

## **Answers to Hemodynamics Problems - Ellsworth**

*Problem #1: A man has a cardiac output of 5.5 L/min. The diameter of his aorta is estimated to be 20 mm, with the total surface area of his systemic capillaries estimated to be 2500 cm<sup>2</sup>. What is the velocity of blood flow in the aorta relative to that in the capillaries. (note: 1 ml = 1 cm<sup>3</sup>)*

**Need to determine velocity in the aorta and capillaries**

$$V_{aorta} = Q/A$$

$$x\text{-sec area} = \pi r^2 = 3.14 (10 \text{ mm})^2 = 3.14 \text{ cm}^2$$

$$V_{aorta} = (5.5 \text{ L/min}) / (3.14 \text{ cm}^2) = 1752 \text{ cm/min}$$

$$V_{capillaries} = (5500 \text{ cm}^3/\text{min}) / (2500 \text{ cm}^2) = 2.2 \text{ cm/min}$$

$$V_{aorta} = \sim 800 - \text{fold greater than that in the capillaries}$$

*Problem #2: Renal blood flow is measured by placing a flow meter on a woman's left renal artery. Simultaneously, pressure probes are inserted in her left renal artery and left renal vein. Renal Q was found to be 500 ml/min. Renal artery pressure was 100 mmHg and renal venous pressure was 10 mmHg. What is the renal vascular resistance in her left kidney?*

$$Q = \Delta P/R$$

$$R = \Delta P/Q$$

$$R = (100 - 10 \text{ mmHg}) / (500 \text{ ml/min})$$

$$R = 0.18 \text{ mmHg/ml/min}$$

*Problem #3: A man suffers a stroke caused by partial occlusion of his left internal carotid artery. An evaluation of the carotid artery using MRI shows a 75% reduction in its radius. Assuming that blood flow through the left internal carotid artery is 400 ml/min prior to the occlusion, what is blood flow through the artery after the occlusion?*

What changes? Diameter of the left internal carotid artery

$$Q = \Delta P/R$$

$$R = 1/r^4 \quad \text{Therefore, 75\% reduction in diameter means that resistance has increased}$$

$$1/(1/4)^4 = 256 \text{ fold}$$

If  $Q = \Delta P/R$ , a 256-fold increase in R means that Q has decreased to 1/256 its original value

$$\text{Thus, } 400 \text{ ml/min} \times 1/256 = 1.56 \text{ ml/min}$$

Problem #4: In a skeletal muscle capillary the following Starling pressures were measured:

$$P_c = 30 \text{ mmHg}$$

$$P_{if} = 1 \text{ mmHg}$$

$$\pi_c = 26 \text{ mmHg}$$

$$\pi_{if} = 3 \text{ mmHg}$$

Assuming that  $K_f = 0.5 \text{ ml/min mmHg}$ , what is the direction and magnitude of fluid movement across the capillary wall?

$$J_v = K_f [(P_c - P_{if}) - (\pi_c - \pi_{if})]$$

$$= 0.5 \text{ ml/min mmHg} [(30-1\text{mmHg}) - (26 - 3 \text{ mmHg})]$$

$$= 3 \text{ ml/min} \quad \text{Value is positive so fluid is leaving the capillary}$$