The Effect of Tube Wall Stiffness on the Speed of Waves in Tubes

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The heart creates pulsatile flow in the arterial and pulmonary circulations. The vessels that make up these systems are distensible, so part of each pulse of blood fills the increasing volume of these vessels, while the remaining blood continues to flow down the vessel. Once the pulse has passed, and the valves from the heart are closed, the vessels contract under their own elasticity, pushing the "stored" blood further down the system. Thus the flow at the beginning of the aorta varies differently over time to flow further down that vessel. Different vessels in each circulatory system appear to have different wall thicknesses and stiffnesses. Further, some organs like the kidney and the brain would appear to function better under continuous blood flow rather than pulsatile flow. Thus we are interested in how wall stiffness of the vessels affects how much blood is "stored" from each pulse and then pushed on down the system, and how the velocity of the wave is affected by wall stiffness. We wish to understand how the body does supply more uniform flow to some organs than to other parts of the circulation.

The distensibility of seven tubes with different wall stiffness and thickness was measured. Meter lengths of the three tubes most sensitive to pressure change were attached to a pump that delivered a pulsatile waveform resembling aortic flow. The flowrate and pressure changes were measured in the proximal and distal part of each tube. The distensibility of each tube was calculated again and found to be slightly larger than in the first experiment, possibly due to the non-steady state situation. As expected, the more stiff the tube the less the volume that can be stored. Of interest are the rate of reduction in storage with wall stiffness, and the rate of change in wave speed.