



In Vitro Comparison of Aerosol Delivery Efficiency of Vibrating Mesh Nebulizers With Different Shapes of T-Adaptors During Adult Mechanical Ventilation

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Introduction

Successful delivery of aerosolized medication with mechanical ventilation (MV) necessitates an efficient vibrating mesh 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, many traditional T-adaptors suffer from significant aerosol impaction, thus reducing drug delivery efficacy. This study compared aerosol drug delivery outcome between conventional and specially engineered T-adaptors when fitted with different vibrating mesh nebulizers during adult MV.

Methods

- Ventilator parameters: Puritan Bennet 760 (Medtronic Plc), respiratory rate 16 breaths/min, tidal volume 600 mL, inspiratory flow 60L/min, and PEEP 5cm H₂O.
- Drug: A unit dose of salbutamol (Ventolin, 5mg/2.5mL, GlaxoSmithKline).
- Nebulizers and accessories: Figure 1 showed each one of μ MVN⁺4.0, μ MVN⁺3.0, μ MVN⁺2.0 (MicroBase Technology Corp, Taiwan), Aerogen Solo (Aerogen Inc.) was separately connected to either MBTC T-adaptor (MicroBase Technology Corp, Taiwan) or Aerogen T-adaptor (Aerogen Inc.). Mass median aerodynamic diameter (MMAD) values were shown in Table 1.
- Placement of nebulizers: nebulizers were placed at inlet of a heated humidifier (MR370; Fisher & Paykel).
- Drug eluted and analyzed: spectrophotometer (U-2900; Hitachi Corp) at wavelength 276 nm for salbutamol.

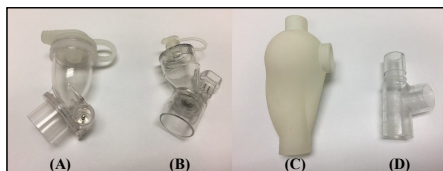


Figure 1. Nebulizers and accessories. (A) MicroBase mechanical ventilator nebulizer plus (μ MVN⁺), (B) Aerogen Solo, (C) MBTC T-adaptor, (D) Aerogen T-adaptor.

Results

Figure 2, Figure 3 and Table 2 showed that inhaled dose (%) of different nebulizers connected to MBTC T-adaptor or Aerogen T-adaptor. The inhaled dose % of μ MVN⁺2.0 was significantly higher than others connected to MBTC T-adaptor (Figure 2). μ MVN⁺4.0 was lower than all others when connected to Aerogen T-adaptor but similar with Aerogen Solo ($p=0.106$) (Figure 3). Table 2 and Figure 4 revealed that inhaled dose (%) of μ MVN⁺4.0 with MBTC T-adaptor exceeded Aerogen Solo with Aerogen T-adaptor ($p=0.026$). Moreover, both μ MVN⁺3.0 and μ MVN⁺2.0 with MBTC adaptors were superior in performance than Aerogen Solo with Aerogen T-adaptor ($p<0.001$). Particularly, inhaled dose % of μ MVN⁺2.0 was achieved to $30.04 \pm 0.63\%$. The use of MBTC T-adaptor further elevated inhaled dose (%) of Aerogen Solo when compared with existing Aerogen T-adaptor ($p=0.009$).

Table 1. The particle size of 4 nebulizers with Andersen cascade impactor (ACI) which tested with salbutamol.

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
Aerogen Solo	3.98	2.11	2.50	61.18

μ MVN⁺: MicroBase mechanical ventilator nebulizer plus.

MMAD: mass median aerodynamic diameter.

GSD: geometric standard deviation.

FPD: fine particle dose.

FPF: fine particle fraction.

Figure 2. Inhaled dose % of vibrating mesh nebulizers with MBTC T-adaptor.

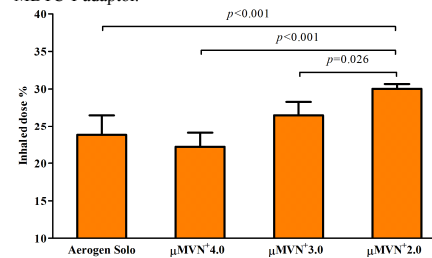


Figure 3. Inhaled dose % of vibrating mesh nebulizers with Aerogen T-adaptor.

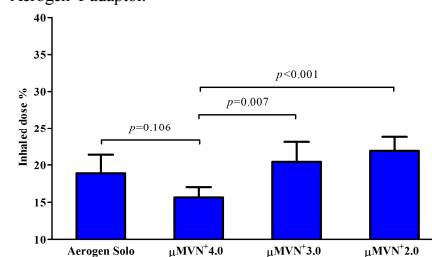
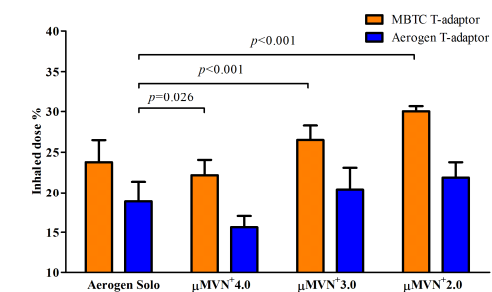


Table 2. The inhaled dose (%), mean \pm SD) of all nebulizers tested with salbutamol.

Nebulizer	Inhaled dose (%)		p
	MBTC T-adaptor (n=6)	Aerogen T-adaptor (n=6)	
μ MVN ⁺ 4.0	22.19 \pm 1.87	15.63 \pm 1.40	<0.001
μ MVN ⁺ 3.0	26.51 \pm 1.78	20.41 \pm 2.68	0.001
μ MVN ⁺ 2.0	30.04 \pm 0.63	21.89 \pm 1.88	<0.001
Aerogen Solo	23.77 \pm 2.72	18.87 \pm 2.49	0.009

Figure 4. Inhaled dose % of vibrating mesh nebulizers with different T-adaptors. On the contrary, Aerogen T-adaptor significantly diminished inhaled dose % of all μ MVN⁺ nebulizers when compared with matching MBTC T-adaptor.



Conclusions

Inhaled dose percentage was influenced by MMAD of vibrating mesh nebulizers and different shapes of T-adaptors. The newly development μ MVN⁺ 2.0 and 3.0 with MBTC T-adaptor dramatically enhanced aerosol drug delivery efficacy possibly through reducing aerosol impaction and condensation within T-adaptor during nebulization.

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