

Comparison of Aerosol Delivery Efficacy by A Specially Designed T-adaptor with Vibrating Mesh Nebulizer and Existing Products in Adult Mechanical Ventilator

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Introduction

Efficiency of drug delivery through mechanical ventilation (MV) could be influenced by the ventilator, aerosol generator, placement of various equipment in the ventilation circuit, types of drug used, and the conditions of the patient.^[1] Studies have illustrated that aerosol delivery efficiencies of both jet and vibrating-mesh nebulizers could be enhanced by placing device at the inlet of a heated humidifier.^[2-5] Traditional T-adaptors had suffered from significant aerosol impaction, thus reducing drug delivery efficacy.^[6] The aim of this study was to compare our novel polymeric vibrating-mesh nebulizer (μ MVN⁺) against existing devices during MV with redesigned adaptors. Drug formulation influencing nebulizer delivery efficacy was also discussed subsequently.

Experimental Methods

- Ventilator & parameters: Puritan Bennet 760 ventilator (Medtronic Corp.), adult parameters (600mL, 16 breaths/min, PEEP 5cm H₂O).
- Drugs : A unit dose of salbutamol (Ventolin, 5 mg / 2.5 mL, GlaxoSmithKline) or budesonide (1.0 mg / 2.0 mL, AstraZeneca).
- Nebulizers: 5 aerosol generators, namely μ MVN⁺4.0, μ MVN⁺3.0, μ MVN⁺2.0 (named base on particle size, MicroBase Tech. Corp., Taiwan), Aerogen Solo (Aerogen Ltd., Ireland) and JN (Galemed Corp., Taiwan) till dryness.
- Analysis methods: spectrophotometer U-2900 (Hitachi Corp., Japan) at a wavelength of 276 nm for salbutamol and 254 nm for budesonide (n=5).
- Particle characterizations: Each nebulizer was tested by Andersen cascade impactor (ACI) with a unit dose of salbutamol. Mass median aerodynamic diameter (MMAD) values were shown in Table 1.

Table 1. The particle size of five nebulizers with Andersen cascade impactor (ACI) tested with salbutamol (mean \pm SD).

Nebulizer	MMAD (μ m)	GSD	FPD (mg) (<5 μ m)	FPF (%) (<5 μ m)
μ MVN ⁺ 4.0	3.99 \pm 0.12	2.13 \pm 0.09	2.68 \pm 0.09	59.91 \pm 0.01
μ MVN ⁺ 3.0	2.73 \pm 0.36	2.35 \pm 0.27	3.29 \pm 0.42	74.11 \pm 0.08
μ MVN ⁺ 2.0	2.06 \pm 0.06	1.74 \pm 0.24	4.15 \pm 0.32	90.09 \pm 0.03
Aerogen Solo	3.98 \pm 0.37	2.11 \pm 0.10	2.50 \pm 0.38	61.18 \pm 0.06
JN	1.46 \pm 0.51	2.20 \pm 0.36	1.05 \pm 0.17	86.26 \pm 0.06

μ MVN⁺: MicroBase mechanical ventilator nebulizer plus.

MMAD: mass medium aerodynamic diameter.

GSD: geometric standard deviation.

FPD: fine particle dose.

FPF: fine particle fraction.

References

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Results & Discussion

In Figure 1, the inhaled dose of all μ MVN⁺ which connected to second generation T-adaptor was significantly greater than Aerogen Solo and JN ($p < 0.001$). Table 2 showed the results of inhaled dose% for nebulizer-adaptor combination. The inhaled dose was raised by approximately 4-6% when μ MVN⁺ 3.0 and μ MVN⁺ 4.0 were used with the MBTC-SG T-adaptor instead of the MBTC-FG T-adaptor. Inhaled dose of Aerogen Solo was significantly greater than JN ($p < 0.001$). Drug formulation influenced nebulizer delivery efficacy since the inhaled dose of salbutamol generated by all devices was significantly greater than that of budesonide ($p < 0.001$).

Table 2. Inhaled dose of salbutamol and budesonide with nebulizers combining with adaptors (% , mean \pm SD).

nebulizer	T-adaptor	Inhaled dose %		p value
		salbutamol	budesonide	
μ MVN ⁺ 4.0	MBTC-FG T-adaptor	17.67 \pm 0.78	13.75 \pm 0.27	<0.001
μ MVN ⁺ 3.0	MBTC-FG T-adaptor	20.46 \pm 0.66	14.12 \pm 0.42	<0.001
μ MVN ⁺ 4.0	MBTC-SG T-adaptor	20.99 \pm 1.00	17.94 \pm 0.47	<0.001
μ MVN ⁺ 3.0	MBTC-SG T-adaptor	26.29 \pm 1.56	18.40 \pm 0.17	<0.001
μ MVN ⁺ 2.0	MBTC-SG T-adaptor	29.71 \pm 0.76	20.31 \pm 0.78	<0.001
Aerogen Solo	Aerogen T-adaptor	17.92 \pm 0.43	9.50 \pm 0.23	<0.001
JN	commercial T-adaptor	12.57 \pm 0.70	6.39 \pm 0.43	<0.001

MBTC-FG: MicroBase Tech. Corp. first generation T-adaptor.

MBTC-SG: MicroBase Tech. Corp. second generation T-adaptor.

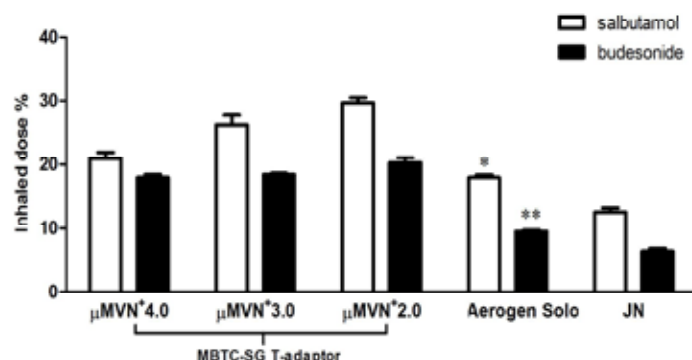


Figure 1. Comparison of inhaled dose % among the five nebulizers.

*Inhaled dose % of salbutamol by Aerogen Solo was significantly greater than JN ($p < 0.001$), yet lower than all μ MVN⁺ ($p < 0.001$). **Inhaled dose % of budesonide by Aerogen Solo was significantly greater than JN ($p < 0.001$), yet lower than all μ MVN⁺ ($p < 0.001$).

Conclusion

The newly designed polymeric vibrating-mesh nebulizer with a MBTC-SG T-adaptor enhanced aerosol drug delivery efficiency, possibly by reducing aerosol impaction and condensation during nebulization. Drug formulation influenced nebulizer delivery efficacy since budesonide suspension had resulted in a lower delivered dose.