CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)

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Project Number

J0104

Project Title

On the Rate of Flow of Liquids in Tubes and Its Implications to Cardiovascular Health

Abstract

Objectives/Goals

The purpose of my experiment is to determine how the rate of flow of a liquid through a tube is affected by the following factors: (a) pressure driving the flow, (b) the length of the tube and (c) the diameter of the tube. I became interested in this topic when I learned that heart disease results when plaque reduces the diameter of blood vessels, causing a dramatic decrease in flow rate. This topic is of interest because the American Heart Association estimates that heart disease costs the U.S. economy nearly half-a-trillion dollars each year.

Methods/Materials

I modeled the human circulatory system using a set of latex tubes, and a large container filled with water. The latex tubes were connected to the side of the container, via a valve. I investigated flow rate dependence on (a) pressure by changing the height of the water in the container, (b) tube length using a set of latex tubes of the same diameter, but different lengths, and (c) tube diameter, using a set of latex tubes of the same length, but different diameters. I measured the flow rate by determining the amount of time (delta_T) taken for a small volume of water (delta_V) to drain from the container through the tube under investigation. The flow rate Q was calculated from the ratio delta_V/delta_T. Since the flow rate can be fast I used a high-definition camcorder to record the change in the height of the water in the container. I viewed the video on my computer in slow motion, and obtained accurate readings of delta_T, and delta_V.

Results

I collected data at 25 conditions, and repeated each measurement 3 times. So I extracted a total of 75 data points from 75 video clips. From this data, I found that the flow rate (a) increases with increasing pressure (agreed with hypothesis), (b) decreases with increasing length (contradicted hypothesis), and (c) increases dramatically with increasing diameter (agreed with hypothesis). My results are in good agreement with the Hagen-Poiseuille Law.

Conclusions/Discussion

I found that a change in tube diameter can dramatically change the flow rate of water. For example, I found that when tube diameter decreases by a factor of 2.65x flow rate decreases by a factor of 18x! This explains why a decrease in blood vessel diameter can be very harmful to health. By exercising more and changing our eating habits we can reduce plaque in our blood vessels.

Summary Statement

My experiment showed how a small decrease in the diameter of a tube can lead to a substantial decrease in the flow rate of fluid in that tube; this explains why plaque-induced blood vessel narrowing is harmful to our cardiovascular health.

Help Received

I would like to thank my father, Dr. Pratheep Balasingam for his encouragement throughout the course of this experiment. I would like to thank my mother for purchasing the necessary materials for me to set up my experiment.