Learn to Teach:
Know more, teach better

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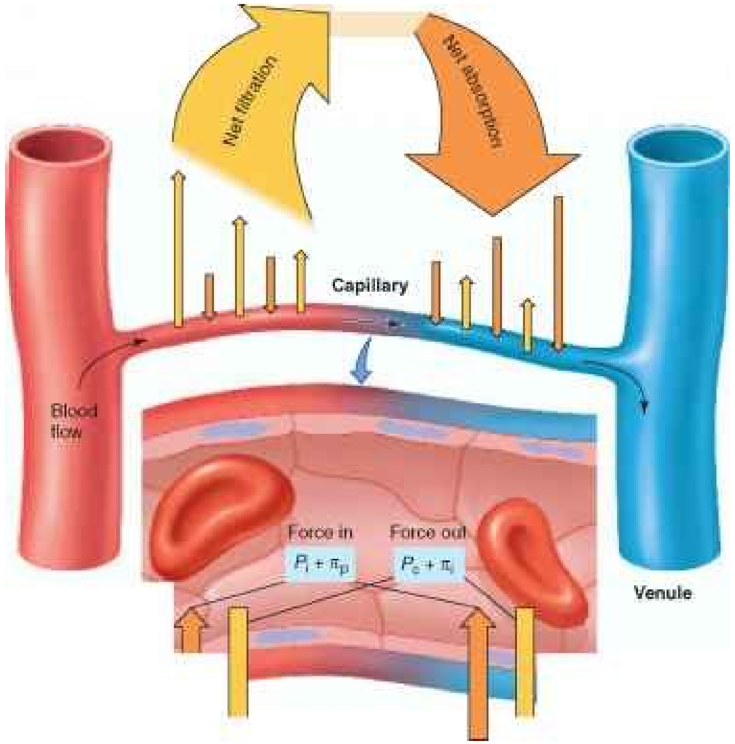


Starling's Law of Trans capillary Exchange

$$Q_f = Lp \times A[(P_{cap}-P_{pl}) - \sigma_d(\pi_{cap}-\pi_{pl})]$$

Q_f = liquid movement

L_p = filtration coefficient /unit area of the membrane

A = surface area of the membrane

σ_d = solute reflection coefficient for protein (membrane's ability to restrict passage of large molecules

P = hydrostatic pressures

π = oncotic pressure

Learn to teach:

Microcirculation and fluid exchange

Questions:

- “What causes edema, in the lungs, periphery or brain?”
- “What is the relationship between dehydration and DKA?”
- “What causes various fluid shifts, such as in burns?”

Objectives:

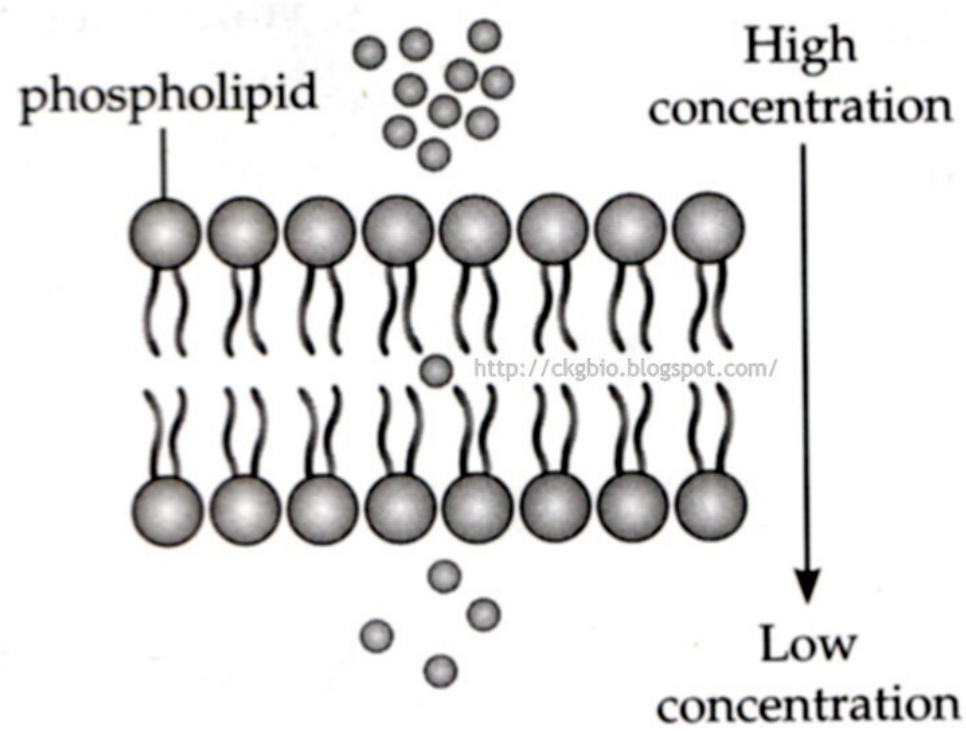
- To develop an understanding of how substances move across a capillary bed
- To apply physiological concepts to commonly encountered prehospital conditions

“What make’s things go back & forth”

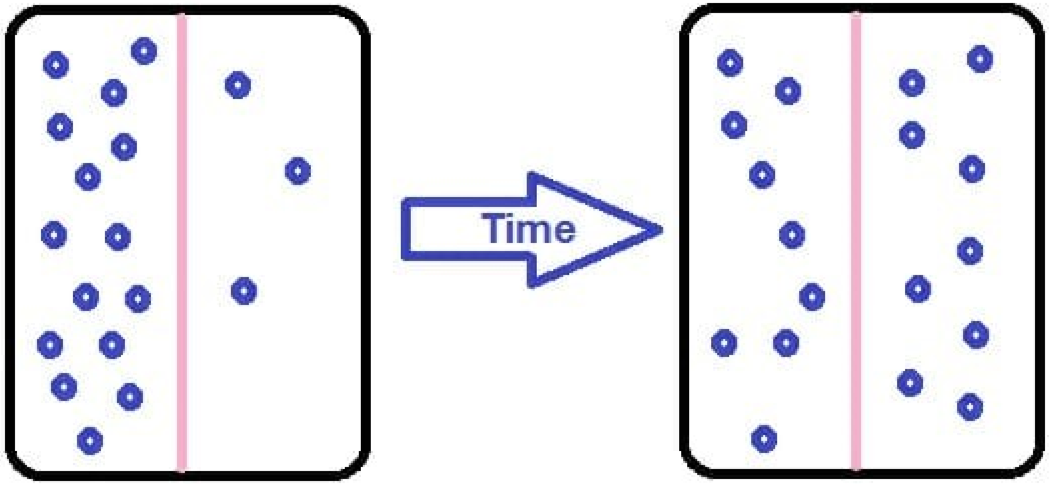
- Osmosis - water
- Diffusion – substances
- Concentration gradients – high to low
- “Starling’s Law of Transcapillary Exchange”

Movement through the capillary wall

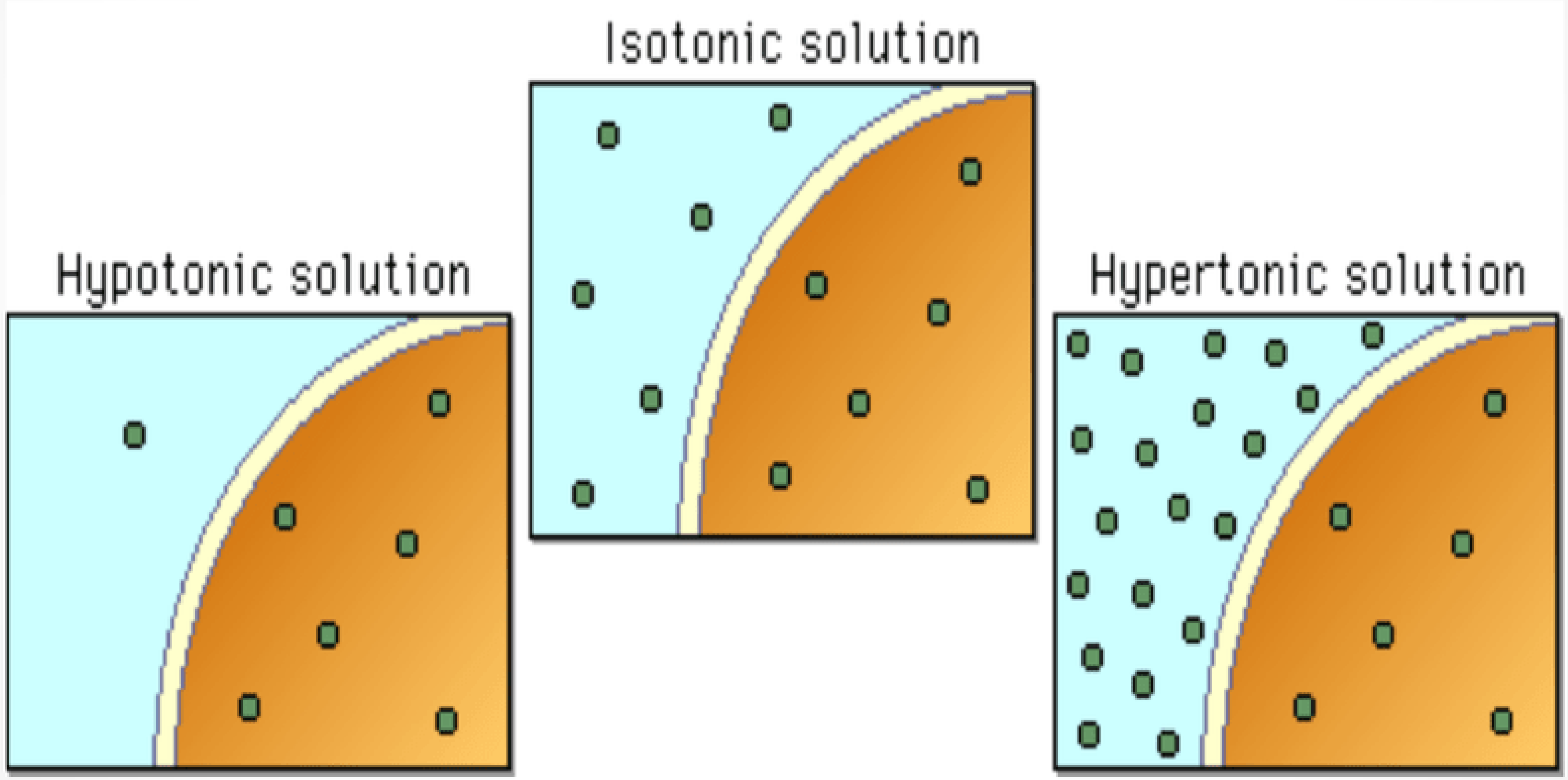
1. By diffusion for fat-soluble substances (O_2, CO_2, etc.)
2. Micro-pores for large or fat-insoluble substances (H_2O, glucose, Na^+, proteins, etc.)



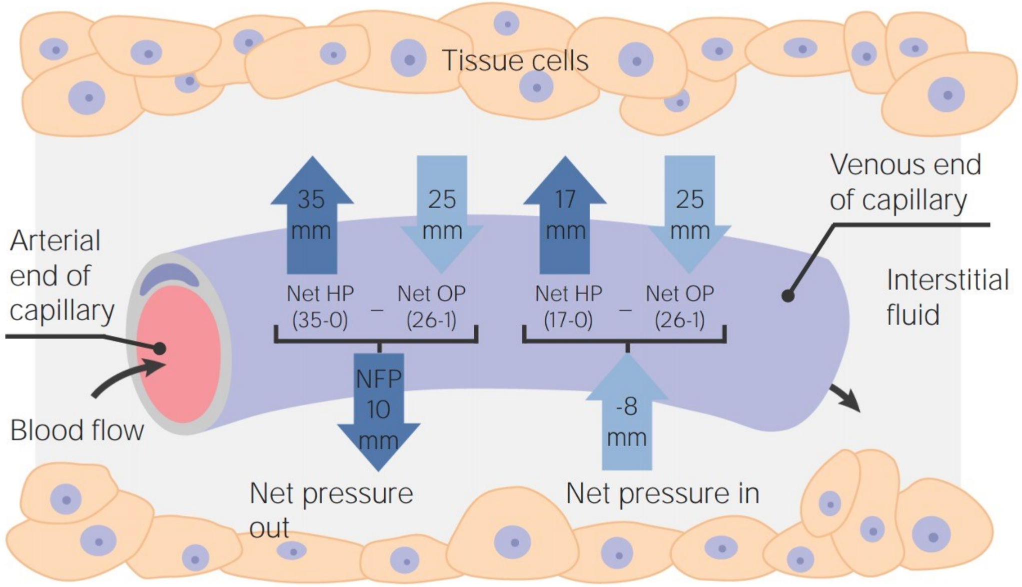
Diffusion



Hypertonic, Hypotonic and Isotonic



Starling's Law of Transcapillary Exchange



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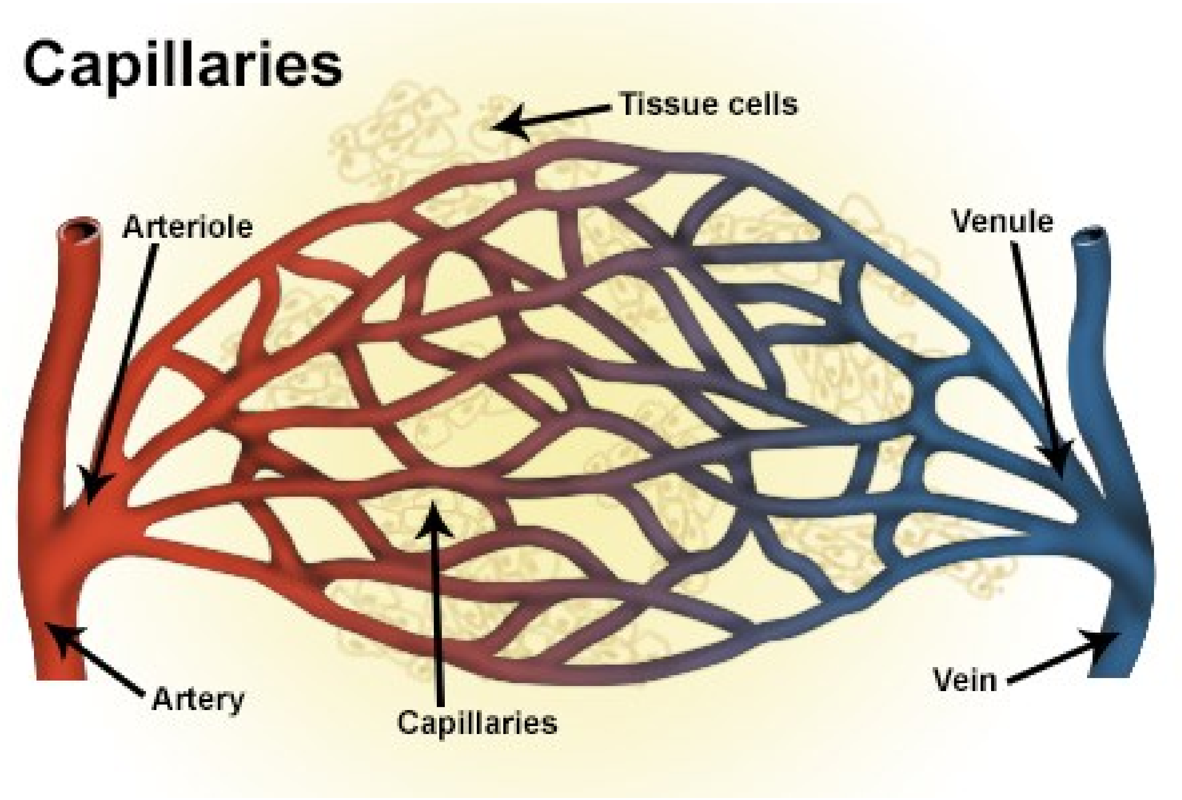
Process occurs at all capillary beds

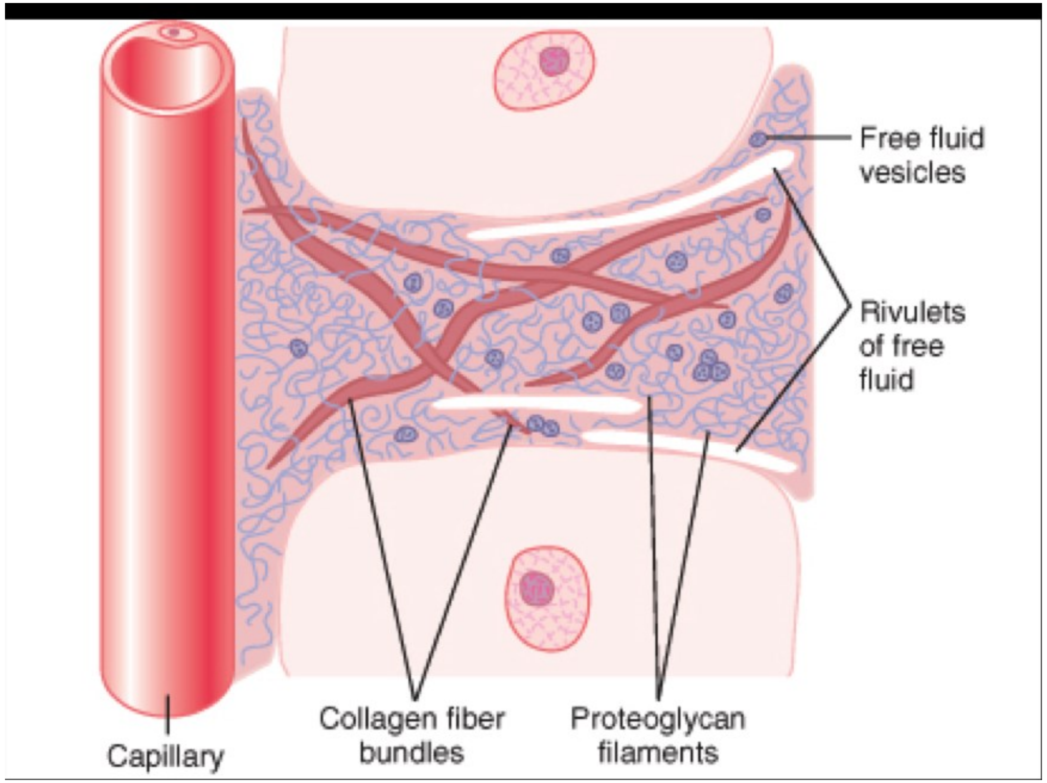


The capillary bed: Key concepts

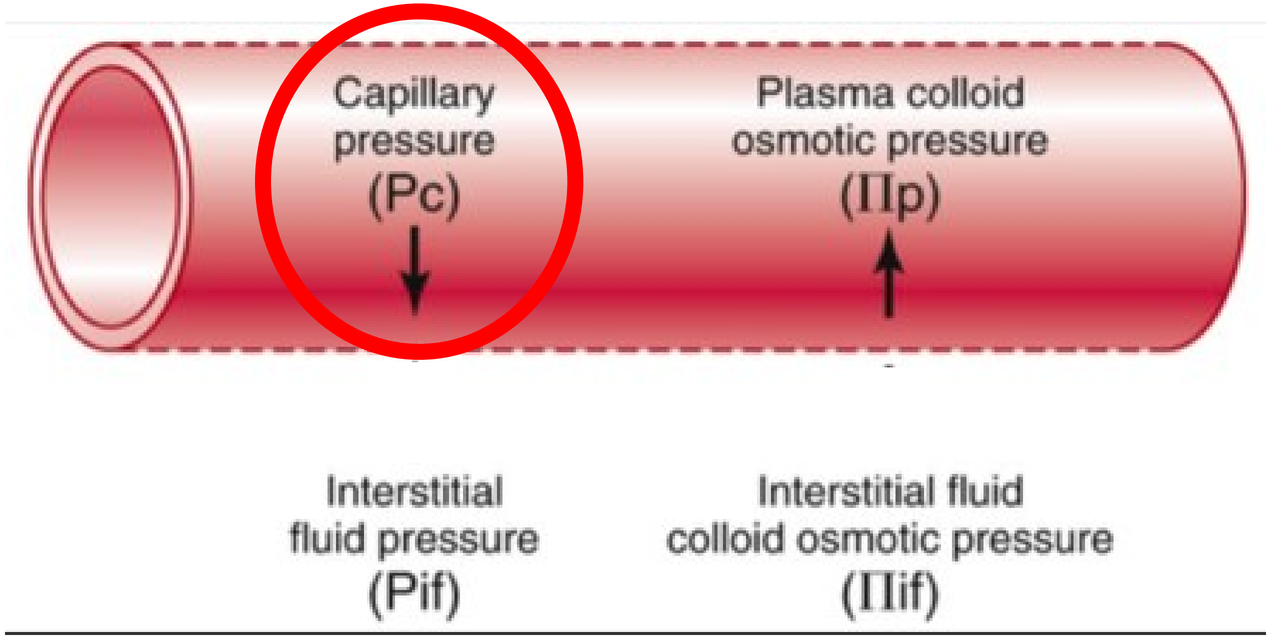
- **Function: Transport of nutrients to tissues and removal of cell waste**
- Single cell thick
- Typically only wide enough to allow 1 RBC at a time to travel through the bed
- Movement of substances through the vasculature wall is site dependent upon need and function:
  - Liver: large molecules (glucose, fibrin, O_2, wastes)
  - Brain: small molecules (CO_2, O_2)

Movement: Four forces

1. Capillary hydrostatic pressure
2. Interstitial hydrostatic pressure
3. Interstitial fluid colloid osmotic pressure
4. Plasma colloid osmotic pressure



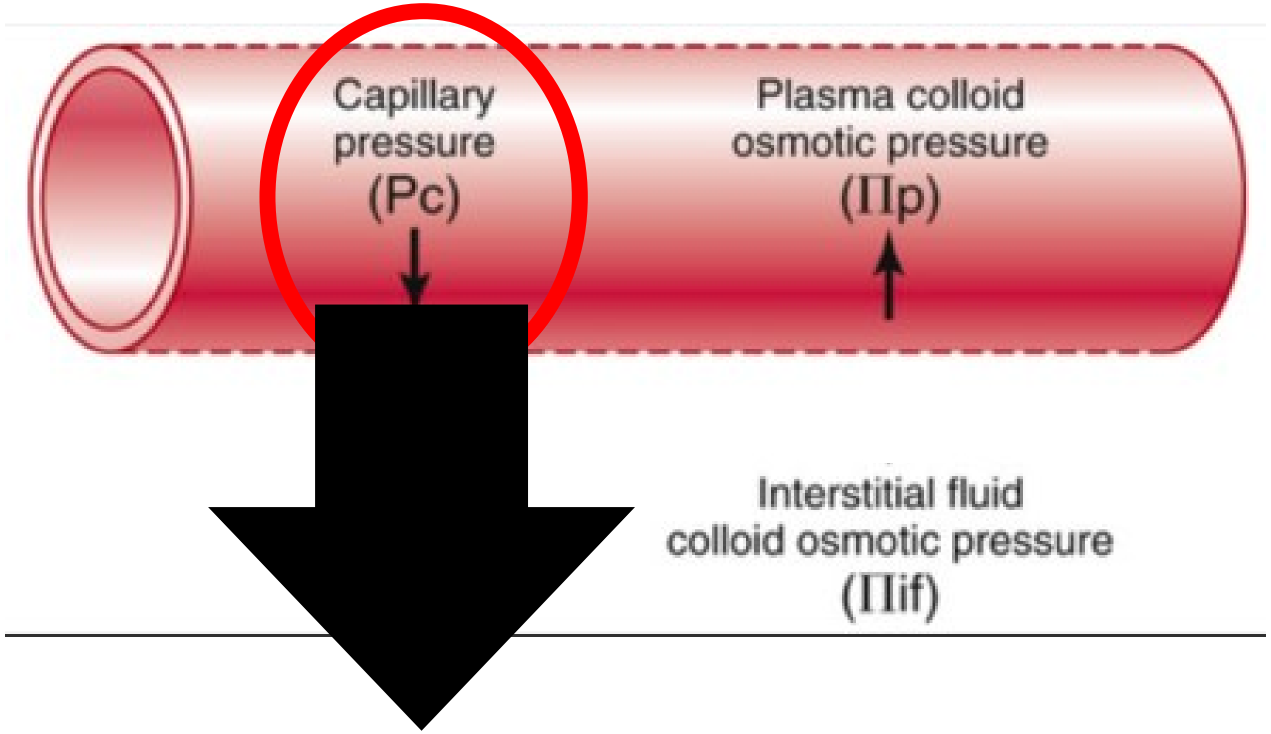
#1: Capillary hydrostatic pressure



A direct function of blood pressure

- A “pushing pressure” (out)
- High BP = ↑ movement outward
- Low BP = ↓ movement outward
- Normal pressures average about **18 mmHg**

#1: Capillary hydrostatic pressure

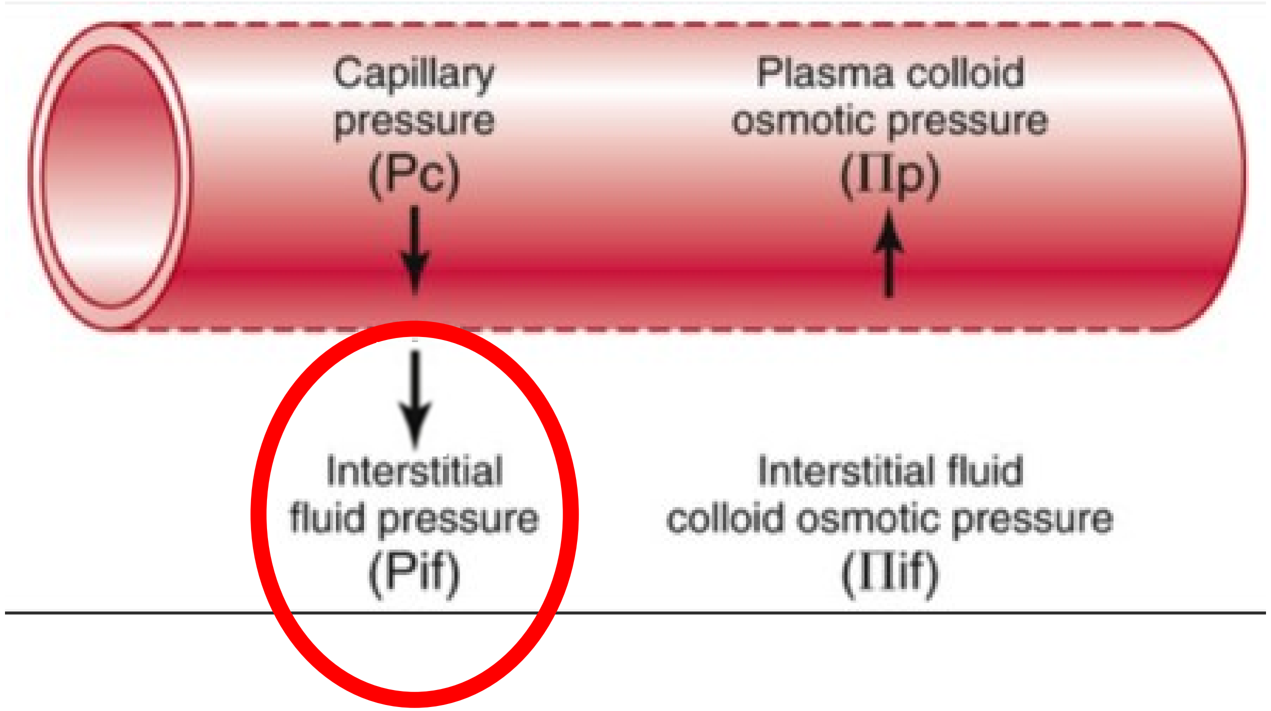


Interstitial space edema:

- High BP lungs = pulmonary edema
- High BP brain = cerebral edema
- High BP in liver = ascites
- High BP in kidneys = high output

- Low BP = no movement, limited waste exchange

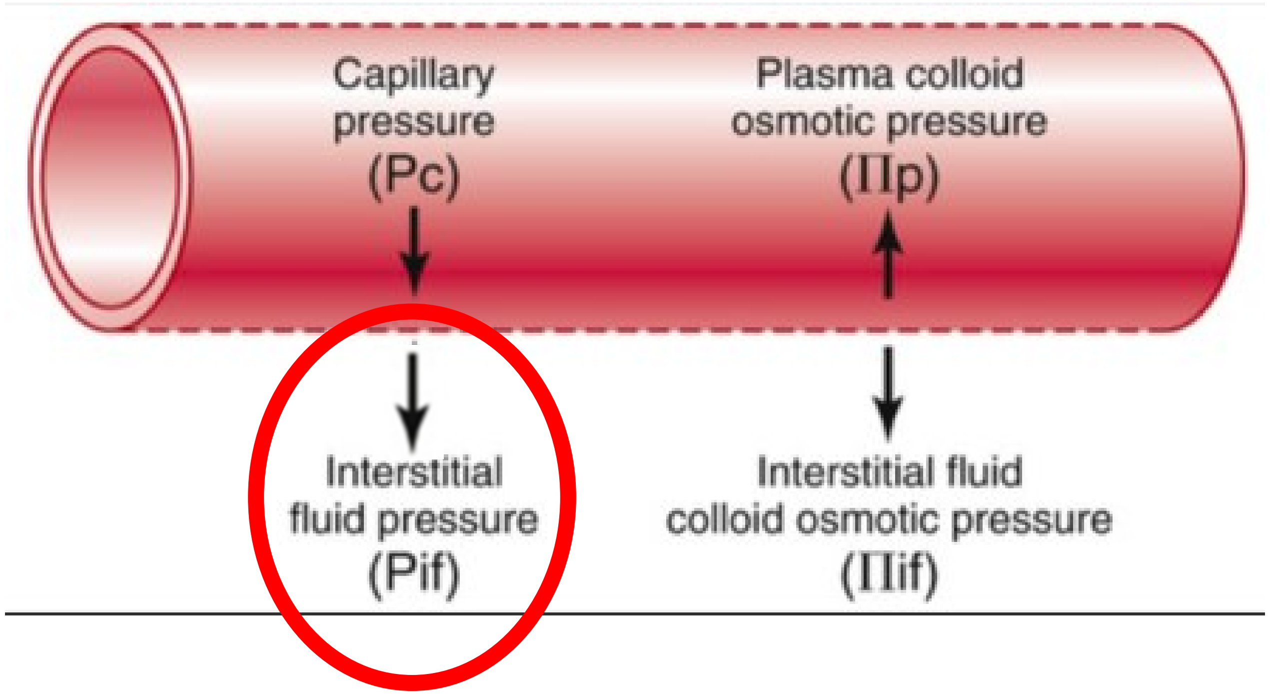
#2: Interstitial hydrostatic pressure



Pressure exerted by fluid (water) in the interstitial space

- A "sucking" pressure (into vessel)
- **Normal = -3 mmHg**
- When the value is a negative number, it acts like a vacuum and **sucks** fluid from the vessel, having a **positive** influence on fluid moving OUTWARD

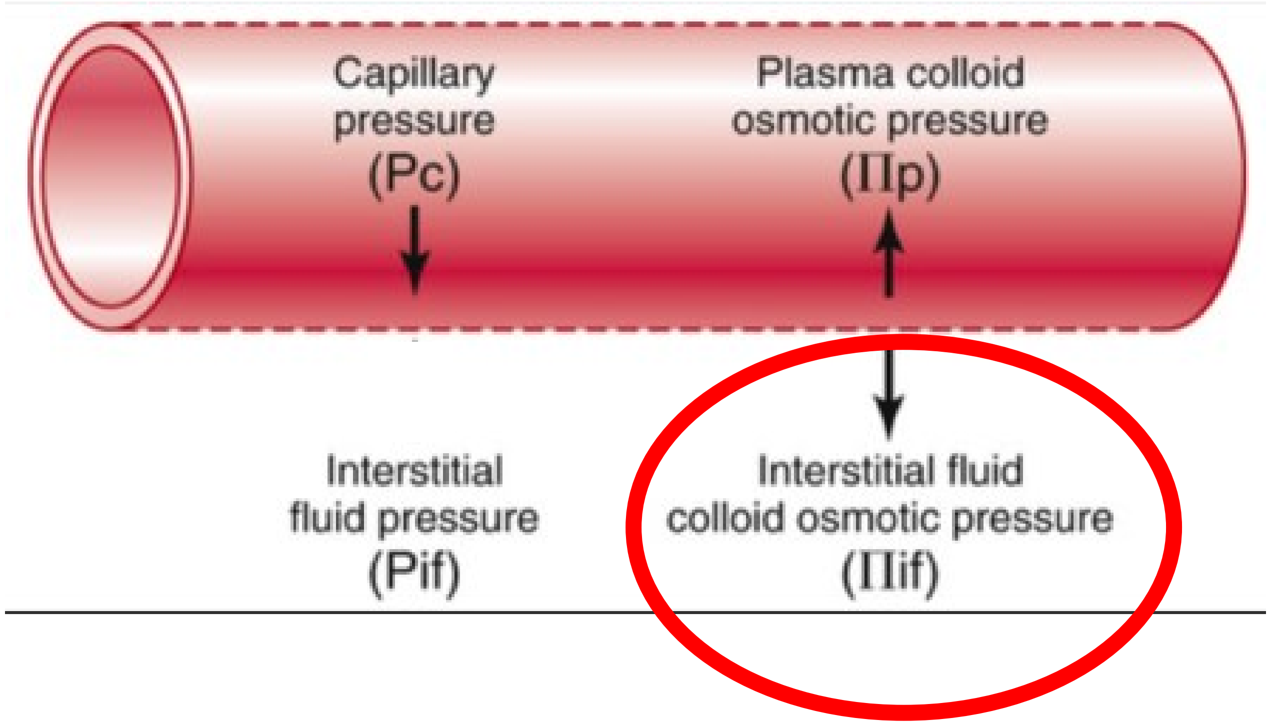
#2: Interstitial hydrostatic pressure



Pressure exerted by fluid (water) in the interstitial space

- If the number is positive (+5 mmHg), it **OPPOSES** fluid coming out of the blood vessel
- If the number is extremely negative (-10 mmHg), it will **SUCK** fluid even more (i.e. dehydration, low skin turgor)

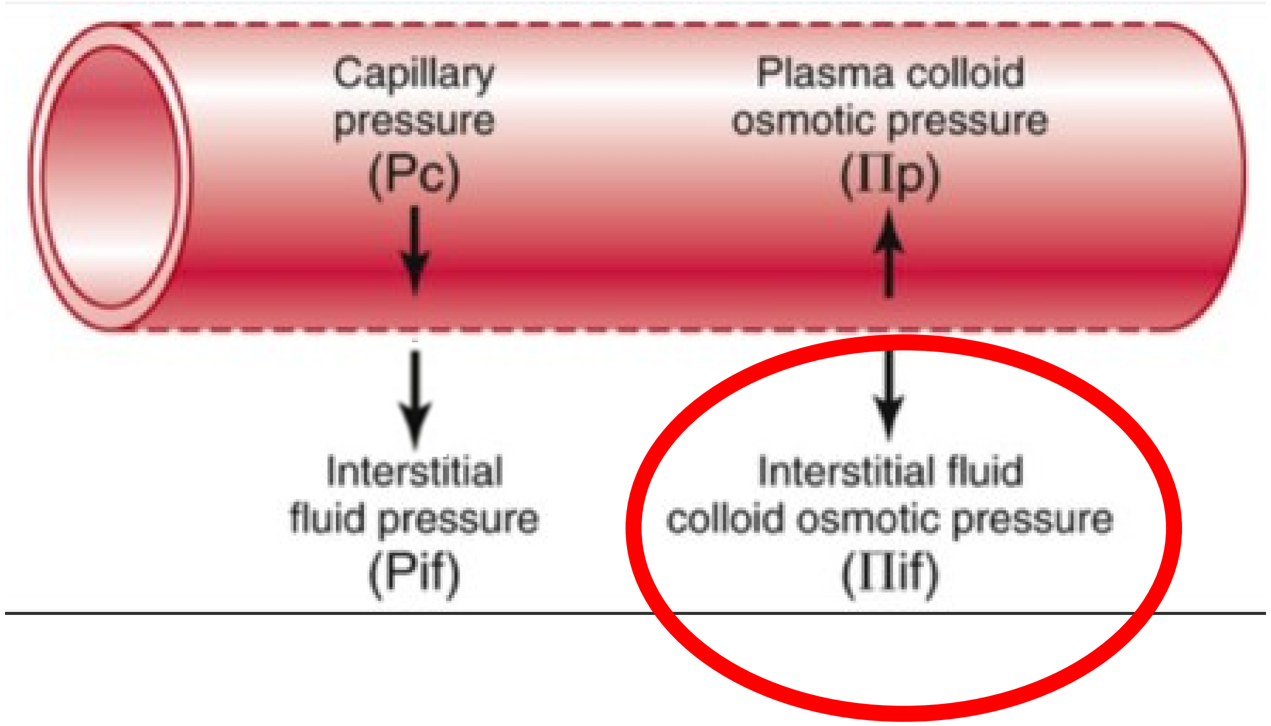
#3: Interstitial (tissue) colloid pressure



Pressure created by large molecule proteins (colloid) or sugar in the interstitial space

- A "sucking" pressure
- Due to the few proteins/sugars that leak out of the vessel into the interstitial space
- **Normal = 8 mmHg**

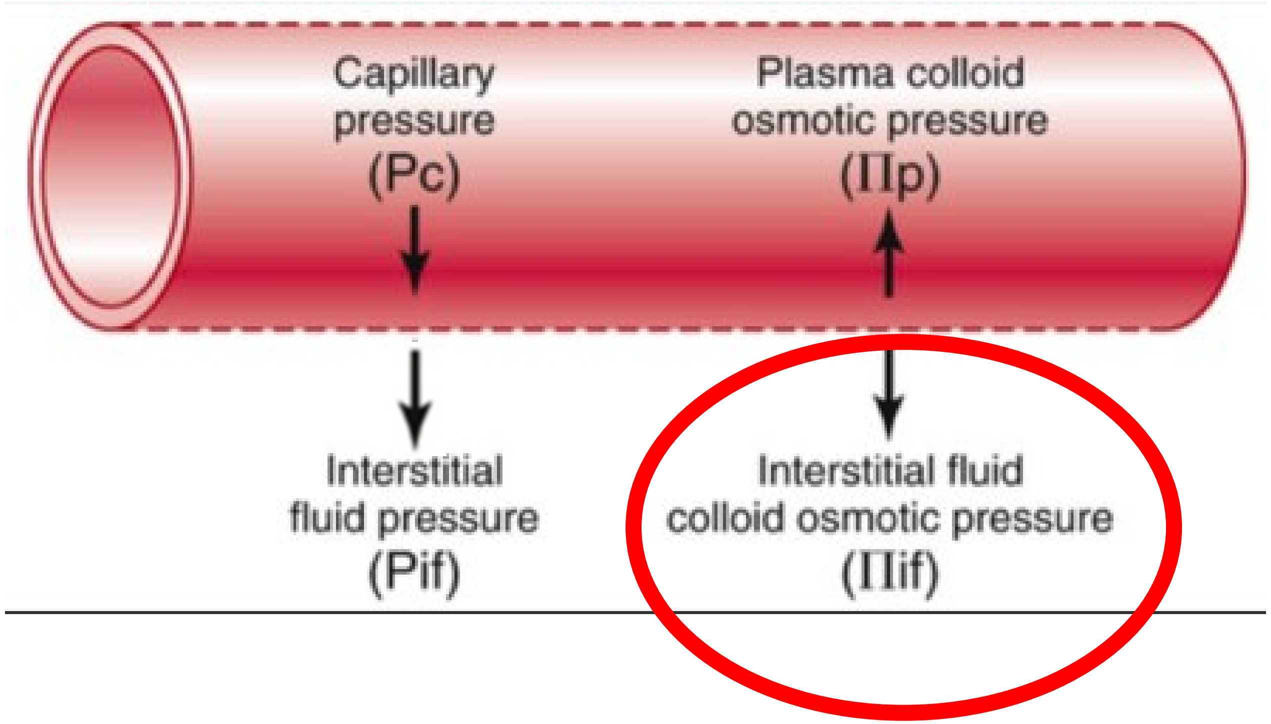
#3: Interstitial (tissue) colloid pressure



Pressure created by large molecule proteins (colloid) or sugar in the interstitial space

- If the number is positive, it will **DRAW** excessive fluid **OUT** of the vessel
- Burns/rhabdomyolisis = damaged vessels, proteins leak out into interstitial space → fluid leakage

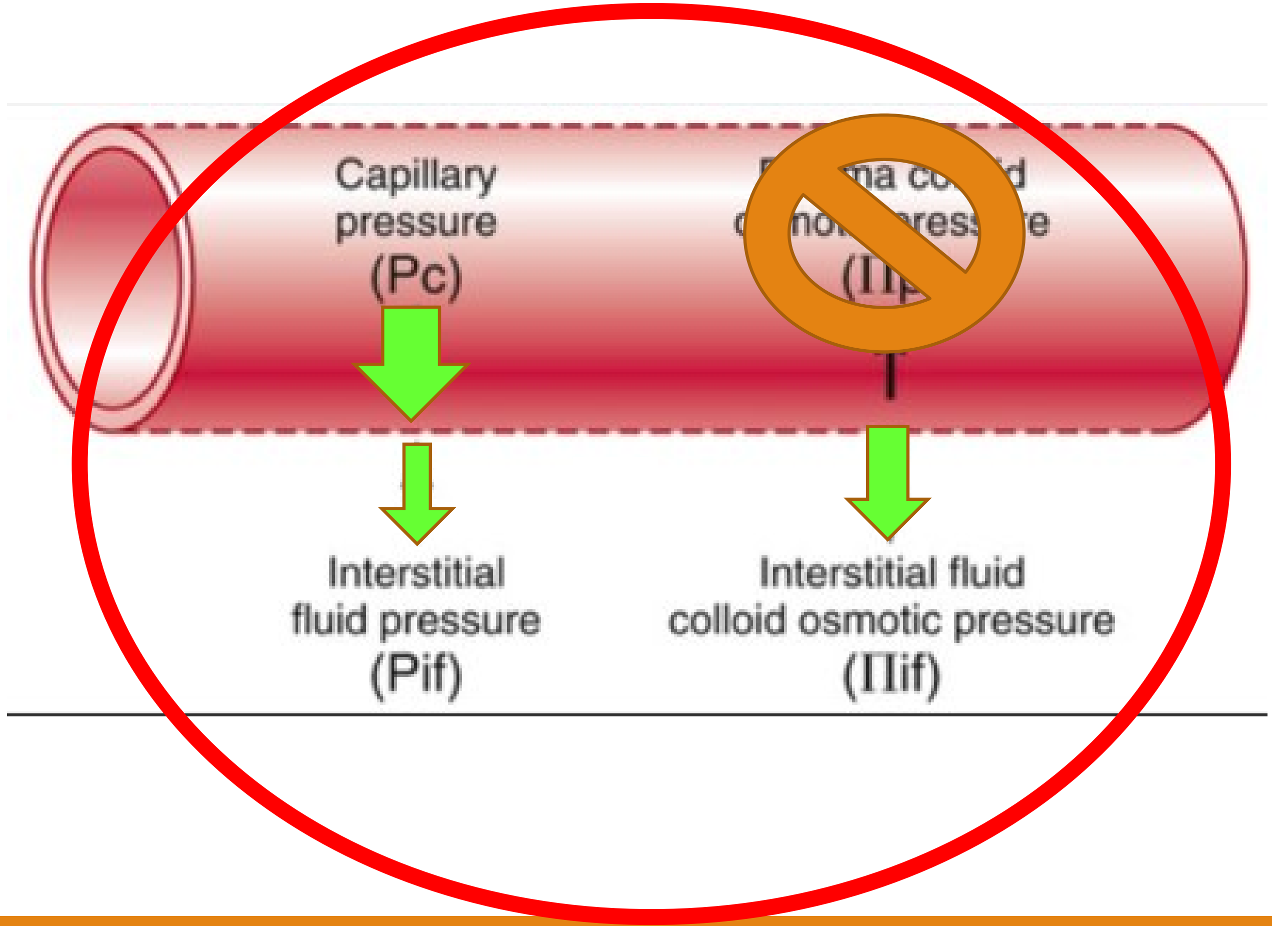
#3: Interstitial (tissue) colloid pressure



Pressure created by large molecule proteins (colloid) or sugar in the interstitial space

- If the number is lower than normal, additional fluid will stay in the vessel

Total OUTWARD effect



Adding the pressures together that influence the shift of fluid **OUT** of the vessel:

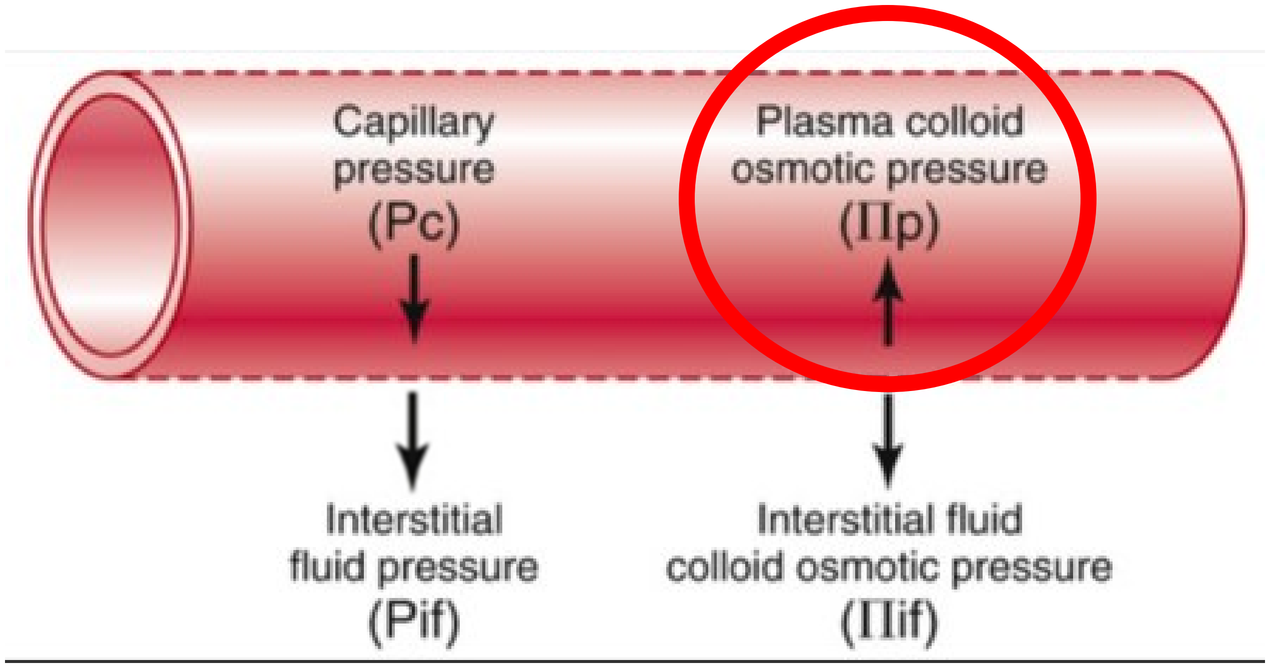
+18 mmHg (pushes out)

(-)+3 mmHg (is negative, so sucks out)

+8 mmHg (pulls out)

29 mmHg

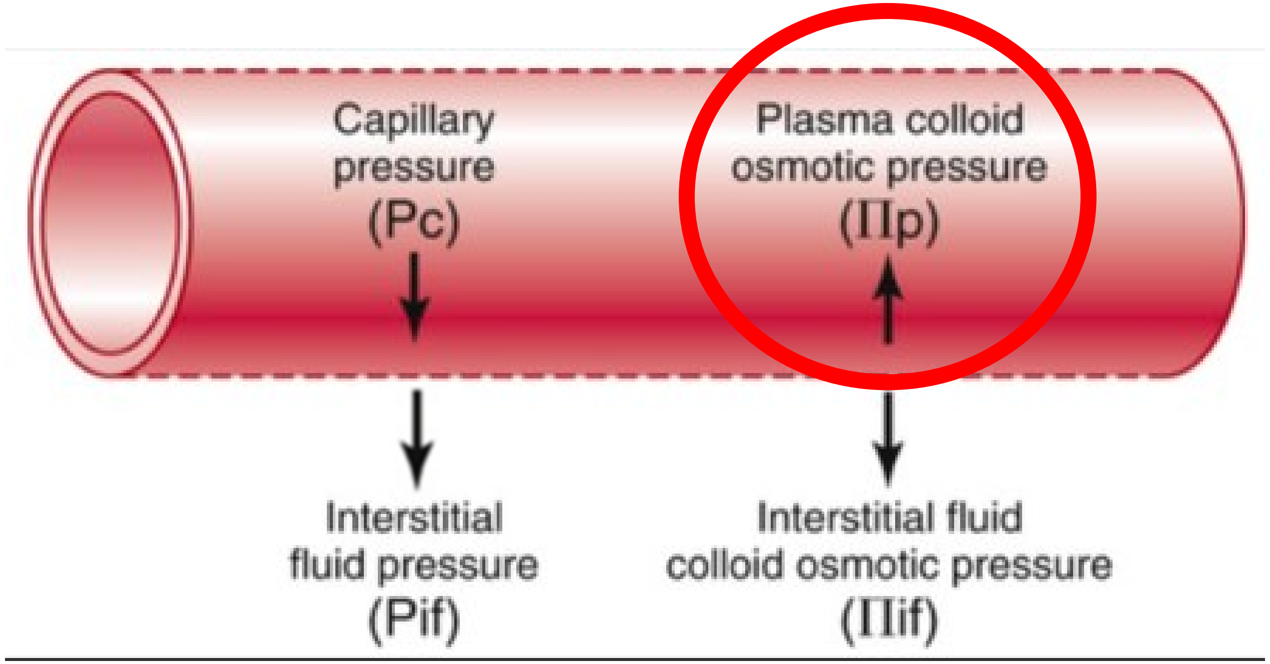
#4: Capillary colloid osmotic pressure



Pressure exerted by the presence of large molecule proteins or sugars IN the blood vessel

- A "sucking" pressure back INTO the capillary
- Normal = 28 mmHg

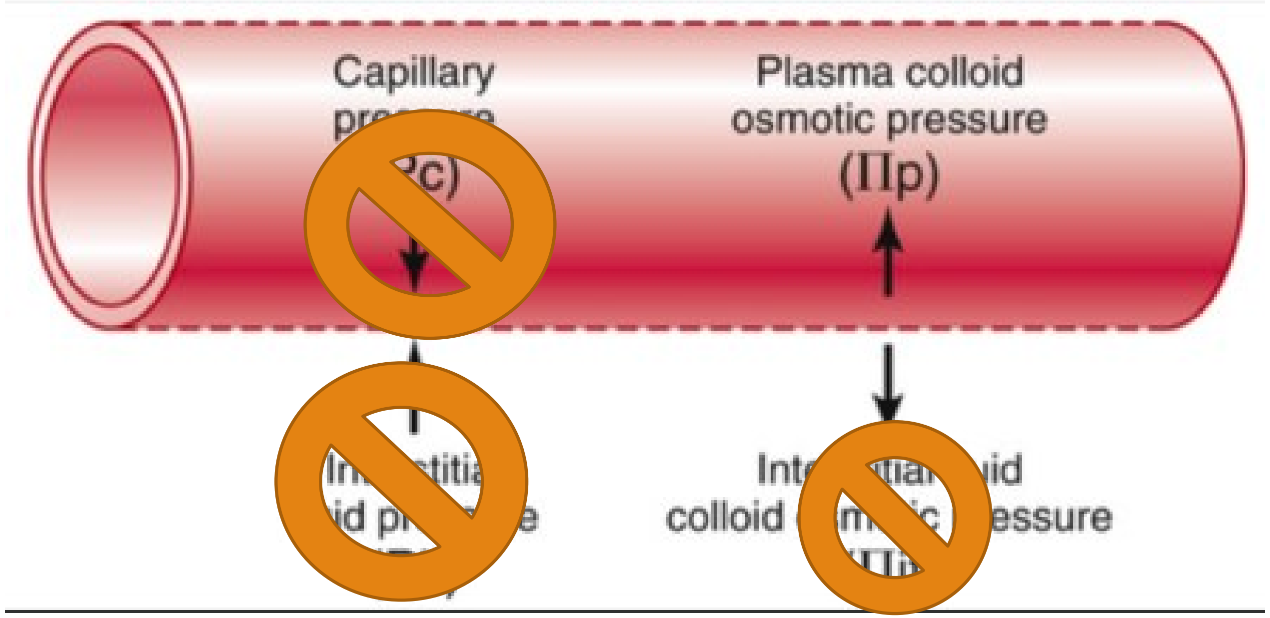
#4: Capillary colloid osmotic pressure



Pressure exerted by the presence of large molecule proteins or sugars **IN** the blood vessel

- If the number is too low (burns, kidney disease) it won't draw enough fluid back into the blood vessel
- If the number is too high, it will SUCK fluid into the vessel even more

Total INWARD effect

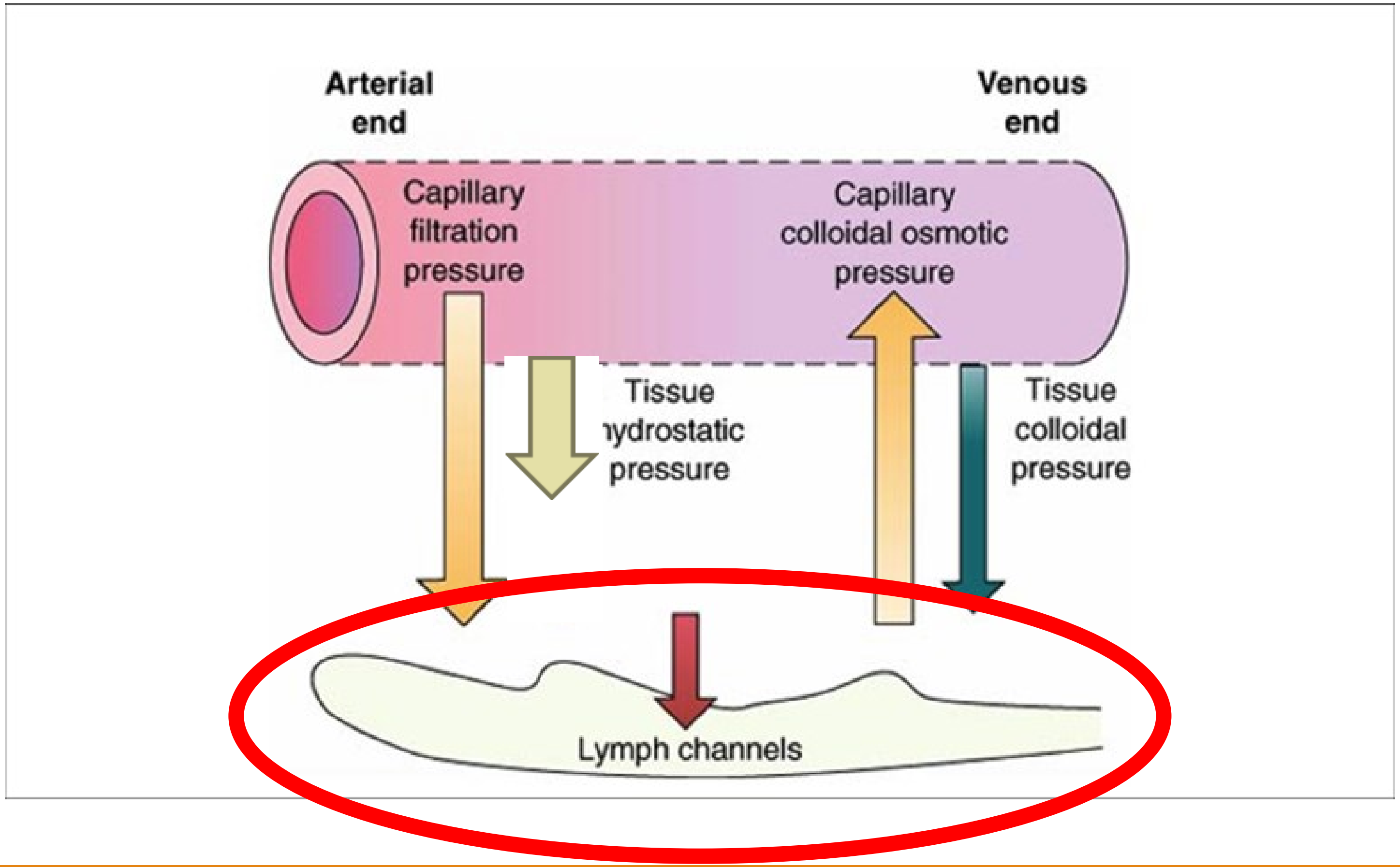


Adding the pressures together that influence the shift of fluid INTO the vessel:

<u>+28 mmHg</u>

28 mmHg

Total **net** effect



29 mmHg **OUT** of the vessel

-28 mmHg **INTO** the vessel

1 mmHg picked up by the lymph system

APPLICATION: Back to our questions:

- “What causes edema, in the lungs, periphery or brain?”
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- “What causes various fluid shifts, such as in burns?”

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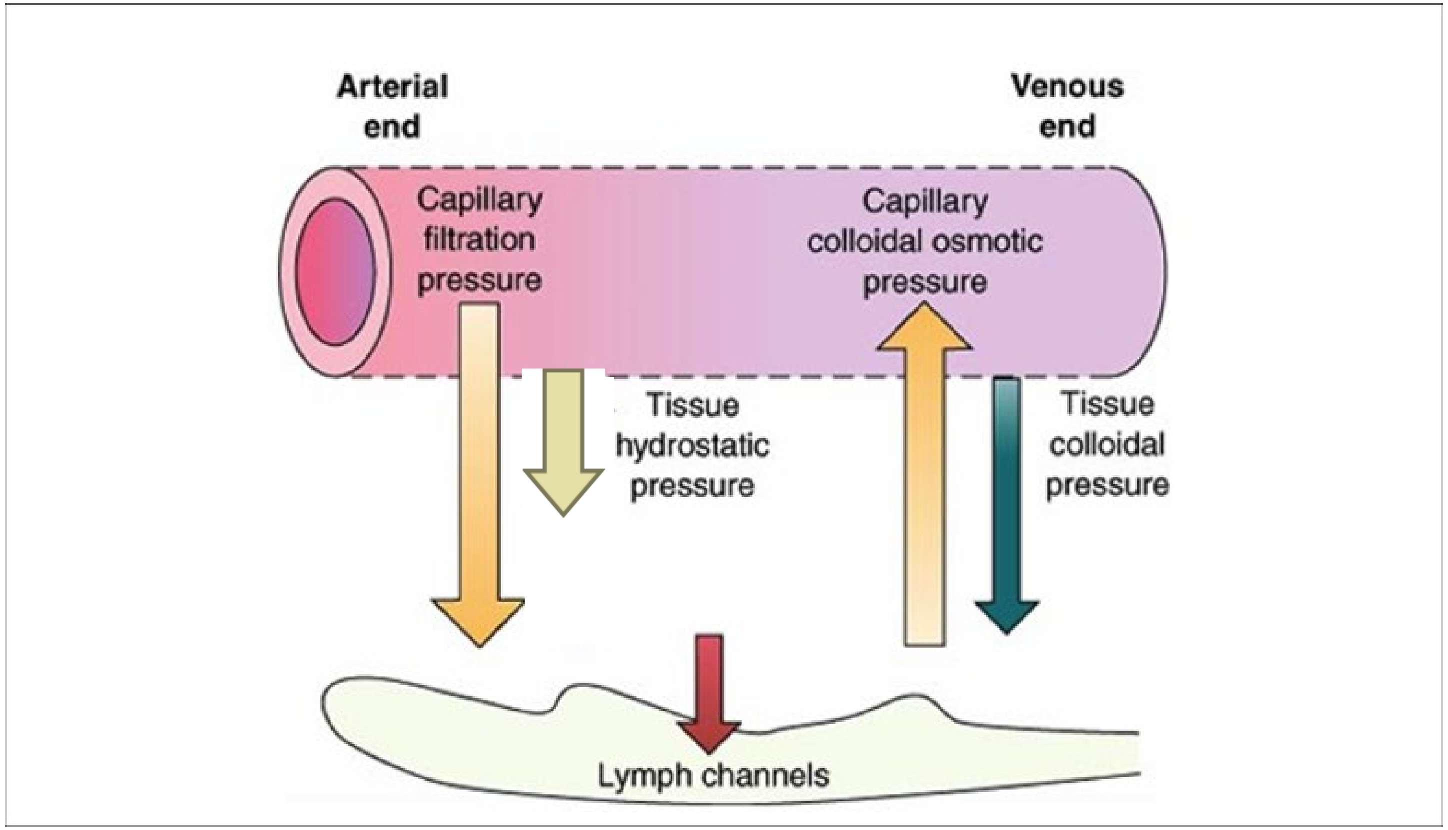
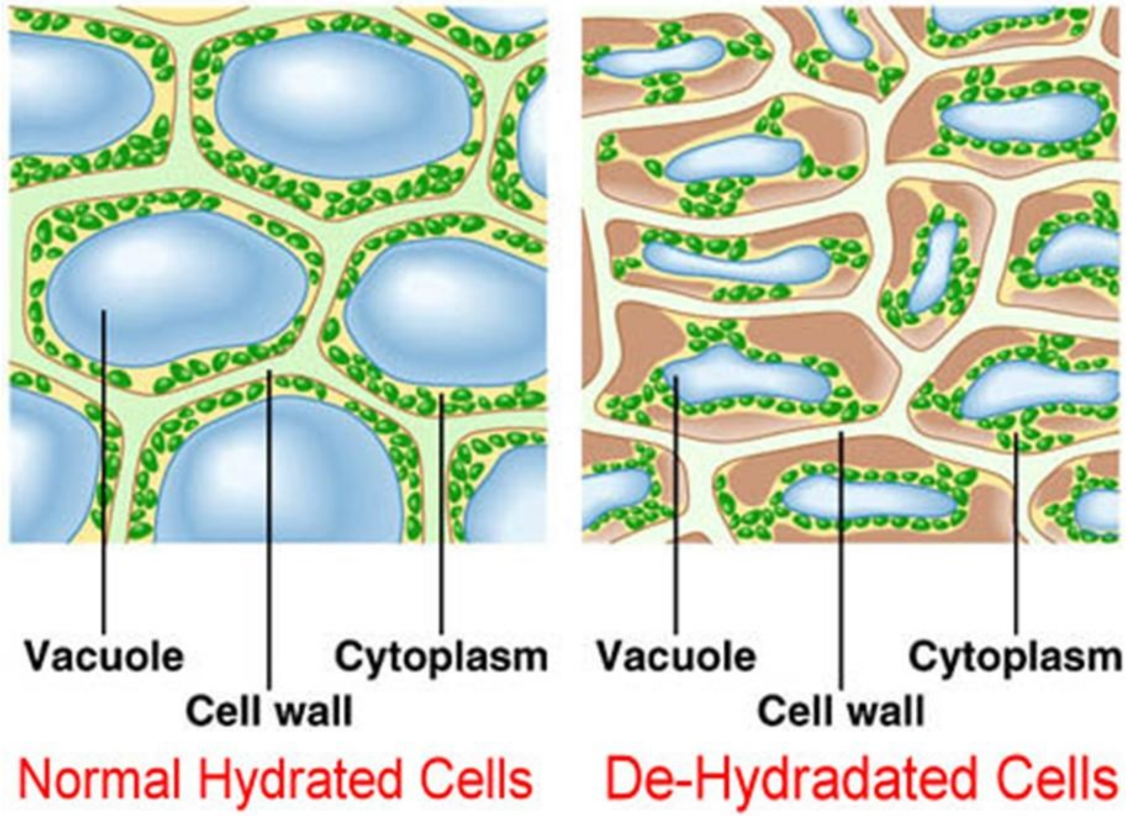


- "What causes edema in the lungs, periphery or brain?"
- "What is the relationship between dehydration and DKA?"
- "What causes various fluid shifts, such as in burns?"
- "Why does a mastectomy pt have swelling in her arm?"

HEAD SCRATCHER?

Does a dehydrated cell have a high osmotic pressure or high hydrostatic pressure?



Pathophysiology

FORMATION OF EDEMA

Decreased plasma osmotic pressure (starvation, protein wasting renal disease)

Increased interstitial hydrostatic pressure (gravity, venous obstruction, CHF)

Increased osmotic pressure (inflammation, trauma)

Lymphatic obstruction/removal

HTN

Cerebral edema post DKA

TISSUE DEHYDRATION

Reduced capillary pressures (BP)

High sugars/proteins in blood (DKA, burns, rhabdomyolysis)

References

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