Important Principles of Aerosol Therapy for Your Patients

By Dave Henry RRT
Clinical Specialist
DeVilbiss Healthcare Inc.

Objectives

1. Describe various methods of aerosol delivery and benefits and limitations of each method.

2. Describe terminology related to aerosol delivery and issues related to concepts in aerosol therapy.

3. Describe various methods of measuring an aerosol and benefits and limitations of those methods.

Disclaimer

Appendix 3 Declaration of Vested Interest Form

Name of presenter: Dave Henry RRT
Name of employer: DeVilbiss Healthcare Inc.

Definition: A presenter may have an interest in or affiliation with an organization, which does not prevent him or her from making a presentation, however, the audience must be informed of this affiliation before the presentation of the activity. For this purpose a real or apparent conflict of interest is defined as having a significant financial interest in a product to be discussed during the presentation; being or having been an employee of a company with such financial interest and/or having had substantial research supported by an industry to study the product to be discussed at the presentation.

[ ] No, I have no real or perceived conflicts of interests that relate to this presentation.

[ X ] Yes, I have the following real or perceived conflicts of interest that relate to this presentation:

I am an employee of DeVilbiss Healthcare and we manufacture respiratory home care equipment.

My presentations are not product specific but relate to the principles involved in best utilizing certain technologies in the home environment.

Polling Question #1

What is your current job title?

a. Home care therapist
b. Hospital based therapist
c. Nurse
d. Other
Aerosol Therapy Indications

- Aid to Bronchial Hygiene
  - Secretions are hydrophilic
  - Hydrate secretions
  - Restore and maintain mucus blanket
  - Promote expectoration
  - Improve effectiveness of cough

Hazards of Aerosol Therapy

- Swelling of retained secretions
- Airway obstruction
- Precipitation of Bronchospasm
- Particulate is foreign body
- Fluid overload
  - Infants only - Congestive Heart failure
- Cross contamination
- Nosocomial infection
- Chemical effects

Polling Question #2

Which of the following are benefits of aerosol delivery of medication.
- Drug NOT disrupted by aerosol delivery
- Topically delivered on area of concern
- Less side effects than systemic delivery of the medication
- All the above

Aerosol Therapy Indications

- Deliver Medication
  - Drug not disrupted by aerosol delivery
  - Topically on area of concern
  - Less side effects compared to systemic delivery of medicine
Device Options

- Compressor Nebulizers (Jet nebulizers)
  - Advantages
    - More medication - longer duration
    - Most meds can be delivered by nebulizer
    - Passive system - easy delivery
    - Works well on children and older adults.
  - Disadvantages
    - Larger
    - More costly?
    - Electricity or battery required

Treatment Options

- MDI
  - Advantages
    - Small
    - Compact
    - Inexpensive?
  - Disadvantages
    - CFC propellant
    - Difficult to coordinate with inhalation
    - Low dose delivery
    - Constant education necessary for proper technique

Aerosol Therapy Choices?

- What modality choices are there for aerosol therapy?
- What modality of aerosol therapy is most common to home care?
- What is the GOLD standards recommendation on aerosol therapy modalities?
- What are the GINA standards recommendations for aerosol therapy?
- What medications are available for aerosol therapy in the US?

2 Standards for Aerosol Therapy

- GINA standards for Asthma (by Level of Control)
- GOLD standards for COPD (by Severity)
Polling Question #3

The GOLD and GINA standards are very supportive of using compressor nebulizers in delivering respiratory medications to the lungs.

a. True
b. False

GOLD Standard Statement on Aerosol Therapy Modality

• “Each treatment regimen needs to be patient-specific as the relationship between severity of symptoms, airflow limitation, and severity of exacerbations will differ between patients. When treatment is given by the inhaled route, attention should be given to effective drug delivery and training in inhaler technique is essential.”

GINA Global Initiative for Asthma

• Route of Administration
  • “Asthma treatment for adults can be administered in different ways – inhaled, orally, or parenterally (by injection). The major advantage of inhaled therapy is that drugs are delivered directly to the airways: producing higher local concentrations with significantly less risk of systemic side effects.”


GINA Global Initiative for Asthma

- Route of Administration
  “Nebulized aerosols are rarely indicated for the treatment of chronic asthma in adults.”

“Au contraire”

Equivalence of Aerosol Device Types

“Historically, nebulizers were thought to be more effective than pMDIs, especially for short-acting bronchodilators in acute exacerbations of airflow obstruction. Contrarily, evidence has shown equivalent clinical results whether a pMDI, a nebulizer, or a DPI is used, provided that the patient can use the device correctly. For bronchodilators, the same clinical response is often achieved with the labeled dose from the pMDI or nebulizer, despite the higher nominal dose for the nebulizer. Because any of these aerosol generators, if used properly, can be effective with their label dose, dosage should be device specific and based on the label claim.”

Polling Question #4

According to “A Guide to Aerosol Delivery Devices For Respiratory Therapists 3rd Edition” pMDI are _____ nebulizers in delivering aerosol to a patient’s lungs.

a. Better than
b. Worse than
c. Equivalent to
d. None of the above

Where’s it go?

Where's it go?

- “200 µg of albuterol in 2 actuations or puffs from a pMDI, only about 20-40 µg reach the lungs with correct technique.”
- “while the typical nebulizer nominal dose is 2.5 mg or 12 times more drug.”


Polling Question #5

Best improvement in FEV₁ based on route of administration for respiratory medications is:

a. Orally
b. Subcutaneous
c. Aerosol
d. None of the above

Polling Question #6

Which of the following is NOT an advantage to compressor nebulizers?

a. Mix more than 1 medication in a nebulizer
b. LESS time consuming than pMDI
c. Can vary drug dosage
d. Has no propellants that may be harmful to a patient.
### Advantages of Aerosol Therapy

Each inhaler type has pros and cons that must be considered in the selection of a device for a particular patient. For example, there is no special technique for using jet nebulizers, as they are quite intuitive to use and most breathing is sufficient. Nebulizers can be used for any type and for any disease severity or quality. In some cases, it is possible to make more precise medication dosing in an nebulizer and deliver them simultaneously, thus lengthening the administration time. One of the benefits of nebulizers is that doses are lower than with MDIs and DPIs. However, the nebulizer does not allow delivery of the indicated dose, thus driving the patient or parent to be more precise in the patient’s or parent’s treatment. The nebulizer is not as easy to use as an MDI, but it is more precise. The lack of knowledge of correct or optimal device use is the most frequent reason for nebulizer underuse.

Geller, David  MD


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### Available Aerosol Formulations

<table>
<thead>
<tr>
<th>Drug</th>
<th>Brand</th>
<th>Device</th>
<th>Dose</th>
<th>Cost</th>
<th>Gross/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuterol</td>
<td>Ventolin</td>
<td>DMI</td>
<td>5 mg</td>
<td>$35.00</td>
<td>$115.00</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>Adrenalin</td>
<td>DMI</td>
<td>0.25 mg</td>
<td>$45.00</td>
<td>$135.00</td>
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<tr>
<td>Levodopa</td>
<td>Stalevo</td>
<td>DMI</td>
<td>25 mg</td>
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<td>$105.00</td>
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<td>Levetiracetam</td>
<td>Keppra</td>
<td>DMI</td>
<td>500 mg</td>
<td>$25.00</td>
<td>$75.00</td>
</tr>
</tbody>
</table>

A Guide to Aerosol Delivery Devices For Respiratory Therapists 3rd Edition

Polling Question #7

What LONG acting bronchodilator is available for SVN (small volume nebulizer)?

a. Arformoterol (Brovana)
b. Formoterol (Perforomist)
c. Tiotropium (Spiriva)
d. Both a and b

Available Aerosol Formulations

<table>
<thead>
<tr>
<th>Drug</th>
<th>Brand</th>
<th>Device</th>
<th>Strength</th>
<th>Doses</th>
<th>Cost</th>
<th>Cost/Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macalective Drugs</td>
<td>Domnoe Alpha</td>
<td>Palmozyme®</td>
<td>SVN</td>
<td>30</td>
<td>$1,728.00</td>
<td>$57.60</td>
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<tr>
<td>Other Drugs</td>
<td>Zanamivir</td>
<td>Relenza®</td>
<td>DPI</td>
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<td>$67.40</td>
<td>$3.37</td>
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<tr>
<td></td>
<td>Tobramycin</td>
<td>TOBI®</td>
<td>SVN</td>
<td>56</td>
<td>$7,266.28</td>
<td>$129.76</td>
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<tr>
<td></td>
<td></td>
<td>DPI</td>
<td>Recently approved by FDA, no cost information at this time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antroemom</td>
<td>Cystene®</td>
<td>SVN</td>
<td>28</td>
<td>$6,181.09</td>
<td>$220.75</td>
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</tr>
</tbody>
</table>

Available Aerosol Formulations

<table>
<thead>
<tr>
<th>Drug</th>
<th>Brand</th>
<th>Device</th>
<th>Strength</th>
<th>Doses</th>
<th>Cost</th>
<th>Cost/Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-acting Bronchodilators</td>
<td>Arformoterol</td>
<td>Brovana®</td>
<td>SVN</td>
<td>30</td>
<td>$640.00</td>
<td>$21.33</td>
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<tr>
<td></td>
<td>Formoterol</td>
<td>Perforomist®</td>
<td>SVN</td>
<td>30</td>
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<td>$31.93</td>
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<td></td>
<td>Freed®</td>
<td>Coat®</td>
<td>DPI</td>
<td>100</td>
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<td>$1.81</td>
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<td>Indacaterol</td>
<td>Amerilag®</td>
<td>DPI</td>
<td>10</td>
<td>$103.38</td>
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</tr>
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<td>Salbutamol</td>
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<td>Terbutalin</td>
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<tr>
<td>Corticosteroids</td>
<td>Beclomethasone (QNI) 100</td>
<td>QNI 100</td>
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<td>60</td>
<td>$125.00</td>
<td>$2.08</td>
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<tr>
<td></td>
<td></td>
<td>QNI 50</td>
<td>MDI</td>
<td>60</td>
<td>$80.00</td>
<td>$1.33</td>
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<tr>
<td></td>
<td>Budesonide</td>
<td>Pulmicort Respules</td>
<td>DPI</td>
<td>67</td>
<td>$50.00</td>
<td>$0.75</td>
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<tr>
<td></td>
<td></td>
<td>Advair®</td>
<td>DPI</td>
<td>200</td>
<td>$144.00</td>
<td>$0.72</td>
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<tr>
<td></td>
<td>Ciclesonide</td>
<td>Alceton®</td>
<td>MDI</td>
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<td>$171.00</td>
<td>$2.85</td>
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<td>Flunisolide</td>
<td>Flonovone®</td>
<td>DPI</td>
<td>50</td>
<td>$156.00</td>
<td>$3.12</td>
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<td></td>
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<td>Flunisolide</td>
<td>DPI</td>
<td>50</td>
<td>$156.00</td>
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<tr>
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<td>Flunisolide</td>
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<td></td>
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<td>Flunisolide</td>
<td>DPI</td>
<td>10</td>
<td>$156.00</td>
<td>$15.60</td>
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<tr>
<td></td>
<td></td>
<td>Mometasone</td>
<td>Fina®</td>
<td>MDI</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>60</td>
<td>$138.00</td>
<td>$2.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>60</td>
<td>$138.00</td>
<td>$2.30</td>
</tr>
<tr>
<td>Combination Drugs</td>
<td>Flunisolide and Inhaled</td>
<td>Albuterol NE®</td>
<td>MDI</td>
<td>48</td>
<td>$270.00</td>
<td>$5.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>48</td>
<td>$270.00</td>
<td>$5.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>48</td>
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<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>48</td>
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<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>48</td>
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<td></td>
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<td></td>
<td></td>
<td>MDI</td>
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<td>$270.00</td>
<td>$5.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>MDI</td>
<td>48</td>
<td>$270.00</td>
<td>$5.62</td>
</tr>
</tbody>
</table>
| Medications and Type of Delivery Device

<table>
<thead>
<tr>
<th>Drug Formulation</th>
<th>Approved Nebulizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchodilators</td>
<td>Nebulizer type not specified</td>
</tr>
<tr>
<td>Acetylcysteine</td>
<td>Nebulizer type not specified</td>
</tr>
<tr>
<td>Budesonide (Pulmicort Respules®)</td>
<td>Should not be used with ultrasonic nebulizer</td>
</tr>
<tr>
<td>Tolbutamycin (TOBI®)</td>
<td>Pari LC®, Sistemas®</td>
</tr>
<tr>
<td>Domnus alfa (Palmozyme®)</td>
<td>Hudson T Up-draft II, Marquest Acorn® II, Pari LC®, Duraline Sistemas®, Pari Baby®</td>
</tr>
<tr>
<td>Pentamidine (NebuPent)</td>
<td>Marquest Respigard II</td>
</tr>
<tr>
<td>Ribavirin (Vira-ace®)</td>
<td>Small Particle Aerosol Generator</td>
</tr>
<tr>
<td>Iprost (Ventavis®)</td>
<td>l-neb Adaptive Aerosol (AAD) System</td>
</tr>
<tr>
<td>Aztreonam (Cysto®)</td>
<td>Altera® Nebulizer System</td>
</tr>
<tr>
<td>Tevapotroin (Tyraso®)</td>
<td>Tyvos® Inhalation System</td>
</tr>
</tbody>
</table>

**Cost of Equipment**

<table>
<thead>
<tr>
<th>Nebulizer Type</th>
<th>Approximate Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic compressor nebulizer</td>
<td>$50-$150</td>
</tr>
<tr>
<td>Ultrasonic nebulizer</td>
<td>$100-$250</td>
</tr>
<tr>
<td>Vibrating mesh/horn nebulizer</td>
<td>$200-$1,200</td>
</tr>
<tr>
<td>Microprocessor-controlled breath-actuated nebulizer</td>
<td>$750-$2,000</td>
</tr>
</tbody>
</table>


**Replenishment Cost of Equipment**

<table>
<thead>
<tr>
<th>Nebulizer Components (Interval)</th>
<th>Approximate Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposable jet nebulizer (1-7 days in acute care, longer use at home)</td>
<td>$1-3</td>
</tr>
<tr>
<td>Jet nebulizer with bag reservoir (1-3 days)</td>
<td>$4-15</td>
</tr>
<tr>
<td>Jet nebulizer with filter (1-3 days)</td>
<td>$10-12</td>
</tr>
<tr>
<td>Breath-enhanced nebulizer</td>
<td>$4-20</td>
</tr>
<tr>
<td>Breath-actuated jet nebulizer</td>
<td>$4-6</td>
</tr>
<tr>
<td>Ultrasonic nebulizer medication chamber (daily or weekly)</td>
<td>$1-5</td>
</tr>
<tr>
<td>USN handset replacement (3-12 months)</td>
<td>$100-250</td>
</tr>
<tr>
<td>Vibrating mesh replacement (3-12 months)</td>
<td>$40-150</td>
</tr>
</tbody>
</table>


**Aerosol Characteristics**

- Factors affecting penetration and deposition
  - Gravity
    - Kinetic activity
    - Inertial impaction
    - Ventilatory pattern

**Aerosol Characteristics**

- Factors affecting penetration and deposition
  - Gravity
Aerosol Characteristics

- Factors affecting penetration and deposition
  - Kinetic activity

Polling Question #8

Best breathing pattern for maximum delivery of respiratory medications is:
- a. Slow, Deep, with breath hold.
- b. Fast, Deep, with breath hold.
- c. Slow, Deep, with no breath hold.
- d. Fast, Deep, with no breath hold.

Aerosol Characteristics

- Factors affecting penetration and deposition
  - Inertial impaction

Aerosol Characteristics

- Factors affecting penetration and deposition
  - Ventilatory pattern
    - Slow (minimize inertial impaction)
    - Deep (good distribution throughout lungs) with
    - Breath Hold (Rain out into the airways)
**Aerosol Delivery Devices**

**SVN – Small Volume Nebulizers**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to aerosolize many drug solutions</td>
<td>Treatment times may range from 5-25 minutes.</td>
</tr>
<tr>
<td>Ability to aerosolize drug mixtures (&lt;1 drug), if drugs are compatible</td>
<td>Equipment required may be large and cumbersome.</td>
</tr>
<tr>
<td>Minimal patient cooperation or coordination is needed</td>
<td>Need for power source (electricity, battery, or compressed gas)</td>
</tr>
<tr>
<td>Useful in very young, very old, debilitated or distressed patients</td>
<td>Potential for drug delivery into the eyes with face mask delivery</td>
</tr>
<tr>
<td>Drug concentrations and dose can be modified</td>
<td>Variability in performance characteristics among different types, brands, and models</td>
</tr>
<tr>
<td>Normal breathing pattern can be used, and an inspiratory pause (breath-hold) is not required for efficacy</td>
<td>Assembly and cleaning are required. Contamination is possible with improper handling of drug and inadequate cleaning.</td>
</tr>
</tbody>
</table>


**Polling Question #9**

What set up of compressor nebulizer delivers the LEAST amount of aerosol into the lung.

a. “T” piece aerosol  
b. Neb with “collection bag”  
c. Breath actuated neb  
d. Breath activated neb.

**Question #10**

According to the National Asthma Education and Prevention program, what is the accepted method of delivering aerosol to children less than 2 years old?

a. MDI  
b. MDI with holding chamber  
c. SVN  
d. DPI

Aerosol Delivery Devices

- 2007 National Asthma Education and Prevention Program guidelines:

<table>
<thead>
<tr>
<th>Aerosol system</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small volume Nebulizer</td>
<td>≤ 2 years</td>
</tr>
<tr>
<td>MDI</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>MDI with holding chamber/spacer</td>
<td>&gt; 4 years</td>
</tr>
<tr>
<td>MDI with holding chamber/spacer and mask</td>
<td>≤ 4 years</td>
</tr>
<tr>
<td>Breath actuated MDI (eg Autohaler)</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>DPI</td>
<td>≥ 5 years</td>
</tr>
</tbody>
</table>

Table 4. Age guidelines for use of aerosol device types. Based on NAEPP guidelines

Table 6. Factors affecting penetration and deposition of therapeutic aerosols delivered by jet nebulizers

<table>
<thead>
<tr>
<th>Technical Factors</th>
<th>Patient Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer of Nebulizer</td>
<td>Breathing pattern</td>
</tr>
<tr>
<td>Flow used to power nebulizer</td>
<td>Nose vs mouth breathing</td>
</tr>
<tr>
<td>Fill volume of nebulizer</td>
<td>Composition of inspired gas</td>
</tr>
<tr>
<td>Solution characteristics</td>
<td>Airway obstruction</td>
</tr>
<tr>
<td>Composition of driving gas</td>
<td>Positive pressure delivery</td>
</tr>
<tr>
<td>Designs to enhance nebulizer output</td>
<td>Artificial airway and mechanical ventilation</td>
</tr>
<tr>
<td>Continuous versus breath actuated</td>
<td></td>
</tr>
</tbody>
</table>

Choice of Devices for Children

Inhalant medications are preferred because they deliver drugs directly to the airways where they are needed, resulting in potent therapeutic effects with fewer systemic side effects.

- Teach children and their parents how to use inhaler devices. Different devices need different inhalation techniques.
- Give demonstration and illustrated instructions.
- Ask patients to show their technique of each task.
- Information about use of various inhaler devices is found on the GINA Website.
- For each child, select the most appropriate device. In general:
  - Children younger than 4 years of age should use a pMDI plus a spacer with face mask, or a nebulizer with face mask.
  - Children aged 4 to 6 years should use a pMDI plus a spacer with face mask.
  - For children using spacers, the spacer must fit the inhaled.
  - Children of any age over 5 years who have difficulty using pMDIs should use a pMDI with a spacer, a breath-actuated inhaler, a DPI, or a nebulizer. DPIs require an inspiratory effort that may be difficult for children to achieve during severe attacks.
  - Children who are having severe attacks should use a pMDI with a spacer or a nebulizer.
  - Potentially among children under age 5, inhaler techniques may be poor and should be monitored closely.

GINA Pocket Pediatric 2006, pg 11.

What’s better for children – Crying or settled?

“Inhaled drugs should be given when they are setted and breathing quietly. Crying children receive virtually no aerosol drug to the lungs with most of the inhaled dose depositing in the upper airways or pharynx, which is then swallowed.”

GINA Pocket Pediatric 2006, pg 11.

Other issues with children

- Mouthpiece or facemask? “Studies suggest that the mouthpiece provides greater lung dose than a standard pediatric aerosol mask.”
- Face mask or blow-by? “… evidence suggest blow-by to be ineffective and use should be discouraged.”


Aerosol Characteristics

Ventilatory Pattern

- Most important clinical variable determining deposition and penetration of medical aerosols
- Directly related to inhaled volume and inversely related to respiratory rate
- Slow deep breath (3-5 second inspiration from FRC to TLC), breath hold up to 10 seconds (facilitates “rain out”)

Aerosol Terminology

- Micron
  - A micron equals 1/1,000,000 of a meter (one millionth)
- MMD
  - Mass Median Diameter
  - Half of the total amount of medication is contained in particles below this number and half of the medication is contained in particles above this number

- Respirable Range
  - 0.5 to 5 microns
  - Above 5 microns aerosol particles “rain out” in the mouth and throat and are swallowed
  - Below 0.5 microns particles do not settle in the lungs and are exhaled
- Respirable Fraction
  - The percentage of the total amount of aerosol below 5 microns
  - The higher the percentage the better
  - Agency standards recommend that at least 50% of the medication be below 5 microns (this means a MMD of 5 microns or less)
Aerosol Deposition Characteristics

Particle Size Analysis

Cascade Impactor

- Least accurate
- Technique for powder analysis
- Plates at closer distance and weighed

Laser Diffraction

- Affordable
- Good accuracy

Principles
Laser diffraction measures particle size distributions by measuring the angular variation in intensity of light scattered as a laser beam passes through a dispersed particulate sample. Large particles scatter light at small angles relative to the laser beam and small particles scatter light at large angles, as illustrated below. The angular scattering intensity data is then analyzed to calculate the size of the particles responsible for creating the scattering pattern, using the Mie theory of light scattering. The particle size is reported as a volume equivalent sphere diameter.

Phased Doppler

- MOST accurate method
- Method Carnegie Mellon uses
- Big Bucks!
- DeVilbiss compares their Laser Diffraction to Phased Doppler
Question #11

Mass Median Diameter and Respiratory Fraction are the BEST specifications to evaluate a nebulizers performance. Which statement BEST describes a good nebulizers specification.

a. MMD > 5 microns and Respiratory Fraction > 50%

b. MMD < 5 microns and Respiratory Fraction > 50%

c. MMD > 5 microns and Respiratory Fraction < 50%

d. None of the above.

Statistics

Example:

- 11 particles in an aerosol cloud produced by a nebulizer
- Ten 2 micron diameter particles and one 10 micron diameter particle.
- 91% of the number of particles are 2 microns
- The average diameter of the particles = 2.7 microns
- The Mass Median Diameter of particles = 9.9 microns

Statistics & Therapy

- If a patient were to inhale this aerosol cloud, only the 2 micron particles would make it to the airways. The 10 micron particle would be deposited in the mouth and be swallowed.
- BUT the 10 micron particle contains over 90% of the total dose of medication. And this was NOT delivered where needed.
- The 10 micron particle also contributes to high aerosol output, but that output is NOT respirable.

Statistics & Therapy

- Don’t be misled by specs of “average” particle size or number distributions
- The Mass Median Diameter is the critical spec and it must be below 5 microns for a nebulizer to be useful.
Specs for 3 Manufacturers of Nebulizers

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<th>#3</th>
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### Technical Specifications

<table>
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<tr>
<th>Specification</th>
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<tbody>
<tr>
<td>Total Output Rate (TOR)</td>
<td>500 mg/min</td>
<td>(1) Albuterol (W / 4.85 μm / 63% ATS 2007&lt;sup&gt;1&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Mass Median Diameter (MMD)</td>
<td>3.1 μm</td>
<td>(2) Albuterol (4.11 min / 3.37 μm / 71% ATS 2007&lt;sup&gt;1&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Percentage Respirable Fraction (PRF)</td>
<td>65%</td>
<td>(3) Budenoside (5.59 min / 5.26 μm / 67% ATS 2007&lt;sup&gt;2&lt;/sup&gt;)</td>
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### Compressors

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<td>Desktop</td>
<td>Portable</td>
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### Nebulizer Choices

- **Compressor Nebulizers**
- **Mesh technology**
- **Ultrasonic**

### Issues

- **Operational**
- **Reliability**
- **Costs**

### Compressor Choices

- **Issues**
  - **Operational**
  - **Reliability**
  - **Costs**
Compressor Characteristics

- Aerosol compressors must produce the optimal pressure and flow range to operate the nebulizers.
- Optimal pressure = 10-15 psig with nebulizer attached.
- Optimal flow = 5-8 lpm with nebulizer attached.

Cleaning Instructions for Nebulizers

**Cleaning After Each Use**
- Wash hands before handling equipment.
- Disassemble parts after each treatment.
- Remove the tubing from the compressor and set it aside. The tubing should not be washed or rinsed.
- Rinse the nebulizer cup and mouthpiece with either sterile water or distilled water.
- Shake off excess water.
- Air dry on an absorbent towel.
- Store the nebulizer cup in a zippered plastic bag.

**Cleaning Once or Twice a Week**
- Wash hands before handling equipment.
- Disassemble parts after each treatment.
- Remove the tubing from the compressor and set it aside. The tubing should not be washed or rinsed.
- Wash nebulizer parts in warm water with liquid dish soap.
- Disinfect the nebulizer based on the manufacturer’s recommendations. The nebulizer parts may be sterilized in one of the following solutions:
  1. One-part household bleach and 56 parts water for three minutes.
  2. 70% isopropyl alcohol for five minutes.
  3. 1% hydrochloric acid for 30 minutes.
  4. One-part distilled white vinegar in three-parts hot water for one hour (not recommended for CF patients).
- Rinse parts with sterile or distilled water.
- Shake off excess water and place all parts on a clean paper towel.
- Allow them to air dry completely on an absorbent towel.
- Reassemble the nebulizer and store in a clean, dry bag container.

Take Home Message on Medication Delivery!

- Nebulizers are a viable alternative to medication delivery.
- MMD and Respirable Fraction important aspects of evaluating ALL nebulizers.
- Technique of treatment administration extremely important.
- Compressor nebulizer development continues to improve and adds benefits to patient management of lung and other diseases.

Thanks for attending!
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