natural method for preventing and breaking down clots) to reduce the risk of clot formation
Intermittent Pneumatic Compression

Venous Stasis

Virchow's Triad

IPC

Blood Chemistry Changes
When Do You Use Compression?

• Surgical Patient
  – Preoperatively, prior to anesthesia induction
  – Intraoperatively
  – Postoperatively – until fully ambulatory

• Non-Surgical Patient
  – Immediately upon identification that the patient is at risk for DVT
**Sequential**

- Chambers compress sequentially
- Distal chamber pressure 45 mmHg
- Proximal chamber 25 mmHg for 2.5 seconds

**Intermittent**

- Posterior bladder
- 40 mmHg of sustained pressure
- Distal to proximal inflation
Foot Compression

- Inflation 0.4 – 3 seconds
- Pressure 80 - 120 mmHg
- Two to three cycles per minute
- Single-Pulse vs Circumferential
When is IPC Contraindicated?

- Severe arteriosclerosis or other ischemic vascular disease
- Phlebitis or any known or suspected DVT
- Pulmonary embolism
- Severe CHF
- Any local condition in which garments would interfere such as: gangrene, untreated or infected leg wounds, recent skin grafts or dermatitis
- Extreme deformity of the limb
- Severe congestive heart failure
Are There Any Reasons to Discontinue Therapy Early?

- Known or suspected DVT
- Signs of pulmonary embolism
- Tingling of extremity
- Skin breakdown
- Numbness
- Pain
Invasive Diagnostic Tests

Contrast Venography

- Dye injected into vein in the foot or ankle
- X-ray imaging taken to reveal the location of possible clots
- One of the most accurate ways to identify DVT
- Potential complications due to invasiveness
- Expensive
- Requires high degree of expertise to perform and interpret correctly

$^{125}$I Fibrinogen Leg Scanning

- Radioactive isotope injected into the legs
- Failure to detect approximately 30% of thrombi
- Poor sensitivity for proximal thrombi
- Time consuming
Non-Invasive Diagnostic Tests

Doppler Ultrasound

• Performed using a Doppler and compression maneuvers to evaluate the sound of blood flow in the veins

• Computerized imaging can reveal the presence of a clot
Non-Invasive Diagnostic Tests

Duplex B-Mode Imaging

• Pulsed Doppler (audio interpretation) of the vein with imaging capabilities through visualization on a computer

• Duplex scanning may establish a diagnosis of DVT, but also defines the location and extent of clot

• Color-flow expedites identification of vessels and improves accuracy
# Non-Invasive Diagnostic Tests

## Helical CT
- Scanners use “slip rings” to power the x-ray tube so that the ring can spin throughout the duration of the scan.
- Lower radiation dose to the patient, decreased artifact, ability to scan greater body length and greater enhancement of body organs.

## MRI
- In preliminary stages.
- Uses a strong magnet to visualize internal structures of the body which generates high quality images.
- Sensitivity and specificity for DVT have been reported as 97% and 95%, respectively.
Treatment of DVT

**Short-term**
- Bedrest until confirmed by duplex
- Discontinue IPC
- Anticoagulants
- Monitor for signs of PE

**Long-term**
- Proper diet and exercise
- Maintain normal weight
- Avoid standing or sitting for long periods
- Compression garments
- Anticoagulants
Treatment of DVT

- Anticoagulants
  - Heparin
  - Low Molecular Weight Heparin
  - Arixtra (Fondaparinux Sodium)
  - Warfarin

- Filters
- Thrombolytic Therapy
- Surgery
Complications of DVT

- Pulmonary embolism
- Valvular incompetence
- Predisposition for further DVTs
- Post-thrombotic syndrome (occurs in 50-75 percent of patients diagnosed with DVT)
- Chronic venous insufficiency
- Venous ulceration
  - The average cost to treat a venous stasis ulcer is estimated to be $40,000
Complications of DVT

In the United States, 6-7 million people have evidence of post-phlebitic syndrome and 500,000-800,000 people have leg ulcers.
Venous Thromboembolism

Prevention is the Key to Saving Lives.
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Clinical Seminar