Aerogen®
Pioneering Aerosol Drug Delivery
Redefining Continuous Aerosol Drug Delivery 2015
PM223
Explanation of Continuous via Traditional Small Volume (Jet) Nebulizer

- Traditional small volume (jet) nebulizers require compressed gas to aerosolize medication
- Solution is placed in a medication cup
- Compressed gas is delivered as a jet through a small orifice at the bottom of the cup creating a pressure change which causes solution to be drawn up a capillary tube sitting in the solution
- The solution is pulled into the gas stream breaking it into particles
- The large droplets impact a baffle which breaks them into smaller particles
- The smaller particles are entrained into the gas stream and are inhaled by the patient
- The larger particles fall back into the nebulizer where they are recycled
- Evaporation increases concentration of drug
- At the end of the treatment residual drug typically 0.5 - 2.2 ml of dose un-nebulized (which in a 3 ml dose can be as much as 2/3 of the solution)

Continuous Aerosol via Traditional Small Volume (Jet) Nebulizer
How did we do it before?

Continuous Dosing of Albuterol with MiniHeart Jet Nebulizer

- Drive nebulizer with 2 lpm flow
- Fixed output 8 ml/hour
- Preload jet nebulizer with 15 ml solution to prevent nebulizer from running dry
- Use common connector to a common feed set
- Change concentration of solution required for a dose change
- Waste of medication and increased time required to adjust dosing

Dosing based on Westmed Dosing for MiniHeart LoFlo jet nebulizer for continuous aerosol

<table>
<thead>
<tr>
<th>Dose (mg/hour)</th>
<th>2.5 mg</th>
<th>5 mg</th>
<th>7.5 mg</th>
<th>10 mg</th>
<th>12.5 mg</th>
<th>15 mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication (5 mg/ml)</td>
<td>0.5 ml</td>
<td>1 ml</td>
<td>1.5 ml</td>
<td>2 ml</td>
<td>2.5 ml</td>
<td>3 ml</td>
</tr>
<tr>
<td>Saline (ml)</td>
<td>39.5 ml</td>
<td>39 ml</td>
<td>38.5 ml</td>
<td>38 ml</td>
<td>37.5 ml</td>
<td>37 ml</td>
</tr>
<tr>
<td>Total fill Volume (ml)</td>
<td>40 ml</td>
<td>40 ml</td>
<td>40 ml</td>
<td>40 ml</td>
<td>40 ml</td>
<td>40 ml</td>
</tr>
</tbody>
</table>

Flow rate = output (for 40 ml of solution)
2 lpm flow rate into the SVN/ jet nebulizer = 8 ml/hour output
Aerogen Continuous Nebulization Tube Set

- Non standard luer connectors eliminate the risk of misconnection
- Unique blue color coding
- Drop by Drop aerosolization
- Works with standard syringe pumps
Drop by Drop (Volumetric) Dosing with Aerogen Solo

- Pioneering aerosol drug delivery with a new paradigm for continuous aerosol delivery creating the most precise variable delivery system in aerosol history
- Medication is dropped onto the vibrating mesh
- *Volumetric dosing* = delivery of a volume of medication over time (drop by drop) i.e. ml per hour
- The rate of drug entering the Aerogen Solo determines drug output rate
- Aerogen drop-by-drop (volumetric) dosing gives you the ability to titrate medication utilizing the infusion rate of the pump
- No need to change concentration of the medication in the syringe or the bag

Rate of the infusion pump = the output of the Aerogen Solo
How does Aerogen Technology Work?

- Vibrating mesh aperture plate with 1000 precision formed tapered holes

- Energy applied to the plate causing it to vibrate > 128,000 times per second

- Rapid vibration causes each aperture to act as a micropump drawing liquid through the holes causing to form consistently sized droplets

- Results fine particle low velocity aerosol optimized for central and deep lung deposition

Video of fine particle low velocity aerosol created by Aerogen Technology
Drop by Drop Aerosolization

Aerogen vibrating mesh is on “continuously” in Continuous Mode

Medication is dropped onto the vibrating mesh

Aerosol is produced immediately.
Aerogen Solo Drop by Drop (Volumetric) Dosing
Drop by Drop (Volumetric) Dosing with 0.5% Albuterol Solution

- Albuterol Sulfate 0.5% is a 5 mg/ml solution
- Load the syringe or bag with desired amount of undiluted 0.5% solution (1, 2, 3 or more bottles based on order)
- Set the rate on the pump to deliver the desired dosage of albuterol
- See example on the next slide
Example of Drop by Drop (Volumetric) Dosing for a 25 mg/hour Dose

**Problem:** What infusion rate do I use to deliver 25 mg per hour of albuterol? What is the output of the solo for a 25 mg per hour dose of albuterol?

- **Infusion rate pump = Solo output** = Desired Dosage (mg/hour) / 5 mg/ml
  - **Solo output** = 25 mg per hour = 5 ml per hour / 5 mg/ml

**Answer:** To deliver 25 mg per hour with undiluted 0.5% albuterol, set the infusion pump rate to 5 ml per hour. The pump rate is the output of the Solo.

**Note:** Maximum input rate of 12 mL per hour.
Drop by Drop (Volumetric) Dosing

- No added saline required
- Delivery rate of infusion = aerosol output rate
- Easy titration available allows quick response to clinical needs of the patient
- Saves clinician time
- Reduces medication waste (use one concentration of medication for the range of doses)

Note: Aerogen’s recommended input rate of medication into the Aerogen Solo nebulizer during continuous nebulization is up to a maximum of 12 mL per hour. The upper limit of 12 mL per hour is based on Aerogen’s specification for the minimum nebulizer flow rate.

### Albuterol 0.5% = 5 mg/ml solution (undiluted)

<table>
<thead>
<tr>
<th>Dose (mg/hr)</th>
<th>5mg</th>
<th>7.5mg</th>
<th>10mg</th>
<th>15mg</th>
<th>20mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infusion Rate = Aerosol output rate</td>
<td>1 ml</td>
<td>1.5 ml</td>
<td>2 ml</td>
<td>3 ml</td>
<td>4 ml</td>
</tr>
</tbody>
</table>
Additional advantages

Control
• Change dose (up or down) with change in pump rate (adjustable up to 12 ml per hour)
• Volumetric control of dosing
• Consistent dose per minute, consistent dose per hour

Easy To Use
• Less rainout in the circuit due to due unstable particles reducing the risk of saturated filters

Efficiency
• Same drug concentration over time reducing medication waste
• Volumetric precision with drop by drop nebulization
• Makes weaning easier – just change the pump rate
Functional Test*

- Perform a functional test with the initial use of Solo prior to inserting into the circuit or accessory (or at any time to verify proper operation).
- Pour 1-6 mL of normal saline (0.9%) into the solo and turn on the power.
- Visually check that aerosol is produced.

*Adapted from Aerogen solo instruction manual. Aerogen.com
Best Orientation of Aerogen Solo for Optimal Aerosol Delivery
Aerogen Solo Set Up

1. Remove the syringe cap from the medication filled syringe and attach the syringe end of the tubing onto the syringe.

2. Prime the tubing until the medication reaches the end of the tubing.
   
   Note: the tubing priming volume maximum is 3.65mL

3. Unplug the tethered cap from the Aerogen Solo, do not remove it from the nebulizer. Screw the nebulizer end of the tubing onto the top of the nebulizer.

4. Insert the syringe filled with medication into the syringe pump.
   
   Refer to pump manual or manufacturer for guidance on pump usage.

   Turn on continuous mode on the controller. Press & hold the on/off button for 3 seconds from the off position to select continuous mode.

   Note: Medication is nebulized on a drop by drop basis. Observe continuous mode in action.

*Parts not supplied by Aerogen. Consult manufacturer for usage guidelines.
Continuous Mode Delivery

- FYI: Rising fluid level in the aerosol cup indicates that the fill rate has exceeded the output rate of the Solo. For further information refer to the instruction manual and/or contact Aerogen clinical support at MedicalScience@aerogen.com

*Reference: Aerogen solo instruction manual. Aerogen.com*