Bioen 3202, Physiology II
Blood Pressure
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Vocabulary

• peripheral resistance
• compliance
• viscosity
• hypoxia

Also, capillaries are made up of only endothelial cells (thinnest material)

Blood Pressure

We can describe mean blood pressure in the arterial system of the body by the equation

$$P = R * \dot{Q}$$

where P=pressure [mm Hg], R=resistance, and Q=flow [1/min]. Note that these are average values. This equation is very similar to Ohm's law, in which voltage is equivalent to pressure, current to flow and resistance the same for both.

We can write an equation for resistance to flow as

$$R = (8\eta L)/\pi r^4.$$

where η is viscosity of blood, r is the radius of the vessel and L is its length. This equation is only an approximation of reality but is useful for qualitative understanding. Note especially the large exponent for the radius term—regulation of blood flow happens by means of changes in vessel radius.

Blood Viscosity

• depends on velocity of blood flow, first increasing as flow velocity drop and then decreasing when vessels are so small that RBC's line up to pass in an orderly manner.

• blood is a suspension of red blood cells (RBC)
  - size: 8 µm diameter
  - They're flexible!

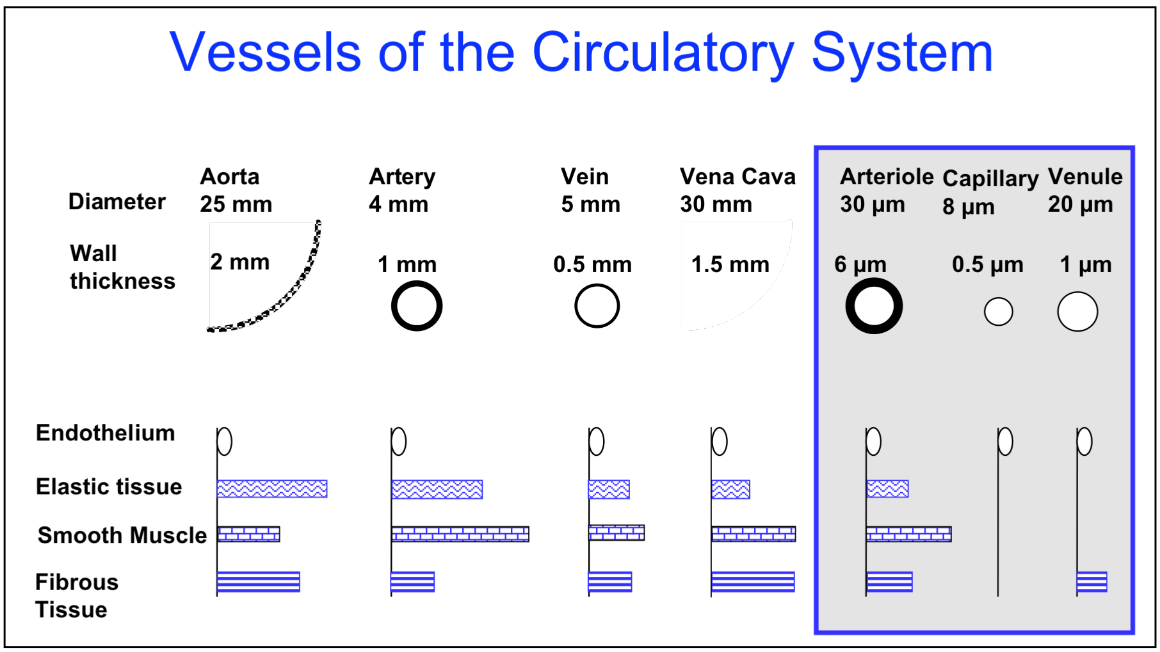
• Viscosity is a function of the interaction of RBC's with vessel walls; increase in electrostatic interaction → increase in viscosity. So smaller vessels will generally have higher viscosity, as will slower flow.

Viscosity also depends on RBCs interacting with each other, so becomes a function of hematrocrit (concentration of RBCs.)

Vasculature

- Each type has a difference mix of….
  - endothelial cells
  - smooth muscle
  - fibrous material
  - Elastic materials

  See diagram below for vessel characteristics.
- Capillaries >- 5 µm diameter
  - RBCs conform to capillary diameter
  - Viscosity decreases with flowing in capillaries because RBCs line up in ordered way.



Result,

High velocity in large vessels → low viscosity
Lower velocity in small vessels → higher viscosity
Lowest velocity in smallest vessels → lowest viscosity (more ordered RBC)

Control of Flow/Pressure

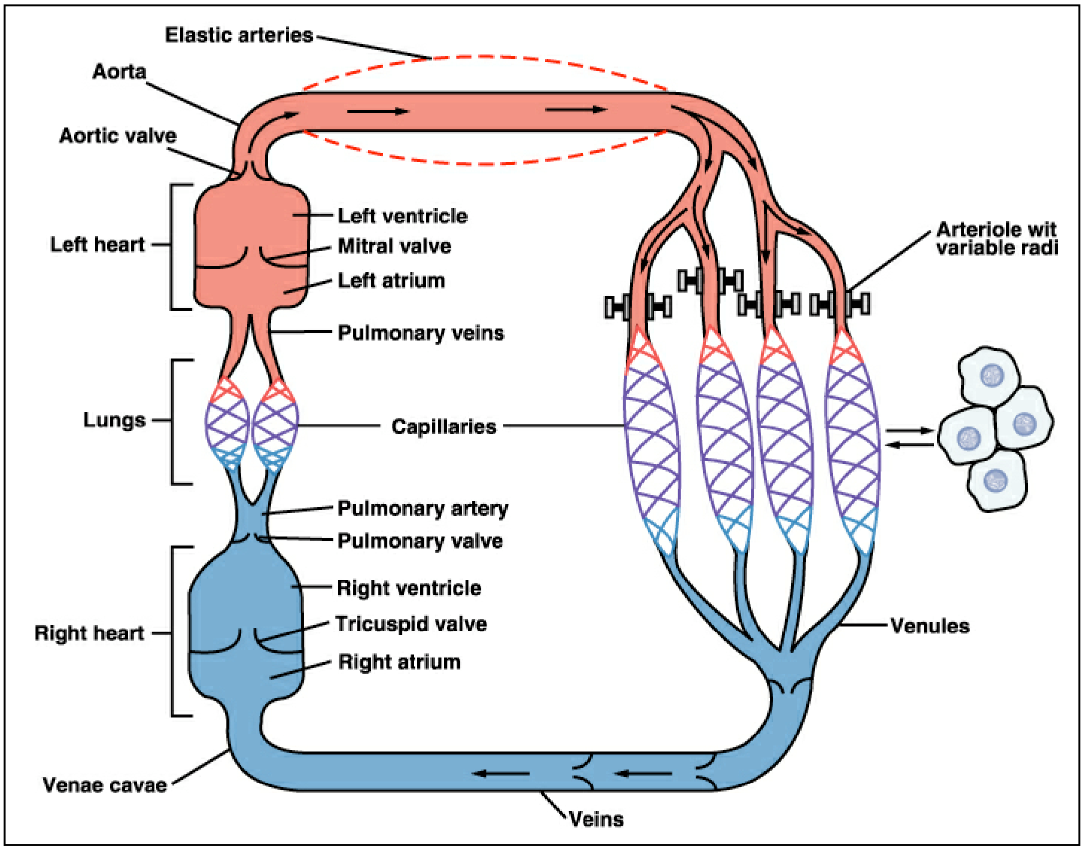


Figure above shows overview of circulatory system. Note the parallel branches of the vessels, each with regulation to control flow.
In general, flow is controlled by vessel diameter controlling resistance

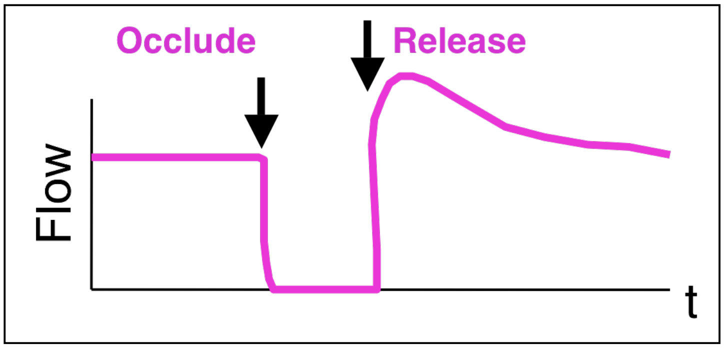
1) R depends on $1/r^4$
2) Parallel vessels
3) Flow control via radius changes
    a. Blood flows path of least resistance
4) Brain has a constant supply

We can also note (again) that all feedback systems require

a. Sensor
b. Feedback
c. Effector
d. Set point

Local vs. Central Control (Figure. Flow vs. Time)

1) Local control:
    a. Is local, i.e., does not require the brain or endocrine systems to function



    b. Figure above shows a local response to occlusion. The flow levels after the release are enhanced and we need to figure out why.
        e. Driving Force Explanation
        f. Local level:
            i. Tissue nutrition
            ii. Hypoxia: lack of O2
            iii. Hypercapnea: increase in CO2
            iv. Change pH
            v. Energy requirement
2) Remote control
    a. Requires brain involvement
    b. Sensors in the body send information to the brain of pressure and metabolic needs and brain decides what has to happen
    c. Sympathetic arm of ANS is means of control
    d. See next days notes for details

Blood Pressure

Exercise

If P_B decreases, driving force is lost

During exercise, some capillary beds shut down because R increases (i.e. GI tract)

Relevance to Lab

Measure systolic vs. diastolic

Compare a constant and increasing profile to check if P_B is balanced by CO and R_P