2015 Phlebology Review Course

Venous Physiology

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Disclosures:

- Royalties from Elsevier, Amirsys, Springer
- Consultant for CeleNova Biosciences, Koo Foundation
- Investor in Althea Healthcare

I will not discuss any off-label use.
Function of Veins:
- Return blood to heart for re-oxygenation and recirculation
- Storage of blood
  - 60-80% of resting blood volume in the venous system
- Maintain cardiovascular stability through changes in capacitance
  - Through sympathetic mediated smooth muscle tone
## Factors Affecting Venous Return

### Intrinsic Factors
- Musculovenous Pump
- Abdomino-thoracic Pump
- Cardiac Pump
- Venous Gradient
- Valve Integrity
- Sympathetic tone

### Extrinsic Factors
- Gravity
- External Compression
- Atmospheric Pressure
Musculovenous Pump
Abdomino-thoracic Pump

![Graph showing the Abdomino-thoracic Pump with pressure changes during inspiration and expiration.](image)

- **Inspiration**
  - $P_{pl}$
  - $P_{RA}$
  - Venous Return

- **Expiration**
  - End-Expiration
Abdomino-thoracic Pump

- Upper Extremity Venous flow:
  - Increases with inspiration, Decreases with expiration

- Lower Extremity Venous flow:
  - Rib-cage breathing (no increase in intra-abdominal pressure)
    - Increases with inspiration, Decreases with expiration
  - Abdominal breathing (increase in intra-abdominal pressure)
    - Decreases with inspiration, Increases with expiration
• Normal cardiac pulsations cause negative pressure in RA and RV that have aspiration effect on the venous return
Venous Gradient

- **Supine:**
  - RA Pressure 0
  - Venous Capillary Pressure 15mmHg
  - Gradient 15

- **Erect**
  - RA Pressure: 0
  - Lower extremity Venous pressure: 15+80mmHg
  - Mean trans-capillary gradient remains the same
Valve Integrity

Normal Valve
Bicuspid
More in leg
Prevent reversed flow

Vein dilation affects superficial veins due to lack of fascial enclosure
Ambulatory Venous Pressure
Ambulatory Venous Pressure

- Deep venous obstruction
  - Deep insuff.
  - Superf. insuff.
- Healthy subjects
- AVP
- ES2010
- RT
Venous Phlethysmography

- $\frac{90\% VV}{VFT90} = VFI$
- $\frac{EV}{VV} \times 100 = EF$
- $\frac{RV}{VV} \times 100 = RVF$
Venous obstruction

(a) Venous volume over time

(b) Venous volume over time
Lymphatic System
Anatomy

- Palatine tonsil
- Submandibular node
- Cervical node
- Right internal jugular vein
- Right lymphatic duct
- Right subclavian vein
- Thymus
- Lymphatic vessel
- Thoracic duct
- Cisterna chyli
- Intestinal node
- Large intestine
- Appendix
- Left internal jugular vein
- Thoracic duct
- Left subclavian vein
- Axillary node
- Spleen
- Small intestine
- Aggregated lymphatic follicle (Peyer's patch)
- Iliac node
- Inguinal node
Micro-anatomy

Endothelial lining of terminal lymphatics has very loose anchoring filaments with flap valve mechanism

Permits passage of fluid with large molecular weight molecules into lymphatics
Lymphatic Function

- Conducts lymph fluid back to central circulation.
- Estimated 10% of capillary fluid volume exits into the extracellular space to form lymph.
- 2-4 liters lymph fluid daily
- Total lymph flow rate: 120 cc/hour
Factors affecting lymph flow:

- Interstitial fluid pressure: normally: $-6.3$ mmHg
- Factors that increase IFP will increase lymph flow
  - Increased capillary pressure
  - Decreased plasma colloid osmotic pressure
  - Increased interstitial fluid protein
  - Increased capillary permeability
Normal Interstitial Tissue Status

• Forces pulling fluid out of capillary:
  • Capillary pressure: 17 mm Hg
  • Interstitial fluid colloid osmotic pressure 5 mm Hg
  • TOTAL: 22 mm Hg

• Forces pulling fluid into capillary:
  • Blood colloid osmotic pressure: 28 mm Hg

• Difference: Interstitial fluid pressure - 6 mm Hg

Any process that alters this balance to yield a positive IFP will exceed capacity of lymphatic uptake and result in edema formation
Causes of Edema

- Increased intra-capillary pressure:
  - Venous hypertension (DVT/Venous insufficiency/Venous obstruction)
- Increased capillary permeability:
  - Sepsis/Inflammatory disorders
- Lymphatic obstruction:
  - Trauma/ Surgical lymphatic disruption/ Tumor/Parasites: Filariasis
- Decreased blood oncotic pressure:
  - Hepatic dysfunction: decreased protein synthesis
  - Protein wasting disorders: Nephrotic syndrome

All edema is lymphatic!
Veins and lymphatic share many common features in terms of vessel structure and pump action.

The two systems coordinate to maintain normal tissue fluid status.

Derangement of either system can shift the balance and result in edema formation.