Using Heliox with the EZflow and EZflow MAX*

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In recent years, heliox has been used increasingly in the treatment of severe acute asthma to delay inspiratory muscle fatigue until bronchodilator and/or corticosteroid therapy is effective. Additionally, Continuous Nebulizer Therapy (CNT) has been shown to be an effective means of treating severe reversible airway disease. Numerous studies comparing CNT to traditional medication aerosol treatments have shown that, for patients with severe reversible airway disease or impending respiratory failure, CNT is both more effective and labor efficient. To date, little work has been done on the combination of delivering heliox and continuous nebulization. This study looks at the use of the EZflow and EZflow MAX continuous nebulizers with heliox, and it's affect on particle size as well as output.

Methods

Three each of the EZflow and EZflow MAX were sampled randomly from sellable stock. Each was mixed with 4 mL of 0.5% albuterol sulfate (5 mg/mL) and 21 mL of normal saline. Each nebulizer was run in turn with 80-20, 70-30, and 60-40 heliox mixtures. Heliox was supplied to the compressed gas inlet of each nebulizer using 7' oyxgen tubing as is done with compressed air or oxygen. Flowrates were set at indicated values of 3.0 L/min for the EZflow and 10.0 L/min for the EZflow MAX. Although it was recognized that the difference in density for each heliox mixture would result in an actual flow different from the indicated flow, indicated flows were kept constant in the interest of simplifying set up for different mixes of heliox. Each nebulizer was run for 10 minutes to reach steady state conditions, afterwhich, an initial weight was obtained followed by another 10 minute run and a final weight. The differences in weights were used to obtain the expulsion rate for each nebulizer and this was repeated three times. During the second run, all aerosol leaving the nebulizer was collected onto a cotton ball filter using a simulated inhalation flow of 10 L/min. Similarly, during the last run, aerosol exiting the nebulizer was sampled using a cascade impactor. Aerosol captured by the cotton ball filter and the cascade impactor underwent spectrophotometric analysis to determine nebulizer delivery efficiency and particle size. Nebulizer delivery efficiency was defined as the fraction of medication delivered by the aerosol as compared to the fraction of medication in the nebulizer reservoir and is calculated by the medication captured in aerosol form divided by the product of the gravimetric aerosol output and the concentration of the nebulizer reservoir.

Results

Table 1 shows the results for gravimetric expulsion rate, particle size, and nebulization efficiency. For both nebulizers the gravimetric expulsion rate with heliox was higher than for the same indicated flow using air or oxygen. This is primarily due to the heliox having a smaller density resulting in actual flow rates being considerably higher than indicated flowrates. For all mixtures of heliox, gravimetric outputs were relatively consistent. The mean output was 9.6 mL/hour for the EZflow and 25.9 mL/hour for the EZflow MAX. The variance for the outputs between mixes of heliox was less than the variance produced by factors within the hospital such as inaccurate flowmeters, variance in environmental conditions, tubing leaks and variance between individual nebulizers. As shown by previous researchers, particle size was reduced using heliox as compared to compressed air of oxygen. Nebulizer efficiencies were equivalent to those measured using compressed air or oxygen.

Nebulizer Performance with Heliox

	Heliox Concentrations		
	60-40	70-30	80-20
EZflow			
Output (mL/hour)	9.9	9.6	9.2
MMAD (microns)	1.5	1.6	1.8
Efficiency (%)	93	91	91
EZflow MAX			
Output (mL/hour)	24.4	25.7	27.6
MMAD (microns)	1.4	1.2	1.3
Efficiency (%)	92	92	91

TABLE 1: Expulsion rate, particle size, and nebulization efficiency for each nebulizer with different mixtures of heliox

Conclusion and Discussion

The EZflow and EZflow MAX both work well with heliox. As expected for the increase in actual flowrate, outputs increased. Nebulizer Efficiency was consistent with values measured using air or oxygen. Particle size was smaller for both nebulizer types than what has been measured using air or oxygen. There is little data on optimum particle size for deposition when using heliox. Although the MMAD has been measured to be smaller, it should be pointed out that smaller particles carried by heliox could reasonably be expected to deposit in bigger airways than when carried by air or oxygen. This is expected primarily because the lighter density of heliox has less capability of causing particles to change direction than heavier air or oxygen, thus smaller particles would undergo inertial impaction on bronchial airways that would of otherwise been circumvented. Significant research is needed regarding this issue.

DOSING CHART FOR HELIOX ONLY

NEBULIZER	EZflow								EZflow MAX			
FLOW(INDICATED)	3 L/min								10 L/min			
OUTPUT	10 mL/hour								26 mL/hour			
RX (mg/hour)	5		10		15		20		5	10	15	20
Treatment Duration (hours)*	1	2	1	2	1	2	1	2	1	1	1	1
Medication @ 5mg/mL (mL)*	1	2	2	4	3	6	4	8	1.0	1.9	2.9	3.8
Saline (mL)*	9	18	8	16	7	14	6	12	24.0	23.1	22.1	21.2

* Rounded to nearest tenth

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** S. David Piper, PE is a registered professional engineer with the state of California, President of Piper Medical Products, and has been involved with the invention and development of continuous nebulizers since 1990. 2054a