Slide 1

Ventilator-associated events: a patient safety opportunity

Michael Klompas MD, MPH, FRCPC, FIDSA

Harvard Medical School, Harvard Pilgrim Health Care Institute, and
Brigham and Women's Hospital, Boston, MA

Hosted by Paul Webber
paul@webbertraining.com

www.webbertraining.com   May 8, 2014

Slide 2

Disclosures

Honoraria from Premier Healthcare Alliance for lectures on VAP surveillance

Slide 3

CDC — Special Point of View Article

Developing a New, National Approach to Surveillance for Ventilator-Associated Events*

Shelley S. Magill, MD, PhD[1]; Michael Klompas, MD, MPH[2,3,4]; Robert Balk, MD[5,6];
Suzanne M. Burns, RN, ACNP, MSN, RRT[6,7]; Clifford S. Deutschman, MS, MD[6,8];
Daniel Diekema, MD[9,10]; Scott Fridkin, MD[1]; Linda Greene, RN, MPS[11,12];
Alice Guh, MD, MPH[1]; David Gutterman, MD[6,13]; Beth Hammer, RN, MSN, ANP-BC[6,14];
David Henderson, MD[15]; Dean Hess, PhD, RRT[16,17,18]; Nicholas S. Hill, MD[6,19];
Teresa Horan, MPH[1]; Marin Kollef, MD[6,20]; Mitchell Levy, MD[6,21]; Edward Septimus, MD[22,23];
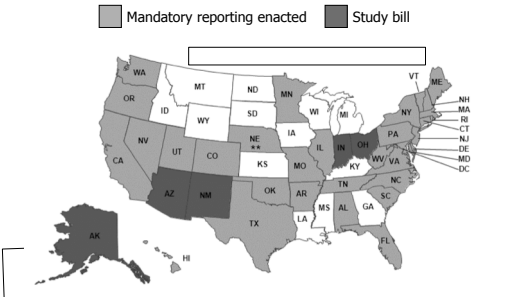Carole VanAntwerpen, RN, BSN[24,25]; Don Wright, MD, MPH[26]; Pamela Lipsett, MD, MHPE[6,27]

Critical Care Medicine 2013;41:2467-2475

Slide 4

Outline

- **VAE – how did we get here?**
  - Limitations of VAP surveillance
- **VAE: morbidity and clinical correlates**
- **Preventing VAEs**
- **Can better surveillance drive better care?**

Slide 5

States with mandatory reporting legislation for healthcare-associated infections

☐ Mandatory reporting enacted   ☐ Study bill

Association for Professionals in Infection Control and Epidemiology 2012

Slide 6

The NEW ENGLAND JOURNAL *of* MEDICINE

Perspective
OCTOBER 18, 2007

Nonpayment for Performance? Medicare's New Reimbursement Rule

Meredith B. Rosenthal, Ph.D.

"Centers for Medicare and Medicaid Services (CMS) announced its decision to cease paying hospitals for some of the care made necessary by 'preventable complications'"

CDC's old surveillance definition for VAP

Patient must fulfill each of the three categories below:

Chest Radiograph	*Any one of the following:* 1. New, progressive, or persistent infiltrate 2. Consolidation 3. Cavitation
Systemic Signs	*Any one of the following:* 1. Temperature >38°C 2. WBC <4,000 or >12,000 WBC/mm³ 3. For adults 70 years old, altered mental status with no other recognized cause
Pulmonary Signs	*Any two of the following:* 1. New onset of purulent sputum, or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements 2. New onset or worsening cough, or dyspnea, or tachypnea 3. Rales or bronchial breath sounds 4. Worsening gas exchange, increased oxygen requirements, or increased ventilation demand

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Complicated

Labor Intensive

Subjective

Non-Specific

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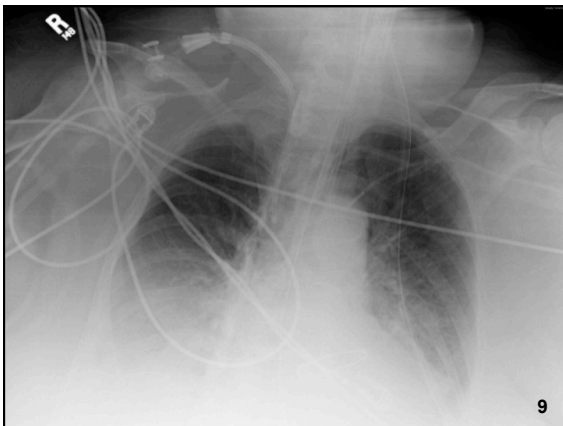
9

"Diffuse patchy airspace disease right greater than left with obliteration of both hemi-diaphragms. Opacities possibly slightly increased since yesterday accounting for changes in patient position and inspiration. This could represent atelectasis, pneumonia, or effusion."

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Sources of fever and infiltrates

ARDS
Diffuse alveolar damage
Thromboembolic disease
Hemorrhage
Infarction
Fibrosis
Carcinoma
Lymphoma
Contusion

Tracheobronchitis
CLABSI
UTI
Drug fever
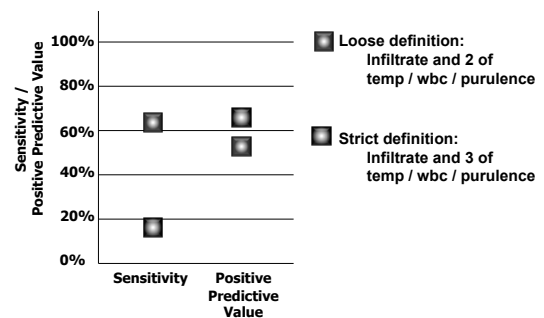
PLUS

Pulmonary edema
Atelectasis
Contusion
Fibrosis

Meduri, *Chest* 1994; 106:221-235
Petersen, *Scand J Infect Dis* 1999; 31:299-303

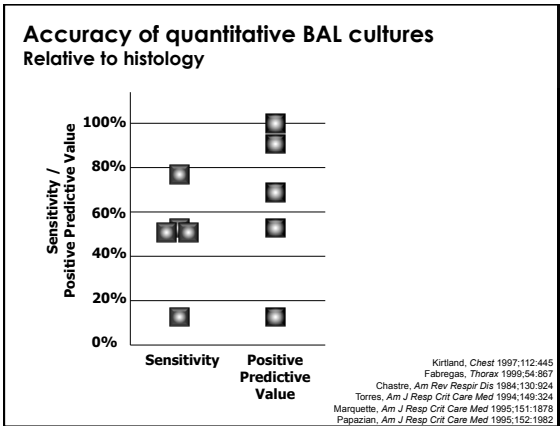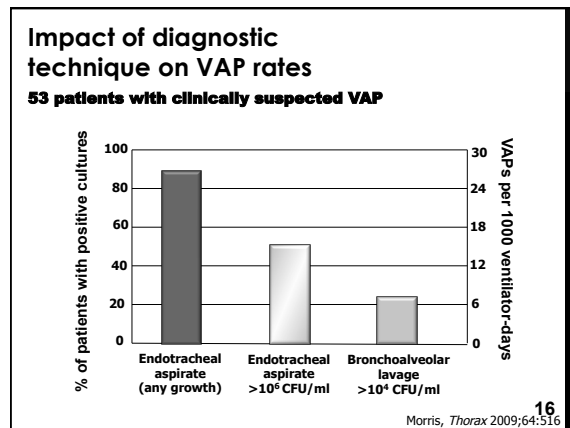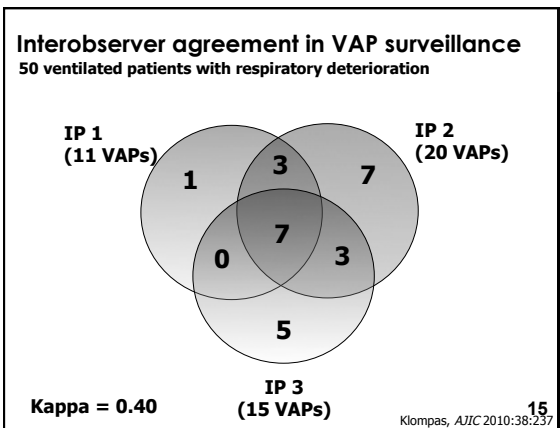## Accuracy of clinical diagnosis of VAP
Relative to 253 autopsies

Loose definition:
Infiltrate and 2 of temp / wbc / purulence

Strict definition:
Infiltrate and 3 of temp / wbc / purulence

Tejerina et al., J Critical Care 2010;25:62

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Accuracy of quantitative BAL cultures
Relative to histology

Kirtland, *Chest* 1997;112:445
Fabregas, *Thorax* 1999;54:867
Chastre, *Am Rev Respir Dis* 1984;130:924
Torres, *Am J Resp Crit Care Med* 1994;149:324
Marquette, *Am J Resp Crit Care Med* 1995;151:1878
Papazian, *Am J Resp Crit Care Med* 1995;152:1982

Implications
for surveillance

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Interobserver agreement in VAP surveillance
50 ventilated patients with respiratory deterioration

IP 1
(11 VAPs)

IP 2
(20 VAPs)

1   3   7

0   7   3

5

IP 3
(15 VAPs)

Kappa = 0.40

Klompas, *AJIC* 2010:38:237   15

Impact of diagnostic technique on VAP rates
53 patients with clinically suspected VAP

Morris, *Thorax* 2009;64:516   16

Ways to lower VAP rates
Without meaningfully changing patient care

1. Narrowly interpret subjective clinical signs
2. Narrowly interpret radiographs
3. Seek consensus between multiple IP's
4. Allow clinicians to veto surveillance determinations
5. Increase use of quantitative BAL for diagnosis

Klompas, *Clin Infect Dis* 2010:51:1123-26
Klompas, *Am J Infect Control* 2012;40:408-10

National VAP rates
United States, 2004-2011

SICUs

MICUs

18
Source: CDC NNIS and NHSN

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International VAP Rates

Source: CDC Europe and CDC USA

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Increasing gap between clinical and surveillance VAP rates

15% of ICU pts on
VAP Rx
on cross-sectional surveys

Thomas et al. *Am Surgeon* 2011;77:998
Skrupky et al. *Crit Care Med* 2012;40:281
Koulenti et al. *Crit Care Med* 2009;37:2360
Vincent et al. *JAMA* 2009;302:2323

Where does this leave hospitals?

We need to publicly report VAP rates to catalyze improved quality of care and save lives!

But the definition of VAP is ambiguous, hard to implement, and open to be gamed!

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An alternative approach to surveillance

Broaden the focus from pneumonia alone to the syndrome of ventilator complications in general

- More accurate description of what can be reliably determined using surveillance definitions
- Emphasizes the importance of preventing **all** complications of mechanical ventilation, not just pneumonia

Streamline the definition using quantitative criteria

- Reduce ambiguity
- Improve reproducibility
- Enable electronic collection of all variables

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VAC
Ventilator-Associated Condition

IVAC
Infection-related
Ventilator-Associated Complication

Possible Pneumonia　　**Probable Pneumonia**

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Ventilator Associated Events: A Patient Safety Opportunity
Prof. Michael Klompas, Harvard Medical School
A Webber Training Teleclass
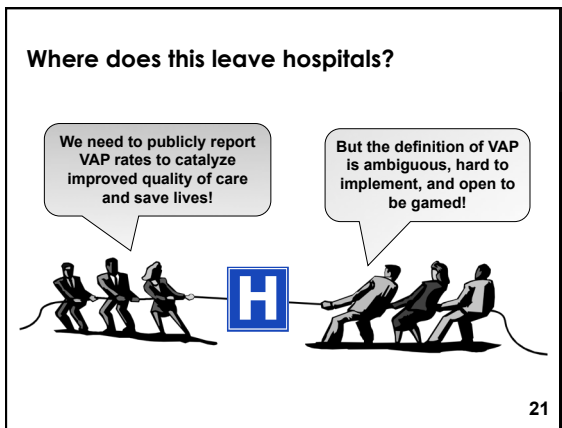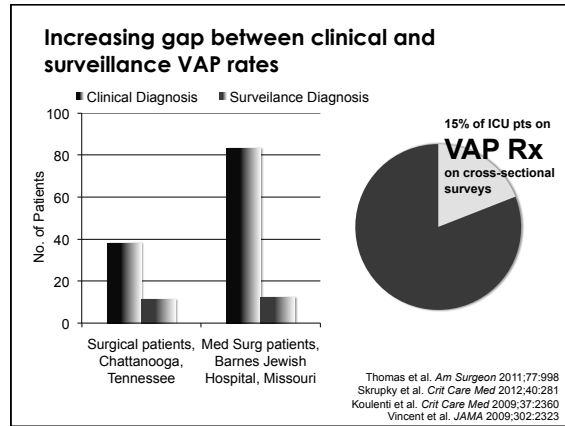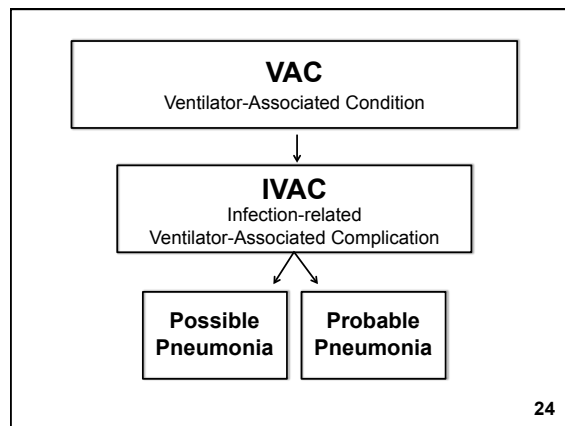
Ventilator-associated conditions (VAC)
Sustained rise in daily minimum PEEP or FiO2 after a period of stable or improving daily minimum PEEP or FiO2

Date	PEEP (min)	FiO2 (min)
Jan 1	10	100
Jan 2	5	50
Jan 3	5	40
Jan 4	5	40
Jan 5	8	60
Jan 6	8	50
Jan 7	8	40
Jan 8	5	40
Jan 9	5	40

VAC

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Infection-related ventilator-associated complications (IVAC)
VAC with concurrent abnormal temp or WBC count AND ≥4 days of new antibiotics

Date	PEEP (min)	FiO2 (min)	T min	T max	WBC min	WBC max	Antibiotic	Antibiotic
Jan 1	10	100						
Jan 2	5	50						
Jan 3	5	40	99.1	99.9	8.4	10.1		
Jan 4	5	40	99.3	101.9	9.9	11.2	Linezolid	Cefepime
Jan 5	8	60	98.6	102.2	12.1	15.3	Linezolid	Cefepime
Jan 6	8	50	98.8	100.3	14.1	17.4		Cefepime
Jan 7	8	40	96.8	99.1	15.0	16.1		Cefepime
Jan 8	5	40						Cefepime
Jan 9	5	40						Cefepime

IVAC

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Ventilator-associated pneumonia
IVAC with concurrent purulent sputum (Gram stain neutrophils) and / or positive pulmonary cultures

Date	PEEP (min)	FiO2 (min)	Gram Stain Polys	Gram Stain Epis	Culture
Jan 1	10	100			
Jan 2	5	50			
Jan 3	5	40			
Jan 4	5	40	3+	0	Klebsiella pneumoniae
Jan 5	8	60			
Jan 6	8	50			
Jan 7	8	40			
Jan 8	5	40			
Jan 9	5	40			

PROBABLE VAP

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http://www.cdc.gov/nhsn/VAE-calculator

Start Over   Calculate IVAC   Explain...   Go to VAP

There are 4 Qualifying Antimicrobial Days (QADs) in a row so this meets the definition of an IVAC. Click on "Go to VAP" button to determine if this case conforms to a Possible or Probable Ventilator-Associated Pneumonia (VAP) definition.

MV Day	Date	Hide... Min. PEEP (cmH₂O)	Hide... Min. FiO₂ (30 - 100)	VAE	36°> T >38°	4,000 cells/mm³ ≥ WBC ≥ 12,000 cells/mm³	Add... Remove... CEFOTAXIME	QAD
1	10/01/2012	10	100		☐	☐	☐	
2	10/02/2012	8	80		☐	☐	☐	
3	10/03/2012	5	50		☐	☑	☐	
4	10/04/2012	5	40	☑	☑	☐	☑	yes
5	10/05/2012	8	50	IVAC	☐	☐	☑	yes
6	10/06/2012	8	60		☐	☐	☑	yes
7	10/07/2012	5	50		☐	☐	☑	yes
8	10/08/2012	5	40		☐	☐	☐	
9	10/09/2012				☐	☐	☐	
10	10/10/2012				☐	☐	☐	

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Intriguing! But many questions

1. How does VAC compare to VAP?
2. What are the clinical correlates of VAC
3. Are these clinically meaningful complications?
4. Are these things preventable?

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Canadian Critical Care Trials Group ABATE Study
11 ICUs, 1330 patients, VAC vs VAP Surveillance

VAC
9.9 events per 1000 vent days
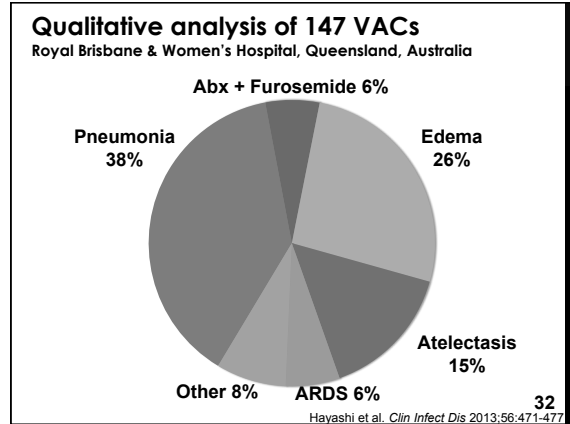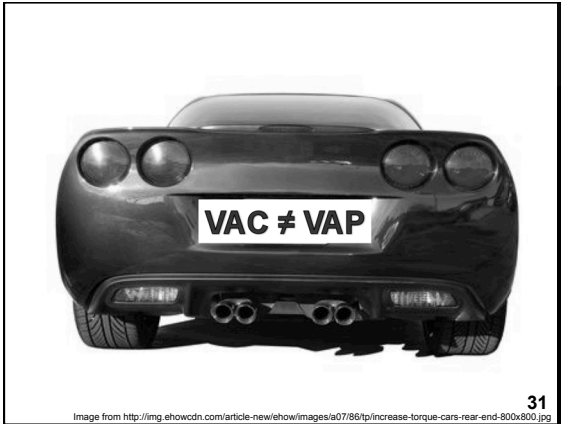
vs

VAP
10.6 events per 1000 vent days

100   39   109

Muscedere et al. Chest 2013;ePub ahead of print

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VAC ≠ VAP

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Image from http://img.ehowcdn.com/article-new/ehow/images/a07/86/tp/increase-torque-cars-rear-end-800x800.jpg

Qualitative analysis of 147 VACs
Royal Brisbane & Women's Hospital, Queensland, Australia

- Abx + Furosemide 6%
- Pneumonia 38%
- Edema 26%
- Atelectasis 15%
- Other 8%
- ARDS 6%

32

Hayashi et al. *Clin Infect Dis* 2013;56:471-477
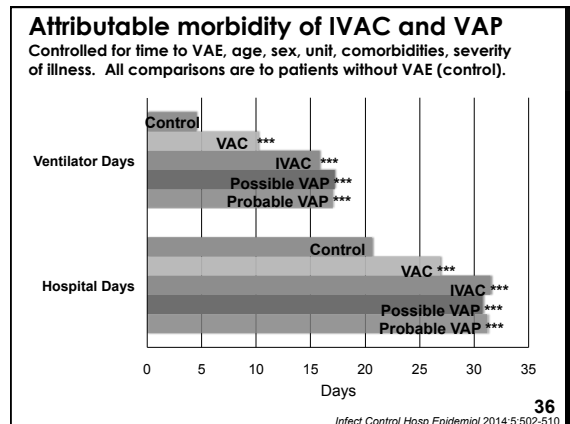
VAC = VAP + CHF + ARDS + Atelectasis + Others

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Attributable mortality and morbidity

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Attributable Mortality of VAC vs VAP

	Adjusted Odds or Hazard Ratio for Death	
	VAC	VAP
USA – 3 Centers	2.0	1.1
USA – 8 Centers	2.4	--
Canada – 11 Centers	2.1	1.5
Netherlands – 2 Centers	3.3	7.2
USA – 1 Center	2.0	--

PLoS ONE 2011;6: e18062; *Crit Care Med* 2012;40:3154-3161; *Chest* 2013;144:1453-1460;
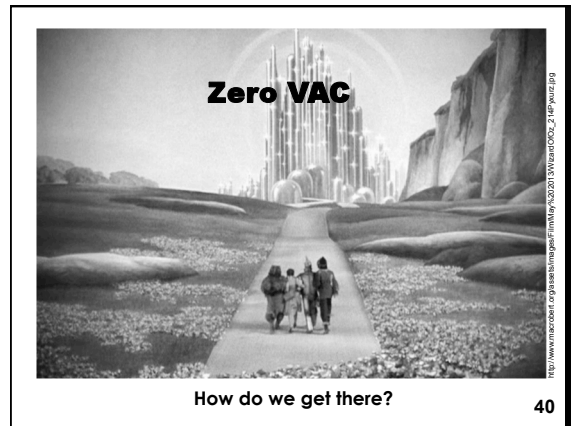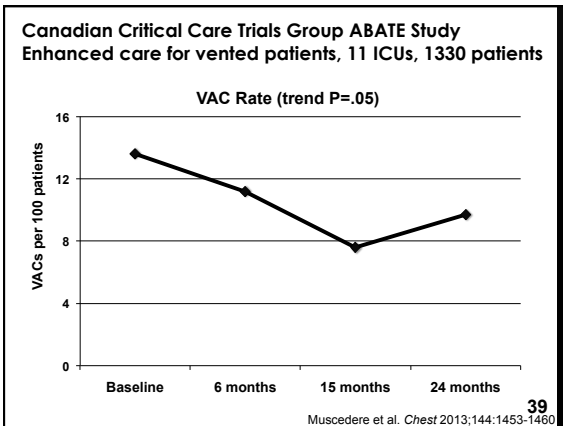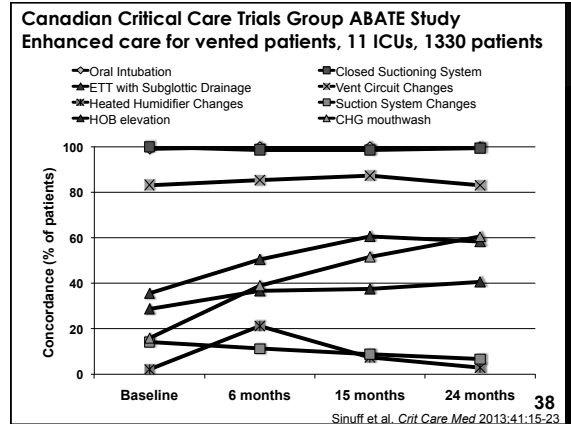*Am J Resp Crit Care Med* 2014;189:947-955; *Infect Control & Hospital Epidemiol* 2014;5:502-510

Attributable morbidity of IVAC and VAP
Controlled for time to VAE, age, sex, unit, comorbidities, severity of illness. All comparisons are to patients without VAE (control).

Ventilator Days
- Control
- VAC ***
- IVAC ***
- Possible VAP ***
- Probable VAP ***

Hospital Days
- Control
- VAC ***
- IVAC ***
- Possible VAP ***
- Probable VAP ***

Days

36

Infect Control Hosp Epidemiol 2014;5:502-510

Preventability

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Canadian Critical Care Trials Group ABATE Study
Enhanced care for vented patients, 11 ICUs, 1330 patients

Legend:
- Oral Intubation
- ETT with Subglottic Drainage
- Heated Humidifier Changes
- HOB elevation
- Closed Suctioning System
- Vent Circuit Changes
- Suction System Changes
- CHG mouthwash

Sinuff et al. *Crit Care Med* 2013;41:15-23

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Canadian Critical Care Trials Group ABATE Study
Enhanced care for vented patients, 11 ICUs, 1330 patients

VAC Rate (trend P=.05)

Muscedere et al. *Chest* 2013;144:1453-1460

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Zero VAC

How do we get there?

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Canadian Critical Care Trials Group
Multivariate analysis of risk factors for VAC

Variable	Odds Ratio (95% CI)	P-value
APACHE II score	0.92 (0.82, 1.04)	0.17
Hospital days to ICU admission	1.09 (0.99, 1.20)	0.09
% ventilator days with SBTs	**0.97 (0.94, 1.01)**	**0.10**
% ventilator days with SATs	**0.93 (0.99, 1.04)**	**0.05**
% ventilator days with CHG oral care	1.02 (0.99, 1.04)	0.18

Muscedere et al. *Chest* 2013;144:1453-1460

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Risk factors for VAC and IVAC

Case control study to identify potentially modifiable risk factors for VAC and IVAC

Patient with VAC matched to patients without VAC

- Matched on age, sex, unit type, Charlson score, and time to VAC
- 110 cases, 110 controls
- 38 of the 110 VAC patients met IVAC criteria

Evaluated vent bundle adherence, sedatives, analgesics, paralytics, nutrition, blood products, fluid balance, vent modes, tidal volumes…

Lewis et al., *Crit Care Med* 2014; ePub ahead of print

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Multivariate Analysis

Risk factors for VAC	Odds Ratio	95% CI
Mandatory ventilator mode (AC, PC, VC)	3.4	1.6-8.0
3-day net fluid balance (per liter)	1.2	1.0-1.4
Propofol	0.5	0.2-1.1
History of congestive heart failure	0.4	0.2-1.0
Risk factors for IVAC		
Benzodiazepines	5.0	1.3-29
Total opioids	3.3	0.9-16
Paralytics	2.3	0.8-8.0

43
Lewis et al., Crit Care Med 2014; ePub ahead of print

Strategies for preventing VAEs

Decrease duration of mechanical ventilation

Target the primary conditions associated with VAC

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Strategies for preventing VAEs

Minimize sedation

Early mobility

ETT with subglottic suction

Low tidal volume ventilation

Conservative fluid management

Minimize blood transfusions

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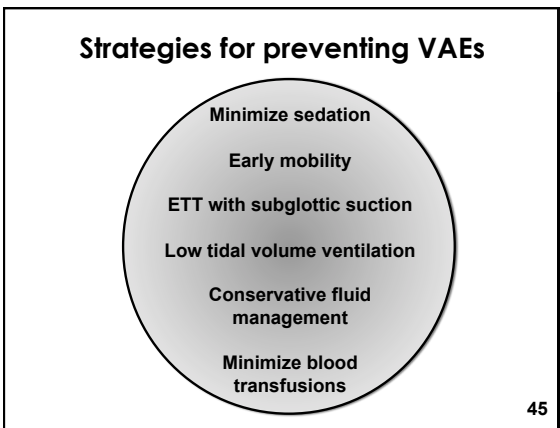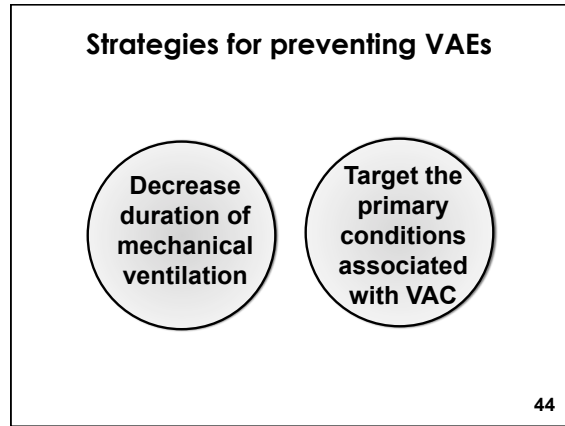
Enhanced prevention of VAEs

⬇ Strong evidence from RCTs and/or meta-analyses

⇩ Probable but not proven

	Duration of Ventilation	Pneumonia	Atelectasis	ARDS	Pulmonary Edema
Paired SATs and SBTs	⬇	⇩		⇩	
Early Mobility	⬇		⇩		
ETTs with subglottic drainage	⬇	⬇		⇩	
Low tidal volume ventilation		⬇	⬇	⬇	
Conservative fluid management	⬇				⬇
Minimize blood transfusions	⇩	⇩		⇩	⇩

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Conservative fluid management

http://microgravity.grc.nasa.gov/SOPO/ICHO/HRP/ExMC/
IVFluids/images/IVbag.jpg

About a third of VACs are due to pulmonary edema

Elevated central venous pressures associated with increased mortality rates

Randomized controlled trial showing conservative fluid management associated with more ventilator-free days compared to liberal fluid management

Boyd et al., *Crit Care Med* 2011;39:259
ARDSnet, *NEJM* 2006;354:2564

BNP Driven Fluid Management

- **Randomized controlled trial of ventilator weaning**

- **304 patients randomized to daily BNP levels versus usual care**

- **Patients randomized to daily BNP levels**
  - More diuretics
  - More negative fluid balance
  - Less time to extubation
  - **50% fewer VACs**

P=.02

48
Dessap et al. *Chest* 2014; ePub ahead of print

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Time for a new ventilator bundle?

Endotracheal tubes with subglottic secretion drainage

Paired daily spontaneous awakening & breathing trials

Early mobility

Conservative fluid management strategy

Conservative blood transfusion strategy

Low tidal volume lung ventilation

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Summary

- VAC intentionally seeks all complications of mechanical ventilation severe enough to require sustained increases in ventilator support

- VAC ≠ VAP. Most cases are attributable to:
  - Pneumonia
  - Pulmonary edema
  - ARDS
  - Atelectasis

- Powerful predictor of adverse outcomes (increased ventilator days, hospital days, and mortality)

- Emerging evidence of preventability but we probably need a new ventilator bundle that specifically targets the fuller array of conditions associated with VAC

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Ventilator-associated events
A patient safety opportunity

Broaden Awareness
- VAE surveillance provides hospitals with a fuller picture of serious complications in mechanically ventilated patients

Catalyze Prevention
- A significant portion of VAEs are likely preventable

Reflect and Inform Progress
- VAE surveillance provides an efficient and objective yardstick to track one's progress relative to oneself and to peers

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NEJM 2013;368:1472

Thank You!

Michael Klompas (mklompas@partners.org)

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