Chapter 03: Administration of Aerosolized Agents
Gardenhire: Rau's Respiratory Care Pharmacology, 9th Edition

MULTIPLE CHOICE

1. A 2-year-old child is seen in the emergency department of a local hospital, and croup is diagnosed. The physician orders a dose of racemic epinephrine via a small volume nebulizer to help reduce the subglottic swelling. What size aerosol particle is most likely to deposit in this region, providing the greatest therapeutic benefit to the patient?
   a. Particles less than 10 µm
   b. Particles 5 to 10 µm
   c. Particles 2 to 5 µm
   d. Particles 0.8 to 3.0 µm

   ANS: B
   The upper airway (nose and mouth) is efficient in filtering particulate matter, so generally there is 100% deposition in the nose and mouth of particles larger than 10 µm and 15 µm. Particle sizes 5 to 10 µm tend to deposit out in the upper airways and the early airway generations, whereas particles 1 to 5 µm have a greater probability of reaching the lower respiratory tract from the trachea to the lung periphery. Larger or coarser aerosol particles (>5 µm) may be useful for treating the upper airway (nasopharynx and oropharynx).

   REF: p. 34

2. The main uses of aerosol therapy in respiratory care include the following:
   1. Humidification of dry gases
   2. Improved mobilization and clearance of secretions
   3. Delivery of aerosol drugs to the respiratory tract
   4. Delivery of nutrients for patients unable to chew food

   a. 1 and 2 only
   b. 1, 2, and 3 only
   c. 1, 2, and 4 only
   d. 1, 2, 3, and 4

   ANS: B
   At the present time, there are three main uses of aerosol therapy in respiratory care, as follows:

   Humidifying dry inspired gases, using bland aerosols
   Improving mobilization and clearance of respiratory secretions, including sputum induction, using bland aerosols of water and hypertonic or hypotonic saline
   Delivering aerosolized drugs to the respiratory tract

   REF: p. 32

3. What is the particle size range for pulmonary diagnostic and therapeutic applications?
   a. 0.5 to 1 µm
   b. 1 to 10 µm
   c. 10 to 15 µm
   d. 15 to 25 µm

ANS: B
For pulmonary diagnostic and therapeutic applications, the particle size range of interest is 1 to 10 μm. This size range is small enough to exist as a suspension and enter the lung and large enough to deposit and contain the required amount of an agent. Larger particles deposit mostly in the nasopharynx or oropharynx, and smaller particles may be too fine to leave suspension and could be exhaled.

REF: p. 32

4. Two hypothetical small volume nebulizers, *A* and *B,* have the following specifications from the manufacturer:

	A	*B*
Count median diameter (CMD)	1.7 μm	1.5 μm
Mass median aerodynamic diameter (MMAD)	3.2 μm	7.7 μm
Geometric standard deviation (GSD)	1.1 μm	1.5 μm

Which nebulizer would be best to use to treat the lower respiratory tract?
a. Nebulizer A
b. Nebulizer B

ANS: A
Although nebulizer B has a smaller CMD than nebulizer A, nebulizer A produces particles whose mass centers within a lower range and so would be the better nebulizer with which to treat the lower respiratory tract. A major factor in lung *penetration* by aerosols is particle size, which is best characterized by the *mass median aerodynamic diameter (MMAD)* for inhaled drugs, because particle mass is a function of the third power of the particle radius. Nebulizer A produces particles whose mass centers within a lower size range (1 to 5 μm), and would be the better nebulizer for treatment of the lower respiratory tract.

REF: p. 33

5. You are a respiratory therapist working in the emergency department; a 67-year-old man with chronic bronchitis presents in acute distress. His vital signs include heart rate (HR) 123 beats/min and respiratory rate (RR) 28 breaths/min. On auscultation, you note faint expiratory wheezing. Which of the following devices would be the *least* appropriate by which to deliver an aerosolized drug to this patient?
a. Jet nebulizer
b. Metered dose inhaler (MDI)
c. MDI with spacer
d. Dry powder inhaler (DPI)

ANS: D
A jet nebulizer and an MDI with spacer would be the most appropriate because they would likely provide the best deposition. Although an MDI without spacer would be less desirable, it would not require the relatively high inspiratory flow rate needed to use a DPI.

REF: p. 53

6. An aerosol is best defined as
   a. a drug in liquid form.
   b. vapor suspended in a carrier gas.
   c. a suspension of solid or liquid particles in a carrier gas.
   d. an invisible drug particle.

   ANS: C
   Drugs in liquid form may be administered in ways other than aerosol (e.g., intravenous [IV] route). By definition, an aerosol may be either solid or liquid particles suspended in a carrier gas, not just a vapor. It is possible to see aerosols, depending on the size of the particles.

   REF: p. 32

7. Traditionally, what percentage of a given dose of aerosolized medication reaches the lower respiratory tract, regardless of the type of delivery device being used?
   a. 5% to 10%
   b. 10% to 15%
   c. 20% to 30%
   d. 40% to 50%

   ANS: B
   Although some modern devices allow for up to 50% deposition, traditionally only 10% to 15% of aerosolized medications reach the lower airways.

   REF: p. 32

8. What is the purpose of the end-inspiratory breath hold used in conjunction with aerosol delivery?
   a. Prevents the patient from hyperventilating
   b. Gives the aerosol more time to reach BTPS conditions
   c. Allows better deposition through gravitational settling
   d. Reduces inertial impaction

   ANS: C
   Although we do not wish a patient to hyperventilate, prevention of hyperventilation is not the purpose of the breath hold. A slow, even respiratory rate is the best way to avoid hyperventilation. The more time an aerosol has to reach BTPS (body temperature, barometric pressure, and saturated with water) under these conditions, the larger its particles become because of their hygroscopic properties and the more likely they are to fall out of suspension before reaching the lower respiratory tract. The encouragement of a breath hold can increase the settling of particles; however, depending on particle size, a particle may not fall out of suspension. Inertial impaction occurs during the initial act of inspiring, before the end-inspiratory breath hold.

   REF: p. 35 | p. 36

9. You are treating a patient who has a confirmed diagnosis of *Pneumocystis* pneumonia. Which type of delivery device should you choose to administer the dose of pentamidine ordered by the attending physician?
   a. Respirgard II®

b. MDI
c. Pari LC®
d. DPI

ANS: A

DRUG	APPROVED NEBULIZER
Bronchodilator	Nebulizer type not specified
Acetylcysteine	Nebulizer type not specified
Budesonide (Pulmicort Respules®)	Should not be used with ultrasonic nebulizer
Tobramycin (TOBI®)	Pari LC®
Dornase alfa (Pulmozyme®)	Hudson T Up-draft II®, Marquest Acorn II®, Pari LC®, Durable Sidestream®, Pari Baby®
Pentamidine (NebuPent®)	Marquest Respirgard II®
Ribavirin (Virazole®)	Small particle aerosol generator (SPAG)

An SVN fitted with inspiratory and expiratory one-way valves and with expiratory filter is used during the administration of aerosolized pentamidine. The one-way valves used with the SVN prevent secondhand exposure of pentamidine by eliminating the contamination of the ambient environment with exhaled aerosol.

REF: p. 44

10. A 7-month-old infant presents with a diagnosis of respiratory syncytial virus. The attending physician agrees with your recommendation of ribavirin to treat the disease. Because ribavirin is delivered as an aerosol, you must decide which method of delivery to use. Which of the following aerosol administration devices would you choose?
    a. Small volume nebulizer
    b. Large volume nebulizer
    c. Dry powder inhaler (DPI)
    d. Small particle aerosol generator (SPAG)

    ANS: D
    Ribavirin is not produced for administration with a DPI. The manufacturer of ribavirin used a SPAG during clinical trials, and the device is marketed for delivery of the drug. A small volume nebulizer is incapable of holding a large enough volume of ribavirin, which is delivered over a long period of time. Although a large volume nebulizer may hold more medication, it is not the device recommended by the manufacturer of ribavirin.

    REF: p. 40

11. After delivering an aerosol treatment, you notice that approximately 0.5 mL of medication remains in the small volume nebulizer. Which of the following actions do you take?
    a. Replace the nebulizer before administering the next treatment
    b. Recommend that subsequent doses be delivered via metered dose inhaler (MDI)
    c. Take no action and deliver the following dose with the same small volume nebulizer
    d. Double the amount of medication administered during the next treatment

    ANS: C

There is nothing wrong with the nebulizer—dead volumes of 0.5 to 1 mL are common. Doubling the amount of medication not only is unnecessary but in some cases may pose a serious risk to the patient.

REF: p. 42

12. Which of the following statements is true concerning the recommended volume of solution when delivering an aerosol treatment via a small volume nebulizer?
1. A volume between 3 mL and 5 mL of solution is recommended.
2. Increasing the volume results in a decrease in the concentration of drug remaining in the dead volume when nebulization ceases.
3. Patient compliance of therapy is directly proportional to its convenience.
4. Increasing the volume of solution results in a net increase in the amount of active drug in the nebulizer.

a. 1 and 2 only
b. 2 and 3 only
c. 1, 2, and 3 only
d. 1, 2, 3, and 4

ANS: C
Increasing the volume of solution has no effect on the net amount of active drug; the only result is that it may take longer to administer an aerosol, and the patient may receive a higher percentage of the available dose.

REF: p. 42 | p. 43

13. You are administering an aerosol treatment to a patient via a small volume nebulizer when you realize that the output appears to be much less than normal. On checking the flow meter, you see that it is set to 4 L/min. Your next action is to:
a. Decrease the flow to 2 L/min
b. Increase the flow to 20 L/min
c. Leave the flow rate unchanged and search for other sources of decreased output
d. Increase the flow rate to 8 L/min

ANS: D
A flow rate of 2 L/min is insufficient to produce an effective mass median aerodynamic diameter (MMAD), whereas a flow rate of 20 L/min is too high for a gas-powered small volume nebulizer. The flow rate of 4 L/min is low enough to be causing the problem and should be addressed before searching for other solutions. On the basis of the results of Hess and colleagues in Figures 3-5 and 3-6, an average optimal volume and flow rate for many nebulizers is a volume of 5 mL with a flow rate of 6 to 8 L/min. Also, each model of jet nebulizer is designed to work best at a specific flow. It is important to operate a jet nebulizer with a compressor or a gas flow that matches the intended design.

REF: p. 43 | p. 44

14. The physician has ordered your patient to receive continuous administration of heliox with racemic epinephrine secondary to postextubation stridor. As you approach the bedside to deliver the ordered dose of racemic epinephrine via small volume nebulizer, what outcome should you expect with a gas flow of 10 L/min of heliox?

a. The nebulization time will be less than when using oxygen as a power gas.
b. The mass median aerodynamic diameter (MMAD) of the aerosolized medication will be greater than when using oxygen as a power gas.
c. There will be a twofold increase in nebulization time (compared with oxygen as a power gas).
d. The MMAD and nebulization time will remain unchanged.

ANS: C
At a given flow rate, nebulization time using heliox is approximately twice that of oxygen. Although the nebulization times are doubled, heliox provides a decrease in particle size. Research has shown a twofold increase in nebulization time when using heliox versus oxygen.

REF: p. 44

15. Your patient is receiving gentamicin (a high-viscosity antibiotic solution) via gas-powered small volume nebulizer. To compensate for the increased viscosity of the aerosol solution, you should
a. set the gas flow to 6 L/min.
b. set the gas flow to 12 L/min.
c. recommend a different method of drug delivery.
d. both A and C.

ANS: B
Higher viscosity antibiotic solutions such as gentamicin or carbenicillin require 10 to 12 L/min power gas flow rates to produce suitably small aerosol particles for inhalation. There is no need at this time to recommend a different method of delivery; delivery of antibiotics directly to the lung has been shown to produce fewer side effects and to require fewer dose administrations when used to combat or prevent lung infection.

REF: p. 44

16. You are instructing the parents of a 4-year-old child with asthma on how to deliver aerosolized medication at home via a traditional small volume jet nebulizer. When the parents ask how much of the medication actually reaches the child's lungs, you answer:
a. 5% to 10% of the total drug dose.
b. 10% to 15% of the total drug dose.
c. 50% to 60% of the total drug dose.
d. Nearly 100% of the total drug dose.

ANS: B
For a traditional small volume jet nebulizer, a typical emitted dose pattern results in the deposition of approximately 10% to 15% of the total drug dose.

REF: p. 32

17. All metered dose inhalers (MDIs) are powered by which propellant?
a. Chlorofluorocarbons (CFCs)
b. Soy lecithin
c. Hydrofluoroalkanes (HFAs)
d. Oleic acid

ANS: C

In agreement with the Montreal Protocol, all MDIs in the United States ceased use of CFCs by the end of 2008. Soy lecithin is not a propellant used to power an MDI; it is a surfactant used to prevent aggregation of drug particles and to lubricate the valve mechanism. HFAs are the new propellant of choice and became a requirement in 2008. Oleic acid, similar to soy lecithin, is a surfactant used to prevent the aggregation of drug particles and to lubricate the valve mechanism. CFCs and HFAs are the two types of propellants used with pressurized MDIs (pMDIs). Although CFC propellants used with pMDIs to create an aerosol were blends of liquefied gas (CFCs) in the past, because 1 CFC molecule can destroy 100,000 molecules of stratospheric ozone, the U.S. Food and Drug Administration (FDA) banned the use of CFC pMDIs. Hydrofluorocarbons (HFCs), also termed HFAs, have been identified as propellants that are nontoxic to the atmosphere and to the patient and that have properties suitable for MDI aerosol generation.

REF: p. 46

18. Which of the following are problems associated with patient use of an MDI?
1. Failure to coordinate inhalation and actuation of the inhaler
2. A too-rapid inspiratory flow rate
3. Failure to shake and mix canister contents
4. Cessation of inspiration as the aerosol strikes the throat

a. 1 and 2 only
b. 2 and 3 only
c. 1, 2, and 3 only
d. 1, 2, 3, and 4

ANS: D
Factors affecting MDI performance include poor patient coordination, oropharyngeal impaction because of high inspiratory flows, settling of canister contents (failure to shake), and abruptly ending inspiration because of oropharyngeal impaction.

REF: p. 50

19. Your patient carries an albuterol MDI, which she claims to use every few weeks. She complains that the first dose actuated from the device seems to have no effect on her bronchospasm. What suggestion would you make to correct the problem?
a. Discharge a waste dose before using the MDI
b. Replace the device
c. Administer three actuations instead of the two that her physician prescribed
d. Recommend use of a small volume nebulizer

ANS: A
Findings suggest discharging a waste dose if 4 hours have elapsed since the last use of an albuterol MDI (or if the device is stored in the valve-down position). The patient has not suggested that the device does not function, only that the initial dose seems to have no effect on her bronchospasm. A new device would likely produce the same result. Although the initial dose may have little or no effect, the practitioner should *never* change a patient's prescribed dosage without first consulting the physician (unless following a physician-prescribed protocol). A small volume nebulizer is not nearly as portable as an MDI and may cause compliance issues with the patient. Proper instruction would allow the MDI to be used with greater effectiveness.

REF: p. 48 | p. 49

20. Advantages of using portable ultrasonic drug nebulizers include that they
    a. require an electrical source.
    b. are inexpensive.
    c. are very durable.
    d. are small in size.

    ANS: D
    Advantages
    Small size
    Rapid nebulization with shorter treatment times
    Smaller drug amounts with no diluent for filling volume
    Can be used during car travel or camping
    Disadvantages
    Expense
    Fragility, lack of durability
    Require electrical source (either AC or DC)
    Possible degrading effect on drug must be determined

    REF: p. 42

21. Your patient asks how long to wait between the first and second doses from her albuterol MDI. You suggest that she
    a. pause 15 minutes between actuations.
    b. not pause at all, but deliver both actuations as quickly as possible, preferably over a time period of 1 second.
    c. pause 1 to 5 minutes between actuations.
    d. pause 30 minutes between actuations.

    ANS: C
    A pause of 1 to 5 minutes has been advocated between each puff of a bronchodilator MDI in an attempt to improve distribution of the inhaled drug in the lung. Also, rapid actuations may provide lower dosages of drug to the lung, probably as a result of turbulence and coalescence of particles.

    REF: p. 50

22. Barring any issues regarding patient coordination or ability to use the device correctly, how should you suggest that a patient administer a drug with an MDI if no spacer is available?
    a. Insert the MDI into the mouth and make a tight seal with the lips.
    b. Hold the MDI several centimeters in front of the open mouth.
    c. Never use the device without a spacer.
    d. Insert the MDI into the mouth and make a loose seal with the lips.

    ANS: B

Insertion into the mouth increases oropharyngeal impaction of the drug. Theoretically, actuating the MDI several centimeters in front of the mouth allows for slowing of particle velocity and evaporation of aerosol particles, resulting in less oropharyngeal impaction and loss. Barring the patient's inability to coordinate such a maneuver, this is the recommended method of administration. During acute episodes, it is understandably pertinent that a patient receive his or her medication, whether or not a spacing device happens to be available at the time.

REF: p. 50

23. Your patient informs you that she keeps her albuterol MDI stored in her refrigerator because she feels that this keeps the medication "fresher" for a longer time. What is your best response?
    a. Tell her that is a fine idea and that you may make the same recommendation to other patients.
    b. Suggest that she put it in the freezer instead because the colder temperature may keep the drug "fresher" for a longer time.
    c. Request that she no longer refrigerate the canister but instead store it at room temperature.
    d. Tell her to place the MDI in the bottom drawer of the refrigerator because this will keep it the "freshest."

    ANS: C
    Data indicate that dose delivery from CFC-propelled MDIs of albuterol decreases with temperature, with a 65% to 70% reduction in dose observed at 10° C.

    REF: p. 49

24. You are teaching proper use of a metered dose inhaler (MDI) to an elderly man who is having trouble coordinating actuation of the device with an inspiratory effort. What suggestion(s) would you make to help him with his problem?
    a. Suggest adding a reservoir device
    b. Suggest that if he cannot effectively use the MDI, he may need to switch to an SVN
    c. Both A and B
    d. Neither A nor B

    ANS: C
    The addition of a reservoir device offers an alternative for individuals who find it difficult to coordinate MDI actuation with inhalation. The practitioner should *never* suggest an increase in the dosage of a drug unless he or she has consulted the physician or is following a physician-prescribed protocol. An SVN may need to be used if the patient cannot effectively use the MDI.

    REF: p. 50

25. The physician has requested that you provide a patient with a reservoir device to use in conjunction with a metered dose inhaler (MDI). Given a choice, which type of device would you give the patient?
    a. Spacer
    b. Traditional holding chamber

c. Antistatic valved holding chamber
d. Non-antistatic valved holding chamber

ANS: C
Although the use of a spacer is preferred over no reservoir device at all, valved holding chambers can increase drug delivery, decrease oropharyngeal impaction, and help with coordination. Valves in the holding chamber act as a baffle reducing particle size, which reduces oropharyngeal impaction, and allow the patient to exhale without disrupting the aerosol inside the chamber. Valved holding chambers are superior to spacers. A traditional holding chamber has the advantage of a one-way valve compared with a spacer; it also has an inherent electrical charge that may affect drug delivery. Antistatic holding chambers reduce the electrostatic charge and can increase delivery of the aerosolized drug by 70%.

REF: p. 52

26. The greatest limitation to patient use of a dry powder inhaler (DPI) is
a. patient preference.
b. patient coordination.
c. patient ability to provide an inspiratory flow rate of 30 to 90 L/min.
d. cost.

ANS: C
Although patient preference may have a large effect on patient compliance, sufficient inspiratory flows are necessary to deliver aerosolized medication through a DPI. Because DPIs are breath-actuated devices, the need for patient coordination is reduced compared with delivery devices such as metered dose inhalers (MDIs). Flow rates of 30 to 90 L/min are necessary for effective delivery of medication from a DPI. Cost of DPI and MDI may be similar depending on medication availability.

REF: p. 53

27. The physician has granted your request to change a patient from a small volume nebulizer (SVN) to a metered dose inhaler (MDI) for administration of albuterol. The dose via SVN was 2.5 mg of drug. What is the equivalent dose via MDI to administer to your patient?
a. 1 puff
b. 2 puffs
c. 3 puffs
d. 4 puffs

ANS: B
The ratio of MDI to SVN dose of albuterol is approximately 1:12; it would require 2 puffs from an MDI (delivering 100 μg per puff) to equal 2.5 mg via SVN administration.

REF: p. 59

28. You have been asked to administer albuterol to a neonate who is currently not intubated. Which of the following aerosol devices would be age appropriate?
a. Dry powder inhaler (DPI)
b. Metered dose inhaler (MDI) with reservoir/mask
c. Small volume nebulizer (SVN)
d. Both B and C

ANS: D
A neonate is incapable of providing sufficient inspiratory flows to administer medication effectively via a DPI. Both MDI with reservoir/mask and SVN are age-appropriate devices for the administration of aerosolized medication to a neonate.

REF: p. 60

29. The physical method used to measure aerosol particle size distribution that uses multiple steps in determining sizes of aerosol particles is referred to as
    a. the laser scattering method.
    b. the Mie-scattering theory.
    c. a cascade impactor.
    d. none of the above.

    ANS: C
    A cascade impactor measures what is termed the *aerodynamic diameter of aerosols* because the measurement is based on the aerodynamic behavior (sedimentation velocity and impaction characteristics) of the particles in the cascade impactor. Measuring particle size with the *laser scattering method,* the instrument determines the relationship between the intensity and the angle of light scattered from a particle and then calculates the particle size based on the Mie-scattering theory.

    REF: p. 33

30. The physical mechanisms usually considered for aerosol particle deposition in the human lung include which of the following?
    1. Inertial impaction
    2. Gravitational settling
    3. Diffusion

    a. 1 only
    b. 2 and 3 only
    c. 1, 2, and 3 only
    d. 1 and 3 only

    ANS: C
    Three physical mechanisms usually are considered for aerosol particle deposition in the human lung: *inertial impaction, gravitational settling (sedimentation),* and *diffusion (Brownian motion).*

    REF: p. 35

31. Your patient is receiving a Duoneb via a small volume nebulizer (SVN) powered by compressed oxygen as part of her maintenance therapy drug regimen. The cylinder runs out before the treatment can be completed. What action would you suggest?
    a. Switch remaining treatment to a metered dose inhaler (MDI)
    b. Switch remaining treatment to a dry powder inhaler (DPI)
    c. Used compressed air to complete the treatment
    d. Chart that the treatment was not completed and move to your next patient

    ANS: C

SVNs are powered by compressed gas (air or oxygen), a compressor, or an electrically powered device.

REF: p. 37

32. Advantages of small volume nebulizers (SVNs) include which of the following?
1. Ability to aerosolize many drug solutions
2. Minimal cooperation or coordination required for inhalation
3. Drug concentration and dose can be modified
4. Normal breathing pattern can be used

a. 1 only
b. 2 and 3 only
c. 1 and 3 only
d. 1, 2, 3, and 4 only

ANS: D
Advantages of SVNs include the ability to aerosolize many drug solutions; the ability to aerosolize drug mixtures (i.e., more than one drug) with suitable testing of drug activity; minimal cooperation or coordination required for inhalation; usefulness in very young or very old patients, debilitated patients, and patients in acute distress; effectiveness with low inspiratory flows or volumes; normal breathing pattern can be used and inspiratory pause (breath hold) not required for efficacy; and drug concentrations and dose can be modified, if desired.

REF: p. 37

33. The most common error in use of pressurized metered dose inhalers (pMDIs) is
a. actuation of the pMDI at total lung capacity.
b. inadequate shaking and mixing of pMDI contents before use.
c. failure to coordinate actuation of pMDI with inhalation.
d. exhaling during pMDI actuation.

ANS: C
The number of patients using pMDIs incorrectly ranges from 12% to 89%, according to available studies. Problems with pMDI use include the following:

Failure to coordinate actuation of pMDI with inhalation (27%)
Too short a period of breath hold after inhalation (26%)
Too rapid an inspiratory flow rate (19%)
Inadequate shaking and mixing of pMDI contents before use (13%)
Abrupt cessation of inspiration as aerosol strikes throat (cold Freon effect) (6%)
Actuation of pMDI at total lung capacity (4%)
Firing of pMDI into mouth but inhaling through nose (2%)
Exhaling during pMDI actuation
Placing wrong end of inhaler in mouth or holding in wrong (nonvertical) position
Failure to take cap off before use
Firing of pMDI multiple times during a single inhalation

REF: p. 50 | p. 51

34. Asthma was recently diagnosed in your patient, and she was prescribed albuterol PRN. She asks you to suggest a delivery device for her albuterol. She is a college student with a busy schedule and spends little time at home. What suggestion would you make?
    a. pMDI
    b. Ultrasonic nebulizer
    c. Small volume nebulizer
    d. Breath-actuated nebulizer

    ANS: A
    Pressurized metered dose inhalers (pMDIs) have been used in respiratory therapy since its development by Maison in 1955. These devices are the most common aerosol generators prescribed for patients with asthma and chronic obstructive pulmonary disease (COPD) because they are small, pressurized canisters for oral or nasal inhalation of aerosol drugs and contain multiple doses of accurately metered drug. pMDIs are portable, light, and compact.

    REF: p. 46

35. A medical student asks about the different ways albuterol and ipratropium bromide can be delivered. What would you tell the student?
    1. pMDI
    2. DPI
    3. Respimat soft-mist inhaler
    4. Solution for nebulization

    a. 1 and 4 only
    b. 2, 3, and 4 only
    c. 1, 3, and 4 only
    d. 1, 2, 3, and 4

    ANS: C
    Albuterol and ipratropium bromide are available in a pMDI, nebulizer, and Respimat soft-mist inhaler.

    REF: p. 58 | p. 59

36. This device releases aerosol only during inspiration, allowing all released aerosol to be available for patient inhalation (examples: AeroEclipse®, Circulaire®).
    a. Breath-enhanced nebulizer
    b. Breath-actuated jet nebulizer
    c. Ultrasonic nebulizer
    d. Soft-mist inhaler

    ANS: B
    Breath-enhanced nebulizers allow more aerosol release during inspiration with decreased output during exhalation or breath hold through two one-way valves used to prevent the loss of aerosol to the environment. Breath-actuated nebulizers release aerosol only during inspiration because they are designed to increase aerosol drug delivery to patients by reducing loss of medication during expiration. Ultrasonic nebulizers (USNs) are electrically powered devices operating on the piezoelectric principle and capable of high output. A soft-mist inhaler is a propellant-free inhaler utilizing mechanical energy in the form of a tension spring.

REF: p. 38

37. This device allows greater aerosol release during inspiration, while decreasing output during exhalation or breath hold (example: Pari LC®).
    a. Breath-enhanced nebulizer
    b. Breath-actuated jet nebulizer
    c. Ultrasonic nebulizer
    d. Soft-mist inhaler

    ANS: A
    Breath-enhanced nebulizers allow more aerosol release during inspiration with decreased output during exhalation or breath hold through two one-way valves used to prevent the loss of aerosol to the environment. Breath-actuated nebulizers release aerosol only during inspiration because they are designed to increase aerosol drug delivery to patients by reducing loss of medication during expiration. Ultrasonic nebulizers (USNs) are electrically powered devices operating on the piezoelectric principle and capable of high output. A soft-mist inhaler is a propellant-free inhaler utilizing mechanical energy in the form of a tension spring.

    REF: p. 38 | p. 39

38. This device is electrically powered and operates on the piezoelectric principle and is capable of high output.
    a. Breath-enhanced nebulizer
    b. Breath-actuated jet nebulizer
    c. Ultrasonic nebulizer
    d. Soft-mist inhaler

    ANS: C
    Breath-enhanced nebulizers allow more aerosol release during inspiration with decreased output during exhalation or breath hold through two one-way valves used to prevent the loss of aerosol to the environment. Breath-actuated nebulizers release aerosol only during inspiration because they are designed to increase aerosol drug delivery to patients by reducing loss of medication during expiration. Ultrasonic nebulizers (USNs) are electrically powered devices operating on the piezoelectric principle and capable of high output. A soft-mist inhaler is a propellant-free inhaler utilizing mechanical energy in the form of a tension spring.

    REF: p. 40

39. This device is propellant-free and utilizes mechanical energy in the form of a tension spring to deliver medication.
    a. Breath-enhanced nebulizer
    b. Breath-actuated jet nebulizer
    c. Ultrasonic nebulizer
    d. Soft-mist inhaler

    ANS: D

Breath-enhanced nebulizers allow more aerosol release during inspiration with decreased output during exhalation or breath hold through two one-way valves used to prevent the loss of aerosol to the environment. Breath-actuated nebulizers release aerosol only during inspiration because they are designed to increase aerosol drug delivery to patients by reducing loss of medication during expiration. Ultrasonic nebulizer (USNs) are electrically powered devices operating on the piezoelectric principle and capable of high output. A soft-mist inhaler is a propellant-free inhaler utilizing mechanical energy in the form of a tension spring.

REF: p. 48

40. A measure of the dispersion of a distribution, calculated as the ratio of particle size below which 84% of the particles occur to the particle size below which 50% occur, in a log-normal distribution is termed
    a. count mode.
    b. count median diameter (CMD).
    c. mass median diameter (MMD).
    d. geometric standard deviation (GSD).

    ANS: D
    Count mode: Most frequently occurring particle size in the distribution.
    Count median diameter (CMD): Particle size above and below which 50% of the particles are found (i.e., the size that evenly divides the number of particles in the distribution).
    Mass median diameter (MMD) or mass median aerodynamic diameter (MMAD): Particle size above and below which 50% of the mass of the particles are found (i.e., the size that evenly divides the mass of the particles in the distribution).
    Geometric standard deviation (GSD): Measure of the dispersion of a distribution (i.e., the scattering of values from the average), calculated as the ratio of particle size below which 84% of the particles occur to the particle size below which 50% occur, in a log-normal distribution. This ratio determines how spread out the particles are in relationship to their size.

    REF: p. 33

41. _____ is the particle size above and below which 50% of the mass of the particles are found.
    a. Count mode
    b. Count median diameter (CMD)
    c. Mass median diameter (MMD)
    d. Geometric standard deviation (GSD)

    ANS: C
    Count mode: Most frequently occurring particle size in the distribution.
    Count median diameter (CMD): Particle size above and below which 50% of the particles are found (i.e., the size that evenly divides the number of particles in the distribution).
    Mass median diameter (MMD) or mass median aerodynamic diameter (MMAD): Particle size above and below which 50% of the mass of the particles are found (i.e., the size that evenly divides the mass of the particles in the distribution).
    Geometric standard deviation (GSD): Measure of the dispersion of a distribution (i.e., the scattering of values from the average), calculated as the ratio of particle size below which 84% of the particles occur to the particle size below which 50% occur, in a log-normal distribution. This ratio determines how spread out the particles are in relationship to their size.

REF: p. 33

42. The most frequently occurring particle size in the distribution is called
    a. count mode.
    b. count median diameter (CMD).
    c. mass median diameter (MMD).
    d. geometric standard deviation (GSD).

    ANS: A
    Count mode: Most frequently occurring particle size in the distribution.
    Count median diameter (CMD): Particle size above and below which 50% of the particles are found (i.e., the size that evenly divides the number of particles in the distribution).
    Mass median diameter (MMD) or mass median aerodynamic diameter (MMAD): Particle size above and below which 50% of the mass of the particles are found (i.e., the size that evenly divides the mass of the particles in the distribution).
    Geometric standard deviation (GSD): Measure of the dispersion of a distribution (i.e., the scattering of values from the average), calculated as the ratio of particle size below which 84% of the particles occur to the particle size below which 50% occur, in a log-normal distribution. This ratio determines how spread out the particles are in relationship to their size.

    REF: p. 33

43. The particle size above and below which 50% of the particles are found is termed
    a. count mode.
    b. count median diameter (CMD).
    c. mass median diameter (MMD).
    d. geometric standard deviation (GSD).

    ANS: B
    Count mode: Most frequently occurring particle size in the distribution.
    Count median diameter (CMD): Particle size above and below which 50% of the particles are found (i.e., the size that evenly divides the number of particles in the distribution).
    Mass median diameter (MMD) or mass median aerodynamic diameter (MMAD): Particle size above and below which 50% of the mass of the particles are found (i.e., the size that evenly divides the mass of the particles in the distribution).
    Geometric standard deviation (GSD): Measure of the dispersion of a distribution (i.e., the scattering of values from the average), calculated as the ratio of particle size below which 84% of the particles occur to the particle size below which 50% occur, in a log-normal distribution. This ratio determines how spread out the particles are in relationship to their size.

    REF: p. 33

44. A device that disperses individual doses that are premetered into a blister, which is mechanically punctured when the cover is lifted (example: Diskhaler®), is called a
    a. unit dose DPI.
    b. multiple unit dose DPI.
    c. multiple-dose DPI.

    ANS: B

Unit-dose, or single-dose, DPIs have individually wrapped capsules that contain a single dose of medication and deliver powder medication from a punctured capsule. Multiple unit-dose DPIs disperse individual doses that are premetered into blisters; the blister is mechanically punctured when the cover is lifted. Multiple-dose DPIs measure the dose either from a powder reservoir or from blister strips prepared by the manufacturers.

REF: p. 53

45. A device that measures the dose either from a powder reservoir or blister strips prepared by the manufacturer (examples: Twisthaler®, Flexhaler®, and Diskus®) is called a
    a. unit dose DPI.
    b. multiple unit dose DPI.
    c. multiple-dose DPI.

    ANS: C
    Unit-dose, or single-dose, DPIs have individually wrapped capsules that contain a single dose of medication and deliver powder medication from a punctured capsule. Multiple unit-dose DPIs disperse individual doses that are premetered into blisters; the blister is mechanically punctured when the cover is lifted. Multiple-dose DPIs measure the dose either from a powder reservoir or from blister strips prepared by the manufacturers.

    REF: p. 53

46. These devices have individually wrapped capsules that contain a single dose of medication and deliver powder medication from a punctured capsule (examples: Aerolizer® and HandiHaler®).
    a. Unit dose DPI
    b. Multiple unit dose DPI
    c. Multiple-dose DPI

    ANS: A
    Unit-dose, or single-dose, DPIs have individually wrapped capsules that contain a single dose of medication and deliver powder medication from a punctured capsule. Multiple unit-dose DPIs disperse individual doses that are premetered into blisters; the blister is mechanically punctured when the cover is lifted. Multiple-dose DPIs measure the dose either from a powder reservoir or from blister strips prepared by the manufacturers.

    REF: p. 53