

IMPACT OF NEBULIZER POSITION IN THE VENTILATOR CIRCUIT ON DRUG DELIVERY DURING MECHANICAL VENTILATION USING THE AERONEB® PROFESSIONAL NEBULIZER

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INTRODUCTION

The position of a nebulizer in a ventilator circuit has been shown to impact drug delivery to the lung during controlled mechanical ventilation (CMV), resulting in up to a four fold increase, when using either jet or ultrasonic nebulizers placed near the patient, when compared with placement close to the ventilator (Fink JB. Chest 1999.116:312S; Figure 1). This effect has not been previously evaluated with the new generation of electronic micropump nebulizers such as the Aeroneb® Professional Nebulizer System (“Aeroneb Pro”) with OnQ™ micropump technology (Figure 2).

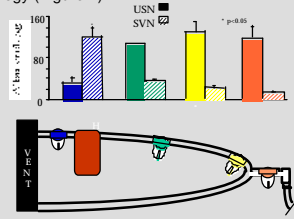


FIGURE 1: RELATIVE AMOUNTS OF ALBUTEROL SULFATE AEROSOL DELIVERED TO THE DISTAL END OF THE ENDOTRACHEAL TUBE FROM SMALL VOLUME JET NEBULIZER (SVN) AND ULTRASONIC NEBULIZERS (USN) WITH A DOSE OF 2.5 MG IN 3 ML. NEBULIZERS WERE PLACED AT FOUR POSITIONS (AT THE VENT, 18 IN FROM THE “Y”, AT THE “Y” AND BETWEEN THE “Y” AND ENDOTRACHEAL TUBE) IN A VENTILATOR CIRCUIT DURING SIMULATED ADULT VENTILATION.

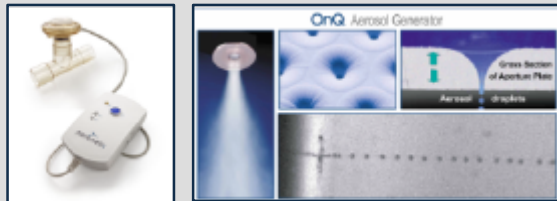


FIGURE 2: THE AERONEB® PROFESSIONAL NEBULIZER SYSTEM (LEFT). THE AEROGEN ONQ™ AEROSOL GENERATOR (RIGHT) WITH THE GENERATOR (LEFT PANEL), A MICROSCOPIC VIEW OF TAPERED APERTURES (UPPER MIDDLE), AND CROSS SECTION OF APERTURES (UPPER RIGHT). HIGH SPEED MICROSCOPIC PHOTOGRAPH OF AEROSOL GENERATED FROM A SINGLE APERTURE (LOWER RIGHT).

OBJECTIVE

We wanted to determine the effect of position of the Aeroneb Pro in the inspiratory limb of a ventilator circuit on delivery of drug to the distal tip of the endotracheal tube during simulated adult ventilation.

MATERIALS AND METHODS

An electronic micropump nebulizer (Aeroneb® Pro; Aerogen), was operated continuously in the inspiratory limb of a 60 inch ventilator circuit at four locations: 6 in from the ventilator (blue), 18 in from the patient “Y” (orange), 6 in from the “Y” (green) and proximal to the “Y” (yellow). A dose of 0.5 mL albuterol sulfate (0.5%; 2.5 mg) was aerosolized continuously, producing a 5.2 μm volume median diameter aerosol, as determined by laser diffraction (Spraytech™ Malvern) during simulated adult ventilation with a Puritan Bennett 760 ventilator (tidal volume of 400 mL, peak flow 30 L/min, ramp flow pattern, I:E ratio 1:1, rate 20/min) attached to an intubated adult lung model. The amount of drug deposited on an absolute filter distal to a 7.5 mm ID endotracheal tube was determined for each position of the nebulizer in the ventilator circuit (n=3). Drug was eluted from the filter and determined by reverse phase HPLC with isocratic elution and UV detection at 275 nm.

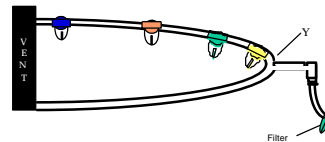


FIGURE 3: MODEL USED FOR MEASURING AEROSOL DELIVERY WITH SIMULATED ADULT BREATHING PATTERN. THE AERONEB PRO WAS TESTED IN EACH OF THE FOUR POSITIONS SHOWN.

In addition to placement, bias flow can have an impact on delivery, so the Aeroneb Pro was placed in the inspiratory limb at the “Y” (yellow) or proximal to the ventilator (blue), with three ventilators using different levels of bias flow through the circuit (Siemens Servo 300A, Puritan Bennett 840 and eVent Inspiration LS; n=3).

RESULTS

The percent of total dose ± standard deviation (SD) delivered to the test lung with the nebulizer at each position was 22.0±0.0% (6 in from the vent), 29.3±4.0% (18 in from the “Y”), 29.3± 2.2% (6 in from the “Y”), and 21.8±2.9% (at the “Y”). The deposited dose was greatest with nebulizer placement 6 and 18 in from the patient “Y”. Unlike jet and ultrasonic nebulizers, delivery was similar for placement 6 in from the vent and at the Y.

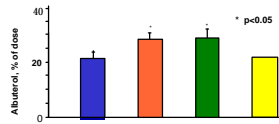


FIGURE 4: TESTING RESULTS FOR ALBUTEROL SULFATE DELIVERED FROM THE AERONEB PRO PLACED IN THE INSPIRATORY LIMB 6 IN FROM THE VENT (BLUE), 18 IN FROM THE “Y” (RUST), 6 IN FROM THE “Y” (GREEN) AND AT THE “Y” (YELLOW), WITH THE SAME DOSE (2.5 MG) OF ALBUTEROL SULFATE (SALBUTAMOL) ADMINISTERED IN DOSE VOLUME OF 0.5 ML. DATA ARE MEAN ± SD.

RESULTS (CONT)

In experiment 2, there were significant variations in aerosol delivery efficiency in different brands of ventilators set to deliver similar parameters of tidal volume, respiratory frequency and inspiratory flow. Variances in the continuous bias flow through the ventilator circuit and in nebulizer position had dramatic effects on aerosol delivery.

Ventilator	Bias Flow Rate	Nebulizer Placement	% Delivered (n=3)
Siemens Servo 300A	2.0 L/min	“Y”	27.3%
Siemens Servo 300A	2.0 L/min	Vent	20.8%
Puritan Bennett 840	3.5 L/min	“Y”	4.7%
Puritan Bennett 840	3.5 L/min	Vent	16.2%
eVent Inspiration LS	8.0 L/min	“Y”	5.2%
eVent Inspiration LS	8.0 L/min	Vent	13.4%

TABLE 1: EFFECT OF VENTILATOR TYPE, BIAS FLOW RATE, NEBULIZER POSITION, AND PERCENT OF DOSE DELIVERED USING THE AERONEB PRO WITH BASIC ADULT VENTILATION PARAMETERS.

SUMMARY

In a standard adult ventilator circuit without bias flow, placement of the Aeroneb Pro at the vent and at the “Y” resulted in less aerosol delivery than placement in the middle of the inspiratory limb. This is in contrast to the jet SVN which was more efficient placed back at the ventilator, and the USN which deposited more drug when placed at or near the “Y”.

The level of continuous or bias flow in the ventilator circuit impacts aerosol delivery with the Aeroneb Pro, with flows = 3.5 L/min resulting in greater deposition with placement of the nebulizer at the ventilator than proximal to the patient “Y”.

CONCLUSION

The Aeroneb Pro nebulizer results in less variability as a function of placement in the ventilator circuit when placed proximal to the vent and to the “Y” than previously described with use of jet or ultrasonic nebulizers during CMV with no bias flow. When bias flow exceeds 3.4 L/min, placement of the Aeroneb Pro proximal to the ventilation improves deposition compared to placement proximal to the patient.