Physiological Considerations for Compression Bandaging

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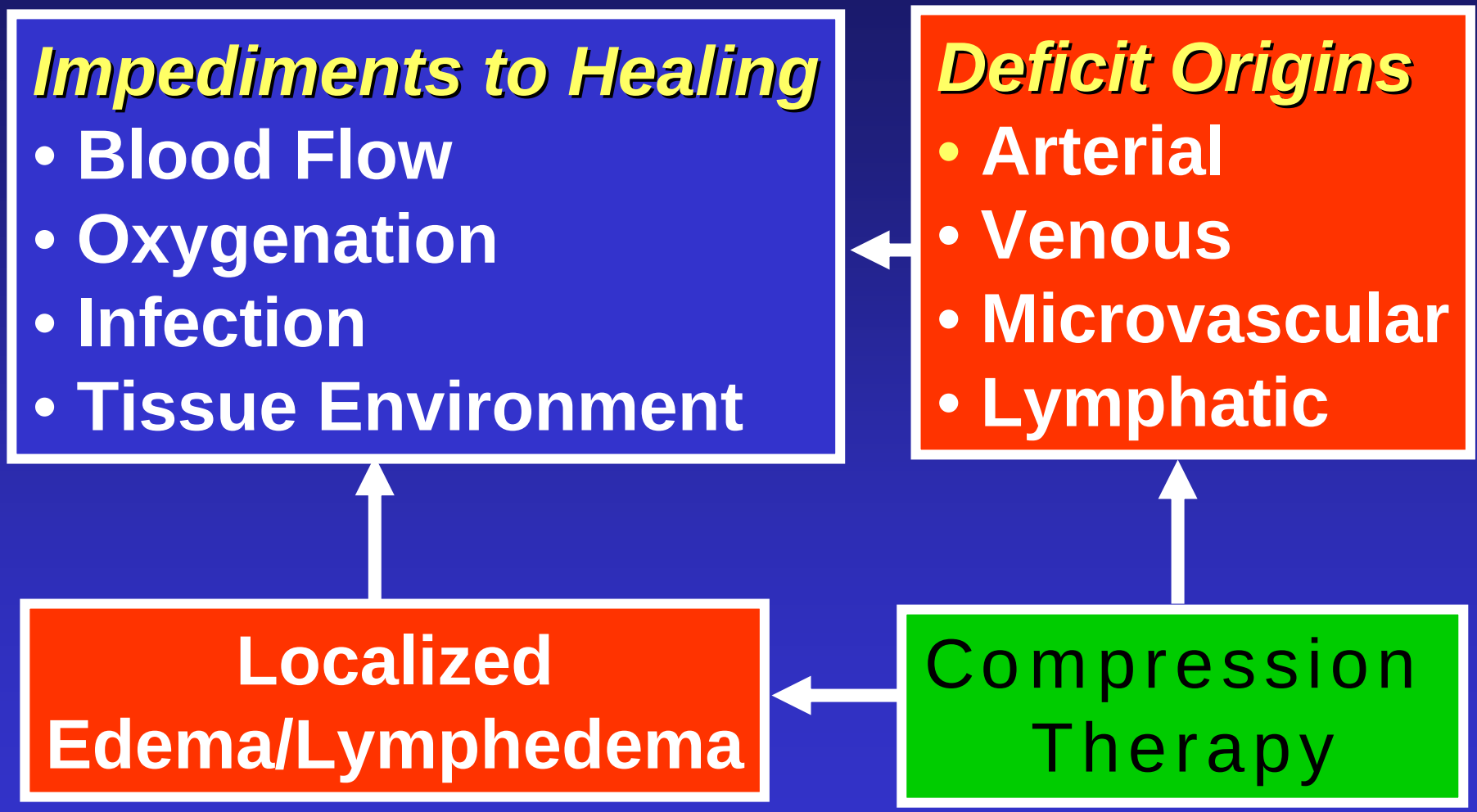
At the completion of this presentation participants will be able to:

1. **State the difference between edema and lymphedema**
2. **State at least one process that can cause edema**
3. **Describe the basic processes involved in lymphatic transport**
4. **Describe long-stretch and short-stretch bandages and their use**
5. **Contrast the effects of resting vs. working pressures**
6. **Describe Laplace's law as it applies to bandaging**

Relationship to Wound Healing



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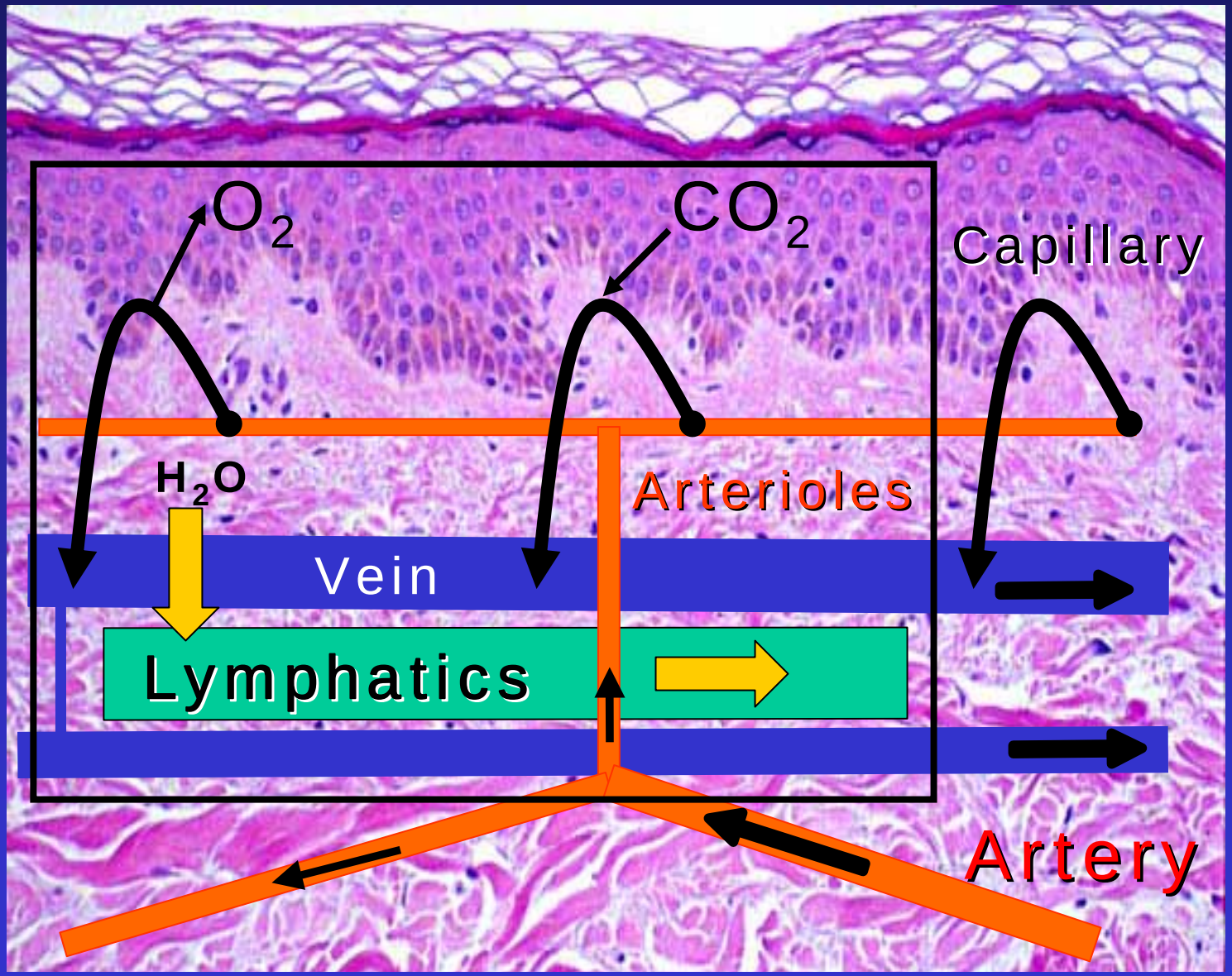
Circulation Schema



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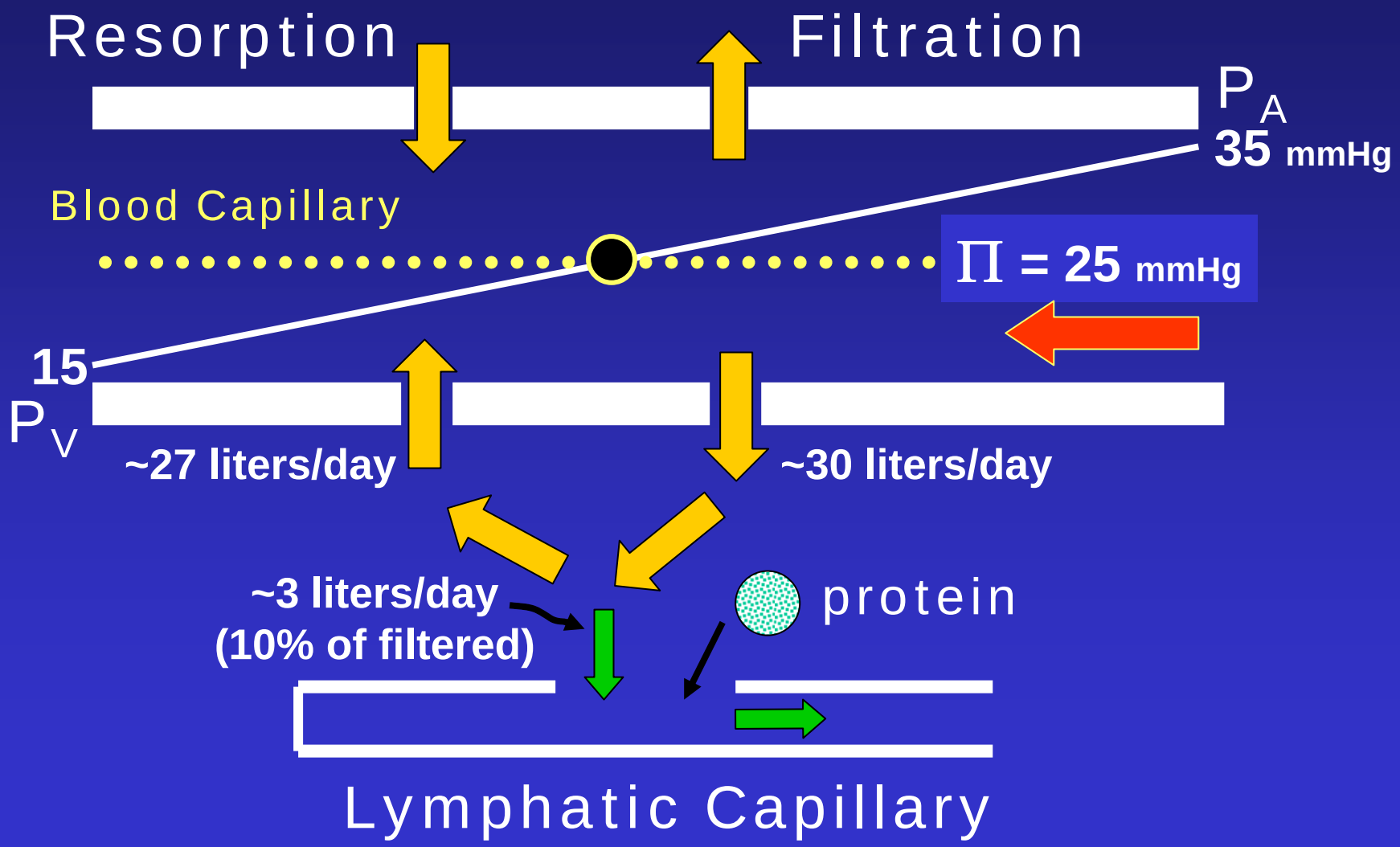
Normal Fluid Balance



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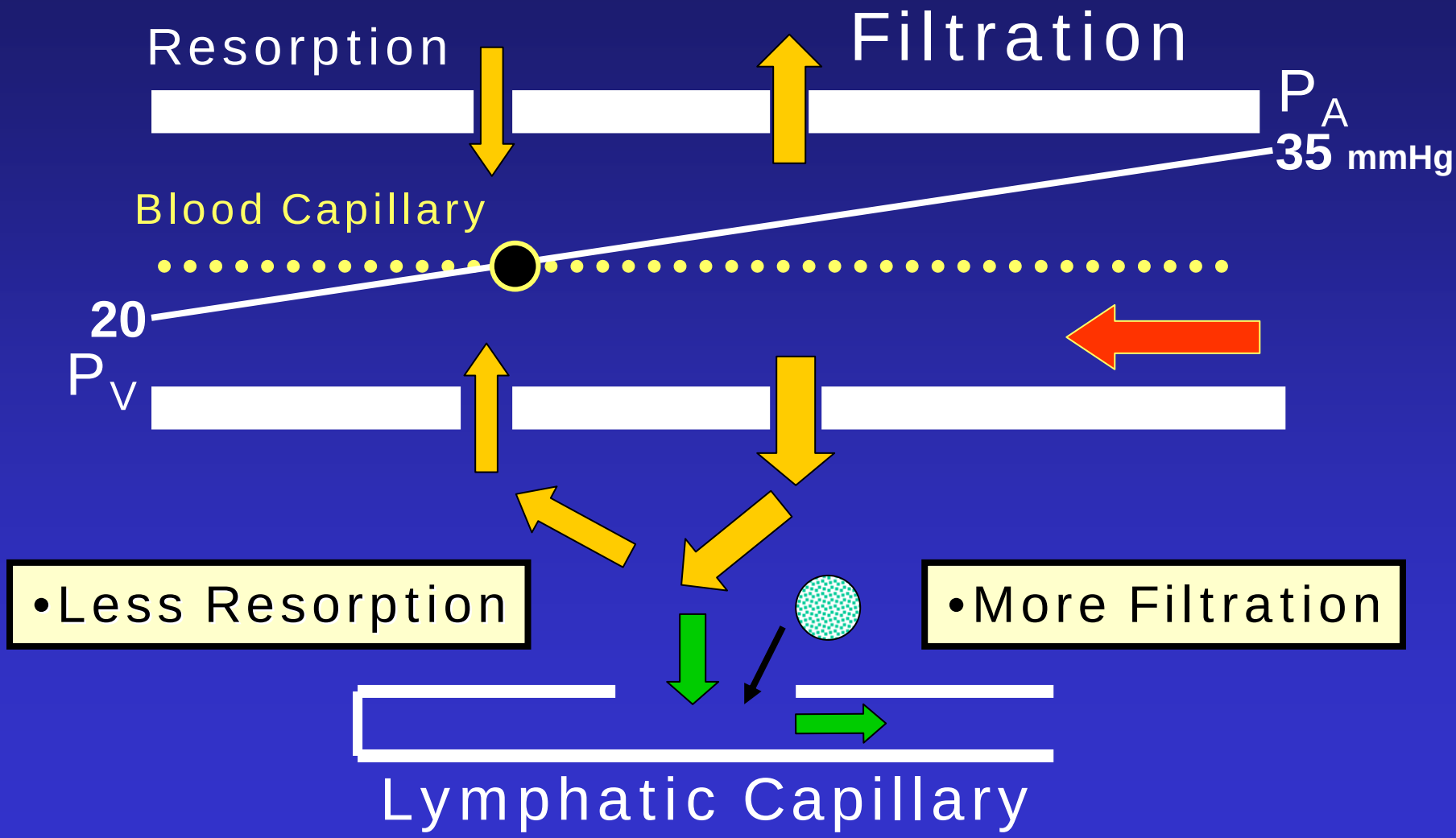
Increased Venous Pressure or Capillary Permeability



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If Net Filtration Exceeds Lymphatic Transport Capacity

Overload = Edema

+ [Protein]

= Lymphedema

Therapy Options

- Reduce Filtration
- Increase Transport

Normal Lymph Transport

- Lymphangion Contraction
- Skeletal Muscle Pump
- Arterial Pulsations
- Body Movements
- Respiration

All are Dynamic Processes

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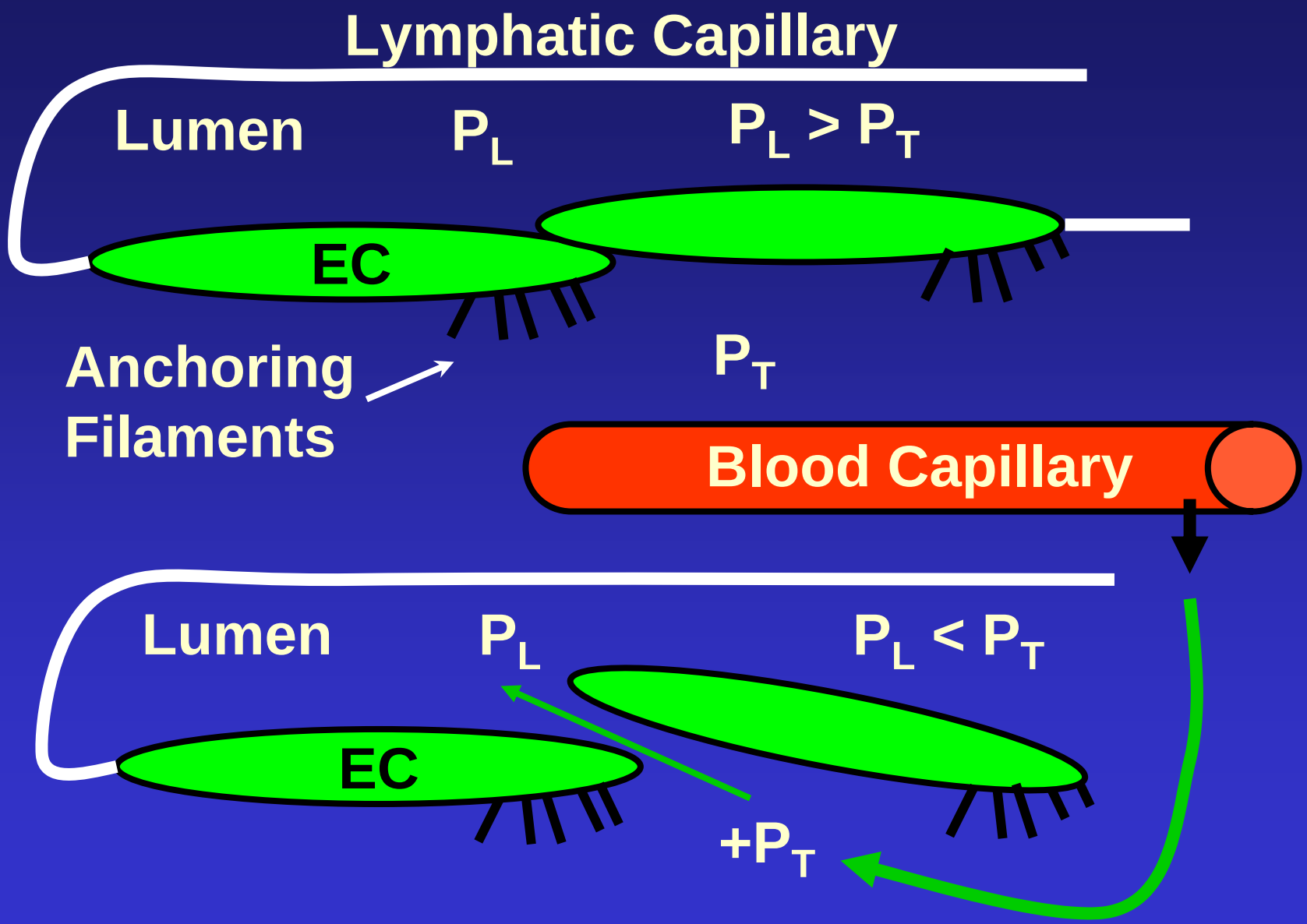
Lymphatic Capillaries



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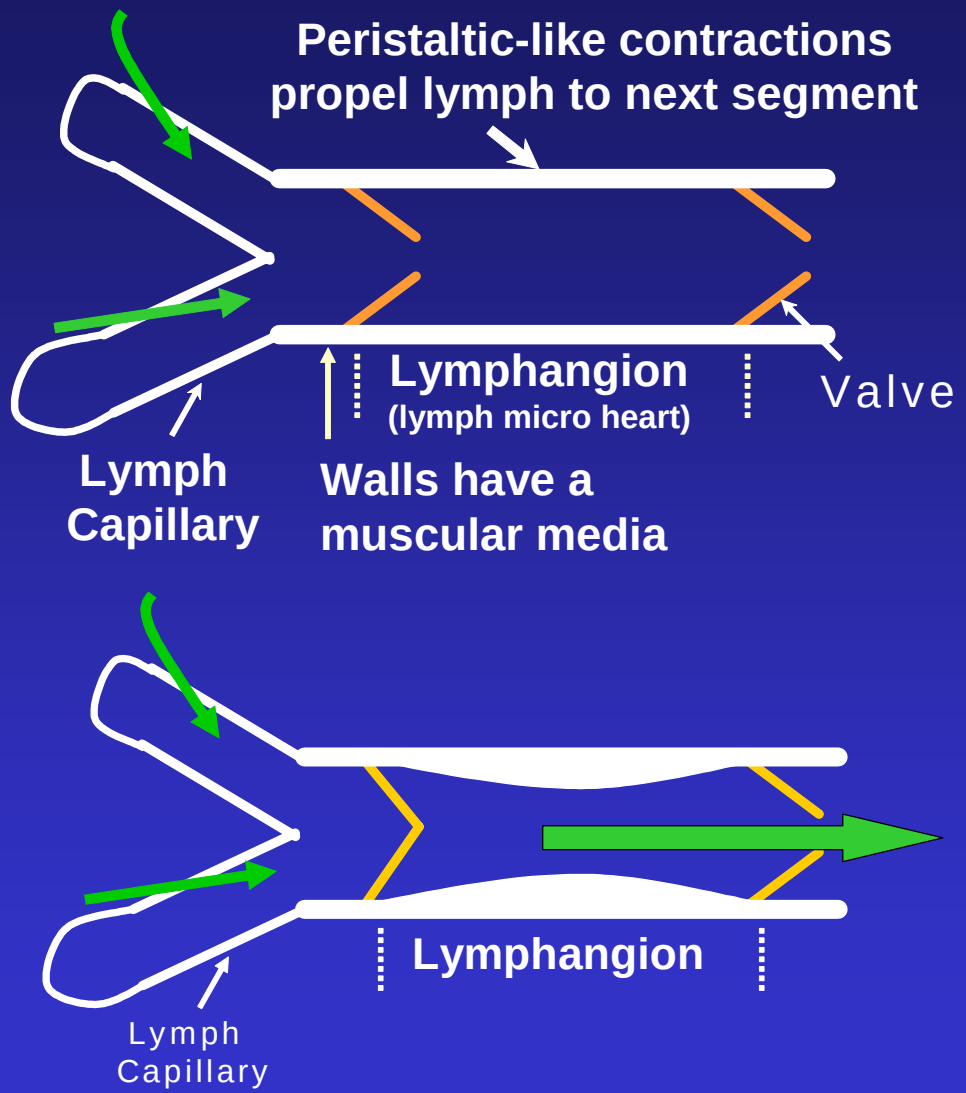
Lymphatic 'Hearts'



Contraction force is preload and afterload dependent - analogous to heart

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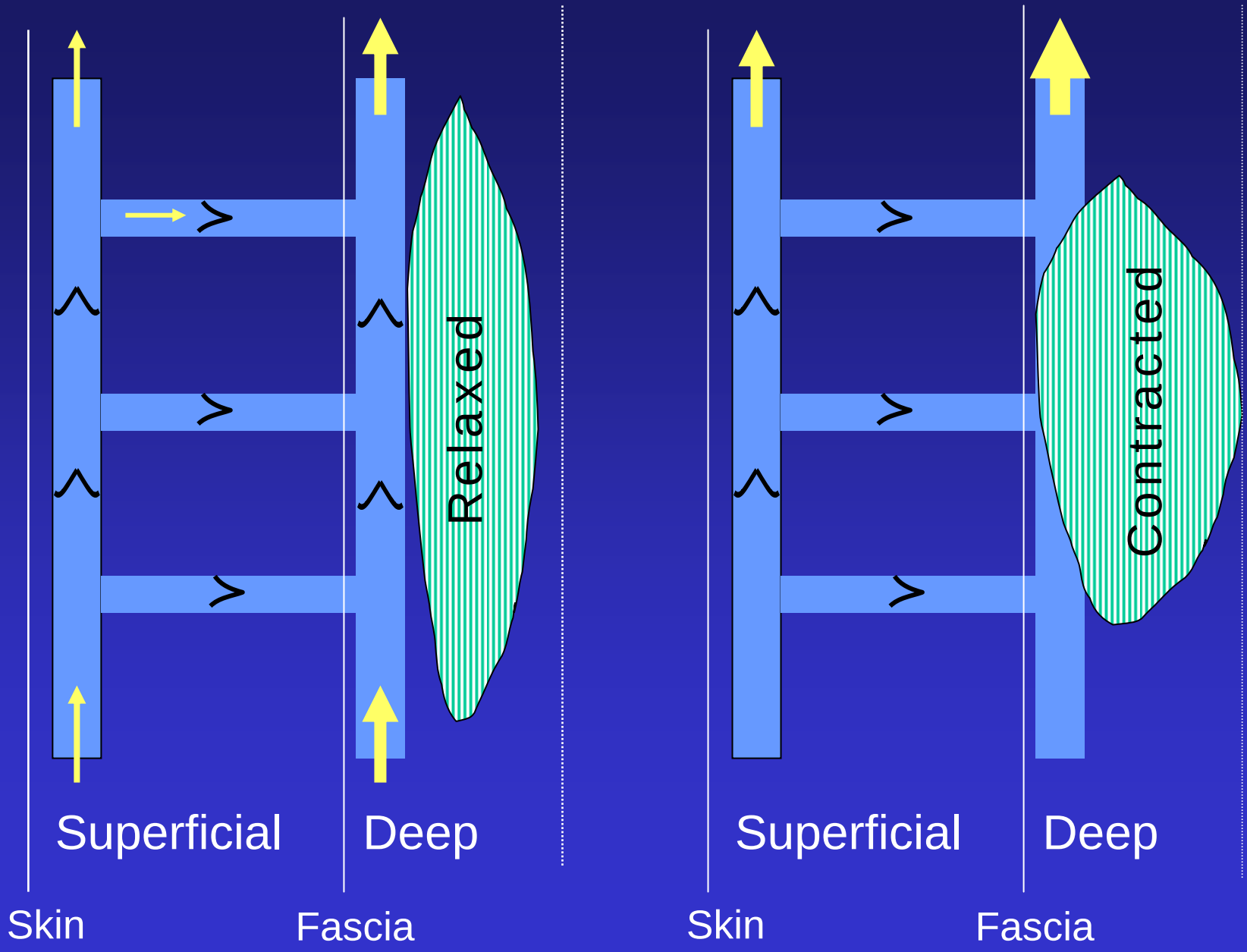
Calf Muscle Pump and Normal Valves



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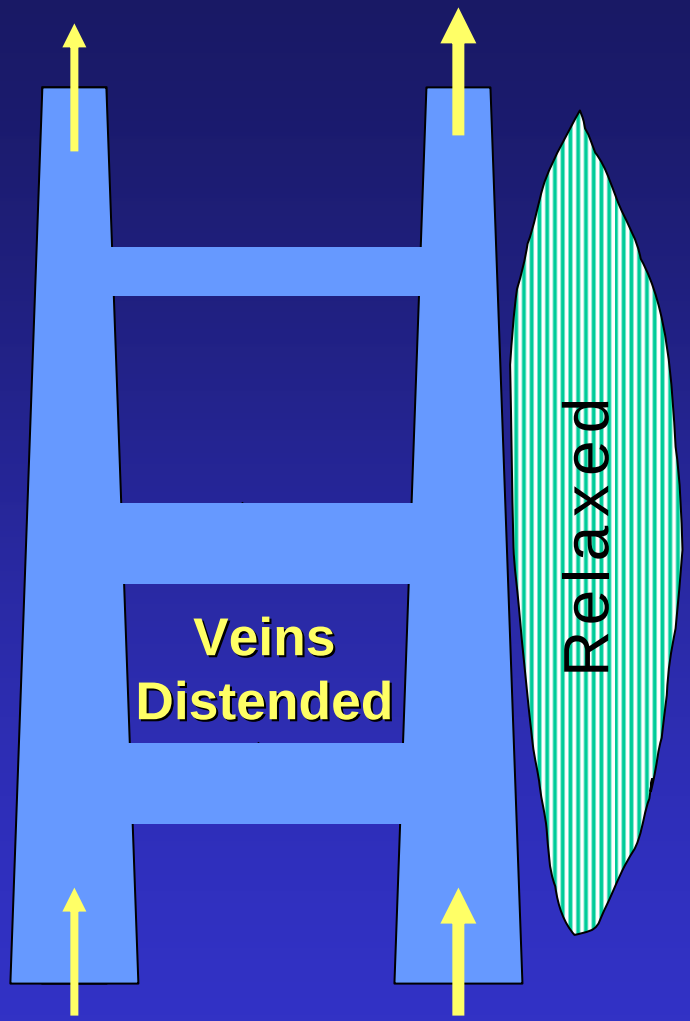
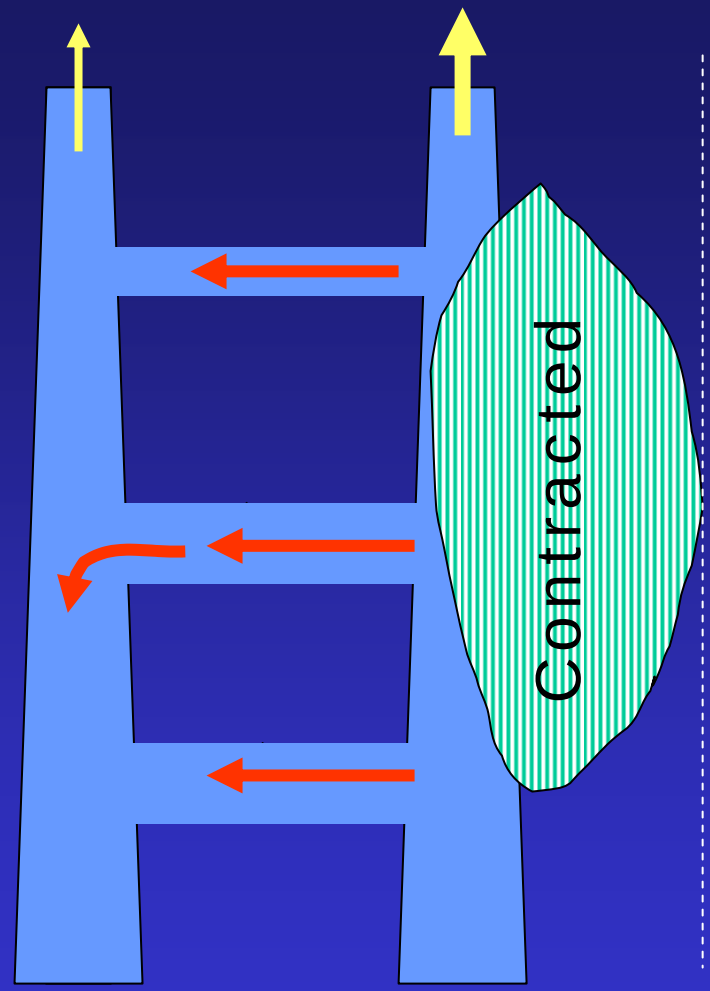
Calf Muscle Pump and Valve Dysfunction



Resting Venous Pressure
INCREASED



- High pressure transmitted to Superficial Veins
- Pump Efficiency Reduced

Venous Valve Dysfunction

Chronic venous hypertension due to Chronic venous insufficiency (CVI) predisposes to developing venous ulcers
Increased Ambulatory Venous Pressure

Venous Pressure

Resting

CVI

Normal

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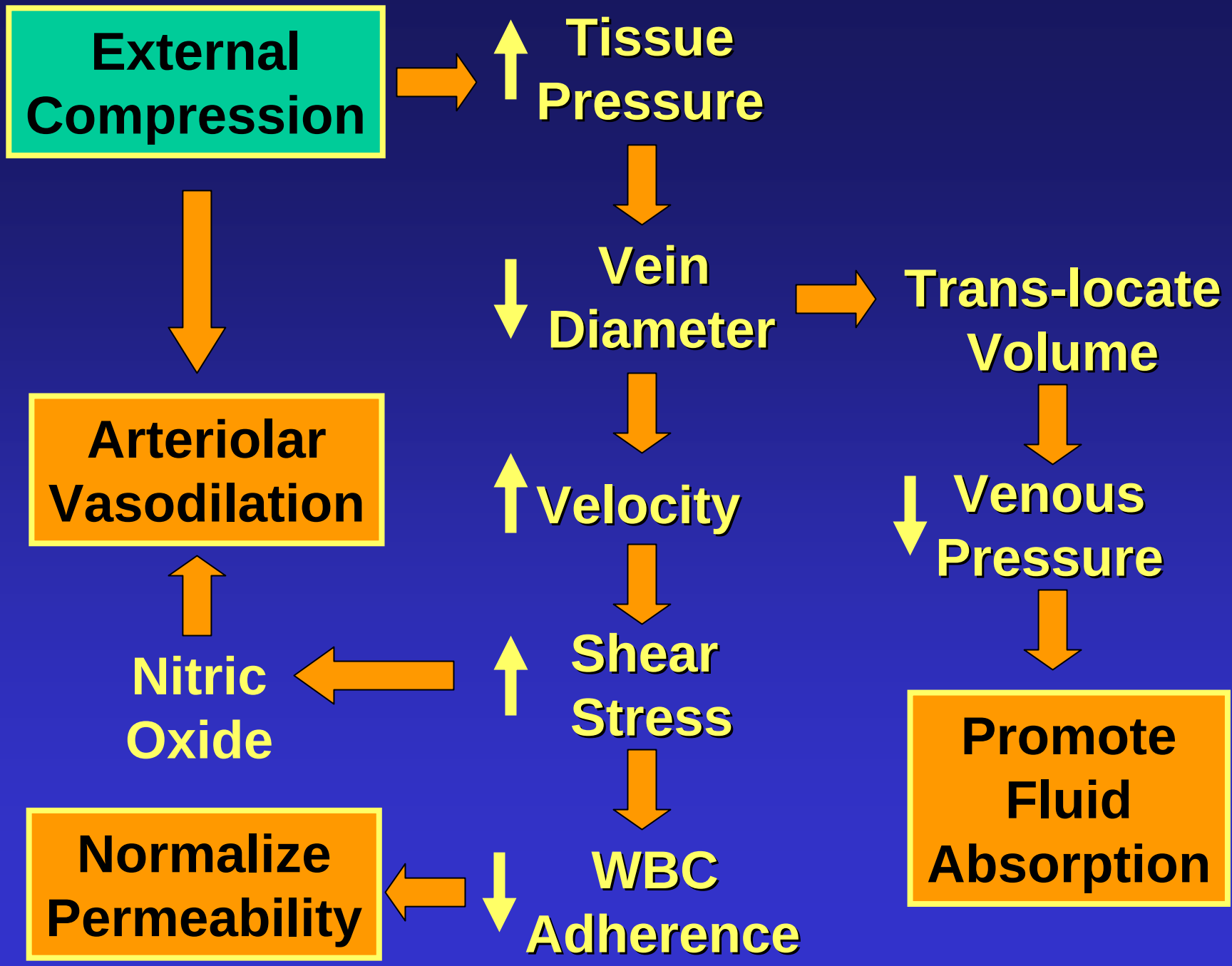

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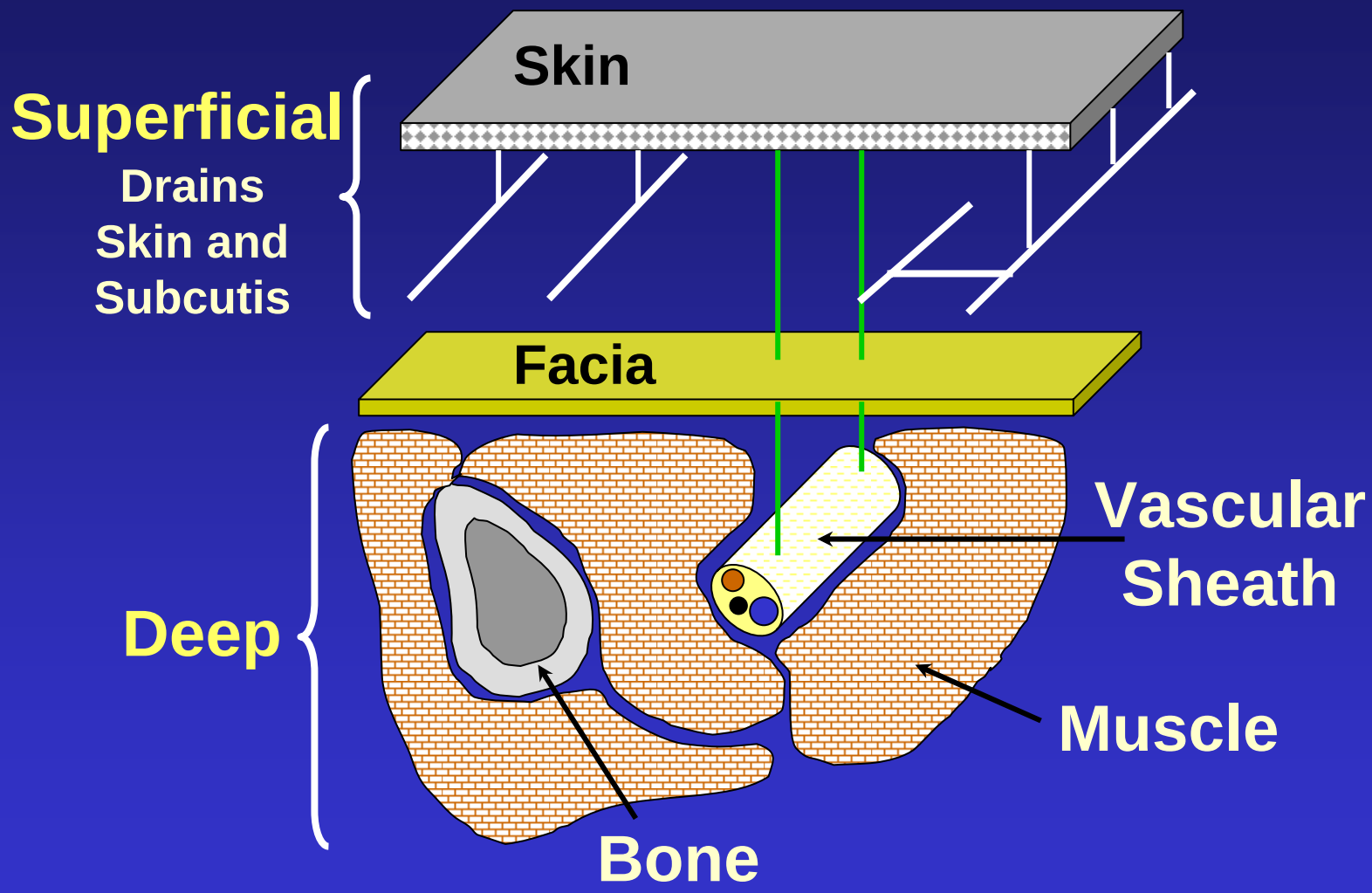
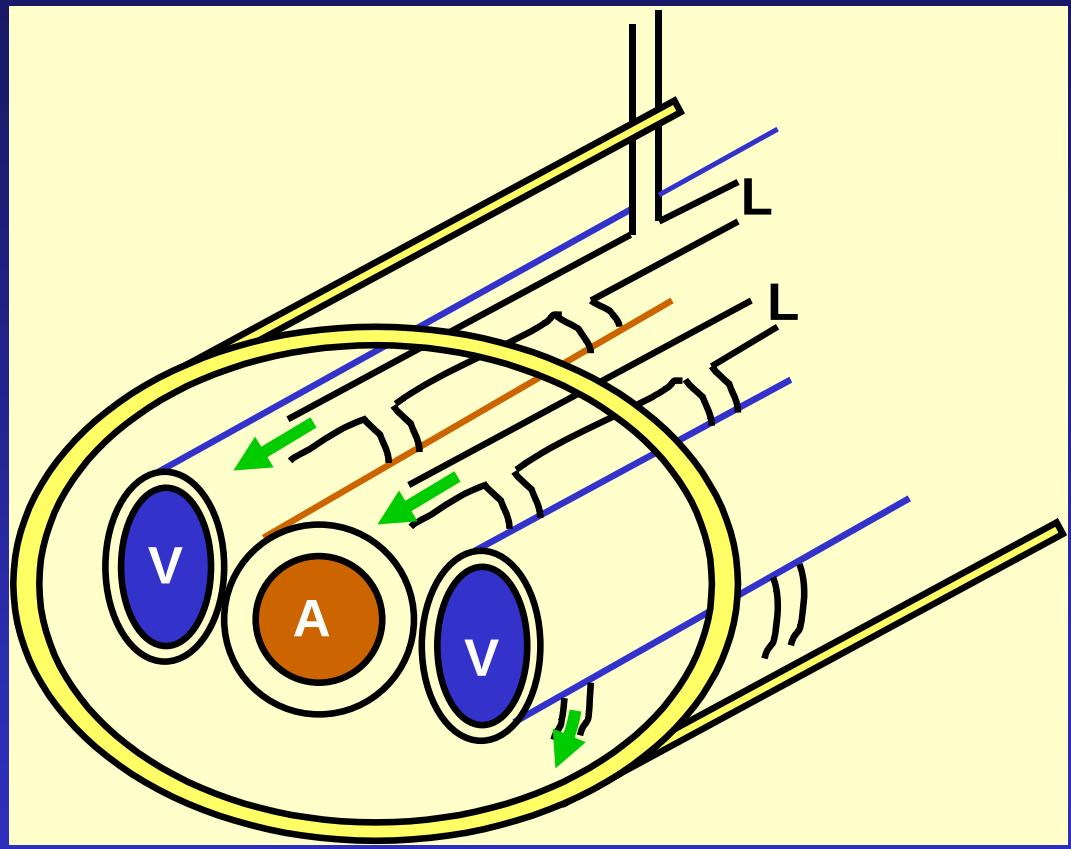
Types of Compression

- **Bandage** → **Short-Stretch**, **Long -Stretch**
- **Bandage-like** → **Short-Stretch**
- **Pumps** → **Dynamic**
- **Stockings** → **Prevention**, **Maintenance**

Arrangement



Vascular Sheath



Arterial Pulsations Can Mechanically Augment Lymph Transport

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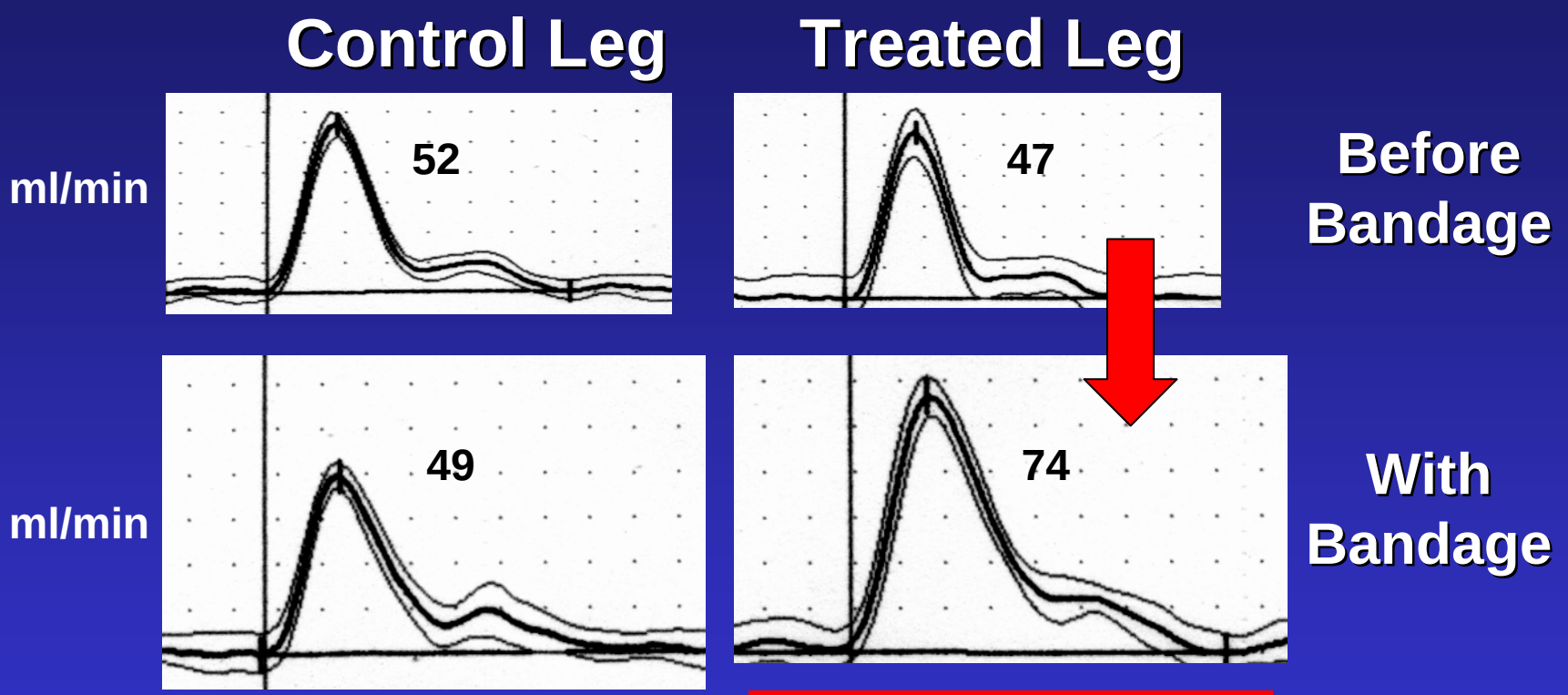
Arterial Flow Pulses

Below Knee Blood Flow via Nuclear Magnetic Resonance



Increased pulses likely augment Lymph/venous transport

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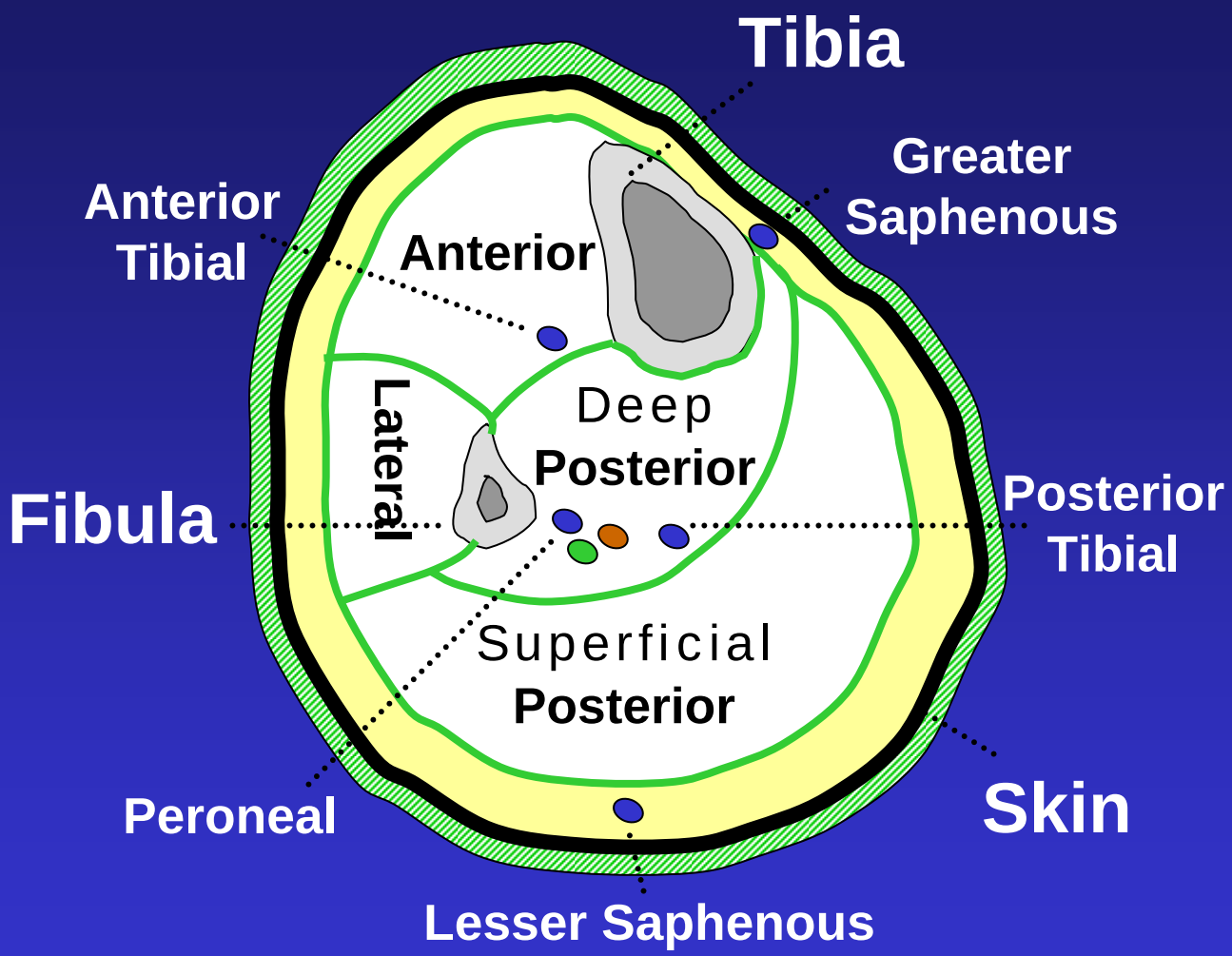
Compartments



Want Therapy to Affect Superficial and Deep

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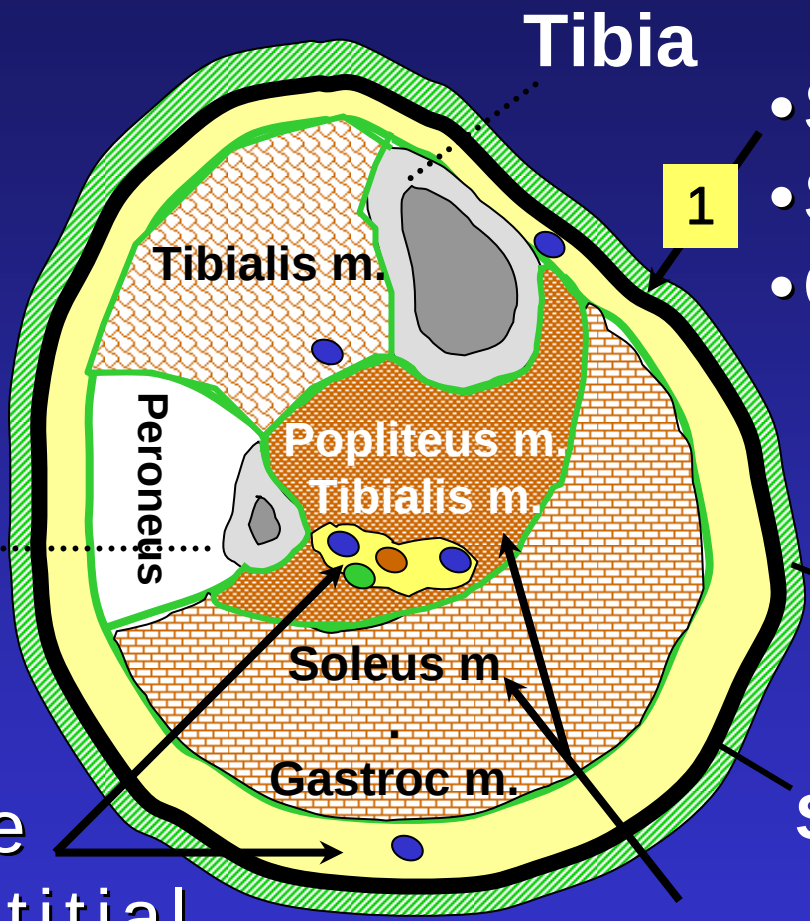
Pressures of Interest



1
- Sub-bandage
- Surface
- Contact

Compression Bandage or Device

Skin

2
- Tissue
- Interstitial

3
- Intramuscular

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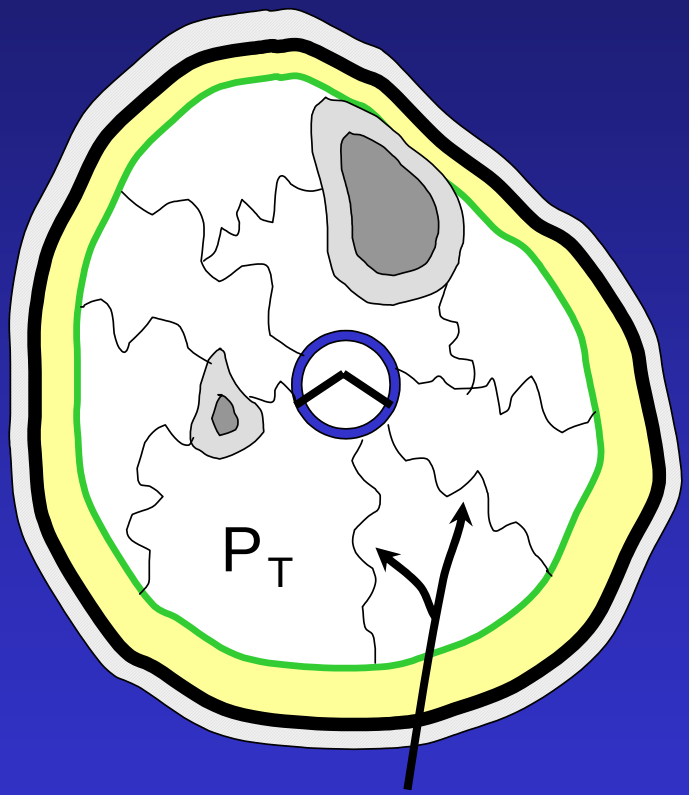
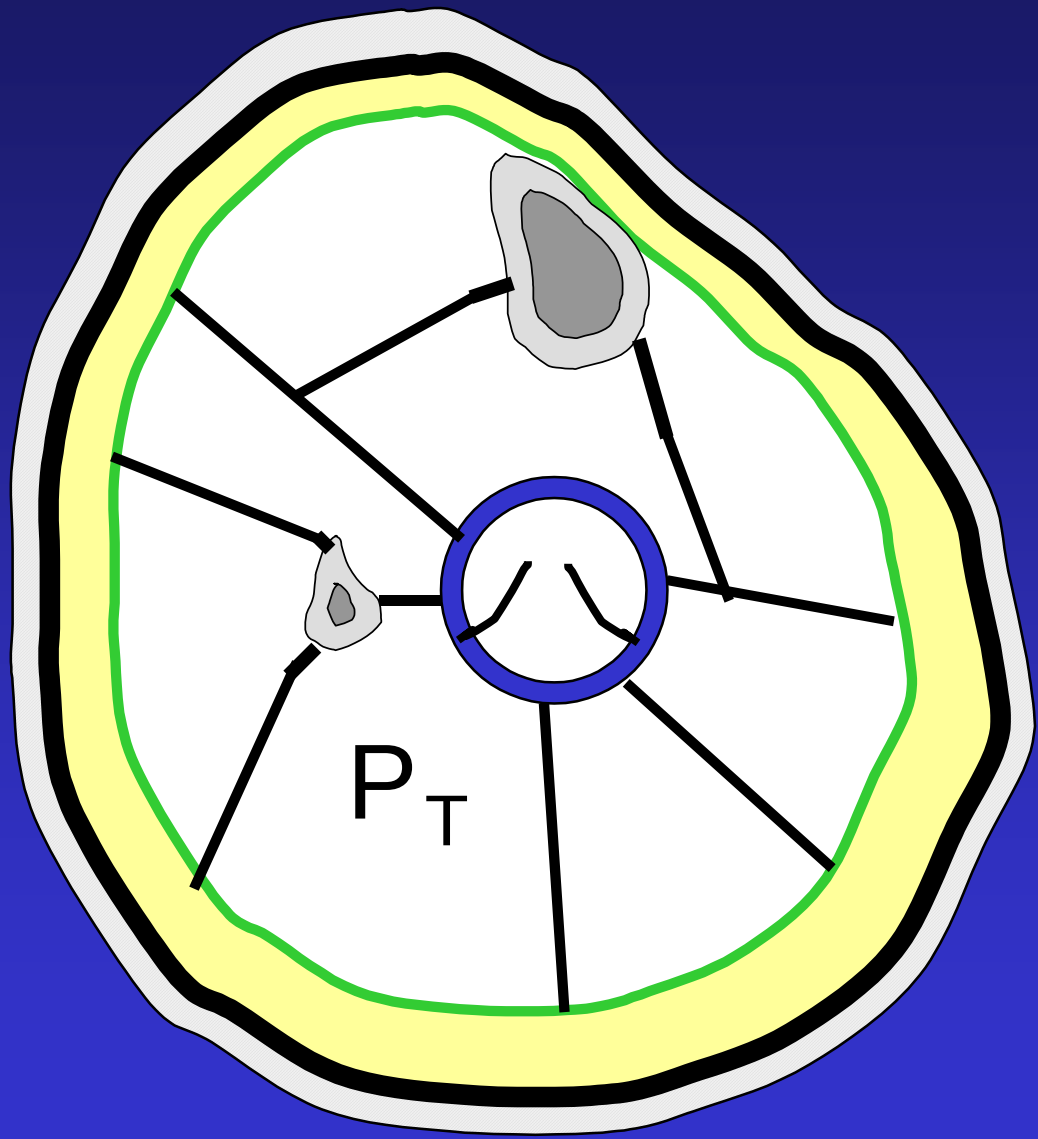
Edema and Tissue Pressure

Normal



Loose Fibrous Trabeculae



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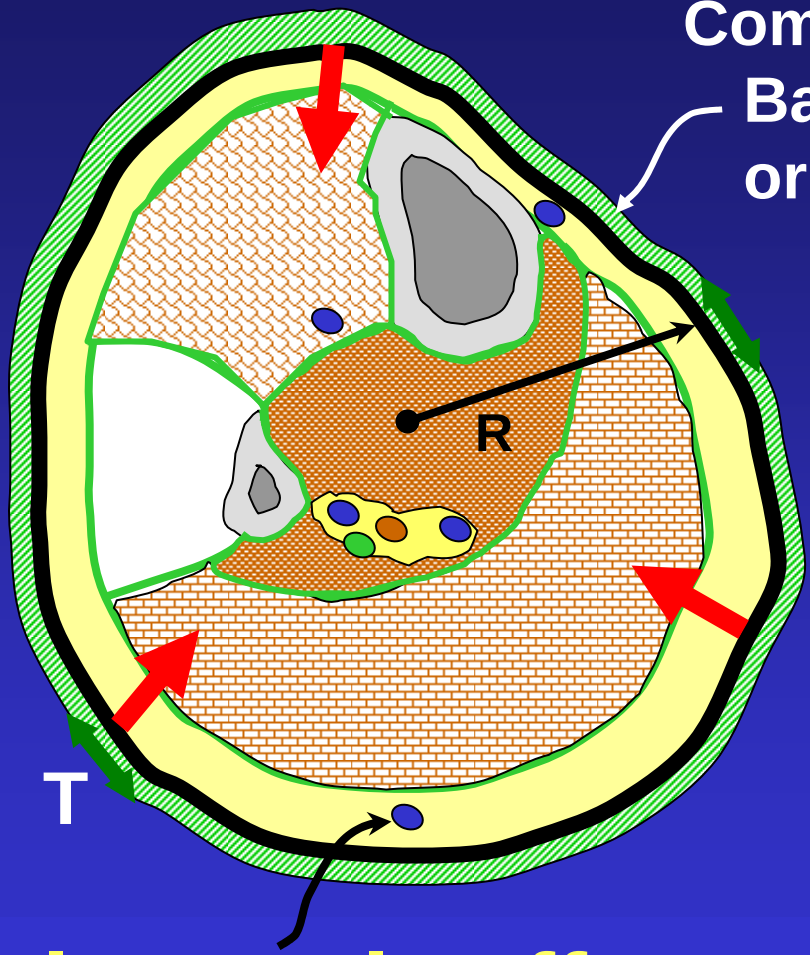
Resting (Static) Pressure

Muscles Relaxed

Pressure due to bandage tension (T) projecting an inward radial pressure (P)



Laplace's Law

$$P \sim \frac{T}{R}$$

Superficial vessels affected the most

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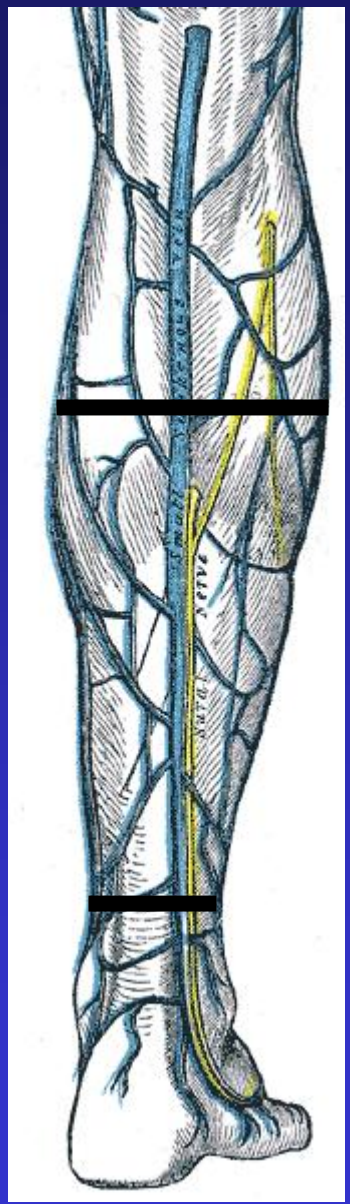
Pressure Gradient Concept

$$P \sim \frac{T}{R}$$



Compression Applied at Constant Tension

Increasing R
Decreasing P

Mimics Normal Intravascular Pressure Gradient

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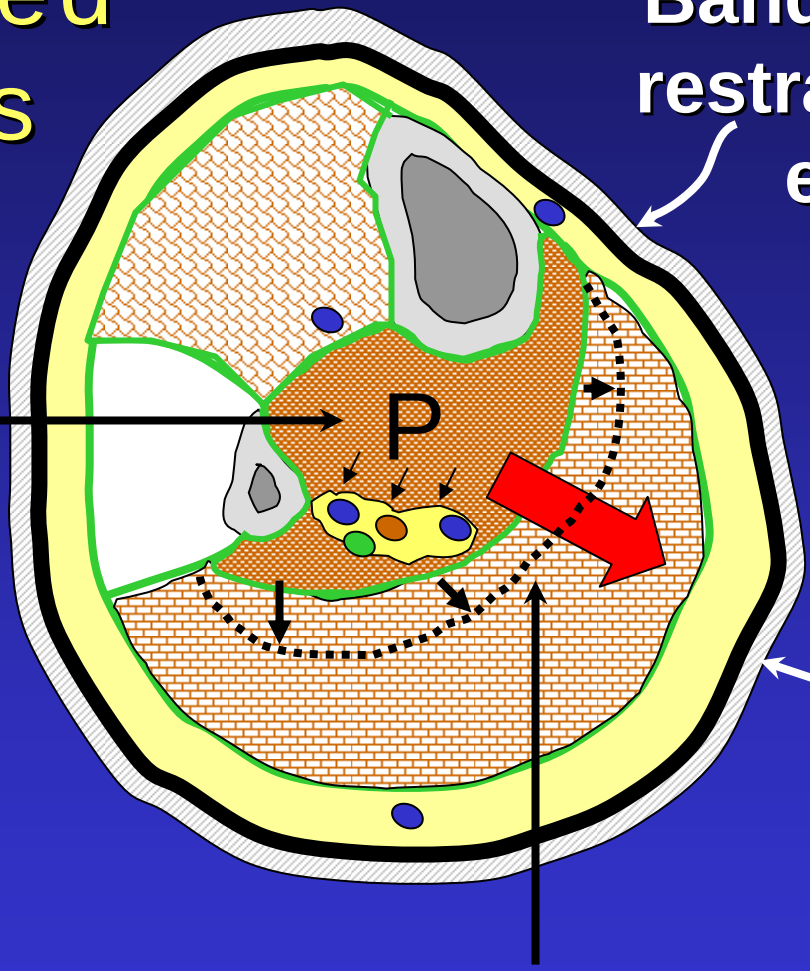
Working (Dynamic) Pressure

Contracted Muscles



Bandage acts as a restraint to muscle expansion

Positive affect on deeper vessels

Pressure is developed from ‘within’

P ~ Contraction Force x ‘Rigidity’

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Dynamic Pressure Depends on Bandage Material Features

Form fitted steel pipe

'short stretch'

'long stretch'

No external compression

Dynamic Pressure (ΔP)

0

Bandage 'Stretchibility'

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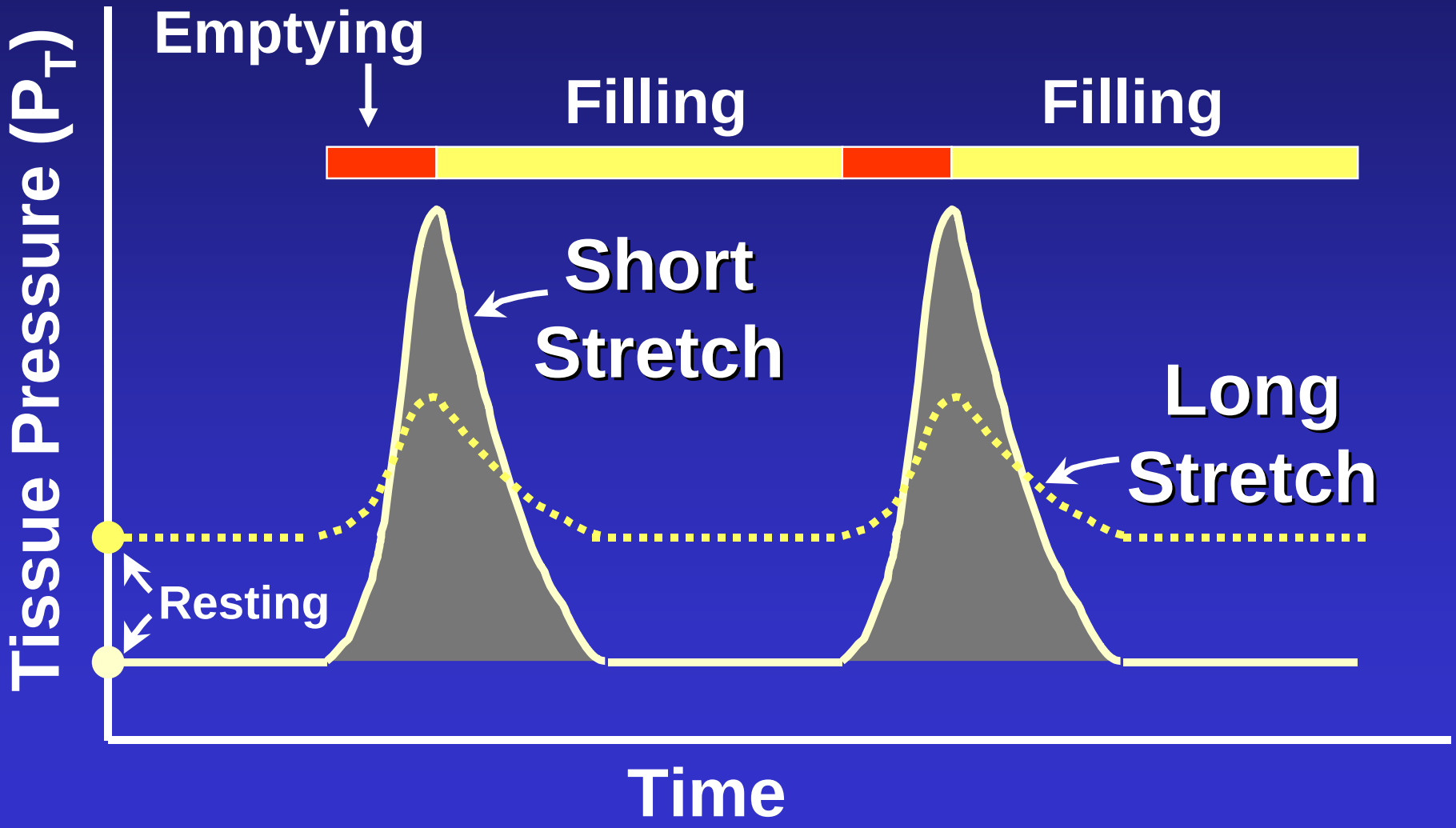
Working vs. Resting Pressures
Role of Compression Material



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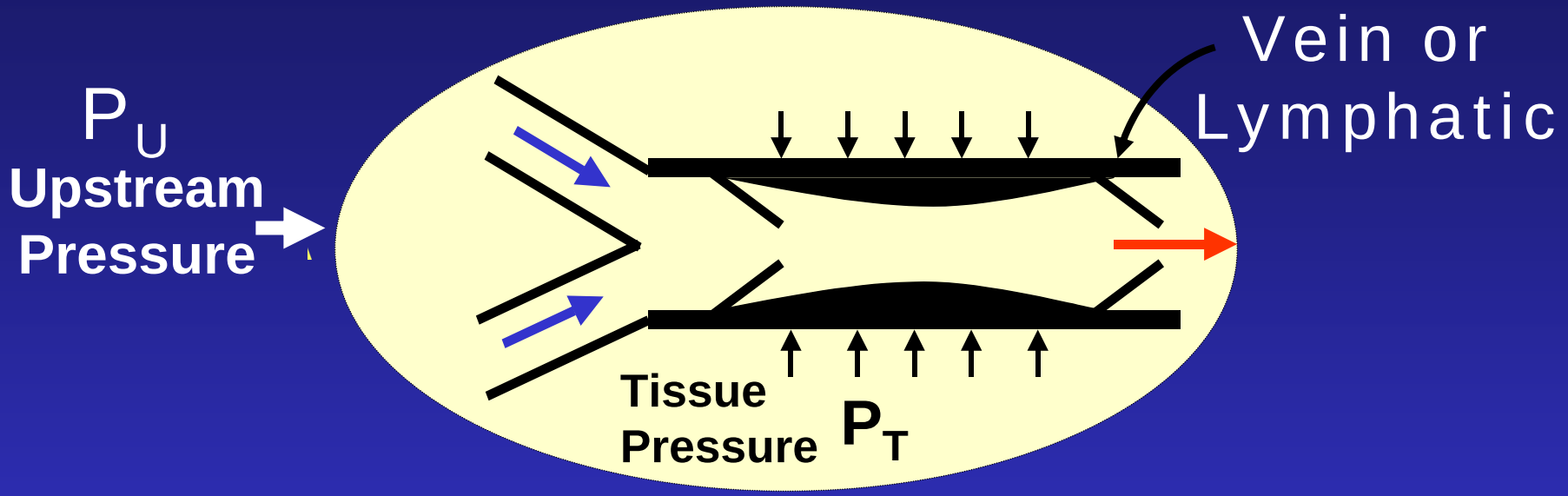
Overall Impact of Compression

Depends on both working and resting pressures



- **Filling:** Inflow ~ $P_U - P_T$
- **Emptying:** Outflow ~ $\Delta V \sim \Delta P_T$
- **Best:** Adequate resting P_T and High ΔP_T

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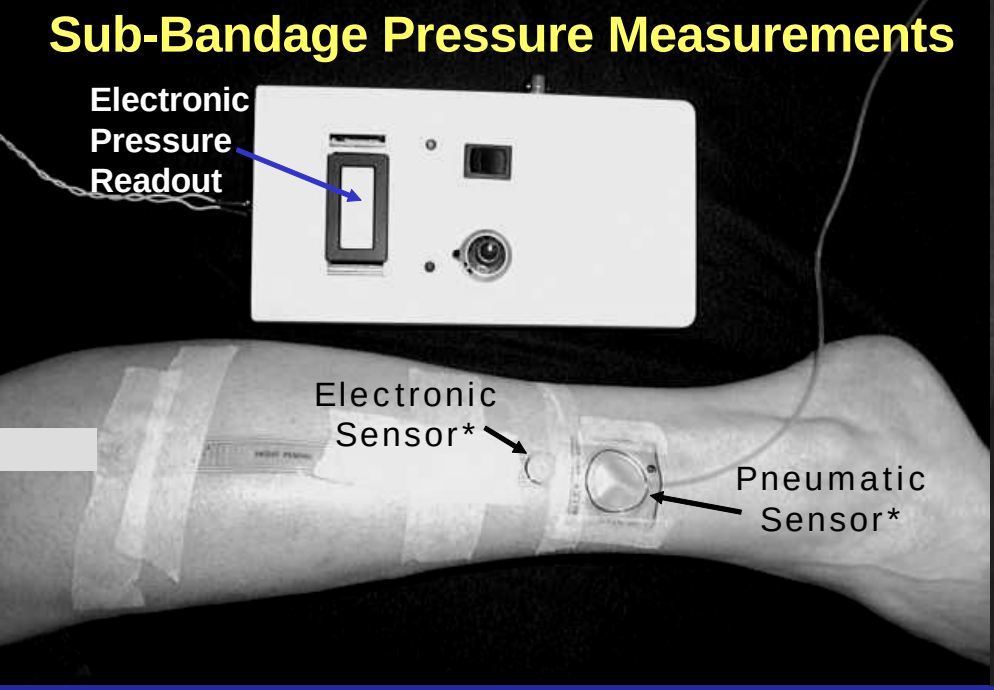
Sub-Bandage Pressure Measurements



Compression set at various static levels to compare dynamic sub-bandage pressures achieved with different bandages during calf muscle contraction and relaxation

*Pneumatic sensor: Talley Oxford Pressure Monitor
*Electronic Sensor: http://bioscience-research.net

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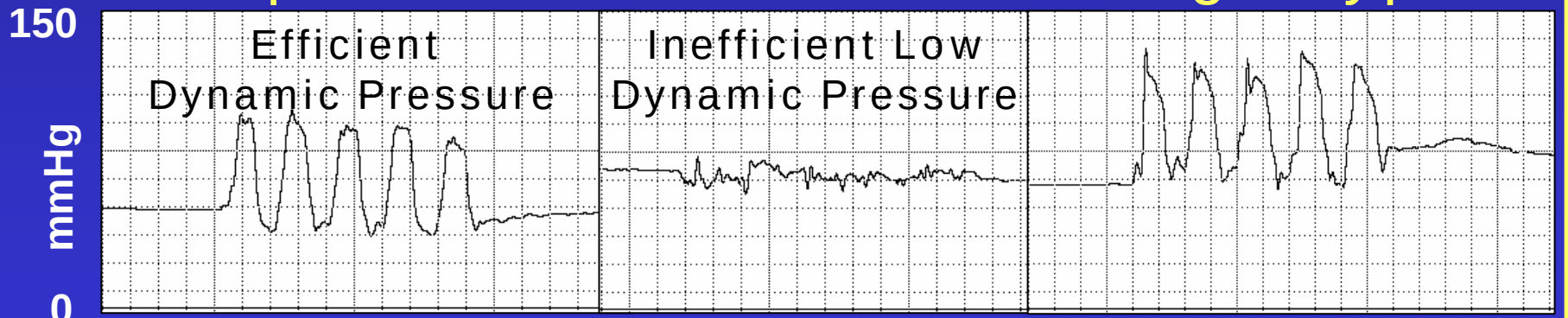
Dynamic (Working) Pressures

Static Pressures Set by Compression

Dynamic pressures via calf muscle contraction

Comparison of Different Bandage Types



Cohesive | Elastic | Multilayer

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Multiple Choice Questions

1. According to Laplace's law, if a limb is bandaged with constant tension, then the contact pressure experienced by the limb will be:
    a) greater where the limb is widest
    b) greater where the limb is narrowest*
    c) equal at all sites since the tension is constant
    d) least over areas of bony prominence such as the malleolus

2. A short-stretch bandage, as compared to a long-stretch:
    a) results in a greater resting pressure
    b) affects the deep vessels more than the superficial vessels
    c) results in a greater working pressure*
    d) has a greater effect on underlying blood vessels at rest

3. A short-stretch bandage provides more efficient venous and lymphatic filling and emptying because it produces:
    a) greater working pressure and greater resting pressure
    b) reduced working pressure and reduced resting pressure
    c) greater working pressure and reduced resting pressure*
    d) reduced working pressure and greater resting pressure

References

1. Mayrovitz HN, Larsen PB. Effects of compression bandaging on leg pulsatile blood flow. *Clinical Physiology* 1997;17:105-17
2. Mayrovitz HN . Compression-Induced pulsatile blood flow changes in human legs. *Clinical Physiology, 1997;*18:117-24.
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