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

Hui-Ling Lin[1,3] RRT MSc FAARC, Yu-Yao Kao[2] RT Bs, Eric Y.T. Chen[2] PhD

[1]Department of Respiratory Therapy, Chang Gung University, Taoyuan, Taiwan
[2]R&D Department, MicroBase Technology Corp, Taoyuan, Taiwan
[3]Respiratory Therapy, Chiayi Chang Gung Memorial Hospital, Chiayi, Taiwan

Introduction

Successful delivery of aerosolized medication within 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 reengineered T-adaptors when fitted with different vibrating mesh nebulizers during adult MV.

Key word: mechanical ventilation; aerosol drug delivery; vibrating mesh nebulizers; T-adaptor; bronchodilator.

Methods

- Ventilator parameters: Puritan Bennet 760 (Medtronic Plc), tidal volume 600 mL, respiratory rate 16 breathes/min, PEEP 5 cmH_2O[1].
- Drug: a unit dose of Ventolin (Salbutamol 5.0 mg/2.5 mL, GSK).
- Nebulizers and accessories: Figure 1 showed each one of μMVN⁺4.0, μMVN⁺3.0, μMVN⁺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.). Median mass aerodynamic diameter (MMAD) values were shown in Table 1.
- Placement of nebulizers: nebulizers were placed at inlet of a heated humidifier (MR370; Fisher & Paykel)[2-5].
- Drug eluted and analyzed: spectrophotometer (U-2900; hitachi Corp) at wavelength 276 nm for Combivent and 254 nm for Pulmicort[6].

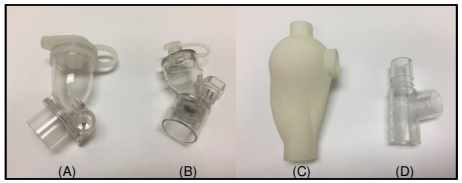

Figure 1. Nebulizers and accessories. (A) MicroBase mechanical ventilator nebulizer plus (μMVN⁺), (B) Aerogen Solo, (C) MBTC T-adaptor, (D) Aerogen T-adaptor.

Results

Table 1. The particle size of four nebulizers with Andersen cascade impactor (ACI)

Nebulizer	MMAD (μm)	GSD	FPD (mg) (<5 μm)	FPF (%) (<5 μm)
μMVN⁺4.0	4.03	1.99	2.78	61.05
μMVN⁺3.0	2.59	2.16	3.57	78.23
μMVN⁺2.0	2.03	1.78	4.19	89.79
Aerogen Solo	3.98	2.11	2.50	61.18

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

Figure 2, Figure 3 and Table 2 showed that inhaled dose (%) of different nebulizers connected to MBTC T-adaptor or Aerogen T-adaptor. The use of MBTC T-adaptor increased inhaled dose of Aerogen Solo (23.77±2.72%; mean±SD) when compared with existing Aerogen T-adaptor (18.87±2.49%; p=0.009). The inhaled dose of μMVN⁺4.0 with MBTC T-adaptor (22.19±1.87%) has exceeded that of the Aerogen T-adaptor (15.63±1.40%, p<0.001). Moreover, smaller particle size generated by μMVN⁺3.0 and μMVN⁺2.0 (with MBTC adaptor) has demonstrated significantly greater dose (26.51±1.78% vs. 30.04±0.63%) than Aerogen Solo with Aerogen T-adaptor (18.87±2.49% vs. 23.77±2.7%, p<0.001) correspondingly.

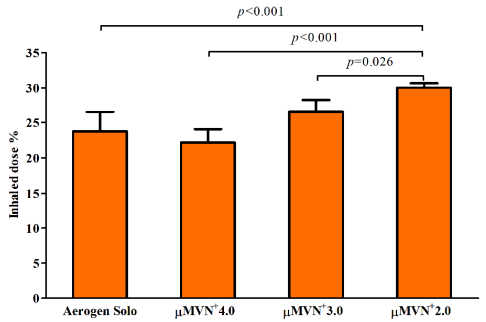

Figure 2. Inhaled dose % of vibrating mesh nebulizers with MBTC T-adaptors.

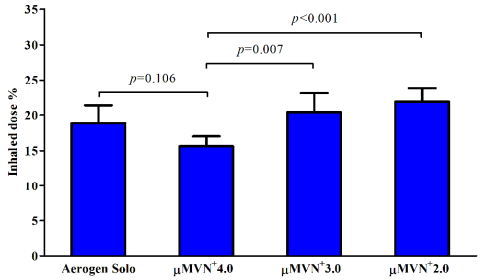

Figure 3. Inhaled dose % of vibrating mesh nebulizers with Aerogen T-adaptors.

Table 2. Delivery efficiency of Ventolin with four type nebulizers (mean ± SD)

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

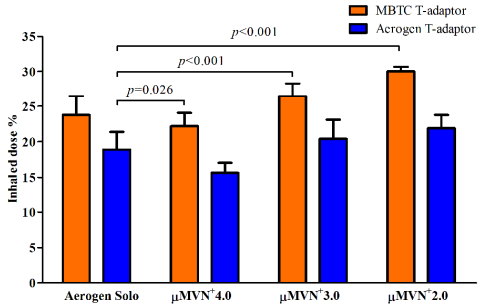

Figure 4. Inhaled dose % of vibrating mesh nebulizers with different T-adaptors. On the contrary, Aerogen T-adaptor significantly diminished inhaled dose % of all μMVN+ nebulizers when compared with matching MBTC T-adaptor.

Conclusion

The newly designed larger volume MBTC T-adaptor with nebulizers generating smaller MMADs enhanced aerosol drug delivery efficacy possibly through reducing aerosol impaction and condensation within Tadaptor during nebulization in a ventilator system.

References

1. Wilkins RL., Stoller JK., Kacmarek RM. (2009) *Egan's Fundamentals of Respiratory Care.* (9th ed.) St. Louis, MO: Elsevier.
2. Ari A, Atalay OT, Harwood R, Sheard MM, Aljamhan EA, Fink JB. Influence of nebulizer type, position, and bias flow on aerosol drug delivery in simulated pediatric and adult lung models during mechanical ventilation. Respir Care 2010;55(7):845-851.
3. Berlinski A, Willis JR. Albuterol delivery by 4 different nebulizers placed in 4 different positions in a pediatric ventilator in vitro model. Respir Care 2013;58(7):1124-1133.
4. Ari A, Areabi H, Fink JB. Evaluation of aerosol generator devices at 3 locations in humidified and non-humidified circuits during adult mechanical ventilation. Respir Care 2010;55(7):837-844.
5. Moraine JJ, Truflandier K, Vandenbergen N, Berre´ J, Me´lot C, Vincent JL. Placement of the nebulizer before the humidifier during mechanical ventilation: effect on aerosol delivery. Heart Lung 2009;38(5):435-439.
6. Wan GH, Lin HL, Fink JB, Chen YH, Wang WJ, Chiu YC, et al. In Vitro Evaluation of Aerosol Delivery by Different Nebulization Modes in Pediatric and Adult Mechanical Ventilators. Respir Care 2014;59(10):1494-1500.

Disclosures

- Ms Lin has received research grants from Aerogen Inc and Microbase Technology Corp. Other authors declare no conflict of interest.
- No financial support is provided for this research.