Compare Aerosol Drug Delivery Efficacy of Two Types of Nebulizer in Adult Mechanical Ventilator

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Introduction

Aerosol drug delivery through small volume nebulizer (SVN) in mechanical ventilation is widely utilized in treating various respiratory disorders; however, studies have also shown concomitant pitfall in delivery inefficiency. The aim of the study was to compare our novel polymeric vibrating-mesh nebulizer (µMVN) to currently used aerosol devices during MV.

Key word: aerosol drug delivery; vibrating-mesh nebulizer; small volume jet nebulizer; bronchodilator; mechanical ventilation.

Methods and Materials

- Ventilator and setting: Puritan Bennet 760 (Medtronic Plc), Vt 600 ml, Rate 16 breaths/min, inspiratory flow 60 L/min, and PEEP 5 cmH2O.
- Nebulizers: µMVN’3.6, µMVN’2.8 (MicroBase Technology Co., Taiwan), Aerogen Solo (Aerogen Inc) and small volume jet nebulizer (SVN; GaleMed Corp) were used. Median mass aerodynamic diameter (MMAD) values were shown on Table 1.
- Placement of nebulizers: Figure 1 showed that nebulizers were placed at inlet of a heated humidifier (MR370; Fisher & Paykel).
- Drug: a unit dose of Ventolin (Salbutamol 5.0 mg/2.5 ml; GSK) or Pulmicort (Budesonide 1.0 mg/2.0 ml; AstraZeneca) was applied.
- Drug eluted and analyzed: drug captured on the filter was eluted and analyzed with an Ultraviolet-Visible spectrophotometer (U-2900, Hitachi Corp). The absorbance wavelengths of Ventolin was at 276 nm and 254 nm for Pulmicort.

Table 1. Particle characterizations of four nebulizers were assessed with Andersen cascade impactor (ACI).

<table>
<thead>
<tr>
<th>Nebulizer</th>
<th>MMAD(µm)</th>
<th>GSD</th>
<th>FPD(&lt;5 µm)</th>
<th>FPF(&lt;&lt; µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>µMVN’3.6</td>
<td>1.56</td>
<td>1.01</td>
<td>2.75</td>
<td>66.89%</td>
</tr>
<tr>
<td>µMVN’2.8</td>
<td>2.88</td>
<td>2.39</td>
<td>3.16</td>
<td>71.23%</td>
</tr>
<tr>
<td>Aerogen Solo</td>
<td>3.11</td>
<td>2.17</td>
<td>7.13</td>
<td>30.90%</td>
</tr>
<tr>
<td>SVN</td>
<td>2.05</td>
<td>2.61</td>
<td>1.24</td>
<td>79.51%</td>
</tr>
</tbody>
</table>

*µMVN*: MicroBase mechanical ventilator nebulizer plus.
MMAD: mass median aerodynamic diameter.
GSD: geometric standard deviation.
FPD: fine particle dose.
FPF: fine particle fraction.

Results

Figure 1. Placement of different nebulizers on mechanical ventilator. (A) µMVN’3.6 or µMVN’2.8, (B) Aerogen Solo, (C) SVN.

Table 2 and Figure 2 demonstrated the inhaled dose percentages of different nebulizers when aerosolizing Ventolin and Pulmicort. The inhaled dose % of Ventolin and Pulmicort using µMVN’ was significantly greater than Aerogen Solo and SVN. Delivered dose % of Ventolin was significantly greater than Pulmicort (p<0.001) by all nebulizers.

Table 2. Inhaled dose (%) of four nebulizers (mean ± SD).

<table>
<thead>
<tr>
<th>Nebulizer</th>
<th>Inhaled dose (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ventolin</td>
<td>Pulmicort</td>
</tr>
<tr>
<td>µMVN’3.6</td>
<td>20.07±0.37†</td>
<td>13.70±0.37†</td>
</tr>
<tr>
<td>Aerogen Solo</td>
<td>17.92±0.43*</td>
<td>9.57±0.20*</td>
</tr>
<tr>
<td>SVN</td>
<td>14.12±0.24</td>
<td>8.00±0.48</td>
</tr>
</tbody>
</table>

*Inhaled dose % of µMVN’ was significantly higher than Aerogen Solo (p<0.001). †Inhaled dose % of Aerogen Solo was significantly higher than SVN (p<0.001).

Figure 2. Comparison of inhaled dose % among four nebulizers.
*Inhaled dose % of Ventolin by Aerogen Solo was significantly greater than SVN (p<0.001), yet lower than both µMVN’ (p<0.001).
**Inhaled dose % of Pulmicort by Aerogen Solo was significantly greater than SVN (p<0.001), yet lower than both µMVN’ (p<0.001).

Conclusions

The novel in-line polymeric µMVN’s were demonstrated superior performance in drug delivery when compared with existing products. Drug formulation influences nebulizer delivery efficacy.