Evaluation of Aerosol Delivery by MicroBase Mechanical Ventilation Nebulizer (μMVN) and Jet Nebulizer at Two Locations in Adult Mechanical Ventilator

Yu-Yao Kao[1], Chi-Shan Hung[1], Yu-Chung Hsu[1], Chia-Chen Huang[1], Wan-Cheng Tang[1], Kai-Yao Lo[1], Eric Y.T. Chen[1*], Hui-Ling Lin[2*]
[1]R&D Department, MicroBase Technology Corp, Taoyuan City, Taiwan
[2]Chang Gung University, Taoyuan City, Taiwan
*Co-correspondents ericchen@microbase.com huiling@mail.cgu.edu.tw

Abstract

Aerosol drug delivery through mechanical ventilation is pervasively applied to hospitalized patients in intensive care unit, respiratory care center and ward. Current delivery method heavily relies on small volume jet nebulizers (SVN). Despite its low cost, it severely suffers from general inefficiency due to high residual volume; troublesome operation instigated by drug dilution; requirement of additional gas supply; and significantly reduced drug delivery efficacy. In order to resolve existing dilemma, we have developed a new vibrating-mesh nebulizer specifically for mechanical ventilation system, the MicroBase mechanical ventilation nebulizer (μMVN). The purpose of this study was to compare the efficacy of μMVN and a SVN on delivering to drugs by placed at two locations.

Methods and Materials

- Ventilator and setting: SERVO-i (Maquet Inc), Vt 600 mL, RR 16 bpm, Ti 0.9 s, and PEEP 5 cmH_2O
- Nebulizer: μMVN (MicroBase Technology Co, Taiwan) (Figure 1) and SVN (GaleMed Corp) were tested (Table1)

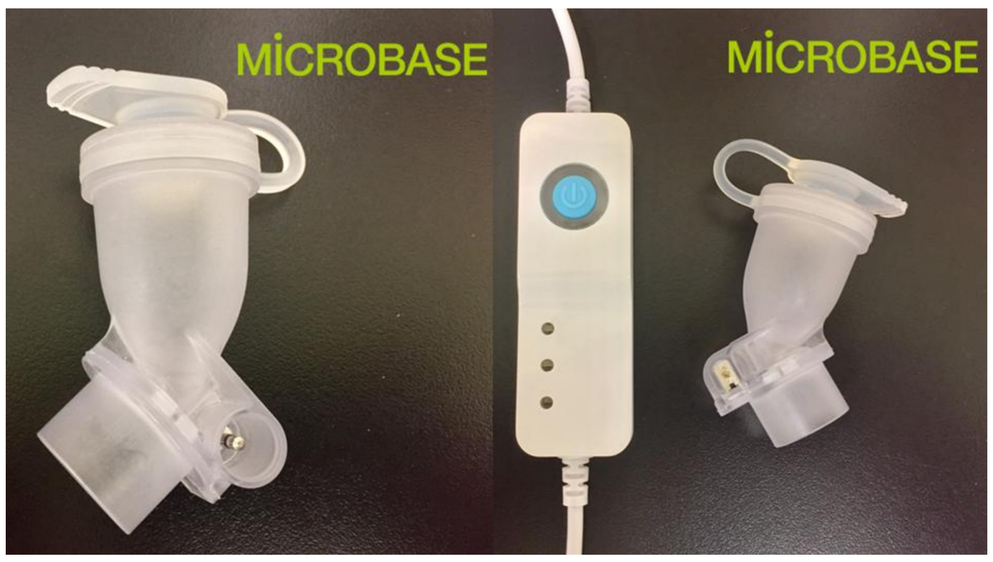

Fig 1. MicroBase mechanical ventilation nebulizer (μMVN) vibrating mesh nebulizer

- Nebulizer location: As Figure 2 presented, nebulizers were placed at A (Y-piece) and B (H.H).
- Drug: A unit dose of Combivent (Boehringer Ingelheim Co) or Pulmicort (AstraZeneca Co)
- Drug eluted and analyzed: spectrophotometer at wavelength 276 nm for Combivent and 254 nm for Pulmicort

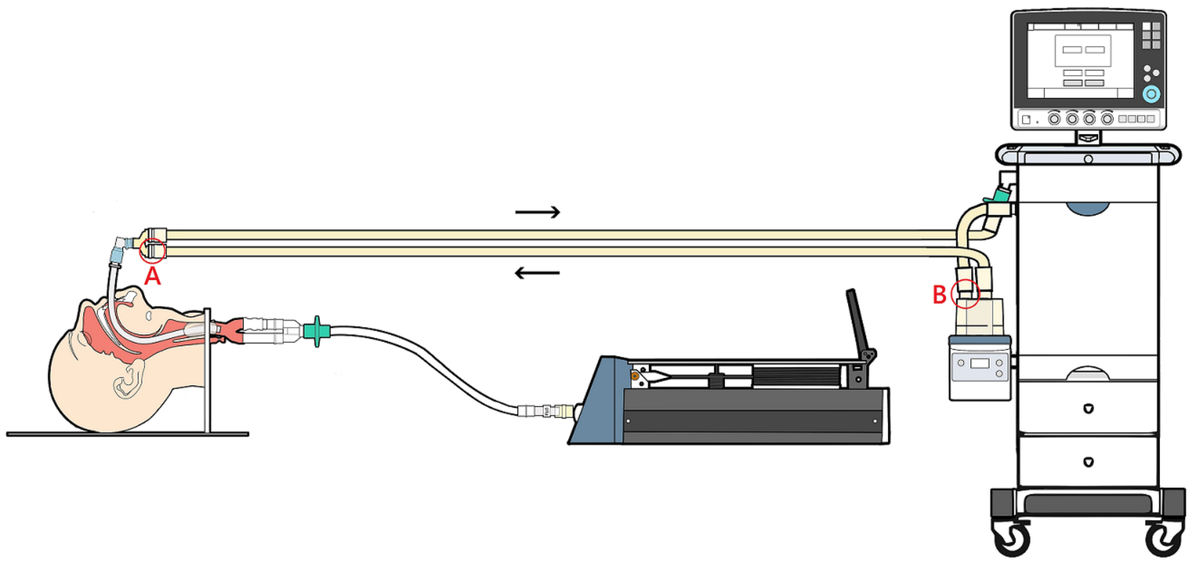

Fig 2. The experiment setup. A and B are nebulizer location.

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

Nebulizer	μMVN	SVN
MMAD(μm)	4.912	2.049
GSD	1.908	2.605
FPD(mg)(<5μm)	2.252	1.244

MMAD: mass medium aerodynamic diameter, GSD: geometric standard deviation, FPD: fine particle dose

Results

Table 2 and Figure 3 compared both inhaled and exhaled mass % of total dose for both Combivent and Pulmicort at Y-piece and H.H locations. The inhaled mass % of Combivent using μMVN was ~1.8 and ~2.0 fold higher than SVN at Y-piece and H.H, correspondingly (p <0.001). On the other hand, the inhaled mass % of Pulmicort using μMVN was ~1.7 and 1.3 fold higher than SVN at Y-piece and H.H, correspondingly. Furthermore, μMVN had generated higher inhaled mass % data for both Y-piece and H.H using water soluble Combivent than Pulmicort (suspension drug). Exhaled mass of each nebulizer at H.H was significantly lower than at Y-piece (p <0.001).

Table 2. Depositions among two nebulizers (mean ± SD)

Drug	Combivent				Pulmicort			
Nebulizer	μMVN		SVN		μMVN		SVN	
Nebulizer location	Y-piece	H.H	Y-piece	H.H	Y-piece	H.H	Y-piece	H.H
Inhaled mass (%)	7.37±0.7*	16.9±1.0*‡	4.13±0.3	8.59±0.6‡	5.53±0.4*	8.72±0.1*‡	3.19±0.4	6.91±0.2‡
Exhaled mass (%)	41.1±1.2†	15.11±0.8	21.8±0.7†	10.28±0.6	26.6±3.6†	12.04±0.5	17.4±2.2†	10.87±0.7

* μMVN was significantly higher than SVN at Y-piece and H.H (p<0.05), † Y-piece was significantly higher than H.H of μMVN and SVN (p<0.05), ‡ H.H was significantly higher than Y-piece μMVN and SVN (p<0.05).

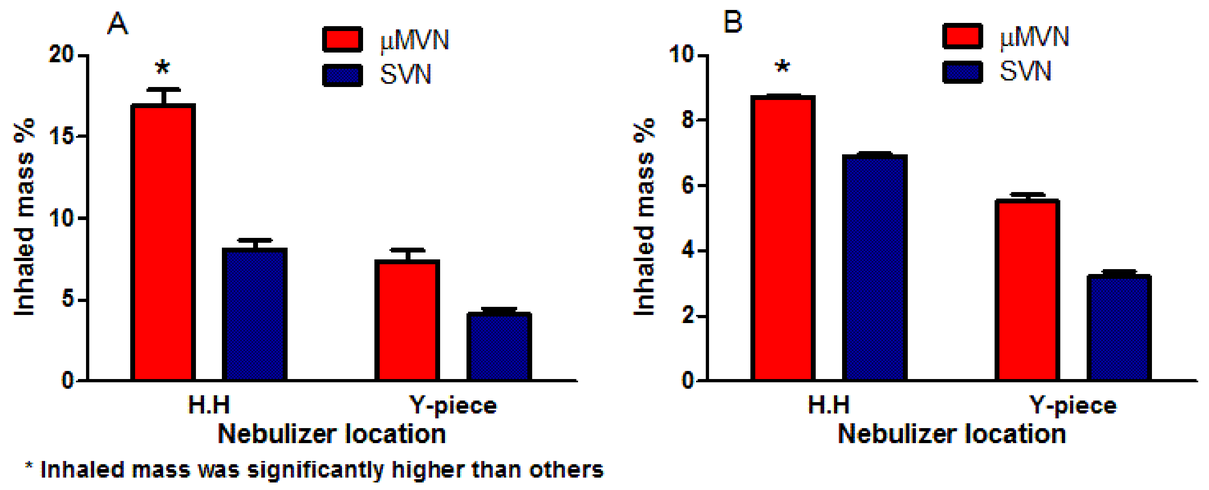

Fig 3. Comparison of inhaled drug mass among two nebulizers at different location. A: Nebulized with Combivent. B: Nebulized with Pulmicort.

Conclusions

Hence, our data revealed that the aerosol drug delivery efficacy of vibrating-mesh nebulizer placed at Y-piece and before H.H was higher than that of jet nebulizer on mechanical ventilator. To further optimize nebulization efficiency, placing the device before heated humidifier chamber could significantly enhance drug delivery and decreased drug waste.