Exam Key

NROSCI/BIOSC 1070 and MSNBIO 2070
Exam # 1
October 2, 2015

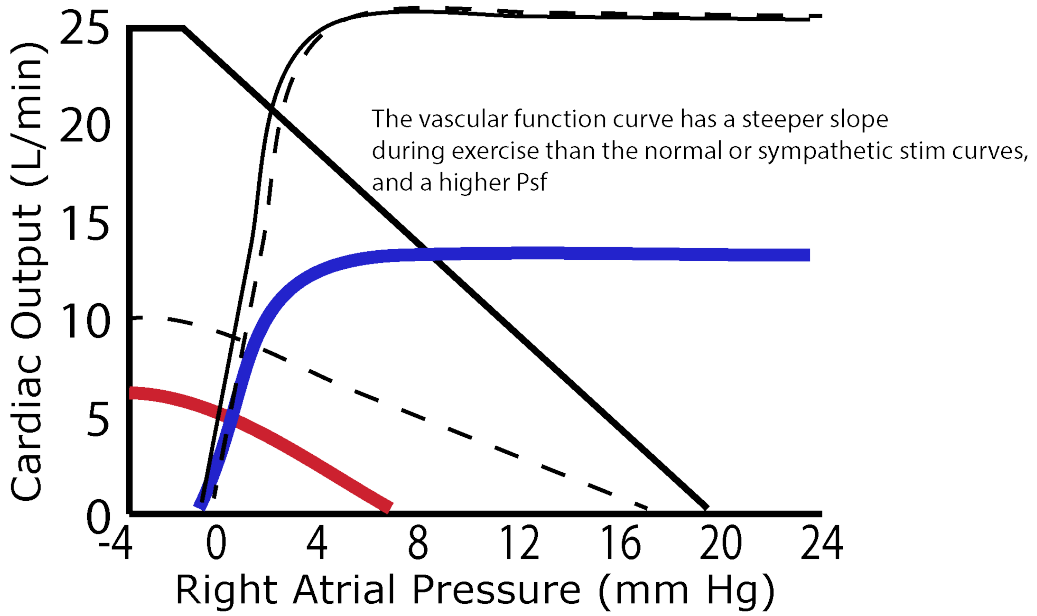
Total POINTS: 100 20% of grade in class

1. A normal vascular function curve and cardiac function curve are plotted below. Indicate how these curves change during:

a) Maximal sympathetic nervous system activation *(dashed lines)*
b) Maximal exercise *(solid lines)*

In drawing the curves, you should be more concerned with the relative changes between conditions than absolute values of the changes. ***(8 points).***

Note: the cardiac function curves during sympathetic stimulation and exercise are similar



c) What are the main factors responsible for differences in the vascular function curve during maximal sympathetic nerve stimulation and exercise? ***(4 points)***

- The vascular function curve has a higher Psf during exercise than during sympathetic stimulation or rest. During both sympathetic stimulation and exercise, venoconstriction occurs, which raises Psf. In addition, Psf is even higher during exercise, due to skeletal muscle pumping.
- The slope of the curve is less steep during sympathetic simulation than at rest, due to an increase in afterload. The slope is more steep during exercise, because of a decrease in afterload.

2. **a)** What is the difference between stressed and unstressed vascular volumes? ***(4 points).***

An unstressed volume is too low to press against the side of the vessel containing it to generate pressure. Stressed volumes are higher than the critical threshold to generate pressure by pressing against the vessel wall.

b) In an individual with normal vascular volumes, what fraction constitutes the stressed volume? ***(2 points).***

Approximately 1 liter out of 5, or 20%.

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3. Men who take anabolic steroids are often sterile. Discuss the physiological mechanism responsible for sterility in individuals who take anabolic steroids. ***(7 points).***

Due to feedback inhibition, GnRh and LH/FSH levels drop in individuals taking anabolic steroids. LH stimulates the production of testosterone in the testis, and FSH stimulates spermatogenesis. Loss of both results in sterility. Note that in normal men, intratesticular levels of testosterone are much higher than blood levels. Thus, even if blood levels of steroid are high, the amount in the testicle is too low to facilitate sperm production.

4. When heart rate increases to 120 beats/min in a normal individual, stroke volume does not decrease despite a reduced ventricular filling time. Indicate 3 reasons why ventricular filling is not compromised during modest increases in heart rate under sympathetic stimulation. ***(6 points).***

- Most ventricular filling occurs just after the mitral valve opens, so just the "slow filling phase" is reduced.
- Sympathetic stimulation results in more atrial contraction, which facilitates ventricular filling.
- Lower ESV allows more filling before pressure rises in the ventricle (EDPVR).

Also acceptable answers:

- The Bowditch effect facilitates ventricular emptying
- Higher ventricular contractility increases stroke volume

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5. A patient comes to the hospital for an exercise stress test. The baseline hemodynamic profile shows the following data:

Systemic systolic pressure	135 mmHg
Systemic diastolic pressure	75 mmHg
Pulmonary systolic pressure	30 mmHg
Pulmonary diastolic pressure	10 mmHg
Left atrial pressure	10 mmHg
Right atrial pressure	5 mmHg
Cardiac output	5 L/min
Coronary blood flow	250 ml/min

During exercise, the following hemodynamic data are obtained:

Systemic systolic pressure	180 mmHg
Systemic diastolic pressure	75 mmHg
Cardiac output	15 L/min
Coronary blood flow	1 L/min

a) What is systemic vascular resistance at rest, and what percentage change in systemic peripheral resistance occurs in the individual during exercise? Indicate whether systemic vascular resistance increases or decreases during exercise ***(5 points).***

$\Delta P/Q=R$
At rest: [((.667*75)+(.333*135))-5]/5=R R=18RU
Exercise: [((.667*75)+(.333*180))-5]/15=R R=7RU

Resistance is lower during exercise

b) What is coronary vascular resistance at rest, and what percentage change in coronary vascular resistance occurs in the individual during exercise? Indicate whether coronary vascular resistance increases or decreases during exercise ***(5 points).***

$\Delta P/Q=R$
At rest: [((.667*75)+(.333*135))-5]/0.25=R R=360RU
Exercise: [((.667*75)+(.333*180))-5]/1=R R=105RU

Note: Resistance is higher in the coronary vasculature than in the entire body!

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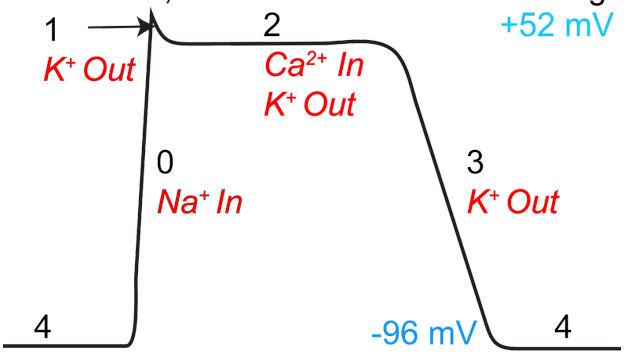
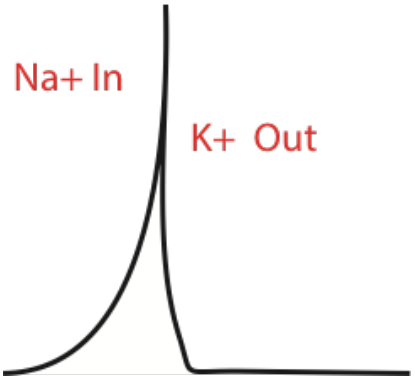
6. In the space below, draw a cardiac and skeletal muscle action potential, and indicate the approximate time scale for both action potentials. For each phase of the action potentials, indicate the ions that are entering or leaving the muscle cells, and whether the ion is moving into or out of the cells. ***(9 points)*.**



Cardiac AP; duration 200-300 msec

1 pt for each ion listed above; 1 pt for duration (6 pts total).



Muscle AP; duration 1-2 msec

1 pt for each ion listed above; 1 pt for duration (3 pts total).

7. **a)** Selective β_1-receptor antagonists such as metoprolol are prescribed much more often than α-receptor antagonists in treating hypertension, as patients taking α-receptor antagonists often experience orthostatic hypotension. Describe why orthostatic hypotension is such a common side effect in patients taking α-receptor antagonists. ***(5 points).***

Alpha-blockers reduce TPR and eliminate venoconstriction, thereby dininishing venous return to the heart. Thus, a patient taking an alpha-blocker has low blood pressure and has a sudden decrease in venous return on standing (due to lowered venoconstriction), and is likely to experience Orthostatic Intolerance.

b) α-receptor antagonists are only prescribed to hypertensive patients with another particular medical problem that can be treated with the same drug. What medical problem combined with hypertension makes a patient a good candidate for α-receptor antagonists? ***(4 points).***

Alpha blockers are used in hypertensive individuals who have difficulty in voiding, as they relax the internal urinary sphincter. This is a common problem in men with prostate hyperplasia.

8. Dopamine receptor agonists such as Parlodel are used to treat Parkinson's disease, as well as a medical problem linked to dysfunction in the anterior pituitary (over-secretion of a particular hormone). Identify the anterior pituitary hormone whose secretion is diminished by Parlodel, and briefly describe why the drug lowers secretion of the hormone. ***(4 points).***

Parlodel is used to treat hypersecretion of prolactin, since release of dopamine from the hypothalamus into the hypothalamo-pituitary portal system inhibits prolactin secretions from the anterior pituitary.

9. Dantrium is a drug used to alleviate severe muscle spasms. Dantrium is lipophilic, and can cross muscle cell membranes, where it inhibits the Ryanodine receptor in skeletal muscle. Briefly describe how a Ryanodine receptor inhibitor can alleviate muscle spasms. ***(4 points).***

The Ryanodine receptor complex is involved in releasing Ca^{2+} from the sarcoplasmic reticulum in skeletal and cardiac muscle. Inhibiting the Ryanodine receptor lowers the amount of Ca^{2+} released into the sarcoplasm following the muscle action potential, and thus lessens unwanted muscle contractions. Dantrium is an additional type of muscle relaxant. Note: Dantrium does not affect the Ryanodine receptor in cardiac muscle, which has a different structure than that in skeletal muscle.

10. Both sympathetic and parasympathetic innervation of the heart is absent in a patient with a heart transplant.

a) How does resting heart rate differ in a patient with a heart transplant from a normal individual? Provide a brief justification for your answer. ***(4 points).***

Heart rate is approximately 100 beats/min after a heart transplant, as tonic vagal activity suppressing HR to ~70 beats/min is eliminated.

b) During exercise, how do changes in cardiac output differ between a patient with a heart transplant and a normal individual? Provide a brief explanation for your answer. ***(4 points).***

Patients with a heart transplant have a similar cardiac output as normal individuals, as they can still release epinephrine from the adrenal medulla. (It is also acceptable to indicate that cardiac output would be slightly lower due to removal of sympathetic innervation of the heart; the key point is that cardiac output still increases markedly during exercise in heart transplant patients).

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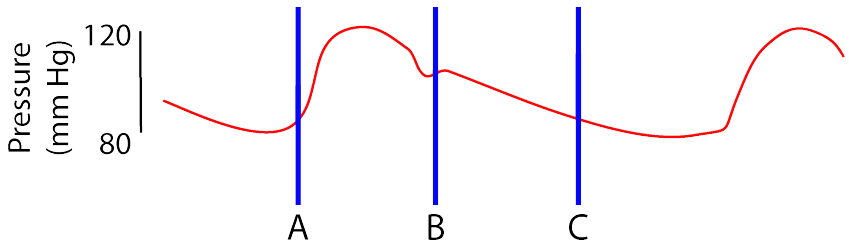
11. A standard pressure wave recorded from the aorta during the cardiac cycle is plotted below.



a) Which component of the ECG (P, QRS, T waves) occurs closest in time to the points labeled A, B, and C in the diagram? ***(6 points).***

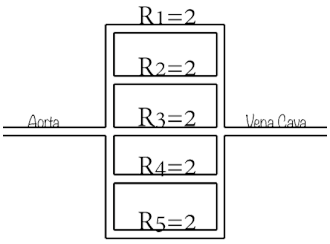
Point	ECG Component Occurring Closest in Time
A	QRS
B	T
C	P

b) At each time indicated, are the mitral and aortic valves open or shut? ***(6 points).***

Point	Mitral Valve (open or shut)	Aortic Valve (open or shut)
A	Shut	Open
B	Shut	Shut
C	Open	Shut

12. In utero, a fetus has a low blood pressure, but blood pressure increases precipitously at birth. Briefly describe the physiological mechanism responsible for the large increase in blood pressure at birth. ***(4 points).***

In utero, a large blood flow is directed to the placenta. Elimination of this large vascular bed at birth causes peripheral resistance to increase, thereby increasing blood pressure. Since resistances for vascular beds add reciprocally, the elimination of vascular beds causes resistance to increase.



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13. The dynamic properties of blood flow through the aorta are quite different from blood flow through the arterioles. The questions below compare blood flow through the aorta and arterioles. Briefly indicate how the properties of blood flow differ in arterioles and the aorta.

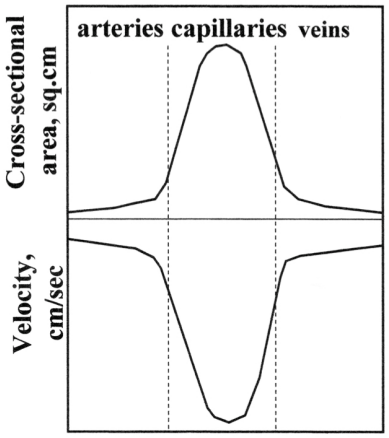
a) Is surface tension higher in the aorta or arterioles? What is the main reason? ***(3 points).***

Surface tension is higher in the aorta. T=Pr, and since the radius of the aorta is much greater than an arteriole, surface tension must be higher in the aorta. This is why the aorta needs such a thick wall.

b) Is blood flow more pulsatile in the aorta or arterioles? What is the main reason? ***(3 points).***

Blood flow is more pulsatile in the aorta. As blood moves through arteries, potential energy is absorbed during systole and imparted back as kinetic energy during diastole. As this process continues down the arteries, blood pressure and blood flow become more streamlined.

c) Is the velocity of blood flow higher in the aorta or arterioles? What is the main reason? ***(3 points).***



Velocity is higher in the aorta, due to a lower surface area.