# *In vitro* Evaluation of a new Spacer with a Small Volume used in Mechanical Ventilation.

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## Introduction

The efficiency of drug delivery in mechanical ventilation depends on multiple factors as for example the position of the device in the mechanical ventilation system [1; 2]. Inserting the inhalation device between the Y piece and the endotracheal tube could be convenient especially when using tubing bonded with Y piece. The aim of this study was to evaluate the in vitro performance of a prototype inhalation chamber (MinimHal®, Laboratoire OptimHal-ProtecSom) which allows the use of both a pressurized metered dose inhaler (pMDI) and a vibrating mesh nebulizer (VMN). The small internal volume of this inhalation chamber permits its insertion between the Y piece and the endotracheal tube. The evaluation of this device with pMDI was performed in comparison with an MDI adapter and with a vibrating mesh nebulizer in comparison with its standard T piece.

## Material and methods

A ventilator (Evita 2 Dura, Dräger) was used in volume controlled mode (Vt = 450 mL, f = 15 cycles/min, Positive End Expiratory Pressure (PEEP) = 5cm$H_2O$, ratio between inspiratory and expiratory time = ½ and a flow rate of 21 L/min) connected to the test lung model ( SmartLung Adult, IMT Medical : Resistance = 5 mbar/L/s and Compliance = 30 mL/mbar) as described in figure 1.

A 7.5 mm ETT and a right-angle elbow adapter were inserted between the Y-piece and the Test Lung. The prototypes were inserted between the Y-piece and the right-angle elbow. The delivered dose was collected on a filter inserted between the ETT and the test lung model.

Two different measurements were performed ;

- Use with a pMDI : 10 doses containing 100 µg of Salbutamol (Ventolin® 100µg, GlaxoSmithKline) were actuated in the prototypes during inspiration.
- Use with a vibrating mesh nebulizer (VMN) : A solution containing 5 mg of Salbutamol (Salbutamol Mylan, 2,5 mg/2,5 mL) was nebulized with the vibrating mesh nebulizer Aeroneb® Pro (Aerogen).

The filter and each component of the mechanical ventilation circuit were recovered with a NaCl solution (0,1M) and quantified by UV spectrophotometry. Each measurement was performed three times. Results are expressed as means ± standard deviation.

Statistical analyses were performed using GraphPad Prism 6.01 (GraphPad Software, CA) and consisted of multiple t-tests. A p-value < 0,05 was considered significant.

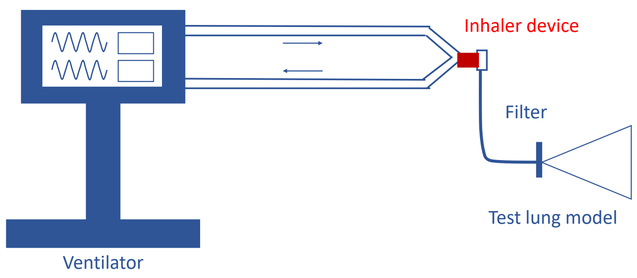



**Figure 1 : schematic drawing of the bench model used for the experiments.**

## References

[1] : Ari A, Aerabi H, Fink JB: Evaluation of Aerosol Generator Devices at 3 Locations in Humidified and non-humidified Circuits During Adult Mechanical Ventilation, *Respir Care* 2010, 55: 837-844.

[2]: Dugernier J, Wittebole X, Roeseler J, Michotte JB, Sottiaux T, Dugernier T, Laterre PF, Reychler G : Influence of Inspiratory Flow Pattern and Nebulizer Position on Aerosol Delivery with a Vibrating-Mesh Nebulizer During Invasive Mechanical Ventilation: An In vitro Analysis, *J Aerosol Med Pulm Drug Deliv* 2014, 27: 1-8.

## Devices used

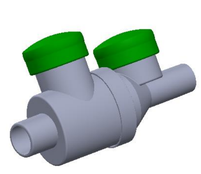
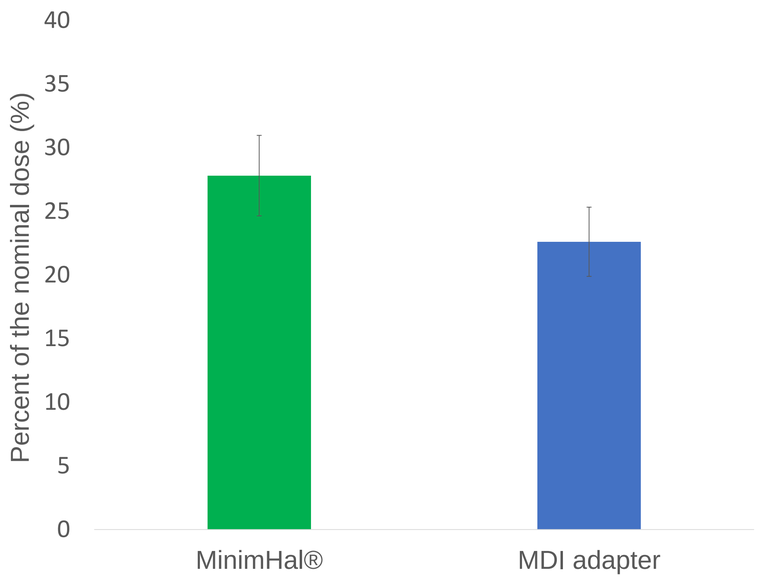


**Fig 2: Drawing of the prototype spacer (MinimHal®) (Volume of 60mL) (Solidworks, France)**

**Fig 3: Picture of the Aeroneb Solo T piece (a) and MDI T adapter (b)**

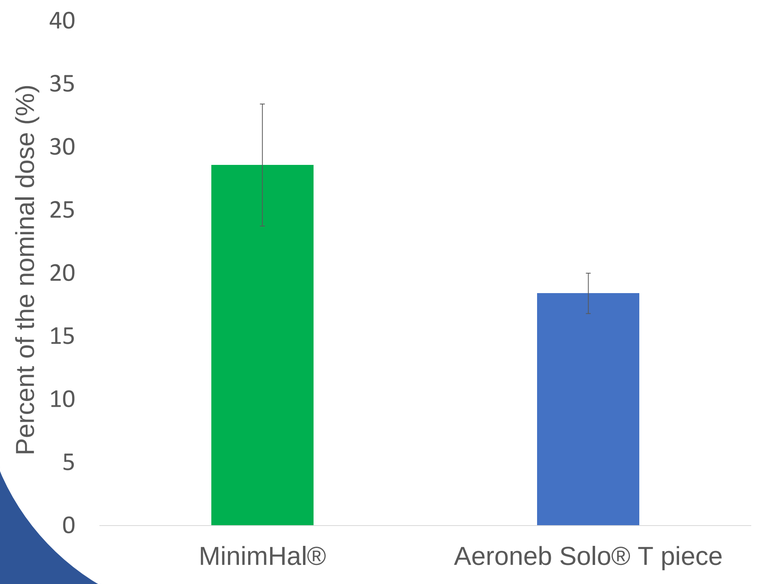
The prototype spacer (MinimHal, Laboratoire OptimHal-ProtecSom) was created with Solidworks (Dassault System) and 3D printed with a PLA material (Figure 2). The performance of the propotype was evaluated in comparison with Aeroneb Solo T piece (Aerogen) when using with a VMN and with a T piece including a MDI nozzle (Intersurgical) when using a pMDI (Figure 3).

## *In vitro* Aerosol delivery




| | Percent of nominal dose (mean ± SD, n=3) |
|---|---|
| prototype spacer | 27.80 ± 3.16 |
| MDI adapter | 22.61 ± 2.72 |

Aerosol deposition obtained on the filter is higher when using the small volume spacer compared to the MDI T adapter (p-value of 0,007). This result could be explained by the larger internal volume of the spacer which decrease impaction of the drugs on the internal walls due to the high velocity of particles exiting the pMDI.




| | Percent of nominal dose (mean ± SD, n=3) |
|---|---|
| prototype spacer | 28,58 ± 4,84 |
| Aeroneb Solo® T piece | 18,41 ± 1,60 |

Aerosol deposition obtained on the filter is higher when using the small volume spacer compared to the Aeroneb Solo T piece (p-value of 0,03). This result could also be explained by the larger internal volume of the spacer which may limit deposition of aerosol on the internal walls by condensation.

## Conclusion

The aim of this study was to evaluate the in vitro performance of a spacer with a small volume which permits its insertion between the Y piece and the endotracheal tube, in comparison with T adapters. In vitro aerosol deposition was higher with the prototype spacer in comparison with the T pieces when using with both a pressurized dose metered and a vibrating mesh nebulizer.

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