EVALUATION OF VIBRATING MESH NEBULIZER, JET NEBULIZER AND pMDI PERFORMANCE DURING SIMULATED ADULT AND PAEDIATRIC CPAP AND NIPPV.

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INTRODUCTION

The efficiency of lung-targeted aerosol delivery during both adult and paediatric CPAP and NIPPV was evaluated in this study.

Both Continuous Positive Airway Pressure (CPAP) and Noninvasive Positive Pressure Ventilation (NIPPV) are commonly administered forms of ventilatory support indicated for use in patients diagnosed with a wide variety of disease manifestations ranging from those requiring simple airway support through to those with acute and chronic respiratory failure.

Concurrent aerosol delivery during noninvasive positive pressure ventilation can be exploited to facilitate administration of a variety of physician prescribed medications for inhalation in the treatment of airway disease in these patients. These include but are not limited to hypertonic saline, steroids and bronchodilators.

METHODS

Respirable Dose [dose delivered to the lung] was used as a comparative measure of aerosol delivery performance across three aerosol generator types for both modes of non-invasive ventilation.

The aerosol generators tested were the NIVO vibrating mesh nebuliser (Aerogen/Philips), designed specifically for inclusion in the Philips Respironics AF-series oro-nasal masks, the Ventstream jet nebuliser (Respironics) and the Ventolin Evohaler metered dose inhaler (100 μg pMDI, GSK). All devices were placed in the circuit between the leak port and the patient facemask.

CPAP was simulated for both adult (BPM 15, Tv 500mL, I:E 1:1, CPAP 4 cmH_2O) and paediatric (BPM 25, Tv 155mL, I:E 1:2, CPAP 4 cmH_2O) patients using a BiPAP/CPAP ventilator (V60 BiPAP/CPAP, Philips).

NIPPV was simulated for adult (BPM 15, IPAP 20 cmH_2O, EPAP 5 cmH_2O, Max Vol. 500mL) and paediatric (BPM 25, IPAP 15 cmH_2O, EPAP 5 cmH_2O, Max Vol. 155mL) patients also using the BiPAP/CPAP ventilator (V60 BiPAP/CPAP, Philips).

Respirable Dose in each setup was measured using an absolute filter (Respirgard 303, Baxter) placed distal to simulated head models. 2.5 mL of Albuterol sulphate (1 mg/mL) was nebulized as a marker aerosol using the nebulizers. Following 2 priming activations, a total of 6 activations of the pMDI were administered (for a total of 600 μg) to the patient interface.

The mass of drug eluted from the filters was determined using spectrophotometry (at 276 nm) and interpolation on a standard curve of Albuterol Sulphate concentrations (200 μg/mL to 3.125 μg/mL).

Results were expressed as a percentage of the nominal dose placed in the nebulizer's medication cup or the stated label claim as was the case for the pMDI.

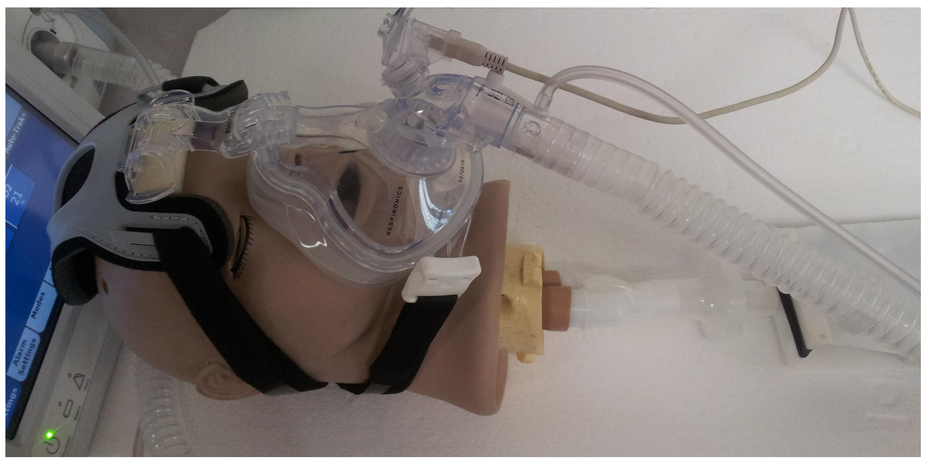

Figure 1: Respirable Dose test setup illustrating the NIVO vibrating mesh nebulizer.

RESULTS

The results of testing the three aerosol generator types, three times each are presented in Table 1.

	NIPPV		CPAP	
	Average Respirable Dose (%)	SD	Average Respirable Dose (%)	SD
ADULT:				
NIVO	21.97	1.77	25.12	1.37
Jet Neb	5.75	0.15	4.57	0.19
pMDI	20.05	1.04	13.21	0.39
PAEDIATRIC:				
NIVO	18.27	1.00	23.33	1.07
Jet Neb	4.51	0.22	3.89	0.15
pMDI	17.31	1.42	10.48	0.79

Table 1: Results for Respirable Dose. [SD = standard deviation] [n=3].

DISCUSSION

The NIVO vibrating mesh nebuliser achieved the highest Respirable Dose of the three aerosol generators tested across both adult and paediatric CPAP and NIPPV settings. The jet nebuliser consistently delivered the lowest Respirable Dose.

Whereas, both the NIVO and pMDI achieved comparable delivery efficiencies in NIPPV, the NIVO delivers a much higher dose (approximately 500 μg) as compared to the total dose delivered by the pMDI (approximately 120 μg) as each activation only delivers 100 μg.

The reduced Respirable Dose recorded for the jet nebulizer may be explained by the relatively high residual volumes remaining after sputter begins (approximately 1.0 mL – data not shown) and losses due to inertial impaction of droplets in the circuit.

Respirable Dose efficiencies for the NIVO are comparable with those reported in the literature for vibrating mesh nebulizers used during non-invasive mechanical ventilation [1,2].

These results provide further proof of principle for concurrent and highly efficient aerosol delivery during non-invasive mechanical ventilation.

REFERENCES

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[2] White CC *et al*., Bronchodilator Delivery During Simulated Pediatric Noninvasive Ventilation. Respir Care. 2013 Feb 5.