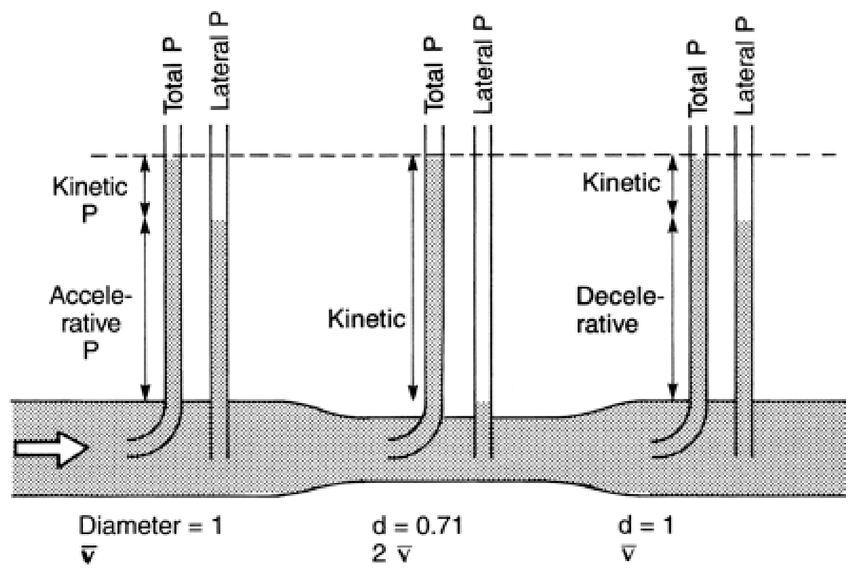
Fluid Models for Hemodynamics

"The best blood will at some time get into a fool or a mosquito" Austin O'Malley

Hemodynamics

Note: Blood flow through cardiovascular system modeled using Bernoulli and Poiseuille principles

Reference: H.S. Badeer, “Hemodynamics for Medical Students”, *Advances in Physiology Education*, 25(1), pp. 44-52, 2001.



Bernoulli Equation: (without viscous effects)

$$\rho g h + \frac{1}{2}\rho \bar{u}^2 + p = C$$

Bernoulli Equation: (with viscous effects)

$$\rho g h + \frac{1}{2}\rho \bar{u}^2 + p + \int \text{Viscous losses} = C$$

$$\Rightarrow \rho g h + \frac{1}{2}\rho \bar{u}^2 + p + \mathcal{R}\mathcal{U} = C$$

Here

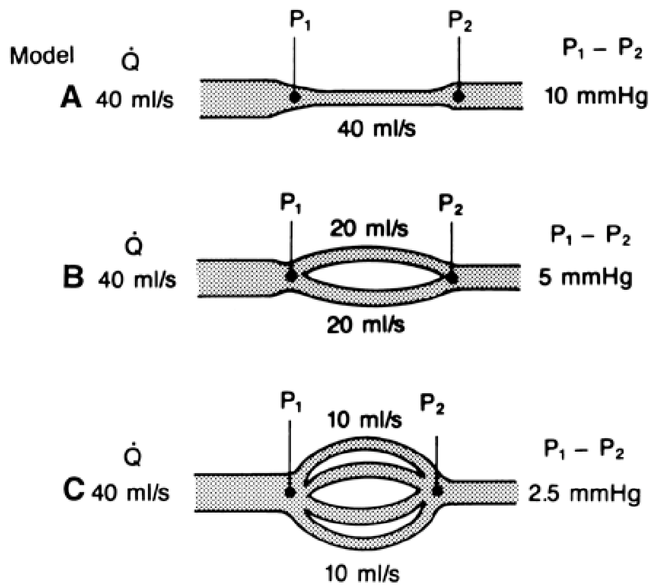
$$\mathcal{U} = \pi r^2 \bar{u} \quad \text{(Volumetric flow rate)}$$

$$\mathcal{R} = \frac{8\mu L}{\pi R^4}$$

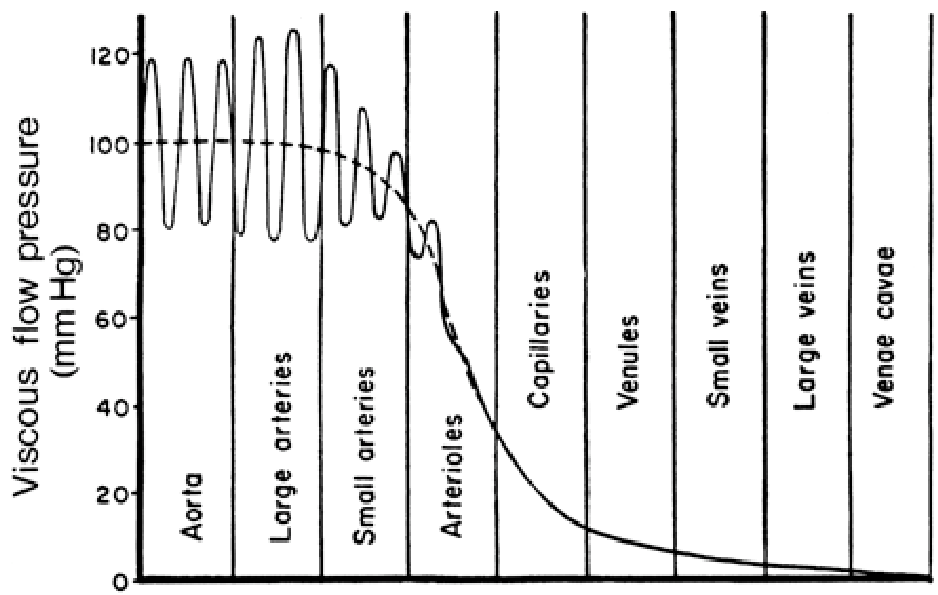
Hemodynamics

Note: $(\dot{Q} = \mathcal{U})$

$$\frac{1}{\mathcal{R}_r} = \sum_{i=1}^{n} \frac{1}{\mathcal{R}_i}$$

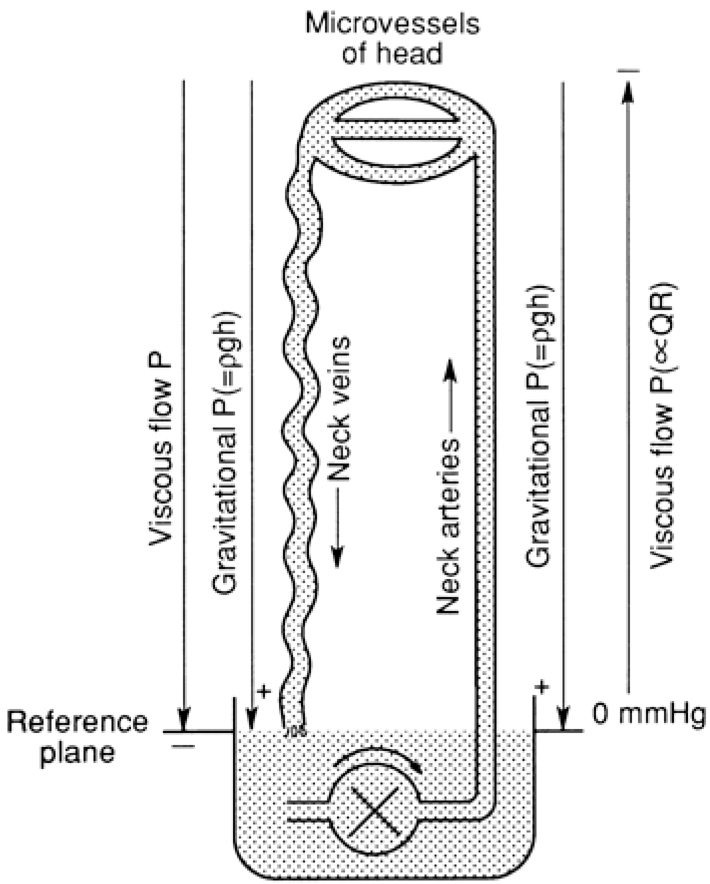


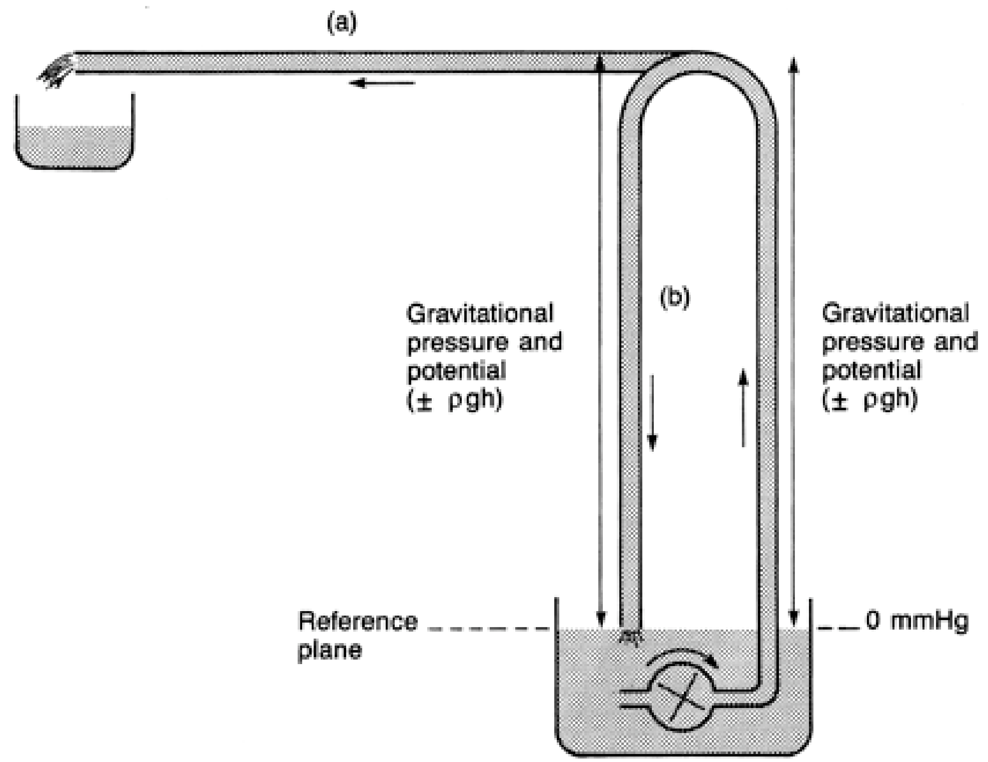
Note: Viscous losses greatest in arterioles



Hemodynamics

Note: Effects of gravity can be significant in the body





Position (a) Work of pump = Gravit. P (ρgh) + Viscous P ($\dot{Q}R$) + Gravit. potential (ρgh) + Kinetic P ($\rho \bar{v}^2/2$)

Position (b) Work of pump = Viscous P ($\dot{Q}R$) + Kinetic P ($\rho \bar{v}^2/2$)

Hemodynamics

Note: A number of effects are being neglected

- e.g., structural-fluid interactions with viscoelastic vessel walls