EVALUATION OF VIBRATING MESH NEBULIZER PERFORMANCE DURING NASAL HIGH FLOW THERAPY

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INTRODUCTION

The efficiency of lung-targeted aerosol delivery during Nasal High Flow therapy (NHF) was evaluated in this study.

There is an increasing adoption of NHF as an effective and noninvasive method of positive pressure ventilation across infant and adult patients in both the homecare and clinical settings. The unidirectional gas flow and relatively uncomplicated large bore circuitry of the NHF setup is hypothesized to allow for efficient transport of aerosol from the nebulizer to the patient. Convenient positioning of the nebulizer pre-humidifier allows for pre-conditioning of the inspiratory gas with aerosol prior to humidification, thereby reducing the amount of medication raining out in the circuitry and becoming unavailable to the patient.

The Aeroneb ® Solo vibrating mesh nebulizer, was selected for concurrent aerosol generation during this sensitive intervention. The Aeroneb Solo vibrating mesh nebuliser does not introduce additional extraneous gas flows or pressures and so does not interfere with the pre-set gas flow rates being delivered to the patient. This reduces the risk of adverse side effects such as baro- and volu- trauma, especially in infants. Additionally, the lack of interference with the gas flow rate helps maintain the relatively laminar flows expected in the circuitry, further increasing efficient aerosol transport to the patient.

The use of concurrent aerosol delivery during NHF can be exploited to facilitate delivery of a variety of physician prescribed medications for inhalation. These include but are by no means limited to hypertonic saline and β-agonists.

METHODS

Two measures of aerosol performance were evaluated, *i.e.* Emitted Dose [dose available for inhalation] and Respirable Dose [dose delivered to the lung].

Adult high flow nasal cannula were used (Optiflow™, Fisher & Paykel). 3.0 mL of Albuterol sulphate (2mg/mL) was nebulized as a marker aerosol using the Aeroneb Solo (Aerogen), a single patient use device, with an average MMAD of 3.4 microns (as measured at 28.3 LPM using the Anderson Cascade Impactor).

Emitted Dose at each gas flow rate under test (15, 30, 45 LPM) was recorded on an absolute filter (Respirgard 303, Baxter) placed at the exit of the cannula (n=3), see Figure 1.

A breathing simulator (ASL5000, Ingmar) was used to generate the adult breath (BPM 15, Vt 500 mL, I:E 1:1, as per EN13544-1) and Respirable Dose at each gas flow rate under test (15, 30, 45 LPM) was recorded distal to the LUCY adult airway model (n=3), see Figure 2.

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. Time to delivery of a full 3.0 mL dose was also recorded.

Figure 1: Emitted Dose test setup.

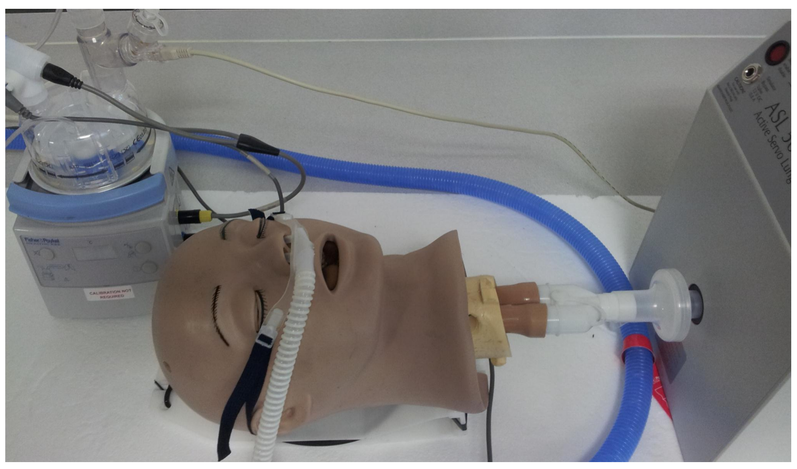

Figure 2: Respirable Dose test setup.

RESULTS

The results of testing are presented in Table 1. Time to delivery of a full 3.0 mL dose of Albuterol Sulphate was recorded at approximately 7 minutes for each run (equating to approximately 0.85 mg/min aerosol output rate and 0.429 mL/min nebuliser flow rate).

Gas Flow Rate (LPM)	EMITTED DOSE		RESPIRABLE DOSE	
	Average (%)	SD	Average (%)	SD
15	64.50	2.00	22.90	1.16
30	50.74	7.20	13.69	4.12
45	34.44	3.91	6.53	1.20

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

DISCUSSION

As expected, higher gas flow rates were associated with reduced efficiency of delivery of drug through this model of a humidified adult nasal high flow therapy system.

In relation to both Emitted Dose and Respirable Dose, this is likely due to impactional losses within the circuit tubing and upper airways of the LUCY model, respectively, with greater losses seen at higher gas flow rates due to potentially turbulent gas flow, and concomitant greater inertial potential for each aerosol droplet.

A near 2-fold difference was noted between minimum and maximum gas flow rates for Emitted Dose, and a near 3.5-fold difference was noted between minimum and maximum gas flow rates for Respirable Dose.

At all gas flow rates Respirable Dose efficiencies are comparable to those reported in the literature with vibrating mesh nebulizers during both invasive [1] and non-invasive mechanical ventilation [2].

These results provide further proof of principle for concurrent and highly efficient aerosol delivery during a nasal high flow therapy intervention.

REFERENCES

[1] Arzu A *et al*., Evaluation of aerosol generator devices at 3 locations in humidified and non-humidified circuits during adult mechanical ventilation. Respir Care. 2010 Jul;55(7):837-44.

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