Humidity and Aerosol Therapy

CRC 330
Cardiorespiratory Care
University of South Alabama
Objectives for Aerosol and Humidity Therapy

- Definition of terms
- Basic science
- Goals
- Contraindications, hazards, precautions
- Assessment of outcome
- Equipment
- Procedures
- Laboratory exercises
- Clinical practice
Definition of terms

- **Absolute humidity**
  - the actual water content of a gas in gm/m³ or mg/L
  - measured by weighing the extracted volume of water from a gas
  - usually indicated in a table
  - \( AH = 16.42 - 0.73T (^\circ C) + 0.04T \)
Relative Humidity

- % expression of the actual water vapor content of a gas compared to its capacity to carry water at a given temperature
- Capacity of a gas to hold water increases with temperature
- As the absolute humidity increases at a given temperature, the relative humidity increases
- When gas is saturated, relative humidity is 100%

\[
RH = \frac{\text{content}}{\text{capacity}} \times 100
\]

- capacity = absolute humidity at 100%
- At 98.6F, absolute humidity is 44 mg/L
Body humidity

- 44mg/L, 5 cm past carina
- Isothermic saturation boundary
- Humidification occurs in the upper airway

Humidity deficit

- Difference between body humidity and the humidity of delivered gas
- 21°C and 100% RH, content is 18 mg/L, so HD is 26 mg/L
- 21°C and 50% RH (as in an air conditioned room), content is 9 mg/L, so HD is 35 mg/L
Dew point

- Temp at which water vapor condenses
- Important in RC equipment as the vapor in a delivery system cools, and condensation occurs, blocking gas delivery

Vapor vs. aerosol

- Vapor is a suspension of water molecules in air (<.25 u)
- Device that increases water vapor is a humidifier
- Aerosol is a suspension of water particles (<.25 to 100 u) in gas
- Device that makes aerosols is a nebulizer
Upper airway structure and function

- Nose to vocal cords
- Functions
  - conduction of air
  - protective function (ciliated columnar epithelial cells)
  - 30-50% of anatomic deadspace
  - speech and smell
  - warms and humidifies the inspired air, traps heat and humidity in expired air
Components of the Upper Airway

- Nose
- Nasopharynx
- Oropharynx
- Laryngopharynx
- Larynx
The nose as humidifier

- Nasal interior is cone shaped, with a large surface area
- Coated by a mucus membrane
- Nasal surface area is increased by the well-perfused turbinates
- Adds 250 mL H₂O/day to inspired air, resulting in 75-80% RH at BT
- Most of this is recaptured during exhalation
- The artificial nose humidifier attempts to mimic this function
Consequences of inadequate humidification

- Decreased ciliary activity and mucus movement
- Inspissation of mucus
- Inflammation of mucosa
- Further retention and incrustation of mucus
- Bacterial infiltration, atelectasis and pneumonia

Factors that increase the likelihood of these consequences

- fever (increased water loss)
- artificial airway (bypasses the upper airway)
- nasal congestion
Goal 1 of humidity therapy: Humidify therapeutic gases

- Increase the RH of dry therapeutic gases
- Entire respiratory tract attempts to overcome humidity deficit
- Inspissated secretions block the ability of water vapor to come from the mucosa
- Need to meet or exceed the normal ambient humidity
  - ANSI standard is 10 mg/L
  - equates to 50% RH at 72°F
Goal 2 of humidity therapy: Provide saturated gas near BT when the upper airway is bypassed

- The complications of inadequate humidification are most likely to occur
- Heated humidifiers should match the humidity provided by the upper airway
- Mucociliary clearance is effective at 32-42°C at 33 mg/L (don’t exceed 40°C)
Goal 2 of humidity therapy: Provide saturated gas near BT when the upper airway is bypassed

- Mucociliary clearance is decreased at higher temperatures
- ANSI recommends humidifier output of at least 30 mg/L at 30°C
- Results in a RH at 100% at 32-34°C to maintain mucociliary function
Humidity versus Exposure time and Mucosal Damage

Factors effecting humidifier performance

- Surface area exposure between gas and water
- Time of gas water-exposure at the interface
- Temperature of the reservoir and downstream connective tubing
Humidity Increases with Temperature

Equipment: Pass-over humidifier

- Reservoir of water over which gas passes en route to the patient
- Unheated, have relatively low efficiency
- Heated pass-over humidifiers for ventilators meet ANSI standards and feature:
  - servo temperature control
  - comprehensive alarm systems
  - noncompliant, small volume humidifier chamber
  - heated wires in the circuit to control rainout
- Fisher and Paykel
Equipment: Bubble Diffusion Humidifier

- Directs a flow of gas below water surface
- Gas is diffused by a stone or other porous material and broken into bubbles, increasing surface area
- Used to humidify oxygen administered via low-flow devices at > 4L/min
- Spit at high flows (>10L)
- 60-100% RH to the dry gas at their operating temperatures but RH is 35-40% at BT
- Also relies upon the humidification provided by the mucosa
- Pressure pop-off sounds if obstructed
Equipment: Wick humidifier

- Bird, Hudson-RCI Conchatherm and others
- Paper wick is partially immersed in water
- Wick is fully saturated, and is surrounded by a heating element
- Gas enters the humidifier chamber, and picks up water vapor from the wick
- Highly efficient at high flows (100% RH at all temperatures)
- Servo-control of temperature, auto-filling, alarms
- Low compliance, resistance, and compressible volume
Wick Humidifier
Under normal conditions the gas is heated to 37 °C in the invasive mode, 31 °C for the non-invasive mode.

4.1.1 Heater wire operation

Figure 4.1 Typical Heater Wire Humidifier Setup

Humidified gas from the chamber travels through the inspiratory limb, where its temperature must be maintained in order to prevent the generated humidity from condensing. This is achieved with a heater wire encapsulated within the inspiratory limb. The humidifier maintains...
Equipment: Vapor-phase humidifier

- Small volume of water is heated below a hydrophobic filter
- Water vapor diffuses through the filter
- Flow of gas over the filter carries vapor to the patient
- Can use tap water
Membrane Type Humidifier

(Modified from Fink J, Cohen N: Humidity and aerosols. In Eubank D, Bons R, editors: Principles and applications of cardiorespiratory care equipment, St Louis, 1994, Mosby.)
Equipment: HME

- AKA artificial nose, hygroscopic condenser humidifier
- A chamber containing cellulose, synthetic felt or polypropylene material
- Upon exhalation, heat and moisture are trapped by the material
- Upon inhalation, heat and moisture are liberated by the material for return to the lower airway
Heat and Moisture Exchangers
Heat and moisture exchangers

- No water or heating element in a passive device; newer device available
- Placed into the ventilator circuit between the Y and the endotracheal tube
- Three types
  - Condenser humidifier
  - Hygroscopic humidifier
  - Hydrophobic humidifier
HMEs

- Most meet ANSI recommendations (10-31 mg/L @ 30°C)
- ISO: 30 mg/L, standard connections, low compliance, minimal DS, weight and flow resistance
- Limited clinical circumstances:
  - Pt must be normothermic
  - adequate hydration
  - Pt does not require therapeutic hydration for retained secretions
- Reserved for use <96 hours (CPG)
Heat and moisture exchangers

- Contraindications (CPG)
  - thick, copious or bloody secretions
  - expired Vt <70% of delivered Vt
  - BT<32C
  - high spontaneous Ve (> 10 b/min)

- Remove or bypass during aerosol treatments

- Cost-effective

- May help decrease nosocomial infection
Heated High Flow Therapy

- Vapotherm
  - Membrane humidifier
  - Up to 40 L/min
Heated High Flow Therapy

- Aquinox
  - heated aerosol is filtered just proximal to the patient
  - 15-35 L/min at 95-100%
Heated High Flow Therapy

- **Patient Benefit**
  - FiO₂ increases with nasal cannula at > 6-8 L/min
  - High flow air is beneficial
  - Improved humidification, ciliary movement and mucous clearance
  - Small amount of CPAP
  - Flushes anatomic deadspace

- **Current use of HFT**
  - In place of NRBM
  - Useful in IPF, CHF, pulmonary edema, COPD
  - Avoidance of mechanical ventilation
  - Heliox and nitric oxide
Humidifier/Humidity Hazards

- Alterations in heat and water exchange
- Infection
- Electrical shock
- Tubing meltdown if covered
- Underhydration if inadequate humidity is provided
- Deadspace and hypoventilation with HME
- Inadvertent tracheal lavage, excessive rainout
- Condensate
Evaluation of Humidifier Effectiveness

- Check to see there are no hazards or complications
- Monitor temperature of the gas
- Remove condensate
- Evaluate sputum and breath sounds
  - sputum should be easily suctioned
  - avoid mucus plugs
  - Fog at wye
- Do not cover tubing or allow a fan to blow on tubing
Monitoring Humidification

- On intubated patients, keep temp at 37°C, 100%RH, 44 mg/L
  - keep temperature probe outside of environmental enclosures
  - keep alarms between 36 and 39°C
  - watch water level, assure that autofill system is operational
  - Hygrometer
  - Adjust humidity so droplets/fog is seen at wye
Infection Control of Humidifiers

- Wear gloves while changing
- Reusable heated humidifiers should be disinfected or sterilized
- Use sterile water to fill the reservoir
- Condensation is infectious waste, dispose of carefully
- Do not drain condensate back into the reservoir
Characteristics of Aerosols

Output

- Mass of fluid or drug in an aerosol
- Expressed as a mass or proportion of dose placed in the nebulizer
- Output rate is mass/time: mg/min
- Variation in output among nebulizers
  - emitted dose is the mass leaving the mouthpiece
- Measured gravimetrically (weight) or by assay (quantity of drug)
Characteristics of Aerosols

Particle size

- Depends on substance being nebulized, method of aerosol generation, environmental conditions
- Measured using cascade impaction or laser diffraction
- Expressed as mass median aerodynamic diameter or as volume median diameter, in microns
- When describing as MMAD, 50% of particles are above and 50% are below the MMAD
- Most medical aerosols are of differing sizes, referred to as heterodisperse
Characteristics of Aerosols

Deposition

- Particles leaving the suspension gas, attaching to a surface
- A portion of the emitted dose is inhaled
- A fraction of the inhaled dose is deposited in the lungs (respirable dose)
- The inhaled mass is the amount of drug inhaled
- The proportion of the drug mass in particles that are small enough (fine particle fraction) to reach the lower respiratory tract is the respirable mass
- 1-5% of the inhaled drug is exhaled (particles too small to deposit)
Deposition

Inertial impaction

- occurs when suspended particles in motion collide with and are deposited on a surface
- when the gas stream changes direction, the particle maintains its inertia and impacts
- increases in turbulent flow, obstructed or tortuous pathways, an inspiratory flow > 30 l/min
Deposition

Gravimetric sedimentation

- aerosol particles settling due to gravity, proportional to mass
- primary mechanism for settling of particles 1-5 μ
- breath holding enhances sedimentation
Deposition

Brownian diffusion

- mechanism of deposition of particles < 3μ in the respiratory region where bulk flow ceases

- Particle size and deposition
  - Upper airway: 5-50μ
  - Lower airways: 2-5μ
  - Parenchyma/alveoli: 1-3μ
Particle sizes and Deposition

(Modified from Yu CF, et al: Am Ind Hyg Assoc J 40:999-1005, 1979.)
Deposition

Aging

- Process by which an aerosol changes over time
- Particles get smaller with time due to evaporation.
- Particles get larger by being hygroscopic
Ventilatory Pattern and Airway Obstruction

- > 1 L/sec encourages turbulent flow and proximal deposition
- < .5 L/sec encourages laminar flow and deeper deposition
- important for MDI and DPI use
- directly related to inhaled volume, inversely related to ventilatory rate
- breath hold can increase alveolar deposition
- mouth breathing enhances deposition
Clearance

- Mucociliary escalator (13.5 mm/mm)
- Goblet cells 5μm mucus layer; Sol/gel layers
- Encapsulation of silica/asbestos
- Phagocytosis
- Clearance of mucus is aided by aerosols, medications, CPT, directed coughing, other tracheobronchial hygiene maneuvers and devices
Indications for Bland Aerosol

- The presence of upper airway edema
  - croup, subglottic edema, postextubation edema, postoperative management of the upper airway
  - soothing to inflamed tissues
  - MMAD>5u
  - physical findings include stridor, brassy croup-like cough, hoarseness following extubation, diagnosis of LTB or croup, suggestive clinical history, patient discomfort associated with airway instrumentation
Indications for Bland Aerosol

- The presence of a bypassed upper airway
  - important source of moisture for humidifying the carrier gas
  - solution to be nebulized may be heated so it is closer to BT
  - may be used in lieu of a heated humidifier, but is not as efficient
    - because of difficulties in maintaining temperature at the patient airway
    - possible irritation of the airway by particles
    - infection risk from the equipment
  - MMAD 2-10u
Indications for Bland Aerosol

The need for sputum specimens
- large volume, high density mists
- water and saline, 3-10%
- often heated
- hypertonic saline draws fluid out of the mucosa into the bronchial lumen
- water condenses on the mucosa, increasing its volume
- MMAD 1-5μ
Indications for Bland Aerosol

- **Dry, retained secretions**
  - directly deposits fluid on the mucosa, making it slippery, perhaps aiding in coughing and expectoration
  - the physical properties of mucus are minimally effected by water
  - not a substitute for adequate systemic hydration
Assessment of Outcome

- Bland aerosol therapy, one or more of the following:
  - decreased WOB, stridor, dyspnea
  - improved vital signs, ABGs, SpO₂
- If for sputum induction with hypertonic saline, an adequate sputum sample
- Improved expectoration, easier suctioning
- Improved sputum characteristics
  - less viscid
  - Ease of expectoration
Hazards of Aerosol Therapy

- Wheezing or bronchospasm
- Bronchial obstruction
- Infection
- Overhydration
- Patient discomfort
- Caregiver exposure
  - Airborne particles
  - Body fluid
- Medication effects
Aerosol Therapy Equipment

- Gas powered nebulizers
  - have common features
  - jet
  - capillary tube
  - reservoir
  - baffles
Bernoulli Principle

- Gas enters the reservoir through a restricted orifice jet
- Lateral to the jet orifice, a negative pressure is generated
- Adjacent to the jet is the top of the capillary tube, which is immersed in the solution
- Atmospheric pressure pushes down on the solution
- Pressure gradient causes solution to go up the tube
- Liquid is blasted into particles by the jet of gas. Jet velocity determines quantity of aerosol
- Particles impact on a baffle, which causes rainout of excessively large particles, and breaks-up other particles into smaller ones
Large Volume Jet Nebulizer
Large Reservoir Air Entrainment nebulizers

- Bland aerosol for airway comfort
- Capacity range 0.5 –3.0 L, 1-2 mL/min.
- 28-100% oxygen depending on model
- Source gas flow 12-15 L/min.
- Heating the solution increases the total water output and % body humidity, up to 75-95% RH at BT
- Solution temperature decreases during nebulization
Small Volume Nebulizers

- Factors affecting SVN function include nebulizer design, gas pressure, gas density, and medication characteristics.
- Used to nebulize medications for medicated aerosol therapy.
- Usually powered by a small compressor or flow meter, 8-10 L/min; droplet size is inversely proportional to flow.
- Reservoir capacity up to 30 mL.
Small Volume Nebulizers

- Patient interface is usually a mouthpiece, preferred over mask
- Reservoirs may be a tube or bag
- Side stream versus main stream
- .5-2.2 mL dead volume, so fill volume should be 3-4 mL
- MMAD is 1-5μ
Small Volume Nebulizers

- Run until they sputter, tap and repeat
- Emitted dose is about 10% of the fill volume
- Tend to be gravity dependent
- If using heliox, a flow of 2-3x more is needed
Small Volume Nebulizer

- Continuous nebulization wastes medication
- Some nebulizers (Pari) are breath enhanced, entrain air through the nebulizer during inspiration
  - Increases inhaled mass by 50%
Breath Actuated Nebulizer

- AeroEclipse
- Reduce or eliminate nebulization during exhalation
- Increases inhaled aerosol mass by 3-4x compared to usual SVN
Respirgard II

- Special filtered sidestream nebulizer used for Pentamidine in the treatment of Pneumocystis carinii
Aerosols to Children

- Breathing rate is faster
- Nose breathing filters out large particles
- Use a mask when tolerated
- Do not use the blow-by technique: no aerosol is delivered
- Do not administer tx to crying child: no aerosol delivery
Metered dose inhalers

- Mainstay of aerosol therapy
- Small vial of medication and HFA propellant gas
- Squeeze of the device releases a premeasured volume of solution, which the patient inhales
- Initial droplet size may be up to 40u, they shrink as the propellant evaporates
- Initial velocity of the plume is high (30m/sec)
- These factors lead to significant impaction in the oral pharynx, unless proper technique is used
Metered Dose Inhalers

Diagram showing the components of a metered dose inhaler:
- Canister
- Drug/propellant liquid mixture
- Actuator
- Metering valve
- Actuator seat
- Actuator nozzle

Diagram illustrating the metering valve function:
- CLOSED
- OPEN
- Canister
- Metered dose of drug
- Actuator seat
- Nozzle

Metered Dose Inhaler with Spacer
Combivent Respimat

- Soft mist inhaler
- Low velocity (10mm/sec)
- Twist and press button
- 40% deposition
- Hand-breath coordination
- No spacer
Evaporative Small Particle Aerosol Generator (SPAG)

- Used for administration of ribavirin (Virazole) in the treatment of Respiratory Syncytial virus
- Ribavirin is reconstituted from a powder with water and placed in the reservoir
- The liquid is nebulized, then the aerosol flows into a drying chamber that has its own gas flow
- The drying chamber reduces the size of the aerosol particles; 95% of the particles are <5u
- Medication goes through large bore tubing to a ventilator or tent; a scavenging system is used
Ultrasonic nebulizer

- Electric current produces sound waves that break up solution into aerosol particle
- A radio frequency generator creates a frequency of 1.3-1.4 MHz (determines particle size)
- The frequency is transmitted through a cable to a piezoelectric crystal
  - crystal changes shape when charged, to focus the energy
  - changes electrical energy into vibrational energy
- The vibrations are transferred through a diaphragm into the solution reservoir, where a geyser is created
Ultrasonic nebulizer

- Continuous disruption of the geyser creates the particle mist
- A blower pushes the particles from the solution chamber to the patient through aerosol tubing
- The solution cup may be self-filling, disposable, or permanent
- Amplitude/power control determines mist density
- Most often used intermittently for sputum induction
- Can deliver up to 500 g/L, MMAD of 5μ, range 1-10μ
- Used when other means are ineffective
- Small volume USNs are available for medicated aerosol therapy, but their efficacy may be limited as drug structure may be disrupted by the vibrations
Handheld USN

From ventilator → Medication mist → To patient

Baffles
Medication cup
Sterile buffer water
Ultrasonic waves
Crystal

Fountain, generated by ultrasonic waves

Cable from control unit

Ultrasonic generator (not visible)

(Courtesy Siemens, Tarrytown, NY.)
Aerogen Nebulizer

- New-generation vibrating mesh technology
- Side stream nebulizer
- MMAD 2-3µ
- Must be kept charged as it is battery powered
Adjunct Aerosol Equipment

- Heater
- Tubing with drain bag
- Delivery devices
  - mouthpiece is most effective, but difficult to use other than for intermittent use
  - mask is most common for continuous use, large holes
  - face tent OK for humidity, but not for oxygen precision
  - oxyhood for infants
  - mist tent for airway disease in pediatrics, oxygen not accurate
  - jet mixing mask adapter
Adjunct Aerosol Equipment

- Tracheostomy collar for patients with a tracheostomy
  - Does not pull like a T-piece
- T-piece for patients with an endotracheal tube
  - Use a 12” piece of reservoir
  - Assure it does not pull
  - Assure presence of mist during inspiration
Infection Control

- Standard precautions
- SVN and LVN are for single patient use, change q24°
- Rinse with sterile water and air dry SVN between treatments
- Handle medications aseptically
- Tap water should not be used
- Medications from multiple dose containers should be discarded after 24°
- MDI spacers are single patient use
Medicated Aerosol Therapy

- Indication: the need to deliver an aerosolized drug to the lower airways
  - beta adrenergic bronchodilators (Albuterol, etc)
  - anticholinergic agents (Ipratropium, tiotropium)
  - anti-inflammatory agents (steroids)
  - antiasthmatic/mediator-modifying compounds (cromolyn)
  - mucolytic/mucokinetics (Acetylcysteine)
  - antifungal agents (Pentamidine Isoethionante: Nebupent)
  - antiviral agents (Ribavirin: Virazole)
Small Volume nebulizers

- **Indications**
  - person unable to follow instruction for MDI
  - poor inspiratory capacity
  - cannot inspiratory hold
  - rapid/unstable ventilatory pattern
  - non-standard drug concentration/solution

- **Use**
  - 3-5 mL, 6-8 L/min air flow
  - < 10 mm. treatment time
  - slow deep breaths, insp. hold if possible, but any breathing pattern is probably effective
Small Volume nebulizers

- **Advantages**
  - any drug solution, concentration or mixture, air or $O_2$
  - uncoordinated, very young, or in acute distress
  - effective with low inspiratory flows or volumes
  - inspiratory pause not required
  - No CFC

- **Disadvantages**
  - equipment is cumbersome and expensive
  - longer treatment time
  - requires cleaning, equipment contamination possible
  - facemask gives a cold wet spray, face and nasal deposition
  - requires compressed gas source (oxygen or compressor)
  - variable performance
SVN during NPPV
SVN during NPPV

### Table 6. Technique for Using a Nebulizer During Bilevel Ventilation

- Assess patient, especially hemodynamic status, mask fit and tolerability, and patient-ventilator synchrony
- Minimize leaks in the mask and or circuit
- Fill nebulizer up to optimal fill volume (4 to 6 mL for a jet nebulizer)
- Place nebulizer upright between air leak in circuit and mask
- Select modest level of CPAP (~5 cm H₂O) and inspiratory pressure support (10 to 15 cm H₂O)
- Humidify inspired air if patient is receiving NIPPV for > 30 min
- Operate nebulizer with gas flow of 6–8 L/min
- Tap nebulizer periodically until it sputters
- Monitor patient and assess clinical response
- Remove nebulizer from circuit, rinse with sterile water, air dry, and store in a clean space
- Reconnect circuit
- Observe patient for any adverse effects

Dhand, J aero med and pulm drug del 2012;25(2):63-78.
Metered Dose Inhalers

- Indications for use
  - ability to follow instructions
  - ability to mechanically coordinate actuation and breathing, breath actuated MDIs are now available
  - adequate inspiratory capacity (>900 mL)
  - capable of inspiratory hold
  - stable ventilatory pattern
MDI Procedure

- Shake canister, prime according to drug being used
- Place MDI between lips, mouth closed, tongue out of the way
- Exhale to end tidal volume
- Start inhaling slowly, actuate canister
- Inhale slowly to TLC
- 5-10 sec breath hold
- Exhale normally
- Repeat after 1 minute
Metered Dose Inhaler

**Advantages**
- portable and compact
- efficient, reproducible aerosol dose delivery
- short treatment time
- no drug preparation or contamination
- some are breath-actuated

**Disadvantages**
- coordination and instruction required
- fixed drug concentrations, more actuations
- airway irritation from propellant may occur
- high oropharyngeal loss if spacer is not used
- environmental release of chlorofluorocarbons
- Not all medications available
MDI during NPPV
### Table 5. Technique for Using pMDI and Chamber Spacer During Bilevel Ventilation

- Assess patient, especially hemodynamic status, mask fit and tolerability, and patient-ventilator synchrony
- Minimize leaks in the mask and or circuit
- Place cylindrical spacer (volume ~ 140 mL) between circuit and mask
- Shake pMDI canister well and place it in the adapter of the spacer chamber
- Select modest level of CPAP (~ 5 cm H₂O) and inspiratory pressure support (10 to 15 cm H₂O)
- Humidify inspired air if patient is receiving NIPPV for > 30 min
- Actuate pMDI at the beginning of inspiratory air flow from the ventilator
- Repeat actuations with at least 15 sec between actuations
- Monitor patient and assess clinical response
- Administer the specified number of doses
- Remove pMDI and chamber spacer and reconnect circuit
- Observe patient for any adverse effects

Spacers

- Technical description
  - reservoirs ranging from 80-750 mL to separate the MDI from the patient’s mouth
  - allow attachment of the MDI, have a mouthpiece
  - may also be installed into ventilator circuit
  - are cylindrical or conical

- Indications for use
  - inhalation of drugs from an MDI: optimal lung delivery and minimizes oropharyngeal deposition
  - subjects with poor hand-breathing coordination
Spacers

- **Advantages**
  - increases time and volume to allow aerosol particle ageing which reduces particle size, allows evaporation of propellant
  - reduced oropharyngeal particle deposition
  - removes the need for hand-breath coordination

- **Disadvantages**
  - large and cumbersome
  - contamination
  - some assembly
  - increased treatment time
Spacers/ VHC

- MDI
- OptiHaler
- Myst Assist
- Toilet paper roll
- Ellipse
- InspirEase
- AeroChamber
- OptiChamber
- ACE
- MediSpacer
Dry Powder Inhaler

- **Description**
  - small MDI sized device into which one places a capsule of dried medication (Spiriva Handihaler, Foradil Aerolizer)
  - May be multi-dose (Advair, Flexhaler, Asmanex)
  - breath actuated

- **Indications**
  - inadequate coordination for MDI use
  - Availability of desired drug
Dry Powder Inhaler

- **Use**
  - load dose/capsule as instructed
  - exhale fully away from the device
  - lips on mouthpiece, inhale quickly
  - repeat if powder remains in the device
Dry Powder Inhaler

- **Advantages**
  - small and portable, no propellants
  - short prep and admin times
  - No propellant
  - Breath actuated
  - Less coordination
  - Dose counter

- **Disadvantages**
  - reaction to lactose or glucose
  - high inspiratory flowrate needed
  - requires coordination to load capsule
  - Some DPIs are single dose
  - Not all medications available
Foradil Inhaler

Tiotropium Inhaler
InCheck Dial

- Measures inspiratory flow
- Scales indicating desired flow ranges for various devices
- Assist with patient teaching for MDI, DPI
## Age Considerations

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<th>Minimum Age</th>
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