Exam KEY

NROSCI/BIOSC 1070 and MSNBIO 2070
Exam # 2
October 23, 2015

Total POINTS: 100 20% of grade in class

1) Arterial and venous blood samples are taken, and other physiological measures are obtained, from a normal individual at rest and while exercising maximally **on a stationary bicycle**. In the table below, indicate whether each value is higher, lower, or relatively the same during exercise compared to the resting state. ***(5 points).***

Parameter	Value During Exercise (relative to resting)
Arterial O_2 Content	Higher **Same** Lower Arterial O2 saturation is near 100% at both rest and during exercise.
Venous O_2 Content (in leg vein)	Higher Same **Lower** Lower as more O2 detaches from hemoglobin in exercising muscle.
Arterial pCO_2	Higher **Same** Lower Although more CO2 is produced during exercise, this is "blown off" in the lungs. Arterial CO2 is the same during rest and exercise.
Venous pCO_2 (in leg vein)	**Higher** Same Lower The additional CO2 produced by metabolism in exercising leg muscles will be present in the venous blood in the legs.
Blood Flow to Arm Muscles	Higher Same **Lower** Since the arms are not utilized during the exercise, metabolism will be similar to that at rest. However, high sympathetic nerve activity will cause a vasoconstriction of arterioles in arm muscles. Thus, blood flow to the arm muscles will be lower than at rest.

2) During exercise, oxygen delivery to working muscle increases. List 4 distinct physiological mechanisms that operate in tandem to increase oxygen delivery to exercising muscle. ***(16 points).***

- Lower pO2 in the interstitial space around the muscle (due to oxygen uptake by the muscle) facilitates unloading of O2 from hemoglobin
- More blood flow per unit time (if more hemoglobin molecules pass through the muscle arterioles, then more oxygen will be unloaded to the muscle)
- Acidification of blood in muscle capillaries facilitates unloading of O2 from hemoglobin
- Higher temperature in muscle capillaries facilitates unloading of O2 from hemoglobin.

Also acceptable:

- Opening of additional capillaries in working muscle through relaxation of precapillary sphincters increases surface area for diffusion of O2 to muscle

3) A patient with serious coronary artery disease also suffers from high blood pressure. A physician prescribes an alpha-receptor antagonist to lower the patient's afterload. However, the patient complains that taking the alpha-receptor antagonist results in chest pain. Briefly describe the physiological mechanism that explains the patient's chest pain after taking an alpha-receptor antagonist. ***(6 points).***

When blood pressure is lowered through vasodilation (actions of alpha receptor antagonist), the baroreceptor reflex causes activation of the sympathetic nervous system. As a result, heart rate and contractility increase, such that the oxygen demands of the heart are increased. The patient with coronary artery disease cannot sustain this increased coronary blood flow, and thus metabolites will accumulate in the heart. Consequently, the patient has angina.

4) Investigators often use animal models to find cures for human diseases. A commonly-used animal model of hypertension is the "one-clip" hypertension model, which is produced by placing a clip on one renal artery, thereby decreasing blood flow to one kidney (called the "Goldblatt hypertension model," after the scientist who first described the method). Shortly after placing the renal artery clamp, blood pressure increases significantly. Discuss the major physiological mechanism responsible for the short-term blood pressure elevation in the Goldblatt hypertension model. ***(6 points***).

Clipping of a renal artery results in increased secretion of renin by the kidney, and thus angiotensin 2 levels increase in the blood. Higher angiotensin 2 levels result in more fluid and salt retention and other physiological changes that increase blood pressure.

5) L-NAME is an inhibitor of the enzyme nitric oxide synthase.

a) Would providing L-NAME to a patient cause their mean blood pressure to change? Briefly discuss the rationale for your response. ***(5 points).***

Yes. There will be a generalized increase in vascular resistance, resulting in an increase in blood pressure.

b) Would providing L-NAME to a patient cause their pulse pressure to change? Briefly discuss the rationale for your response. ***(5 points).***

Yes. The large arteries will become stiffer, such that less energy is absorbed by the vessels during systole. As a result, systolic BP is higher and diastolic BP is lower.

6) Alirocumab (trade name Praluent) is a biopharmaceutical drug approved by the FDA on July 24, 2015 as a treatment for high cholesterol in adults whose cholesterol is not controlled by diet and statin treatment. Briefly describe the mechanism through which Alirocumab acts to radically lower blood cholesterol levels. ***(7 points).***

Alirocumab is a monoclonal antibody that inactivates the signaling protein that mediates the downregulation of LDL receptors.

7) Pregnant women are advised to avoid talking common pain relievers such as aspirin; such drugs act by inhibiting the synthesis of prostaglandins. Continuing use of aspirin during the third trimester can cause pulmonary hypertension in the fetus, resulting in serious medical problems. Briefly describe why taking aspirin can result in fetal pulmonary hypertension. ***(6 points).***

Prostaglandins from the placenta play a key role in maintaining the patency of ductus arteriosus. Aspirin inhibits the formation of prostaglandins, so ductus arteriosus can collapse. Since the pulmonary vasculature has an extremely high resistance in the infant (as there is no O2 in the alveoli), the collapse in ductus arteriosus causes blood pressure in the pulmonary circulation to rise precipitously (in essence, ductus arteriosus is the major vessel that blood ejected from the right ventricle can circulate through).

Collapse of ductus arteriosus in the fetus typically results in serious cardiovascular problems, and often results in fetal death.

8) Buminate is a preparation of albumin that can be injected intravenously. What effect, if any, would intravenous Buminate administration have on lymph fluid flow? Provide a brief explanation for your answer. ***(5 points).***

Injection of Buminate causes fluid to leave the interstitial space, lowering interstitial pressure. As a result, lymph fluid flow decreases.

9) Hemophiliacs have malformed clotting Factor VIII. Does a lack of functional Factor VIII pose a more or less serious medical problem then a lack of functional Prothrombin? Provide a brief explanation for your answer. ***(6 points).***

Factor VIII is a component of the intrinsic pathway, and loss of Factor VIII blocks the intrinsic pathway. However, it is also possible to generate thrombin through the extrinsic pathway, although generating enough thrombin to form a clot is delayed. Thus, hemophiliacs experience substantial blood loss following injuries. In contrast, loss of prothrombin prevents clots from ever forming, so an injury will never stop bleeding. This is a worse medical problem.

Exam KEY

10) The chart below shows pH, pCO_2 and HCO_3^- levels measured from an arterial blood sample. For each example, indicate whether 1) acidosis or alkalosis is present, 2) whether the cause is metabolic or respiratory and 3) whether the condition is compensated or uncompensated. Circle the correct choices. ***(9 points).***

pH: 7.43	pCO_2: 55 mmHg	HCO_3^-: 35 mEq/L
Acidosis Alkalosis	Respiratory Metabolic	Compensated Uncompensated

Although pH is near normal, pCO_2 and $HCO3^-$ are both high. The patient likely has compensated respiratory acidosis. Another possibility (also acceptable) is that the patient has metabolic alkalosis that is compensated via respiration.

pH: 7.25	pCO_2: 45 mmHg	HCO_3^-: 19 mEq/L
Acidosis Alkalosis	Respiratory Metabolic	Compensated Uncompensated

pH is acidotic; the low $HCO3^-$ indicates the cause is metabolic. pCO_2 is near normal, and thus no compensation has occurred.

pH: 7.64	pCO_2: 25 mmHg	HCO_3^-: 24 mEq/L
Acidosis Alkalosis	Respiratory Metabolic	Compensated Uncompensated

pH is alkaline and pCO_2 is low, but $HCO3^-$ is normal. Thus the patient must have uncompensated respiratory alkalosis.

11) The following physiological parameters are determined for a patient:
Oxygen consumption: 250 ml O_2/min
Arterial oxygen content (CaO_2): 0.2 ml O_2/ml blood
Venous oxygen content (CvO_2): 0.15 ml O_2/ml blood

Based on these parameters, calculate the patient's cardiac output. You must show your calculation. ***(6 points).***

$CO = VO2/(CaO2 - CvO2)$
$CO= 250 ml/min / (0.2-0.15)$
$CO=250/0.05=5000 ml/min$

12) Which of the major respiratory "pump" muscles (diaphragm, intercostals, abdominals) would be paralyzed following a T2 spinal transection, and which would not be? Circle the correct answers. ***(6 points).***

Diaphragm:	Paralyzed	Unparalyzed
Intercostals:	Paralyzed	Unparalyzed
Abdominals:	Paralyzed	Unparalyzed

13) During surgery to remove a tumor from the throat, an unfortunate patient's larynx is denervated (the nerves to the larynx are cut). Which lung volume would be most profoundly altered following the laryngeal denervation? Provide a brief explanation. ***(6 points).***

Following denervation of the larynx, the vocal cords are no longer retracted during inspiration. This adds inspiratory resistance, so the inspiratory reserve volume is reduced.

Exam Key

14) An arterial blood sample for a patient at sea level is obtained, and the following physiological values are measured:

pCO_2: 55 mmHg
HCO_3^-: 33 mEq/L

What is the patient's arterial pH? You must show your calculations. ***(6 points).***

$pH=6.1+Log([HCO3^-]/0.03*P_{CO2})$
$pH=6.1+Log(33/(0.03*55))$
$pH=7.4$