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“Clearer Airways, Fewer Ventilator Days”

Covenant Respiratory Conference
May 5, 2015 / Gary W. Saur, MBA, RRT

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Disclosure:

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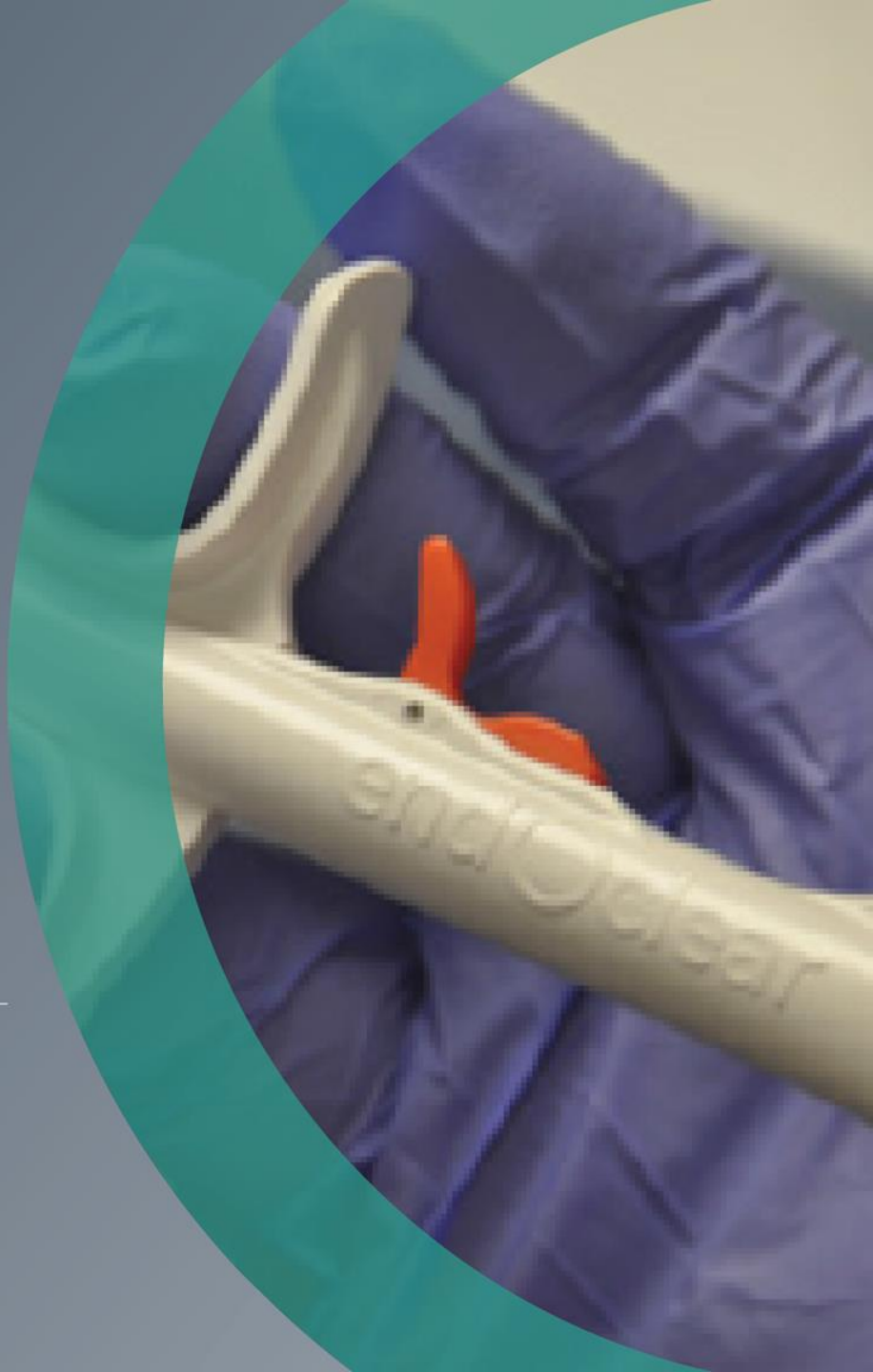
“Cleaner Airways, Fewer Ventilator Days”

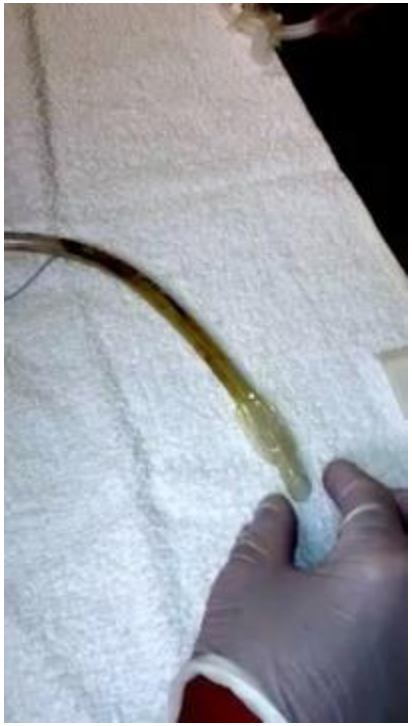
1. Current standard of care closed suction does not keep the ETT patent or free of bacterial and fungal colonization.
2. The build-up of biofilm is harmful and can lead to infection and increased duration of ventilation and ICU length of stay.
3. Using an ETT cleaner addresses retained secretions and colonization in a positive way.
4. Effective cleaning of the ETT results in improved outcomes when used in both PRN and protocol fashion.
5. Alternatives to standard of care?

Current standard of care closed suction does not keep the ETT patent or free of bacterial and fungal colonization.

Suction catheters (closed systems and open) have been the standard of care for clearing endotracheal tubes since the inception of intubation and mechanical ventilation, yet the consensus is that suction is generally ineffective in cleaning the endotracheal tube.



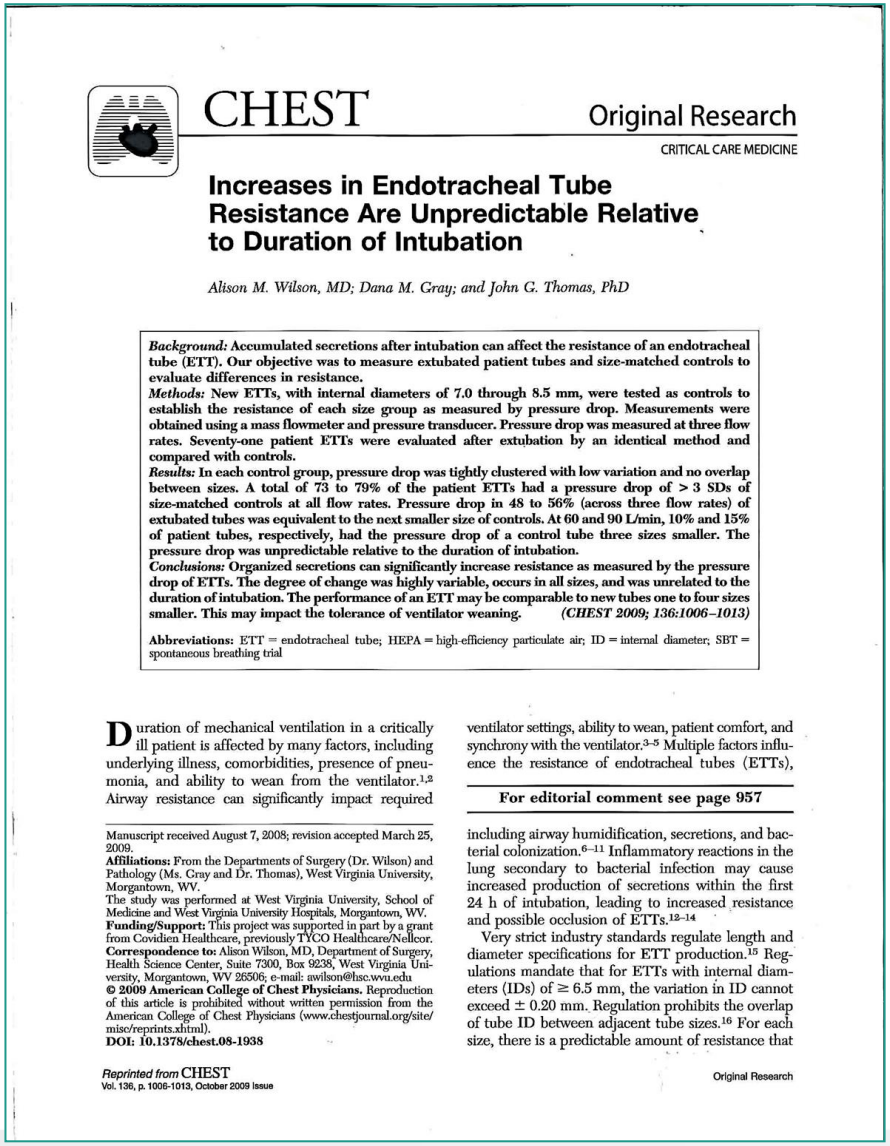
Current Standard of Care Closed Suction.....



Quantifying the Opportunity:

- ≈100,000 ICU Beds in the US[1]
- Occupancy range 57.4% to 82.1% (Mean of 69,750)[2]
- Mechanically ventilated patients range 20.7% to 38.9% (Mean of 21,909)[2]
- Estimated annual ventilator days 7.99M (21,909 x 365)
- Spending for hospital care was $937B for 2013[4]
- ICU costs account for 17-39% of hospital care (Mean of 262B)[5]
- Day 3 on the ventilator in the ICU 32B ($3,968 x 7.99M)[6]
- ***Process Improvement opportunity:***
  - ✓ ***Quality or outcome improvement (reduce time on ventilator)***
  - ✓ ***Cost reduction (decrease length of stay)***

Current Standard of Care Closed Suction.....



CHEST Original Research

CRITICAL CARE MEDICINE

Increases in Endotracheal Tube Resistance Are Unpredictable Relative to Duration of Intubation

Alison M. Wilson, MD; Dana M. Gray; and John G. Thomas, PhD

Background: **Accumulated secretions after intubation can affect the resistance of an endotracheal tube (ETT). Our objective was to measure extubated patient tubes and size-matched controls to evaluate differences in resistance.**
Methods: **New ETTs, with internal diameters of 7.0 through 8.5 mm, were tested as controls to establish the resistance of each size group as measured by pressure drop. Measurements were obtained using a mass flowmeter and pressure transducer. Pressure drop was measured at three flow rates. Seventy-one patient ETTs were evaluated after extubation by an identical method and compared with controls.**
Results: **In each control group, pressure drop was tightly clustered with low variation and no overlap between sizes. A total of 73 to 79% of the patient ETTs had a pressure drop of > 3 SDs of size-matched controls at all flow rates. Pressure drop in 48 to 56% (across three flow rates) of extubated tubes was equivalent to the next smaller size of controls. At 60 and 90 L/min, 10% and 15% of patient tubes, respectively, had the pressure drop of a control tube three sizes smaller. The pressure drop was unpredictable relative to the duration of intubation.**
Conclusions: **Organized secretions can significantly increase resistance as measured by the pressure drop of ETTs. The degree of change was highly variable, occurs in all sizes, and was unrelated to the duration of intubation. The performance of an ETT may be comparable to new tubes one to four sizes smaller. This may impact the tolerance of ventilator weaning.** ***(CHEST 2009; 136:1006–1013)***

Abbreviations: ETT = endotracheal tube; HEPA = high-efficiency particulate air; ID = internal diameter; SBT = spontaneous breathing trial

Duration of mechanical ventilation in a critically ill patient is affected by many factors, including underlying illness, comorbidities, presence of pneumonia, and ability to wean from the ventilator.[1,2] Airway resistance can significantly impact required ventilator settings, ability to wean, patient comfort, and synchrony with the ventilator.[3–5] Multiple factors influence the resistance of endotracheal tubes (ETTs),

For editorial comment see page 957

including airway humidification, secretions, and bacterial colonization.[6–11] Inflammatory reactions in the lung secondary to bacterial infection may cause increased production of secretions within the first 24 h of intubation, leading to increased resistance and possible occlusion of ETTs.[12–14]

Very strict industry standards regulate length and diameter specifications for ETT production.[15] Regulations mandate that for ETTs with internal diameters (IDs) of ≥ 6.5 mm, the variation in ID cannot exceed ± 0.20 mm. Regulation prohibits the overlap of tube ID between adjacent tube sizes.[16] For each size, there is a predictable amount of resistance that

Manuscript received August 7, 2008; revision accepted March 25, 2009.
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The study was performed at West Virginia University, School of Medicine and West Virginia University Hospitals, Morgantown, WV.
Funding/Support: This project was supported in part by a grant from Covidien Healthcare, previously TYCO Healthcare/Nellcor.
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DOI: 10.1378/chest.08-1938

Secretion build-up in ETT:

- Occurred in <u>all</u> patients
- 48% had pressure drop equivalent to next smaller size tube
- 10% to 15% of patient tubes had a pressure drop of a tube three sizes smaller
- Independent of duration of ventilation
- Cannot predict which patients will have high volume of secretions

Wilson, A., Gray, D., Thomas, J., 2009, Increases in Endotracheal Tube Resistance Are Unpredictable Relative to Duration of Intubation, CHEST October 2009 vol. 136 no. 4 1006-1013[7]

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Current Standard of Care Closed Suction

Endotracheal tube intraluminal volume loss among mechanically ventilated patients

Shah, Chirag MD; Kollef, Marin H. MD
Critical Care Medicine: January 2004 - Volume 32 - Issue 1 - pp 120-125
doi: 10.1097/01.CCM.0000104205.96219.D6 Clinical Investigations

Abstract

Objective: To measure endotracheal tube intraluminal volume loss among mechanically ventilated patients.

Design: Prospective observational study.

Setting: Medical intensive care unit (19 beds) of an urban university-affiliated teaching hospital.

Patients: A total of 101 patients with acute respiratory failure requiring >24 hrs of mechanical ventilation.

Interventions: None.

Measurements and Main Results: Acoustic reflectometry was employed to measure the intraluminal volume of 13-cm endotracheal tube segments. The endotracheal tube segment volumes were statistically smaller among endotracheal tubes used in patients compared with unused endotracheal tubes (5.4 ± 0.7 vs. 6.0 ± 0.6 mL, $p < .001$). The average percentage
difference in endotracheal tube segment volumes, between the unused endotracheal tubes and the endotracheal tubes used in patients, was 9.8% (range, 0–45.5%). The percentage difference in the endotracheal tube segment volumes increased significantly with increasing duration of tracheal intubation ($r2 = .766$, $p < .001$). The minimum diameter of the endotracheal tube segments was also statistically smaller among endotracheal tubes used in patients compared with the unused endotracheal tubes (7.5 ± 0.4 vs. 6.7 ± 1.2 mm, $p < .001$).

Conclusions:

Endotracheal tube intraluminal volume loss is common among patients with acute respiratory failure requiring mechanical ventilation and increases with prolonged tracheal intubation.

Shah, Chirag MD; Kollef, Marin H. MD, Endotracheal tube intraluminal volume loss among mechanically ventilated patients, Critical Care Medicine: January 2004 - Volume 32 - Issue 1 - pp 120-125 doi: 10.1097/01.CCM.0000104205.96219.D6 Clinical Investigations[8]

Current Standard of Care Closed Suction……

High-Resolution Computer Tomography in Assessing Endotracheal Tube Obstruction

Cristina Mietto[1], Riccardo Pinciroli[1], Annop Piriyapatsom[1], John G. Thomas[2], Lynn Bry[1], Mary L. Delaney[3], Andrea Du Bois[3], Jessica Truelove[4], Gregory R. Wojtkiewicz[4], Matthias Nahrendorf[4], Robert M. Kacmarek[1,5], Lorenzo Berra[1]

1, Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Boston, MA; 2, School of Dentistry, West Virginia University, Morgantown, WV; 3, Center for Clinical and Translational Metagenomics, Department of Pathology, Brigham and Women's Hospital, Boston, MA; 4, Center for System Biology, Massachusetts General Hospital, Boston, MA; 5, Department of Respiratory Care, Massachusetts General Hospital, Boston, MA.

Introduction

The presence of the endotracheal t… physiological homeostasis of mucus cle… ETT becomes covered in a thick layer … preventable by the use of commer… catheters (Fig. 1).

Fig. 1. ETT in mucus layer.

The reduction in ETT lu… increased airflow resist… of breathing.[2]

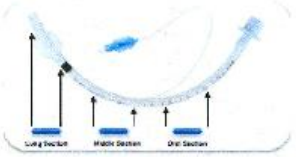
The two parts of this s… use of High-Resolution … (HR-CT) in measurin… obstruction and B) dete… between volume loss … resistance in the ETT.

Methods

Part A.

From Nov-Dec 2012, we collected 2… intensive care units at MGH. Patients … study group if they required mech… more than 48 hours. Immediately after extubation, these study ETTs were sealed and cut at 24 cm from the Murphy Eye (lung end).

The control group (n=24) consisted of new adult ETTs matched with the study group by size and brand. All the ETTs underwent HR-CT scanning within 48 hours after extubation. HR-CT was performed with an isotopic spatial resolution of 110μm (Siemens Inveon system).



The entire 24cm ETT was scanned. However, three 4.4cm long sections of each tube were used for the analysis (Fig. 2)

Fig. 2. Scheme of ETT sections for HR-CT scan analysis

On the CT images, the luminal space open to ventilation (air) … Hounsfield … as chosen to … or mucus …

…ages of a used …ed ETT (B).

… filled with …retions. The … the ETT was …tween HR-CT …

Part A.

ETTs from 20 patien… 68±14 years, BMI 26±6 kg/m²) who were int… re than 48 hours (average time on ventilato… were collected.

Study group ETT analysis: HR… ysis showed an average reduction of 8.2±7.1% o… al air volume, ranging from 0.0% to 23.7% (p=0.013 … trol group). Minimum CSA reduction was 24.9±3.9% … n control group.

Cross secti… a was progressively… ced from oral to lung e… ral section 4.7±5.5%, m… section 7.8±8.0% and lun… section 12.6±14.4%; p=0.031 for oral vs. lung section) (Fig. 4).

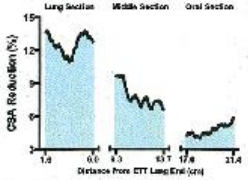


Fig. 4. Distribution of CSA reduction of used ETT group along the tube length.

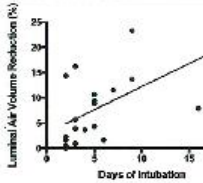


Fig. 5. Correlation between grade of ETT occlusion and days of intubation.

The grade of occlusion was weakly correlated with the length of intubation (R^2=0.352, p=0.006) (Fig. 5).

The mean internal diameters (ID) free of secretions were reduced from initial IDs of 7.0mm to 6.74±0.24mm (p=0.026), of 7.5mm to 7.10±0.52mm (p=0.007), and of 8.0mm to 7.63±0.43mm (p=0.038).

Part B.

Pressure drop (a surrogate of airflow resistance) strongly correlated with an increase in volume loss from the ETT silicone filling. This correlation is maintained at different airflows. (Airflow 30 l/min: R^2= 0.87, p=0.021; 50 l/min: R^2= 0.91, p=0.013; 70 l/min: R^2= 0.90, p=0.015) (Fig. 6).

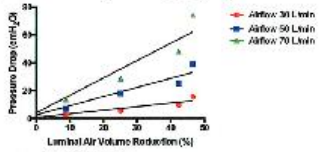


Fig. 6. Correlation between ETT luminal air volume reduction and pressure drop at different airflows.

Conclusions

Part A. In a group of 20 prolonged mechanically ventilated adult patients, the CSA of the ETT was reduced by about 25%.

Part B. Volume loss determined an increase in airflow resistance.

In summary, standard methods for ETT cleaning are insufficient to prevent ETT narrowing, leading to an increase in patient work of breathing.

References

1. Knowles MR *et al*, J Clin Invest 2002;109:571-9
2. Wilson AM *et al*, Chest 2009;136:1006-13

"In summary, standard methods for ETT cleaning are insufficient to prevent ETT narrowing, leading to an increase in patient work of breathing."

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Current Standard of Care Closed Suction.....

The primary goal of mechanical ventilation is to reduce the **"work of breathing."** Work of breathing is both the effort to inspire air into the lungs and the effort to exhale. This effort depends on compliance (How elastic the lung is) and resistance (How much obstruction exists in the airway).

The total work of breathing in the mechanically ventilated patient consists of:

1. the patient's own physiologic work of breathing,
2. the disease process that the patient is suffering from, and,
3. **the resistance offered by the ventilator circuit and endotracheal tube (known as the "imposed work of breathing").**

Current Standard of Care Closed Suction.....

Airway resistance and lumen radius are exponentially related to the fourth power. This means any change in the radius causes a tremendous change in the airway resistance.

For example, if the radius is cut in half airway resistance doesn't just double. It increases by a factor of 2 X 2 X 2 X 2 =16 (Poiseuille's equation).

If the radius increases 2 times, airway resistance decreases by the same factor of 16.

Because of this relationship any small amount of bronchospasm, secretion accumulation in the endotracheal tube, water in the ventilator tubing, or other obstruction considerably increases airway resistance.

Kevin T Martin., *RESISTANCE AND COMPLIANCE*, RC Educational Consulting Services, Inc., 1985, Revised 2008, 9-10[10]

Current Standard of Care Closed Suction.....

Suction does not effectively clean endotracheal tubes and can be harmful!

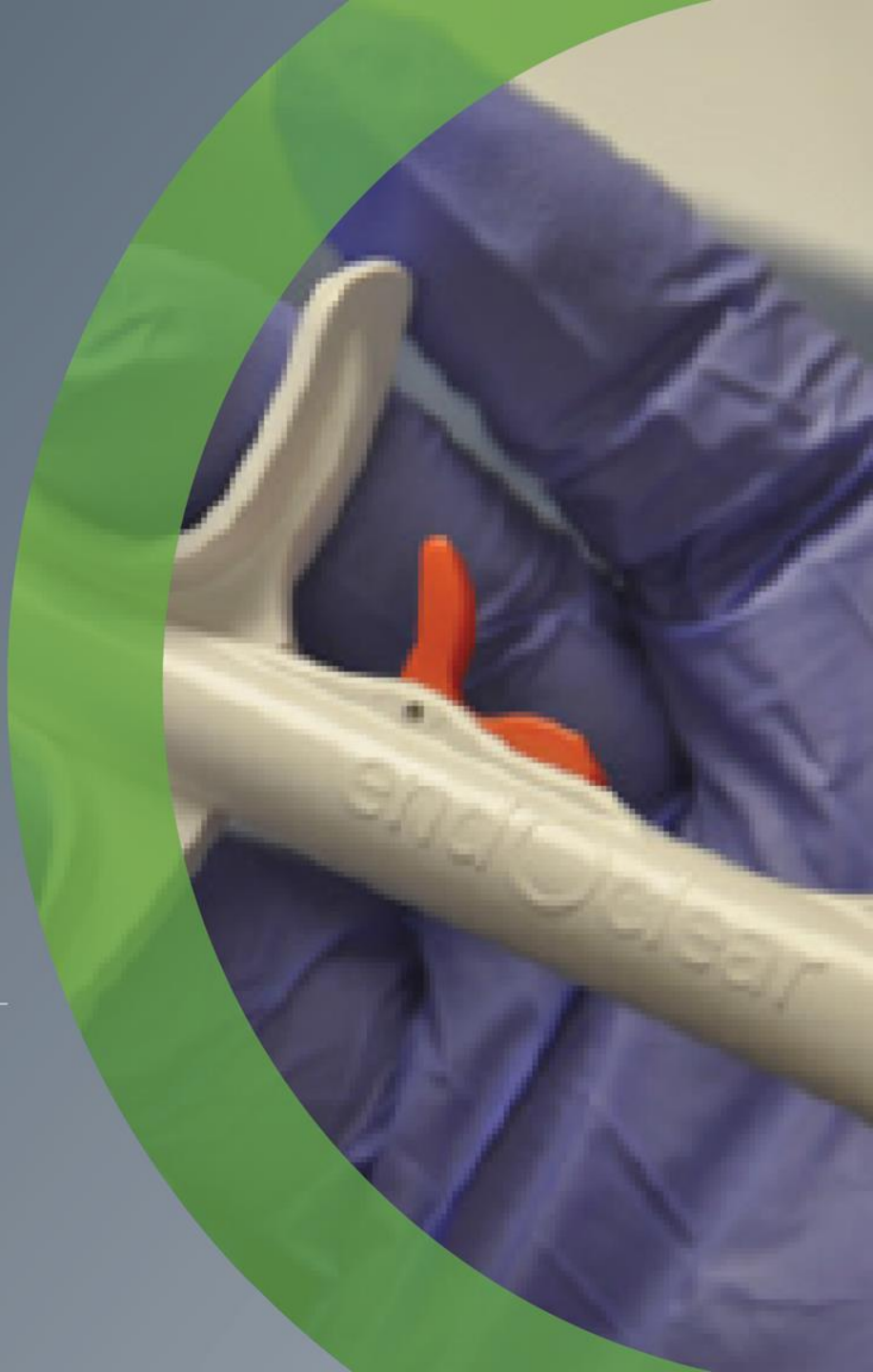
AARC Clinical Practice Guidelines

Endotracheal suctioning of mechanically ventilated patients with artificial airways (2010):

Although the internal lumen of an ETT decreases substantially after a few days of intubation, due to formation of biofilm, suctioning should be performed ***only*** when clinically indicated in order to maintain the patency of the artificial airway used. Special consideration should be given to the potential complications associated with the procedure.

The build-up of biofilm is harmful and can lead to infection and increased duration of ventilation and ICU length of stay.

Endoluminal narrowing is generally under-appreciated for it’s severe impact on pressure and resistance.



2 The Build-up of Biofilm is Harmful ……

Tracheal Tube Biofilm as a Source of Bacterial Colonization of the Lung

TIMOTHY J. J. INGLIS,1* MICHAEL R. MILLAR,2 J. GARETH JONES,3 AND DAVID A. ROBINSON4
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Received 10 January 1989/Accepted 7 June 1989
JOURNAL OF CLINICAL MICROBIOLOGY, Sept. 1989, p. 2014-2018 Vol. 27, No. 9

Biofilm formation in tracheal tubes, its bacterial content, and its interaction with ventilator gas flow were investigated. At least 50 mg (dry weight) of biofilm was found in 30 of 40 tracheal tubes used in intensive care patients for 2 h to 10 days. Electron microscopy showed bacteria in this layer, and quantitative studies showed that bacterial counts could reach up to 106/cm of tube length. Bacteria were cultured from the patient sid… 18' of 78 heat and moisture exchanger-microbiologi… units removed from ventilator circuits. Particles w…own to detach from tracheal tube luminal biofilm and w…e projected up to 45 cm from the tracheal tube tip. Following contamination of the tracheal tube biofilm with a patient's own gastrointestinal flora, entrainment of bacteria in the inspiratory gas flow provides a mechanism for initial and repeated lung colonization.

"Following contamination of the tracheal tube biofilm with a patient's own gastrointestinal flora, entrainment of bacteria in the inspiratory gas flow provides a mechanism for initial and repeated lung colonization."

Inglis, T., Millar, M., Jones, G., Robinson, D., 1989, Tracheal Tube Biofilm as a Source of Bacterial Colonization of the Lung, Journal of Clinical Microbiology, Vol. 27, No. 9, p. 2014-2018[11]

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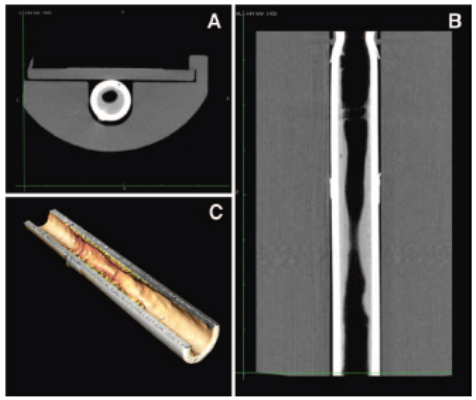
The Build-up of Biofilm is Harmful ……

IMAGES IN ANESTHESIOLOGY

Hugh C. Hemmings, Jr., M.D., Ph.D., Editor
Alan Jay Schwartz, M.D., M.S. Ed., Associate Editor

Use of High-definition Computed Tomography to Assess Endotracheal Tube Luminal Narrowing after Mechanical Ventilation

Riccardo Pinciroli, M.D., Cristina Mietto, M.D., Lorenzo Berra, M.D.*
* Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts. lberra@partners.org



PRODUCTION and clearance of mucus are key mechanisms in the physiology of the respiratory system. Their regulation is often impaired in intubated patients who show superabundant production and inefficient clearance. As a result, a variably thick layer of mucus ultimately adheres to the inner surface of the endotracheal tube (ETT), reducing its original cross-sectional area. This luminal narrowing significantly impacts airflow resistance that varies inversely to the fourth power of the conduit's radius according to the Poiseuille's equation ($\Delta P = 8\ \mu L \dot{Q}(\pi r^4)^{-1}$). Patient's work of breathing may consequently increase.[1] However, the importance of ETT progressive luminal narrowing during… tion is still widely… used suctioning systems are unable… tain the ETT function.[2]

To study the magnitude of this adverse event, we developed an innovative approach to visualize the accretion of mucus in extubated ETTs with high-definition computed tomography. The ETT is collected on extubation and sealed. Scanning is performed on a positron emission tomography-computed tomography scanner (Siemens, Malvern, PA), with resolution down to 15 μm. Multiplanar images of the ETT, particularly its lung end (terminal 10 cm), show the reduced inner diameter on coronal (fig. A) and transverse (fig. B) sections. 3D-volume rendering reconstructions of the lumen can also be obtained (fig. C). This technique precisely visualizes the morphology of the lumen and quantifies the existing amount of mucus. Measurements such as volume of secretions/air or minimum cross-sectional area can be collected, all of which may have exerted significant effects *in vivo*. High-definition computed tomography may also be useful to study the efficacy of devices for the maintenance of the ETT function.[3]

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Financial support: endOclear, LLC. Otsego, MI) covered the costs of high-definition computed tomography and provided study supplies.

"However, the importance of ETT progressive luminal narrowing during mechanical ventilation is still widely unrecognized, and currently used suction systems are unable to maintain the ETT function[1]"

Berra, et al. Use of High-definition Computed Tomography to Assess Endotracheal Tube Luminal Narrowing after Mechanical Ventilation, the American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins. Anesthesiology 2013; 119:202[12]

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The Build-up of Biofilm is Harmful ……

Advanced endotracheal tube biofilm stage, not duration of intubation, is related to pneumonia

Wilson, Alison MD, FACS; Gray, Dana; Karakiozis, Jacqueline BS; Thomas, John PhD

Journal of Trauma and Acute Care Surgery: April 2012 - Volume 72 - Issue 4 - p 916–923
doi: 10.1097/TA.0b013e3182493a10 Original Articles

Abstract

BACKGROUND: Biofilms are complex communities of living bacteria surrounded by a protective glycocalyx. Biofilms have been implicated in the development of infections such as dental caries and hardware infections. Biofilms form on endotracheal tubes (ETT) and can impact airway resistance. The lifecycle of a biofilm has four stages. We hypothesize that there is a relationship between the stage of biofilm on the ETT and development of pneumonia.

METHODS: Thirty-two ETT were analyzed for biofilms and staged. Staging was performed by a microbiologist blinded to all patient information. Data included development of pneumonia, duration of intubation, comorbidities, and microbiology. Pneumonia was defined as presence of fever, WBC >12 K or <4 K, infiltrate on chest X-ray, and purulent sputum with +lower airway culture (bronchoalveolar lavage or brush). Statistics were performed by a biostatistician; $p < 0.05$ defined significance.

RESULTS: There were 11 women and 21 men with a mean age of 50 years. Mean intensive care unit days were 13 (standard deviation ± 9.9) and mean length of intubation was 7.4 days (standard deviation ± 5.0). Half (16 of 32) the patients developed pneumonia while intubated. Eight of 10 patients with a stage IV biofilm had pneumonia. There was a relationship between increasing biofilm stage with the incidence of pneumonia ($p < 0.05$). Stage IV biofilms were associated with pneumonia ($p < 0.02$). There was no relationship to duration of intubation, patient age or hospital stay and biofilm stage.

CONCLUSIONS:

"Advanced biofilm stage (stage IV) is associated with pneumonia. Duration of intubation does not predict biofilm stage."

Wilson, A., Gray, D., Karakiozis, J., Thomas, J., 2012, Advanced endotracheal tube biofilm stage, not duration of intubation, is related to pneumonia, Journal of Trauma and Acute Care Surgery, April 2012 - Volume 72 - Issue 4 - p 916–923[13]

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2 The Build-up of Biofilm is Harmful ……

Implications of endotracheal tube biofilm in ventilator-associated pneumonia response: a state of concept

Critical Care 2012, 16:R93 doi:10.1186/cc11357

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Results:

Eighty-seven percent of the patients were colonized based on ETA cultures. Biofilm was found in 95% of the ETTs. In 56% of the cases, the same microorganism grew in ETA and biofilm. In both samples the most frequent bacteria isolated were Acinetobacter baumannii and Pseudomonas aeruginosa. Nineteen percent of the patients developed VAP (N=14), and aetiology was predicted by ETA in 100% of the cases. Despite appropriate antibiotic treatment, bacteria involved in VAP were found in biofilm (50%). In this situation, microbial persistence and impaired response to treatment (treatment failure and relapse) were more frequent (100% vs 29%, P=0.021; 57% vs 14%, P=0.133).

Conclusions:

"Airway bacterial colonization and biofilm formation on ETTs are early and frequent events in ventilated patients. There is microbiological continuity between airway colonization, biofilm formation and VAP development. Biofilm stands as a pathogenic mechanism for microbial persistence, and impaired response to treatment in VAP.

In summary, our study supports the idea of a dynamic relationship between airway colonization, biofilm, and VAP development. The idea of bacterial survival on ETT biofilm as a pathogenic mechanism for microbial persistence and impaired response to antibiotic therapy highlights the importance of discovering new strategies focused in the removal of biofilm from the ETT."*

Gil-Perotin, S. et. al., 2012, Implications of endotracheal tube biofilm in ventilator-associated pneumonia response: a state of concept , Critical Care 16:R93 doi: 10.1186/cc11357[14]

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2 The Build-up of Biofilm is Harmful ……

Description and Microbiology of Endotracheal Tube Biofilm in Mechanically Ventilated Subjects

Pierre-Eric Danin MD, Emmanuelle Girou PharmD, Patrick Legrand MD, Bruno Louis PhD, Redouane Fodil PhD, Christo Christov MD, Jérôme Devaquet MD, Daniel Isabey PhD, and Laurent Brochard MD

BACKGROUND: A biofilm is found on the inner side of endotracheal tubes (ETT) in mechanically ventilated patients, but its features and role in pneumonia remain unclear. METHODS: This prospective, observational, monocentric study included critically ill ventilated subjects. Measurement of the ETT inner volume was first performed before extubation using the acoustic reflection method. After extubation, the biofilm was studied by means of optical and atomic force microscopy. Bacteriological analysis was then performed and compared with clinical documentation. RESULTS: Twenty-four subjects were included. Duration of intubation lasted from 2 to 79 d (mean ± SD 11 ± 15 d). The mean percentage of ETT volume loss evaluated in situ (n = 21) was 7.1% and not linked with the duration of intubation. Analyses with atomic force microscopy (n = … a full coverage of the inner part of the tube with biofilm, even after saline rinse. Its thi… from 0.8 to 5 μm. Bacteriological cultures of the biofilm (n = 22) often showed … as in tracheal secretions, especially for pathogenic organisms. *Pseudomonas …* *albicans* were among the most frequent microorganisms. In subjects w… cessfully treated episode of ventilator-associated pneumonia (n = 5… still present in the biofilm. CONCLUSIONS: ETT biofilm is … patient whatever the duration of intubation and appears quickly after intubation. Even after soft rinse, … small but measurable part of biofilm remains always present, and seems strongly adherent to the ETT lumen. It contains potentially pathogenic bacteria for the lung. *Key words: biofilm; endotracheal tube; ventilator-associated pneumonia.* [Respir Care 2015;60(1):21–29. © 2015 Daedalus Enterprises]

Biofilm build-up in ETT
Respiratory Care 2015

- Biofilm is always present whatever the duration of intubation and appears quickly.
- Biofilm is strongly adherent and remains after rinse.
- Average total volume loss was 7.1% which is equivalent to 1 – 1.5 cc of material in tubes ranged 7 – 9 mm.

Danin, P.E., et. al., Description and microbiology of endotracheal tube biofilm in mechanically ventilated subjects, Respir Care. 2015 Jan;60(1):21-9. doi: 10.4187/respcare.02722. Epub 2014 Nov 4[15]

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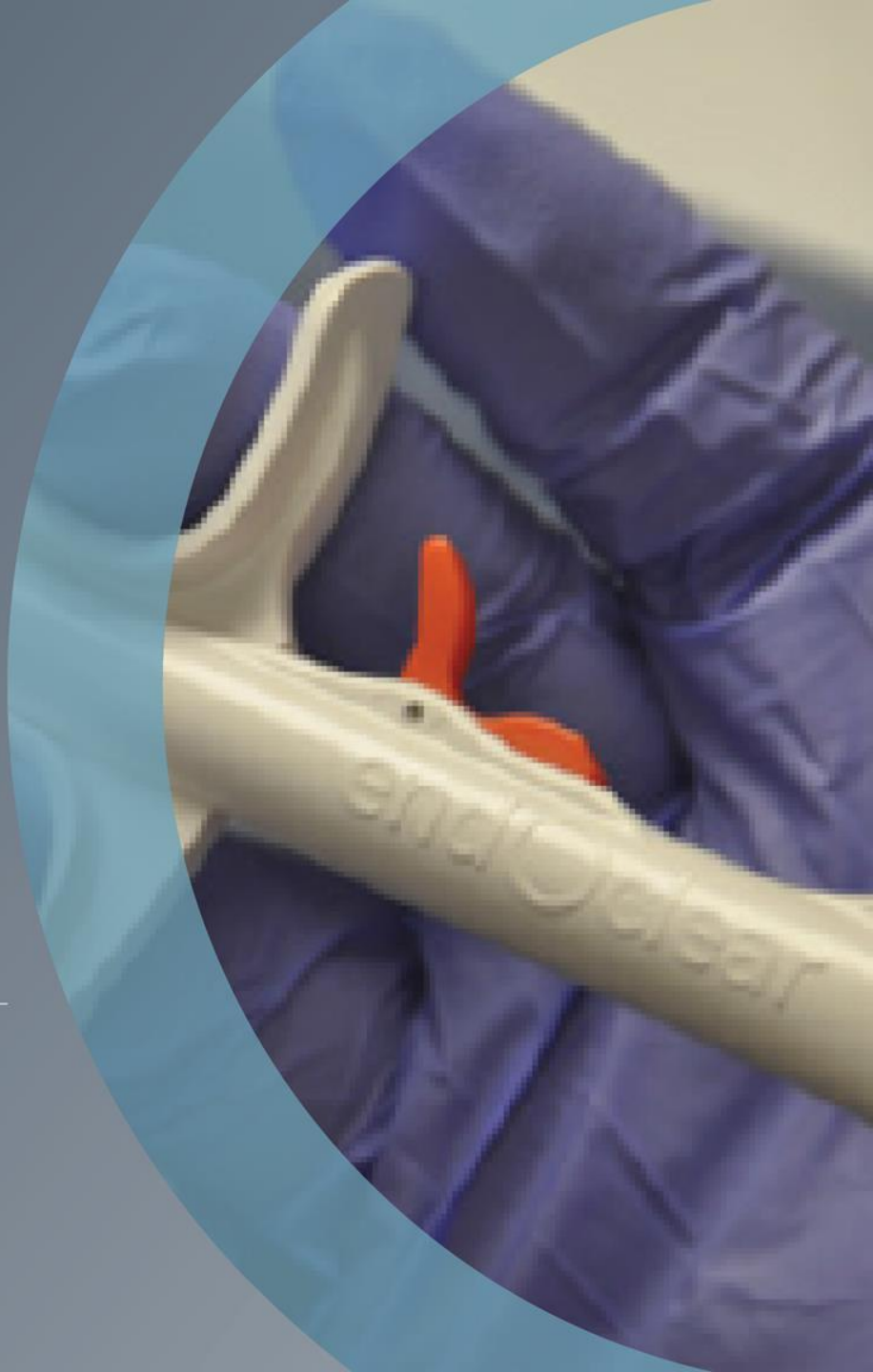
Using an ETT cleaner addresses retained secretions and colonization in a positive way.

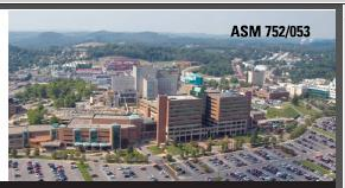
Current indications for endotracheal tube suctioning are to use as minimally as possible



3 Using an ETT Cleaner Addresses……

Quantifying the Benefit of an Optically Directed Endotracheal Tube Clearing Device Using Bioluminescent Bacteria

John G. Thomas, PhD[1]; Hamed M. Motlagh, MPH[1]; Christopher Waters, MS[1]; Sarah L. McLaughlin, BS2
[1]West Virginia University, Department of Pathology; [2]West Virginia University, Animal Models and Imaging Facility



INTRODUCTION:

Previously, we had optimized the use of 1) our Adult Ventilator-Endotrach-Lung Simulator (A-VEL) (Fig. 3) combined with 2) bioluminescent (BL) bacteria *Staphylococcus aureus* (*Sa*) (Xen 036) or *Pseudomonas aeruginosa* (Pa) (Xen 05) (Fig. 4a & 4b) to measure the efficacy of an endo-tracheal tube (ETT) luminal clearing device. (Fig. 2a)

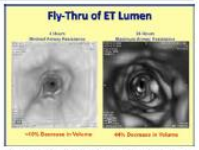


Figure 1: Shows CT-Radiography occlusion from 500 cross sections emphasizing ETT luminal restriction of intubation @4 hours (A) and @48 hours (B). (See Fig. 8)

HYPOTHESIS:

Here, we wanted to evaluate the device, integrating quantitative BL photonic assessment addressing three ETT regions (A- Oral, B- Middle, C- Lung,) (Fig. 2b) while visualizing the distribution of labeled biofilm-accretion, Pre and Post clearing.

METHODS:

The A-VEL is composed of three integrated systems: Puritan-Bennett Ventilator 720, anatomically designed head position, and a compliant bi-lobed Michigan Lung; model settings were those used for a COPD patient. Extubated ETTs were received within two hours after extubation, and placed on the A-VEL with a nebulized broth/ glucose mixture for 12 hours. Bioluminescent mixture of *Sa* and *Pa*, were grown independently overnight, and nebulized for 6 hours at the ETT-Lung interface, combined or independently, at a concentration of $1x10^6$ CFU's/ml. The ETT was placed in an anatomically correct head, and cleared in approximately 10 seconds from Murphy's eye, backward to the Oral end, recovering biofilm accretion material utilizing the EndoClear device. IVIS (Fig. 4a & 4b) (Caliper Life Sciences) Photonic Intensity measurements were taken Pre cleaning for each ETT zone, and Post cleaning three times.

Figure 2a & 2b: Representation of the endOclear endotracheal tube clearing device (ECCD) composed of five components: 1) Lighted tip with optics 2) Wiper 3) Activating handle 4) Fiberoptic cable 5) Camera and display including touchscreen monitor for still image/movie capture for simultaneous visualization of device placement and potential obstruction viewing.

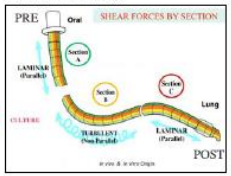


Figure 3: Adult VEL

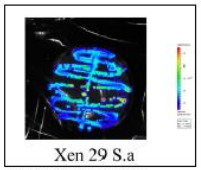


Figure 4a: Engineered bacteria IVIS

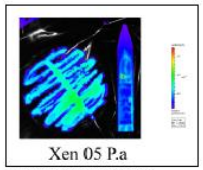
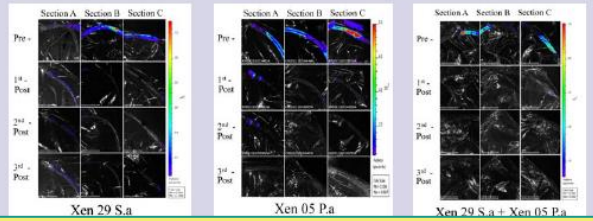


Figure 4b: Engineered bacteria IVIS

RESULTS:

For Pre samples, Pa labeled ETT accretion alone or in combination with Sa produce the greatest intensity (p/sec / cm2/sec), with each sector different: A (2.1-6.1), B (2.2-5.5), C (5.1-7.0). Visualization highlighted differences in distribution, with Region C having greatest intensity and near occlusion. Post clearing for all section detected zero labeled ETT accretion, independent of times cleared. *Sa*, alone, gave similar visual imprint but intensity.

Visualization in Photonic Intensity



CONCLUSION

The combination of the IVIS technique and the A-VEL simulator provided a method which demonstrated the clearing device eliminated photonic labeled ETT accretion after one pass. This was independent of luminal endotrach location (A, B, C).

DISCUSSION:

The impact of occulusion is highlighted by our previouse ex-periments, where with the use of CT radiography the endotrach-biofilm occulusion reduced airway volume by 44%. (Poster ASM 578/038) (Fig. 1)

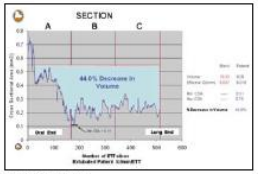


Figure 8: (See Fig. 1)

CLINICAL APPLICATION:

The application of IVIS and engineered bioluminescent bacteria, particularly bio-film associated, is an unrecognized tool for clinical microbiologists; it's application here, particularly quantification, clearly highlighted the benefit of the clearing devise.

The clearing device could be part of routine ETT suctioning that has the potential of reducing 1) BF occlusion and 2) nidus of infection without the use of antibiotics.

…NCES:
…Gru… …IG. Increases in endotracheal tube resistance …duration of intubation. Chest. 2009;136(4):1006-
…n Research—Overview Sheet, Caliper Life Sciences. …n http://www.caliperLS.com.
…uthschild MA, Delgado M, Isenberg H, Holzman I. Bacterial …l Endotracheal Tubes in Intubated Neonates. Arch Otolaryngol …urg. 2001;127:525-528.
…harma PK, Dijkstra RJ et al. The potential for bio-optical imaging …l-associated infection in vo. Biomaterials. 2010;31(8):1984-

…T:
…ndOclear, Inc., Petoskey MI.
…Randolph Cancer Center and NIH grants P20 …nd P30 RR032138/ GM103488.

"The clearing device could be part of routine ETT suctioning that has the potential of reducing 1) BF occlusion and 2) nidus of infection without the use of antibiotics."

3 Using an ETT Cleaner Addresses……

WVU, IVIS Imaging. Freshly suctioned ETT, pre and post endOclear® use
Florescence Key: Blue = Low, Green/Yellow = Medium, Red = High bacteria counts

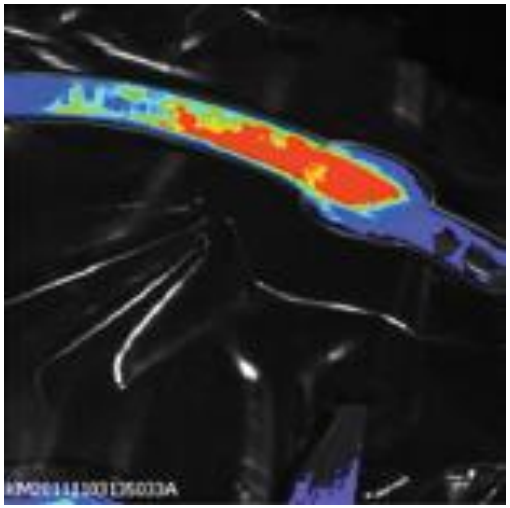


Figure 1

Bioluminescence from pseudomonas bacteria within in an ET Tube after suctioning

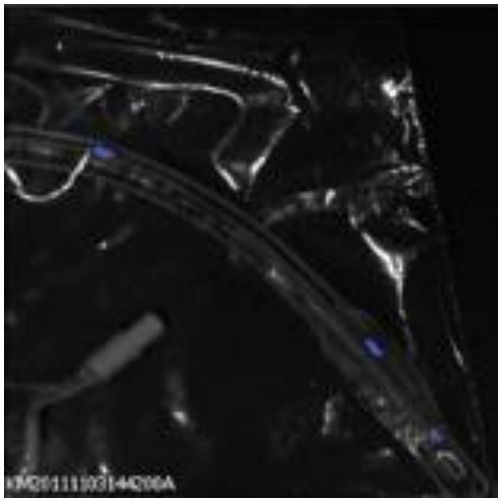


Figure 2

Near absence of bioluminescence after one cleaning with the endOclear® device

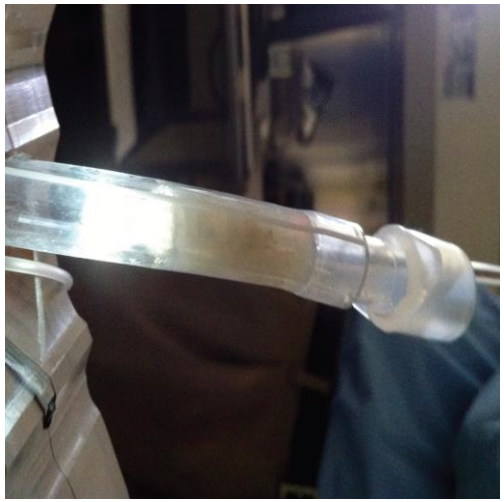


Figure 3

Amount of mucous and secretions removed from the ET Tube in Figure 1

3 Using an ETT Cleaner Addresses.....

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A clinical assessment of the Mucus Shaver: A device to keep the endotracheal tube free from secretions

Lorenzo Berra, MD; Andrea Coppadoro, MD; Edward A. Bittner, MD, PhD; Theodor Kolobow, MD; Patrice Laquerriere, PhD; Joshua R. Pohlmann, BS; Simone Bramati, MD; Joel Moss, MD, PhD; Antonio Pesenti, MD

Objective: We evaluated a new device designed to clean the endotracheal tube in mechanically ventilated patients, the Mucus Shaver.

Design: Prospective, randomized trial.

Setting: University hospital intensive care unit.

Patients: We enrolled 24 patients expected to remain ventilated for >72 hrs.

Interventions: The Mucus Shaver is a concentric inflatable catheter for the removal of mucus and secretions from the interior surface of the endotracheal tube. The Mucus Shaver is advanced to the distal endotracheal tube tip, inflated, and subsequently withdrawn over a period of 3–5 secs. Patients were prospectively randomized within 2 hrs of intubation to receive standard endotracheal tube suctioning treatment or standard suctioning plus Mucus Shaver use until extubation.

Measurements and Main Results: During the study period, demographic data, recent medical history, adverse events, and staff evaluation of the Mucus Shaver were recorded. At extubation, each endotracheal tube was removed, cultured, and analyzed by scanning electron microscopy. Twelve patients were assigned to the study group and 12 were assigned to the control group. No adverse events related to the use of the Mucus Shaver were observed. At extubation, only one endotracheal tube from the Mucus Shaver group was colonized, whereas in the control group ten endotracheal tubes were colonized (8% vs. 83%; $p < .001$). Scanning electron microscopy showed little secretions on the endotracheal tubes from the study group, whereas thick bacterial deposits were present on all the endotracheal tubes from the control group ($p < .001$ by Fisher exact test, using a maximum biofilm thickness of 30 μm as cut-off). The nursing staff was satisfied by the overall safety, feasibility, and efficacy of the Mucus Shaver.

Conclusions: The Mucus Shaver is a safe, feasible, and efficient device for endotracheal tube cleaning in the clinical setting. The Mucus Shaver is helpful in preventing endotracheal tube colonization by potentially harmful microorganisms. (Crit Care Med 2012; 40:000–000)

KEY WORDS: bacterial biofilm; endotracheal tube; endotracheal tube occlusion; endotracheal tube suctioning; mechanical ventilation; Mucus Shaver; secretion removal; ventilator-associated pneumonia

An endotracheal tube (ETT) is generally required for the management of critically ill mechanically ventilated patients. Airway patency is maintained by using suctioning catheters. Nevertheless, it has been shown that intraluminal volume loss attributable to the accumulation of secretions is prevented by standard suctioning treatment or by optimal humidification (1–4). This vicious process of secretion accumulation can lead to life-threaten-

- Bacterial colonization:
  - Control group – 83%
  - Study group – 8%
- Biofilm by SEM > 30um thickness:
  - Present in all control group
  - Minimal in study group

"In conclusion, we propose the Mucus Shaver as a device able to improve care of mechanically ventilated patients by reducing bacterial colonization of the inner ETT lumen, suggesting a potential role in infection prevention, and reducing secretion deposits, preventing possible partial or complete ETT occlusion and leading to increased airway resistance and work of breathing."

Berra L, et. al, A clinical assessment of the Mucus Shaver: a device to keep the endotracheal tube free from secretions. Crit Care Med. 2012 Jan;40(1):119-24. doi: 1097/CCM.0b013e31822e9fe3[17]

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3 Using an ETT Cleaner Addresses.....

The Impact of a Unique Airway Clearance System on Airway Mechanics in Ventilated Patients

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Abstract

Background: The adherence of secretions along the endotracheal tube (ETT) lumen in mechanically ventilated (MV) patients' results in airway narrowing and concomitantly may increase patients' work of breathing. Biofilm accumulation may also promote the development of ventilator-associated pneumonia. Routine suctioning does not address the potential risks associated with secretions and biofilm that collect within the ETT lumen. A unique mucus shaver system (endOclear®) facilitates removal of secretions and biofilm.
The purpose of this study is to determine the effectiveness of reducing peak airway pressures and resistance in ventilated patients who have their ETT cleared with a mucus shaver system. The hypothesis is: Application of a mucus shaver system in addition to routine suctioning prior to spontaneous breathing trials (SBTs) lowers both peak airway pressures and airway resistance.

Methods: This study retrospectively identified all subjects having their ETTs cleared at a single institution prior to beginning a SBT between Jan 2012-Jul 2013. All subjects had received at least 24 hrs of MV prior to the SBT, and all underwent routine suctioning with a closed in-line system prior to use of the mucus shaver. Peak airway pressures before and after the additional use of the mucus shaver along with changes in airway resistance served as our co-primary endpoints. The study also compared changes in these variables as function of the ETT lumen size.

Results: The median peak airway pressure measured 29 cmH_20 before use of the mucus clearance system and fell to 23 cm H_20 (p<0.001). There was a similar decline in the median airway resistance (27 cm H_20/Lps to 15 cm H_20/Lps, p < 0.001). The average percent decline in peak airway pressure equaled 17.6±13.3% while the mean drop in airway resistance was greater, 33.3±18.9%. Seventy-five percent of subjects experienced a greater than 10% and 19% fall in peak airway pressure and airway resistance, respectively. Differences in ETT lumen size did not alter the magnitude of the fall seen in either of the co-primary endpoints.

Conclusions: The addition of a unique mucus shaving and tube cleaning system to routine suction prior to an SBT significantly reduces both peak airway pressure and airway resistance in persons undergoing SBTs.

Introduction

- Current standard of care closed suction systems do not completely clean the inside of the endotracheal tube.[1,3,4,5]
- Secretions and biofilm accumulation may lead to decreased liberation from the ventilator[7,8] and increased ventilator associated pneumonia (VAP).[6]
- Recent protocol use of an endotracheal tube cleaning device prior to spontaneous breathing trials at one center was associated with improved patient outcome (decreased length of intubation and decreased length of ICU and hospital stay) and decreased hospital cost.[2]
- Physiologic implications of this new secretion management tool have not yet been described

Study Objective

To describe the effect of routine, protocolized use of endOclear® device on physiologic measures of airway resistance and peak pressures during efforts to liberate patients from the ventilator

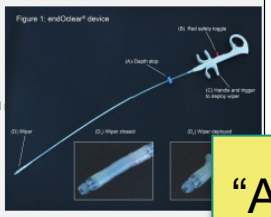
Methods

Design: Prospective, observational quality assurance study, January 2012 through July 2013

Setting: Community hospital mixed medical-surgical ICU

Subjects: Mechanically ventilated patients on the ventilator over 24 hours

Protocol:
- Prior to SBT, the patient undergoes standard closed suctioning
- peak-airway-pressure (PAP) and resistance are measured while the patient is still on the vent in ventilated
- endOclear® (Figure 1) is used and measurements on the same settings are repeated
- patient undergoes SBT



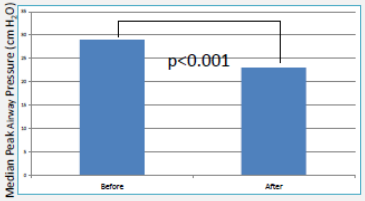
Endpoints: PAP and airway resistance

Statistics:
- Endpoints from before and after period compared with either Student's t test (paired)
- p < 0.05 assumed to represent statistical significance

Results

- Cohort
  - n = 109 patients, 18 bed mixed surgical / medical ICU
  - In 2011, prior to use of endOclear® the mean duration of MV was 4.3 days
  - Mean duration of MV in current population 3.4 days
- Median airway resistance declined from 27 cm H_20/Lps to 15 cm H_20/Lps (p < 0.001).
- The average percent decline in peak airway pressure equaled 17.6+13.3%
- The mean drop in airway resistance was greater, 33.3+18.9%.
- Seventy-five percent of subjects experienced a greater than 10% and 19% fall in peak airway pressure and airway resistance, respectively.
- Differences in ETT lumen size (e.g., whether 8.0 mm vs. smaller) did not alter the magnitude of the fall seen in either of the co-primary endpoints

Results:
Impact on Peak Airway Pressure



Results:
Effect on Airway Resistance

Conclusions

- Addition of a unique mucus shaving and tube cleaning system (endOclear®) to routine suctioning prior to an SBT significantly reduces both peak airway pressure and airway resistance

"Addition of a unique mucus shaving and tube cleaning system (endOclear®) to routine suctioning prior to an SBT significantly reduces both peak airway pressure and airway resistance"

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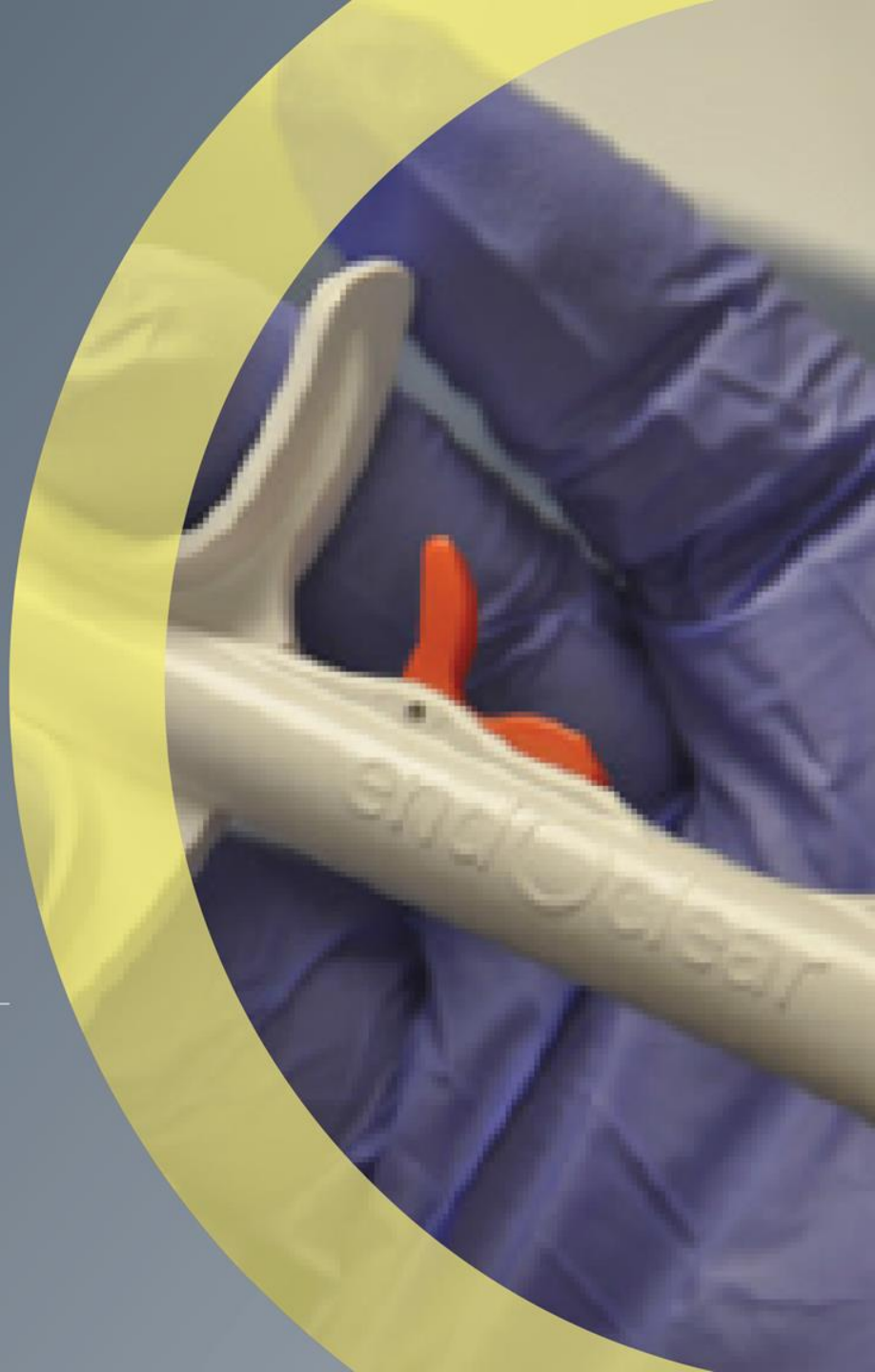
Effective cleaning of the ETT results in improved outcomes when used in both PRN and protocol fashion.

The build-up of biofilm is harmful and can lead to infection and increased duration of ventilation and ICU length of stay



4 Effective cleaning of the ETT results ……..

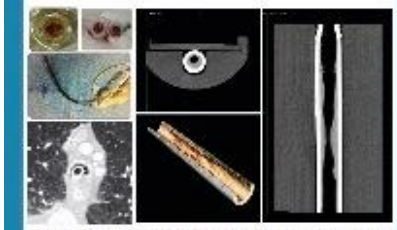
Efficacy Study of a Novel Device to Clean the Endotracheal Tube

Massimiliano Pirrone[1,3], Riccardo Pinciroli[1], Cristina Mietto[1,3], David Imber[1], Christopher Chenelle[2], Robert M Kacmarek[2], Lorenzo Berra[1]

1, Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Boston, MA; 2, Department of Respiratory Care, Massachusetts General Hospital, Boston, MA; 3, Dipartimento di Anestesiologia, Terapia Intensiva e Scienze Dermatologiche, Università degli Studi di Milano, Milan, Italy

Background

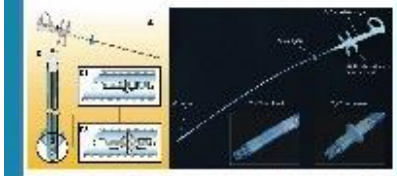
The Endotracheal Tube (ETT) is a life-saving device for respiratory support and airway protection. However, its sustained presence in the trachea disrupts the physiological mechanisms that maintain mucus homeostasis. The process of mucus buildup and luminal narrowing leads to an increased ventilatory effort and might delay liberation from mechanical ventilation. In addition, potential lung pathogens often colonize the ETT lumen in the form of complex biofilms, with the plastic surface offering the ideal environment for their proliferation. Nevertheless, in everyday practice the extent of ETT biofilm formation and the degree of occlusion are generally not investigated. Blind tracheal suctioning, the standard procedure adopted to clear secretions from the ETT and the airway, is poorly effective.



Upper left: Section of an ETT immediately after extubation. Obstruction and cross-sectional area reduction are visible. The reduction of volume available to airflow increases airway resistance and consequently, ventilatory effort. Lower left: ETT obstruction due to secretion accumulation is visible on a side-slant CT chest scan. Middle and right: High-Resolution Computed Tomography of an ETT after extubation reveals clinically significant obstruction and limited internal volume.

Rationale

Different new medical devices have been recently developed specifically for ETT cleaning. Among them, the endOclear catheter (Endoclear, LLC, Petoskey, MI) has been recently reported to be an effective tool in relieving life-threatening ETT obstruction. We designed a randomized clinical trial to test the hypothesis that the implementation of routine ETT cleaning with endOclear prevents ETT luminal occlusion and reduces biofilm accumulation.



Left: The endOclear cleaning catheter is a recently developed device aimed at improving ETT cleaning procedures and restore ETT patency in case of acute ETT obstruction. The device features an extendable mesh at its tip. After insertion of the catheter inside the ETT, the device trigger is pulled and the extendable mesh touches the inner layer of the ETT. By gently pulling the catheter out of the tube, secretions accumulated inside the ETT are removed from the tube. Right: Actual picture of the endOclear device, with details of the closed and deployed wiper mesh.

Methods

We enrolled in the study adult intubated patients expected to be ventilated for more than 48 hours. Random allocation to either treatment or control arm was performed with a 1:1 ratio. Control group consisted in institutional standard of care (suctioning every 4 hours or as needed), while treatment group received standard of care plus a single pass of the endOclear catheter, three times per day every 8 hours.

Protocol Flowchart

Endotracheal tube analysis

ETTs were collected at the bedside, sealed and rapidly processed. High-Resolution Computed Tomography (HRCT) was obtained for the terminal 22 cm of each ETT. Raw imaging data of mucus and air volumes were acquired and subsequently elaborated as volume percentages. "Overall occlusion" was defined as the average ratio of mucus volume vs total ETT volume throughout all the scan slices. "Maximum occlusion" was defined as the maximum ratio within each ETT scan. Cross-sectional area (CSA) was estimated for each tube by taking into consideration the narrowest conduit available to flow. By assuming the measured CSA was circle-shaped, we estimated for each tube a virtual "minimum ID".

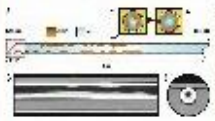
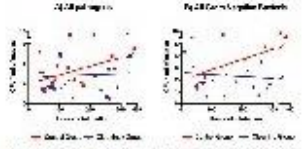


Figure A: HRCT analysis on ETTs was performed after removal of the distal 1.6 cm that includes the murphy's eye, in order to achieve complete ETT seal. Irregular cross-sectional surfaces (A1) were approximated to regular circular surfaces (A2) in order to allow the estimation of the internal diameter. Figures B and C: An example of HRCT scan of an used ETT.

Microbiology

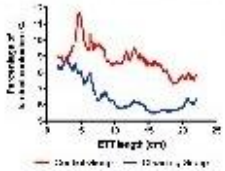
After HRCT scan, we processed each tube in order to collect microbiological samples from the inner layer. On these samples we performed microbiological identification and quantitation of bacteria and fungi.



Above: In our study population there was no correlation between the length of intubation and the estimated total microbial load.

Results

526 patients were screened across different Intensive Care Units. 74 patients met enrollment criteria and were randomized. 37 ETTs were collected from the cleaning group and 40 ETTs from the control group. ETTs from the cleaning group showed reduced mucus accumulation (p=0.004). A significant difference was also recorded when mucus volume was calculated as "Overall occlusion" (p=0.04). "Maximum occlusion" was significantly different between the two groups (p=0.007). Although ETTs from both groups showed variable degrees of reduction of inner diameter (ID), only in the most numerous subgroup of ID size 7.5mm we were able to detect a significant difference (p=0.001). The degree of ETT occlusion did not correlate with the length of intubation.
Pathogenic bacteria were isolated in ETTs from both groups and no difference in antibiotic susceptibility was noted. However, there was a trend towards reduction of total microbial load in ETT biofilm.



Left: Degree of ETT occlusion (% of cross-sectional area lost due to mucus) after extubation (based on the distance from the Murphy's eye (ETT length). Endotracheal tubes cleaned with the endOclear device every 8 hours in addition to standard of care showed reduced mucus accumulation (p=0.004).

Above: Summary table of HRCT results. Significant differences in ETT obstruction were recorded with all the techniques adopted for mucus detection. The HRCT slice showing narrowest lumen appeared significantly less occluded in tubes treated with the device. The most numerous subgroup (ETT size 7.0), occlusion as measured through their HRCT was lower in the cleaning group. No differences were recorded for ETTs of size 7.0 or

Conclusions

Preservation of ETT patency is a feasible goal pursued when caring for mechanically ventilated trial, endoluminal narrowing was safely implementation of a cleaning protocol with subsequent reduction in airway resistance terms of reduced ventilatory effort by the patient. Regular ETT cleaning might also disrupt the biofilm formation process at the ETT luminal surface, having the potential to significantly reduce bacterial colonization.

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Kolobow et al. Novel system for complete removal of secretions within the endotracheal tube: the Mucus Shaver. Anesthesiology 2008;103(5):1063-1068.

In our trial, endoluminal narrowing was safely prevented by the implementation of a cleaning protocol with a novel device. The subsequent reduction in airway resistance might be beneficial in terms of reduced ventilatory effort by the patient. Regular ETT cleaning might also disrupt the biofilm formation process at the ETT luminal surface, having the potential to significantly reduce bacterial colonization.

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Effective cleaning of the ETT results ……..

Removal of Endotracheal Tube Debris Obstruction by a Clearing Secretion Device.

Cristina Mietto1 MD, Kevin Foley2 RRT, Lindsay Salerno2 RRT, Jenna Oleksak2 RRT, Riccardo Pinciroli1 MD, Jeremy Goverman3 MD, Lorenzo Berra1 MD
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RESPIRATORY CARE Paper in Press. Published on December 24, 2013 as DOI: 10.4187/respcare.02995

ABSTRACT

Accumulation of secretions may suddenly occlude the endotracheal tube (ETT) requiring immediate medical attention. The endOclear® catheter (EndOclear LLC, Petoskey, MI) is a novel device designed to clean the ETT from mucus debris and restore the luminal patency. We present a series of three subsequent cases of life-threatening partial ETT-occlusion recorded over a period of six months at Massachusetts General Hospital.

After the failure of conventional methods, standard tracheal suctioning and bronchoscopy, the endOclear® device was implemented with successful restoration of the airways in all three cases. The three patients rapidly improved their respiratory conditions and tolerate well the ETT-clearing maneuver.

"These observations showed that such device is (I) safe, (II) easy to use during an emergent-airway situation, and (III) efficient to rapidly remove secretions in the setting of ETT obstruction by the respiratory therapist personnel."

Mietto, et., al, Removal of Endotracheal Tube Debris Obstruction by a Clearing Secretion Device, RESPIRATORY CARE Paper in Press. Published on December 24, 2013 as DOI: 10.4187/respcare.02995[20]

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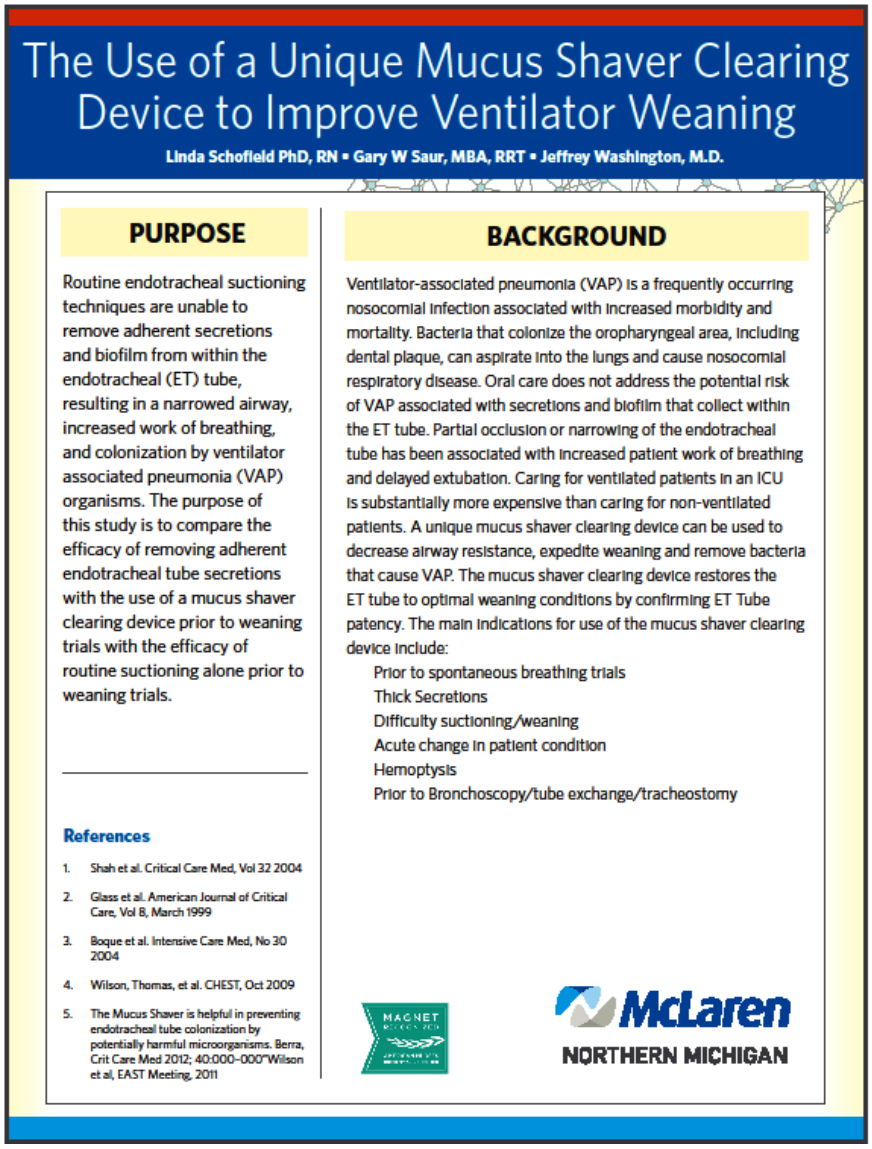
4 Effective cleaning of the ETT results ……..



The Use of a Unique Mucus Shaver Clearing Device to Improve Ventilator Weaning

Linda Schofield PhD, RN • Gary W Saur, MBA, RRT • Jeffrey Washington, M.D.

PURPOSE

Routine endotracheal suctioning techniques are unable to remove adherent secretions and biofilm from within the endotracheal (ET) tube, resulting in a narrowed airway, increased work of breathing, and colonization by ventilator associated pneumonia (VAP) organisms. The purpose of this study is to compare the efficacy of removing adherent endotracheal tube secretions with the use of a mucus shaver clearing device prior to weaning trials with the efficacy of routine suctioning alone prior to weaning trials.

BACKGROUND

Ventilator-associated pneumonia (VAP) is a frequently occurring nosocomial infection associated with increased morbidity and mortality. Bacteria that colonize the oropharyngeal area, including dental plaque, can aspirate into the lungs and cause nosocomial respiratory disease. Oral care does not address the potential risk of VAP associated with secretions and biofilm that collect within the ET tube. Partial occlusion or narrowing of the endotracheal tube has been associated with increased patient work of breathing and delayed extubation. Caring for ventilated patients in an ICU is substantially more expensive than caring for non-ventilated patients. A unique mucus shaver clearing device can be used to decrease airway resistance, expedite weaning and remove bacteria that cause VAP. The mucus shaver clearing device restores the ET tube to optimal weaning conditions by confirming ET Tube patency. The main indications for use of the mucus shaver clearing device include:

- Prior to spontaneous breathing trials
- Thick Secretions
- Difficulty suctioning/weaning
- Acute change in patient condition
- Hemoptysis
- Prior to Bronchoscopy/tube exchange/tracheostomy

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3. Boque et al. Intensive Care Med, No 30 2004
4. Wilson, Thomas, et al. CHEST, Oct 2009
5. The Mucus Shaver is helpful in preventing endotracheal tube colonization by potentially harmful microorganisms. Berra, Crit Care Med 2012; 40:000–000"Wilson et al, EAST Meeting, 2011

MAGNET

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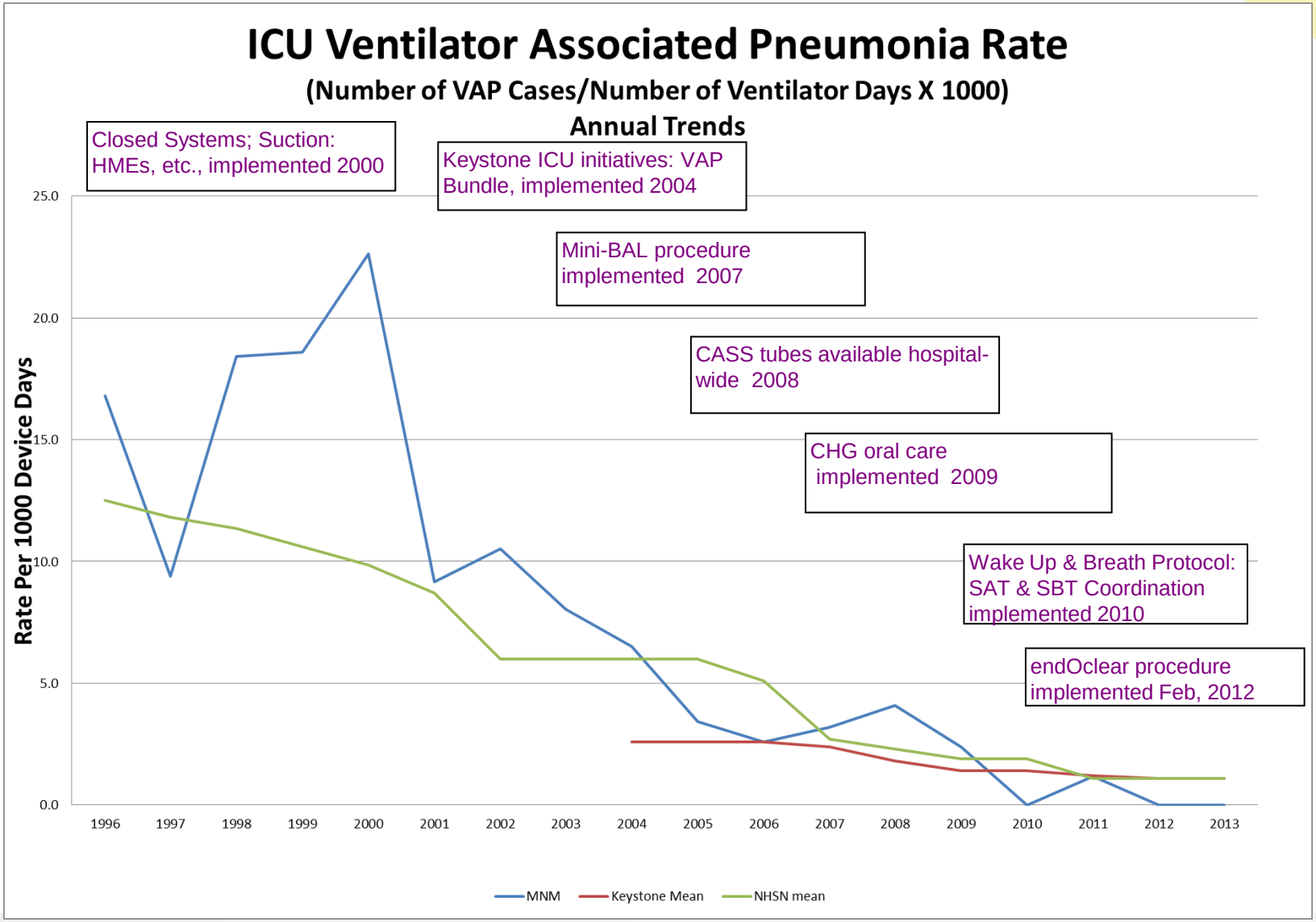
4 Effective cleaning of the ETT results ……..



CHEST 2013[21]

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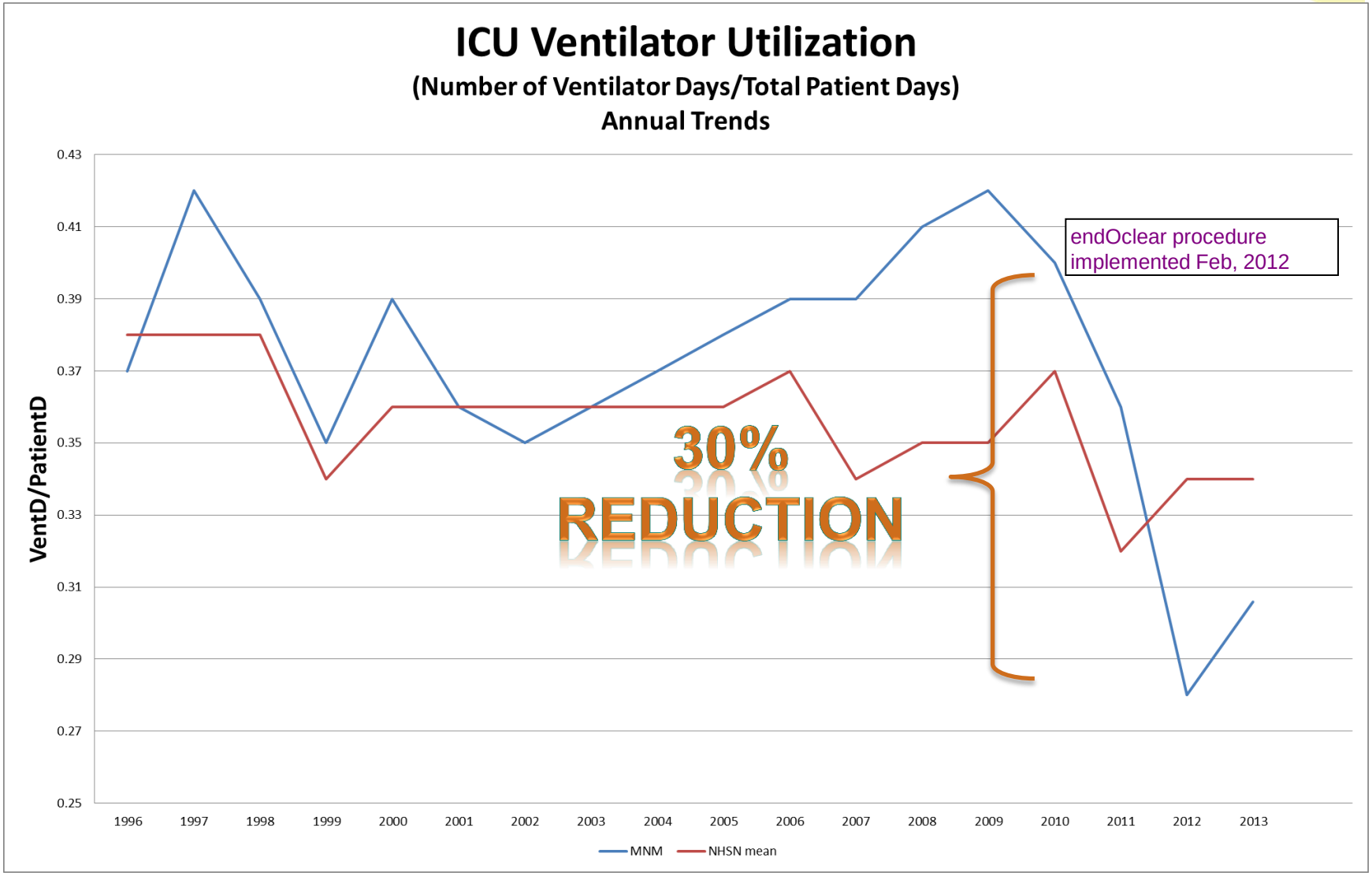
4 Effective cleaning of the ETT results ……



CHEST 2013[21]

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Effective cleaning of the ETT results ……

McLaren Northern Michigan

The Use of a Unique Mucus Shaver Clearing Device to Improve Ventilator Weaning

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BACKGROUND

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ostomy

McLaren Northern Michigan
$1.96 million cost savings

	McLaren Northern Michigan		
	Twelve Months Ending		
	7/31/2011	7/31/2012	7/31/2013
	Actual	Actual	Actual
	Pre endOclear	**Post endOclear**	
Ventilator Days per Case	4.3	3.4	3.2
ICU Days per Case	5.2	4.6	3.7
Hospital ALOS per Case	9.7	9.0	8.0
Direct Cost per Case	$ 18,802	$ 17,680	$ 15,590
Annual Savings (Direct Costs)		$ 578,952	$ 1,383,580
Number of Cases	583	516	662

References:

1. Shah et al. Critical Care Med, Vol 32 2004
2. Glass et al. American Journal of Critical Care, Vol 8, March 1999
3. Boque et al. Intensive Care Med, No 30 2004
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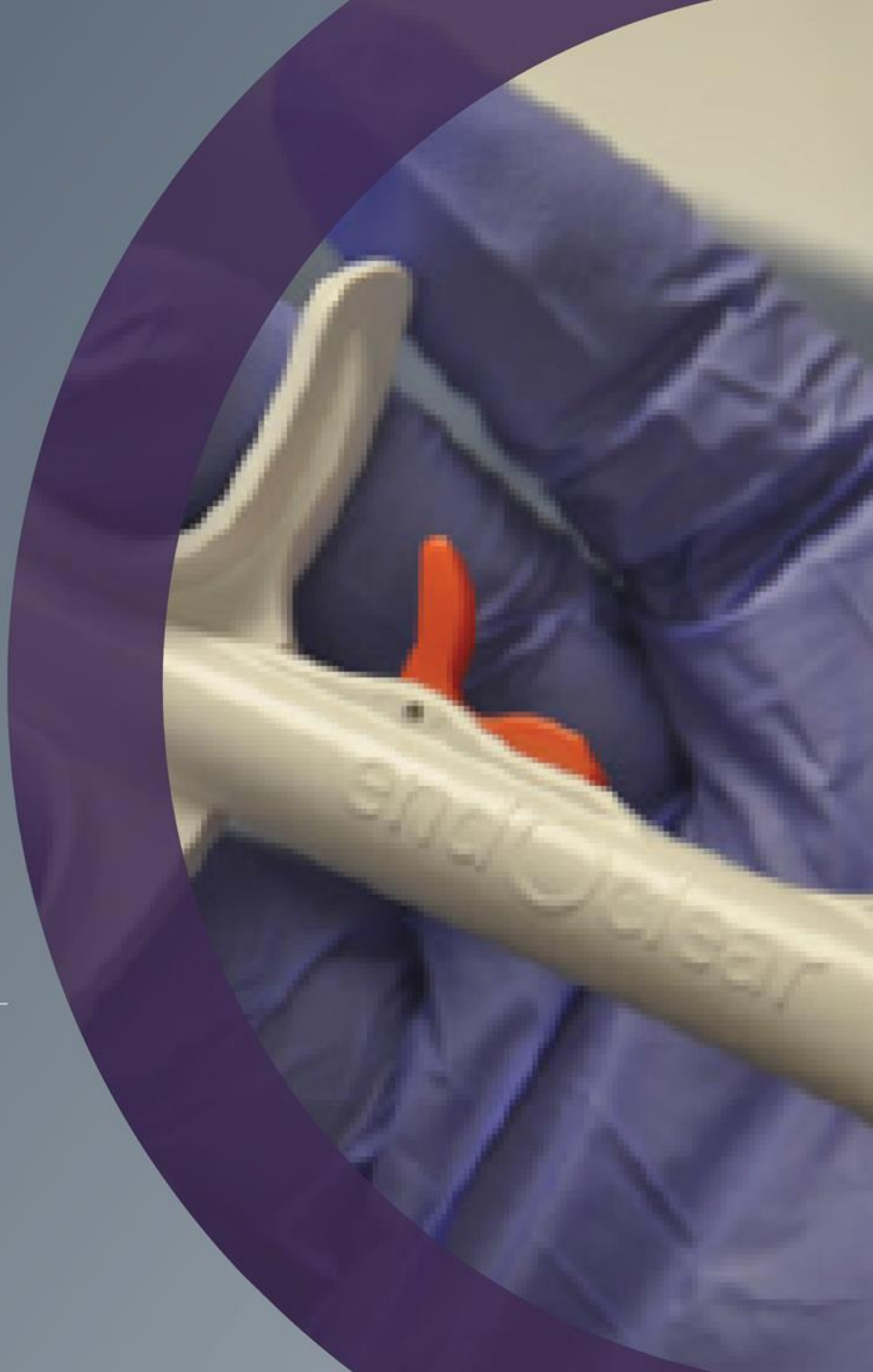
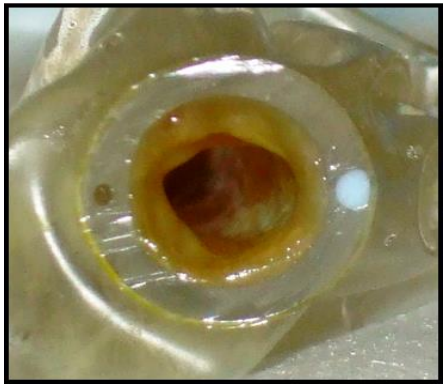
Alternatives to standard of care?

SThe standard of care does not effectively clean the endotracheal tube and the AARC guidelines recommend limiting it's use. Is this the best we can do? Is there an alternative?



Alternatives to standard of care?

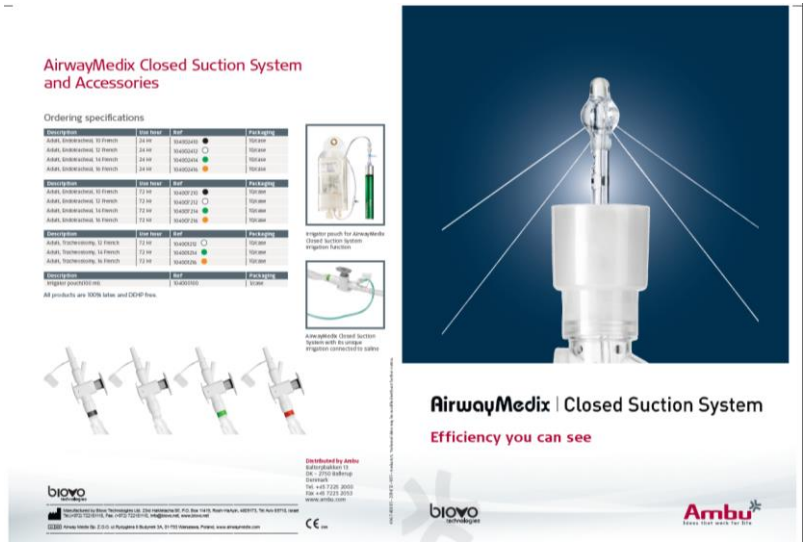
- Research and experience teaches that endotracheal tube biofilms, secretion build-up and narrowing occur in as many as 95% (Gil-Perotin[14]) to 100% (Danin[15]) of endotracheal tubes and is unpredictable in its progression (Wilson[13]).
- Biofilms, bacteria and fungus in the ETT repeatedly colonize the lung (Inglis[11]) and are associated with pneumonia (Wilson[13]).
- AARC guidelines promote a minimalist approach to suctioning to avoid complications.
- Are we then accepting that “this is the best we can do” in clearing endotracheal tubes?

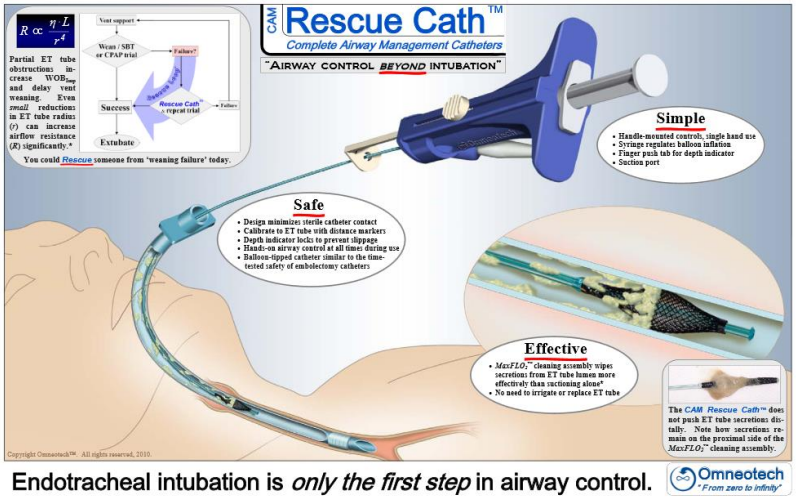


Alternatives to standard of care?

Complex patients, numerous variables!

Alternatives to standard of care?





Novel devices for cleaning endotracheal tubes:

- Mucus Shaver™ (not shown)
- endOclear®
- Biovo – Airwaymedix
- Rescue Cath®

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Conclusion - Summary

1. Biofilm, mucus, secretions and fungus represent an under-recognized cause of serious complications in mechanically ventilated patients and current standards of care (closed and open suction) do not adequately address biofilm, bacterial and fungal growth and intraluminal narrowing. The AARC recommends minimizing suction (confounding for trying to clear the ETT).
2. Biofilm, mucus, secretions and fungus are increasingly linked to prolonged length of ventilation, VAP, ICU and hospital stay.
3. The impact of endotracheal tube narrowing and subsequent clearing can have a profound impact on patient status.
4. Effective cleaning of the ETT has the potential to assist in improved outcomes when used in both a PRN and protocol fashion.
5. Alternatives may help us do better.

Contact: gsaur@endoclearllc.com

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