Exam KEY

NROSCI/BIOSC 1070 and MSNBIO 2070
Exam # 2
October 25, 2019

1) The following questions relate to drugs commonly used in cardiology. Circle the drug that best fits the characteristics indicated. ***(2 points each; 10 points total)***

a. Phenylephrine: an α_1 receptor agonist
b. Prazosin: an α_1 receptor antagonist
c. Metoprolol: a β_1 receptor antagonist
d. Phenoxbenzamine: an α_1 + α_2 receptor antagonist
e. Clonidine: an α_2 agonist that affects the central nervous system
f. Propranolol: a combined β_1 + β_2 antagonist

a) Which of the following drugs produces the greatest **positive** chronotropic effect?

Phenylephrine Clonidine Prazosin

b) Which of the following drugs produces the greatest **increase** in total peripheral resistance?

Propranolol Clonidine Metoprolol

c) Which of the following drugs produces the greatest **positive** inotropic effect?

Prazosin Clonidine Phenoxbenzamine

d) Which of the following drugs induces the largest **increase** in activity of RVLM neurons?

Phenylephrine Clonidine Phenoxbenzamine

e) Which of the following drugs produces the greatest **increase** in activity of NTS neurons?

Phenylephrine Clonidine Metoprolol

2) A research subject is taking L-NAME, a nitric oxide synthase inhibitor. The subject subsequently exercises on a stationary bicycle. Will blood flow to his leg muscles be different from that which typically occurs during exercise? If so, how are the responses different and what is the physiologic mechanism? ***(5 points).***

Sheer stress along vessels and other nitric oxide-mediated mechanisms will not cause dilation of skeletal muscle arterioles. As a consequence, muscle blood flow will decrease.

3) A patient taking an ACE-inhibitor to treat hypertension presents to the Emergency Department with muscle weakness and paralysis and severe ECG abnormalities. Discuss the physiologic changes induced by the ACE inhibitor that resulted in these medical signs and symptoms. ***(5 points).***

The ACE inhibitor has produced hyperkalemia (3 points) as aldosterone secretion is impaired (2 points), such that clearing K+ from the plasma is limited

4) A patient with cerebral edema is infused with **hypertonic** saline. At 45 minutes after the start of infusion (when blood osmolarity is higher than normal), how will the following physiologic parameters have changed from those prior to infusion? ***(2 points each; 10 points total).***

a) Hematocrit

Higher Same Lower

Plasma expansion occurs, which decreases hematocrit (red blood cells in larger volume)

b) Flow of fluid from the interstitial space into lymph capillaries

Higher Same Lower

Less fluid in interstitial space, so less interstitial pressure

c) Cell size

Cells Expand Same Cells Shrink

Fluid leaves cells, so they shrink

d) Firing rate of RVLM neurons

Higher Same Lower

Fluid expansion causes BP to rise

e) Firing rate of arterial baroreceptor afferents

Higher Same Lower

Fluid expansion causes BP to rise

5) During exercise, a number of physiological parameters change. Indicate the change in each of the following physiological parameters in an individual after 25 minutes of maximal exercise on a stationary bicycle. Assume that the individual is drinking water to account for fluid loss by sweating. ***(2 points each; 10 points total).***

a) Angiotensin-II Levels

Higher Same Lower

Modest increase due to afferent arteriole constriction in kidney

b) Diastolic Blood Pressure

Higher Same or Slightly Lower Over 50% Lower

c) Atrial Natriuretic Peptide Levels

Higher Same Lower

Due to increased venous return to heart

d) Sensitivity (Responsiveness) of NTS Neurons to Baroreceptor Inputs

Higher Same Lower

e) Right Atrial Pressure (Central Venous Pressure) Just Prior to Tricuspid Valve Opening

Higher Same Lower

Due to higher venous return to the heart

6) A patient presents to the Emergency Department with dyspnea (shortness of breath). To diagnose the patient's condition, the attending physician orders a blood test for B-type (brain) natriuretic peptide. B-type natriuretic peptide levels are elevated, and a subsequent echocardiogram is ordered, which reveals aortic valve stenosis.

Discuss why: 1) B-type natriuretic peptide levels are elevated in the patient and 2) aortic valve stenosis resulted in dyspnea in the patient. ***(10 points).***

B-type natriuretic peptide is a hormone secreted by the heart ventricles in response to stretching caused by increased ventricular blood volume (2 points). Heart ventricles are only stretched if they become dysfunctional and end diastolic volume increases. In other words, elevated B-type natriuretic peptide signals ventricular failure (3 points).

The ventricular failure in this case is due to aortic valve stenosis, which resulted in congestive heart failure (2 points). Since the left ventricle is pumping out less blood than the right ventricle, blood accumulates in the pulmonary circulation, the pressure in pulmonary capillaries increases, and fluid builds up in the interstitial space in the lungs negatively affecting gas exchange. (3 points).

7) Samples of filtrate are obtained from Bowman's capsule and the end of the thick ascending limb of the loop of Henle in a normal healthy individual. Compare the concentration of the following substances in the two samples (end of thick limb of loop of Henle compared to Bowman's capsule). ***(2 points each; 10 points total).***

Substance	**Relative Concentration at the End of Loop of Henle**		
Creatinine	Higher	Lower	Same
Na^+	Higher	Lower	Same
Glucose	Higher	Lower	Same
Tyrosine (Amino Acid)	Higher	Lower	Same
Urea	Higher	Lower	Same

8) The table below indicates the major segments of the nephron. For each segment, indicate the major Na^+ transporter on the apical membrane (if any is present) and the approximate amount of sodium reabsorption that occurs. ***(12 points).***

Segment	**Na^+ Transporter on Apical Membrane** (if no Na^+ reabsorption occurs, indicate "NONE")	**% of Filtered Na^+ Reabsorbed in Segment**
Proximal Convoluted Tubule	Na+ - Glucose co-transporter (SGLT) Na+-H+ antiporter is also OK	~65% (50-75% OK, key is that over half is reabsorbed, but not all)
Thin Descending Limb of Loop of Henle	NONE (Na+ moves out in small amounts but this is passive)	Small (anywhere from 0-10% is acceptable)
Thin Ascending Limb of Loop of Henle	NONE (Na+ moves out in small amounts but this is passive)	Small (anywhere from 0-10% is acceptable)
Thick Ascending Limb of Loop of Henle	Na+/K+/Cl− co-transporter	~25% (20-35% OK)
Distal Convoluted Tubule	Sodium-Chloride Co-Transporter	~5% (5-15% acceptable)
Collecting Duct	ENACs	~3% (0-10% acceptable)

9) Measurements of creatinine in blood and urine are used to estimate glomerular filtration rate (GFR), whereas measurements of PAH (para-aminohippurate) are used to estimate renal blood flow.

a) Describe the characteristics of creatinine that make it ideal for estimating GFR. ***(5 points).***

Creatinine is freely filtered (2 points) but is not appreciably secreted or reabsorbed (3 points).

b) Describe the characteristics of PAH that make it ideal for estimating renal plasma flow. ***(5 points).***

PAH is freely filtered (1 point), is not reabsorbed (2 points), and is secreted within the nephron (2 points) so it is completely removed from the blood in one pass through the kidney.

c) Using these methodologies and others, a nephrology clinic determines the following physiologic parameters for a patient:

Renal blood flow=1000 ml/min
Hematocrit=40%
GFR=120 ml/min
Urine flow=1 ml/min
Cardiac output=5000 ml/min
Systolic blood pressure=120 mm Hg
Diastolic blood pressure=80 mm Hg

Calculate the patient's filtration fraction. You must show your calculations. (***5 points).***

FF = GFR/RPF

RPF=0.6 X1000=600 ml/min (Determining plasma volume from hematocrit)

FF=120/600 = 20%

d) Is the patient's filtration fraction normal, higher than normal, or lower than normal? ***(3 points).***

Normal High Low

10) The liver generates urea from NH_4^+, the primary nitrogenous end product of amino-acid catabolism. The kidney freely filters urea at the glomerulus, and then it both reabsorbs and secretes it.

a) What is the physiological reason for this complex handling of urea by the kidney? ***(5 points).***

The main purpose is that it allows urea to build-up in the deep parts of the renal medulla. This high extracellular solute in the renal medulla (urea + sodium) is a large driving force for the reabsorption of water.

b) Does urea concentration in the filtrate increase, decrease, or remain constant from the beginning to end of the proximal convoluted tubule? What is the physiologic mechanism responsible for the change in urea concentration along the proximal convoluted tubule? ***(5 points).***

It increases because water is leaving, so the remaining urea is diluted less.