SABS I: Vascular Physiology

CAPILLARIES

Steven J. Miller, Ph.D.

Office: 274-2657
E-Mail: sjmiller@iupui.edu
http://www.iuvascular.com/Unthank/teach.html

III. Capillaries

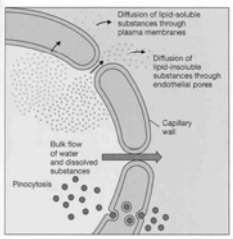
A. Fundamental Facts

1. Transcapillary exchange is essential for cell function and survival.
2. Normal tissue function requires selective permeability of capillaries to different solutes.
3. The permeability of capillaries in various tissues must be different for normal organ function to occur.
4. Net water movement across capillary must be controlled to maintain proper tissue hydration

III. Capillaries

B. Transcapillary Exchange of Solute

- Mechanisms for exchange
  - Diffusion
  - Bulk flow
  - Pinocytosis/vesicular transport



III. Capillaries

B. Transcapillary Exchange of Solute

- Factors contributing to rapid diffusional exchange
  - Diffusion distance – cells within 20 μm of a capillary
  - Large total surface area – 7000 sq. ft.
  - Slow rate of blood flow – 0.1 to 1.0 mm/sec (vs. 40 cm/sec in aorta

III. Capillaries

B. Transcapillary Exchange of Solute

- Diffusion
  - **for a single capillary: Js=[PS(Co-Ci)]/d**
    - **Js = solute transferred, moles/min**
    - **d = distance for diffusion**
    - **(Co-Ci) = concentration gradient from outside to inside of capillary**
    - **PS = permeability coefficient**
      - **P = capillary permeability of specific substance**
      - **S = capillary surface area**

Difference in PS for various solutes due primarily to pathway available for exchange

Substance	Molecular Weight	Molecular Radius (Å)	Specific Permeability
H_2O	18	1.5	28
NaCl	58	2.3	15
Urea	60	2.6	14
Glucose	180	3.7	6
Sucrose	342	4.8	4
Inulin	5,500	12-15	0.3
Myoglobin	17,000	19	0.1
Serum Albumin	67,000	36	0.0001

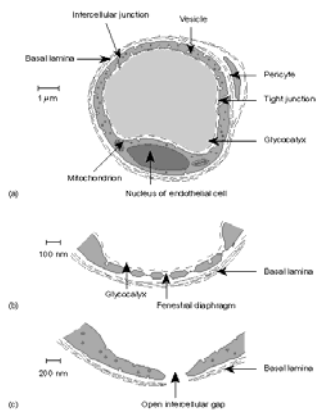
Difference in PS for various solutes due primarily to pathway available for exchange

- **Plasma membrane**
  - **largest area for exchange**
  - **major pathway for lipid soluble solutes such as oxygen, carbon dioxide, and urea**
- **Small pores**
  - **3-4 to 6-7nm in diameter**
  - **0.02-0.05% of total capillary wall**
  - **major path for small, water soluble solutes such as glucose**

Difference in PS for various solutes due primarily to pathway available for exchange

- **Large pores**
  - **30-100 nm in diameter**
  - **theoretically, only one large pore for 300 small pores**
  - **major pathway for lipid insoluble substances such as albumin**

Endothelium Types



Difference in PS for same substance between different tissues

Organ	Hydraulic Conductivity	Type of Endothelium
Brain	3	continuous
Skeletal Muscle	250	continuous
Lung	340	continuous
Heart	860	continuous
Intestinal Mucosa	13,000	fenestrated
Renal Glomerulus	15,000	fenestrated
Liver, spleen	+++	discontinuous

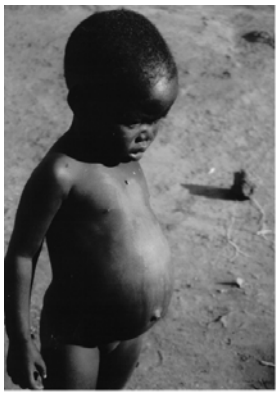
III. Capillaries

C. Water Filtration and Absorption

1. Importance

- Tissue fluid ⇔ blood volume ⇒ End Diastolic Volume
- Edema: can compromise tissue function in all tissues, tissue perfusion in encased tissues

Severe Malnutrition – Kwashiorkor



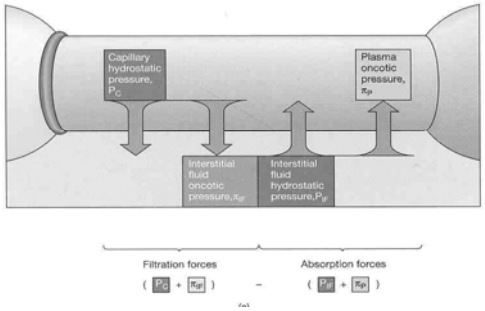
III. Capillaries

C. Water Filtration and Absorption

2. Filtration/absorption forces

- Hydrostatic pressures
  - capillary pressure (Pc), (15-35 mmHg)
  - interstitial fluid pressure (IFP or Pt), (~0 mmHg)
- Colloidal osmotic (oncotic) pressures
  - plasma oncotic pressure (π_p), (28 mm Hg)
  - tissue oncotic pressure (π_t), (3 mmHg)

Filtration/Absorption Forces



III. Capillaries

C. Water Filtration and Absorption

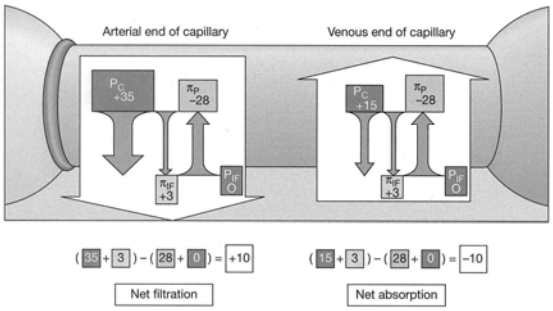
3. Changes along an ideal capillary

- P_c decreases from arteriolar to venular end of capillary
- Filtration forces decrease

4. Net exchange

- Filtration forces – Absorption forces
- $(P_c + \pi_t) – (\pi_p + P_t)$

Changes along an ideal capillary



test Overview 16

III. Capillaries

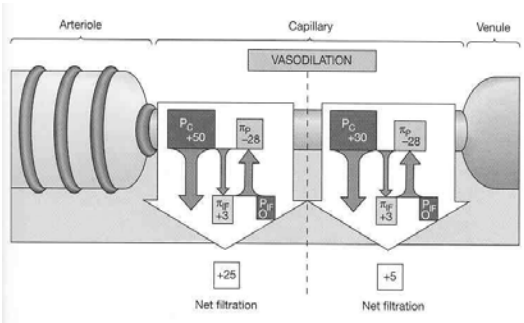
D. Sites of Exchange

E. Conditions altering transcapillary exchange of H_2O

- Hydrostatic pressures: arteriolar tone, fluid loss, venous compression
- Oncotic pressures: inflammation, severe malnutrition
- Permeability: inflammation

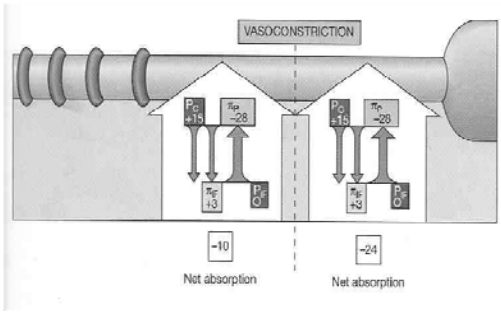
SABS I Capillaries 17

Net Exchange



test Overview 18

Net Absorption



III. Capillaries

CONDITION	ALTERATION	NET EFFECT
Arteriolar Vasodilation	$\uparrow P_C$	Filtration
Hemorrhage	$\downarrow P_C$	Absorption
Elevated venous pressure	$\uparrow P_C$	Filtration
Malnutrition	$\downarrow \pi_p$	Filtration
Congestive heart failure	$\uparrow P_C$	Filtration
Tissue inflammation	$\uparrow P_C$, $\uparrow$PS, $\uparrow \pi_t$	Filtration