Introduction

In the circulatory system, blood that is pumped by the heart flows through blood vessels and provide tissues with nutrients and oxygen. This flow, which is created by each heartbeat, is pulsatile; that is, the flow created is a series of discontinuous pulses. However, for optimal function, our body requires a steady, continuous flow of blood. How do blood vessels control this?

In addition to controlling blood flow, blood vessels are subject to mechanical stress during the pumping of blood. Thus, blood vessels must have mechanical properties that can withstand these stresses. Again, the mechanical properties of blood vessels are a function of the underlying tissue structure. Since blood vessels are soft collagenous tissues (with a good deal of elastin, another biomolecule), their stress-strain behavior resembles that of other soft collagenous tissues like ligaments and tendons.

Blood vessel tissue structure can change due to aging, disease, or altered mechanical load. Sometimes it is a combination of all three factors. For example, hypertension or high blood pressure is a disease that raises the mechanical load on the blood vessel. Due to higher stresses, the structure of the blood vessel is altered.

In disease states such as atherosclerosis, arteries lose their elastic properties which results in the disruption of continuous blood flow. Additionally, blockages of blood vessels may lead to aneurysms, which are localized balloon-like dilations of the vessel. Aneurysms are often fatal if they rupture. Therefore, changes in mechanical properties may have dire consequences!

Objective

In this lab, we will use various tubing and a ball pump to model the circulatory system and observe how the mechanical properties of blood vessels alters blood flow.

Materials

- Ball pump and white nozzle
- 2 pieces of clear, stiff tubing
- 1 piece of amber, latex tubing
- 1 piece of pink, latex tubing
- 2 cable ties
- 1 beaker
Procedure

1. Fill beaker halfway with water. Set up the circulatory system as follows: Screw the white nozzle into the ball pump. Connect the clear tubing to the pump. Then connect the amber latex tubing to the clear tubing. Finally, connect the other piece of clear tubing to the latex tubing and place the other end into the beaker.

2. Briskly pump the ball pump several times. Note how violently the bubbles appear in the beaker of water. What does each pump (down-stroke) represent?

Heartbeat

3. Disassemble the amber latex tubing and now replace it with the thinner pink latex tubing. Tie this onto the clear tubing with two cable ties. Make sure the connection is air-tight and there is no air leakage. Now pump several times. Do bubbles still form?

If yes, how do they compare to the amber latex?

Yes, but much less violently.

Which latex tubing results in higher pressure? How do you know?

Amber, the bubbles that formed were much more violent, meaning the air pressure was much higher.

What happens to the pink tubing during each down-stroke and upstroke?

The swells during the down-stroke and recoils during the upstroke.
In our tube model, which component represents...

a. the heart? **Pump**

b. blood? **Air**

c. a healthy artery? **Pink latex**

d. an atherosclerotic artery? **Amber latex**

From your observations, how does the elasticity of a blood vessel affect blood pressure?

**The less elastic, the higher the blood pressure.**

How does the elasticity of a blood vessel control the continuous flow of blood when the heart only contracts in pulses?

**Elastic vessels can expand during the down-stroke and recoil normally, moving blood continuously. Stiff vessels do not expand or recoil so blood moves at higher pressures.**

4. **Empty your beaker into the sink. Now, instead of allowing air to flow into water, plug the end of the tubing with your thumb. Now pump several times.** What happens to the pink latex tubing?

**Balloons.**

What does your thumb represent?

**A thrombus (blood clot) or some kind of occlusion.**

What does the expanded pink latex tubing represent?

**An aneurysm.**
5. Gently squeeze the air-filled pink latex with your fingers. How does this feel compared to an unfilled chamber?

**Much less elastic due to high pressure.**

What can you say about the thickness of the latex as it expands?

**Gets thinner.**

What about its stiffness?

**Stiffer.**

**Conclusion:**

Describe how the function of a blood vessel is altered when the mechanical properties of the blood vessel are altered.

**Loses its ability to expand and recoil normally, and therefore, its ability to regulate blood pressure flow.**

If an individual has atherosclerosis what happens to mechanical properties of their arteries?

**The arteries stiffen.**

Explain how atherosclerosis could lead to an aneurysm in a patient.

**Fatty plaques can rupture and cause clots that occlude the artery.**

How would you design a drug or treatment for atherosclerosis?

**A drug that can reverse artery stiffening. A drug that prevents lipids or cholesterol from sticking and hardening arteries. A drug that helps the body clear plaques.**