Prevention of Ventilator-Associated Events

Developing a Bundle

Mark J. Rosen, MD, FCCP, FCCM, FACP
Director, Global Education
American College of Chest Physicians
Professor of Medicine
Hofstra North Shore-LIJ School of Medicine

Suhail Raoof, MD, FCCP, FCCM, MACP
Chief, Pulmonary and Critical Care Medicine
Vice-Chair, Department of Medicine
Methodist Hospital Brooklyn, NY
Professor of Clinical Medicine
Weill Medical School of Cornell University New York
Eligible for VAE Surveillance

- ≥18 years of age
- Inpatients of acute care, long term acute care, inpatient rehabilitation

- Excluded
  - High frequency ventilation
  - Extracorporeal life support

- Included
  - Conventional mechanical ventilation in the prone position
  - Conventional of mechanical ventilation while receiving nitric oxide or epoprostenol therapy
  - Airway Pressure Release Ventilation (APRV) or related modes: VAC determined by changes in FiO\textsubscript{2} only. Change in PEEP may not be apply to APRV.
VAE Definition

Respiratory

- Patient on mechanical ventilation > 2 days
- Baseline period of stability or improvement, followed by sustained period (>2 days) of worsening oxygenation

Infection / inflammation

- General evidence of infection/inflammation
- Infection-Related Ventilator-Associated Complication (IVAC)

Microbiology

- Positive results of microbiological testing
- Possible or Probable VAP

Ventilator-Associated Condition (VAC)

No CXR needed!
VAE Definition Algorithm

Respiratory
- Mechanical ventilation > 2 days
- Baseline stability or improvement, followed by sustained period of worsening oxygenation
- Ventilator-Associated Condition (VAC)

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Microbiology
- Positive results of microbiological testing
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- **VAE Definition Algorithm**

  **Respiratory**
  - Mechanical ventilation > 2 days
  - Baseline stability or improvement, followed by sustained period of worsening oxygenation
  - **Ventilator-Associated Condition (VAC)**

  **Infection / inflammation**
  - General evidence of infection/inflammation
  - **Infection-Related Ventilator-Associated Complication (IVAC)**

  **Microbiology**
  - Positive results of microbiological testing
  - **Possible or Probable VAP**

  - FiO₂ or PEEP
VAE Definition Algorithm Summary

1. Patient on mechanical ventilation > 2 days
2. Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
3. Ventilator-Associated Condition (VAC)
4. General evidence of infection/inflammation
5. Infection-Related Ventilator-Associated Complication (IVAC)
6. Temperature or WBC and New antimicrobial agent > 4 days
7. Positive results of microbiological testing
8. Possible or Probable VAP
**VAE Definition Algorithm Summary**

- **Patient on mechanical ventilation > 2 days**
- Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
- **Ventilator-Associated Condition (VAC)**
- General evidence of infection/inflammation
- **Infection-Related Ventilator-Associated Complication (IVAC)**
- Positive results of microbiological testing
- **Possible or Probable VAP**

- **Respiratory status component**
- **Infection / inflammation component**

- Purulent secretions and/or other positive laboratory evidence
Proposed Bundle for Preventing VAE

- Interdisciplinary approach
- Lung-protective ventilation
- Early liberation from mechanical ventilation
- Titrated analgesia and sedation
- Daily sedation holiday
- Elevation of head of bed
- Early mobilization
- Mouth and endotracheal tube hygiene
- DVT prophylaxis
- GI prophylaxis

- Pressure- or Volume- Targeted
- VT 6 mL/Kg ideal body weight [IBW], then 5 or 4 ml/Kg IBW in 2-4 hours if plateau pressure is >30 cm H2O

- Targets:
  - Pplat < 30 cm H2O
  - SpO2 >87% or PaO2 >55 mm Hg
  - FiO2 ≤ 0.6, PEEP 5-15 cm H2O
  - pH >7.25
  - When any of goals cannot be met, discuss priorities with health care team (MD, RT, and RN)

*(Mortality Reduction 39.8% to 31% (22% reduction) N=861)*
Ventilator Management

ARDS Risk Factors

- Tidal volume >700 ml (OR 2.6)
- PIP >30 cm (OR 1.6)
- PEEP >5 cm (OR 1.7)


- Reducing TV (10.6 to 7.7 mL/kg IBW) and reducing blood transfusions (63% to 38%) reduced incidence of acute lung injury from 28% to 10% (p < .001).

Yilmaz M. Crit Care Med 2007; 35(7): 1660-6
Direct pulmonary insult:
- Pneumonia
- Aspiration
- Toxic inhalation
- Pulmonary contusion
- Pulmonary vasculitis

Indirect pulmonary insult:
- Extra-pulmonary sepsis
- SIRS
  - Trauma
  - Pancreatitis
  - Post-circulatory arrest
- Multiple transfusions
- Severe burns
- Cardiopulmonary bypass

Insult secondary to mechanical ventilation
Ventilator Strategies: non-ARDS

*Similar to ARDS*

- **Mode:** Volume or Pressure-Assist
- **VT:** 6-8 mL/kg IBW (lower TV=lower incidence of lung injury)
- **PEEP(e) ≥ 5 cm**
- **Targets**
  - $P_{plat} < 30$ cm H2O
  - Minimize PEEP(i) – up to 80% PEEP(i) in asthma, COPD
  - $\text{SpO}_2 > 90\%$ or $\text{PaO}_2 > 60$ mm Hg
  - $\text{FiO}_2 \leq 0.6$
  - When any of these goals cannot be met, review priorities with team (MD, RT, and RN)
Rescue Therapy
Don’t wait-you may be too late

Prone position, recruitment, extracorporeal
Rescue Strategies

Consider if after 12 - 24 hours if any of the following:

- $\text{PaO}_2/\text{FIO}_2$ ratio < 100 mmHg
- Plateau pressure > 30 cm H$_2$O on a tidal volume of 4 mL/Kg IBW
- Oxygenation index > 30

Ventilator Management

Early Extubation

- Reduced risk of ventilator associated pneumonia, LOS, costs
- Daily spontaneous breathing evaluation unless:
  - Worsening respiratory status
  - Hemodynamic instability and/or arrhythmias
  - Heavy sedation and/or paralysis
  - P/F ratio <150-200
  - PEEP >10 cm H2O
  - pH <7.25
Preventing VAE

Pain

- Assess daily with validated scales (Behavioral Pain Scale, Critical Care Pain Observation Tool)

- Treatment
  - Pre-emptive analgesia prn (procedures)
  - Opioids are first-line drugs
  - Titrate to specific endpoints
  - Consider nonopioids to decrease amount of opioids

- Special considerations: see guidelines

Preventing VAE

Sedation

- Light levels associated with shorter duration of MV and ICU stay
- Monitor with validated assessment tools:
  - Richmond Agitation-Sedation scale (RASS)
  - Sedation-Agitation Scale (SAS)
- Non-benzodiazepine (propofol, medetomidine) may be preferred over benzodiazepines (midazolam, lorazepam)

A Common Algorithm for the Transition from Mechanical Ventilation to Spontaneous Breathing.


Spontaneous Breathing Trial

- Perform daily assessment of patient’s readiness to undergo SBT
  - Ready
    - SBT for 30 min
      - SBT successful
        - Assess airway, cough, airway secretions, and mentation
          - Factors adequate
            - Extubate
          - Factors inadequate
            - Resume ventilatory support
      - SBT stopped because of tachypnea, poor gas exchange, or discomfort
    - Not ready
Spontaneous Breathing Trial

**Methods**

- T-piece
- CPAP ~ 5cm H$_2$O;
- PSV (5 – 7 cm H$_2$O)

*Automatic tube compensation*

*Proportional Assist Vent*

*Servo Controlled Vent*
Extubation Algorithm

- Underlying problem reversed
- Pre-requisites fulfilled (FIO₂, PEEP, P/F, BP, Respiratory Drive)

SBT → Few minutes

Monitor patient (simple parameters)

Stable → Continue SBT 30 – 120 min

Unstable → Ventilation

Stable → Unstable

Disconnect → Stable
DIFFICULT TO LIBERATE

T-piece trial
1-3 min
✓ RSBI

RSBI < 100
T-piece
CPAP
PSV = 7-8 cm
No SIMV

RSBI > 100

30 – 120 min SBT
Search, treat reversible causes of resp failure

RSBI < 100
HR increase 20 – 25%
BP increase by 20 – 25%
SpO2 ≥ 90%, RR < 35/min

(20 – 30 % pts)

Yes
Liberate (70%-80%)

No

Khatib MF. CCM 2008; 12 : 221
**FAILED SBT**

- **RSBI < 100**
  - **Full Vent Support 24 hrs**
  - **PSV**
  - **PSV**
  - **Run in phase** 1-3 min
  - **RSBI < 100**
  - **30 – 120 min trial**
  - **ET tube occlusion**
  - **Leak test**
  - **Secretions**
    - **RSBI < 100**
      - **Favorable**
        - **Liberate ± NIPPV**
    - **RSBI > 100**
      - **Look for reversible causes**
      - **Tracheostomy**
  - **Newer Modes**
    - **ATC**
    - **PAV**
    - **Servo vent**

- **T- PIECE**
  - **1-3 min**
Prevent extubation failure in patients with successful SBT and the following risk factors:

- Age > 65 yrs
- Cardiac failure
- APACHE II Score > 12 at time of extubation
- Failure of consecutive weaning trials
- PaCO$_2$ > 45 post-extubation
- Weak cough

Extubate directly to NIV (2B)

*Canadian Critical Care Trials. CMAJ 2011.183(3);E195-214*
Preventing VAE-Delirium

- Goals for delirium in ICU:
  - Prevention
  - Reduction in duration
- Affects 60-80% MV pts\(^{(1)}\)
- Effects\(^{(2)}\):
  - Duration of MV
  - Self-extubation risk
  - Physical restraints
  - LOS/costs\(^{(3)}\)
  - Mortality\(^{(4, 5)}\)

1. Ely EW. JAMA 2001;286(21):2703
2. Dubois MJ.ICM 2001.27(8):1297
4. Ely EW. JAMA 2004; 291(14);1753
5. Quimet S. ICM 2007; 33(1);66
## Prevent Delirium

<table>
<thead>
<tr>
<th>RISK FACTORS</th>
<th>PREVENTION</th>
<th>EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEDATIVES</td>
<td>• Daily spontaneous awakening</td>
<td>• Coma duration reduced</td>
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<tr>
<td></td>
<td>• Daily SBT</td>
<td>• Reduced ICU days with acute brain dysfunction</td>
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<tr>
<td></td>
<td>• Avoid BENZODIAZEPINES</td>
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<tr>
<td></td>
<td>• Coma duration reduced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reduced ICU days with acute brain dysfunction</td>
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<tr>
<td>IMMOBILITY</td>
<td>• Minimal sedation (comfort and safety)</td>
<td>• PT/OT beginning within 72 hrs of ET reduced delirium by 50%</td>
</tr>
<tr>
<td></td>
<td>• Daily awakenings</td>
<td>(Schweickert WD. Lancet 2009;373:1874)</td>
</tr>
<tr>
<td></td>
<td>• Early proactive approach</td>
<td>• Fewer days delirium and coma by reducing sedation, early mobilization</td>
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<td></td>
<td>• Cultural change, trained personnel</td>
<td></td>
</tr>
<tr>
<td>SLEEP ARCHITECTURE</td>
<td>Minimize</td>
<td>Ear plugs reduced delirium or mild confusion (von Rompaey-Crit Care 2012;16(3):R73)</td>
</tr>
<tr>
<td></td>
<td>• Discomfort</td>
<td></td>
</tr>
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<td></td>
<td>• Minimize vent dyssynchrony</td>
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<tr>
<td></td>
<td>• Noise (ear plugs)</td>
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<td></td>
<td>• Nocturnal interventions</td>
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<td></td>
<td>• Normalize day-night illumination</td>
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</tbody>
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Prevent Delirium
ABCDE

Awakening
Spontaneous Breathing
Choosing sedatives less likely to cause delirium
Delirium management
Early mobility
Harmful effects of immobility:
- Delirium
- Decubitus ulcers
- Muscular atrophy (decline of 1-1.5% per day-mass)
- Deconditioning

Causes:
- Atelectasis + pneumonia
- Orthostatic hypotension
- Deep venous thrombosis
## Early Mobilization

<table>
<thead>
<tr>
<th>Trials</th>
<th>Reference</th>
<th>Main conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDS Hospital, Salt Lake City</td>
<td>Bailey CCM 2007</td>
<td>Intubated pts OOB to chair, walk asap. Sedation minimized. Adverse events very rare</td>
</tr>
<tr>
<td>Wake Forest Univ</td>
<td>Morris. CCM 2008</td>
<td>330 pt: early mobilization group OOB to chair 5 days sooner and LOS reduced by 2 days. Adverse events rare.</td>
</tr>
<tr>
<td>Belgium group</td>
<td>Burtin. CCM 2009</td>
<td>Mainly surgical ICU. Bicycle ergometer at foot of bed. 84% intubated and MV. Strength and 6MWT were improved in test group. Rare adverse events</td>
</tr>
<tr>
<td>FRENCH group</td>
<td>Bourdin. Resp Care 2010</td>
<td>20 pts, start at median of 5 days. Sitting in bed—OOB to chair—walking. Adverse events 3% of cases</td>
</tr>
<tr>
<td>RCT blinded observers evaluating</td>
<td>Schweickert. Lancet 2009</td>
<td>Start immediately after ET placement in MICU. Daily sedation interruption, SBT, early enteral nutrition, tight sugar control. ICU delirium reduced by 50%. 59% test group achieved functional independence at discharge, 35% in control. Premature d/c of therapy occurred in 4% test group</td>
</tr>
<tr>
<td>Hopkin’s experience</td>
<td>Needham. Arch Phys Med Rehabil 2010</td>
<td>Minimize sedation, awaken, OOB, P/T. ICU LOS shortened 2.1 days and hosp LOS by 3.1 days</td>
</tr>
</tbody>
</table>
Preventing VAE-Early Mobilization

Stiller safety considerations for mobilizing critically ill patients (2007).

(1) Safer to increase the intensity of activity slowly and progressively as each treatment is tolerated
(2) General physiological principle and clinical acumen guide clinical practice
(3) Activity should be selected based on assessment of patient's underlying cardiovascular and respiratory reserve
(4) Activity should be determined from the patient's response to previous mobilization treatments
(5) Appropriate activity duration and frequency are extremely variable for critically ill patients
(6) Duration and frequency depend on patient's underlying condition
(7) Mobilization should be functional as possible
(8) If possible, a short warm-up period should be accomplished
(9) Patient safety should be considered during all phases of a mobilization activities
Preventing VAE
Early Mobilization

- **Pre-requisites**
  - Patient awake
  - Able to interact with environment
  - Respiratory stability
    - FiO2 <0.6
    - PEEP <10 cm H2O
  - Cardiac stability
    - No orthostasis
    - Not on catecholamine infusions
  - Miscellaneous
    - No unstable pelvic conditions, femoral arterial line
    - BMI<40
Early Mobilization

Principles

- Team approach: PT, OT, RN, Assistant
- Not if patient deeply sedated
- Should be gradually stepped up
- Start as soon as patient responsive
- Practical sequence may be:
  - Active bed exercises
  - Sitting at edge of bed
  - Standing
  - Marching in place
  - Walking
Proposed Bundle for Preventing VAE

- Interdisciplinary approach
- Lung-protective ventilation
- Early liberation from mechanical ventilation
- Titrated analgesia and sedation
- Daily sedation holiday
- Elevation of head of bed
- Early mobilization
- Mouth and endotracheal tube hygiene
- DVT prophylaxis
- GI prophylaxis
- IV fluid administration as per ICU protocol
There are people who make things happen…

Steve Jobs

People who watch things happen…

And there are people who wonder… “What happened?”
Thank You