Chapter 3: Mechanics of Ventilation
Test Bank

MULTIPLE CHOICE

1. Which of the following mechanisms is responsible for the creation of the subatmospheric pressure between the lung and chest wall?
   I. Both lungs and chest wall pull outward.
   II. The lung has a tendency to recoil inward and pull away from the chest wall.
   III. The thorax has a tendency to recoil outward, away from the lung.
   a. I, II
   b. III
   c. I, II, III
   d. II, III

   ANS: D
   The healthy lung has a tendency to recoil inward and pull away from the chest wall. At the same time, the thorax has a tendency to recoil outward, away from the lung. These two oppositely directed recoil forces create a subatmospheric pressure between the lung and the chest wall.

   DIF: Application REF: 45

2. What causes air to move in or out of the lungs?
   a. Volume gradients
   b. Pressure gradients
   c. Temperature gradients
   d. Flow gradients

   ANS: B
   A pressure gradient is simply a pressure difference between two points that causes air to move in or out of the lungs. It is the force responsible for keeping the lungs in an inflated state.

   DIF: Recall REF: 47

3. At the end of a spontaneous 500 mL inspiration, the P_A is 0 mm Hg, and at the end of a positive pressure lung inflation to 500 mL, P_A is 10 mm Hg. Why does the lung contain the same volume at these two different alveolar pressures?
   a. The volume is the same regardless of the type of breath.
   b. That is the lung capacity.
   c. The pressure gradient is the same.
   d. The flow gradient is the same.

   ANS: C

Figure 3-4 compares PPV and SB. The lung diagrams illustrate conditions at the end of an inspiration. Although the transpulmonary pressures were achieved by different means in SB and PPV, P_L is 10 cm H_2O in both instances. This means that elastic lung fibers are stretched to the same extent in both instances. The PPV inspiration places no more stress on the lung than the SB inspiration, although P_A is 10 cm H_2O greater in PPV than in SB. This fact has relevance to therapeutic lung expansion techniques used in respiratory care. Given normal inspiratory muscle function, a mechanical positive pressure inspiration is not in some way superior to a spontaneous inspiration in expanding the lung, nor is a 500 mL positive pressure breath any more likely than a 500 mL spontaneous breath to injure the lungs.

DIF: Application REF: 49

4. Which of the following terms defines the amount of gas the lung contains after a maximal inspiratory effort?
   a. TLC
   b. RV
   c. FRC
   d. IC

   ANS: A
   The total lung capacity (TLC) is the amount of gas the lung contains after a maximal inspiratory effort.

   DIF: Recall REF: 49

5. What is the minimum MIP required to confirm adequacy of ventilatory muscle strength?
   a. More than –20 cm H_2O
   b. Less than –20 cm H_2O
   c. More than –40 cm H_2O
   d. Less than 50 cm H_2O

   ANS: A
   Severe compromise of ventilatory muscle strength is evident when no more than –20 cm H_2O MIP can be generated.

   DIF: Recall REF: 52

6. When lung inflation pressure is increased from 10 cm H_2O to 20 cm H_2O, what happens to the alveolar size?
   a. Increases by 50%
   b. Increases by 100%
   c. Does not change but more alveoli are recruited
   d. Increases by 50% and more alveoli are recruited

   ANS: C
   When lung inflation pressure was increased from 10 cm H_2O to 20 cm H_2O, and then from 20 cm H_2O to 30 cm H_2O, the alveolar size did not change but the number of recruited alveoli changed in direct proportion to the applied pressure.

   DIF: Application REF: 53

7. The change in lung volume resulting from a unit of pressure change is known as:
   a. Elastance
   b. Lung compliance
   c. Airway resistance
   d. Lung recoil

   ANS: B
   Lung compliance (C_L) is defined as the change in lung volume resulting from a unit of pressure change and is measured in liters per centimeter of water pressure (L/cm H_2O).

   DIF: Recall REF: 55

8. What is the normal lung compliance (C_L)?
   a. 0.1 L/cm H_2O
   b. 0.2 L/cm H_2O
   c. 0.3 L/cm H_2O
   d. 0.4 L/cm H_2O

   ANS: B
   Normal compliance of the lung alone (C_L) is 0.2 L/cm H_2O or 200 mL/cm H_2O.

   DIF: Recall REF: 55

9. What is the best word to define elastance?
   a. Compliance
   b. Recoil
   c. Airway resistance
   d. Inflation

   ANS: B
   The more elastic the lung, the less its compliance. Elastance can be conceptualized as recoil force; highly elastic lungs are stiff and difficult to inflate and exhibit a high recoil force.

   DIF: Recall REF: 55

10. The presence of high lung elastance will produce which of the following effects on a quiet, passive exhalation?
    a. The expiratory time will be shorter.
    b. The inspiratory time will be shorter.
    c. The expiratory time will be longer.
    d. The inspiratory time will be longer.

    ANS: A
    The person with high lung compliance (low elastance) requires the longest passive exhalation time because of reduced elastic lung recoil forces. A lung with high elastance (low compliance) has a high recoil force and thus empties more quickly.

    DIF: Application REF: 55

11. Which of the following statements explains why compliance is greater in the adult than the infant?
    a. Infant lungs are smaller and accept less volume for a given pressure.

b. Adult lungs are larger and accept less volume for a given pressure.
c. The infant lung is more elastic.
d. The adult lung is more elastic.

ANS: A
Clearly, compliance (L/cm H_2O) is greater in the adult than the infant because adult lungs are larger and accept more volume for a given pressure.

DIF: Application REF: 55

12. Which of the following conditions is characterized by a loss of elastic lung tissue?
a. Chronic bronchitis
b. Acute respiratory distress syndrome
c. Emphysema
d. Pneumonia

ANS: C
Emphysema is characterized by a loss of elastic lung tissue, which means the lungs can be easily distended and have an abnormally low recoil force.

DIF: Recall REF: 55

13. Which of the following conditions is characterized by high lung recoil forces?
a. Pulmonary fibrosis
b. Pleural effusion
c. Emphysema
d. Pneumonia

ANS: A
Pulmonary fibrosis is characterized by high lung recoil forces.

DIF: Recall REF: 64

14. According to Laplace's law, if surface tension remains constant, what will happen to small alveoli?
a. They will receive volume from larger alveoli.
b. They will retain the same volume even at the end of an exhalation.
c. They will require a lower distending pressure.
d. They will empty into larger alveoli.

ANS: D
If surface tension remains constant, small alveoli require higher distending pressure than large alveoli; the equation thus predicts that the smaller alveoli should empty into larger alveoli—assuming that all alveoli have the same surface tension.

DIF: Application REF: 56-57

15. What is the normal composition of the surfactant?
a. 90% phospholipid and 10% protein
b. 50% phospholipid and 50% protein
c. 10% phospholipid and 90% protein
d. 30% phospholipid and 70% protein

ANS: A
Pulmonary surfactant is a complex substance composed of 90% phospholipid and 10% protein.

DIF: Recall REF: 58

16. Which of the following is the function of the surfactant?
    a. To feed alveolar cell type I
    b. To lower surface tension
    c. To increase surface tension
    d. To lubricate alveoli

ANS: B
Dipalmitoyl phosphatidylcholine (DPPC) composes approximately 50% of surfactant's phospholipid content and is primarily responsible for surfactant's surface tension–lowering properties.

DIF: Recall REF: 58

17. Which of the following statements are true of the lecithin-to-sphingomyelin ratio?
    I. It is predictive of fetal lung maturation.
    II. An L/S ratio greater than 2:1 indicates fetal lung maturity in nondiabetic pregnancies.
    III. The L/S ratio is falsely high in diabetes.
    IV. The L/S ratio is generally 2:1 at 35 weeks' gestation.
    a. III, IV
    b. I, II, III
    c. I, II, IV
    d. I, II, III, IV

ANS: D
The ratio of lecithin to sphingomyelin (L/S ratio) in amniotic fluid is predictive of fetal lung maturation. An L/S ratio greater than 2:1 indicates fetal lung maturity in nondiabetic pregnancies. (The L/S ratio is falsely high in diabetes.) The L/S ratio is generally 1:1 at 31 to 32 weeks' gestation, and 2:1 at 35 weeks.

DIF: Recall REF: 59

18. What are the tests that are considered the "gold standard" for determining fetal lung maturity?
    I. L/S ratio
    II. DPPC measurement
    III. PG in amniotic fluid
    IV. Lamellar body count
    a. I, III
    b. III, IV
    c. I, II, III
    d. I, III, IV

ANS: A
The L/S ratio and the presence of PG in amniotic fluid continue to be the "gold standard" for determining fetal lung maturity.

DIF: Recall REF: 59

19. Which of the following are true physiological benefits of surfactant?
I. It reduces the work of breathing.
II. It reduces the distending pressure required to keep small alveoli open.
III. It provides a stabilizing influence to alveoli of different sizes.
IV. It enhances the elastic properties of the lung.
a. III, IV
b. I, II, III
c. I, II, IV
d. I, II, III, IV

ANS: B
In summary, the physiological importance of pulmonary surfactant is that (1) it reduces the work of breathing, (2) it reduces the distending pressure required to keep small alveoli open, and (3) it provides a stabilizing influence, allowing alveoli of different sizes to coexist at the same distending pressure.

DIF: Recall REF: 60

20. What is the normal C_{LT}?
a. 0.1 L/cm H_2O
b. 0.2 L/cm H_2O
c. 0.3 L/cm H_2O
d. 0.4 L/cm H_2O

ANS: A
The normal value is 0.1 L/cm H_2O for C_{LT}.

DIF: Recall REF: 61

21. A female approximately 25 years old was thrown from a vehicle and sustained a penetrating wound to her left chest. The wound is deep and emits a sucking sound with each inspiration. The woman is complaining of severe left chest pain and has no breath sounds over the left side of the chest. Her trachea is in the midline position. What is the most probable diagnosis?
a. Left-sided pulmonary contusion
b. Right-sided atelectasis
c. Left-sided non-tension pneumothorax
d. Left-sided tension pneumothorax

ANS: C
The woman in the accident sustained a simple, or open, pneumothorax. Each time she inhaled, the rib cage expanded, creating subatmospheric pressure inside her chest.

DIF: Application REF: 63

22. What is the normal airway resistance?
a. 4.0 to 4.5 cm H_2O/L/sec
b. 3.0 to 3.5 cm H_2O/L/sec
c. 2.0 to 2.5 cm H_2O/L/sec
d. 0.5 to 1.5 cm H_2O/L/sec

ANS: D
Normal Ra_w in adults measured at the FRC level at a constant flow rate of 0.5 L/sec is about 0.5 to 1.5 cm H_2O/L/sec.

DIF: Recall REF: 65

23. According to Poiseuille's law, if an airway's radius decreases to one-half of its original size, what pressure will be required to maintain the original flow through the airway?
    a. 2 times more pressure
    b. 4 times more pressure
    c. 8 times more pressure
    d. 16 times more pressure

ANS: D
The equation shows that if an airway's radius decreases to one-half of its original size (e.g., by bronchospasm or mucosal edema), 16 times more pressure is required to maintain the original flow through the airway.

DIF: Recall REF: 66

24. Helium is sometimes used in patients with severe airway obstruction to reduce the work of breathing. Which of the following properties of helium allows better airflow in these patients?
    a. Density
    b. Viscosity
    c. Velocity
    d. Molecular weight

ANS: A
A gas mixture of 80% helium and 20% oxygen (Heliox) has a lower density but a higher viscosity than air. Delivering Heliox to a child who has severe croup (subglottic swelling) may decrease the work of breathing (WOB).

DIF: Recall REF: 67

25. Which of the following structures accounts for almost 50% of total Ra_w at FRC?
    a. Upper airways
    b. Airways less than 3 mm in diameter
    c. Main bronchi
    d. Trachea

ANS: A
The upper airways, including the larynx, mouth, and nose, normally account for approximately 50% of total Ra_w at FRC; airways less than 3 mm in diameter account for less than 10% of the total Ra_w.

DIF: Recall REF: 67

26. Which of the following parameters is the most relevant in assessing the potential for pressure-induced alveolar injury during positive pressure mechanical ventilation?
    a. P_{peak}
    b. P_{mouth}
    c. P_{pl}

d. P_{plat}

ANS: D
One should note that P_{plat} is equal to P_A because it is measured under static conditions after pressures equalize across the airways. P_{plat} is therefore more relevant than P_{peak} in assessing the potential for pressure-induced alveolar injury **(barotrauma)** during positive pressure mechanical ventilation.

DIF: Recall REF: 68

27. In order to determine the ventilator parameter that reflects both elastic and flow resistive opposition to lung inflation, the respiratory therapist should assess which of the following pressures?
a. P_{peak}
b. P_{mouth}
c. P_{pl}
d. P_{plat}

ANS: A
The peak inspiratory pressure (P_{peak}) during mechanical ventilation reflects both elastic and flow resistive opposition to lung inflation, whereas the P_{plat} reflects only elastic resistance.

DIF: Application REF: 69

28. The respiratory system equation of motion is the theoretical basis for what kind of mechanical ventilation?
a. Inverse ratio ventilation
b. Proportional assist ventilation
c. High-frequency ventilation
d. Negative pressure ventilation

ANS: B
The respiratory system equation of motion is the theoretical basis for proportional assist ventilation (PAV).

DIF: Recall REF: 71

29. The point at which intraairway pressure equals the surrounding P_{pl} is knows as:
a. Dynamic airway compression
b. Equal pressure point
c. Lower inflection point
d. Critical opening pressure

ANS: B
The point at which intraairway pressure equals the surrounding P_{pl} is the equal pressure point (EPP).

DIF: Recall REF: 71

30. A patient's PIP has increased significantly since the last measurement 2 hours ago. It is noticed that the P_{plat} has not changed. What is the most probable explanation for the increased PIP?

a. Increased lung compliance
b. Increased airway resistance
c. Decreased lung compliance
d. Decreased airway resistance

ANS: B
In this situation, the unchanged P_{plat} tells you the lung's recoil force did not change. The increased peak pressure therefore must mean your patient has increased Ra_w.

DIF: Application REF: 72

31. People with emphysema have an increased work of breathing (WOB) as a result of their high expiratory Ra_w. In order to keep their airways open during exhalation, they perform which of the following maneuvers?
a. Deep inhalation
b. Rapid exhalation
c. Breath hold
d. Pursed-lip breathing

ANS: D
To keep their airways open during exhalation, they tend to purse the lips or partially close the vocal cords. This action increases pressure in the airways during exhalation, counteracting the outside collapsing force (pleural pressure) on the airway walls.

DIF: Application REF: 73

32. A time constant determines how rapidly the source pressure and lung pressure equalize. Which of the following parameters determine the time constant?
I. C_L
II. Ra_w
III. TLC
IV. FRC
a. I, II
b. I, II, III, IV
c. I, III
d. II, IV

ANS: A
C_L and Ra_w determine how rapidly the source pressure and lung pressure equalize. The product of C_L and Ra_w is the time constant (TC), expressed in seconds.

DIF: Recall REF: 73

33. With normal values for total compliance (0.1 L/cm H_2O) and Ra_w (1.0 cm H_2O/L/sec), one TC should be approximately:
a. 0.1 sec
b. 0.2 sec
c. 0.3 sec
d. 0.4 sec

ANS: A

With normal values for total compliance (0.1 L/cm H_2O) and Ra_w (1.0 cm H_2O/L/sec), the TC is as follows:TC = 0.1 L/cm H_2O × 1.0 cm H_2O/L/sec = 0.1 sec

DIF: Application REF: 74

34. If the calculated time constant is 0.1 sec, what time will be required to achieve 99.3% equilibrium of pressure or volume?
    a. 0.3 sec
    b. 0.4 sec
    c. 0.5 sec
    d. 0.6 sec

    ANS: B
    After one time constant elapses, about 63% of the final equilibrium pressure or volume is achieved; 86.5% is achieved at the end of two time constants, 95% is achieved at the end of three time constants, and 99.3% is achieved at the end of four time constants.

    DIF: Application REF: 74

35. A patient who is critically ill and endotracheally intubated is admitted to the ICU for ventilatory management. Which of the following lung conditions explains the patient's having short time constants?
    a. Decreased C_L
    b. Increased Ra_w
    c. Normal C_L and normal Ra_w
    d. Normal C_L and high Ra_w

    ANS: A
    Stiff lungs (low C_L) empty quickly because of their high elastic recoil. Thus lungs with low compliance and normal Ra_w have short time constants. Four to five time constants are still required for complete inflation or deflation, but the absolute time required is less than for a normally compliant lung.

    DIF: Application REF: 74

36. Which of the following conditions are associated with the presence of air trapping and auto-PEEP?
    I. High airway resistance
    II. Weak lung recoil force
    III. High breathing rates
    IV. Short expiratory times
    a. I, II
    b. II, III, IV
    c. I, II, III, IV
    d. I, III, IV

    ANS: C

High airway resistance, as seen in asthmatic patients, and weak lung recoil force, as seen in emphysema patients, require abnormally long expiratory times. High breathing rates shorten the time available for expiration, and if this is coupled with high airway resistance or weak lung recoil force, there may not be enough time for the lungs to empty to the normal FRC level before the next inspiration.

DIF: Application REF: 75

37. Auto-PEEP is known to increase WOB in spontaneously breathing and mechanically ventilated patients. Which of the following maneuvers will reduce auto-PEEP in both types of patients?
    a. Increasing C_L
    b. Promoting a breath hold
    c. Shortening the expiratory time
    d. Lengthening the expiratory time

    ANS: D
    Because auto-PEEP is a problem associated with high airway resistance and inadequate expiratory time, it stands to reason that any measure that (1) reduces airway resistance or (2) lengthens expiratory time could reduce or eliminate auto-PEEP.

    DIF: Application REF: 75

38. Which of the following ventilatory strategies is useful in managing a patient with status asthmaticus?
    a. Decreasing inspiratory flow rates
    b. Increasing inspiratory flow rates
    c. Shortening the expiratory time
    d. Lengthening the inspiratory time

    ANS: B
    It would seem that a high inspiratory flow rate will exaggerate the effects of high Ra_w, making PIP even higher. Although PIP does indeed rise, an important goal in ventilating this patient's lungs is to allow enough time for expiration.

    DIF: Application REF: 78

39. Patients with pulmonary fibrosis tend to have rapid and shallow respiration. Which of the following lung conditions explains their breathing pattern?
    a. High compliance
    b. High elastance
    c. High airway resistance
    d. High peak airway pressures

    ANS: B
    The person with pulmonary fibrosis adopts a rapid, shallow breathing strategy. Elastic recoil is high; therefore, work is minimized by breathing smaller tidal volumes.

    DIF: Application REF: 79

40. What is considered the "gold standard" index of diaphragmatic fatigue?
    a. Tension-time index of the diaphragm

b. Plateau pressure
c. Low inflection determination
d. Duty cycle

ANS: A
The "gold standard" index of diaphragmatic fatigue is the tension-time index of the diaphragm (TT_{di}), which relates the $P_{di}/P_{di}max$ to the time spent in inspiration (T_i).

DIF: Recall REF: 79

41. Although an increased use of accessory ventilatory muscles coupled with rapid, shallow breathing may signal impending diaphragmatic fatigue, which of the following signs is typically seen in critically ill patients with ventilatory failure and diaphragmatic fatigue?
a. Retractions
b. Cyanosis
c. Abdominal paradox
d. Stridor

ANS: C
Critically ill persons exhibiting asynchrony have an increased risk of ventilatory failure. A visual sign of overt diaphragmatic fatigue is abdominal paradox, in which the abdomen is sucked inward during inspiration as the rib cage expands outward—evidence that the rib cage muscles are predominantly being used.

DIF: Recall REF: 80