Atlanta Trauma Symposium

Post-Traumatic Swelling

LymphEd

Disclaimer

• Owner of LymphEd, LLC
  • A educational company providing courses on lymphedema to medical professionals.
  • Casley-Smith International Certified Lymphedema Instructor

Objectives

• To learn the revised Starling’s Equilibrium
• To be able to understand how the revised Starling’s can impact orthopedic trauma
• To recognize when edema may need assistance to clear
• To know what treatment options are available for prolonged edema
STARLING’S EQUILIBRIUM

Starling Forces

- **Hydrostatic Pressures:**
  - Pressure exerted by the fluid
  - Is considered a “pushing” force
  - Blood (BHP); Tissue (THP); Lymphatic (LHP)

- **Colloidal Osmotic Pressure:**
  - Pressure exerted by the proteins
  - Is considered a “pulling” force
  - Blood (BCOP); Tissue (TCOP); Lymphatic (LCOP)

- Note: Blood can impact tissue pressures; yet, tissue can not impact blood

Other Important Terms

- Ultrafiltration
  - Fluid coming out of the capillaries into the tissues

- Reabsorption
  - Fluid going back into the capillaries from the tissues - Transient

- Proteolysis
  - Proteins broken down by Macrophages in the tissues
**Starling’s Equation**

Net fluid flow = $K_f \cdot (BHP - THP) - \sigma(BCOP - TCOP)$

*Fluid in the tissues = ultrafiltration - reabsorption*

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**Levick’s Work on Starling’s**

- Why reabsorption is transient
  - Previous theory: reabsorption was not transient. 90% of excess fluid was reabsorbed at venous end of capillaries because of BCOP pulling fluid in.
  - New understanding: the normal TCOP is much higher than previously known (~16 mm Hg) It acts as a stronger counterforce to BCOP and does not allow much fluid to be reabsorbed by capillaries. Instead the majority of the fluid is absorbed by the lymphatics.

- Revised Starling’s
  - Instead of the lymphatic system being a backup to the venous system in cases of increased fluid in the tissues, the **lymphatic system is the main remover of tissue fluid.**
  - The venous end of the capillaries reabsorbs a small amount of the excess. It is the backup for the lymphatic system instead of vice versa. This is very rare and only a very small amount.
**Endothelial Glycocalyx**

- A fiber matrix that is hydrophobic
- It binds to plasma proteins, resulting in a high intravascular oncotnic pressure
- Opposes the ultrafiltration rate and helps limit the amount of fluid going into the tissues
- Prevents fluid from being reabsorbed from the tissues on the venous side of the capillaries

**Glycocalyx**

**Capillaries**

**Updated Starling’s**

**Ultrafiltration**

**Venous Reabsorption**

- Main conditions when reabsorption happens
  - BCOP must be higher than BHP
  - THP is very high and/or lymph uptake is low
  - TCOP is low compared to THP
- When does this occur:
  - Temporarily will occur with hypovolemia-trauma
  - With Pre-capillary vasoconstriction
  - With post-capillary vasodilation
  - With all- will only last a few minutes and then ultrafiltration resumes at the new lower BHP, usually no change to BCOP.
**PATHOLOGY WITH STARLING’S EQUATION**

**Functional Lymphatic System**
- The TC is the amount of fluid the lymphatics can carry.
- The LTV, the Lymph Time Volume, is the total amount that can be carried to reach equilibrium.
- FR, Functional Reserve, is the amount of remaining space in the lymphatics to reach LTV.

**Dynamic Insufficiency**
- There is an increased lymphatic load—on a healthy lymphatic system.
- The fluid level is now greater than the TC and LTV loads.
- Examples of dynamic insufficiency:
  - Venous hypertension
  - Congestive heart failure
  - Injury from fall
  - Post Operative
  - Trauma
Mechanical Insufficiency
- Normal lymphatic load on a damaged lymphatic system.
- The TC has reduced
- There is more fluid, or LL than the TC can accommodate.
- Examples of mechanical insufficiency:
  - Primary lymphedema
  - Lymphadenectomy

Combined Insufficiency
- Increased lymphatic load – on a damaged lymphatic system
- Combined insufficiency, or a composite of the two
- Examples:
  - Cellulitis after a lymph node dissection (mechanical first)
  - Prolonged post-op or post trauma edema (dynamic first)
  - Infection post-op or post trauma

Effects of Edema: Clinical
- Clinical presentation of patients:
  - Swelling
  - Pain/Discomfort
  - Loss of function
  - Reduced healing
Effects of Prolonged Edemas, Especially High Protein Edemas

- Lymphatics
  - ↑ numbers
  - ↑ uptake of fluid and proteins
  - Eventually initial vessels will collapse and larger vessels will have fibrosis and stop functioning.
  - This will lead in proteins and other debris to be left behind in the tissues.

- Blood Vessels
  - Initial collapse
  - ↑ growth of blood vessels
  - Arterio – venous anastomoses used

- Tissue Cells
  - ↓ elastin
  - ↑ fibroblasts → excess fibrosis
  - Fibrocytes turn to adipocytes
  - ↑ macrophages, but many are lipid ‐ filled
  - ↓ oxygenation

- Clinical
  - Poor healing of incisions
  - Reduced gains in ROM and strength
  - Prolonged pain and numbness
  - Increased risk of infections
  - Reduced outcomes

Tissue Elements in Chronic High Protein Edema

(Rats injected with own plasma, Casley-Smith & Gaffney, 1981)

HOw TO ADDRESS EDEMA
Complex Lymphatic Therapy (CLT)

1. Manual Lymphatic Drainage
2. Compression Bandaging or Garments
3. Exercises
4. Education
5. Home Program

• For orthopedics this is often shortened.
Complex Lymphatic Therapy (CLT)

2. Gradient Compression: Bandages or garments
   • Most pressure distal and most go ~ 2 inches above the edema
   • Needs to be measured to fit the patient
   • Often painful to use garments on very swollen limbs, better to use compression bandages to reduce.
   • Garments DO NOT REDUCE

Orthopedic Benefits With CLT

• Post-Op:
  • Reduces edema
  • Helps with wound healing
  • Reduces edema’s impact on ROM and strength
  • Speeds up return to function
  • Gentle scar tissue techniques may be used to break up restrictions and encourage flow

• Patient must also be doing regular post-op ortho program - can not limit general rehab. Usually see ortho therapist 2 x week and lymph therapist 1 x week.

ORTHODO CASE STUDIES
Case Study #1

• Presentation:
  • Volume of foot/calf:
    o L 1498.0cm³
    o R 1212.0cm³
    o A 23.6% difference

• Treatment
  • 5 visits in 3 weeks
  • MLD
  • Compression Bandaging
  • Exercises

Case Study #1

• Results
  • Volume:
    o L 1103.5cm³
    o 137% reduction

Case Study #2
Case Study #2

• Presentation
  • Volume
    o L entire LE: 8834.6 cm³
    o R entire LE 8368.6 cm³
    o 5.6% difference

• Treatment
  • MLD
  • Exercise
  • Compression shorts/hose with foam pack

Case Study #2

• Liposuction
• Current status
  • Volume
    o L: 10028.2 cm³
    o R: 8732.5 cm³
    o 14.8% difference
Questions?