Study Questions for Control of Respiration

1. Name the single most important blood gas value determining the level of central chemoreceptor stimulation? Peripheral chemoreceptor stimulation?

2. A lightly anesthetized patient is removed from a ventilator after surgery and the patient fails to breath for one minute. Offer a possible explanation for this observation.


4. What is the Hering-Breuer reflex, what is its physiological role, and what receptors are involved?

5. True or False. An increase in CSF [H+] will suppress ventilatory drive.

6. What is meant by the term apneuses? Experimental brainstem section in what 2 places would combine to produce it? Input from what respiratory centers or pulmonary receptors is being removed and what function do they normally serve?

7. How is the ventilatory response to hypercapnia altered by hypoxia?

8. Which chemoreceptors show some responsiveness to arterial oxygen content?
Answers to Control of Respiration Study Questions

1. $P_aCO_2$ is most important for central chemoreceptors. $P_aO_2$ is most important for peripheral chemoreceptors.
2. If the patient had been hyperventilated he would be hypocapneic (low $P_aCO_2$) as he came off the ventilator. The central chemoreceptors would not be stimulated.
3. Patients with COPD often retain CO$_2$ chronically. HCO$_3^-$ moves into the CSF in exchange for Cl$^-$ and decreases the CSF[H$^+$]. This removes the central chemoreceptor drive to breath. The only remaining drive is from the peripheral chemoreceptors driven by the hypoxia (low $P_aO_2$). Administering $O_2$ removes the peripheral drive and the patient stops breathing.
4. The Hering-Breuer is an inspiratory-stopping reflex mediated through the slowly adapting pulmonary stretch receptors. It is thought not to be important in human adults during normal breathing. It becomes important during exercise when tidal volume increases and during chronic obstructive pulmonary disease when patients breath at high lung volume.
5. False. Increased CSF[H$^+$] increases ventilatory drive.
6. Apneuses is a tonic inspiratory effort seen if the brainstem is sectioned at midpontine levels and the vagus is cut. Descending input from the pneumotaxic center and feedback from slowly adapting pulmonary receptors is removed by the lesion. Both are involved in inspiratory termination.
7. Hypoxia potentiates the inspiratory drive to hypercapnia.
8. Aortic body show some response to arterial $O_2$ content.

Clinical cases pulmology

A 60-year-old man comes to your office complaining of dyspnea (difficult breathing). His laboratory values were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Breathing Air</th>
<th>Breathing 100% $O_2$ for 7 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial $P_aCO_2$ (mm Hg)</td>
<td>76</td>
<td>500</td>
</tr>
<tr>
<td>Arterial $P_aO_2$ (mm Hg)</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>Arterial $Hb$ (g/100 mL)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Arterial $O_2$ Sat (%)</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>Arterial $pH$</td>
<td>7.35</td>
<td>7.20</td>
</tr>
</tbody>
</table>

1. Which of the following diagnoses best explains the laboratory test findings?
A. A patent ductus arteriosus
B. A patent foramen ovale
C. Complete obstruction of the right bronchus  
D. Thickened alveolus membrane impairing diffusion  
E. Pulmonary fibrosis restricting lung movement  

Figure shows the oxyhemoglobin dissociation curves for a healthy patient and for an anemic patient.

![Figure 3–13. Oxyhemoglobin dissociation curves.](image)

2. Which of the following statements concerning these patients is true? 
A. Patient A is anemic. 
B. Arterial $P_{O_2}$ is likely to be similar for both subjects. 
C. Venous $P_{O_2}$ of the anemic subject will be greater than that of the normal subject at rest or during exercise. 
D. If cardiac output is identical, then oxygen delivery will be identical in subjects A and B. 

A 25-year-old, 70-kg man broke several ribs as a result of a fall from a ladder. His treatment at a nearby hospital included stabilizing his chest with bandages. The bandages were tied in a way that reduced his tidal volume by 50%. To compensate, he doubled his respiratory rate. Two hours later, an arterial blood sample was taken.

3. Which of the following conditions would have been observed? 
A. Increased $P_{O_2}$ and decreased $P_{CO_2}$  
B. No change in $P_{O_2}$ or $P_{CO_2}$  
C. Decreased $P_{O_2}$ and increased $P_{CO_2}$  
D. Increased $P_{O_2}$ and increased $P_{CO_2}$  

A patient has an increased airway resistance to gas flow but a normal compliance.

4. In comparison to the findings in a healthy person, intrapleural pressure will be 
A. More positive during inspiration  
B. More negative during expiration  
C. Increased at functional residual capacity  
D. Normal during breath holding at total lung capacity  
E. Decreased during breath holding at total lung capacity

An individual’s total lung capacity (TLC) is 6.5 L, and her inspiratory capacity (FRC ↑ TLC) is 3.55 L. At the end of a normal expiration, her lung volume is 4.45 L.  

5. The individual’s tidal volume ($V_{T}$) is
A. 1.50 L
B. 3.00 L
C. 0.500 L
D. 0.750 L
E. 0.900 L

Following infusion of lactic acid into the blood of a healthy subject, arterial pH falls to 7.35.

6. Which of the following would be expected to occur?
A. A decrease in ventilation
B. A rise in the pH of the cerebrospinal fluid
C. A decrease in arterial $P_{O_2}$
D. A rise in arterial $P_{CO_2}$
E. A decrease in the ratio $\frac{V_A}{Q}$

7. Which of the following causes of brain hypoxia would most strongly stimulate the aortic and carotid chemoreceptors?
A. Carbon monoxide poisoning
B. Severe anemia
C. Formation of methemoglobin
D. A marked decrease in pulmonary diffusing capacity
E. Acute respiratory alkalosis

ANSWERS

1. D is correct. A thickened alveolar membrane impairs diffusion of both oxygen and carbon dioxide. A patent ductus arteriosus (choice A) would not depress arterial $P_{O_2}$. A patent foramen ovale (choice B) would cause arterial $P_{CO_2}$ to be elevated. Complete obstruction of the right bronchus (choice C) would result in blood being shunted away from the right lung to the left lung in order to preserve a more normal $P_{O_2}$. Pulmonary fibrosis (choice E) would not negatively influence diffusion of $O_2$ and $CO_2$.

2. B is correct. Arterial $P_{O_2}$ would be similar for both because the $P_{O_2}$ is indicative of dissolved plasma oxygen, not oxygen combined with hemoglobin. Choice A is incorrect because the $O_2$ in the blood is decreased in patient B, not patient A. Choice C is incorrect because $P_{O_2}$ is indicative of dissolved oxygen, which should be the same in both individuals at rest or during exercise. Choice D is incorrect because oxygen delivery to the tissues depends on both oxygen bound to hemoglobin and dissolved oxygen. In the anemic individual, less oxygen is delivered because less hemoglobin is bound to oxygen.

3. C is correct. A reduction in alveolar ventilation (inspired air available for exchange) would decrease $P_{O_2}$ and increase $P_{CO_2}$. Choices A and B are incorrect because arterial blood samples would show a decrease in $O_2$ and an increase in $CO_2$. Choice D is incorrect because there would be no increase in oxygen with a reduction in alveolar ventilation.

4. D is correct. During breath holding at total lung capacity, the intrapleural pressure
would be normal when no air is moving. Choice A is incorrect because during inspiration, intrapleural pressure is more negative due to increased airway resistance. Choice B is incorrect because positive elastic recoil during expiration makes intrapleural pressure more positive. Choice C is incorrect because functional reserve capacity is the volume of air remaining in the lungs after a normal expiration and no air is moving; thus, intrapleural pressure is not increased. Choice E is incorrect because intrapleural pressure will be normal when no air is moving.

5. A is correct. It is calculated as follows: The individual’s inspiratory capacity is 3.55 L, and the volume at the end of a normal expiration is 4.45 L. Because these volumes contain the tidal volume, they must be summed \((3.55 + 4.45 = 8.0 \text{ L})\). The TLC (6.5 L) is then subtracted from 8.0 L. Therefore, \(8.0 \text{ L} - 6.5 \text{ L} = 1.5 \text{ L}\), the individual’s tidal volume.

6. B is correct. Infusion of lactic acid will decrease the partial pressure of CO\(_2\) in the blood and cause diffusion of CO\(_2\) from the cerebrospinal fluid to the blood, thereby increasing the pH of the cerebrospinal fluid. A decrease in ventilation (choice A) would not occur because acidosis would increase, not decrease, ventilation. A decrease in arterial P_O2 (choice C) would not occur because ventilation would be increased, enhancing arterial P_O2 levels. A rise in arterial P_CO2 (choice D) would not occur because lactic acid infusion would reduce the arterial CO\(_2\). A decrease in the ratio (choice E) would not occur because ventilation would be increased, not decreased.

7. D is correct. A marked decrease in pulmonary diffusing capacity decreases PaO\(_2\) and increases PaCO\(_2\), both of which would increase the firing of peripheral chemoreceptors. Choices A and B are incorrect because carbon monoxide poisoning and severe anemia reflect less O\(_2\) binding to Hb, but this does not alter PaO\(_2\) because it reflects dissolved O\(_2\), not O\(_2\) combined with Hb. Formation of methemoglobin (choice C) occurs when the ferrous iron of the heme molecule is converted to ferric iron, but this choice is incorrect because hemoglobin binding has little to do with stimulation of peripheral chemoreceptors by dissolved O\(_2\). Respiratory alkalosis (choice E) would not stimulate peripheral chemoreceptors because PaCO\(_2\) levels are decreased, not increased.