CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
Vivian R. Chiang

Project Number
J0107

Project Title
Pulse Wave Analysis in Simulated Vascular System

Abstract

Objectives/Goals
The purpose of my experiment is to understand how doctors use blood pressure waves to diagnose the patient's sickness.

Methods/Materials
In my experimental setup, I have two pumps, representing the atrium and the ventricle. Check valves are located between vein and atrium, between atrium and ventricle, and between ventricle and aorta to enforce one-directional flow. Next, the aorta tube is connected to the ventricle which leads to smaller arterioles. Then, several loads are connected, representing organs. Finally, the vein takes the "blood" back to the atrium. There is a vein reservoir in between the vein tubes to emulate the property of the vein. The variables were the rate of pulses, the stiffness and length of the aorta tube, clogging in the tube, and the viscosity of the fluid.

Results
The pressure pulse wave traveled much slower in the Latex tube than in the Vinyl tube and the Polyethylene tube. The pressure waveforms in Polyethylene tube and Vinyl tube were similar with a slightly higher pressure with Polyethylene tube. The pressure pulse propagation delay was slightly smaller with Polyethylene tube than that with Vinyl tube.
The observed pressure was much higher with non-fat milk than that with water in Latex, Vinyl, and Polyethylene tube cases. However, the pressure pulse propagation delay was only slightly larger with non-fat milk than that with water in all three tube types.
In the cases with Latex tube, pinching aorta or the short load caused the pressure to increase slightly. However, the pressure pulse waveforms were not changed significantly. In the case with Vinyl tube, pinching aorta or the short load caused no noticeable change in both pressure and waveform.

Conclusions/Discussion
The pressure wave propagated faster in the stiffer Vinyl and Polyethylene tubes resulting higher systolic pressure. The pressure wave propagated slowly in more distensible Latex tube as the tube expanded and contracted resulting lower systolic pressure.
The longer the aorta is, the longer it takes for the reflected wave to reach back to the aorta/ventricle junction, resulting lower peak pressure at the junction and wider pressure pulse.
When the fluid had higher viscosity, it took much higher pressure to get the same flow through the system. However, the increase in propagation delay seemed to be not very significant.
Clogging caused flow resistance to increase but the effect was not very strong.

Summary Statement
Using real pumps, valves, and tubes, I investigated how stiffness and length of tubes, pulse rate, clogging in the tube, and viscosity of fluid affect the pulse wave propagation in a simulated vascular system.

Help Received
Dad helped to buy materials and operated power tools to build the setup.