

What all IPC staff should know about practices for preventing VAP

Nikolaos Spervovasilis BSc, MD, MPH, PhD
Internist – Infectious Diseases Specialist
nikspe@hotmail.com

Conflict of Interest: None



Presentation Outline

- ❖ Burden and risk factors for VAP
- ❖ Pathogenesis of VAP
- ❖ The 3 components of the pathway for preventing VAP
- ❖ VAP prevention strategies

Motivation to prevent VAP

- Within ICUs, VAP is the most frequent nosocomial infection, impacting 20–36% of critically ill patients
- Incidence rates vary, ranging from 2 to 16 episodes per 1000 ventilator days, and are influenced by factors such as diagnostic criteria, preventative measures, and patient and geographical variations
- Reported mortality rates for VAP span a wide range (24–76%); however, attributing mortality solely to VAP is complex due to the severity of underlying illnesses and diagnostic heterogeneity within ICU populations
- **VAP increases hospital length of stay by an average of 4-9 days and healthcare costs by £9000 per patient**

Risk factors for VAP

Table 1: Risk factors for ventilator associated pneumonia

Host factors	Intervention factors	Other factors
Age \geq 60 yr	Duration of MV	Season: fall, winter
Severity of illness	Reintubation	
Organ failure	PEEP	
Poor nutritional state or hypoalbuminemia	Frequent ventilator circuit changes	
Upper abdominal or thoracic surgery	Nasogastric tube	
ARDS	Intracranial pressure monitoring	
Chronic lung disease	Paralytic agents, sedation	
Neuromuscular disease	H ₂ blockers \pm antacids	
Trauma, burns	>4 units of blood products	
Coma, depressed level of consciousness	Supine head position	
Large-volume aspiration	Transport out of the ICU	
Upper respiratory tract colonization		
Gastric colonization and pH		
Sinusitis		

VAP pathophysiology

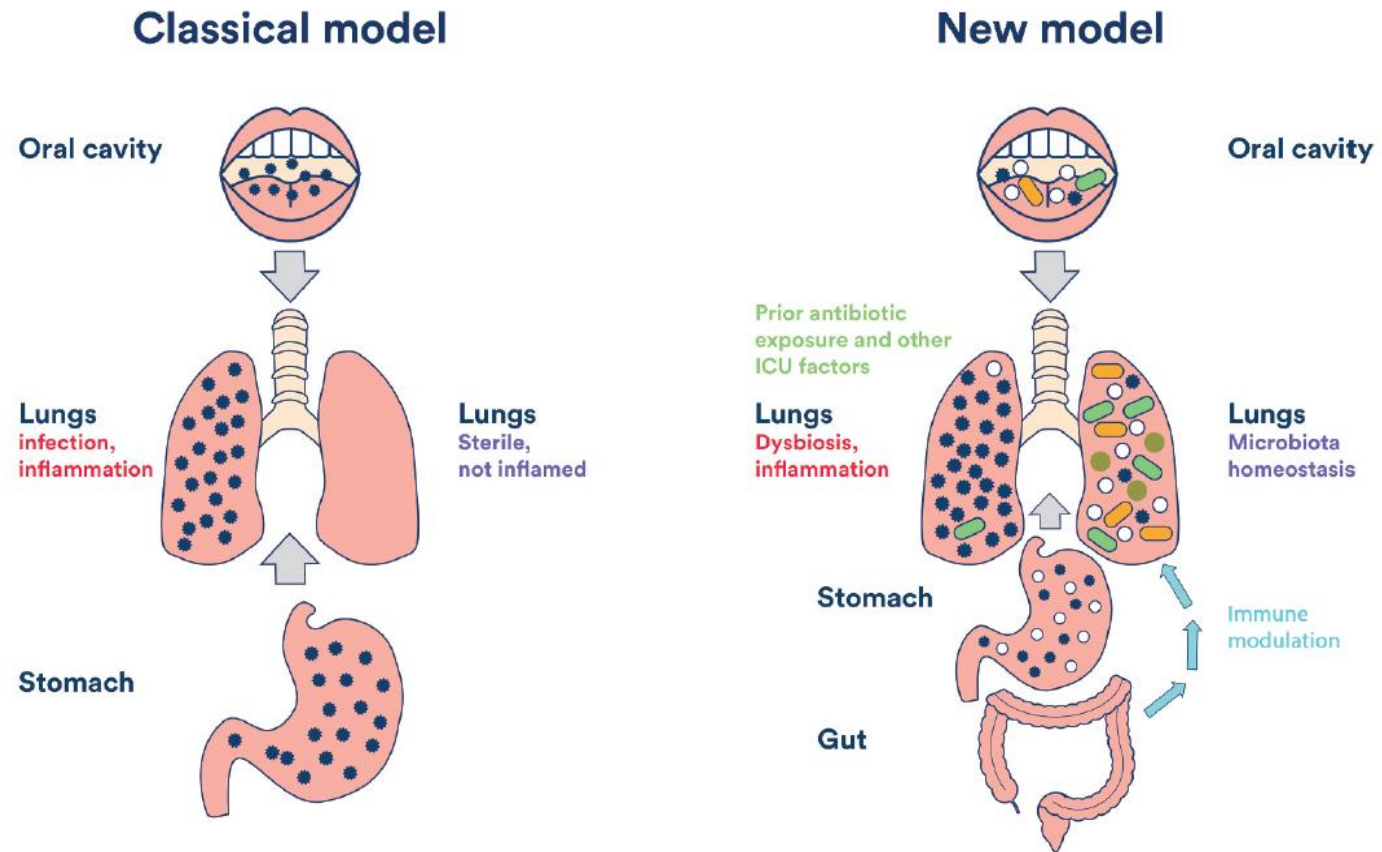


Figure 3. Classical vs new model of VAP. In the classical model (left side), infection is shown by the presence of pathogenic bacteria (black) inside the lung, leading to inflammation. In the new model (right side), infection is linked to the concept of dysbiosis in the lung represented as lack of diversity and proliferation of pathogenic bacteria (black) inside the lung. In this new model, dysbiosis occurrence is linked to gut-regulated immunomodulation and ICU factors such as mechanical ventilation time, length of stay, steroid use, adequate antibiotic prophylaxis and adherence to infection prevention measures.

VAP pathophysiology

Classical mechanisms

Endogenous sources of micro-organism

(1) Impaired natural protection/clearance system allows increased colonization of nasopharynx

(2) Colonized oropharynx and gastric fluid pool along tube in neonates

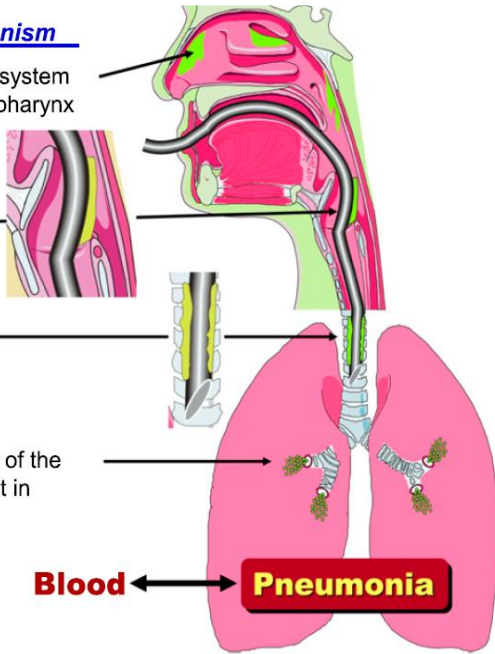
(3) Colonized tracheal secretions

Mechanism for pneumonia

(1) Aspiration of colonized fluids from any of the above sources into the lungs can result in pneumonia

(2) A hematogenous source seeding the lungs may rarely cause pneumonia

Blood ↔ **Pneumonia**



Exogenous sources of micro-organism

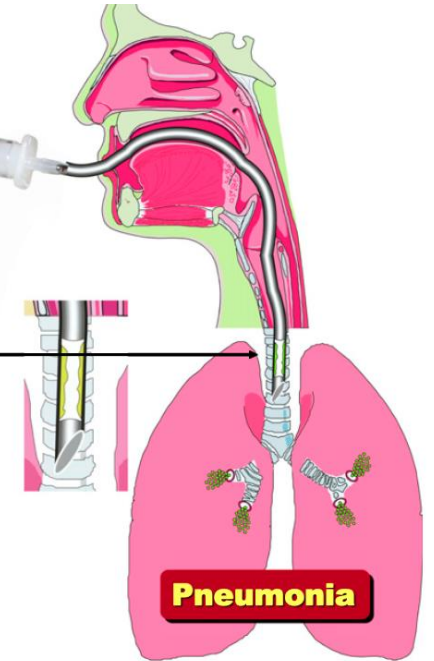
(1) Hands of health-care worker

(2) Ventilator circuit

(3) Biofilm of endotracheal tube

Mechanism for pneumonia

Pneumonia occurs when colonized secretions are inhaled into the lungs through the endotracheal tube



- Via **microaspiration** of secretions containing bacteria, either from the oral cavity and then into the lungs, or by reflux from the stomach into the oral cavity and then into the lungs, in a process called transcolonization
- By **continuity**, due to the formation of biofilm in the ET or TT
- **Directly** through the artificial airway, without previous colonization, due to the use of an incorrect aseptic technique during the intubation procedure or aspiration of secretions, and/or aerosolization by contamination of ventilation devices (gas blenders, flow regulators, etc.)
- Via **hematogenous** route through dissemination of bacteria to the lower respiratory tract from distant sites of local infection

VAP pathophysiology

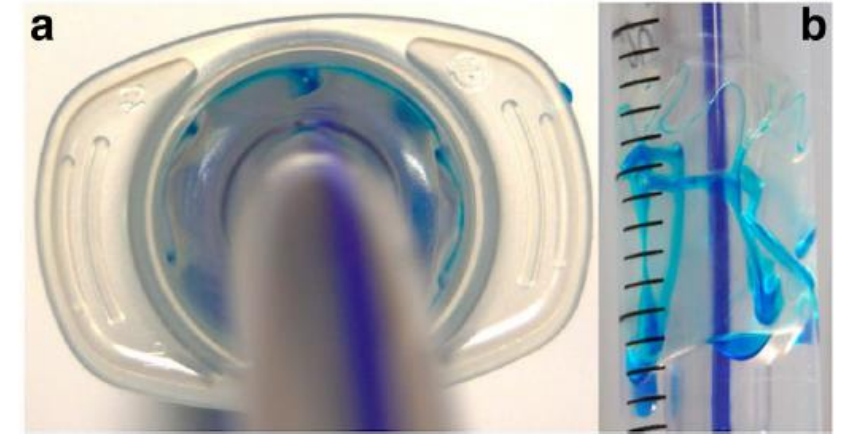
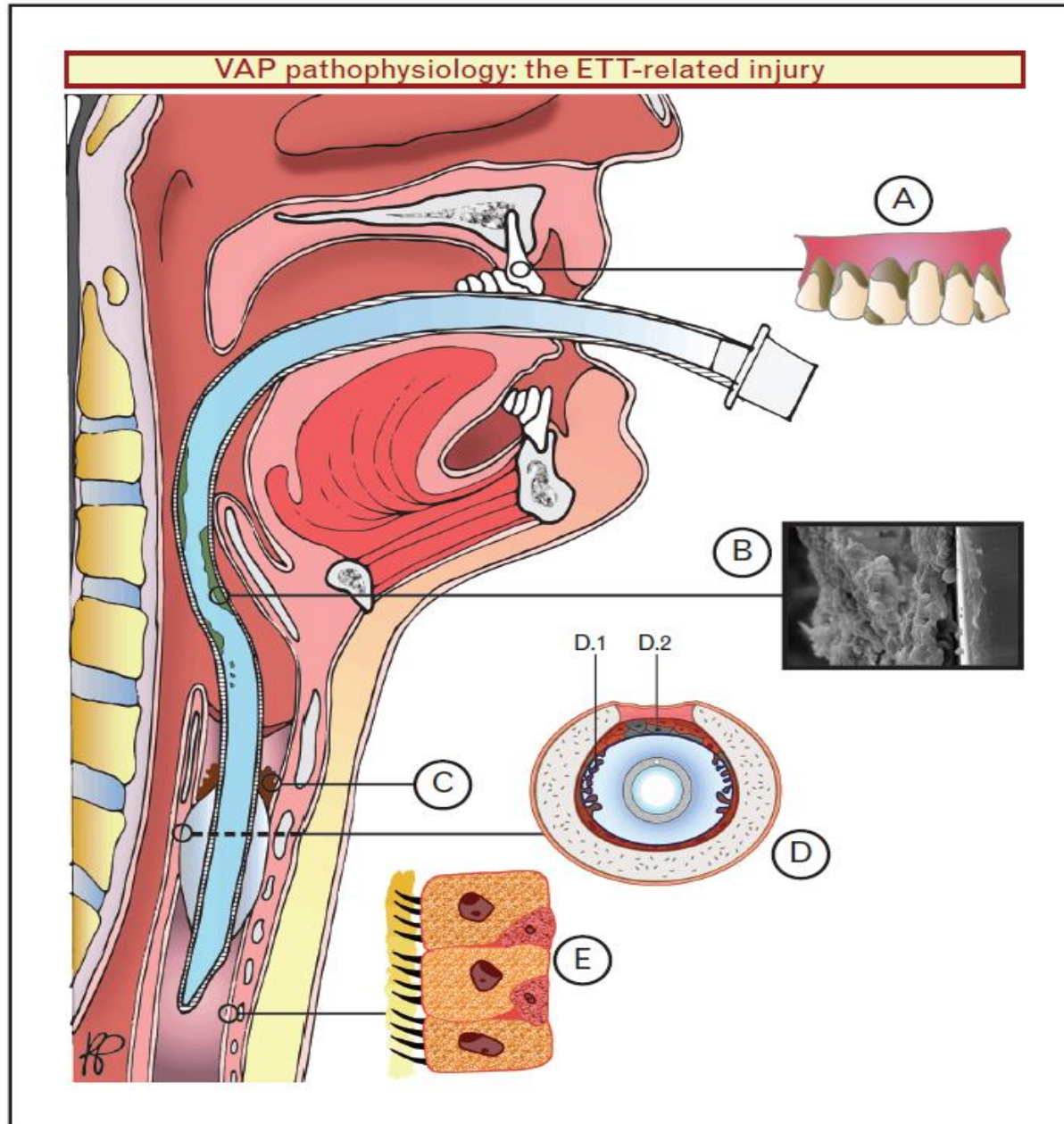


Fig. 1 A high-volume-low-pressure cuff inflated to 30 cmH₂O inside a 2.0 cm 'trachea'. The blue dye is placed above the inflated cuff to demonstrate aspiration of fluid past the cuff. Despite inflating the ETT cuff to the correct tracheal wall pressure, it is only partially inflated with excess material folding and causing involutions. The blue dye highlights the formation of channels, which allow leakage of subglottic fluid into the lungs overhead view (a) and a lateral view (b)

Prevention of VAP








Recommendations for VAP prevention

Infection Control & Hospital Epidemiology (2022), 43, 687–713
doi:10.1017/ice.2022.88



SHEA/IDSA/APIC Practice Recommendation

Strategies to prevent ventilator-associated pneumonia, ventilator-associated events, and nonventilator hospital-acquired pneumonia in acute-care hospitals: 2022 Update

Michael Klompas MD, MPH^{1,2} , Richard Branson MSc, RRT³ , Kelly Cawcutt MD, MS⁴ , Matthew Crist MD⁵ , Eric C. Eichenwald MD^{6,7}, Linda R. Greene RN, MPS, CIC⁸, Grace Lee MD⁹, Lisa L. Maragakis MD, MPH¹⁰, Krista Powell MD, MPH⁵ , Gregory P. Priebe MD¹¹ , Kathleen Speck MPH¹², Deborah S. Yokoe MD, MPH¹³ and Sean M. Berenholtz MD, MHS^{12,14,15}

- Provide practical recommendations to assist acute care hospitals to prioritize and implement strategies to prevent VAP in adults, children and neonates



Contents lists available at [ScienceDirect](#)

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid



ISID Guideline

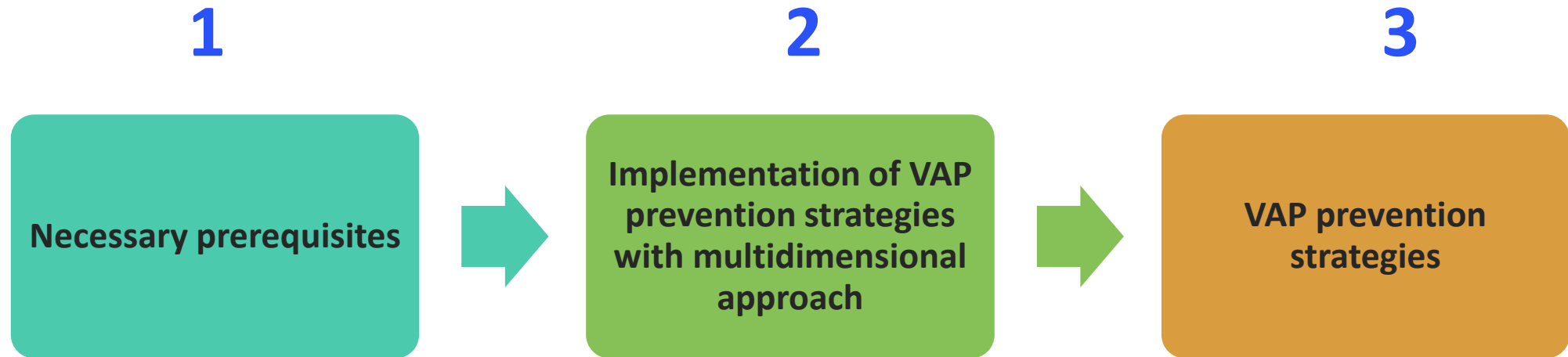
Preventing ventilator-associated pneumonia: A position paper of the International Society for Infectious Diseases, 2024 update



Victor Daniel Rosenthal^{1,2,3,*}, Ziad A. Memish^{3,4}, Gonzalo Bearman^{3,5}

- Provide recommendations on prevention of hospital-acquired VAP in adults, while addressing risk factors in high-income and low- to middle-income countries

Suggested pathway for preventing VAP



1. Necessary prerequisites

Assets for delivering suitable education and training

- regular workshops, hands-on simulations, and competency assessments to maintain adherence to guidelines
- the content should be tailored to the facility's patient population and local antimicrobial resistance patterns

A sufficiently staffed infection prevention program

- responsible for identifying patients who meet the surveillance definition for VAP
- conducting audits, reviewing clinical data, and ensuring accurate VAP case reporting

Information technology support

- IT departments help to streamline data collection and ensure precise tracking of cases and MV-days
- IT systems enables efficient and accurate computation, facilitating real-time monitoring of VAP rates and allowing for timely interventions and adjustments in infection control strategies

Effective laboratory support

- crucial for the timely processing of specimens and reporting results

Providing epidemiological bulletins to doctors

- essential for effective empirical therapy
- access to localized infection data, such as VAP incidence and antimicrobial resistance patterns, enables doctors to make informed decisions, tailor treatments, and improve patient outcomes

2. Implementation of VAP prevention strategies - Multidimensional approach

Bundles

- simple sets of evidence-based practices that, when implemented collectively, improve the reliability of their delivery and enhance patient outcomes

Education

- HCPs involved in managing MV patients should receive training and demonstrate competence according to their roles

Surveillance

- uniform surveillance methods and definitions are needed, to facilitate the comparison of data with benchmark standards

Internal reporting of VAP rates

- to bolster internal hospital quality improvement initiatives, emphasizing the importance of communicating them to senior leadership and clinicians

Compliance

- monitoring compliance with recommendations to prevent VAP (checklists, assigning knowledgeable HCPs to oversee this task)

Performance feedback

- charts displaying data on attending HCPs' monthly compliance with infection prevention practices

Impact of evidence-based bundles on preventing VAP



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Journal of Intensive Medicine

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IN DEVELOPING COUNTRIES

Original Article

Impact of evidence-based bundles on ventilator-associated pneumonia prevention: A systematic review

Maria Dagmar Da Rocha Gaspar^{1,2}, Elaine Cristina Antunes Rinaldi¹, Rosiane Guetter Mello³, Fábio André Dos Santos⁴, Jessica Mendes Nadal², Luciane Patricia Andreane Cabral¹, Paulo Vitor Farago²

Meta-Analysis

Prevention of ventilator-associated pneumonia through care bundles: A systematic review and meta-analysis



Raquel Martinez-Reviejo¹, Sofia Tejada^{1,2}, Miia Jansson^{3,4}, Alfonsina Ruiz-Spinelli^{5,11}, Sergio Ramirez-Estrada⁶, Duygu Ege⁷, Tarsila Vieceli⁸, Bert Maertens⁹, Stijn Blot⁹, Jordi Rello^{1,2,10,11,*}

- A meta-analysis on the effectiveness of ventilator care bundles in preventing VAP - 36 studies were included
- Implementing care bundles significantly reduced the number of VAP episodes. The most utilized components of the ventilator bundle were head-of-bed elevation and oral care

- A systematic review to examine the impact of evidence-based bundles on preventing VAP in adult and elderly populations – 18 studies were included
- Key bundle components: daily evaluation of sedation interruption, assessment for extubation readiness, head-of-bed elevation at 30°, cuff pressure monitoring, prophylaxis for coagulation disorders, and oral hygiene. Head-of-bed elevation at 30° was universally reported in all studies
- Implementing bundle items was associated with a reduction in VAP incidence

J Intensive Med. 2023;3(4):352-364

J Infect Dev Ctries. 2023;17(2):194-201







3. VAP prevention strategies



SHEA/IDSA/APIC Practice Recommendation

3. VAP prevention strategies

Strategies to prevent ventilator-associated pneumonia, ventilator-associated events, and nonventilator hospital-acquired pneumonia in acute-care hospitals: 2022 Update

Michael Klompas MD, MPH^{1,2} , Richard Branson MSc, RRT³ , Kelly Cawcutt MD, MS⁴ , Matthew Crist MD⁵ , Eric C. Eichenwald MD^{6,7}, Linda R. Greene RN, MPS, CIC⁸, Grace Lee MD⁹, Lisa L. Maragakis MD, MPH¹⁰, Krista Powell MD, MPH⁵ , Gregory P. Priebe MD¹¹ , Kathleen Speck MPH¹², Deborah S. Yokoe MD, MPH¹³ and Sean M. Berenholtz MD, MHS^{12,14,15}

- ✓ **Essential practices:** improve objective outcomes or are outcome-neutral but cost saving
- ✓ **Additional approaches:** improve objective outcomes but carry some risk of harm, and also include interventions that lower VAP rates, but insufficient data exist to determine their impact on objective outcomes
- X **Not recommended interventions:** they do not improve VAP rates, and they have no impact or negative impact on objective outcomes
- ? **Interventions with no recommendation:** no impact on VAP rates or other patient outcomes, unclear impact on costs

VAP prevention strategies – Essential practices

Category	Rationale	Intervention	Quality of Evidence
Essential practices	Good evidence that the intervention decreases the average duration of mechanical ventilation, length of stay, mortality, and /or costs. Benefits likely outweigh risks.	Avoid intubation and prevent reintubation • Use high-flow nasal oxygen or noninvasive positive pressure ventilation (NIPPV) as appropriate whenever safe and feasible ^{91-93,96,99}	HIGH
		Minimize sedation ^{105,106} • Avoid benzodiazepines in favor of other agents ¹⁰⁶ • Use a protocol to minimize sedation ¹¹⁰ • Implement a ventilator liberation protocol ¹¹³	MODERATE
		Maintain and improve physical conditioning ^{113,120-123}	MODERATE
		Elevate the head of the bed to 30–45° ^{125,388-390}	LOW ^a
		Provide oral care with toothbrushing but <i>without</i> chlorhexidine ^{126,127}	MODERATE
		Provide early enteral vs. parenteral nutrition ¹³¹	HIGH
		Change the ventilator circuit only if visibly soiled or malfunctioning (or per manufacturers' instructions) ³⁹¹⁻³⁹⁴	HIGH
<i>Another essential practice proposed by ISID in 2024:</i>		Use continuous cuff pressure control	

Oral care with toothbrushing but without CHG



Cochrane Database of Systematic Reviews

Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia (Review)

Zhao T, Wu X, Zhang Q, Li C, Worthington HV, Hua F

- CHG, as part of OHC, probably reduces the incidence of VAP in critically ill patients from 26% to about 18%, when compared to placebo
- no difference in mortality, duration of MV or LOS in ICU, although the evidence was of low certainty
- OHC including both antiseptics and toothbrushing may be more effective than OHC with antiseptics alone

Cochrane Database Syst Rev. 2020;12(12):CD008367
Intensive Care Med. 2021;47(11):1295-1302

ORIGINAL



Effect of oral chlorhexidine de-adoption and implementation of an oral care bundle on mortality for mechanically ventilated patients in the intensive care unit (CHORAL): a multi-center stepped wedge cluster-randomized controlled trial

Craig M. Dale^{1,2,3}, Louise Rose^{4,5}, Sarah Carbone¹, Ruxandra Pinto⁶, Orla M. Smith^{1,7,8}, Lisa Burry^{5,9,10}, Eddy Fan^{5,11}, Andre Carlos Kajdacsy-Balla Amaral^{3,5,6}, Victoria A. McCredie^{5,11,12}, Damon C. Scales^{3,5,6} and Brian H. Cuthbertson^{3,5,6,13*}


Table 2 Adjusted primary and secondary trial outcomes

	Control, n (%)	Intervention, n (%)	Estimate ^a , (95% CI)	P value
ICU mortality group, N	1555	1691		
ICU mortality ^b	330 (21.2)	399 (23.5)	1.13 (0.82 to 1.54)	0.46
IVAC group, N	947	987		
IVACs ^b	24 (2.5)	48 (4.8)	1.06 (0.44 to 2.57)	0.90
BOAS group, N	154	182		
BOAS mean score (SD) ^c	11.24 (3.2)	10.47 (3.2)	-0.96 (1.75 to -0.17)	0.02
BOAS categorized				
No dysfunction (5)	8 (5.0)	6 (3.1)		
Mild dysfunction (6-10)	50 (32.5)	86 (47.2)		
Moderate dysfunction (11-15)	80 (51.9)	78 (42.8)		
Severe dysfunction (16-20)	16 (10.4)	12 (6.5)		
C POT group, N	154	184		
C POT mean score (SD)	2.32 (1.9)	2.27 (1.9)	1.62 (0.91 to 2.91)	0.10
C POT categorized ^c				
< 3	77 (50)	106 (57.6)		
≥ 3	77 (50)	78 (42.3)		
Time to extubation group (survivors), N	1061	994		
Time to extubation, median, days (IQR) ^b (SD)	2 (1-5)	2 (1-5)	1.03 (0.85 to 1.23)	0.79

BOAS Beck Oral Health Assessment Score, C POT Critical-Care Pain Observational Tool, ICU Intensive Care Unit, IQR interquartile range, IVAC infection-related ventilator-associated, SD standard deviation

Oral care with toothbrushing but without CHG

Selective digestive or oropharyngeal decontamination and topical oropharyngeal chlorhexidine for prevention of death in general intensive care: systematic review and network meta-analysis

 OPEN ACCESS

Richard Price *intensivist*¹, Graeme MacLennan *senior statistician*², John Glen *intensivist*³, on behalf of the SuDDICU collaboration

- Evaluation of SDD, SOD, and topical CHG on mortality in ICU patients
- SDD significantly reduced mortality, while SOD also showed a reduction in mortality
- CHG was linked to an increased risk of mortality

BMJ. 2014;348:g2197

Intensive Care Med. 2018;44(7):1017-1026

Intensive Care Med (2018) 44:1017–1026
<https://doi.org/10.1007/s00134-018-5171-3>

ORIGINAL

Effects of chlorhexidine gluconate oral care on hospital mortality: a hospital-wide, observational cohort study



Mieke Deschepper¹, Willem Waegeman², Kristof Eeckloo^{1,3}, Dirk Vogelaers^{4,5} and Stijn Blot^{5,6*} 

- A single-center cohort study investigated the impact of CHG oral care on mortality in a general hospitalized population - 82,274 adult patients, of which 11,133 (14%) received CHG
- Exposure to CHG was associated with an increased risk of death in all patients except those with extreme initial risk of death
- The increased risk of death was observed in patients who did not receive mechanical ventilation and were not admitted to ICUs

Use of continuous cuff pressure control

Effectiveness of Continuous Cuff Pressure Control in Preventing Ventilator-Associated Pneumonia: A Systematic Review and Meta-Analysis of Randomized Controlled Trials*

Maertens, Bert MD¹; Lin, Frances PhD²; Chen, Yingyan PhD²; Rello, Jordi PhD³; Lathyris, Dimitrios PhD⁴; Blot, Stijn PhD^{1,5}


[Author Information](#) 

Critical Care Medicine 50(10):p 1430-1439, October 2022. | DOI: 10.1097/CCM.0000000000005630

- 11 RCTs with 2092 intubated adult patients
- CCPC reduced the risk of VAP (OR 0.51) compared with standard methods
- secondary outcomes revealed no significant differences in mortality but a decrease in the duration of MV and ICU stay
- the evidence was “very low”

Original Research

Continuous Versus Intermittent Control Cuff Pressure for Preventing Ventilator-Associated Pneumonia: An Updated Meta-Analysis

Yanshuo Wu, MD¹, Yanan Li, MD¹, Meirong Sun, BS¹, Jingjing Bu, BS¹, Congcong Zhao, PhD¹, Zhenjie Hu, PhD¹, and Yanling Yin, MD¹ 

- 14 RCTs with 2080 patients
- CCCP significantly reduced VAP incidence compared to ICCP (RR = 0.52, 95% CI = 0.37-0.74, P < 0.001) despite considerable heterogeneity (I² = 71%)
- CCCP also decreased the duration of MV
- no significant differences in LOS or mortality

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VAP prevention strategies – Additional approaches

Additional approaches	Good evidence that the intervention improves outcomes in some populations, but may confer some risk in others.	Use selective oral or digestive decontamination in countries and ICUs with low prevalence of antibiotic-resistant organisms ^{128,134,135}	HIGH ^a
	May lower VAP rates but insufficient data to determine impact on duration of mechanical ventilation, length of stay, or mortality.	Utilize endotracheal tubes with subglottic secretion drainage ports for patients expected to require >48–72 hours of mechanical ventilation ³⁹⁵	MODERATE
		Consider early tracheostomy ¹⁴⁴	MODERATE
		Consider postpyloric rather than gastric feeding for patients with gastric intolerance or at high risk for aspiration ^{131,147}	MODERATE

VAP prevention strategies – Not recommended interventions or without recommendation

Generally not recommended	Inconsistently associated with lower VAP rates and no impact or negative impact on duration of mechanical ventilation, length of stay, or mortality.	Oral care with chlorhexidine ^{75,128-130,150}	MODERATE	
		Probiotics ¹⁵³⁻¹⁵⁶	MODERATE	
		Ultrathin polyurethane endotracheal tube cuffs ¹⁶⁵⁻¹⁶⁷	MODERATE	
		Tapered endotracheal tube cuffs ¹⁶⁹	MODERATE	
		Automated control of endotracheal tube cuff pressure ^{170,171,174,175}	MODERATE	
		Not addressed by ISID in 2024 ←	Frequent cuff-pressure monitoring ¹⁷⁶	MODERATE
			Silver-coated endotracheal tubes ¹⁷⁸	MODERATE
			Kinetic beds ¹⁸⁰	MODERATE
			Prone positioning ^{181,183,a}	MODERATE
			Chlorhexidine bathing ^{184-186,a}	MODERATE
No impact on VAP rates, average duration of mechanical ventilation, length of stay, or mortality. ^a		Stress-ulcer prophylaxis ^{190,191,193}	MODERATE	
		Monitoring residual gastric volumes ¹⁹⁴	MODERATE	
		Early parenteral nutrition ¹⁹⁵	MODERATE	
No recommendation	No impact on VAP rates or other patient outcomes, unclear impact on costs.	Closed endotracheal suctioning systems ¹⁹⁷⁻¹⁹⁹	MODERATE	

ISID 2024

Prevention of ventilator-associated pneumonia by noble metal coating of endotracheal tubes: a multi-center, randomized, double-blind study

Pierre Damas^{1*}, Caroline Legrain², Bernard Lambert¹, Nadia Dardenne³, Julien Guntz², Grâce Kisoka¹, Pierre Demaret², Anne-Françoise Rousseau¹, Laurent Jadot², Sonia Piret¹, Didier Noirot², Axelle Bertrand¹, Anne-Françoise Donneau³ and Benoît Misset¹



Studies in larger populations are needed

- Single-center study in an ICU in Romania
 - 180 patients; 97 in the intervention group (n = 97) and 83 in the control group
 - the incidence of VAP in the intervention and control groups was 27.83% and 43.16% (P = 0.03) and the VAP ratio per 1000 ventilation-days was 51.26/1000 and 83.38/1000 (P = 0.01), respectively
 - no statistically significant difference between groups in terms of mortality and duration of MV or hospital stay
- 9 ICUs in Belgium
 - 323 patients; 168 in the NMA-coated group and 155 in the control group
 - a delayed occurrence of VAP in the NMA-coated group (HR = 0.41, 95% CI = 0.19-0.88, P = 0.02)
 - the number of antibiotic days was 58.8% of the 1,928 ICU days in the NMA-coated group and 65.4% of the 1774 ICU days in the control group (p = 0.06)

In dark times, the weak suffer the most

Make Infectious Diseases Great Again!



Suggested practice for preventing VAP in under-resourced settings

J Crit Care 80 (2024) 154500



Assessing the impact of a multidimensional approach and an 8-component bundle in reducing incidences of ventilator-associated pneumonia across 35 countries in Latin America, Asia, the Middle East, and Eastern Europe



➤ included a multidimensional approach and an 8-component bundle in 374 ICUs across 35 LMICs from Latin-America, Asia, Eastern-Europe, and the Middle-East, to reduce VAP rates

VAP rate, incidence rate ratio of VAP, and mortality comparing baseline with intervention periods

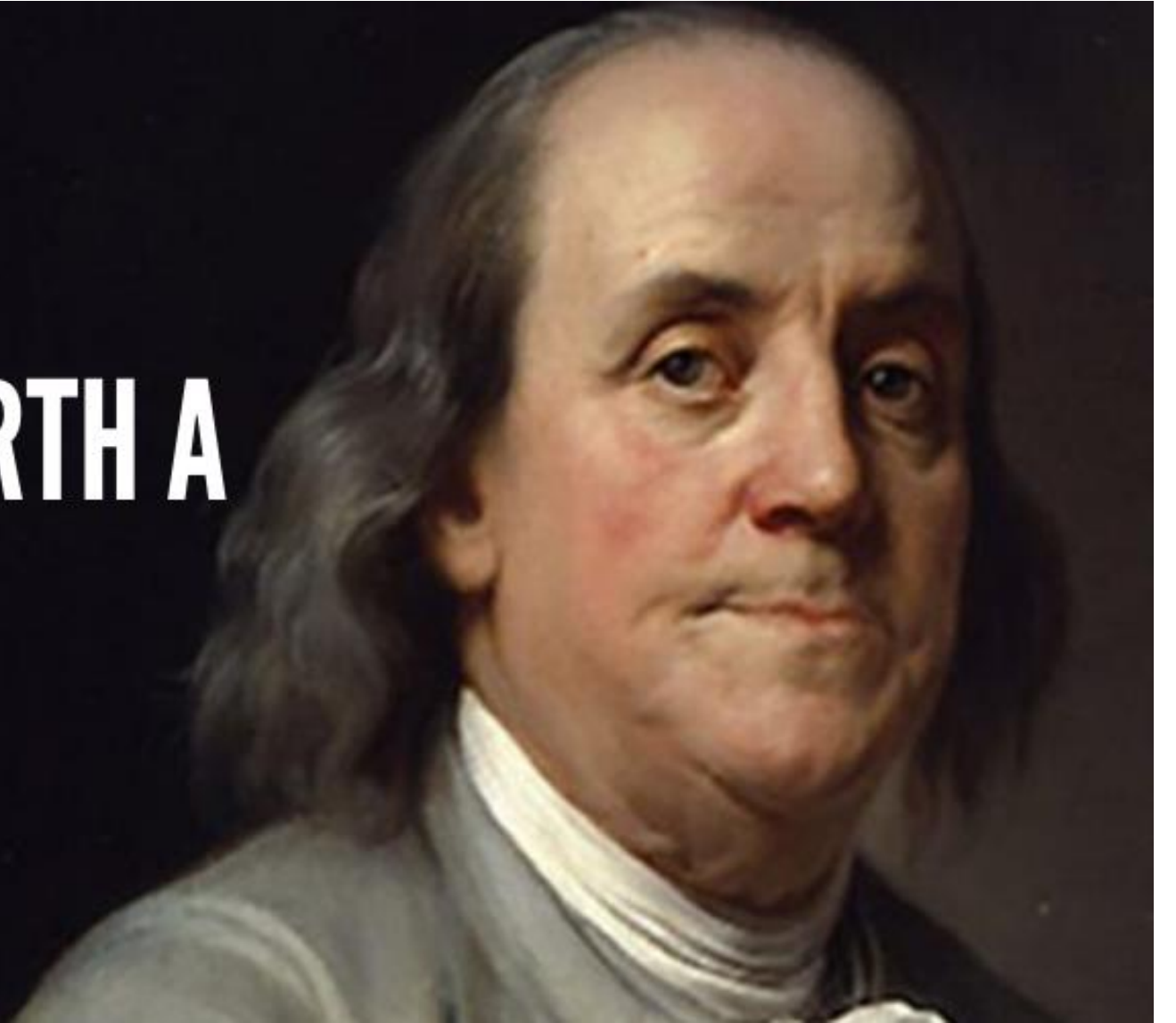
Study period	MV-days, n	VAPs, n	VAP rate ^a Median (95% CI)	RR (95% CI)	P-value	Incidence Rate Ratio (95% CI)	P-value	Mortality rate (%)	P-value
Baseline	22,241	633	28.46 (28.39,28.53)			1.00		15.76% (14.87%,16.71%)	
2nd month	20,132	354	17.58 (17.53,17.64)	0.61 (0.58,0.65)	<0.0001	0.61 (0.45,0.77)	<0.0001	14.35% (13.51%,15.22%)	0.0247
3rd month	19,610	274	13.97 (13.92,14.03)	0.49 (0.46,0.52)	<0.0001	0.55 (0.39,0.72)	<0.0001	14.02% (13.18%,14.91%)	0.0063
4th to 15th mo	194,179	2803	14.44 (14.42,14.45)	0.51 (0.48,0.53)	<0.0001	0.48 (0.31,0.66)	<0.0001	13.76% (13.49%,14.03%)	<0.0001
16th to 27th mo	135,739	1547	11.40 (11.38,11.41)	0.41 (0.38,0.42)	<0.0001	0.41 (0.23,0.58)	<0.0001	NA	NA
28th to 39th mo	71,691	694	9.68 (9.66,9.71)	0.34 (0.32,0.36)	<0.0001	0.39 (0.21,0.56)	<0.0001	NA	NA

- Optimizing hand hygiene compliance
- Assessing readiness to extubate daily patients without contraindications
- Maintaining cuff pressure and volume at the minimal occlusive settings to prevent clinically significant air leaks around the ETT, ~ 20 cm of water
- Minimizing the duration of MV
- Minimizing the duration of the ICU stay
- Elevating the head of the bed to 30–45°
- Providing oral care with toothbrushing but without CHG
- Preventing condensate from reaching the patient

This intervention resulted in a significant VAP rate reduction by 66% that was maintained throughout the 39-month period

**AN OUNCE OF
PREVENTION IS WORTH A
POUND IN CURE**

Benjamin Franklin



*Crete,
Greece*

Thank you for your attention!

