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ORIGINAL ARTICLE

The impact of aerosolized mucolytic agents on the airflow resistance of bacterial filters used in mechanical ventilation

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Background/Purpose: In order to reduce the contamination in the ventilator, bacterial filters were placed on the expiratory limb of a ventilator circuit. Aerosolized mucolytic agents may increase the resistance of the ventilator. The goal of this study is to determine the impact of aerosolized mucolytic agents on the pressure change during mechanical ventilation.
Methods: A lung model was investigated with mucolytic inhaled agents of 10% acetylcysteine and 2% hypertonic saline. The agents were administered using a jet nebulizer every 45 minutes for 15 minutes. The pressure drop was measured after nebulization. The end point was referred to the 45th dose or obstruction of the filter. Furthermore, the pressure drop after steam autoclaving was also measured.
Results: The maximum pressure was significantly higher with 10% acetylcysteine than with 2% sodium chloride (39.32 $\pm$ 7.22 cmH_2O vs. 3.53 $\pm$ 0.90 cmH_2O, $p < 0.001$). With acetylcysteine filters, the pressure drop over 4 cmH_2O occurred earlier and had a good relationship between the degree of pressure drop and doses. The acetylcysteine group yielded a significant difference in the pressure drop compared to the newly autoclaved and the end point of inhalation ($p = 0.043$).

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Conclusion: This study demonstrated the aerosolized mucolytic agents could increase the pressure drop of the bacterial filters during mechanical ventilation. The pressure drop of the bacterial filters was higher with 10% acetylcysteine. It is critical to continuously monitor the expiration resistance, auto-positive end-expiratory pressure, and ventilator output waveform when aerosolized 10% acetylcysteine was used in mechanical ventilation patients.

Introduction

Breathing system filters are expected to prevent the transmission of microbes and other particulate substance in breathing systems when the patient's upper airway has been bypassed during anesthesia and intensive care.[1] In order to reduce the risk of contaminating the ventilator when mechanically ventilating a patient with suspected or confirmed infectious disease, a bacterial filter was placed on the expiratory limb of the breathing circuit of a ventilator.[2]

Aerosolization of medications is the optimal route of administration for some pulmonary diseases.[3] Many aerosolized medications could be administered after nebulization, such as bronchodilators, steroid, antibiotics, hypertonic saline, and mucolytic agents.[4–8] Jet nebulizer can be used during mechanical ventilation. The jet nebulizer functions by passing compressed gas through a narrow orifice and creating an area of low pressure at the outlet of the adjacent liquid feed tube. This results in the drug solution being drawn up from the fluid reservoir, which then shatters into droplets in the gas stream.[9]

There is a potential adverse effect that aerosolized particles can accumulate on the bacterial filter, increasing the resistance to restrict the patient's normal breathing pattern. Some adverse reports indicated that the nebulization treatment caused the malfunction of the exhalation valve or bacterial filter and patients could not exhale properly.[10–12] A previous study had reported that the bacterial filter in a nebulizing system with bronchodilator treatment such as salbutamol and ipratropium could be safely employed.[13] However, to the best of our knowledge, there is very little research on nebulized mucolytic agents. The goal of this study is to determine the impact of aerosolized mucolytic agents on the bacterial filter during mechanical ventilation.

Materials and methods

Lung model and ventilator settings

To simulate the adult mechanical ventilation, the ventilator (Galileo, Hamilton Medical, Switzerland) settings were adjusted as follows: a tidal volume of 0.6 L, a respiratory rate of 12 b/min, an inspiratory time of 1 second, positive end-expiratory pressure (PEEP) of 5 cmH_2O, and an inspiratory flow rate of 54 L/min in a descending ramp flow pattern. The ventilator alarm was set at a pressure of more than 45 cmH_2O, which implied that the filter would be obstructed. This model included a ventilator circuit, a combined heat and moisture exchanger filter (Fig. 1, collection filter) (Hygrobac S, Tyco Healthcare, Italy), and a test lung [Training/Test Lung (TTL) Michigan Instruments, Grand Rapids, Michigan] with lung mechanics of 0.05 L/cmH_2O compliance and 20 cmH_2O/L/s resistance (Rp20 resistor; Fig. 1).

Filter and nebulizer

The brand new pleated hydrophobic filters (OmniFilter Tyco Healthcare Eastern and Central Europe, Puritan-Bennett Corporation, Pleasanton, CA, USA, diameter of 3.5 in., surface area of around 62.2 cm^2) were located in the exhalation limb closed to the ventilator (Fig. 1, exhalation bacterial filter). The nebulizer was placed 6 in. from the Y-piece adapter, using standard attachment corrugated tubing (Fig. 1, aerosol generator). The aerosol generator used here was a jet nebulizer (Neb-Easy Nebulizer Kit, GaleMed, Wu-Jia, I-Lan, Taiwan). This device was fabricated from acrylic and polypropylene plastics; it was operated under the Venturi principle and was refillable. The nebulizer had several attachments that came with it during the nebulization process. These included a Tee connector, which connected to the top of the nebulizer; and a 6-inch corrugated tube, which connected to the side of the Tee connector. A standard oxygen tube is connected to the bottom of the nebulizer, which connected the nebulizer to a pressurized gas source.

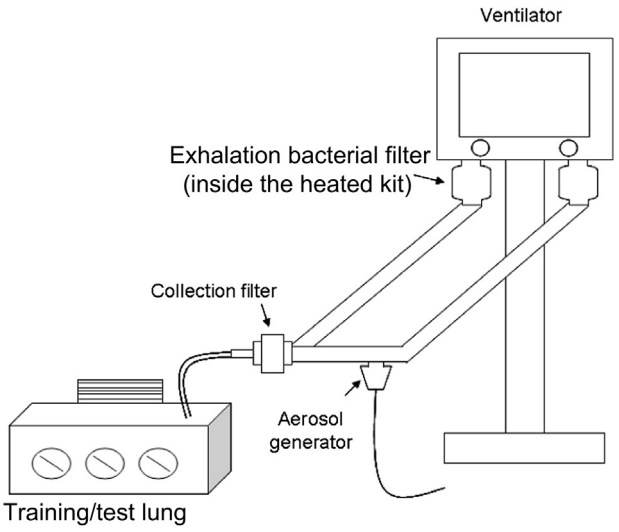

Figure 1 Schematic representation of the experimental apparatus.