A4561

Assessment Of The Efficacy Of A Novel Closed Suctioning System In The Prevention Of Endotracheal Tube Obstruction By Airway Secretions

G. Li Bassi, MD, PhD[1], E. Aguilera, Bsc[1], J.D. Marti, RPT, PhD[1], D. Wyncoll, MD[2], G. Ntoumenopoulos, RPT, PhD[3], T. Comaru, RPT, PhD[1], F. De Rosa, MD[1], M. Rigol, DVM, PhD[1], M. Rinaudo, MD[1], A. Torres, MD[1]

[1] Department of Pulmonary and Critical Care Medicine, Division of Animal Experimentation, Thorax Institute, Hospital Clínic, Barcelona, Spain; [2] Critical Care Unit, Guy's & St Thomas' NHS Foundation Trust, London, United Kingdom; [3] School of Physiotherapy, Australian Catholic University, North Sydney Campus, North Sydney, Australia

glibassi@clinic.ub.es www.idibapsrespiratoryresearch.org

Abstract

RATIONALE: Mucus build-up on the endotracheal tube (ETT) surface increases airflow resistance, work of breathing, and potentially leads to a delayed liberation from mechanical ventilation. We evaluated the efficacy of a novel closed suctioning system in the prevention of intraluminal accumulation of secretions and airflow resistance.

METHODS: We studied 16 mechanically ventilated pigs (32.6±2.9 Kg) with severe *P.aeruginosa* pneumonia, randomized to be tracheally suctioned with a standard catheter (8 animals, KIMVENT® Closed Suction Systems, Kimberly Clark, USA) or with a novel catheter (8 animals, Airway Medix Closed Suction System, Biovo Technologies, Israel). The novel catheter was designed to dislodge, and mechanically remove intraluminal secretions through high-pressure jets of sterile saline and an inflatable distal balloon. Tracheal suctioning was performed every 6h or when clinically indicated. Every 24h, one hour after tracheal suctioning, airflow/pressure waveforms were recorded and inspiratory resistance calculated using standard formulae. Upon autopsy - following 76h from intubation - the animal was extubated and pictures of the ETT lumen were taken. The gross appearance of the ETT lumen was later scored as follows: no mucus (0); mucus covering <10% (1), 10 to 25% (2), 25-50% (3) and >50% (4) of the endotracheal tube length. During aforementioned analyses, investigators were blind to treatment allocation. Quantity of aspirated secretions was estimated with a scale from 0 to 5 (none, few, mild, moderate, abundant).

RESULTS: The number of tracheal suctioning per day was 7.7±3.7 in the treatment group, and 7.7±4.5 in the control group (p=0.989). On average , the semi-quantitative amount of aspirated secretions was 1.9±0.8 and 2.3±1.1 in the treatment and control group, respectively (p<0.001). Airflow resistance did not differ between groups – 8.6±1.4 cm H_2O/L/sec in the treatment group, and 8.7±1.1 in the control (p=0.756). Upon extubation, mucus covered <10% of the ETT length (median 1, range 0-3) in the treatment group; whereas, in the control group, mucus covered between 25 and >50% of the ETT length (median 3.25, range 1-4), p=0.007.

CONCLUSIONS: The novel closed suctioning system prevents the build-up of mucus within the ETT. Nevertheless, during mechanical ventilation up to 76h, the novel catheter does not affect airflow resistance. Further studies are needed to investigate the long-term benefits of the device.

Introduction

Endotracheal tube (ETT) biofilms rapidly develop during the course of mechanical ventilation (MV) (1,2). Importantly, retained respiratory secretions often overlay ETT biofilm and form a miscellaneous bio-structure within the tube. Retained secretions and biofilm gradually narrow the ETT internal lumen (3); as a result, airflow resistance and the patient's work of breathing increases (4,5).

Aims

Here we report the results of a randomized laboratory study, in mechanically ventilated pigs to compare the efficacy of a novel closed suctioning system (CSS) with standard CSS, in the prevention of retention of mucus within the ETT.

Methods

Design: Prospective randomized animal study.

Setting: Animal experimentation, University of Barcelona, Spain.

Subjects: 16 tracheally intubated pigs on invasive mechanical ventilation and with severe *Pseudomonas aeruginosa* pneumonia

Figure 1: Animal model of severe P. aeruginosa. 15 mL of 10^8 cfu/mL of *P. aeruginosa* were instilled into each lobe through bronchoscopy.

Figure 2: Pulmonary measurements. Every 24h – one hour after tracheal suctioning – airway pressure and airflow rate were assessed.

Figure 3: Airflow resistance. Pressure/Flow waveforms were recorded for subsequent analysis through dedicated software. Airflow resistance was computed using standard formulae.

Tracheal/ETT suctioning was performed every 6 hours, or in case of clinical signs of mucus retention. Quantity of aspirated secretions was estimated with a scale from 0 to 5 (none, few, mild, moderate, abundant)

CONTROL GROUP: Tracheal/ETT suctioning via the KIMVENT® CSS (Kimberly Clark, USA)

TREATMENT GROUP: Tracheal/ETT suctioning through a novel CSS (Airway Medix Closed Suction System, Biovo Technologies, Israel) (*Figure 4*).

Upon autopsy - following 76h from intubation - the animal was extubated and the ETT longitudinally cut open (*Fig. 5A-B*).

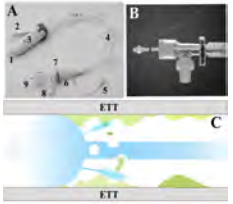
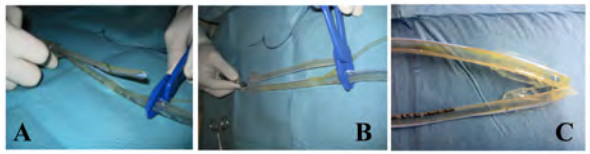


Figure 4
A: The Airway Medix Closed Suctioning System; 1, vacuum connection port; 2, aspiration handle; 3, saline infusion connection port; 4, protective plastic sheet; 5, lavage line; 6, hinged valve to isolate catheter tip between applications; 7, Y-piece connector part; 8, ETT connection piece; 9, catheter tip. B: The distal balloon is inflated with saline instilled at high pressure, through a custom-made syringe pump; thus, fluid jets are generated through minute holes at the proximal portion of the balloon, and projected toward the ETT wall. C, The balloon is inflated within the ETT to adhere against its wall; then, the catheter is gently pulled back, while saline jets and aspiration operate simultaneously to displace biofilm and continuously aspirate debris via the suction openings, proximal to the balloon.

Figure 5: At extubation, the endotracheal tube was longitudinally cut open and pictures of the entire endotracheal tube length were taken (A-C). Subsequently, these pictures were analyzed by an operator blind to treatment allocation and the gross appearance of the ETT lumen was scored as follows: 0, no mucus; 1, mucus covering <10%; 2, 10 to 25%; 3, 25-50% and 4, >50% of the ETT length



Results

The number of tracheal suctioning per day was 7.7±3.7 in the treatment group, and 7.7±4.5 in the control group (p=0.989). On average , the semi-quantitative amount of aspirated secretions was 1.9±0.8 and 2.3±1.1 in the treatment and control group, respectively (p<0.001).

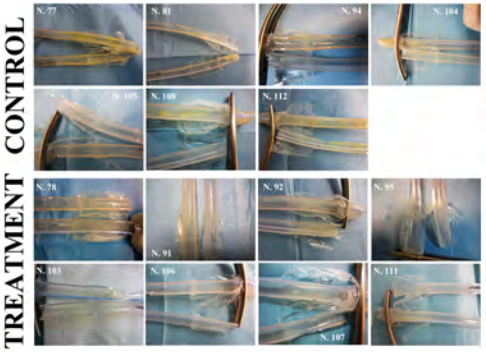


Figure 6: Gross-appearance of the internal endotracheal tube surface. Upon extubation, ***mucus covered <10% of the ETT length (median 1, range 0-3) in the treatment group; whereas, in the control group, mucus covered between 25 and >50% of the ETT length (median 3.25, range 1-4), p=0.007***. Of note, in pig n. 81, 105, 108, 112 of the control group, more than 50% of the endotracheal tube internal surface length was covered by mucus. Whereas, in pig n. 95 and 106, of the treatment group, no mucus was found on the endotracheal tube internal lumen. In pig #104 of the control group, full ETT obstruction, requiring emergency bronchoscopy was reported after 70 hours of mechanical ventilation.

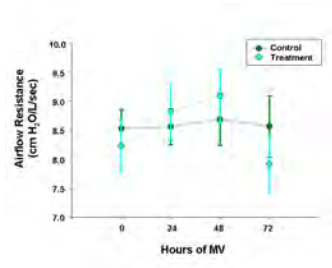


Figure 7: Airflow resistance. Airflow resistance did not differ between groups – 8.6±1.4 cm H_2O/L/sec in the treatment group, and 8.7±1.1 in the control (p=0.756).

Discussion

In comparison with a standard CSS, the novel CSS was effective in removing mucus from the ETT internal lumen. Although gross examination of the ETT revealed a reduction in mucus buildup, we did not find any decrease in airflow resistance. This suggests that the accumulation of mucus during the limited time of our study was not sufficient to significantly increase airflow resistance. The benefits associated with the routine use of the novel CSS in critically ill patients need to be verified; yet, the clinical usefulness could be substantial, particularly in clearing small ID ETTs, and in patients with overproduction of mucus.

FUNDING: Biovo Technologies, Israel, the manufacturer of Airway Medix Closed Suctioning System

1) Inglis, TJ et al. *Journal of clinical microbiology* 27, no. 9 (1989): 2014-8
2) Sottile, FD et al. *Critical care medicine* 14, no. 4 (1986): 265-70
3) Shah, C et al. *Critical care medicine* 32, no. 1 (2004): 120-25
4) Villafane, MC, et al. *Anesthesiology* 85, no. 6 (1996): 1341-9
5) Shapiro, M et al. *Critical care medicine* 14, no. 12 (1986): 1028-31