



Preventing Secondary Lung Infections in COVID 19 Patients: Implementing Evidence Based Practices to Save Lives

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Disclosures

- Consultant-Michigan Hospital Association Keystone Center
- Subject matter expert on CAUTI, CLABSI, HAPI, Sepsis, Safety culture for HRET/AHA
- Consultant and speaker bureau
 - △ Stryker's Sage business
 - △ LaJolla Pharmaceutical
 - △ Potrero Medical
 - △ Practical Hospital Services
- Baxter Advisory Board



Session Objectives

- Outline the problem of secondary bacterial infections in the COVID patient population
- Discuss key evidence based clinical intervention to prevent ventilator associated pneumonia
- Demonstrate the impact of new technology in reducing significant risk factors



Notes on Hospitals: 1859

“It may seem a strange principle to enunciate as the very first requirement in a Hospital that it should do the sick no harm.”

- Florence Nightingale

Advocacy = Safety



The Why



Ventilator Associated Pneumonia: Pre-Pandemic

- Rates in US: 1-2.5 cases per 1000 vent days
- Premier Database 2012-2019:
 - △ Ventilator hospital acquire ventilator pneumonia 25.6% (HAP requiring vent)
 - △ Ventilator associated bacterial pneumonia 47.9%
- VAP is associated with ↑ MV days and ↑ ICU & hospital LOS
- Attributable mortality estimated to be 4.0–13.5% (driven by underlying condition)
- Financial cost of a VAP \$19,325-\$80,013



TABLE 3. Costs in a Matched Cohort of 2,144 Patients with Ventilator-Associated Pneumonia (VAP) and 2,144 Patients without VAP

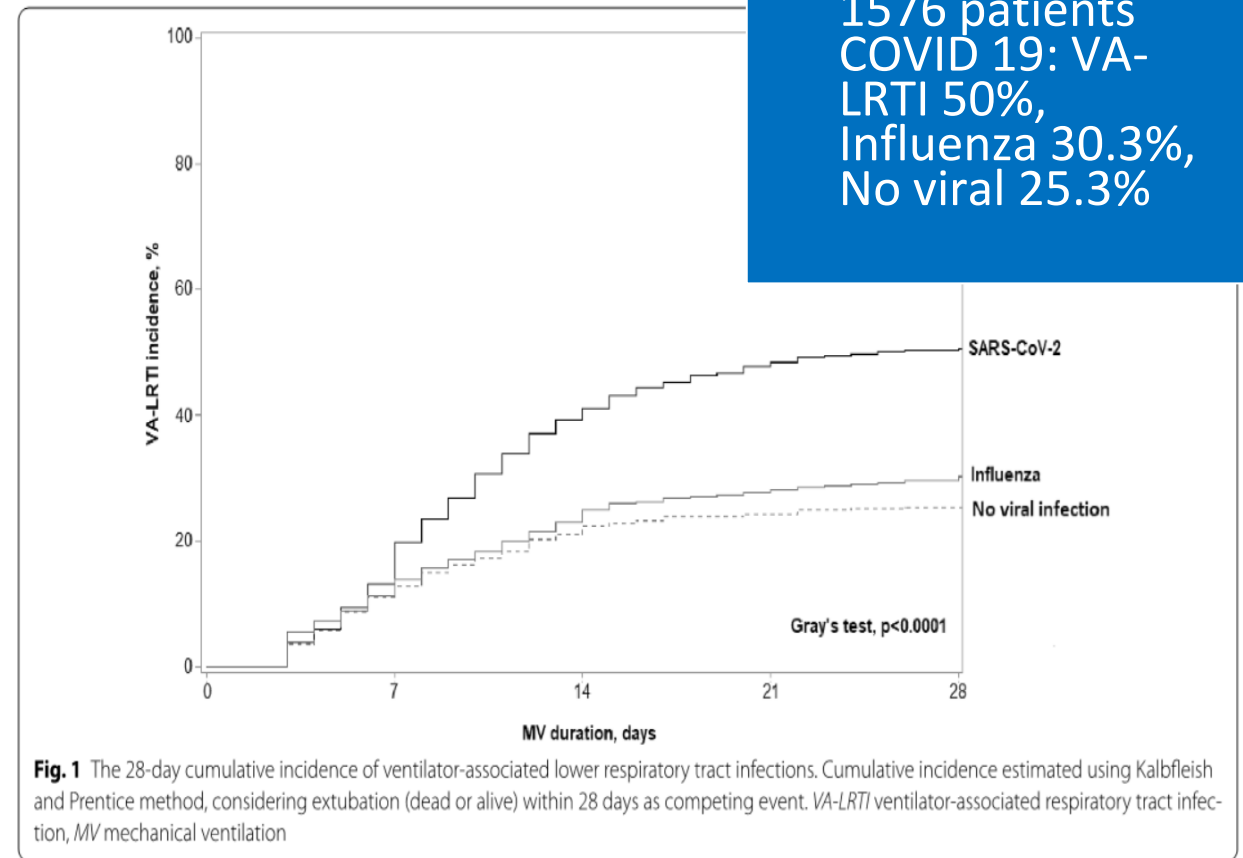
Outcome type	Cost, dollars, mean \pm SD ^a		<i>P</i>	Difference in dollars (%)
	With VAP	Without VAP		
Hospitalization	99,598 \pm 86,359	59,770 \pm 58,278	<.0001	39,828 (40.0)
Nursing time	3,369 \pm 16,487	2,980 \pm 14,109	.568	389 (11.5)
Pharmacy	14,345 \pm 16,992	8,547 \pm 14,497	<.0001	5,798 (40.4)
Antibiotic	1,947 \pm 4,095	1,011 \pm 2,039	<.0001	936 (48.1)
Vancomycin	327 \pm 564	248 \pm 420	<.0001	79 (24.2)
Propofol for sedation	947 \pm 1,768	585 \pm 1,202	<.0001	362 (38.2)
Ventilator	4,710 \pm 6,251	2,184 \pm 2,807	<.0001	2,526 (53.6)
Ventilator in ICU	3,716 \pm 4,479	1,909 \pm 2,304	<.0001	1,807 (48.6)
Respiratory therapy	2,650 \pm 4,007	1,496 \pm 2,539	<.0001	1,154 (43.5)
Chest x-rays	1,762 \pm 1,594	1,009 \pm 958	<.0001	753 (42.7)

NOTE. ICU, intensive care unit; SD, standard deviation.

^a Costs represent medical direct and indirect costs (not Medicare charges). Costs were not additive (eg, antibiotic and propofol costs were a subset of pharmacy costs).

Relationship Between COVID 19 infection & Incidence of Ventilator Associated Lower Respiratory Tract Infections

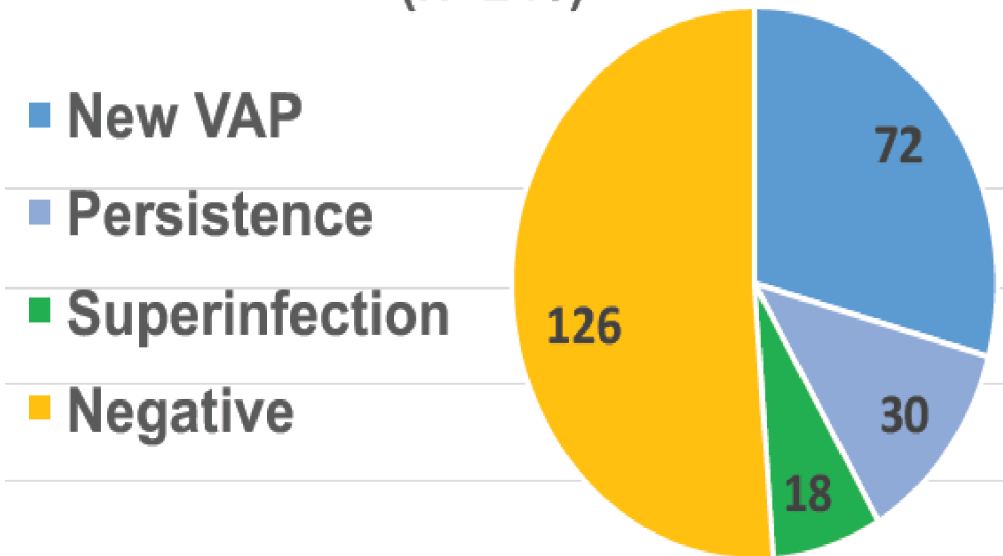
- Multicenter retrospective cohort/36 ICUs
- All patients MV > 48hrs, if had COVID 19 pneumonia, influenza pneumonia or no viral infection on admission
- Measured ventilator-lower respiratory tract infections (VA-LRTI) (VAT & VAP)
- 1576 patients: COVID 19: VA-LRTI 50%, Influenza; 30.3%, No viral: 25.3%



Bacterial Superinfection Pneumonia in COVID 19 Respiratory Failure

- Examined BAL samples from patients with COVID 19 pneumonia requiring mechanical ventilation
 - △ Sampled at time of intubation & identified episodes of VAP
- 179 ventilated patients (June 2020)
 - △ 90% 1 BAL procedure, 74.3% 48 hrs post intubation, 62.6% at least 1 during hospitalization
- Results:
 - △ 44.4% of patients developed at least 1 VAP
 - △ 20.8% of initial VAP multidrug resistant pathogens

Subsequent BALs for Suspected VAP (N=246)



VAP rate: 45.2/1000 ventilator days

Significance of VAP in COVID Patients: A Systematic Review and Case Series

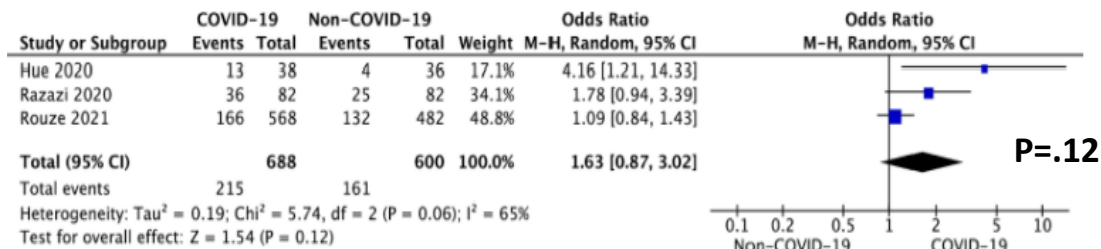
- Case series & systematic review (5 studies)
- COVID and Non COVID studies that measured VAP using the same methodology
- Outcome measures

△ Mortality during hospitalization

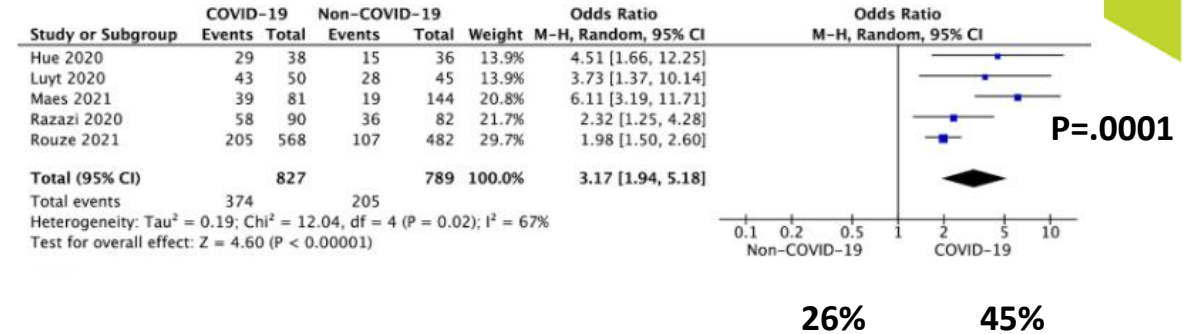
△ Secondary

- Mortality at ICU
- LOS
- VAP

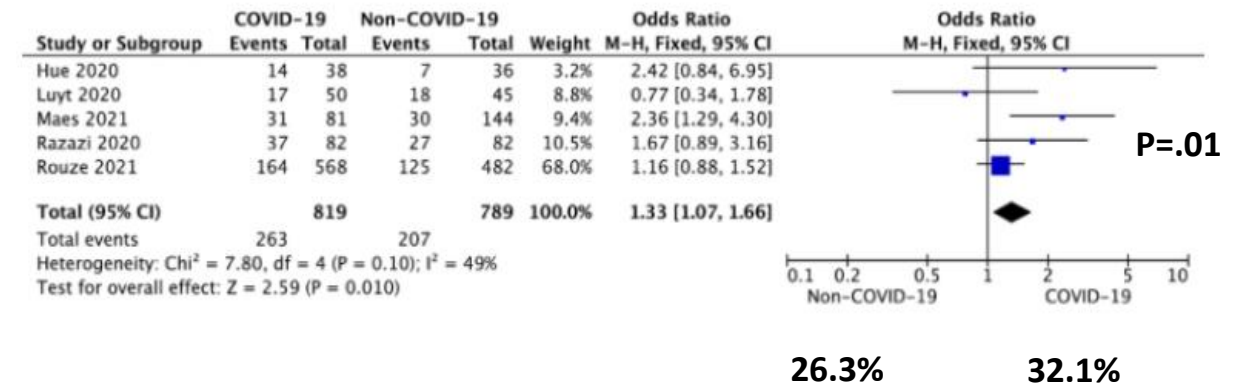
- Results: Mortality at 28 days



VAP Rates



ICU Mortality



Impact of COVID on HAI's in 2020 Compared to 2019: Data from NHSN

	2020 Q1	2020 Q2	2020 Q3	2020 Q4
CLABSI	↓ -11.8%	↑ 27.9%	↑ 46.4%	↑ 47.0%
CAUTI	↓ -21.3%	No Change ¹	↑ 12.7%	↑ 18.8%
VAE	↑ 11.3%	↑ 33.7%	↑ 29.0%	↑ 44.8%
SSI: Colon surgery	↓ -9.1%	No Change ¹	↓ -6.9%	↓ -8.3%
SSI: Abdominal hysterectomy	↓ -16.0%	No Change ¹	No Change ¹	↓ -13.1%
Laboratory-identified MRSA bacteremia	↓ -7.2%	↑ 12.2%	↑ 22.5%	↑ 33.8%
Laboratory-identified CDI	↓ -17.5%	↓ -10.3%	↓ -8.8%	↓ -5.5%

What to Remember



1. All patients with SARS-CoV-2 are at increased risk of bacterial infections
2. Infections in COVID-19 patients are often antibiotic resistant
3. The risk of bacterial infections is concentrated in the critically ill and mechanically ventilated population.

1. 50% of mechanically ventilated COVID-19 patients contract Ventilator-Associated Pneumonia (VAP)
2. COVID-19 + VAP = Increased Mortality
3. Thus VAP prevention in COVID-19 patients = decreased mortality



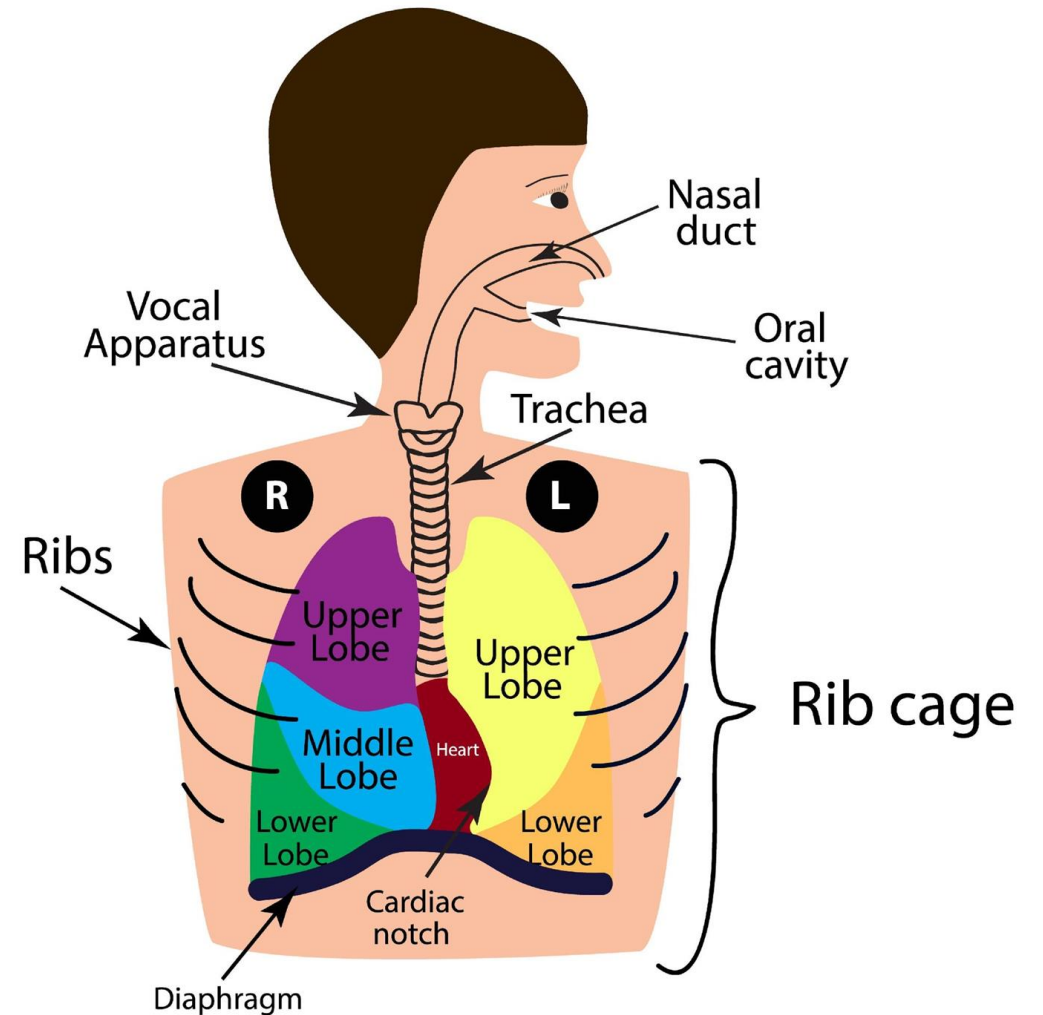
Risk Factor Categories for Hospital Acquired Pneumonia

- Factors that increase bacterial burden or colonization
- Factors that increase risk of aspiration



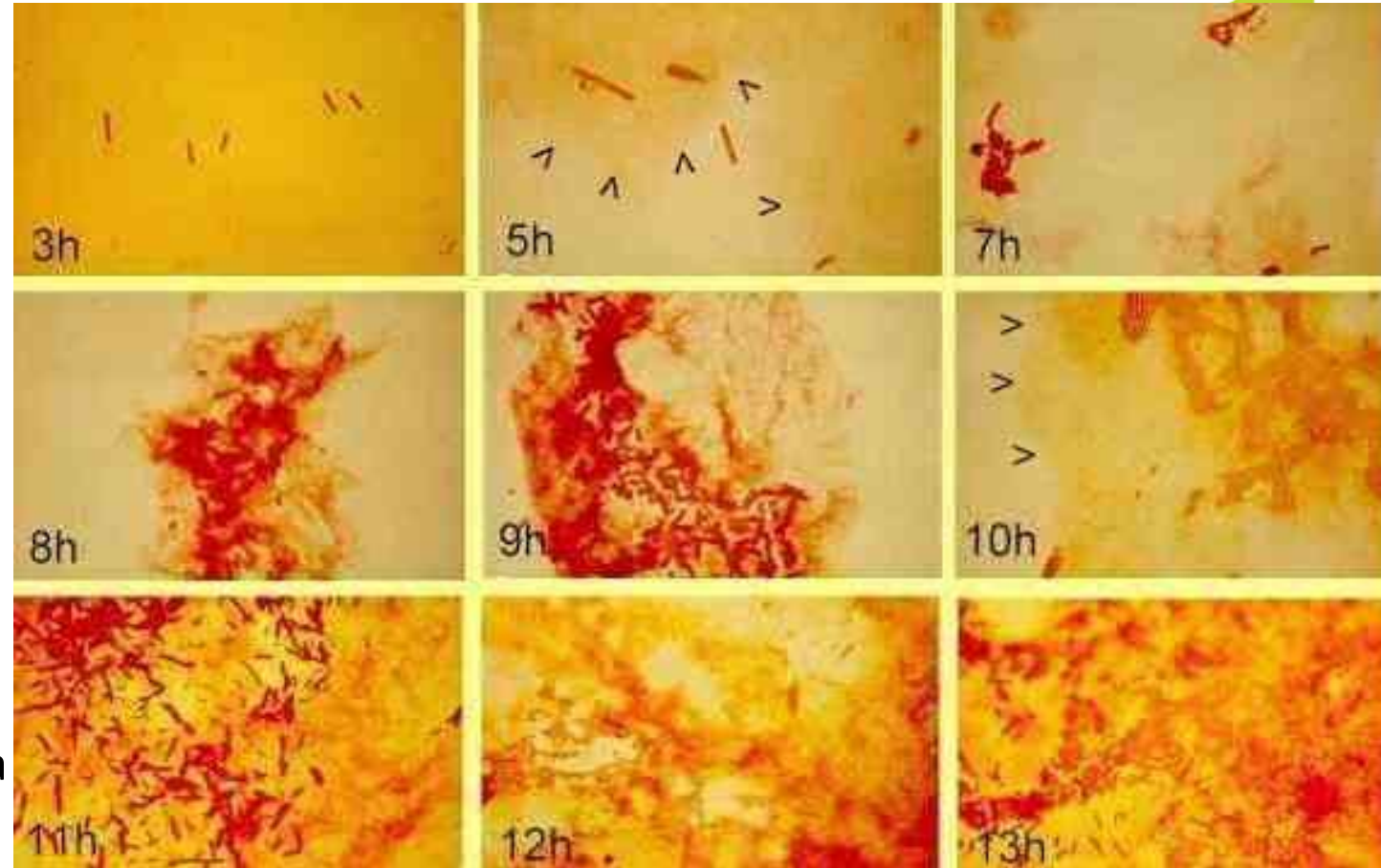
Single Ecosystem

- Entire respiratory tract is one ecosystem
 - △ Upper-nasal and oral cavities
 - △ Lower-alveoli
- Not sterile environment
- Oral flora changes in hospitalized patients
- Relationship between dental plaque and pulmonary lavage fluid

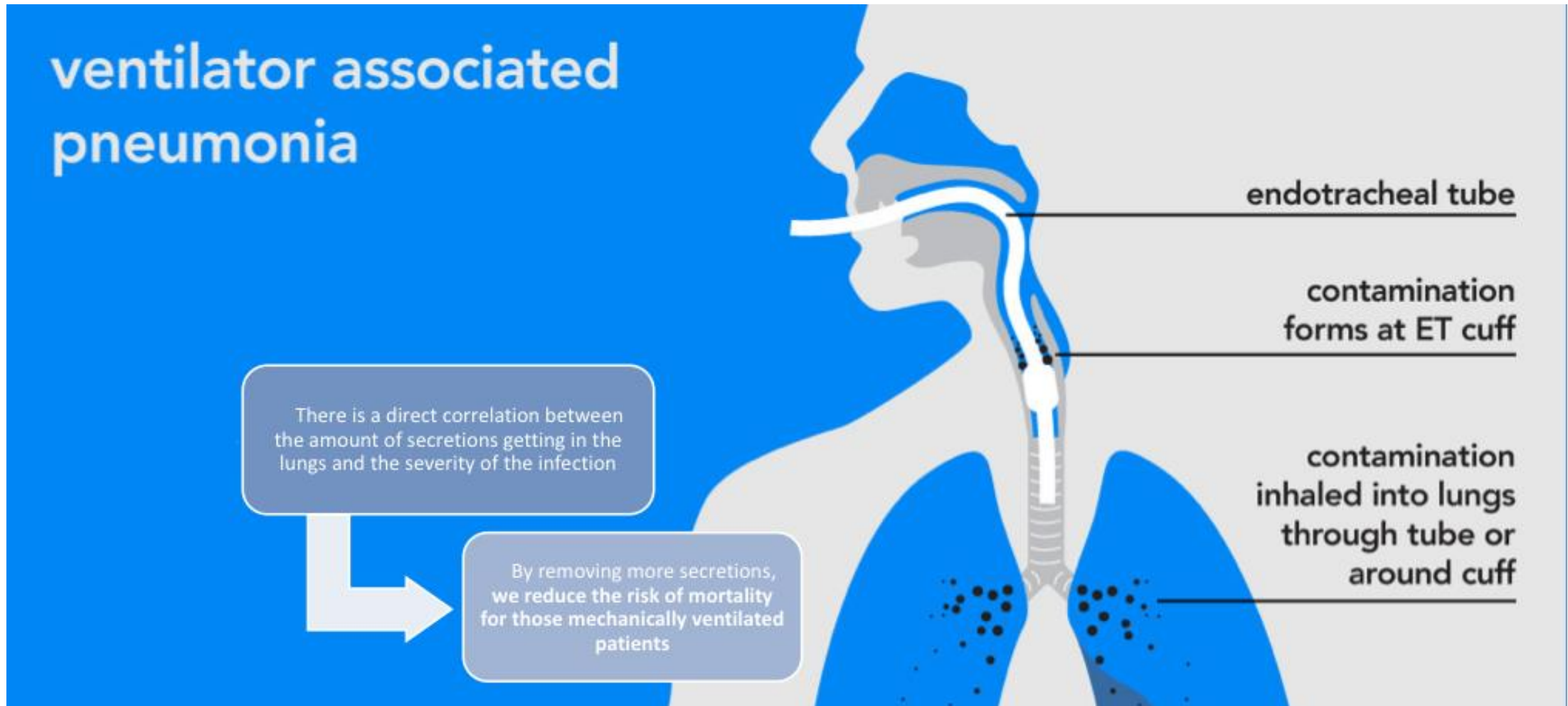


Where does Pneumonia Start: Oral Bacteria during Hospitalization & Illness

- Oral cavity
 - △ > 1 billion oral microbes
 - △ 700-1000 species
 - △ Replicate's 5 x in 24hr period
- Disruption of Microbiome
 - △ Plaque, gingivitis, tooth decay
 - △ Reduced salivary flow/change in pH
- 24-48 hours for HAP pathogens in mouth
- If aspirated =100,000,000 bacteria/ml saliva into lungs



What to Remember



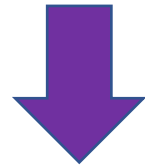


“Even if you are on the
right track, you will get
run over if you just sit
there.”

Will Rogers

Building Blocks to Best Practice in Caring for Mechanically Ventilated Patients

Ventilator Bundle: HOB 30, Deep Vein Thrombosis (DVT) prophylaxis, Peptic Ulcer Disease (PUD) prophylaxis, Sedation interruption, Spontaneous breathing trial, daily care with chlorhexidine



VAP Bundle: HOB 30, Sedation interruption, Spontaneous breathing trial, oral care 6x per day, CHG rinse 2x per day, subglottic secretions drainage if expected to be ventilated > 72hrs

Micro Aspiration during Sleep in Healthy Subjects



- Prospective duplicate full-night studies
- 10 normal male's 22-55 years of age
- Methods:
 - Radioactive 99 mTc tracer inserted into the nasopharynx
 - Lung scans following final awakening
 - No difference in sleep efficacy between 2 study nights
- Results:

50%

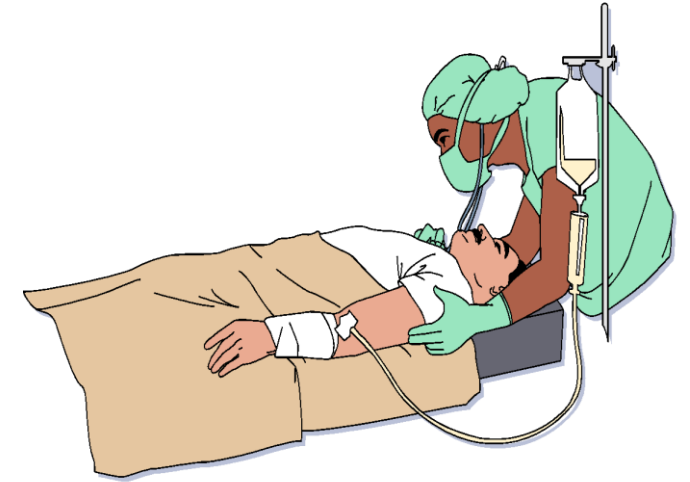
In the lung parenchyma



Body Position: Supine versus Semi-recumbent (30-45 degrees)

Methodology

- 19 mechanically ventilated patients
- 2 period crossover trial
- Study supine and semirecumbent positions over 2 days
- Labeled gastric contents (Tc 99m sulphur colloid)
- Measured q 30 min content of gastric secretions in endobronchial tree in each position
- Sampled ET secretions, gastric juice & pharyngeal contents for bacteria



Body Position: Supine versus Semi-recumbent

Results:

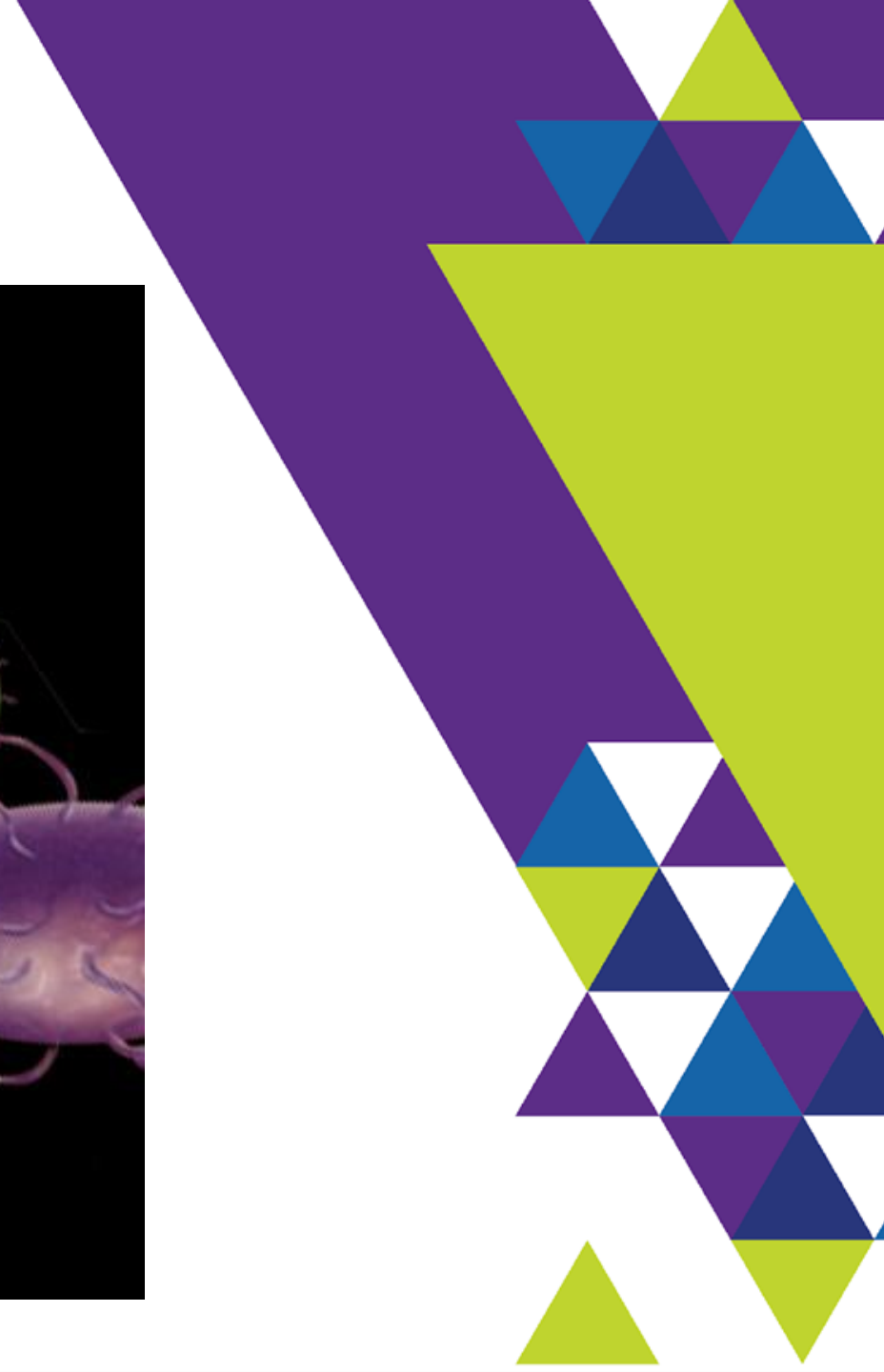
- Radioactive contents higher in endobronchial secretions in supine patients
- Time dependent:
 - Supine: 298cpm/30min vs. 2592cpm/300min
 - HOB: 103cpm/30min vs. 216cpm/300min



Same microbes cultured in all 3 areas

- HOB: 32%
- Supine: 68%

Oral Hygeine



What Does the Evidence Tell Us?



Brush

CHG rinse alone

CHG rinse in Combination

Swab/Clean/Moisturize

Suction

All of the above

Comprehensive Oral Care Program



Literature Review: Oral Care

Impact of VAP

Comprehensive Oral Care:

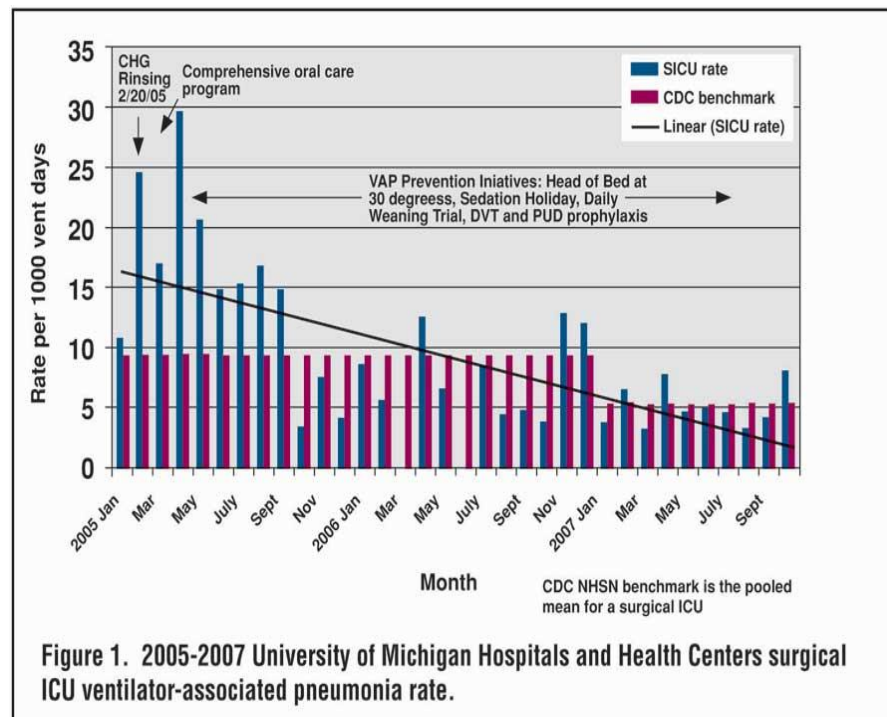
- Reduction in VAP from 5.6 to 2.2 (Schleder B. et al. J Advocate Health 2002;4(1):27-30)
- Reduction in VAP from 4.10 (2005) to (2.15) in 2006 with addition of CPC & comprehensive oral care. Vent bundle & rotational therapy already being performed
- Reduction in VAP from 12.0 to 8.0 ($p=.060$) with 80% compliance, vent bundle already being performed, 1538 patients randomized to control or study group, Additional outcomes; \square vent days ($p=.05$), \square ICU LOS ($p=.05$) \square time to VAP ($p= <.001$) & reduction in mortality ($p=.05$) (Garcia R et al AJCC, 2009;18:523-534)



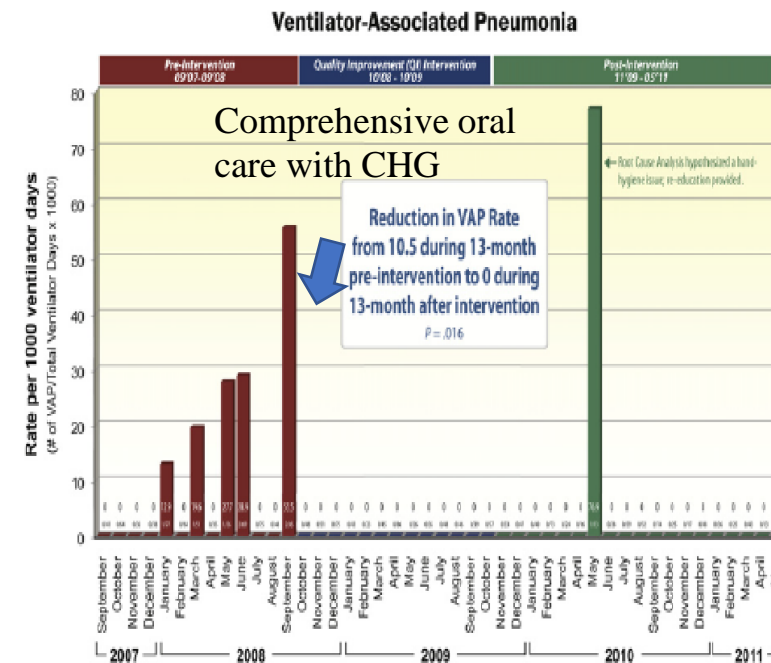
Literature Review: Oral Care Impact of VAP

Comprehensive Oral Care & CHG:

- Reduction in VAP to zero for 2 years, vent bundle, mobility, oral care & CHG with comprehensive education preformed (Murray TM et al. AACN Advanced Critical Care. 2007;18(2):190-199)



Dickinson S et al. SCCM Critical Connections, 02/2008



Heck K, et al. American Journal of Infection Control 40 (2012) 877-9

Does CHG Oral Care Impact VAP and Mortality

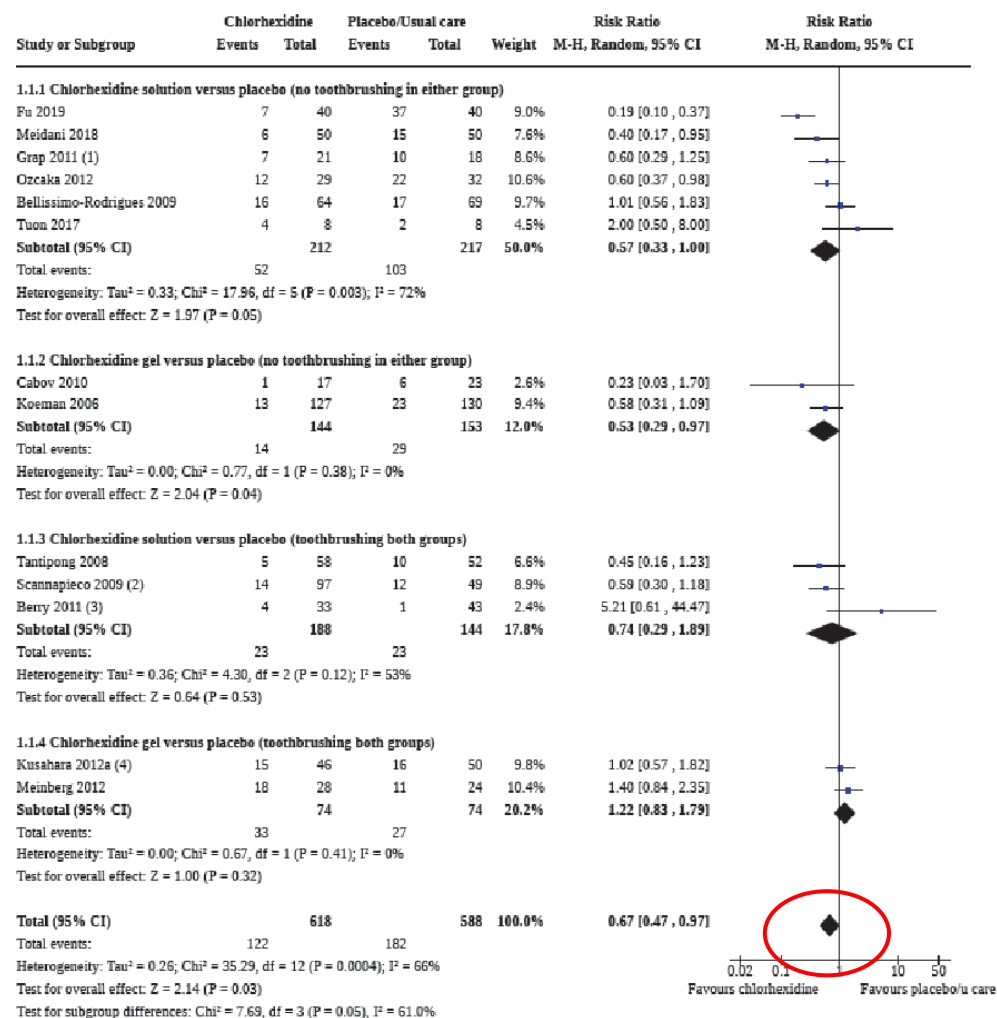


- Klompas Study-
Retrospective review
 - △ Single center
 - △ Impact of vent bundle (5536 patients)
 - △ Connection of CHG with increase mortality on patients vented > 3 days

- Deschepper study: **Retrospective Review**
 - △ Hospital wide retrospective cohort (82,274 patients)
 - △ 11,133 patients received CHG oral care
 - △ Divided into low exposure-cumulative dose < 300 mg (8080 pts)
 - △ High exposure > 300 mg (3053 pts)
 - △ 300 mg CHG is equivalent to 1 bottle of 250ml of oral care soln at .12%-covers 5-6 days at 3 times a day)
- In the sickest group CHG low or high exposure was not a risk for increased mortality
- Showed improvement on mortality in ICU patients ventilated < 96hrs and not harm if vented > 96 hrs
- Greatest risk for mortality increase is use in non-ICU patients.

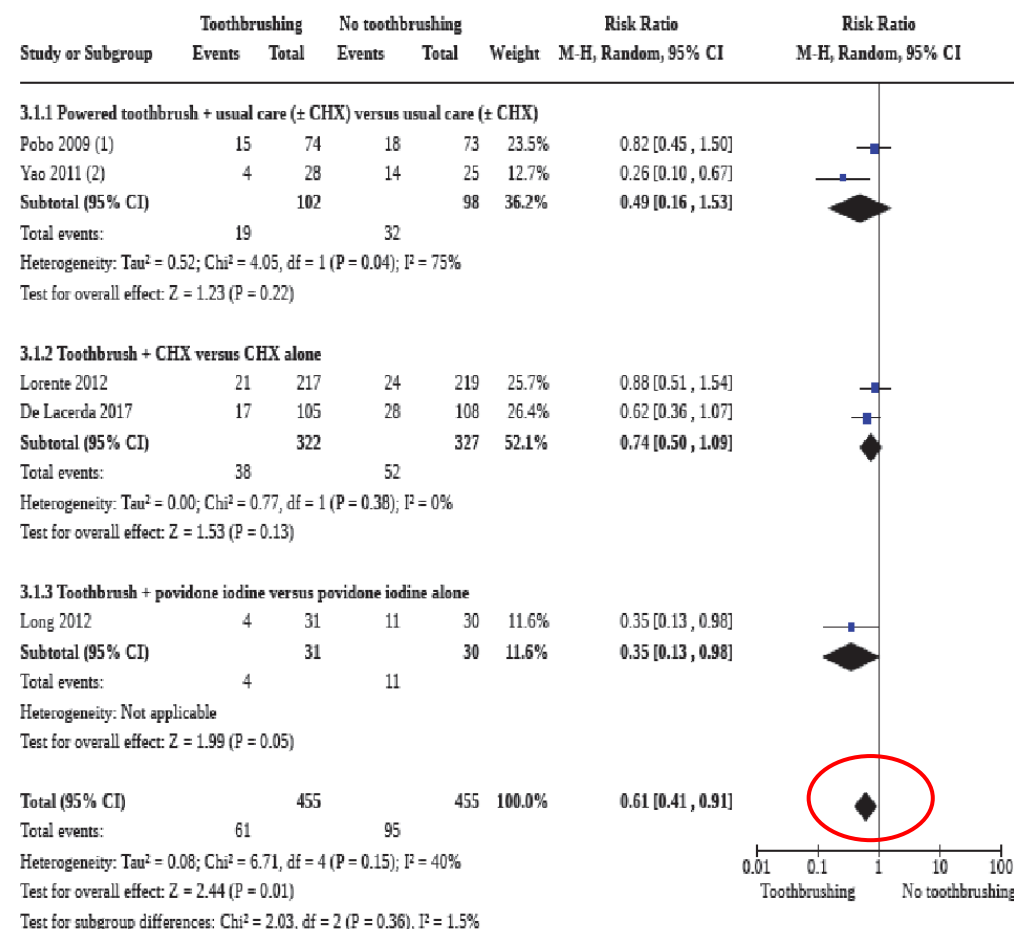
Cochrane Meta-Analysis 2020 of RCT's

Analysis 1.1. Comparison 1: Chlorhexidine versus placebo/usual care, Outcome 1: Incidence of VAP



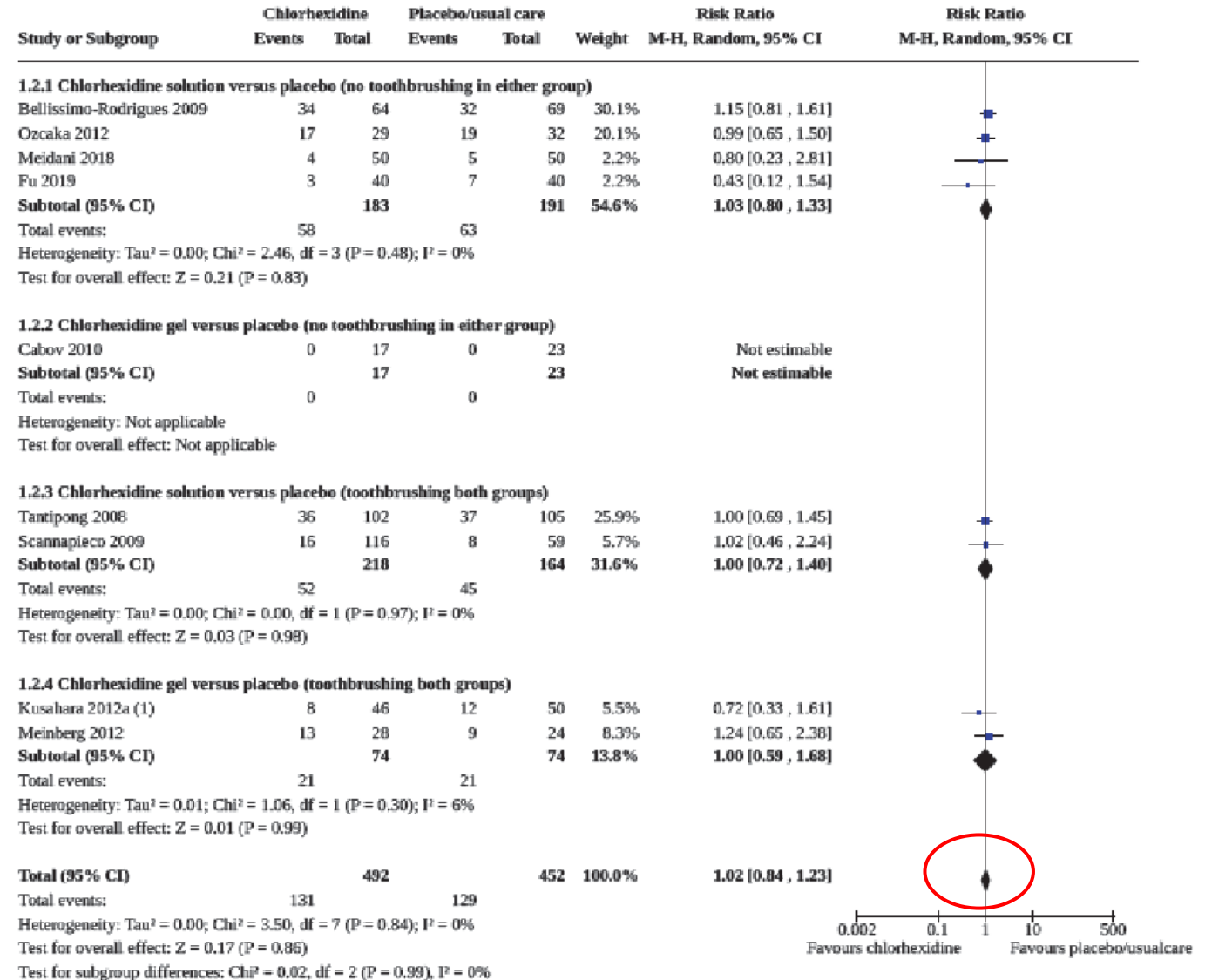
NNT
12

Analysis 3.1. Comparison 3: Toothbrushing versus no toothbrushing, Outcome 1: Incidence of VAP



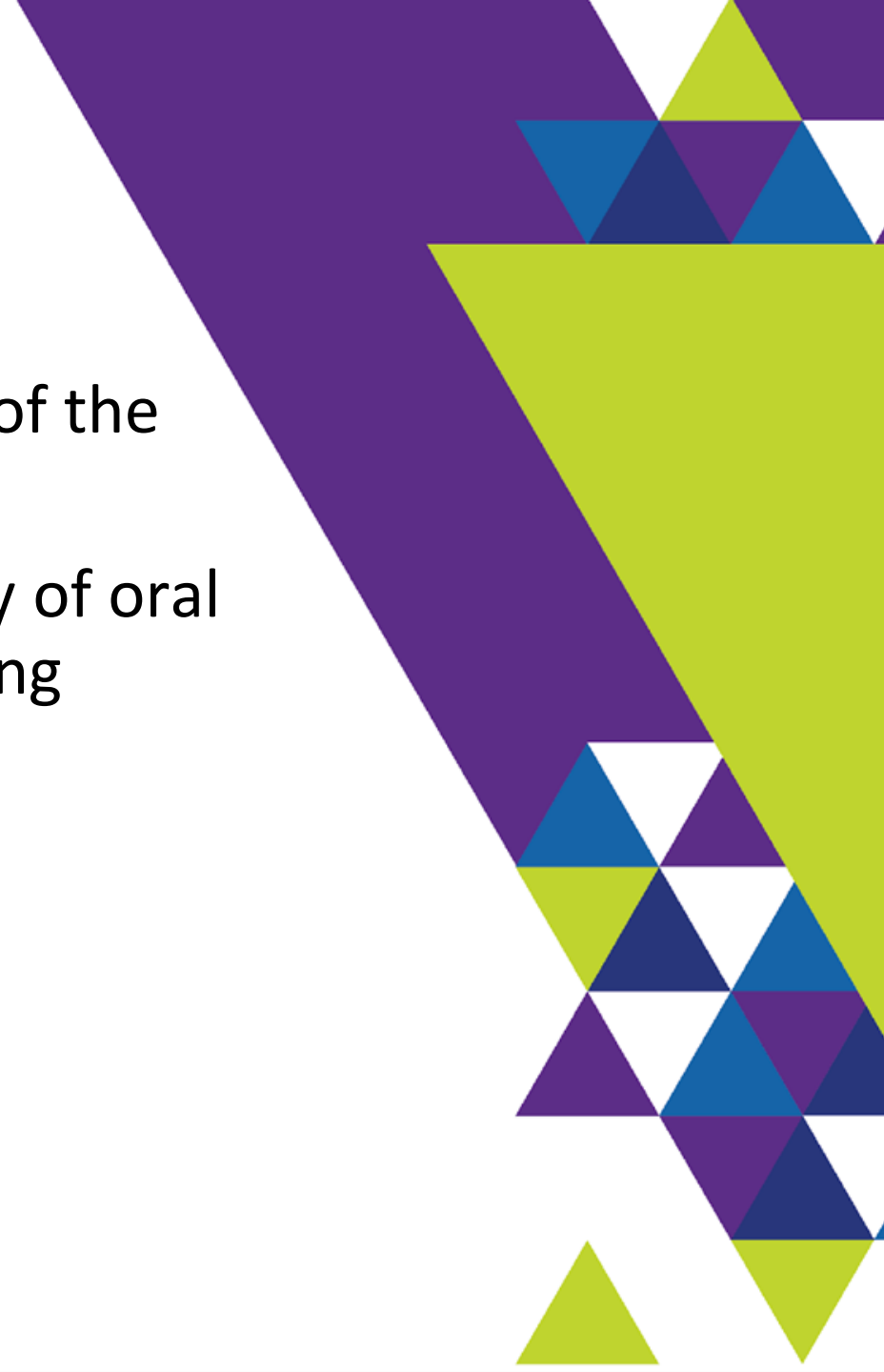
Impact on Mortality

Analysis 1.2. Comparison 1: Chlorhexidine versus placebo/usual care, Outcome 2: Mortality

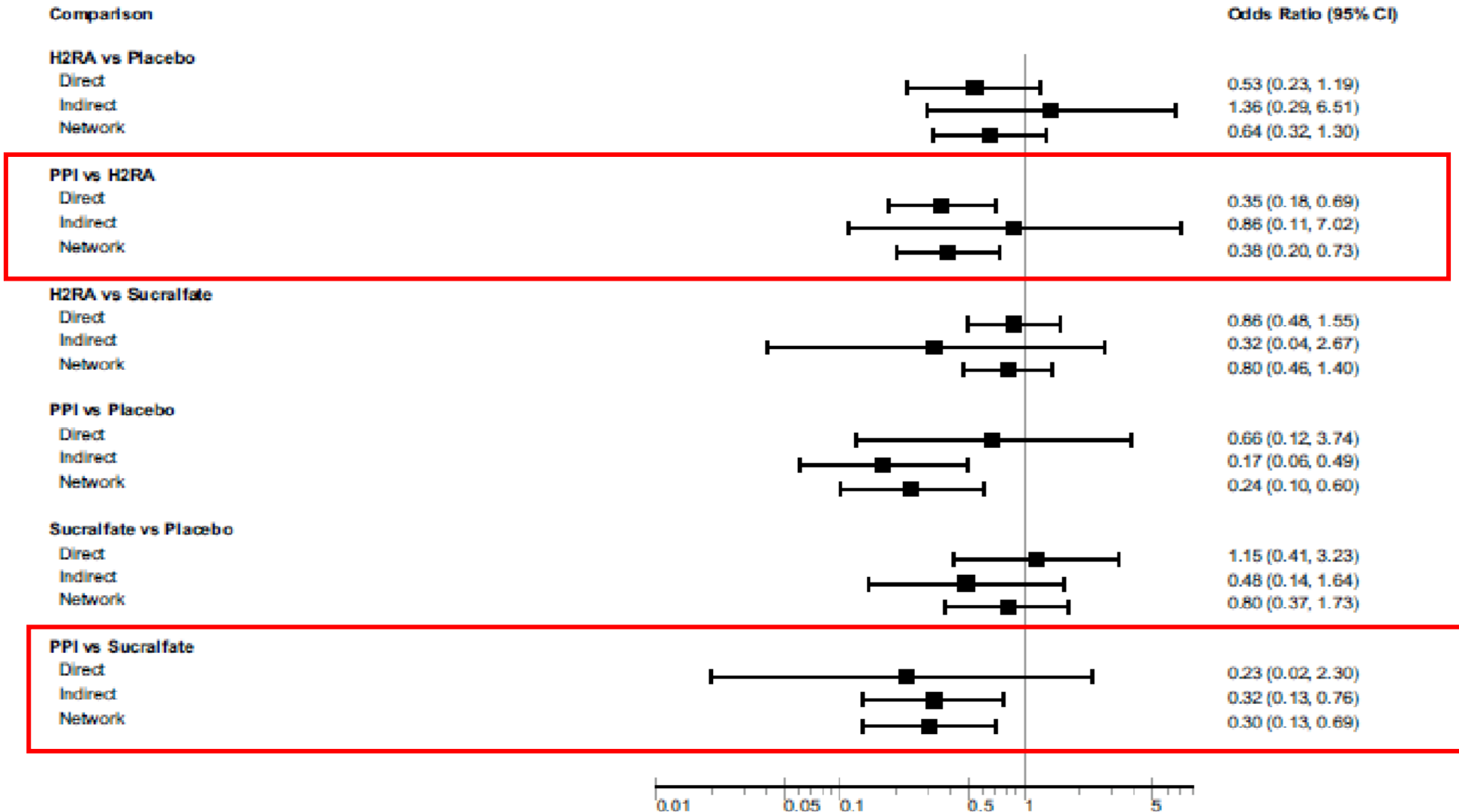


It is More than CHG

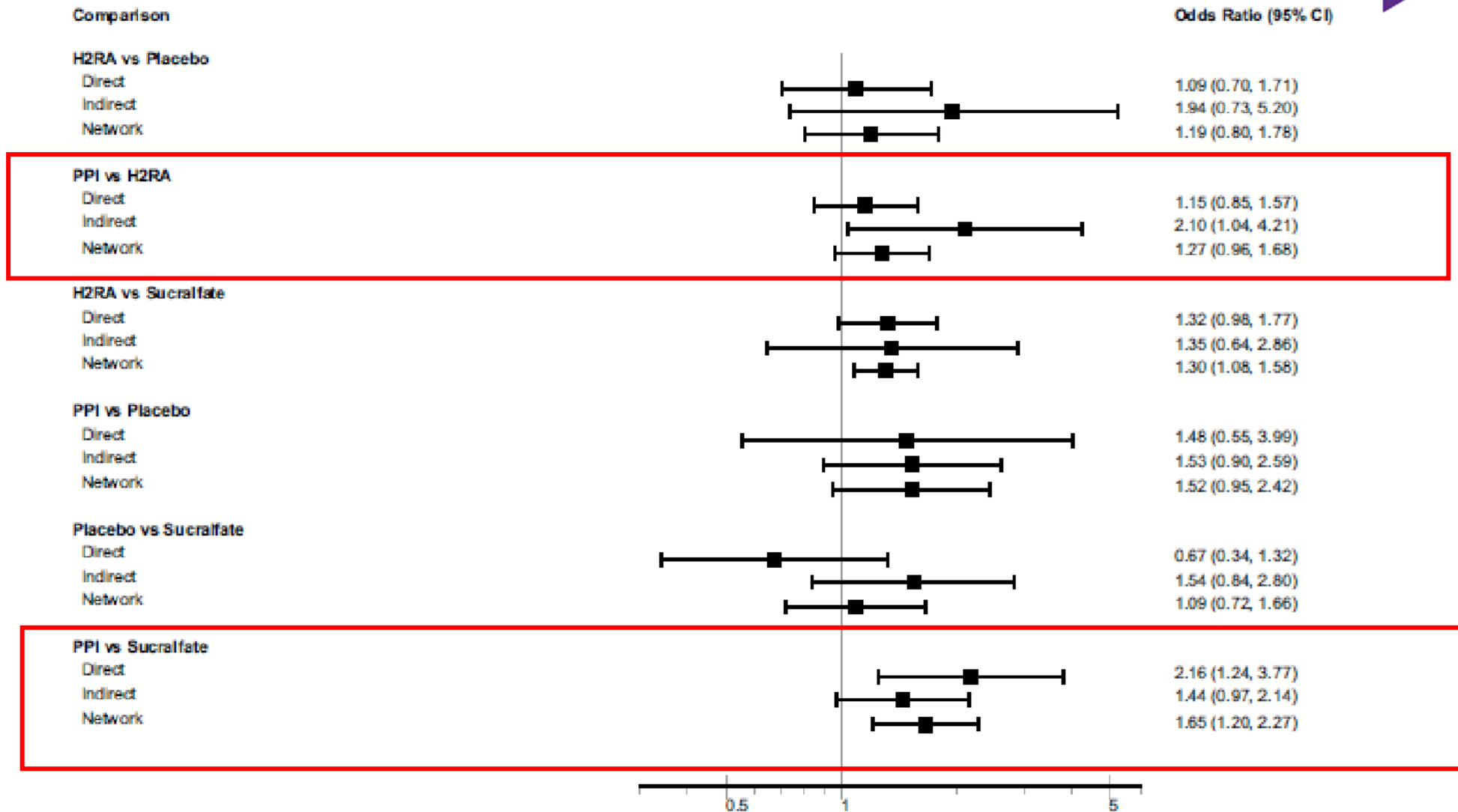
- .12% CHG application 2x daily is a small part of the oral care equation
- It is the comprehensive and frequent delivery of oral hygiene, including toothbrushing and cleansing



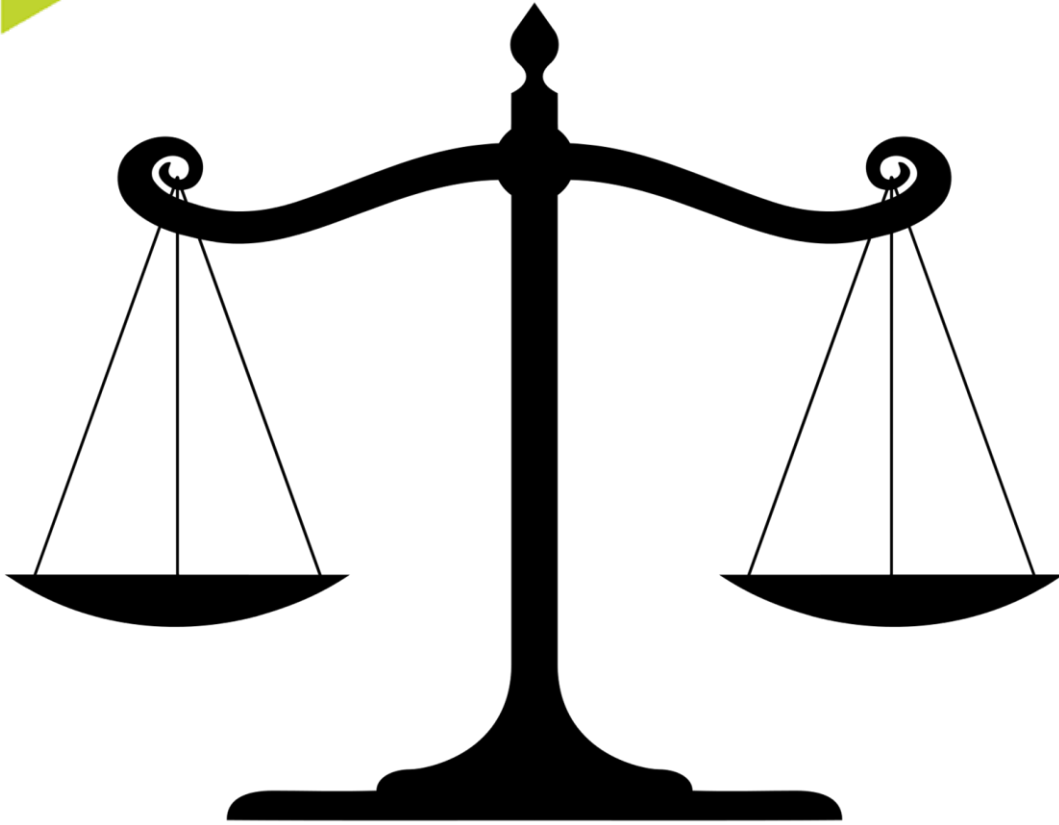
SUP: Impact on Bleeding Risk



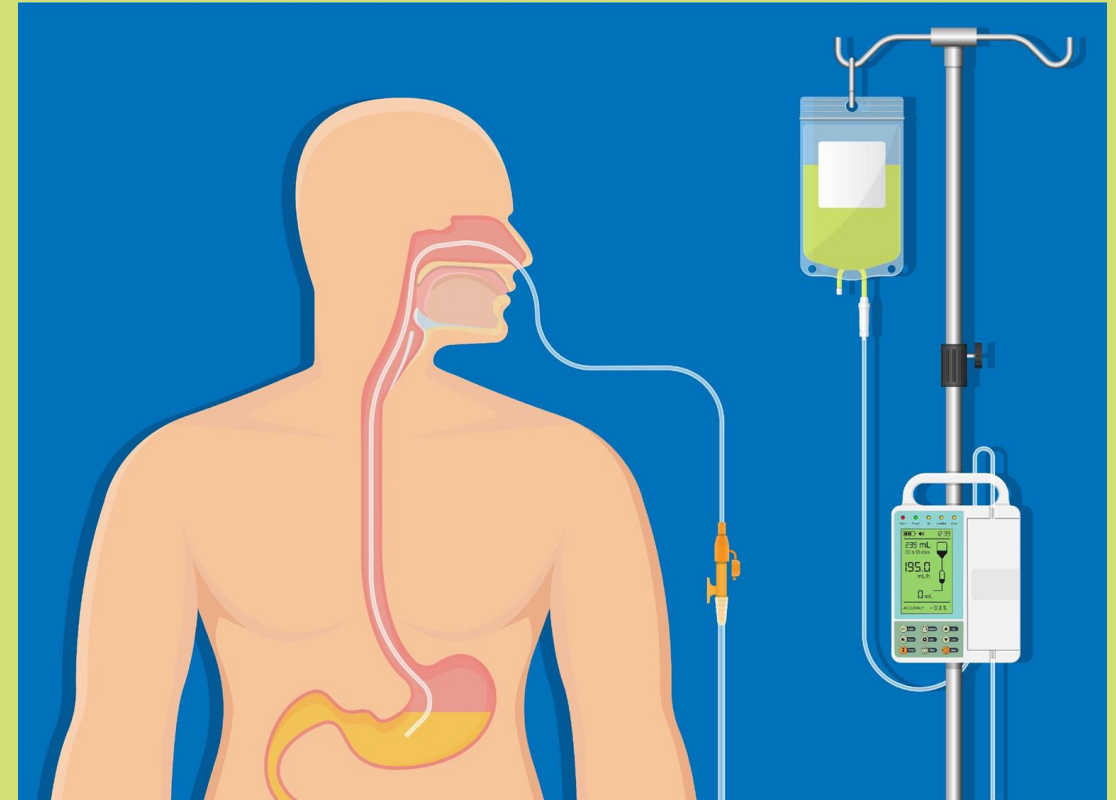
SUP: Impact on Risk of Pneumonia



Risk Benefit



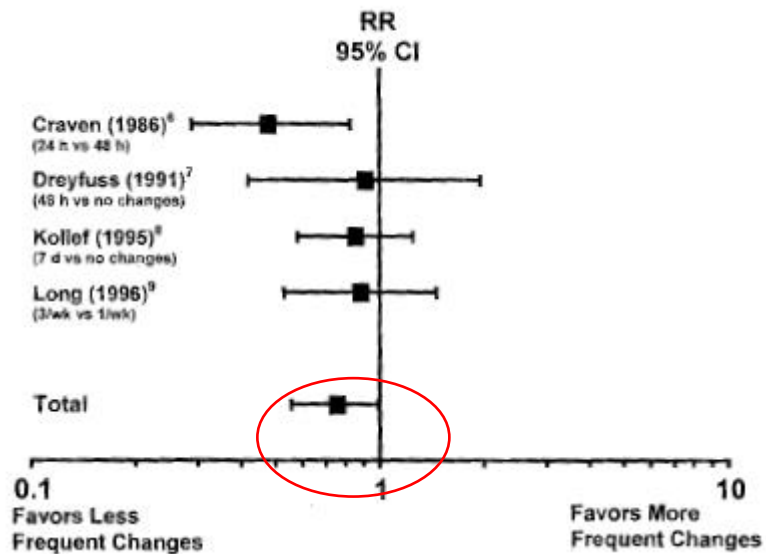
Treat patients at high risk of stress bleed?



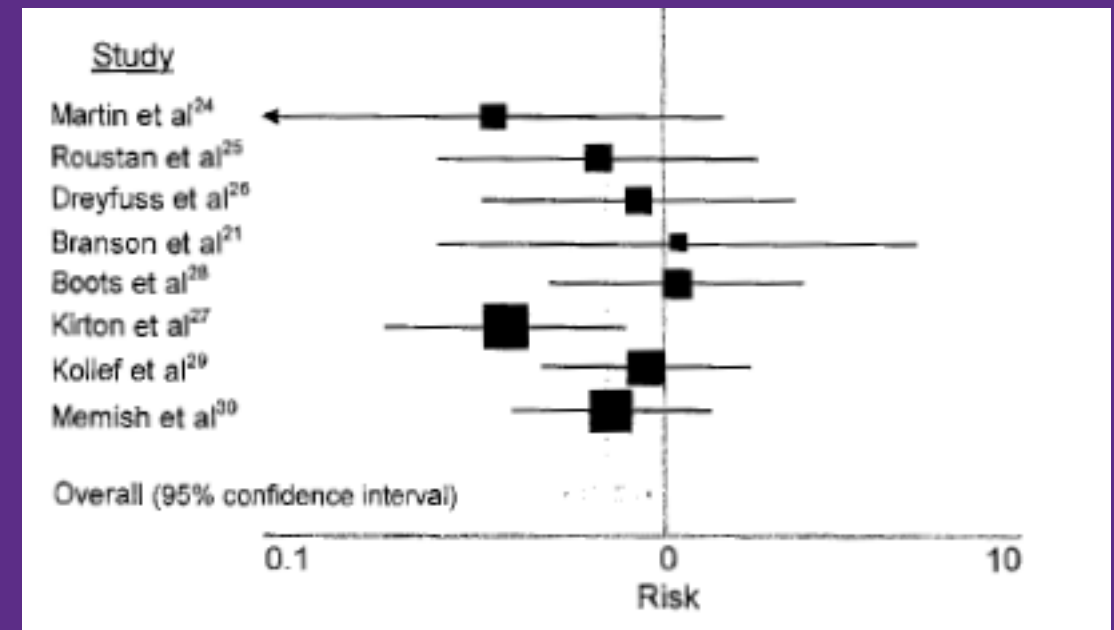
Receiving EN, pharmacologic SUP offered no beneficial effect GI bleeding and other clinically important outcomes.

Strategies to Reduce VAP

Heat Wire Exchange vs Humidifier



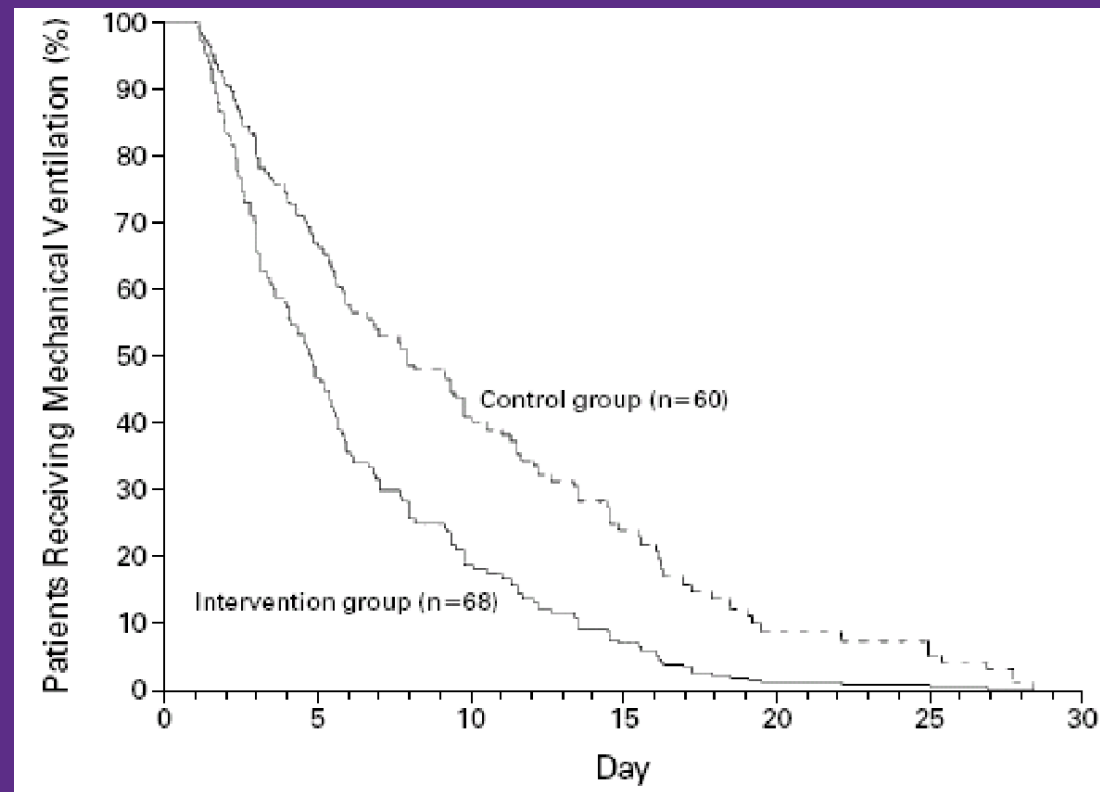
Ventilator Circuit Change



Some benefit on pneumonia prevention/no difference in airway occlusion

Daily Sedation Interruption Decreases Duration of Mechanical Ventilation

- Hold sedation infusion until patient awake, then restart at 50% of prior dose
- “Awake” defined as any 3 of the following:
 - Open eyes in response to voice
 - Use eyes to follow investigator on request
 - Squeeze hand on request
 - Stick out tongue on request



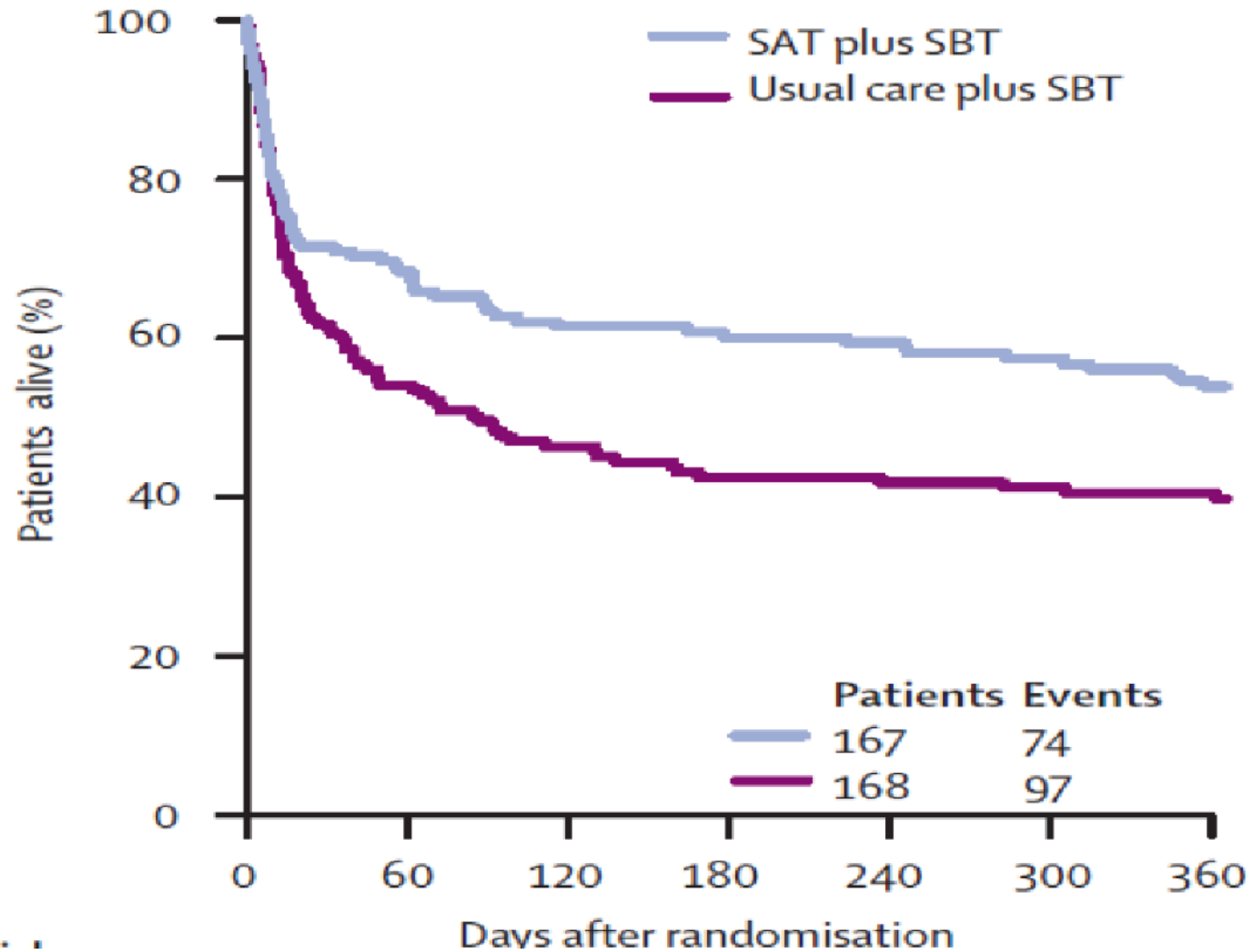
- Length of MV 4.9 vs. 7.3 days ($P=0.004$)
- ICU LOS 6.4 vs. 9.9 days ($P=0.02$)
- Fewer diagnostic tests to assess changes in mental status
- No increase in rate of agitated-related complications or episodes of patient-initiated device removal
- No increase in PTSD or cardiac ischemia

ABC Trial (RCT Paired Sedation & Vent Weaning Protocols)

Outcome*	SBT	SAT+SBT	P value
Ventilator-free days	12	15	0.02
Time-to-event, days			
Successful extubation, days	7.0	5	0.05
ICU discharge, days	13	9	0.02
Hospital discharge, days	19	15	0.04
Death at 1 year, n (%)	97 (58%)	74 (44%)	0.01
Days of brain dysfunction			
Coma	3.0	2.0	0.002
Delirium	2.0	2.0	0.50

*Median, except as noted

ABC Trail: Mortality at 1 Year



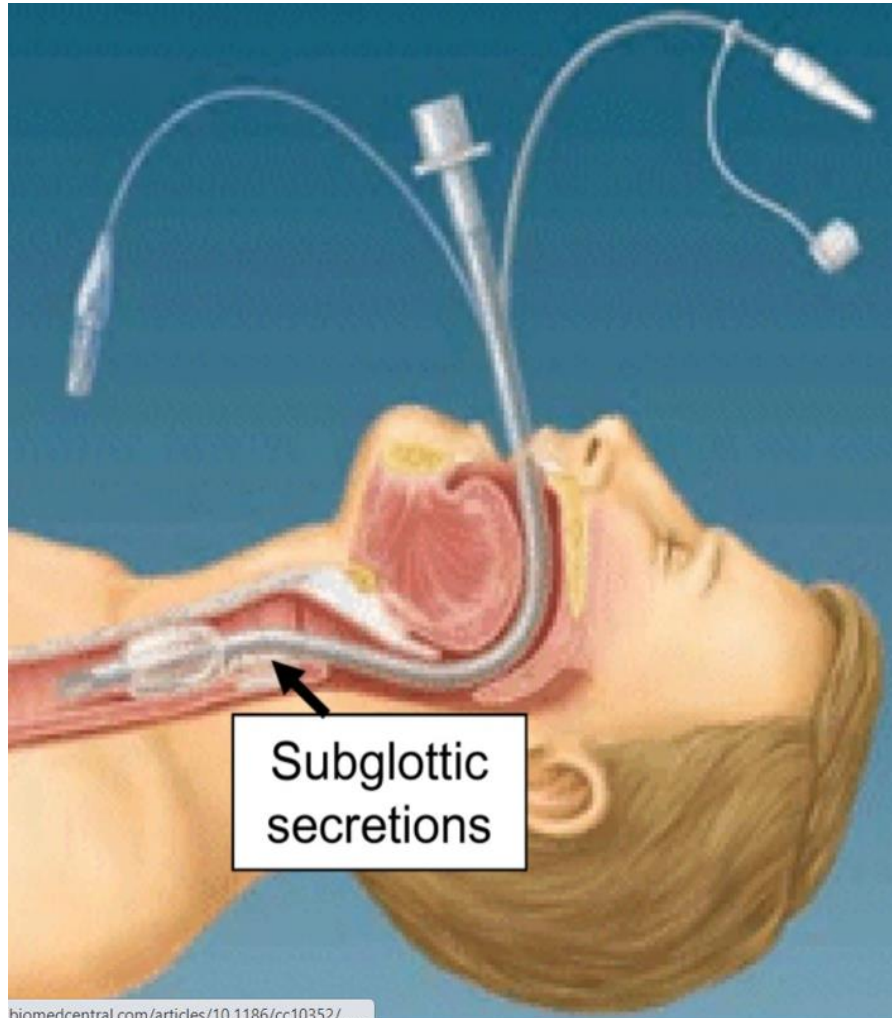
Endotracheal / Nasogastric Tube/ Sinusitis



- Carriage of oropharyngeal bacteria during intubation
- If cuff pressure < 20 cm 4x \square risk VAP
 - △ Cuff pressure range btwn 25-40cm (JBI-Level A) with maintenance at 25cm-30cm of H2O pressure.
 - △ No difference between freq & infrequent measurement
 - △ Continuous monitoring resulted in a lower portion of out-of-range cuff pressure (11% vs. 51.7% $p < 0.001$) and \downarrow in VAP
- Use oral ET versus nasal (CDC-Cat IB)
 - △ NGT increases risk of sinusitis/gastric reflux & increases oropharyngeal colonization
 - △ Sinusitis increases the risk of nosocomial pneumonia by 3-fold



Current Subglottic Suctioning Endotracheal Tubes



Subglottic suctioning ETTs in patients mechanically ventilated for >72 hours

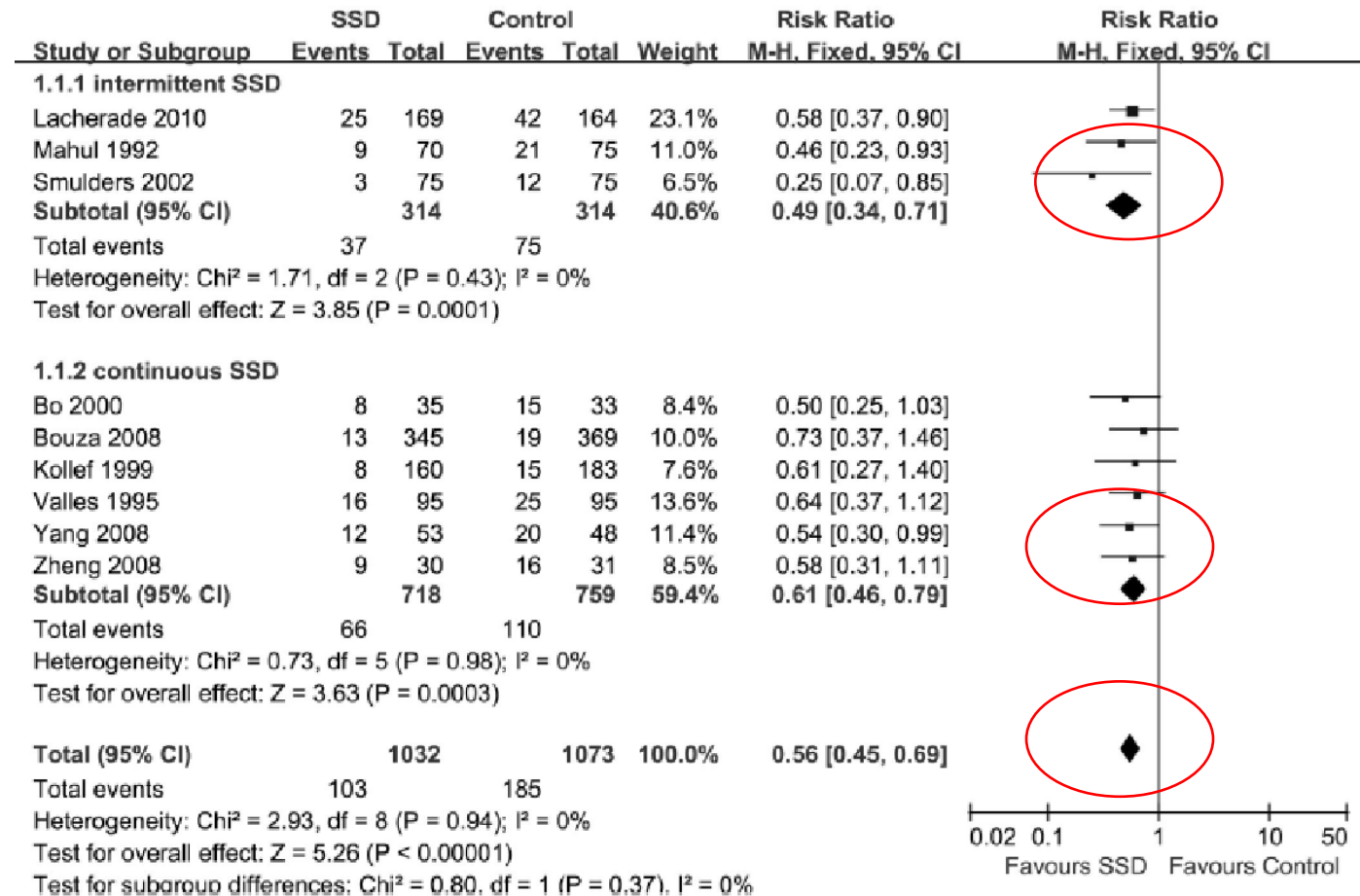
Results of Subglottic Suctioning Study

	Suction Group 1 (n=170)	No Suction Group 2 (n=182)
VAP	8.8%, 15 patients	17.6%, 32 patients
VAP by vent days	9.6 of 1000 days	19.8 of 1000 days
VAC	21.8%	22.5%
Antibiotic days	61% 1696 of 2754 days	68.5% 1965 of 2868 days

Subglottic Secretion Drainage: Meta-analysis

■ Results

- Shorten vent days 1.55
- Prolonged VAP by 4 days
- ISSD may result in less mucosal injury

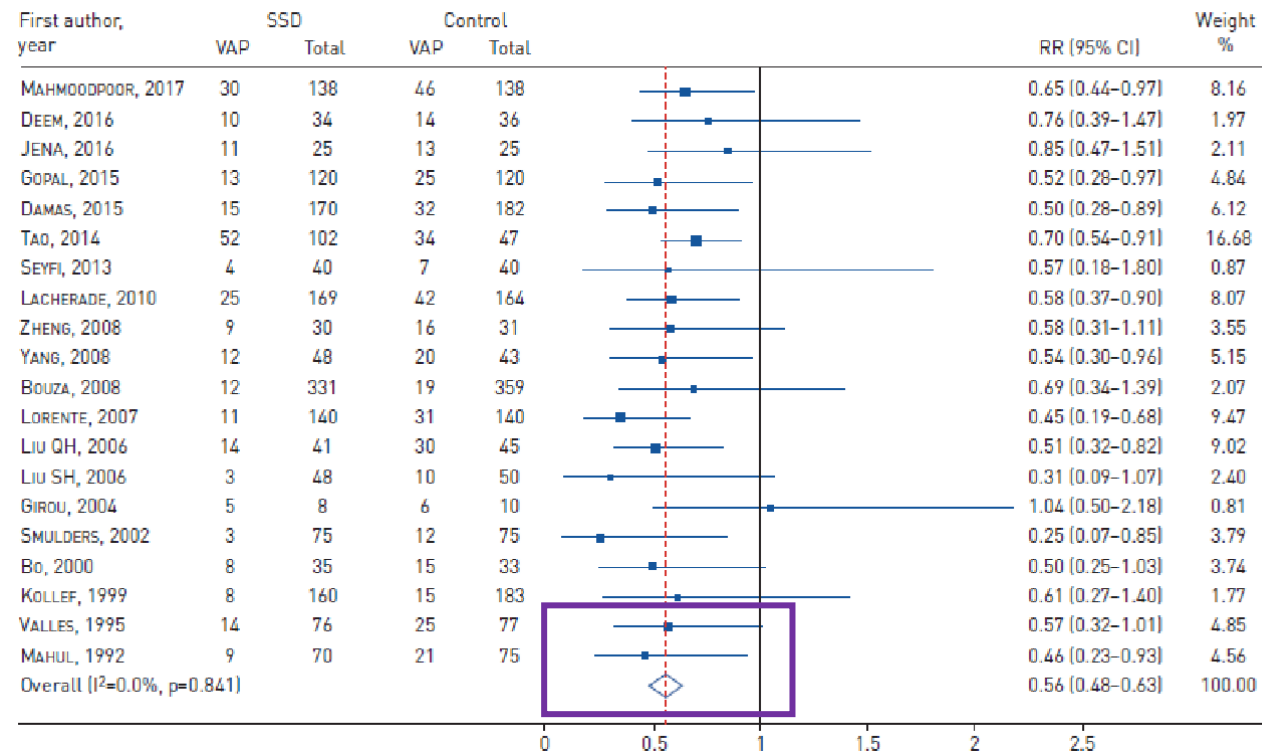


Update: Subglottic Secretion Drainage Meta-Analysis

20 RCT's, studies from 1992-2017, 3684 Patients



VAP Incidence



Mortality

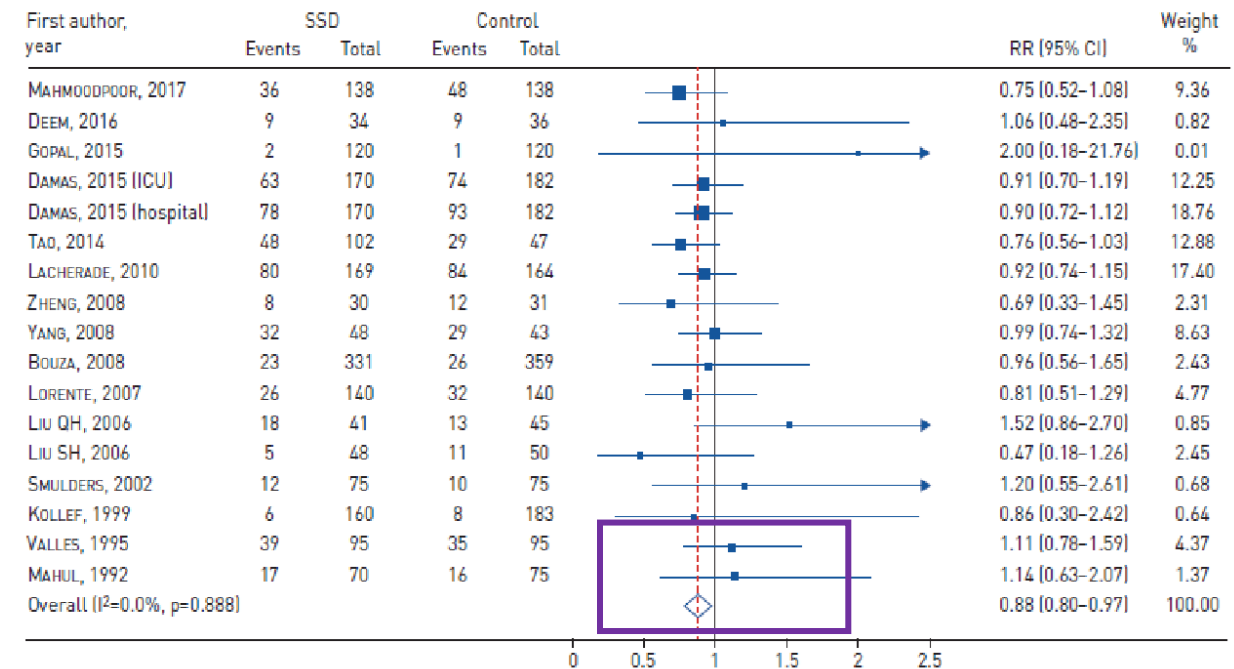


FIGURE 3 Forest plot comparing subglottic secretion drainage (SSD) versus non-SSD on mortality. RR: risk ratio; ICU: intensive care unit.

Guideline Recommendations: Subglottic Secretion Drainage

- HIPAC Pneumonia Guidelines 2003
- ATS pneumonia prevention & treatment 2005
- Spanish Guidelines
- Ireland VAP Guidelines 2011
- SHEA Pneumonia Prevention Guidelines 2014
- VAP Bundle (National Delphi Study)

ATS/IDSA 2016 Clinical Practice Guidelines

AARC 2010 Clinical Practice Guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways

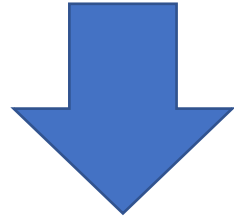
AACN VAP Practice Alert

APIC 2009 Guide to the Elimination of VAP

SHEA 2008 Strategies to Prevent VAP in Acute Care Hospitals



So Why is SGD not being used?



**Suctioning
Apparatus**

Subglottic ETT



Challenges: Current Suctioning

- Intermittent suction q 1hr for SGD with a syringe/labor intensive & difficult to achieve
- Intermittent suction by machine or syringe-exerts 2 to 5x more pressure than AARC recommends
- A high variability in the volume of secretions suctioned between patients and, for each individual patient, during the period of MV
- Continuous suction continues even if clogged grabbing the subglottic wall-keeps on going
- Back flow leading to potential vector for infection
 - △ 470 regulators/11 facilities/5 states
 - △ 37% found to be colonized
 - △ Pathogens can disseminate throughout the circuit (antegrade & retrograde)

Challenges: Current Suctioning

- Poor removal of pathogenic fluid
- Increased rates of complications
- Increased workflow
- Increased Costs of SSETTs



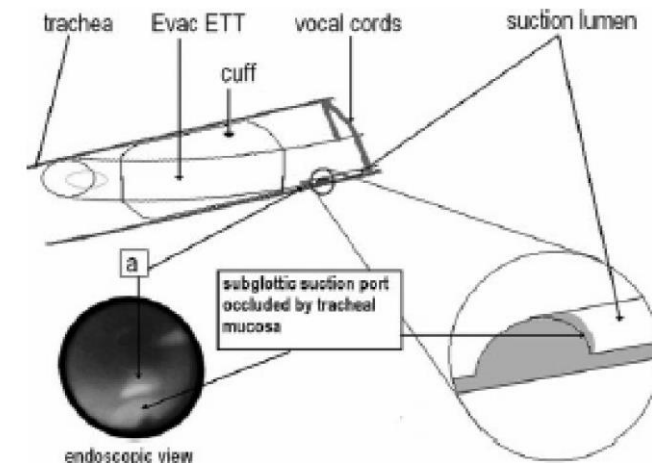
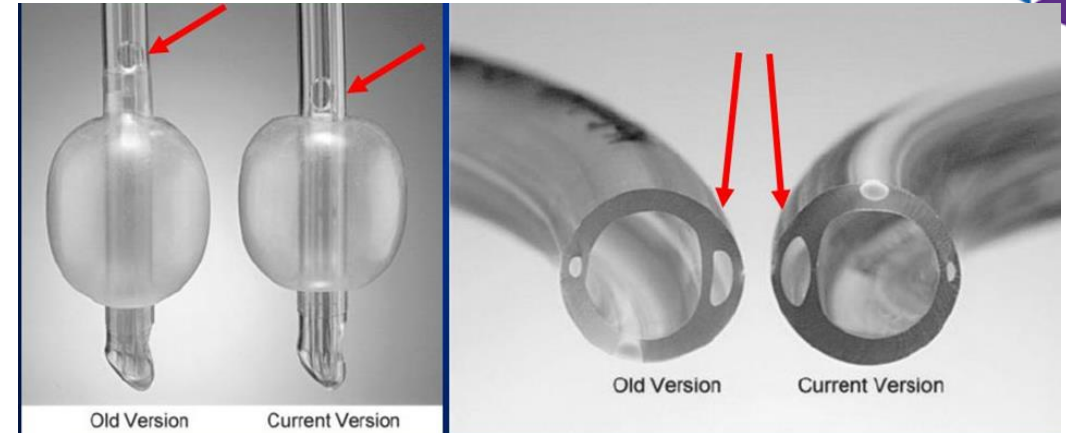
Challenges: Suction Apparatus



	Traditional Approaches			Automated Approach
	Continuous	Intermittent	Manual	Intermittent
Method	Wall Suction or General Suction	Wall Suction or General Suction	Syringe	Specialized Suction Device
Pressure	-20 mmHg (may be too low to aspirate viscous secretion and increased above recommended guidelines)	-150 mmHg (high frequency aspiration – virtually continuous at a much higher pressure)	-580 to -720 mmHg (nearly 4-5 times higher than recommended)	Tailored by patient, -50 to -150 mmHg
Accuracy of Pressure Delivered	Not reliable	Not reliable	Always Higher than recommended Guidelines	Accurate/reliable
Frequency	Continuously, 24/7	Aspirating virtually continuously with short pauses (16 seconds), 24/7	Hourly (often less regularly)	Tailored by patient, Aspiration for 10 - 20 seconds and pause for 5 - 20 minutes, 24/7
Daily Aspirations	Non-Stop Aspiration	1,440 - 3,600 aspirations daily	24 aspirations daily	24 - 144 aspirations daily
Noise Level	Highly Noisy	Highly Noisy	None	Quiet
Staff Time (per bed per day)	10 minutes	10 minutes	120 minutes	10 minutes
Volume of Secretions	10 - 30 ml	10 - 30 ml	30 ml	100 - 500 ml
FDA Cleared	No	No	No	Yes
Specifically Designed for SSD	No	No	No	Yes
Potential for Cross Contamination	Yes	Yes	Yes	Minimized

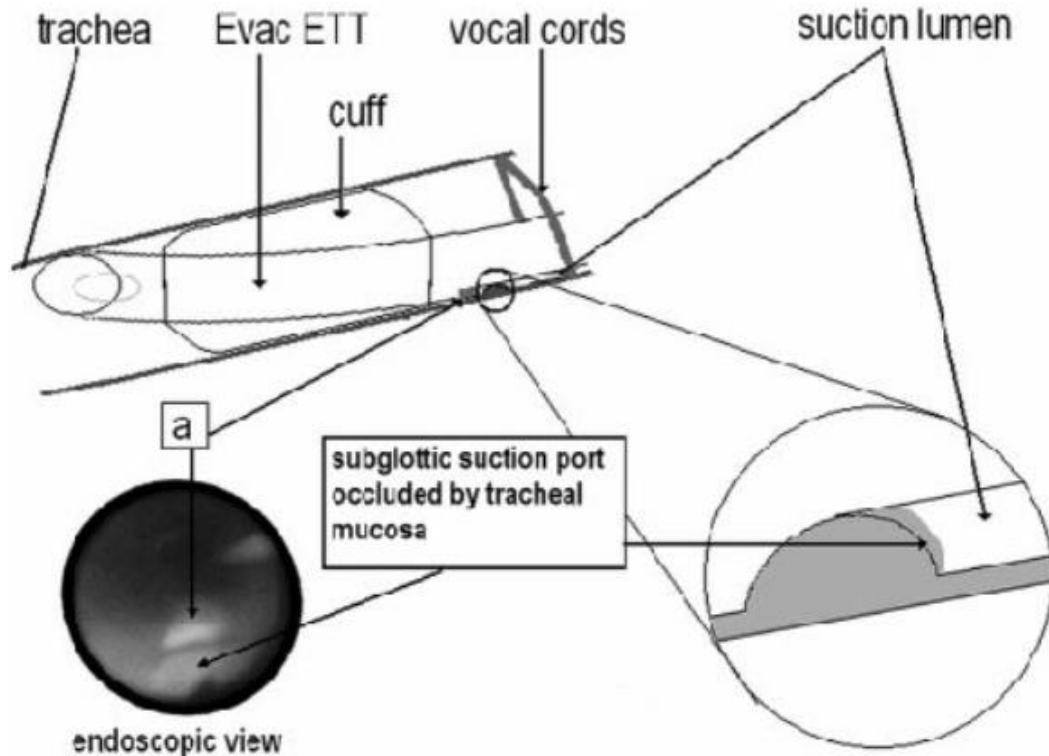
Challenges: SGD ET Tube

- Configuration of the tube
- Suction blockage
 - △ 40 intubated patients/SGD
 - 48% blockage
 - 43% caused by suctioned tracheal mucosa
- Safety of the tube with continuous or intermittent suction and mucosal tissue damage
- 40% laryngeal edema



Challenges: SGD ET Tube

Investigating the Failure to Aspirate Subglottic Secretions with the Evac Endotracheal Tube



DISCUSSION

The observed incidence of Evac ETT suction lumen dysfunction in our study was high, 48% (95% CI: 32%–63%). Moreover, it appears that the dominant cause of suction lumen dysfunction was occlusion of the subglottic suction port by suctioned tracheal mucosa (Fig. 1). This finding raises significant questions concerning the safety of evacuation of subglottic secretions with subglottic suction using the Evac ETT.

- 40% laryngeal edema

Subglottic Suction Endotracheal Tube: A Better Way

- Tissue Spacer
 - △ Multiple Ports, smooth, soft,
- When it does a better job*
 - △ Reduces Risk of VAP
 - △ Reduces Respiratory Needs
 - △ Reduces Time on Ventilation
 - △ Reduces Antibiotics Use



*Pozuelo-Carrascosa DP, et al. Eur Respir Rev. 2020 Feb 12;29(155)

*Szarpak L, et al. Am J Emerg Med. 2021 Feb 2:20 (21)

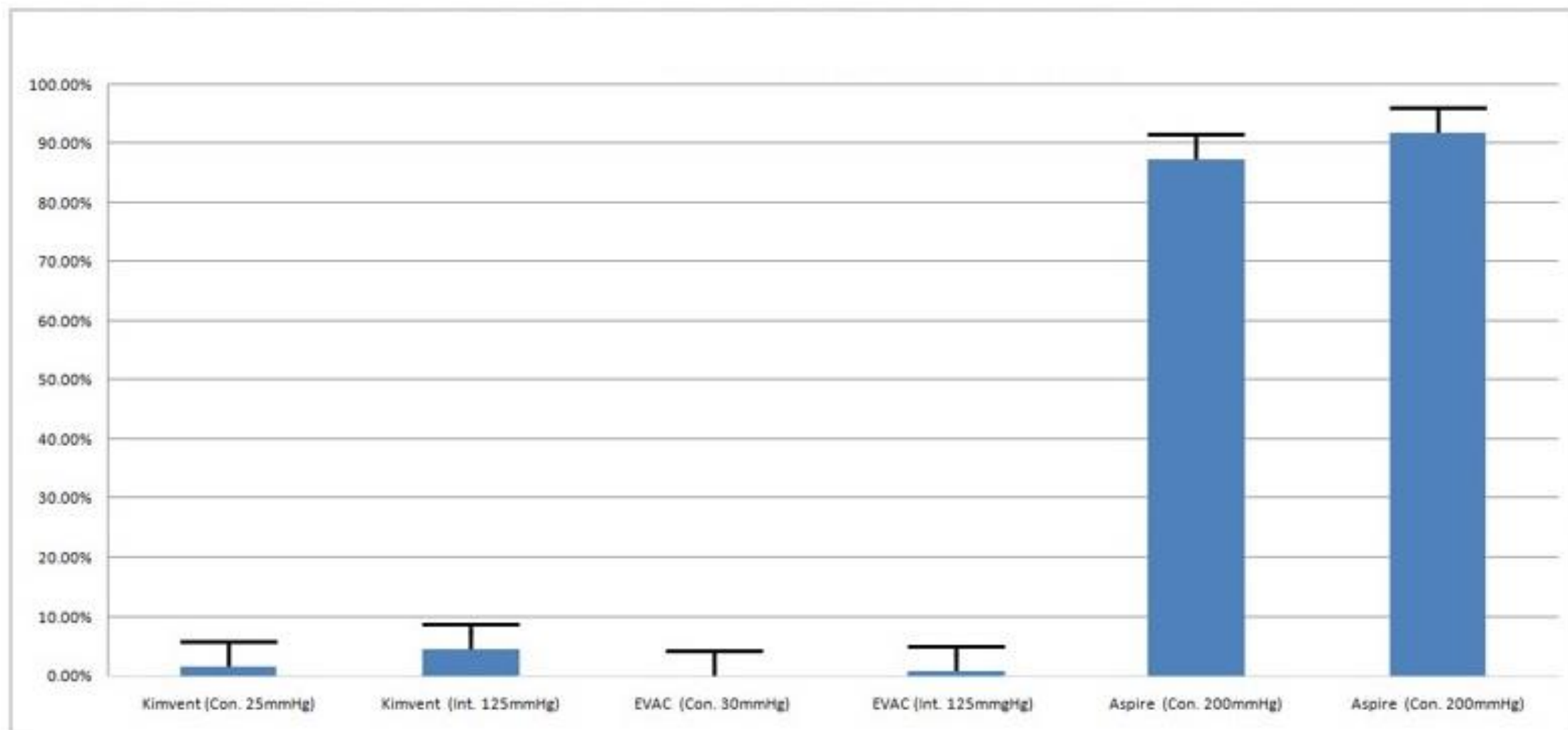
Comparison of Single and Multi-Port SGD tubes



- 7 porcine trachea/set up to simulate 30° HOB
- Controlled model without SG tube
- 1033 cc of simulate oral secretions were dripped over 52 hrs.
 - △ Regular ET tube: 95% leaked past cuff
 - △ Single port SG tube: All experience suction failure due to tissue
 - △ Multi-Port SG tube: Rapidly removed fluid/preventing leakage (0 % leakage)

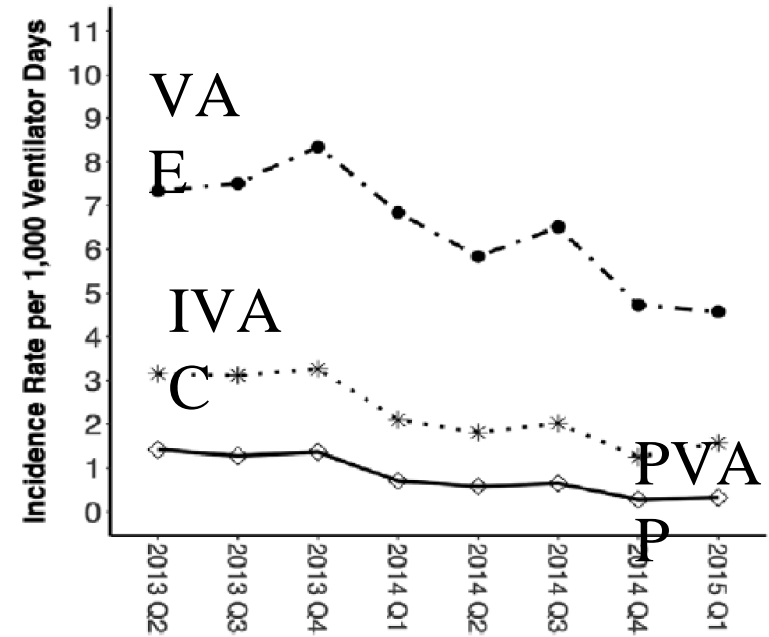


Comparison of Single and Multi-Port SGD tubes



Impact of a New Bundle/2 State Collaborative

- 38 hospitals, 56 ICU's in 2 states from October 2012 to March 2015
- Evidence based interventions, teamwork & safety culture
- Head-of-bed elevation, use of subglottic secretion drainage endotracheal tubes, oral care, chlorhexidine mouth care, and daily spontaneous awakening and breathing trials.



- VAE: 7.34 to 4.58 cases per 1,000 ventilator-days ($p = 0.007$)
- IVAC 3.15 to 1.56 per 1,000 ventilator days ($p = 0.018$)
- PVAP 1.41 to 0.31 cases per 1,000 ventilator-days ($p = 0.012$)



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