Roadmap to HAI & VAE: Neglecting Oral Care



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Disclosures

Jerry King

► I receive a stipend as speaking consultant for Avanos.

Objectives

- Discuss prevalence and consequences of hospital-associated infection (HAI) and ventilator-associated event (VAE)
- Describe how the mouths of critically ill patients undergo radical changes to become reservoirs of pathogens
- Identify the means by which poor oral care in the ICU can result in complications including pneumonia
- List recommended oral care interventions and associated evidencebased rationales



Healthcare-Associated Infections (HAI) Acute Care Through Hospital: USA

- Occur in ~ 7% of all patients in developed countries
- 4 most common HAI
 - Central Line-Associated
 Bloodstream Infection (CLABSI)
 - Catheter Associated Urinary Tract Infection (CAUTI)
 - Surgical Site Infection (SSI)
 - Ventilator Associated Pneumonia (VAP)



Central Line-Associated Bloodstream Infection (CLABSI)

▶ 46% decrease from 2008-2013

~30,000 occur per year

Cause death in 12-25% of cases

Catheter Associated Urinary Tract Infection (CAUTI)

Urinary catheters retain some urine in the bladder and provide a conduit for bacteria.

~12% of HAI's reported are CAUTI's

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Surgical Site Infections (SSI)

~2-5% of surgical patients develop an infection at the surgical site

Can be as high as 20% depending on procedure and surveillance criterial used

Ventilator Associated Pneumonia (VAP)

Occurs in 9-27% of patients on mechanically assisted ventilators

Personal opinion- variance in % is due to reporting criteria

86% of Nosocomial pneumonia is associated with ventilation

Hospital Acquired Infections (HAI)

Hospital- Acquired Pneumonia (HAP)	 HAP develops at least 48 hrs after admission (infection not present/incubating on admission) 22% of all Hospital Acquired Infections * NO GOLD STANDARD DEFINITION
Ventilator- Associated Pneumonia (VAP)	 VAP is a subset of HAP develops in patients on ventilator ≥ 48 hrs occurs in ~10% of all intubated patients *NO GOLD STANDARD DEFINITION

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Source: Kalil, Andrec C., et. al. Management of Adults with Hospital Acquired and Ventilator Associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of American and the American Thoracic Society [ATS]. Clinical Infectious Diseases 2016:63

VAP DEFINITIONS-

Early	 Occurs <5 days of hospitalization Carries better prognosis More likely caused by antibiotic sensitive bacteria
Onset	(Unless hospitalization & antibiotics within prior 90 days)
Late Onset	 Occurs >= 5 days of hospitalization More likely cause: MDR bacteria Associated with increased morbidity and mortality

Restrepo, Marcos I, et. al. Comparison of the Bacterial Etiology of Early-Onset and Late-Onset Ventilator-Associated Pneumonia in Subjects Enrolled in 2 Large Clinical Studies. Respirator Care. July 2013; 58(7): 1220-1225

Pneumonia Cost & Recovery

Lungs usually return to normal after HAP resolution

However

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- Can be at greater risk for pneumonia thereafter
- Lungs can be permanently damaged (necrotizing pneumonia) especially if Staphylococcus or Pseudomonas - scarring
- Bacteria may migrate to remote locations:

Heart valves

Trauma damaged areas: ex. CNS causing encephalitis or meningitis

Kalil, Andrec C., et. al. Management of Adults with Hospital Acquired and Ventilator Associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of American and the American Thoracic Society [ATS]. Clinical Infectious Diseases 2016:63.
 Chastre J 2002; Byers JF 2000

Pneumonia Cost & Recovery

- Increased VAE costs:
 - >\$40,000 per incident
 - Additional length of mechanical ventilation of 7.6-11.5
 - Additional total hospital LOS of 11.5-13.1



Kalil, Andrec C., et. al. Management of Adults with Hospital Acquired and Ventilator Associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of American and the American Thoracic Society [ATS]. Clinical Infectious Diseases 2016:63.

Chastre J 2002; Byers JF 2000

Etiology Nosocomial Pneumonia: (Early Onset)

Common gram negative pathogens:

- Hemophilus influenzae
- Methicillin-sensitive Staph Aur
- Escherichia coli
- ▶ Klebsiella pneumoniae
- Enterobacter

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Streptococcus pneumoniae





Etiology Nosocomial Pneumonia: (Late Onset)

- Staphylococcus aureus (ex. MRSA)
- Pesudomonas aeruginosa
- Acinetobacter



Kalanuria, Atul Ashok, et. al. Ventilator-associated pneumonia in the ICU. Critical Care. 2014; 18(2): 208



Initiating Nosocomial Pneumonia

Centers for disease control and prevention (CDC)
 Identifies 4 mechanisms to nosocomial pneumonia

1) Aspiration of oropharyngeal organisms

2) Inhalation of aerosols containing bacteria

3) Hematogenous spread from distant body sites/infections

4) Bacteria translocated from gastrointestinal site

- Mayhall emphasized: aspiration of organisms from the oropharynx is considered most important of these mechanisms (mayhall CG 1996)
- CDC: in 76% of VAP cases, bacteria colonizing the mouth before pneumonia is diagnosed are the same as those causing the pneumonia





Stick An Endotracheal Tube (ETT) In the Throat.....

- Cough reflex blocked
- Mucociliary clearance compromised
- Epiglottis is propped open by ETT
- Bacteria that enter through ETT during ventilator disconnects have direct lung access
- Biofilm within ETT can be scraped off and aspirated into lungs
- Bacteria from mouth accumulate in pooled fluid above ETT cuff

¹⁶ Source: Medical Illustration Copyright ©2006 Nucleus Medical Art, All rightsreseved.www.nucleusinc.com Diaconu, Olguta, et. al. Endotracheal Tube Biofilm and its Impact on the Pathogenesis of Ventilator-Associated Pneumonia. The Journal of Critical Care Medicine. Apr 2018; 4(2): 50-55



Endotracheal Tubes Cause:

- ► A. Ineffective cough reflex
- **B.** Mucociliary compromise
- C. Aspiration risk due to an open epiglottis
- ▶ D. All of the above
- **E.** None of the above

Endotracheal Tubes Cause:

▶ D. All of the above

Will Pathogens Get Past Your Patient's ETT Cuff?

Two ways to monitor adequate cuff pressure:

- 1) Pressure gauge to prevent:
 - Under inflation enabling leakage of bacteria
 - Over inflation which can injure tracheal tissues
- 2) Escaping CO₂: indicates leakage around cuff or through fold channels



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Under-Inflated Cuff

Source: Coffin SE 2008//Chastre J 2002//Marik PE 1999Cook D 1998//Mayhall CG 1996//Valles J 1995//du Moulin GC 1982 //Cameron JL 1973

Channeling

Leakage of pathogen-rich bacteria can also gain access to lower respiratory tract through cuff fold channels



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Risk Factors







Patient Risk Factors

- Depressed consciousness
- Underlying chronic lung disease (ex. COPD, ARDS, cystic fibrosis)
- Acute lung injury
- Older age
- Prolonged hospitalization before ventilator
- Duration of mechanical ventilatory support
- Smoker (slowed ciliary activity)
- Obesity
- Previous and prolonged intubation

Klompas, Michael, MD. Risk factors and prevention of hospital-acquired and ventilator-associated pneumonia in adults. UpToDate. July 2020.



Patient Risk Factors

- Immune compromised (steroids, chemotherapy, disease, genetics)
- Immobilization due to trauma or illness
- Chest or abdominal surgical procedures
- Aspiration
- Prior antibiotics resistant strain pathogens
- Multiple trauma
- Malnutrition

²³ Klompas, Michael, MD. Risk factors and prevention of hospital-acquired and ventilatorassociated pneumonia in adults. UpToDate. July 2020.



Mouth: is a major source of respiratory pathogens causing nosocomial pneumonia





Intubated patients are at risk of developing VAP/VAE due to?

► A. Laying still for long periods of time

▶ B. Oral secretions aspirated into the lungs

C. Inspired air from the ventilator

D. Inadequate PEEP levels

Intubated patients are at risk of developing VAP/VAE due to?

B. Oral secretions aspirated into the lungs

The ICU from the mouth's point of view



Normal Mouth Ecology

Normal bacteria almost all gram positive

- Oral bacteria are usually "normal flora" greater than 350 different species, but most prominent are:
 - Teeth: streptococcus mutans, S.Sanguis, actinomyces vicosus, bacteroides gingivalis
 - Buccal/tooth surfaces: S. Mitis
 - Dorsal tongue: S.Salivarius, various anaerobes

Yet, none of these bacteria cause pneumonia! So how can the mouth be a major source of pneumonia pathogens?



Normal Mouth Ecology

Protective umbrella

Fibronectin:

- "Umbrella" of glycoprotein in normal saliva distributed over the surface cells of the oropharynx
- Helps retain tissue moisture
- Major role in wound healing
- Helps prevent colonization of oral cavity and pharynx with potentially pathogenic bacteria by
 - Blocking pathogen-compatible receptor sites

Fibronectin distributed across tissues (blue)



cell migration - cell adhesion - matrix

tTG

fibronectin

integrin

assembly

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Normal Mouth Ecology

Saliva

- Daily total: 0.5-1.5 liters
 - 0.3-0.4 ml/min at unstimulated
 - 4-5 ml/min at stimulation (i.e. chewing)
 - 0.1 ml/min at sleep

FUNCTION

- Remineralization of teeth
- Restoration of soft tissue
- Lubrication capacity
- Digestion
- Antimicrobial capacity
- 30 Source: lorgulescu, Gabriela. Saliva between normal and pathological. Important factors in determining systemic and oral health. Journal of Medicine and Life. Sep, 2009; 2(3): 303-307.



Critically Ill Mouth Ecology

- Fibronectin depleted within 48 hours
- Dental plaque develops on teeth within 72 hours
- Saliva production decreased
- External stresses increase drying of oral mucosa
- Oral bacteria increases creating increased biofilm

Gupta, A, et. al. Role of oral care to prevent VAP in mechanically ventilated Intensive Care Unit patients. Saudi Journal of Anaesthesia. Jan-Mar 2016; 10(1): 95-97

So what's been happening inside the mouth?

Biofilm Initiation

- 1) Brushed teeth
- 2) Immediately teeth recoated by salivary pellicle and acts as an adhesive
- 3) Bacterial Biofilm begins to form
 - Multiply
 - Form micro-colonies
- 4) Early colonizers
 - Streptococcus (60-90%)



Cate JM (September 2006). "Biofilms, a new approach to the microbiology of dental plaque". *Odontology*. **94**(1): 1-9.

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Biofilm: Plaque

- 5) Beyond 2 hrs: Biofilm thickens
 - Bacteria are reproducing
 - ▶ New bacteria attracted in: gram (+) & (-)
 - More slimy matrix produced
 - 4 72h: respiratory pathogens colonize biofilm of intubated patients in ICU
- 7) 48 hours: Mature plaque
 - ~300 layers of bacteria-mixed species
 - Complex organized community with different locations performing unique interlinked tasks

³⁴ Source: Cate JM (September 2006). "Biofilms, a new approach to the microbiology of dental plaque". *Odontology*. **94**(1): 1-9.



Plaque to Calculus

- 8) Calculus is hardened plaque
- 9) Mature biofilms actively release pioneer bacteria to form new colonies

10) Mature biofilm residents communicate: even between bacterial species!!

Velsko, Irina, et al. Microbial differences between dental plaque and historic dental calculus are related to biofilm maturation stage. Microbiome, 2019; 7: 102



And Saliva Production Turns Off!

ICU patient rapidly loses saliva associated:

- Anti-bacterial, anti- fungal and anti-viral agents
- Moisturizing, function
- Anti-inflammatory components
- Dry mouth termed xerostomia
- Saliva diminishes even faster if:
 - Stress
 - Fever
 - Diarrhea
 - Reduced fluids intake
 - Medication side effects
 - ETT inserted; mouth propped open





Diminishing Saliva

Mounting pathogens not confronted by salivary antibacterial agents

- Rapidly enter biofilm communities
- Pathogens within any biofilm matrix more often antibiotic resistant
- Pathogens like *pseudomonas* extremely aggressive
 - Take over biofilm communities
 - Form expansive slimy matrixes

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Pathogens attack dried gums, amplify gingivitis, infect oral lesions

Biofilm takeover by Pseudomonas aeruginosa







Poor or Delayed Oral Care

- If the intubated and/or critically ill patient does not receive effective oral hygiene, then bacterial plaque structures form heavily within 72 hours (Berry AM 2006)
- Oral colonization by respiratory pathogens, fostered by poor oral hygiene & periodontal diseases, associated with nosocomial pneumonia (Scannapieco FA 2003)
- Higher dental plaque scores confer greater risk for ventilatorassociated pneumonia, particularly for patients with greater severity of illness (Munro CL 2006)
- Dental plaque colonization highly predictive of concurrent or subsequent nosocomial infection with same bacteria (Fourrier F 1998)
- Oral surfaces, especially dental plaque, could be major
 reservoir of infection by respiratory pathogens in ICU (Scannapieco F 2006)



Mucositis/Oral Lesions

- Also as saliva diminishes
 - Oral mucous membranes dry out
 - Anti-inflammatory agents gone
 - Oral lesions increase: mucositis
- Additional risk factors for mucositis:
 - Chemotherapy
 - Physical trauma
 - Poor oral hygiene
- Pathogens spread in newly weakened area





Lips

Lips lose moisture

- Drying hastened by the same co-morbidities, fevers, medications and dehydration that increase xerostomia and mucositis
- Dried, chapped lips: colonized, biofilm, infection, become pathogen reservoirs
- Flaccid face-muscles, lips droop, mouth corners crack (perleche or cheilosis)





Minimize The Risks



Aspirated bacteria forming biofilm in alveoli

Evidence-Based Strategies for VAP Elimination

Component	CDC	APIC	IHI	AACN
Head of bed elevation (Semi-recumbent 30°-45 °)		✓	\checkmark	✓
Daily "sedation vacation" /readiness to extubate		\checkmark	✓	
Peptic ulcer disease (PUD) prophylaxis	✓	\checkmark	\checkmark	
Reliable, comprehensive oral hygiene program		 Image: A second s	 Image: A second s	~
Cleaning of equipment		\checkmark		
Avoid routinely replacing ventilator circuits		\checkmark		✓
Hand hygiene	✓	✓		
Subglottic secretion drainage – continuous or intermittent	✓	✓		✓
Prevention of oropharyngeal colonization	✓	\checkmark		

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Source: IHI Getting Started Kit: VAP How-to Guide; CDC Guideline for Preventing Healthcare-Associated Pneumonia, 2002.

Ways to minimize VAE/VAP include?

- ► A. Appropriate oral care
- **B.** Subglottic suction drainage
- C. Sedation vacations
- ▶ D. All of the above
- E. None of the above

Ways to minimize VAE/VAP include?

▶ D. All of the above

Oral Care for Patients at Risk for VAP AACN Practice Alert 2018

Develop and implement a comprehensive oral hygiene program for patients in who are at high risk for VAP

- Brush teeth, gums & tongue at least twice a day using a soft toothbrush
- Provide moisturizer to oral mucosa and lips every 2 to 4 hours
- Use a 0.12% oral chlorhexidine gluconate (CHG) rinse twice a day during perioperative period for adult patients who undergo cardiac surgery - also recommended by CDC

[Professional standards based on clinical studies]

Routine use of oral CHG in other populations is unresolved at this time (Institute for Healthcare Improvement (IHI): add CHG rinse to VAE bundles)

https://aacnjournals.org/ccnonline/article-abstract/38/6/80/20842/Oral-Care-for-Acutely-and-Critically-Ill-Patients?redirectedFrom=fulltext

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Appropriate Oral Care

Intervention starts with preparation

- Staff education in comprehensive oral care and WHY
- Written oral care protocol
- Conduct an initial admission assessment of the patient's oral health and self-care deficits soon after admission
- Monitor and adjust assessment and interventions as patient's condition indicates



Patient:	Example Oral Assessment Score (OAS) and Description						
Date:	Normal no changes 1	Mild to moderate change 2	Moderate to severe change 3	Score			
Lips	 smooth & pink 	 dry or cracked 	 ulcerated or bleeding 				
Mucous membranes	• pink & moist	 redness or blue-red white or patchy white blisters no ulceration minimal debris 	 very red or thick white coating ulceration bleeding moderate to large amount of debris 				
Tongue	 pink & moist papillae distinct 	 coated or loss of papillae shiny appearance with or without redness 	 blistered or cracked 				
Gingiva (gums)	• pink & firm	 swelling redness white coating/no ulceration 	 bleed easily and/or thick whitish coating 				
Teeth	 clean no debris	 plaque or debris in localized areas 	 generalized plaque or debris 				
Saliva	• watery	thick or ropey	absent				
Modified from: Eilers 1988 Score Total							

Setting It Up

Set determinants based on patient's condition

Example: Score each category with a 1, 2 or 3 & total

- Score of 6 indicates a healthy oral cavity
- Score of 18 indicates severe mucositis: warranting treatment, start intervention

Interventions

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- Use a small, soft toothbrush
- Use toothpaste with additives to help break down mucus and biofilm matrix (dental plaque)
- Brush teeth, tongue and gums at least twice daily
- Foam swabs or gauze should not be used for plaque removal, as they are not effective tools for this task





Tongue: Often Overlooked Hide-out

- Back of tongue heavily colonized crevices between papillae
- Enmeshed in biofilm mixed with debris, bacteria metabolic wastes, dead cells and thick-waxy secretions
- ▶ Highest number of anaerobic bacteria in the mouth
- Tongue becomes a reservoir of respiratory pathogens in the ICU (Sumi Y 2006)



Keep Moist; But Don't Leave Free Fluids

Interventions

- Use a water-soluble moisturizer to help maintain healthy gums and oral tissues at least once every two hours
- Avoid using lemon-glycerin swabs for oral care to moisten oral mucosa as it is acidic: dries mucous tissues
- Lubricate lips with lip balm routinely
- Perform oral suction frequently

Oral Suction is a Critical Task

Purpose: prevent fluids from draining to pool above cuff reducing risk of pathogen contaminated fluid leaking past cuff

Suction

- As brushing teeth and applying rinse
- Before moving patient
- Before any manipulation of ETT
- Before airway clearance suctioning
- After use, keep clean suction catheter covered
 - Place suction device in provided holder
 - Position protective sheath appropriately
 - Make certain patient's ventilator circuit remains closed



Study of Oral Suction Yankauers

47 observations. Storage area:

- 66% placed on shelf near patient's bedside
- > 21% attached to connection suction tubing & hanging freely

"In-line suction catheter was not connected to any suction and the distal end was open disrupting the "closed system"

- 13% located in the patient's bed
- 51% of the time the device was uncovered
- None were placed on paper towel



Recommended Oral Care

Interventions

- Continue daily assessments/adjust care
- Keep head of bed elevated at least 30°
 - Position patient so oral secretions pool into buccal pocket; especially important during feeding, brushing teeth, etc.
 - Oral suction before tracheal suctioning, prior to repositioning or patient transporting, when performing fluid associated oral hygiene (ex. Tooth brushing; antiseptic application)
- Use an oral antiseptic rinse
- Monitor compliance
- Track VAE rate and post for staff

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Oral Antiseptics

Existing antiseptic mouth rinses

- Chlorhexidine gluconate (CHG)
- Hydrogen peroxide
- Triclosan
- Cetylpyridinium chloride (CPC)
- Polyhexamethylene biguanide (PHMP)
- Iodine
- Methyl silicate
- Thymol
- Natural oil derivatives:
 - Eucalyptol
 - Menthol
 - Tea tree oil
- 54 🕨 🕨 Orange oil



Oral antiseptics do not negate the need for the toothbrush!

Oral Antiseptic Studies

- Some studies showed decreased VAE. DeRiso 1996:
- DeRiso 1996: CHG rinse perioperatively reduced VAE in cardiac surgery patients now recommended for that indication by:

► CDC

- IHI (Institute of Healthcare Improvement)
- ATS (American Thoracic Society)
- ► AANC
- Other studies have presented mixed results with other ICU patient populations: some with VAE reduction and others without reduction
- No matter what antiseptic study you are reviewing or participating in - important to learn from errors and poor study designs



Oral Antiseptic Poor Studies

Many rinse studies on VAE reduction often clouded:

Underpowered



- Subjects infected at study admission (bronchitis, pneumonia, sinusitis)
- Failure to exclude test subjects for recent, prior antibiotic use
- Failure to equally utilize tooth brushing during study
- Failure to standardize recommended VAE prevention measures
- Failure to equalize and/or record length of ventilation time
- Mixing co-morbidities unevenly in test groups
- Failure to score severity of periodontal disease on admission or account for in analysis
- Failure to completely describe oral care details & compliance

After all that work!!

Assessing Antiseptics

- Effective antiseptic rinse as part of overall oral care makes sense
- An effective rinse kills a broad range of bacteria:
 - Gram positive
 - ► Gram negative
 - Aerobic
 - ► Anaerobic
- It would be able to kill bacteria
 - Within established biofilms of dental plaque
 - In the gingival crevices
 - In periodontal pockets
 - On oropharyngeal mucosal surfaces
 - In oral lesions

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In anaerobic biofilm-rich debris, between papillae on tongue surface



Assessing Antiseptics: An Effective Rinse

Would



- Have persistence (continues to kill hours after application)
- Not be inactivated by moisturizers, toothpaste, other oral care products Would prevent
 - Plaque formation by killing the bacteria that create biofilms
 - Gingivitis by killing bacteria whose growing presence, wastes and toxins can inflame gingival crevice, cause bleeding, bloodstream
 - Reduce total oral bacteria, reducing potential for lung contamination
 - Periodontal disease, most important for long-term care patients and those patients with already advanced gingivitis

Assessing Antiseptics A Good Rinse

Would **not** cause:

- excessively dry oral mucosa
- sores with repeated use
- unacceptable contraindications for target patients (age, co-morbidities, pregnancy, etc.)
- allergic reactions beyond anticipated per ingredient list
- irreversible staining



Reducing Oral Bacteria; Is VAE Reduced?

Background

- All ventilator patients Jan-Dec 2002:
 - Standard oral care
 - Yankauer suction and glycerin swabs
- All ventilator patients Jan-Dec 2003:
 Comprehensive oral care including
 - Daily oral assessment
 - Tooth brushing
 - Oral and orotracheal suctioning
 - Hydrogen peroxide rinse
 - Oral mucosa moisturizer
 - Covered yankauers



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Does Reduction in Oral Bacteria and Dental Plaque Reduce VAE?

Results

Rate of VAE was reduced 42.1% in the intervention group

Conclusion

Careful assessment, then excellent oral care prevents build-up of pathogens awaiting access to lungs & thereby reducing VAE



Source: Garcia R. APIC 2004 Abstract.

Quality of Education Impacts Patients

Background: VAE rates NOT significantly decreased when:

- Evidence-based oral care protocol written & posted
- Available best practice oral care tools available
- Nurses provided oral care

Intervention: evidence-based practice (EBP) education:

- Why & how oral care makes a difference
- Provide studies to solidify it really works

Results: following EBP education:

- Improved oral care quality
- Oral care documentation
- ► VAE rates decreased 50%

Conclusion: EBP education focused on patient outcome, rather than a task to be performed, improved oral care & reduced VAE

Source: Ross A. J Intensive and Critical Care Nursing 2007;23:132-136



"Findings add to growing body of evidence implicating poor oral hygiene as an important risk factor in the development of VAE in critically ill patients and should serve to refocus our attention on the teeth and oropharynx as a reservoir for bacterial pathogens in transit to the lungs." Fourier F, 2005



Source: Fourrier F. Crit Care Med 2005;33:1728-1735

Tools in the toolbox

No one tool in the care and treatment of intubated patients has shown a consistent reduction in the prevention/minimization of VAE/VAP.

However, when bundled together, the more tools we successfully utilize, the better outcomes for our patients.



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Thank You!