

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 (μ MVN⁺) 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: μ MVN⁺3.6, μ MVN⁺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).

Nebulizer	MMAD(μ m)	GSD	FPD(mg) (<5 μ m)	FPF (<5 μ m)
μ MVN ⁺ 3.6	3.66	2.04	2.55	64.09%
μ MVN ⁺ 2.8	2.88	2.39	3.16	71.23%
Aerogen Solo	4.31	2.17	2.11	56.42%
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.

Results

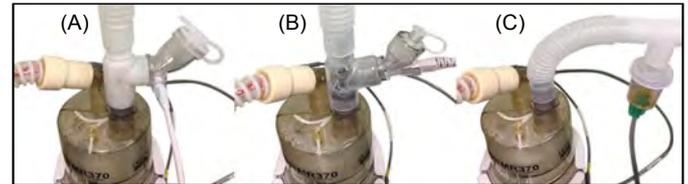


Figure 1. Placement of different nebulizers on mechanical ventilator. (A) μ MVN⁺3.6 or μ MVN⁺2.8, (B) Aerogen Solo, (C) SVN.

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 μ MVN⁺ was 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 \pm SD).

Nebulizer	Inhaled dose (%)		p
	Ventolin	Pulmicort	
μ MVN ⁺ 3.6	20.07 \pm 0.37*	13.70 \pm 0.37*	<0.001
μ MVN ⁺ 2.8	20.46 \pm 0.66*	14.12 \pm 0.42*	<0.001
Aerogen Solo	17.92 \pm 0.43†	9.57 \pm 0.20†	<0.001
SVN	12.57 \pm 0.70	6.39 \pm 0.43	<0.001

*Inhaled dose % of μ MVN⁺ was significantly higher than Aerogen Solo ($p < 0.001$). †Inhaled dose % of Aerogen Solo was significantly higher than SVN ($p < 0.001$).

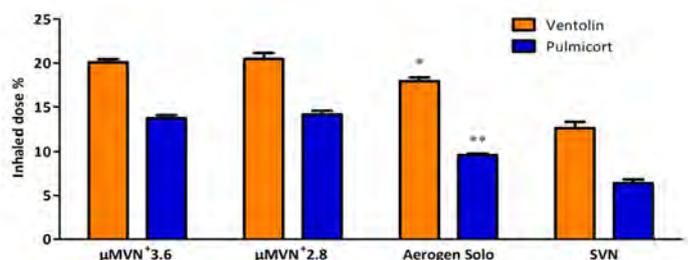


Figure 2. Comparison of inhaled dose % among four nebulizers.

*Inhaled dose % of Ventolin by Aerogen Solo was significantly greater than SVN ($p < 0.001$), yet lower than both μ MVN⁺ ($p < 0.001$).

**Inhaled dose % of Pulmicort by Aerogen Solo was significantly greater than SVN ($p < 0.001$), yet lower than both μ MVN⁺ ($p < 0.001$).

Conclusions

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