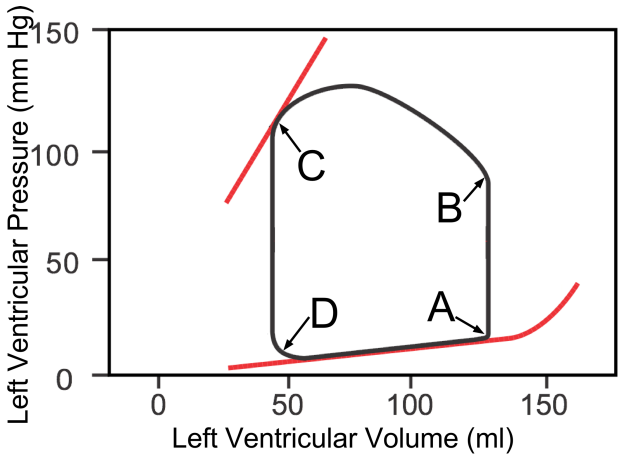
Exam KEY

BIOSC 1070, NROSCI 1070, MSNBIO 2070
Exam # 1
September 28, 2018

Total POINTS: 100 20% of grade in class

1) A standard left ventricle pressure-volume curve is illustrated to the right. At each of the four points illustrated, a valve in the left heart either opens or closes. Indicate which valve has a mechanical change, whether it opens or closes, and which wave of the electrocardiogram (P, QRS, T) occurs closest in time (either before or after) the mechanical event in the valve. ***(12 points).***



Valve	Opens or Closes?	Closest ECG Wave
Mitral (0.5 pts)	Opens **Closes** (0.5 pts)	QRS (2 pts)
Aortic (0.5 pts)	**Opens** Closes (0.5 pts)	QRS (2 pts)
Aortic (0.5 pts)	Opens **Closes** (0.5 pts)	T (2 pts)
Mitral (0.5 pts)	**Opens** Closes (0.5 pts)	T (2 pts)

2) The individual whose data are shown above has a heart rate of 70 beats/min. What is their cardiac output? You must show your calculations. **(2 points).**

Stroke volume = 135 – 50 = 85 ml *(note: some variance in numbers due to graph reading is acceptable)*

Cardiac output = 70 beats/min * 85 ml/beat = 5.95 L/min

3) What is the ejection fraction of this individual? You must show your calculations. Also indicate if their ejection fraction is normal, high, or low. **(3 points).**

Ejection Fraction =SV/EDV
Ejection Fraction = 85/135 = 0.63 (or 63%)

This value is near normal: 67%.

4) Peripherally-acting α_1 and α_2 receptor agonists (don't cross the blood brain barrier) have different effects on blood pressure. Briefly describe the effects of the two drugs (when administered intravenously) on blood pressure, and why they have different effects. ***(6 points).***

α_1 agonists raise blood pressure by binding to receptors on vascular smooth muscle and producing vasoconstriction. (3 points).

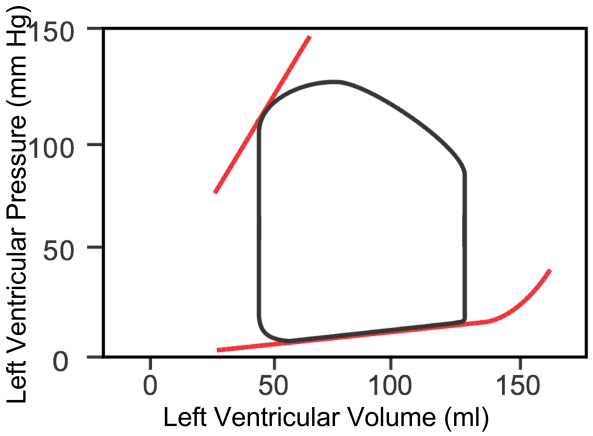
α_2 agonists lower blood pressure by binding to receptors on presynaptic sympathetic terminals, thereby reducing norepinephrine release. (3 points).

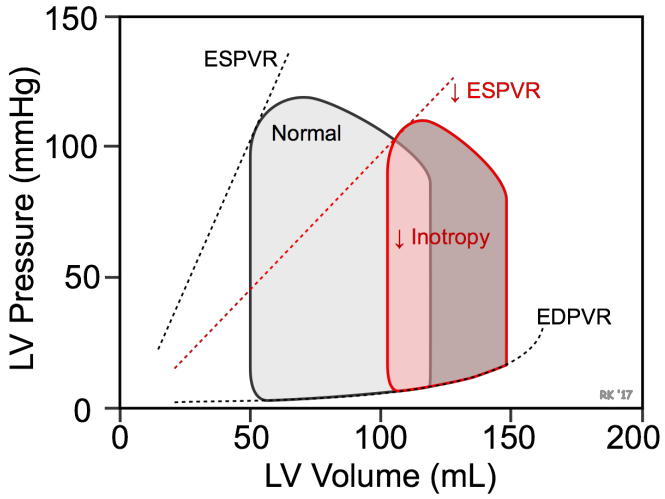
5) Indicate three additional physiological effects other than cardiovascular responses that would be produced by intravenous administration of a peripherally-acting α_1 receptor agonist. ***(6 points).***

Any three of the following (2 points each):

→ Pupillary dilation
→ Decreased bronchial secretion
→ GI sphincter contraction (poor motility)
→ Urinary bladder sphincter contraction (inability to void)
→ Sweating on the palms and feet

6) A standard left ventricle pressure-volume curve is illustrated below. On the diagram, indicate the changes that occur in the curve for a patient prescribed a β_1 receptor antagonist (beta-blocker). Assume that the drug doesn't produce any compensatory (reflex) changes in the cardiovascular system. You may also provide a written description of the effects of the drug if it is helpful. ***(15 points).***





Key points (5 points each):

1) ESPVR is less steep (slope is less)
2) Curve shifts to the right, as there is more filling time with reduced heart rate.
3) Stroke volume (width of the curve) is reduced due to diminished contractility, such that end systolic volume is larger.

   It is also acceptable to indicate that the curve is shifted downwards due to reduced afterload.

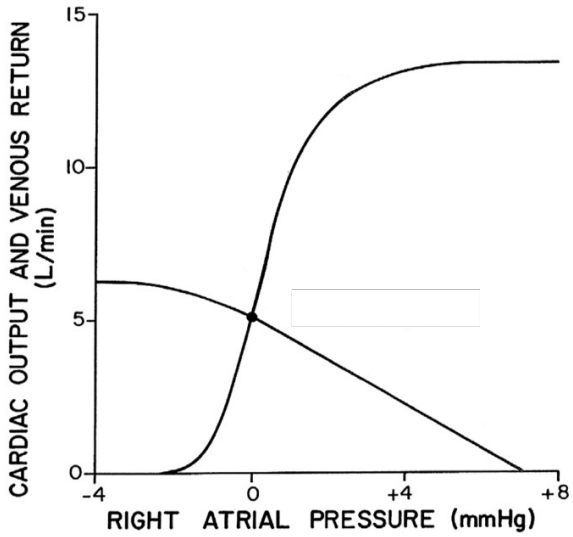
7) Both norepinephrine and epinephrine are commonly used drugs in the emergency room. However, the two drugs don't produce equivalent changes in total peripheral resistance (TPR). Indicate which drug induces the largest changes in TPR, whether TPR increases or decreases, and two reasons (mechanisms) why the two drugs have differing effects on TPR. ***(9 points).***

Norepinephrine (2 points) produces a much larger increase in TPR (1 point) for two reasons:

Norepinephrine binds more effectively to α_1 receptors on vascular smooth muscle, which causes strong vasoconstriction. (3 points).

Epinephrine binds to β_2 receptors in some vascular beds, which promotes vasodilation. (3 points).

8) Using data obtained from the curves to the right, determine resistance to vascular return (RVR). You MUST show your calculations. **(6 points).**



Cardiac Output (CO)= 5L/min
P_{sf} = 7mmHg
Right atrial pressure (RAP)= 0 mmHg

$$RVR = \frac{\text{Psf - RAP}}{CO}$$

$$RVR = \frac{7-0}{5}$$

RVR =1.4 mmHg * min/L

9) The drug Cabergoline was developed to inhibit breast milk production in women who choose not to breastfeed. The drug has also been used to treat a number of neurological disorders, including Parkinson's disease. Describe the mechanism through which Cabergoline acts to suppress lactation. ***(8 points).***

Cabergoline is a dopamine receptor agonist. Dopamine transferred to the anterior pituitary from the hypothalamus through the hypothalmo-pituitary portal system inhibits prolaction secretion. Cabergoline is sometimes used with other drugs like levodopa to treat advanced Parkinson's disease.

10) Would you expect cardiac myocytes to more closely resemble type FF or type S skeletal muscle fibers? Provide a brief explanation for your answer. ***(6 points).***

Type S muscle fibers. (3 points). Type FF fibers contract powerfully, but fatigue rapidly. The heart must never fatigue or death would occur! (3 points).

11) The inside of a neuron has a charge that is about 70 mV more negative than the outside. List three factors contributing to the negative intracellular charge of neurons, and indicate which of these factors has the strongest effect. ***(10 points).***

- The sodium-potassium pump removes three intracellular Na+ ions for every two K+ ions it lets in. (3 points).
- Proteins that carry a negative charge are in high concentration inside a cell, and in low concentration outside. (3 points).
- Neuronal membranes tend to be leakier for K+ than for Na+. This causes a net loss of K+ cations from the inside of the neuron, making it more negative. (3 points). **This is the major factor**. (1 point).

12) Is a drug available that acts on a single type of receptor and suppresses both parasympathetic and sympathetic nervous system activity without paralyzing skeletal muscle? If so, describe the actions of the drug. If not, discuss why it would be impossible to generate a drug with these properties. ***(6 points).***

Hexamethonium is a drug with these properties (no need to indicate the drug name). Hexamethonium blocks the subtype of nicotinic receptors in sympathetic and parasympathetic ganglia (on the surface of postganglionic neurons), but not the subtype at the neuromuscular junction.

13) A patient presents for an exercise stress test. The baseline hemodynamic profile provides 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 cc/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

Determine the change in coronary vascular resistance that occurs during exercise, specifying the percent change in resistance. You must show your calculations. ***(5 points).***

$$R = \frac{\Delta P}{Q}$$

Normal:
MAP = (0.67*75) + (0.33*135) = 95mmHg
ΔP =95 – 5 = 90 mmHg
R=90 mmHg / 0.25 L/min = 360 RU

Exercise:
MAP = (0.67*75)+(0.33*180) =109 mmHg
ΔP =109 – 5 = 104 mmHg
R=104 RU

Percent change = (Exercise – Normal) / Normal *100
= (104-360)/360 = 71% decrease in coronary vascular resistance

14) Elderly individuals more commonly experience orthostatic hypotension, or a drop in blood pressure, than younger individuals. What is the main factor contributing to a predisposition for orthostatic hypotension in the elderly? ***(6 points).***

The main reason is that venous compliance increases with aging, such that there is less venous return to the heart on standing and thus a drop in blood pressure.