Effectiveness evaluation of a novel closed suctioning system in vitro biofilm removal from endotracheal tubes

Elad Landau1, Nimrod Adi MD2, Michal Pfeffer RN 2 and Roni Shapiro1

1Institute of Biochemistry, Food Science and Nutrition, Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel. 2Department of Intensive Care, Kaplan Medical Center, Rehovot, Israel

Introduction:
The lower respiratory tract of healthy humans is normally kept sterile by natural defense mechanisms: airway barriers, mucociliary clearance, and cough. Common nosocomial pathogens cultured from the lumen of Endotracheal tubes (ETT) of intensive care unit (ICU) patients include Staphylococcus aureus, group A-Streptococcus, Acinetobacter spp., Moraxella catarrhalis, Haemophilus influenzae, and Pseudomonas aeruginosa. Formation of biofilm on the surface of ETT is an almost universal phenomenon, which has been related to the pathogenesis of ventilator-associated pneumonia.

Biovo Technologies (Tel Aviv, Israel) developed a novel device (AirwayMedix Closed Suction System, AMCSS). This system employs a unique cleaning mechanism comprising of simultaneous operation of fluid jets, suction and balloon wiping, maintaining a clear and clean airway during the entire period of mechanical ventilation.

Objectives:
1. Develop a reproducible system of in vitro biofilm formation and evaluation in ETT by P. aeruginosa.
2. Compare the amount of biofilm removal after cleaning with AirwayMedix versus the KIMVENT® device.

Methods:
Over night cultures of P. aeruginosa PAO1 were diluted to 1x10^7 CFU/ml in Luria broth medium (LB) in 8 mm diameter closed ETT and incubated horizontally at 37°C for 24 h. planktonic bacteria were removed by washing with three volumes of the ETT tubes and were divided into three groups: biofilm removal with AirwayMedix, KIMVENT® (Kimberly Clark, USA) or control. Quantification of attached bacteria was performed on 4 cm segments from the middle part of the ETT. Transmission electron micrographs of the tubes before and after treatment were taken.

Results:
1. The conditions of in vitro biofilm formation by P. aeruginosa in ETT and its evaluation were achieved.
2. Enumeration of the attached bacteria: control=1X10^7 CFU/cm², KIMVENT=4.86x10^6 CFU/cm² (p= 0.01), Airway Medix 1.1X10^4 CFU/cm² (p=0.01).
3. The conditions of in vitro mixed biofilm by Pseudomonas, Staphylococcus and Candida in ETT were established and demonstrated.

Conclusions:
The Airway Medix system proved to be superior to the KIMVENT system in its ability to remove bacterial biofilms from ETT.

Pseudomonas count (CFU/cm2) in ETT treated with AMCSS, KimVent or control:

Removal of Pseudomonas biofilm and generation of mixed biofilm (Pseudomonas, Staphylococcus and Candida) in ETT

Scanning electron micrographs of biofilm within ETT: Pseudomonas colonization and removal: one day colonization (A), six days colonization. After treatment with Airway Medix (B, D respectively) – Left panel. Generation of mixed biofilm- Right panel.

Possible table and figure contents:

| Pseudomonas count (CFU/cm²) in ETT treated with AMCSS, KimVent or control: |
|--------------------------|--------------------------|--------------------------|
| Control      | AMCSS       | KimVent     |
| 1.00E+00     | 1.00E+01    | 1.00E+02    |
| 1.00E+05     | 1.00E+06    | 1.00E+07    |
| 1.00E+02     | Control     | AMCSS       |
| 1.00E+01     | KimVent     | Control     |

Removal of Pseudomonas biofilm and generation of mixed biofilm (Pseudomonas, Staphylococcus and Candida) in ETT

Scanning electron micrographs of biofilm within ETT: Pseudomonas colonization and removal: one day colonization (A), six days colonization. After treatment with Airway Medix (C, D respectively) – Left panel. Generation of mixed biofilm- Right panel.

Microscopic photo of biofilm within ETT: Pseudomonas, Staphylococcus and Candida

Photo 1. Microscopic photo of samples of cultures ETTs: one day colonization (A, B) and six days (C,D); No treatment (A, C) after treatment with AirwayMedix (B, D)