

INTERMITTENT NEBULIZATION DURING INSPIRATION IS THE LEAST EFFICIENT MODE IN AN *IN VITRO* PEDIATRIC VENTILATOR-LUNG MODEL

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INTRODUCTION

Jet nebulizers (JNs) are used to administer bronchodilators and antibiotics to mechanically ventilated children. Different patient-, delivery system- and ventilator-related factors may influence the efficacy of nebulization. According to the last American and British guidelines [1, 2], actuation of JNs during the inspiratory phase of the ventilator cycle is recommended.

AIM

To evaluate the influence of four different nebulization modes on salbutamol delivery in an *in vitro* pediatric ventilator-lung model.

MATERIAL ET METHODS

Ventilator lung model (Fig. 1):

Galileo (Hamilton Medical), with the following settings: pressure-limited mode, V_T 100 ml, PIP 25 cm H_2O , PEEP 5 cm H_2O , Rate 25/min, Cycle 2.4 sec. (t_{insp} 0.8 sec, t_{exp} 1.6 sec), in order to simulate a 10-kg child. Endotracheal tube: 4.0 mm (Portex). Test-lung: RÜsch 0.5 L, with Rexp 55-60 mbar/l/sec. Humidifier: MR 700/600 (Fisher & Paykel). JN positions: in the inspiratory line (10 cm or 120 cm from the Y-piece). Test-solution: 4.0 ml of a 0.25% salbutamol solution (Ventolin®, ut sulfate, Glaxo-Wellcome) diluted in NaCl 0,9% (Braun).

Nebulizers (n = 5):

1. Microneb NA420 (Europe Medical); 2. Sidestream durable (Medic-Aid); 3. Acorn II (Marquest Medical Products); 4. Cirrus (Intersurgical); 5. Upmist (Hospitak); 6. Micro Mist (Hudson).

Nebulization modes:

Driving air source (A-C from the ventilator and D from an external source): (A) intermittent nebulization during the inspiratory phase ("Intermittent/Inspiratory" mode); (B) continuous nebulization ("Continuous" mode); (C) intermittent nebulization during the expiratory phase ("Intermittent/Expiratory" mode); and (D) continuous external flow at 6 L/min (dry air, Carbagas) controlled by a mass-flow meter and a rotameter. Nebulization time: 30 min.

Flow tracings:

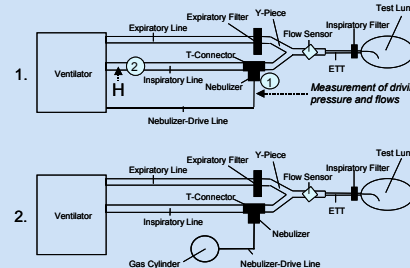
Nebulizer flow tracings measured with a fast response anemometer (Florian) to determine graphically t_{=>5} L/min (time to reach 5 l/min or acceleration time) (Fig. 2).

Salbutamol delivery:

Salbutamol sulphate deposited on the inspiratory filters (Respigard 301, Marquest) and expiratory filters (Respigard 303) and remained in the JNs was analysed by HPLC.

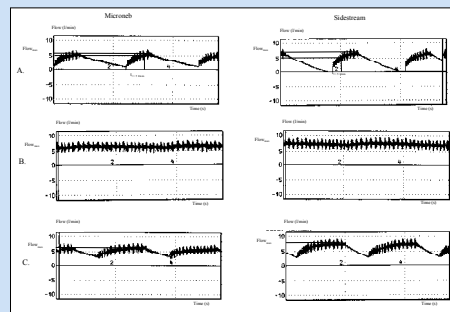
Statistical tests: ANOVA (Instat).

Fig. 1 Pediatric ventilator lung model. 1. Nebulization with air from the ventilator driver (H: humidifier). 2. Nebulization generated by an external source of air.



RESULTS

Fig. 2 Typical flow tracings for Microneb and Sidestream (A. Intermittent/Inspiratory; B. Continuous; C. Intermittent/Expiratory)



Using intermittent nebulization during the inspiratory phase, salbutamol deposition (expressed as the % of the nominal dose) at the end of ETT was low and varied highly among JN brands: from $0.3 \pm 0.1\%$ (Microneb) to $3.4 \pm 0.6\%$ (Upmist) (Fig. 3). This nebulization mode was the least efficient mode ($1.9 \pm 1.2\%$, n = 30) compared to continuous ($4.0 \pm 1.5\%$, p < 0.001) or continuous with an external fixed flow ($4.2 \pm 1.0\%$, p < 0.001) (Fig. 4). The most efficient was intermittent during the expiratory phase, with $6.5 \pm 2.5\%$ of salbutamol deposition (p < 0.001 with all other modes). The major part of drug remained in the JNs (range: 26.8-85.3%) or was expired (range: 7.2-47.4%). A highly significant inverse correlation was found between the drug delivery at the end of the ETT and t_{=>5} l/min. (r²: 0.99, p < 0.0001) (Fig. 5).

Fig. 3 Salbutamol delivery at the end of the ETT (for the six JN models, n = 5)

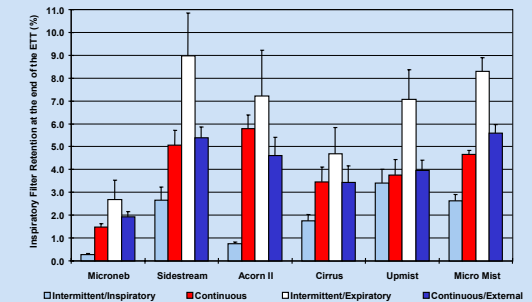


Fig. 4 Salbutamol delivery at the end of the ETT (Data pooled for each nebulization mode, n = 30)

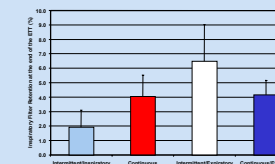
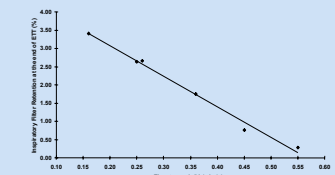


Fig. 5 Correlation between salbutamol delivery at the end of the ETT and t_{=>5} L/min ("Intermittent/Inspiratory" mode)



CONCLUSIONS

- Intermittent nebulization during the inspiratory phase and continuous nebulization were not the most efficient modes in our *in vitro* pediatric ventilator-lung model. Intermittent nebulization during the expiratory phase permitted a mean increase of 55-242% of salbutamol deposition at the end of the ETT.
- Important differences existed between JN brands due to their internal resistance and design.
- > 90% of salbutamol remained in the JNs, was expired or lost in the ventilator circuit.
- It is important to evaluate the clinical consequences of this bench study.

REFERENCES

- [1] AARC clinical practice guideline: Selection of device, administration of bronchodilator, and evaluation of response to therapy in mechanically ventilated patients. *Respir Care* 1999;44:105-113.
- [2] British Thoracic Society Nebulizer Project Group. Current best practice for nebulizer treatment. *Thorax* 1997;52 (Suppl 2):S1-S24.