Teaching Physics with the Physics Suite

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Hold the mayo!

Coronary arteries are responsible for supplying oxygenated blood to heart muscle. Coronary heat disease is caused by the arteriosclerosis (the deposition of plaque along the arterial walls) of those arteries. One common response of the body to coronary arteriosclerosis is to increase the blood pressure. An average normal blood pressure is 120 mm Hg maximum (systolic) when the heart is pumping its hardest, falling to 80 mm Hg when the heart is relaxed (diastolic) between beats. This is typically reported as "120/80 mm Hg". (Read: "120 over 80".) If your systolic pressure gets above 140 mm Hg, you will be diagnosed with incipient high blood pressure. Pressures at that level and above can cause damage to the body's organs.

Let´s see what physics can tell us about coronary arteriosclerosis and its consequences. [Note: Medical measurements of pressure tend to be in the old-fashioned units "mm Hg" -- how high a column of mercury can be held up against a vacuum. A conversion factor can be obtained to the more natural Pascals, 1 Pa = 1 N/m^2, by noting that 1 standard atmospheric pressure = 14.7 lbs/in^2 = 10^5 Pa = 760 mm of Hg.]

In a "mild" case of coronary arteriosclerosis, plaque may line the walls so that it occludes one third of the cross section of the artery. One might predict at first glance that the flow rate in the occluded artery is two thirds of the healthy artery. Let's see how accurate that is.

A. The radius of a typical open artery is 1.5 mm. What is the radius of an artery that is 33% occluded? (33% of the cross-sectional area is taken up by plaque.)

B. Assuming that the pressure drop across the artery remains the same, calculate the ratio of current flow (J) in the 33% occluded vs. the open artery.

C. The body attempts to compensate with reduced flow in part by increasing the blood pressure. How much would the pressure drop across the artery (Δp) have to increase in the 33% occluded artery to have the volume of blood flow (J) equal to that in the open artery?

D. Assuming you have completely open arteries now, estimate what your own systolic

pressure would have to be in order to compensate for the decreased flow.

(problem by Todd Cooke, Heather Dobbins, and Joe Redish, UMd)

Page last modified December 4, 2008: M22