Ventilator Associated Events (VAE): Can They Be Prevented?

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Objectives

• Define Ventilator Associated Events (VAEs) and their clinical significance

• Describe potential strategies for prevention of VAEs through the critical care continuum
The Complexity of Critical Illness

Photo by John Gallagher
What is it that we do?

Create safe passage for our patients through the healthcare experience

• Treating the patient for the immediate problems

• Protecting them from complications of injury/illness and the associated treatments
What are Ventilator Associated Events (VAE)?

CDC Surveillance Definitions (2017)

Causes of VAE

- **Pneumonia**: 20% (20% of the frequency)
- **Fluid Overload** (Pulmonary Edema): 30% (30% of the frequency)
- **Atelectasis**: 10% (10% of the frequency)
- **ARDS**: 5% (5% of the frequency)
Interventions to Reduce VAE

PREVENT INTUBATION

CARE DURING VENTILATION

VENTILATOR LIBERATION
Interventions to Prevent Intubation

• High Flow Nasal Cannula (HFNC)
• Use of non-invasive positive pressure ventilation (NIPPV)
• Fluid Management
High Flow Nasal Cannula (HFNC)

- 40 to 60 liters per minute
- FiO₂ 100% (titrate to requirement)
- No limit to length of use

Indications
- Acute Hypoxemic RF/Respiratory distress
- Oxygenation during procedures
- Post-extubation support
- Prevention of Intubation/DNR
- Palliative support
High Flow Nasal Cannula (HFNC)

- Flushes CO$_2$ of physiologic deadspace (150 mls)
  - Oro-pharynx
  - Large airways
- Meets Higher Minute Ventilation Demands
  - Improves V/Q matching
- Nasal CPAP
  - Prevents small airway closure
  - Prevents alveolar collapse
High Flow Nasal Cannula (HFNC)

- 310 patients with hypoxemic respiratory failure
  - Standard Oxygen therapy
  - HFNC
  - NIPPV
- Intubation rates did not differ significantly among the three groups but trended lower in the high-flow–oxygen group
- This group also had a significantly lower mortality at 90 days, more ventilator-free days, and less respiratory discomfort

Non-invasive Positive Pressure Ventilation

Avoidance of Intubation
Non-invasive Positive Pressure Ventilation
Patient Selection

Level B: Evidence from well designed controlled studies, both randomized and nonrandomized, with results that consistently support a specific action, intervention or treatment.

- OSA
- Cardiogenic Pulmonary Edema
- Acute on chronic respiratory failure (i.e., chronic obstructive pulmonary disease)

Level C: Evidence from qualitative research, observational studies or controlled trials with inconsistent results

- Immunosuppressed patients with pneumonia
- Acute hypoxemic respiratory failure.

Level D: Evidence from peer reviewed professional organization standards, or integrative reviews, no clinical studies to support recommendations

- To prevent re-intubation following extubation.

Level E: Evidence, theory based, from expert opinion or multiple case reports

- Failure to wean.
- Invasive ventilation not desired; palliative or end-of-life care
NIPPV for Prevention of Complications

- Lower risk of pneumonia
- Decrease duration of MV
- Decrease ICU and Hospital LOS
- Death

Hess, D. R. (2005) Resp Care, 50(7)
Burns et al. (2013) Cochrane Review
Contraindications

- Inability to protect the airway
- Inability to manage secretions (aspiration risk)
- Hemodynamic instability
- Agitation
- Claustrophobia (relative)
- Worsening acidosis
Interventions During Ventilation

- Airway/Oral Care
- Head of Bed Elevation
- Low Tidal Volume Ventilation (LTVV)
- Fluid Management
- Minimizing Sedation
- Exercise/Mobilization
Airway Management and Oral Care

Prevention of Aspiration

Airway Technology

Oral Care

Airway Maintenance
Airway Technology

Altering Cuff Shape Allows for Better Sealing Characteristics

Proximal cuff:
Cuff diameter > Tracheal diameter

Sealing band (mid cuff):
Cuff diameter = Tracheal diameter eliminating excess cuff material locally
• 24 bed Medical Surgical ICU

• 280 intubated patients
  • 140 Conventional ETT (ETT-C)
  • 140 Polyurethane cuff with sub-glottic secretion drainage (PUC-SSD)

• Results
  • ETT-C VAP Rate: 22.1% (31/140)
  • PUC-SSD VAP Rate: 7.9% (11/140)

• Conclusion
  • PUC-SSD endotracheal tube helps to prevent both early and late VAP
Removal of Subglottic Secretions

• Aspiration of pooled secretions above the endotracheal cuff

• Research
  • Mixed results in preventing VAP
  • Statistically significant delay in onset of VAP
  • No mortality improvement

Cuff Pressure and ETT Repositioning

- Cuff Pressure Maintain between 20 to 30 cmH₂O
  - Minimal Occlusive Volume (MOV)
  - Minimal Leak Technique (MLT)

- Suction the oral cavity/above the cuff
  - Every 2-4 hours
  - Before repositioning the ETT
  - Before manipulating the cuff pressure
  - Before extubation
Oral Hygiene

- Prevention or modification of oropharyngeal decontamination
  - Mechanical cleansing of teeth/mucosa
  - Application of local antibacterial agents
    - 1.5% peroxide
    - Chlorhexidine (0.12%)
    - Topical antibiotics

Chlorhexidine

• Topical Chlorhexidine is beneficial in preventing or delaying the onset of VAP (concentration range: 0.12, 0.2, 2%)
  • Most compelling evidence in cardiac surgery population
  • Reduction in other populations also noted at 2% concentration
  • Optimal frequency of application to be determined

• No impact on mortality

• Grap, MJ (2004) Heart and Lung; 33(2)83-91
Aspiration Prevention

• Supine position identified as an independent risk factor for VAP
  • Three (3) trials of 337 patients
    • 1 found significant benefit

• Easy, Low cost and Low risk
Low Tidal Volume Ventilation (LTVV)

- ARDSNET Trial 2000
  - Lower mortality rate with 6 ml/Kg IBW (vs. 12 ml/Kg) in ARDS

- Protective impact now extended to those without ARDS
  - Each ml above 6 ml/Kg PBW increases VAE odds 21%
Mechanical Ventilation

Volume Control
- A/C
- SIMV

Pressure Control
- PEEP
- A/C
- SIMV
- Support
Ventilator Induced Lung Injury

Mechanical Ventilation–associated Lung Fibrosis in Acute Respiratory Distress Syndrome: A Significant Contributor to Poor Outcome
Lung Protective Principles

- Maintain safe transalveolar pressures
  - Plateau pressure $< 30 \text{ cm H}_2\text{O}$

- Prevent end-tidal alveolar collapse
  - PEEP
Improving Oxygenation

- Manipulation of FiO$_2$
- Manipulation of Mean Airway Pressure (Paw)
Mean Airway Pressure (Paw)

\[ \text{Paw} = \frac{\text{area under the pressure curve}}{\text{duration of the cycle}} \]
Increase Mean Airway Pressure

- PEEP
- Square Waveform
- I:E Ratio Manipulation
  - Inverse Ratio Ventilation (IRV)
- Recruitment maneuver
APRV Characteristics

- High CPAP level with a short expiratory releases at set intervals (rate).
- APRV always implies an inverse I:E ratio
- All spontaneous breathing is done at upper pressure level
Alveolar Volumetric Changes

Conventional

Exp.

Insp.

APRV

Insp. $\approx$ Exp.
Volume Overload

• Volume overload increases interstitial edema worsening gas exchange

• Positive fluid balance associated with increase in VAEs and mortality
  • ARDS
  • Sepsis
  • Pneumonia

• Compounded by PPV/PEEP/ARDs
Conservative Fluid Management/Endpoints

• Static Parameters
  • Measure a point in time
  • CVP, PCOP, LVEDV

• Dynamic Parameters (Functional)
  • Measure a functional change in stroke volume or surrogate (PPV, SVV, SPV)
  • Echo
  • May require a “challenge”
Volume Challenge Process

1. Assessment Findings/Decision to Challenge
2. Volume Challenge
   - Passive Leg Raise/Rapid Fluid Bolus
3. Evaluation of Response
4. Dynamic Monitoring Device
Transgastric Short Axis

**GOAL**
- Assess preload and contractility

**TECHNIQUE**
- Advance probe past gastroesophageal junction into stomach
- Anteflex to optimize contact
- Image at the mid-papillary level

**ASSESSMENT**
- Assess preload using LV size, measure the LVEDA
- Assess LV contractility by FAC

Midesophageal Four Chamber

**GOAL**
- To evaluate biventricular size and function

**TECHNIQUE**
- Position probe just below aortic valve level
- Retroflex to visualize four chambers in long axis (LAX)

**ASSESSMENT**
- Evaluate relative size of RV and LV in diastole
- Left ventricular systolic function
- Right ventricular systolic function
- Shape and kinetics of interventricular septum

Superior Vena Cava

**GOAL**
- To assess volume responsiveness

**TECHNIQUE**
- Position probe above the aortic valve
- Visualize SVC adjacent to the ascending aorta

**ASSESSMENT**
- SVC size and collapsibility
Conservative Blood Transfusion Threshold

- Associated risks for VAE related to volume overload (TACO) or inflammatory response trigger
  - TRALI
  - ARDS
  - Sepsis
  - Pneumonia

- Reserved for clear indication of component therapy
Interventions to Promote Ventilator Liberation

• Spontaneous Awake Trial (SAT)
• Spontaneous Breathing Trial (SBT)
• Mobilization
• Fluid Management
ABCDEF Bundle

- Assess, Prevent and Manage Pain
- Both SAT and SBT
- Choice of Analgesia and Sedation
- Delirium: Assess, Prevent and Manage
- Early Mobility and Exercise
- Family Engagement and Empowerment
- Goals of Care

http://www.iculiberation.org

Assess, Prevent and Manage Pain
Agitation
Both SAT and SBT
Choice Analgesia Sedation
Early Mobility and Exercise

Benefits of Early Mobility

- Preserves musculoskeletal and neuromuscular integrity
- Enhances cardiovascular function
- Enhances endothelial function
- Decreases chronic inflammation
- Regulates hormone levels
- Improves blood sugar homeostasis
- Decreases depression and improves cognition
Equipment Helps
Summary: VAE Prevention Strategies

- Avoid mechanical ventilation through the use of non-invasive Positive Pressure Ventilation and HF Nasal Cannula

- Prevent complications during mechanical ventilation by using LTVV, elevating the HOB, providing oral care and giving fluids and transfusions conservatively

- Limit the duration of mechanical ventilation by minimizing Sedation, perform daily SAT and SBT, and implementing Early Exercise and Mobility programs

- Engage family

- Goals of Care
Caring for the critically-ill patient is both art and science

It requires mastery of assessment skills and the ability to understand both the benefits as well as limitation technology in monitoring and treatment of our patients.
Thank You

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