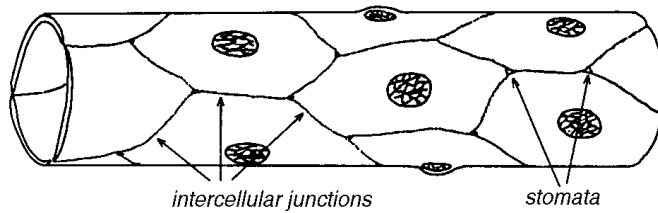


INTRODUCTION

A. Functional Anatomy

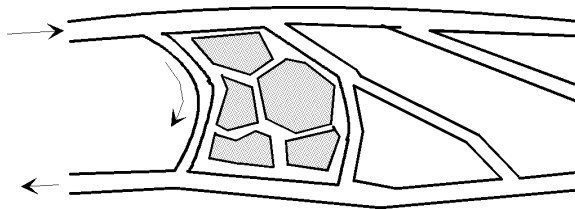


B. Functional Histology

1. Single layer of endothelial cells
2. Dimensions
 - diameter: 5-10 μM
 - length: 0.5-1 mm
 - (blood cell velocity approximately 0.3-1.0 mm/sec)
3. Junctions between capillary cells normally "tight", but
 - a. liver & bone marrow: large clefts between cells
 - b. central nervous system: very tight ("blood-brain barrier")

C. Properties

1. Short distance between each capillary and the cells it serves
2. Continual renewal of capillary blood by the circulation

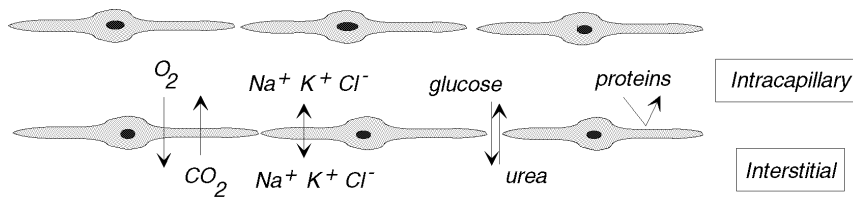


MOVEMENT ACROSS CAPILLARIES

- A. Mode: Simple diffusion, due to concentration difference between capillary blood plasma (" C_c ") and tissue (" C_t ")

Note: The electrical force on charged particles is not important because there is only a small electrical potential difference across the capillary. Active transport generally does not occur, and when it does, it is too slow to be of major importance.

MOVEMENT ACROSS CAPILLARIES (continued)



B. Capillary Permeability

1. Selectivity: based only on size of the particle. All particles smaller than plasma proteins readily pass through capillary walls
2. Exceptions: In very tight capillaries, even small ions pass only slowly through the capillary wall. In open capillaries, even plasma proteins and cells can pass through the capillary wall

C. Composition of Interstitial Fluid

Because only large particles are filtered out by the capillary walls, normal interstitial fluid is an ultrafiltrate of blood plasma; that is, it has the same composition as plasma except that its concentration of plasma proteins is much less.

WATER MOVEMENT

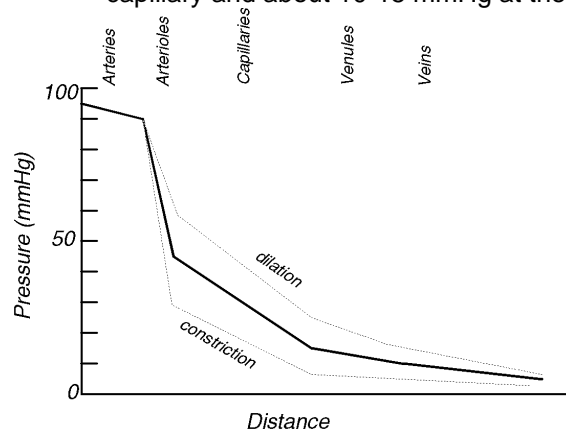
A. Forces

1. Hydrostatic Pressure

- a. Symbol: P
- b. Movement: Fluid moves from regions of high hydrostatic pressure to regions of low hydrostatic pressure
- c. Components

1) intracapillary (mural) pressure: P_C

normal value of P_C : depends on vasomotor state; in systemic capillaries, averages about 40 mmHg at the arteriolar end of the capillary and about 10-15 mmHg at the venular end



Note the effect on capillary pressure of the following:

- arteriolar vasodilation
- arteriolar vasoconstriction
- increased venous pressure

2) interstitial tissue pressure: P_t

normal value of P_t : a few mmHg (close to zero)

WATER MOVEMENT

A. Forces (continued)

2. Osmotic Pressure

- a. Symbol: π (π_i)
- b. Basis: Osmosis is based on the tendency of water to diffuse. The tendency of water to diffuse depends on the number of particles dissolved in the water. The greater the total concentration of dissolved particles, the less the tendency of water to diffuse.
- c. Measurement: The force for water diffusion is measured as the value of the hydrostatic pressure necessary to stop net water movement. This force is termed the osmotic pressure.
- d. Movement: Water moves from regions of low osmotic pressure (dilute solution) to regions of high osmotic pressure (concentrated solution).

B. Osmotic Pressure across the Capillary Wall

1. Only those particles to which the capillary wall is relatively impermeable need be considered in evaluating transcapillary osmotic pressure (the permeable particles have equal intracapillary and interstitial concentration and so make no net contribution).
2. Normally plasma proteins are the only dissolved substances to make a major contribution to net transcapillary osmotic pressure.

Note: Plasma protein osmotic pressure is termed colloid osmotic pressure or, sometimes, oncotic (swelling) pressure

3. Normal colloid osmotic pressure in plasma and typical tissue

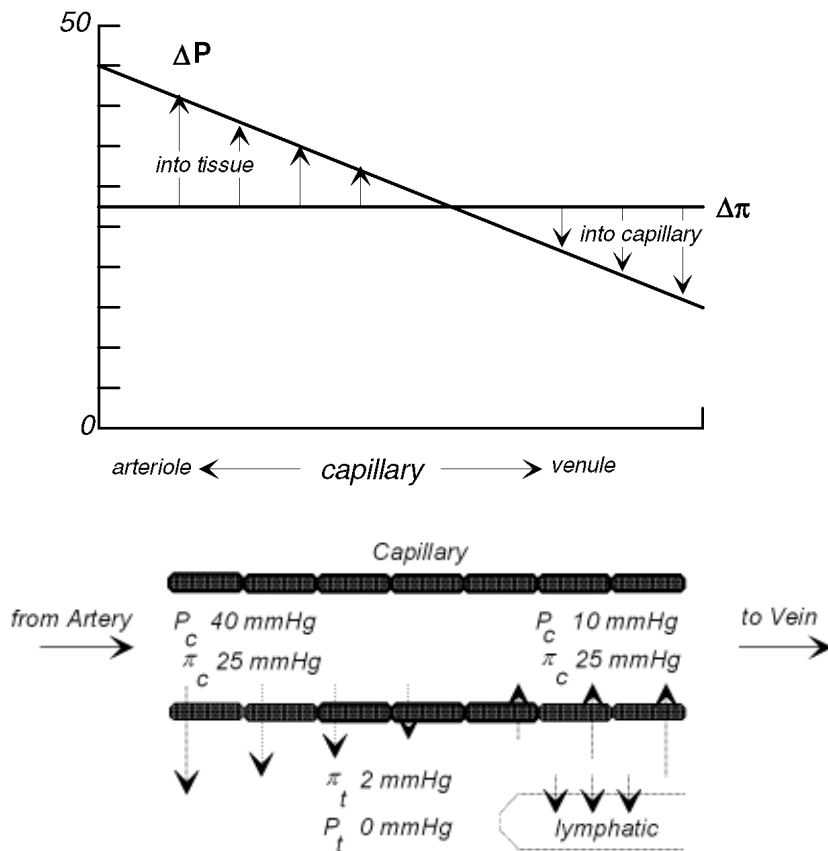
Plasma: $\pi_C = 28$ mmHg

Tissue: $\pi_t = 4$ mmHg (typical value in tissue with "tight" capillaries)

C. Starling's Law of the Capillaries

1. The net hydrostatic force moving water out of the capillaries is ($P_C - P_t$). The net osmotic force moving water back into the capillaries is ($\pi_C - \pi_t$). The net movement of water depends on which of these forces predominates.
2. Pattern of capillary fluid exchange
 - a. movement out of the capillary at the arteriolar end
 - b. movement into the capillary at the venular end
 - c. Normally these two movements are closely balanced, so there is little net fluid loss or gain. Often there is a slight predominance of efflux (loss from the capillary).

WATER MOVEMENT (continued)



D. Role of the Lymphatics

1. Return excess filtered fluid to the circulatory system; the normal rate of lymph formation is only about 2 ml/min; mechanisms for lymph movement
 - a. pressure gradient (small)
 - b. pumping (contractile elements in lymphatics)
 - c. valves
2. Return plasma proteins that leak slowly across the capillary wall to the circulatory system
3. Remove debris from interstitial fluid and serous cavities (and trap in lymph nodes)

DISTURBANCES OF CAPILLARY FLUID BALANCE

A. Movement of Fluid from Tissue to Blood

1. Reduced capillary pressure; examples:
 - a. hemorrhage
 - b. excess sweating
 - c. diarrhea

Note: Tissue fluid functions as a volume reservoir to prevent cardiovascular collapse due to loss of blood in the case of hemorrhage.

DISTURBANCES OF CAPILLARY FLUID BALANCE (continued)

B. Movement of Fluid from Blood to Tissue

Note: the observable collection of fluid in the tissue is termed edema (collection of fluid in the abdominal cavity is called ascites)

1. Decreased plasma osmotic pressure due, for example, to plasma protein deficiency (e.g. starvation, protein wasting renal disease)
2. Increase intracapillary hydrostatic pressure (e.g. gravity, venous obstruction, congestive heart failure)
3. Increase tissue osmotic pressure, due, for example, to increase capillary permeability to plasma proteins (e.g. inflammation, trauma)
4. Lymphatic obstruction (e.g. elephantiasis)