Exam Key

NROSCI/BIOSC 1070 and MSNBIO 2070
Exam # 1
October 27, 2017

Total POINTS: 100 20% of grade in class

1) An individual with untreated emphysema and COPD reports to the hospital emergency department.

a) The patient was found to have a normal arterial blood oxygen content. Briefly describe the physiological mechanism accounting for this, despite the fact that the patient has severe pulmonary disease. ***(4 points).***

The patient produced more red blood cells (polycythemia) so the same amount of oxygen could be carried in the blood despite the fact that Hb was not totally saturated with O2 *(3 points).* This resulted from release on erythropoietin from the kidney *(1 point)*.

b) Would intravenous injection of bicarbonate likely improve the patient's condition or make it worse? Provide a brief explanation for your answer. ***(4 points).***

Bicarbonate would improve the patient's condition *(3 points)*, as they have respiratory acidosis. Bicarbonate infusion helps to normalize blood pH in any patient with acidosis, as mass action causes the following equation to shift to the left, lowering plasma H^+ *(1 point)*:

$$CO_2 + H_2O \leftarrow \rightarrow H_2CO_3 \leftarrow \rightarrow H^+ + HCO_3^-$$

c) If the patient does not receive treatment, would they likely develop heart failure? Provide a brief explanation for your answer. ***(4 points).***

Yes *(2 points)*. Hypoxia would cause the pulmonary arterioles to constrict, increasing pulmonary resistance *(1 point)*. As a result, output from the right heart would lag the left heart *(1 point)*.

d) How would vital capacity differ in this patient from a normal individual? Provide a brief explanation for your answer. ***(2 points).***

Yes *(1 point)*, as emphysema results in alveolar destruction *(1 point)*, and thus less total lung volume.

e) How would inspiratory reserve volume differ in this patient from a normal individual? Provide a brief explanation for your answer. ***(2 points).***

Inspiratory reserve volume tends to decrease in patients with emphysema *(1 point)*, due to a loss of alveoli *(1 point)*.

f) How would expiratory reserve volume differ in this patient from a normal individual? Provide a brief explanation for your answer. ***(2 points).***

Expiratory reserve volume tends to increase in patients with emphysema *(1 point)*, due to a decrease in lung elasticity resulting in larger residual volumes at the end of expiration *(1 point)*.

It would also be acceptable to argue that due to a loss of alveoli, expiratory reserve volume would decrease or stay constant. However, this line of argument would need to clearly articulate that there is a tendency for expiratory reserve volume to increase, which is offset by a decrease in total lung volume.

g) How would transpulmonary pressure differ in this patient from a normal individual? Provide a brief explanation for your answer. ***(2 points).***

Transpulmonary pressure would decrease *(1 point)* due to a loss of lung elasticity *(1 point)*.

h) How would the firing rate of peripheral chemoreceptor afferents differ in this patient from a normal individual? Provide a brief explanation for your answer. ***(2 points).***

Firing of peripheral chemoreceptor afferents would increase *(1 point)*, due to decreased plasma pO_2 and pH and increased pCO_2 *(1 point)*. Grading note: mentioning any of these stimulants for peripheral chemoreceptor activity is OK.

i) What are the <u>two</u> most likely treatments that would be provided to the patient in the emergency room to stabilize their condition? Provide a brief explanation for your answer. ***(4 points).***

The two most likely treatments are oxygen *(2 points)* and beta-2 agonist (albuterol)*(2 points)*. Oxygen would directly increase alveolar (and plasma) pO_2, while albuterol would dilate the airways, indirectly causing an increase in alveolar pO_2 .

It would also be acceptable to mention an inhaled cholinergic antagonist (Spiriva) as a treatment, to replace one of the primary answers.

2) During a routine medical examination, a quadriplegic patient is found to have high blood pressure. Would it be prudent for the physician treating the patient to prescribe an ACE inhibitor to take when they get home? Provide a brief explanation for your answer. **(5 points).**

No *(2 points)*. Blood pressure in high spinal patients is maintained by the renin-angiotensin system. Giving an ACE inhibitor would cause blood pressure to be constantly low *(3 points)*.

3) An army medic is treating a solider on the battlefield who is believed to have high intracranial pressure following a head injury. As treatment options, the medic can provide the soldier intravenous hypertonic saline, hypotonic saline, or isotonic saline. Which of these solutions would be most helpful for treating the wounded soldier? Provide a brief explanation for your answer. **(5 points).**

Hypertonic saline *(3 points)* would pull water from the interstitial space and brain cells, reducing intracranial pressure *(2 points).*

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4) A neuroscientist is conducting an experiment on an anesthetized and artificially ventilated animal. The GABA receptor agonist muscimol is injected into the animal's CVLM to inhibit the activity of neurons located there. Indicate the effect, if any, of inhibition of CVLM neurons on the following physiological parameters. Provide a brief explanation of your answer.

a) Blood pressure. ***(4 points).***

Blood pressure would increase *(2 points).* The CVLM inhibits the RVLM, and removing this inhibition results in a higher firing rate of RVLM neurons, higher sympathetic efferent activity, and thus higher blood pressure *(2 points).*

b) Activity of vagal efferent fibers that innervate the SA node. ***(4 points).***

Activity of vagal efferent fibers that innervate the SA node would increase *(2 points).* Higher blood pressure would cause more baroreceptor afferent fiber activity, which stimulates NTS neurons and parasympathetic preganglionic fibers that innervate the heart *(2 points).*

c) Plasma levels of angiotensin-2. ***(4 points).***

Angiotensin-2 levels would tend to increase (2 points), because of high renal sympathetic nerve activity (2 points).

However, full points if someone argues that high sympathetic nerve activity and higher blood pressure have offsetting effects on JG cells.

2 points if someone argues that high pressure tends to lower angiotensin-2. (High sympathetic nerve activity is a primary stimulant).

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5) Mast cells, a type of white blood cell, release histamine when activated by allergens. If a large number of mast cells are activated, blood pressure drops considerably and the patient experiences shock. Histamine produces several physiological effects that cause additional filtration from capillaries, and thus a loss of plasma volume. Describe two distinct actions of histamine that serve to increase capillary filtration. ***(6 points).***

Histamine would dilate arterioles, resulting in higher hydrostatic pressure in capillaries *(3 points).*

Histamine would increase the spaces between endothelial cells, increasing K_f *(3 points)*.

6) Nesiritide (Natrecor) is a synthetic form of B-type natriuretic peptide. Nesiritide has been used to treat patients with congestive heart failure. Describe two actions of Nesiritide that would be beneficial for patients with heart failure. ***(6 points).***

Any two of these would be satisfactory:

Decreased fluid volume or natriuresis
Decreased activation of renin-angiotensin system
Venodilation (dilation of veins)
Vasodilation (arteriole dilation)

7) Coumadin (warfarin) is a commonly prescribed drug that reduces the risk of heart attacks. Discuss the actions of warfarin, and why these actions reduce the risk of heart attacks. ***(8 points).***

Warfarin affects vitamin K metabolism *(3 points)* and thus inhibits the formation of blood clots *(2 points)*. Blood clots can form in the uneven edges of atherosclerotic coronary arteries, break free and clog smaller arteries downstream *(3 points)*. Anticoagulants prevent this from happening.

8) The following blood gases are determined for a patient: pH 7.46, pCO_2 32 mm Hg, HCO_3^- 23 mEq/L.

a) Is the alkalosis respiratory or metabolic in origin? ***(2 points)***

Respiratory

b) Is the alkalosis partially compensated or uncompensated? ***(2 points)***

Uncompensated

9) The following blood gases are determined for a patient: pH 7.31, pCO_2 50 mm Hg, HCO_3^- 22 mEq/L.

a) Is the acidosis respiratory or metabolic in origin? ***(2 points)***

Respiratory

b) Is the acidosis partially compensated or uncompensated? ***(2 points)***

Uncompensated

10) The following blood gases are determined for a patient: pH 7.30, pCO_2 46 mm Hg, HCO_3^- 16 mEq/L.

a) Is the acidosis respiratory or metabolic in origin? ***(2 points)***

Metabolic

b) Is the acidosis partially compensated or uncompensated? ***(2 points)***

Uncompensated

11) An astronaut has been living on the International Space Station for 2 months. Indicate how the following physiological parameters differ from those prior to the astronaut leaving Earth. ***(2 points each; 4 points total)***

a) Atrial natriuretic factor

Higher *Lower* *Same*

b) Aldosterone

Higher *Lower* *Same*

12) A person is exercising vigorously in hot weather. How does oxygen delivery to the following organs change during exercise? ***(2 points each; 6 points total)***

a) Brain

Higher *Lower* *Same*

b) Heart

Higher *Lower* *Same*

c) Skin

Higher *Lower* *Same*

13) Oxygen delivery is greatly enhanced to working muscle during exercise. In one sentence each, discuss five factors that contribute to increasing oxygen delivery to working muscle. ***(2 points each; 10 points total)***

Any combination of the following merits full points:

Higher blood flow to muscle (more Hb passing through per unit time) OR dilation of muscle arterioles (either answer is OK, both count as only one factor). Higher cardiac output is also acceptable, in the context of higher blood flow to muscle

Sheer stress leading to dilation of muscle arterioles.

Recovery of nitric oxide by binding to open Hb binding sites

Bohr effect (pH effect on Hb)

Temperature effect on Hb

Decreased affinity of Hb for O2 as it passes through muscle capillaries (in lieu of mentioning Bohr and temperature effects on Hb; this is redundant with those answers).

Decreased pO2 in muscle interstitial space and muscle cells.

Opening of muscle capillaries and more surface area for diffusion of O2 into muscle

NOTE: increased affinity of Hb for O2 and increased saturation of Hb with O2 in the lungs are wrong answers. Neither of these happen.