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A Laboratory-Based Examination of the Potential for Fugitive Emission of Aerosols to the Local Environment from a Range of Commercially Available Nebulizer Systems

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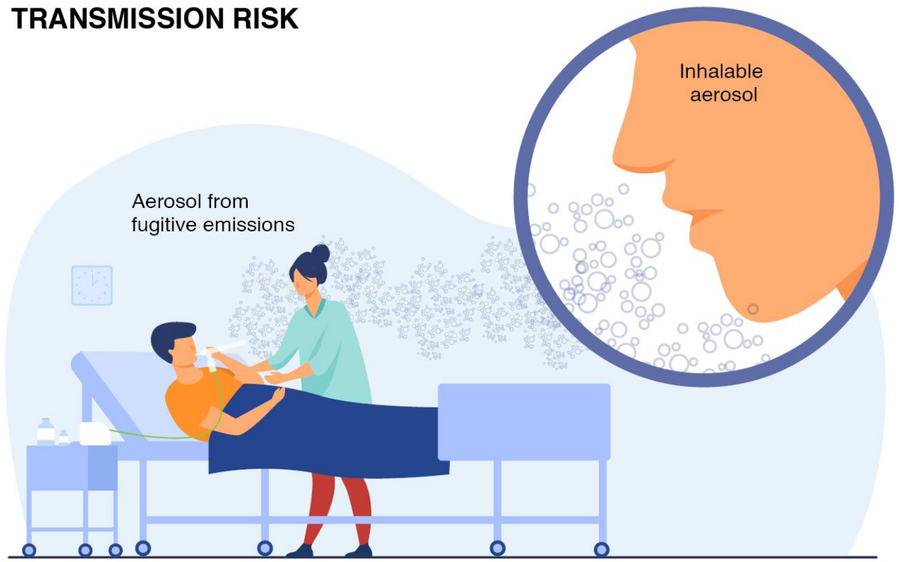
INTRODUCTION

Background

- An unintended consequence with inhaled medication from nebulizing systems is the potential for fugitive emission during treatment
- There exists a potential risk factor in both clinical and home care settings, particularly in the context of the present COVID-19 pandemic



Purpose

- Compare the potential for fugitive emission from a variety of widely encountered nebulizers during simulated adult tidal breathing

MATERIALS & METHODS

Patient Simulation

- 3 mL of salbutamol (2.5 mg / 3 mL) used as the tracer aerosol
- The mouthpiece of the nebulizer-on-test was connected to an ASL 5000 (Ing Mar Medical), set to simulate realistic variations in inspiratory/expiratory (I:E) ratio associated with different patients' disease states

Tidal Volume (mL)	Respiration Rate (cycles/min)	I:E ratio	Minute Volume (mL)	Example Condition
500	15	1:1	7500	Intervention to improve arterial oxygenation
	10	1:2	5000	Normal adult respiration
	7	1:3	3500	Slight/Moderate obstructive disease
	6	1:4	3000	Severe obstructive disease

Table 1. ASL 5000 breathing simulator operating conditions.

MATERIALS & METHODS

Nebulizer

- A filter was placed at the nebulizer mouthpiece and replaced after every minute of nebulization. The process repeated until sputter occurred
- 10 commonly available small volume nebulizers (SVNs) were tested - jet, breath actuated, and vibrating mesh

Environmental loss of Salbutamol (L_{env} , µg)

- Calculated as per the following:

$$L_{env} = 2500 - (M_f + M_{residual}),$$ where

M_f = total mass recovered from the inhalation filter

$M_{residual}$ = residual mass recovered from the nebulizer

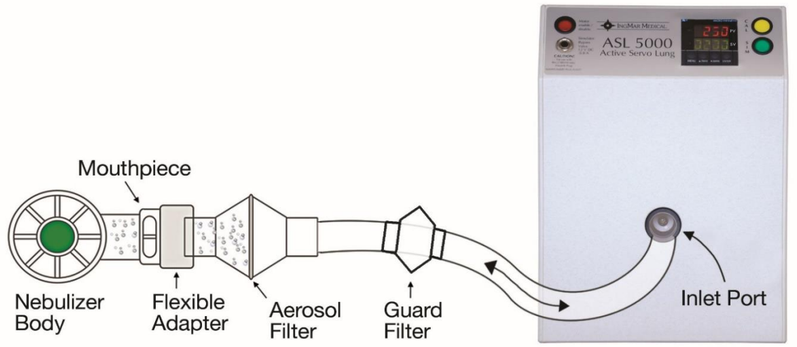


Figure 1. The set-up for nebulizer testing by breathing simulator

Name	Abbreviation
AeroEclipse®-II	AE-II
NebuTech™ HDN™	NTEC
Salter Labs® 8900-7	8900
Circulaire®-II	CIRC
Hudson RCI® MicroMist®	MIST
AirLife® SideStream High Efficiency	SSHE
Vyaire AirLife™ Misty Fast™	AIRMF
Philips Sidestream Disposable	SS-D
AirLife™ Misty Max™ 10*	AIR-MM
Aerogen® Ultra	ULTRA

Table 2. Nebulizers evaluated for comparative fugitive emissions

RESULTS

Wide variations in total dose observed with different nebulizer types (see abstract)

Considerable variations in L_{env} across different nebulizer systems

- L_{env} was influenced by the change in I:E ratio, increasing with an increase in the length of the exhalation phase

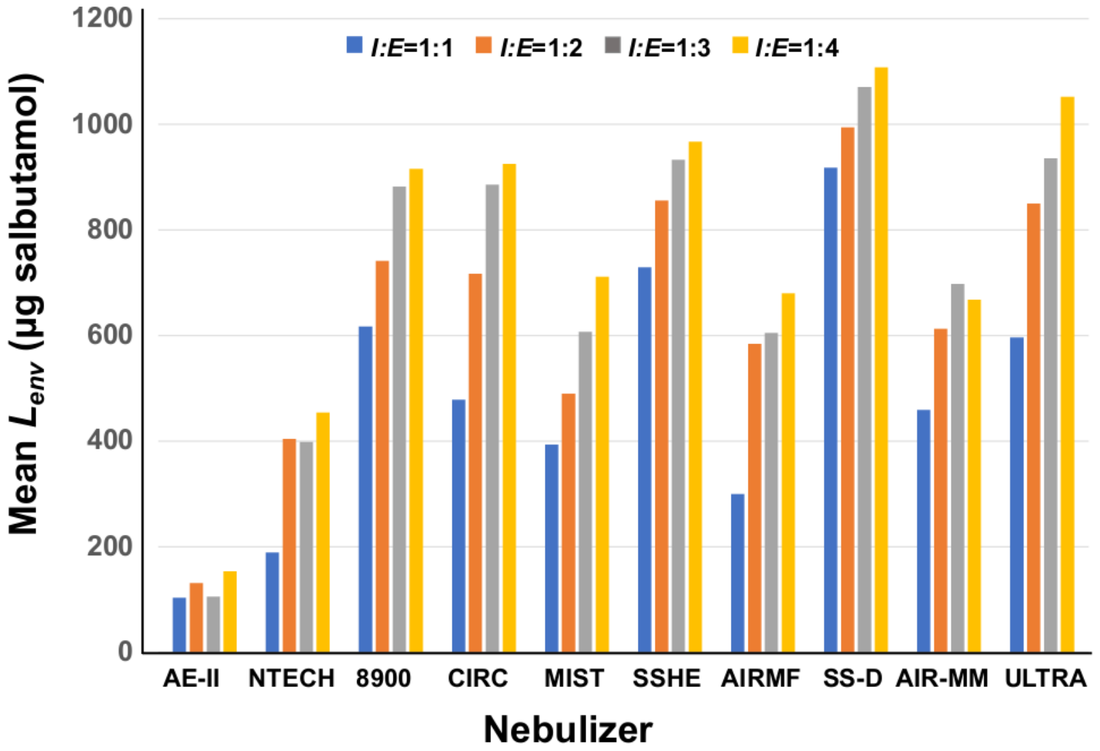
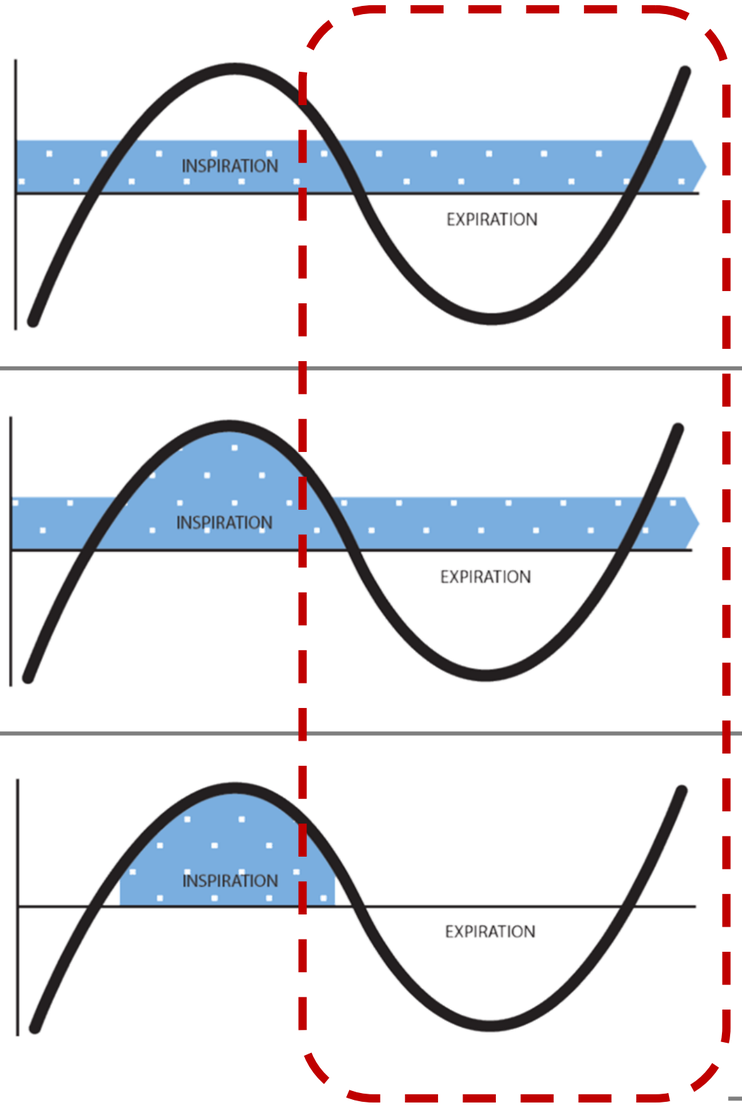


Figure 2. Variation of environmental loss of salbutamol tracer (L_{env}) for the nebulizers studied, showing the influence of inspiratory/expiratory (I:E) ratio

DISCUSSION

Constant Output		
Breath Enhanced		
Breath Actuated		

CONCLUSION

Summary of Key Findings

- A wide variation in total dose across the different nebulizer types – a feature that is consistent with previous laboratory-based comparisons [1]
- Growing L_{env} as a proportion of exhalation time, given that more time is proportionately available for fugitive emission generation
- Breath-actuation (AE-II) substantially reduced L_{env} but did not completely eliminate it

Future Directions

- These findings could help develop policies and best practices for the risk mitigation of fugitive emissions from nebulizing systems

[1] Rau JL. Ari A, Restrepo RD: Performance comparison of nebulizer designs: Constant-output, breath-enhanced, and dosimetric. *Respir Care* 2004, 49 (2): 174–179.