Aerosol Therapy

**Use of Inhalational Drugs**

**Aerosol Therapy**

- **Inhaled Topical Drugs**
  - Concept is similar to that of dermatologic drug therapy
  - For the respiratory patient, the major benefits are
    - decrease risk of side effects
    - decreased dosage

From the Text

- **Key Terms and Definitions**
  - Page 36
- **Advantages and Disadvantages of Aerosol Drugs**
  - Box 3-1; page 37
- **Advantages and Disadvantages of SVN**s
  - Box 3-3; page 43
- **Advantages and Disadvantages of MDIs**
  - Box 3-4; page 48
- **Advantages and Disadvantages of Reservoir Devices**
  - Box 3-5; page 52

- **Advantages and Disadvantages of DPIs**
  - Box 3-6; page 54
- **Self-Assessment Questions**
  - p. 61
- **Clinical Scenario**
  - p. 61

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Aerosol Therapy

Gardenhire
Chapter 3
Aerosol Therapy

- Particle deposition
  - best deposition is with slow rates and large $V_t$
  - best deposition is of particles around 2 $\mu$m in diameter
  - very large particles (>15 $\mu$m) do not reach distal lung
  - very small particles (<0.5 $\mu$m) tend to be exhaled
  - particles <0.2 $\mu$m generally behave as a gas with the majority exhaled

Particle deposition

- size is important due to the location of receptors
  - parasympathetic (vagal) are located in larger, upper airways
  - beta receptors are located in smaller, conducting airways
- with most current aerosol generators, only 2 physical properties influence particle deposition
  - inertial impaction (5-15 $\mu$m) - occurs primarily in the area just below the larynx; particle velocity is highest and cross-sectional area of airway is smallest
  - gravitational settling ($\geq 1 $ $\mu$m) - this is a function of decreased particle velocity and large cross-sectional area; since this process is time dependent, an end-inspiratory pause will increase peripheral deposition
- prediction of particle deposition is further complicated because aerosols are generated at relatively dry ambient conditions, then introduced into the airway where temperature and humidity rapidly increase to BTPS; some studies have shown that particle size increases in a high humidity environment

- Patient factors
  - flow - 1983 study showed whole lung deposition is inversely proportional to inspiratory flow rates

- Small volume nebulizers (HHN, EzPAP, etc.)
  - major advantage - allow for nebulization of any solution
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- Small volume nebulizers (HHN, EzPAP, etc.)
  - deposition is still only about 10%
    - meds trapped inside nebulizer
    - dead volume
    - loss of aerosol during exhalation
    - loss of aerosol in nasopharynx when using mask
    - 35-60% of solution is delivered - with agitation this may be increased to 53-72%
  - considerations
    - volume affects tx duration; below 2 ml most don’t function well, above 6 ml duration is too long
    - effect of filling volumes and flow rate on treatment time

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    - effect of filling volumes and flow rate on treatment time
    - effect of flow rate on median aerodynamic diameter (MMAD)

- Small volume nebulizers (HHN, EzPAP, etc.)
  - type of power gas
    - use of gases other than oxygen can change the performance characteristics of a nebulizer
    - using heliox to deliver albuterol causes particle size and inhaled drug mass to decrease and doubles nebulization time

- Small volume nebulizers (HHN, EzPAP, etc.)
  - type of solution
    - particle size of a nebulized solution is related to surface tension and viscosity of the solution
    - on most nebulizers recommended filling volumes and flows are for aqueous bronchodilator solutions
    - other drugs/solutions, e.g. pentamidine or antibiotics require modifications in volume or flow
      - for example higher viscosity antibiotics may require flows of 10-12 L/min - which some nebulizers cannot accommodate
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- Small volume nebulizers (HHN, EzPAP, etc.)
  - nebulizer design
    - constant output - continuous nebulization; drug is lost during exhalation
    - breath enhanced - allows more aerosol during inspiration, decreased output during exhalation
      - PARI LC is an example
    - dosimetric (BAN) - aerosol released only during inspiration, and all released aerosol is available
      - AeroEclipse and Circulaire are examples

- Metered Dose Inhalers
  - in use over 60 years
  - the drug is either a suspension of micronized powder in a liquid propellant or a solution in a cosolvent mixed with the propellant
    - dispersing agents or surfactants are added to prevent aggregation of drug particles and lubricate the MDI mechanism
  - original propellants were chlorofluorocarbons (CFC)
    - since 1 CFC molecule can destroy 100,000 molecule of stratospheric ozone, CFCs were banned as of 12/31/2008

- Metered Dose Inhalers
  - hydrofluorocarbons (hydrofluoroalkanes; HFA) are now used
  - these new propellants produce less plume force and warmer aerosol temperatures
  - some pts may think there is reduced or no drug delivery with HFA MDIs

- Metered Dose Inhalers
  - the reality is that some of the HFA MDIs have increased the traditional 10% of drug inhaled into the lung to 50-60%

- Metered Dose Inhalers
  - reservoir devices
    - can modify the discharged aerosol in three ways
      1. allow space and time for vaporization of propellant and evaporation of large particles to smaller ones
      2. allow the high initial particle velocity (>30 m/ sec) to decrease
      3. act as holding chambers so canister actuation can be separated from inhalations, simplifying the coordination
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- Metered Dose Inhalers
  - reservoir devices - terminology
    - reservoir device - generic term
    - spacer - simple tube or extension device
    - valved holding chamber - spacer with one-way valves to contain the aerosol cloud until inspiration occurs

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- Dry Powder Inhalers
  - similar to MDI - med is in powdered form
  - main advantage is that DPIs are breath actuated - no hand/breathing coordination required
  - main disadvantage is that they require a high (30-90 L/min) inspiratory flow to dispense the drug
  - may preclude use by children under age 5 and any pt with severe airflow obstruction

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- Dry Powder Inhalers
  - mechanism
    - Turbuhaler (Pulmicort) and Diskus (Advair, Serevent, Flovent) - multiple dose devices
    - Aerolizer (Foradil) and HandiHaler (Spiriva) - use individual capsules for each treatment
  - clinical efficacy
    - DPIs and MDIs show similar efficacy and results in most clinical situations

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- MDI/DPI/SVN
  - equipotent doses? (p. 57)
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- Newer Devices
  - Development of increasingly efficient MDIs, DPIs, and SVNs are producing increases in the percent of drug deposited in the lung

- Patient/Device Interface
  - Face Mask Administration
    - Use of a face mask with an aerosol generator usually occurs with infants and young children or with debilitated, unresponsive patients
    - The clinical efficacy of a face mask in a pediatric application has been studied, comparing face mask and mouthpiece delivery of nebulized albuterol in children and adolescents ages 6 to 19 years for emergency department treatment of acute asthma

- Patient/device interface
  - Face mask administration
    - Face mask administration did not significantly improve lung function measures
    - Greater tremor was observed with the face mask group
      - Higher systemic level of drug?

- Patient/device interface
  - Endotracheal Tube Administration
    - Data quantifying the efficiency of aerosol administration with this interface are well summarized
    - Evaluation is complicated by the number of variables

- Patient/device interface
  - What is known:
    - MDIs and nebulizers can be effectively used in administering inhaled agents to a patient receiving mechanical ventilation
    - The diameter of the tube plays a role in the impaction of aerosol particles
      - The narrower the tube, the lower the percentage of drug that is delivered to the patient

- Patient/device interface
  - What is known:
    - Reducing humidity may increase the number of inhaled particles
      - Disconnecting a circuit to bypass the humidifier could lead to increased risk of VAP
    - HMEs should be bypassed when delivering aerosolized agents
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- Patient/device interface
  - What is known:
    - Using a less dense gas (heliox) can increase particle deposition
    - Nebulizers should be positioned 30 cm from the ETT, not between the circuit Y and the ETT
    - With MDIs, precise timing of actuation with inspiration by the ventilator may increase drug delivery by 30%