Length of endotracheal tube, humidification system and airway resistance: An experimental bench study

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INTRODUCTION

After intubation, the resistance of the inspiratory line is usually increased. This rise in airway resistance is associated to the presence of the endotracheal tube, a Heat Moisture Exchanger (HME) and/or any another tubing in the breathing circuit. During assisted ventilation or in spontaneously breathing patient, these high resistances will increase the work of breathing and negatively impact the chance of weaning. To limit this elevation in resistance, the endotracheal tube is sometime shortened and a heated humidifier used instead of a HME. The aim of this study was to evaluate the actual effect of these strategies on the airway resistance.

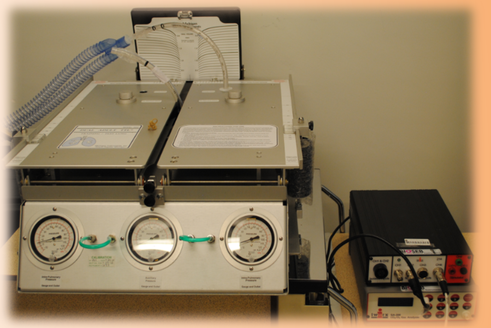
METHODS

A two-compartment model of adult lung (TTL 1600 Dual Test Lung Michigan Instrument-DTL) was connected to an Dragër Evita 4® Ventilator. The ventilator was set in volume-controlled mode (Vt: 0.5 L; respiratory frequency: 20 bpm; inspiratory flow: 70 L.min^{-1}). To simulate normal and obstructive clinical conditions, two different resistances were placed at the entry of the airline connected to DTL by using pneuflo® (parabolic resistor Michigan Instrument; mean ± SD: 2,5 ± 0.06 and 17.04 ± 0.03 cm H_2O/L.sec^{-1}). Compliance of the artificial lung was set to 70 ml/cm H_2O. The airline was compounded of an endotracheal tube and a humidification system. Three different inside diameters (ID) (Portex® endotracheal tube of 7, 8 and 9 mm) and two humidification systems (HME (Gibbeck Humid Vent® Adult) or Fisher and Paykel MR850 Heated Humidifier®) were evaluated before and after shortening of the tube at 10 cm length. The change in pressure was measured by an analog IWorx station / digital IWx / 214.
Resistance value was calculated with from the following equation:

$$Inspiratory\ Resistance = \frac{Peak\ pressure - Plateau\ pressure}{Inspiratory\ flow}$$

RESULTS

Resistance value (cm H_2O/L.sec-1) and variation in %			
Normal initial Resistance		High initial Resistance	
HME	Heated humidifier	HME	Heated humidifier
4,88 (+/- 0,04)	2,5 (+/-0,06)	19,73 (+/- 0,03)	17,04(+/-0,03)
(**) -95%		(**) - 15,8 %	
Tube 7	Tube 7 cut down	Tube 7	Tube 7 cut down
13,36 (+/-0,06)	11,74 (+/- 0,03)	26,19 (+/-0,04)	25,13(+/-0,02)
(**) -13,8%		(**) -4,2%	
Tube 8	Tube 8 cut down	Tube 8	Tube 8 cut down
8,36(+/-0,05)	7,27(+/-0,01)	22,99(+/- 0,02)	22,2(+/-0,01)
(**) -15%		(**) -3,6%	
Tube 9	Tube 9 cut down	Tube 9	Tube 9 cut down
4,39(+/-0,05)	3,98 (+/-0,10)	18,79 (+/-0,04)	18,42(+/-0,02)
(*) -10,3%		(*) -2%	
	** p<0,001		* p<0,01



CONCLUSION

The use of heated humidifier instead of HME and shortening of endotracheal tube (10 cm of length) allow significant decrease in airway resistance. Both strategies may be helpful for the weaning of obstructive patients. However, the shortening of the tube(relative impact) has a decreasing impact when the tube diameter is growing and even for smaller tube the impact of humidifier is more important.

REFERENCES

Morgan NJ. Air flow resistance of three heat and moisture exchanging filter designs under wet conditions: implications for patient safety. Br J Anaesth 2001; 87: 289–91