RESPIRATORY VENTILATION QUESTIONS

Indicate the best answer or completion.

1. Due to polio, a patient suffers total paralysis of his intercostal muscles. For this patient, which of the following values would still be expected to be essential normal?

A. inspiratory reserve volume (IRV)
B. expiratory reserve volume (ERV)
C. total lung capacity (TLC)
D. vital capacity (VC)
E. none of the above

2. A child with normal lung volumes for his age (TLC = 2.5 liters, VC = 2.0 liters, ERV = 0.5 liters) would expected to have an FEV_1 (one-second forced expired volume) in the range of

A. 0.5-1.0 liters
B. 1.0-1.6 liters
C. 1.6-2.0 liters
D. 2.0-2.5 liters
E. 2.5-3.0 liters

3. Contraction of the abdominal muscles is important in

A. normal (quiet) inspiration
B. forced (maximum) inspiration
C. normal (quiet) expiration
D. forced (maximum) expiration
E. none of the above

4. Alveolar surfactant acts to increase pulmonary

A. surface tension
B. compliance
C. airway resistance
D. blood flow
E. both B and D above

5. Administration of an agonist for which of the following autonomic receptors would be expected to cause airway resistance to decrease?

A. muscarinic-cholinergic
B. nicotinic-cholinergic
C. alpha-adrenergic
D. beta-adrenergic
E. histaminic

6. In emphysema, which of the following would be expected to be below normal (less positive or more negative than normal)?

A. airway resistance
B. lung compliance
C. intrapleural pressure
D. FEV_1
E. B, C, and D above

7. At which of the following times in the respiratory cycle is the intrapleural pressure most negative?

A. just after the beginning of inhalation (inspiration
B. just before the end of inhalation
C. just after the beginning of exhalation (expiration)
D. just before the end of exhalation
E. any of the above, since the intrapleural pressure is constant during the normal respiratory cycle

The following questions refer to measurements taken on a male subject, age 25, at rest. Indicate whether the value given for a particular measurement is above the value that would be expected for a normal subject, below normal, or contained within the normal range.

8. Residual volume of 2.5 liters

A. above normal
B. below normal
C. within the normal range

9. Intrapleural pressure with relaxed respiratory muscles of -5 cmH_2O

A. above normal (less negative than normal)
B. below normal (more negative than normal)
C. within the normal range

10. PEF (peak expired flow rate) of 250 liters/minute

A. above normal (less negative than normal)
B. below normal (more negative than normal)
C. within the normal range

PRACTICE QUESTIONS -- ANSWERS: Respiratory Ventilation

1. E. The external intercostals contribute to inspiration and thus affect IRV and TLC and VC. The internal intercostals contribute to forced expiration and thus affect ERV, TLC, and VC. Thus, none of the volumes listed would be normal.

2. C. Normal FEV-1 is 80% or more of VC. Since this child's VC is 2.0 liters and 80% of 2.0 is 1.6, the FEV-1 should be in the range 1.6-2.0 liters.

3. D. Why is choice C incorrect? Answer: quiet expiration involves elastic recoil only and not active muscle contraction.

4. B. Surfactant reduces lung surface tension, thereby increasing lung compliance.

5. D. Activation of the beta-adrenergic receptors on bronchial smooth muscle cause smooth muscle relaxation, thus increasing airway diameter and reducing airway resistance.

6. D. In emphysema, airway resistance increases in expiration because of airway collapse; lung compliance increases due to loss of lung elastic tissue; intrapleural pressure increases (becomes less negative) because of the increased lung compliance. Of the choices listed, only FEV-1 decreases below normal.

7. B. At the end of inspiration, the lungs are the most stretched and therefore pull back the hardest, causing the intrapleural pressure to become the most negative.

8. A, Above Normal. Normal RV in an adult male of average size is 1.2 liters. What conditions might lead such a high residual volume? (Hint: consider the effects of emphysema.)

9. C, Normal.

10. B, Below Normal. The normal range for PEF is 400-600 liters/minute, for an adult, with the exact value depending upon size, age, and sex.

PRACTICE EXAMINAITON QUESTIONS: Alveolar Gas Exchange

1. What would be the expected effect of pulmonary edema on the pulmonary diffusing capacity for oxygen (D_{O2}) and carbon dioxide (D_{CO2})

A. reduce D_{O2} and reduce D_{CO2}
B. reduce D_{O2} but no effect on D_{CO2}
C. reduce D_{CO2} but no effect on D_{O2}
D. no effect on either D_{O2} or D_{CO2}
E. no effect on either D_{O2} or D_{CO2} unless diffusing area is reduced also

2. At which of the following sites is the partial pressure of carbon dioxide (P_{CO2}) <u>highest</u>?

A. exhaled gas
B. alveolar gas
C. systemic arterial blood
D. systemic venous blood
E. about the same in all of the above (40 mmHg)

3. At which of the following sites is the partial pressure of oxygen (P_{O2}) highest?

A. exhaled gas
B. anatomical dead space at the end of expiration
C. anatomical dead space at the end of inspiration
D. alveolar gas
E. about the same in all of the above (100 mmHg)

4. An individual who breaths through a hose or tube while keeping his tidal volume normal would be expected to have an increased (compared to normal) of which of the following?

A. dead space
B. wasted ventilation
C. systemic arterial carbon dioxide content ($C_{a\text{-}CO2}$)
D. all of the above
E. only A and B above

5. At the top of a 3000 meter high mountain, which of the following alveolar partial pressures would be expected to be lower than normal? (Remember that barometric pressure, P_B, decreases as one goes higher.)

A. oxygen ($P_{A\text{-}O2}$)
B. carbon dioxide ($P_{A\text{-}CO2}$)
C. water vapor ($P_{A\text{-}H2O}$)
D. all of the above
E. only A and B above

6. Reduction of the pulmonary diffusing capacity to one-fourth of its normal value would be expected to have what effect on systemic arterial oxygen and carbon dioxide partial pressures (compared to normal)?

A. decrease $P_{a\text{-}O2}$ and decrease $P_{a\text{-}CO2}$
B. decrease $P_{a\text{-}O2}$ and increase $P_{a\text{-}CO2}$
C. increase $P_{a\text{-}O2}$ and decrease $P_{a\text{-}CO2}$
D. increase $P_{a\text{-}O2}$ and increase $P_{a\text{-}CO2}$
E. decrease $P_{a\text{-}O2}$ but no change in $P_{a\text{-}CO2}$

7. At rest, wasted ventilation as a percent of total ventilation of 30% is

A. above normal
B. below normal
C. within the normal range

Alveolar Gas Exchange Answers

1. A. Pulmonary edema increases diffusion distance between the alveoli and the pulmonary capillaries; therefore both D_{O2} and D_{CO2} would be reduced. Note, however, that the diffusing capacity decrease has a greater effect on blood oxygen than on blood carbon dioxide because D_{CO2} is normally so much higher than D_{O2}.

2. D. Systemic venous blood contains both the CO_2 that was in systemic arterial blood plus the CO_2that is added to the blood by tissue metabolism as the blood passes through the systemic capillaries. Question: What would be the answer is the question read "At which of the following sites is P_{CO2} lowest?"

3. C. At the end of inspiration, the dead space contains ambient or inspired air (saturated), which has a P_{O2} of 150 mmHg.

4. D. Breathing though a tube increases the dead space and the wasted ventilation. If the tidal volume remains constant, then the increased dead space means the alveolar ventilation is reduced, so alveolar P_{A-CO2} increases. If P_{A-CO2} increases then systemic arterial P_{a-CO2} must increase also.

5. E. P_{A-O2} would be lower than normal due the reduced P_{I-O2}. P_{A-CO2} would probably be lower due to hyperventilation caused by the hypoxia. However, P_{A-H2O} would be normal, as water vapor pressure in the alveoli depends only on the temperature. Note: I would also accept choice A as the correct answer.

6. E. P_{a-O2} decreases when D_{O2} decreases to less than one-third its normal value. But D_{CO2} is so high normally that even a decrease to one-fourth will still permit carbon dioxide to equilibrate in the time that blood passes through pulmonary capillaries.

7. C. Since the Dead Space is about 30% of the tidal volume at rest, then the Wasted Ventilation will be about 30% of the Total Ventilation at rest, also.

PULMONARY CIRCULATION QUESTIONS

Indicate the best answer or completion.

1. When is the resistance to blood flow of the pulmonary vascular bed lowest?

A. When a person is at rest sitting up
B, When a person is at rest lying down
C. When a person is breathing air at high altitude
D. When a person is exercising maximally
E. None of the above because pulmonary vascular resistance is constant

2. Which of the following might be expected to lead to pulmonary edema?

A. decrease pulmonary arterial pressure (pulmonary hypotension)
B. decrease in systemic arterial pressure (systemic hypotension)
C. decrease volume of blood in the pulmonary circulation (as in hemorrhage)

D. increase systemic venous pressure (as in right heart failure)
E. increase pulmonary capillary permeability to plasma proteins (as in pulmonary inflammation)

3. In a person standing upright, which region of the lungs has the highest ventilation rate and which region has the highest circulatory perfusion rate?

A. highest ventilation: Apex; highest perfusion: Apex
B. highest ventilation: Apex; highest perfusion: Base
C. highest ventilation: Base; highest perfusion: Apex
D. highest ventilation: Base; highest perfusion: Base
E. there is no "highest" region as the apex and base have equal ventilation and perfusion rates

PULMONARY CIRCULATION ANSWERS

1. D. Pulmonary vascular resistance decreases as pulmonary blood flow increases due to increasing blood vessel diameter and recruitment of more blood vessels. Note that choice C is incorrect as high altitude causes pulmonary vasoconstriction due to the low oxygen partial pressure.

2. E. Increase pulmonary capillary permeability will let plasma proteins diffuse into the lung interstitial space, thereby decreasing the osmotic (or oncotic) pressure difference. Remember that it is the osmotic pressure that keeps fluid from leaving the pulmonary capillaries and moving into the interstitial space and alveoli.

3. D. The base of the lungs in the upright posture receives both the most ventilation and the most perfusion.

ALVEOLAR-ARTERIAL EQUILIBRATION QUESTIONS

1. Which of the following represents a "right-to-left shunt"?

A. pulmonary blood flow through a region of lung atelectasis (alveolar collapse
B. blood flow from the left ventricle to the right ventricle through a hole in the interventricular septum
C. blood flow from skin arteries to skin veins which does not pass through skin capillaries
D. blood flow from the aorta into the pulmonary artery through the ductus arteriosis
E. all of the above

2. A patient has an alveolar P_{A-O2} of 60 mmHg and a systemic arterial P_{a-O2} of 56 mmHg. The most likely explanation for these values is

A. hypoventilation
B. diffusion limitation
C. right-to-left shunt
D. ventilation-to-perfusion nonuniformity
E. either B, C, or D above

3. All of the following are possible causes of a higher than normal $AaDO_2$ except

A. pulmonary edema
B. mismatching of alveolar ventilation and pulmonary perfusion
C. chronic bronchitis
D. a cardiac septal defect that allows blood to flow from the right atrium to the left atrium
E. none of the above; that is, none are exceptions, since all could lead to a high $AaDO_2$

4. Lack of oxygen equilibration due to diffusion limitation ("alveolar-capillary block") can be evaluated by measuring the

A. distribution of an inhaled gas mixture containing a radioactive marker
B. diffusing capacity of CO (carbon monoxide)
C. diffusing capacity of CO_2 (carbon dioxide)
D. diffusing capacity of N_2 (nitrogen) when inhaling air
E. FEV-1/VC when inhaling pure oxygen

5. Blood gas measurements in an hypoxic patient indicates that the patient's systemic arterial oxygen content is normal but his systemic venous oxygen content is low. This is characteristic of

A. diffusion limitation
B. right-to-left shunt
C. pulmonary ventilation/perfusion nonuniformity
D. anemic hypoxia (low Hb concentration)
E. stagnant hypoxia (low cardiac output)

6. A patient has a normal oxygen partial pressure and content in pulmonary venous blood but his systemic arterial blood shows a significantly lower than normal oxygen partial pressure and content. This is diagnostic of

A. diffusion limitation
B. right-to-left shunt
C. pulmonary ventilation/perfusion nonuniformity
D. stagnant hypoxia (low cardiac output)
E. A, B. or C above

ALVEOLAR-ARTERIAL EQUILIBRATION ANSWERS

1. A. A "right-to-left" shunt permits blood to flow from the right heart (or pulmonary artery or systemic veins) directly into the left heart (or systemic artery or pulmonary vein) without exchanging oxygen and carbon dioxide with pulmonary alveoli. Since an atelectatic region of the lungs consists of collapsed alveoli which are not ventilated, blood flowing through this region represents a "right-to-left" shunt.

2. A. Assuming the patient is breathing air, the low $P_{a\text{-}O2}$ must be due to ether hypoventilation (choice "A") or a lack of alveolar-arterial equilibration (due to choices "B", "C", and/or "D"). Since the $AaDO_2$ is 4 mmHg, which is within the normal range of 0-5 mmHg, "B", "C", and "D" are ruled out, so the correct answer must be "A". The low $P_{A\text{-}O2}$ also indicates hypoventilation.

3. C. Chronic bronchitis could lead to hypoventilation but not to a high $AaDO_2$.

4. B. D_{CO} is a good index of D_{O2}.

5. E. High oxygen extraction (the difference between $C_{a\text{-}O2}$ and $C_{v\text{-}O2}$) is characteristic of inadequate blood flow.

6. B. Since pulmonary venous blood has a normal oxygen content, equilibration between alveolar gas and pulmonary capillary blood must be normal, ruling out choices "A" and "C". The low systemic arterial oxygen means that systemic venous blood must have mixed with pulmonary venous blood to form systemic arterial blood ("venous admixture"), which is a type of right-to-left shunt.

RESPIRATORY NEUROGENESIS AND REGULATION QUESTIONS

1. A stroke that destroyed the respiratory center of the medulla would be expected to lead to

A. immediate cessation of breathing
B. apneustic breathing
C. ataxic breathing
D. rapid breathing (hyperpnea)
E. none of the above, since breathing would remain normal

2. The afferent (sensory) endings for the Hering-Breuer reflex are stretch receptors (mechanoreceptors) in the

A. aorta and carotid arteries
B. arteries in the cerebral circulation
C. lungs
D. heart
E. diaphragm and intercostal muscles

3. Stimulation of the reticular activating system of the brainstem (RAS) plays what role in ventilation?

A. stimulates ventilation
B. inhibits ventilation
C. stimulates inhalation but inhibits exhalation (apneustic breathing) D. stimulates exhalation but inhibits inhalation
E. causes ventilation to cease entirely ("Ondine's Curse")

4. Hyperventilating allows one to hold one's breath for a longer period of time, because hyperventilation

A. increases the oxygen reserve of systemic arterial blood
B. decreases the P_{CO2} of systemic arterial blood
C. decreases the pH of systemic arterial blood
D. increases brain blood flow
E. none of the above, since hyperventilation reduces the time one can voluntarily stop breathing

5. The <u>most important</u> afferent (sensory) receptors for the respiratory response to systemic arterial carbon dioxide ($P_{a\text{-}CO2}$) are the

A. CO_2 receptors of the aortic and carotid bodies
B. H^+ receptors of the aortic and carotid bodies
C. CO_2 receptors in the medulla of the brain
D. H^+ receptors in the medulla of the brain
E. CO_2 receptors in the airways and lungs

NEUROGENESIS AND REGULATION ANSWERS

1. A. The medullary respiratory center is essential for automatic breathing and its destruction would cause breathing to cease.

2. C. The Hering-Breuer reflex is initiated by activation of stretch receptors in the lungs.

3. A. Activation of the RAS causes a general increase in respiratory ventilation.

4. B. Breath holding is limited by the increase in $P_{a\text{-}CO2}$ to the level where involuntary breathing overcomes voluntary breath holding. Hyperventilation before holding ones breath lowers the starting $P_{a\text{-}CO2}$ permitting a longer breath holding time. Decrease in blood pH is not a correct answer, although decrease in CSF pH would have been correct had it been one of the choices.

5. D. The most important receptors in chemical regulation of ventilation by carbon dioxide are the hydrogen ion receptors in the medulla, since the pH of CSF and brain interstitial fluid are controlled by blood P_{CO2} as CO_2 readily crosses the blood-brain barrier.