In vitro evaluation of a spacer in a pediatric model of mechanical ventilation.

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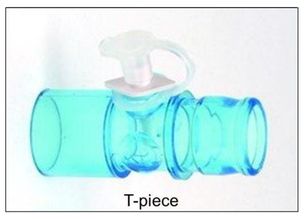
Introduction

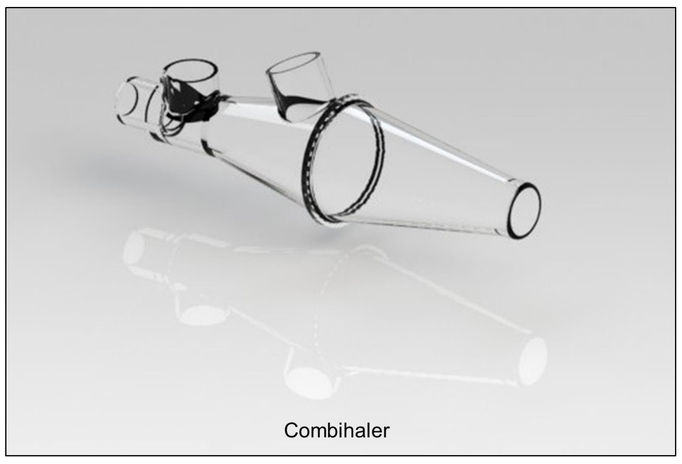
The factors influencing aerosol delivery in mechanical conditions relate to the ventilator, the ventilation circuit and the device used to administer inhaled medication. Use of a spacer would appear therefore as a way to optimize aerosol delivery in mechanical ventilations, both with pMDIs and mesh nebulizers. A new spacer suitable for either a pMDI or a mesh nebulizer has been specifically designed for circuits of invasive mechanical ventilation.

The purpose of this study was to evaluate the mass of salbutamol delivered by a pMDI or a mesh nebulizer using a Combihaler® spacer in a model of pediatric mechanical ventilation.

Materials and methods

- In this study, different devices were used :
  - T-piece (Allegiance Healthcare Corporation, Jackson, USA)
  - T-adapter (Aerogen® T-adapter, Aerogen, Ireland)
  - Combihaler® spacer (Protec'Som, France)
  - Aeroneb Solo nebulizer device (Aerogen, Ireland) with the Aerogen controller
  - Ventoline® 100 µg per dose (GlaxoSmithKline, France)
  - Salbutamol (2.5 mg/2.5 mL, Arrow Génériques, Lyon, France)

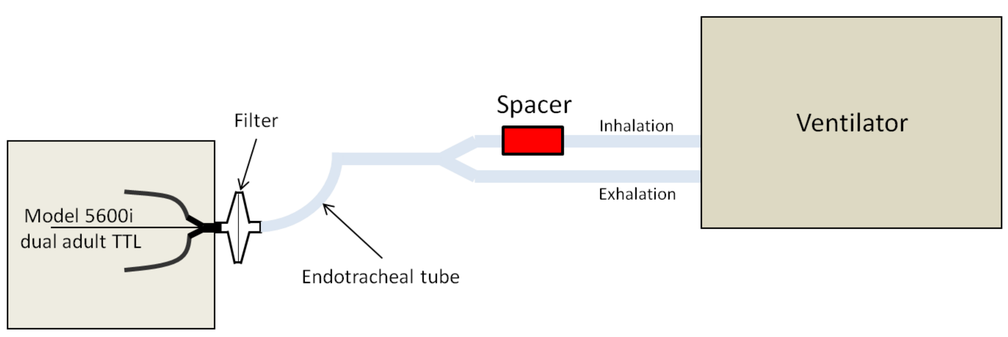




•We used a ventilator (Servo300 ventilator, Maquet, Rastatt, Germany) in volume-controlled mode (sinus flow rate, Vt = 155 mL, f = 25/min, PEEP = 6 cm, H2O, P max = 8 cm H2O, ratio between inspiratory and expiratory time = 50/50) connected to the Dual Adult Training and Test Lung (model 5600i, Michigan Instruments: Resistance = 5 cm H2O/L/s, Compliance = 0.05 L/cm H2O) modeling the patient lung. A 5.0 mm endotracheal tube and a right-angle elbow adapter were inserted between the Y-piece and the Test Lung. An absolute filter (Gelman, Ann Arbor, Michigan, USA) was placed between the extremity of the endotracheal tube and the lung model to filter the aerosol delivery to the lung model. A second expiratory filter was inserted between the ventilator and the expiratory circuit to protect the expiratory port of the ventilator against exhaled aerosol.

•Combihaler, T-piece or T-adapter was inserted between the inspiratory circuit and the Y-piece. Concerning nebulization, Combihaler was evaluated between the inspiratory circuit and the Y-piece (position 1) and between the Y-piece and the endotracheal tube (position 2).

•Spacer was cleaned between each test.



•Statistical analyses were performed using GraphPad Prism 5.01 (GraphPad Software, San Diego, CA) and consisted of a two-way ANOVA and t tests. For all tests, $p < 0.05$ was considered significant..

Results

Figure 1: Calibration curve for the salbutamol.

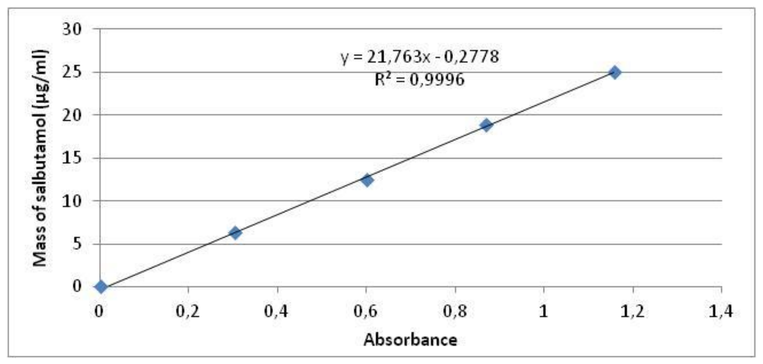
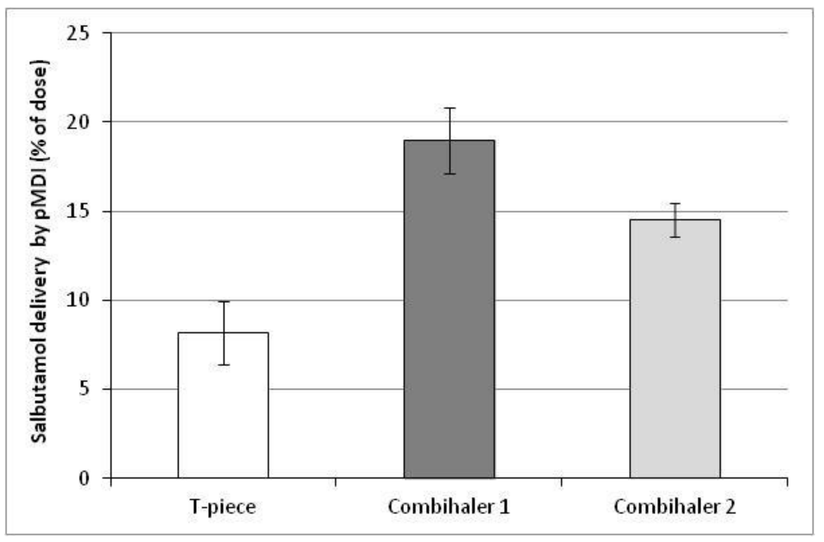


Figure 2: Salbutamol delivery by pMDI expressed as a percentage of the dose.

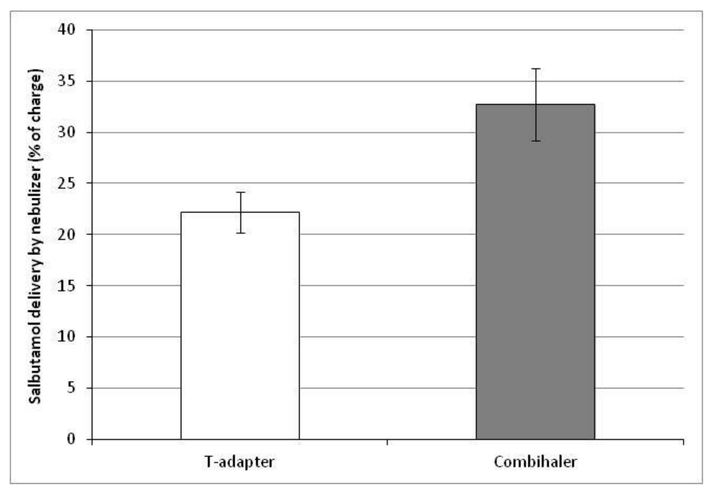


♦With T-piece, salbutamol aerosol delivery by pMDI is 8.2 ± 1.7 %.

♦With combihaler 1 placed between the ventilator and the Y-piece, salbutamol aerosol delivery by pMDI is 19 ± 1.5 %.

♦With combihaler 2 placed between the Y-piece and the endotracheal tube, salbutamol aerosol delivery by pMDI is 14.5 ± 0.9 %.

Figure 3: Salbutamol delivery by nebulizer (% of charge) using T-adapter or Combihaler.



♦ With T-adapter, the delivered mass of salbutamol is 553.8 ± 61.7 µg. Salbutamol aerosol delivery by nebulization is 22.2 ± 2.0 %.

♦With combihaler, the delivered mass of salbutamol is 817.4 ± 85.7 µg. Salbutamol aerosol delivery by nebulization is 32.7 ± 3.5 %.

Conclusion

In pediatric conditions, with the pMDI, the spacer increase the deposition of salbutamol by a factor 2 compared with the T-piece. Concerning the nebulization, the deposition of salbutamol is increased by a factor 1.5 with the spacer compared with T-adapter.