

In Vitro Comparison of Aerosol Medication Delivery Efficiency of a Newly Designed T-adaptor with Different Nebulizers during Adult Mechanical Ventilation

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Introduction

Successful delivery of aerosolized medication within mechanical ventilation (MV) necessitates an efficient nebulizer connected to a well-designed T-adaptor that is subsequently conjoined to the inlet of a heated humidifier in a closed ventilator circuit. However, small volume jet nebulizers (SVN) severely suffer from general inefficiency due to high residual volume and significant aerosol impaction at a conjoined T-adaptor. This study compared aerosol drug delivery efficiency of MicroBase Mechanical Ventilation Nebulizer Plus (μ MVN⁺), novel polymeric vibrating-mesh nebulizer, and jet nebulizer (SVN), capillary action nebulizer with a specially engineered T-adaptor during adult MV.

Key word: aerosol drug delivery; mechanical ventilation; small volume jet nebulizer; novel polymeric vibrating-mesh; spacer adaptor

Methods

- Ventilator parameters: Puritan Bennet 760 (Medtronic Plc), Tidal volume 600 mL, Respiratory rate 16 breaths/min, and PEEP 5 cmH₂O.
- Nebulizers: μ MVN⁺4.0 (MicroBase Tech. Corp., Taiwan, MMAD 4.0 μ m), μ MVN⁺3.0 (MicroBase Tech. Corp., Taiwan, MMAD 3.0 μ m), μ MVN⁺2.0 (MicroBase Tech. Corp., Taiwan, MMAD 2.0 μ m) which were each connected to MicroBase Tech. Corp. (MBTC) T-adaptor, and small volume jet nebulizer SVN (Galemed Corp., Taiwan) which was connected to a standard T-adaptor. Table 1 shows particle size distributions of each nebulizer.
- Placement of nebulizers: Figure 1 shows the nebulizers placement at inlet of the heated humidifier (Fisher & Paykel, New Zealand).
- Drug: A unit dose of Ventolin (Salbutamol 5.0 mg/2.5 mL, GSK) was applied. N=5.
- Drug assay: Collected drug was analyzed with an UV spectrophotometer (U-2900, Hitachi Corp.) at a wavelength of 276 nm.

Table 1. The particle size of different nebulizers with Andersen cascade impactor (ACI) tested with Ventolin.

| Nebulizer | MMAD (μ m) | GSD | FPD (mg) (<5 μ m) | FPF (%) (<5 μ m) |
|----------------------------|-----------------|------|-----------------------|----------------------|
| μ MVN ⁺ 4.0 | 4.03 | 1.99 | 2.78 | 61.05 |
| μ MVN ⁺ 3.0 | 2.59 | 2.16 | 3.57 | 78.23 |
| μ MVN ⁺ 2.0 | 2.03 | 1.78 | 4.19 | 89.79 |
| SVN | 2.05 | 2.61 | 1.24 | 79.51 |

μ MVN⁺: MicroBase mechanical ventilator nebulizer plus.

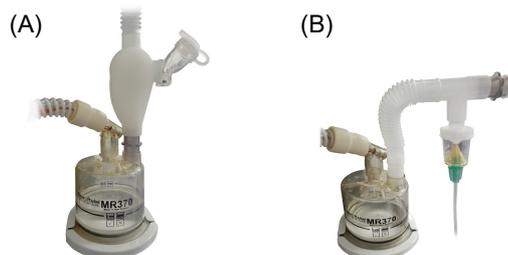
MMAD: mass medium aerodynamic diameter.

GSD: geometric standard deviation.

FPD: fine particle dose.

FPF: fine particle fraction.

Figure 1. Placement of different nebulizers on the mechanical ventilator.



(A) μ MVN⁺4.0 or μ MVN⁺3.0 or μ MVN⁺2.0 with a MBTC adaptor; (B) a SVN.

Results

Table 2 shows the inhaled dose (%) and the Figure 2 shows comparison of among 4 nebulizers. There are significant different ($p < 0.001$) across 4 nebulizers. The μ MVN⁺2.0 with the MBTC T-adaptor was outperformed μ MVN⁺3.0, μ MVN⁺4.0, and the SVN ($p < 0.001$). The inhaled mass by μ MVN⁺3.0 was significant greater than μ MVN⁺4.0 and SVN ($p < 0.001$), and it by μ MVN⁺4.0 was significant greater than the SVN ($p < 0.001$).

Table 2. Inhaled dose % (mean \pm SD) with different nebulizers.

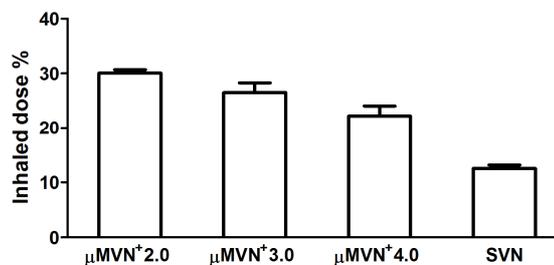
| Nebulizer | Inhaled dose (%) | |
|-----------------------------|------------------|------|
| | mean | SD |
| μ MVN ⁺ 2.0* | 30.04 | 0.63 |
| μ MVN ⁺ 3.0† | 26.51 | 1.78 |
| μ MVN ⁺ 4.0‡ | 22.19 | 1.87 |
| SVN | 12.57 | 0.70 |

* μ MVN⁺2.0 significant greater than μ MVN⁺3.0, μ MVN⁺4.0, and SVN ($p < 0.001$)

† μ MVN⁺3.0 significant greater than μ MVN⁺4.0 and SVN ($p < 0.001$)

‡ μ MVN⁺4.0 significant greater than SVN ($p < 0.001$)

Figure 2. Comparisons of Inhaled dose % across 4 nebulizers.



Conclusions

The newly designed mesh nebulizer with a MBTC T-adaptor enhanced aerosol drug delivery efficacy possibly through reducing aerosol impaction and condensation within T-adaptor during nebulization. Furthermore, aerosol delivery by a MBTC mesh nebulizer was more efficient than the SVN. It apparently nebulizers generated smaller the particle size delivered greater inhaled dose through mechanical ventilation.