Performance Evaluation of Four Models of Small Volume Nebulizer

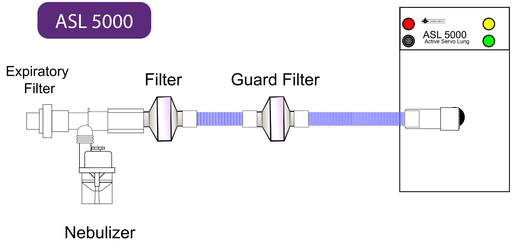
Daniel F Fisher,[1] Cathy Doyle,[2] Rubina Ali[2]

[1] Department of Respiratory Care, Milford Regional Medical Center, Milford, MA, USA, 01757 [2] Aerosol Science Laboratory, Trudell Medical International, London, ON, Canada, N5V 5G4

Milford Regional Medical Center
Celebrating 120 Years of Caring

BACKGROUND

Various improvements have been made to the basic jet nebulizer design with the intent of delivering more medication to the distal airways while still providing aerosol within the respirable range of 3 – 5 µm. The design changes can be one of three categories; breath-enhanced (BE), breath-actuated (BA), and breath-enhanced and breath-actuated (BE/BA). With breath enhancement, air is entrained into the nebulizer as the patient inspires providing greater inspiratory flow; breath-actuated nebulizers generate aerosol when inspiratory efforts are sensed by the nebulizer and cease upon expiration. Breath-enhanced nebulizers entrain air to provide extra flow, while breath-actuated only aerosolize when triggered by inspiration. The aim of the enhancements is to increase drug deposition within the lung, this can be done by increasing aerosol output and maintaining the majority of particles generated to be within the respirable range.



METHODS

Four different nebulizers were evaluated each representing a specific design; a breath-actuated (AeroMist), a breath-enhanced (Respironics SideStream), a breath-actuated and breath-enhanced (AeroEclipse II BAN), as well as a standard jet nebulizer (Misty Max 10). Each nebulizer was loaded with 3 ml of 2.5 mg albuterol sulfate solution. The mouthpiece of the nebulizer was connected inline to a spontaneous breathing Servo lung model (ASL 5000) using the following settings: V_T 500 ml, respiratory rate 10 bpm, I:E 1:2. A filter was positioned between the test lung and the nebulizer to capture inspired aerosol. The filter was changed every minute and output was determined using HPLC. Parallel measurements of Fine Droplet Fraction <4.7 µm diameter ($FDF_{<4.7µm}$) were made with each nebulizer using a laser diffractometer. Fine Droplet Mass <4.7 µm was determined as the product of Mass Recovered and $FDF_{<4.7µm}$.

DISCLOSURES

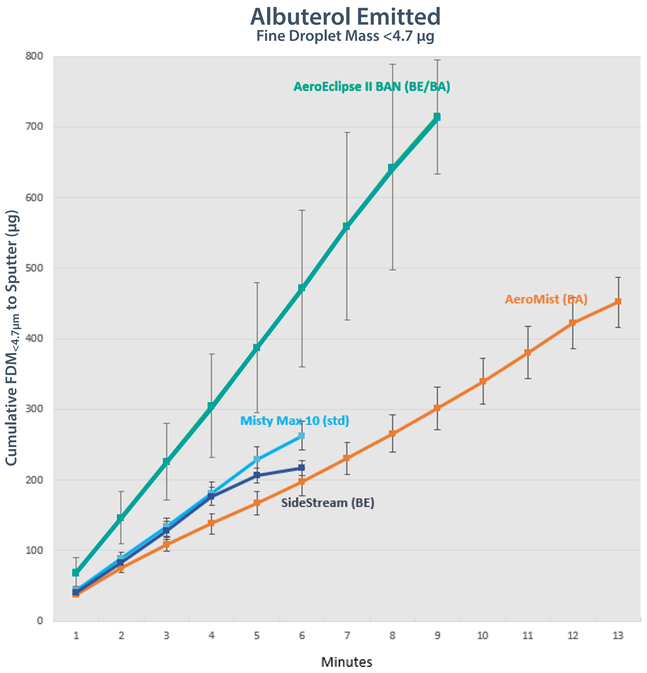
Trudell Medical International provided technical (C Doyle and R Ali are affiliated with Trudell), but no financial, support for this study.

ACKNOWLEDGEMENTS

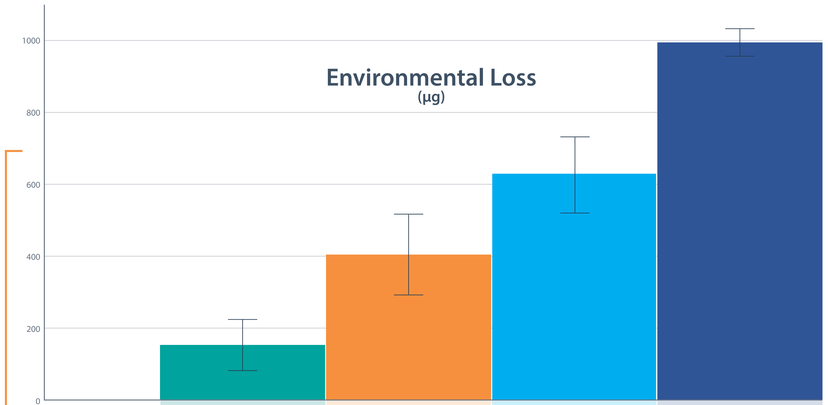
We thank Mark Nagel and Judy Schloss for their assistance.

RESULTS

Five new nebulizers were tested for each design. All values were significant for both AeroMist and the AeroEclipse II BAN ($p < 0.01$). The SideStream and Misty Max 10 performed similarly ($p > 0.05$). There was no significant difference in environmental medication loss with longer run time, ($p > 0.99$), but significant loss when compared with shorter run times ($p < 0.01$).



AeroEclipse II BAN Nebulizer was operated in breath actuated mode.



	AeroEclipse II BAN (BE/BA)	AeroMist (BA)	Misty Max 10 (std)	SideStream (BE)
Mass Delivered (µg)	860.3 ± 97.0	535.8 ± 42.1	339.8 ± 26.3	280.6 ± 13.6
Mass Recovered (µg)	2369.5 ± 67.5	2095.1 ± 109.6	1886.9 ± 110.3	1506.2 ± 45.8
Time to Sputter (sec)	458.0 ± 69.5	693.0 ± 7.1	287.0 ± 9.0	266.0 ± 4.0
Run Time (sec)	540.0 ± 60.0	780.0 ± 0.0	360.0 ± 0.0	360.0 ± 0.0
Fine Droplet Mass <4.7µm (µg)	714.6 ± 80.6	452.0 ± 35.5	262.5 ± 20.3	216.9 ± 10.5
Environmental Loss (µg)	130.5 ± 67.5	404.9 ± 109.6	613.1 ± 110.3	993.8 ± 45.8
Efficiency	30.1%	21.5%	13.9%	14.4%

Table 1: Nebulizer Performance

CONCLUSION

Enhancements to jet nebulizers which allow for increased inspired flow and limiting the cycle for aerosol generation have a positive influence on both delivered medication and particle size fraction delivered to the patient.

American Association for Respiratory Care Congress
November 5 - 8, 2023