Nurses and Respiratory Therapists – Working Together for Safe Alarm Systems Management

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AAMI Foundation

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  • Contact Sarah Lombardi at slombardi@aami.org
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LinkedIn Questions

Please post questions about alarms on the AAMI Foundation’s LinkedIn page:
http://www.linkedin.com/groups/Healthcare-Technology-Safety-Institute-HTSI-4284508
Speaker Introductions

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Disclosures

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Objectives

- Describe the basics of ventilator alarms
- Rank the importance of ventilator alarms based on the physiologic responses the ventilator alarms represent
- Develop a strategy to respond appropriately to various ventilator alarms
- Identify the daily nursing activities that trigger ventilator alarms
# Alarm Safety and Fatigue

## The Problem
- Visual/audible alarms when the patient’s condition changes or machine error
- Drastically increased number of devices with audible alarms at the bedside.
- Overwhelmed bedside practitioners exposed to different levels of audible alarms

## The Effects
- Alarm fatigue
- “False alarms” versus non-clinically actionable alarms
- Nuisance alarms
- Adverse patient outcomes
- #1 on ECRI Institute Top 10 Health Technology Hazards in 2015
- TJC National Patient Safety Goals
- AAMI Foundation National Coalition for Alarm Management Safety
Mechanical Ventilation 101

Indications

• Apnea
• Acute respiratory failure
• Impending respiratory failure
• Refractory hypoxemia

Types

• Invasive
  • Requires artificial airway (endotracheal tube or tracheostomy tube)
  • Provides airway for patient who cannot protect his/her own airway

• Non-invasive
  • Delivered via face mask, nasal mask/pillows
  • Does not provide a protected airway
    • Patient must be able to protect his/her own airway
Mechanical Ventilation 101

Pressure v Volume
- **Pressure:**
  - Breath terminates when pre-set pressure is reached
  - Volume is variable depending on patient compliance and resistance
- **Volume**
  - Breath terminates when pre-set volume is reached
  - Pressure is variable depending on patient compliance and resistance

Modes
- **Pressure**
  - PC-CMV, PC-SIMV, PSV, AVAPS
- **Volume**
  - VC-CMV, VC-SMIV
- **Dual modes**
  - Pressure limited, volume targeted (VS, PRVC)
  - Pressure limited, volume guaranteed
Mechanical Ventilation 101

Breath Types
- Spontaneous
  - Patient initiates, patient determines depth and length
- Supported
  - Patient initiates, machine supports depth
- Mandatory
  - Machine initiates, machine determines depth and length

Trigger Types
- Pressure
  - Preset pressure detected
- Flow
  - Preset flow detected
- Volume
  - Preset volume detected
- Time
  - Preset time interval has elapsed
Patient effort; patient triggers machine with negative pressure

No patient effort; no negative deflection below pressure baseline
Pressure Support Ventilation

A. Patient effort
B. Support from machine (PS)
   B1-Over-shoot
   B2-Under-shoot
C. Plateau
D. Termination of support
Mechanical Ventilation 101

**Pressure Settings**
- Respiratory rate \((f)\)
- Peak pressure \((\text{PIP})\)
- Inspiratory time \((T_I)\)
- Positive expiratory pressure \((\text{PEEP})\)
- Fraction of inspired oxygen \((\text{FiO}_2)\)

**Volume Settings**
- Respiratory Rate \((f)\)
- Tidal volume \((V_T)\)
- Inspiratory flow \((V)\)
- Positive expiratory pressure \((\text{PEEP})\)
- Fraction of inspired oxygen \((\text{FiO}_2)\)
Mechanical Ventilation 101

• Measured values
  • Peak inspiratory pressure (PIP)
  • Plateau pressure ($P_{PLAT}$)
  • Minute ventilation ($V_E$)
  • Auto-PEEP
  • Total respiratory rate
  • Exhaled tidal volume ($V_T$)
Anatomy of a Waveform
Influencing Factors

Oxygen

Carbon Dioxide
Patient in Distress

- Heightened sternomastoid activity is evidence of increased patient effort.
- Recession may be seen in the suprasternal and supraclavicular spaces.
- Intercostal space recession also indicates increased patient effort.
- Tachycardia is an indicator of severe cardiopulmonary distress.
- Diaphoresis and nasal flaring indicate increased patient effort.
- Cyanosis is not a reliable physical sign.
- Tachypnea determined over the course of a full minute is a sensitive sign of failure.
- Paradoxical motion of the abdomen is also evidence of increased patient effort.

Potential Ventilator Alarms

- High pressure
  - Achieved PIP is too high
- Low pressure
  - Achieved PIP is too low
- High PEEP
  - Measured PEEP is too high
- Low PEEP
  - Measured PEEP is too low
- Apnea
  - RR falls below set threshold
- Inverse I:E ratio
  - Inspiration is longer than exhalation

- High tidal volume
  - Exhaled $V_T$ is too high
- Low tidal volume
  - Exhaled $V_T$ is too low
- High minute volume
  - Exhaled $V_E$ is too high
- Low minute volume
  - Exhaled $V_E$ is too low
- High/low respiratory rate
  - Patient total RR too high/low
  - Includes spontaneous rates
What did I do?

$\uparrow V_T, V_E$ or RR alarm

- Air hungry
- Sigh
- Pain
- Agitation
- Under sedation
- Procedures
- Water in tube
What do I do?

$V_T$, $V_E$ or RR alarm

Always check the patient first!

Is patient demand $V_E$ increased?

No

Is the ventilator auto-triggering?

No

Is a nebulizer in use?

No

Call RT

Yes

Check the cause of the $V_E$ demand & determine if change is needed

Yes

Check sensitivity

Yes

Collaborate with RT to adjust settings until treatment is complete
What did I do?

↓ pressure, PEEP, VT, $V_E$ alarm

• Disconnected the vent
• Didn’t inflate cuff
• Suctioning
• Over sedation (spontaneous modes)
• Leak in circuit
What do I do? ↓ pressure, PEEP, VT, $V_E$ alarm

- Always check the patient first!
- Is patient disconnected? NO: Reconnect
- Is there a leak in the circuit? NO: Eliminate circuit leak
- Is there a leak in the ETT cuff? NO: Reinflate cuff, check pressure. If cuffless ETT, reposition patient
- Is there a chest tube leak? YES: Determine cause, contact physician and RT, monitor patient
- NO: Call RT
↓ pressure, PEEP, VT, $V_E$ alarm: Air Leaks

Volume-Time Scalar  Pressure-Volume Loop
What did I do?

 Kota pressure or PEEP alarm

- Patency of tube (blocked/clamped/bent)
- Secretions
- Cough
- Resistance
- Poor positioning
What do I do?

→ pressure or PEEP alarm

Always check the patient first!

- Is ETT/trach tube obstructed?
  - Yes: Change the ETT or trach tube
  - No: Is patient coughing?
    - Yes: Suction or relieve irritation
    - No: Are there secretions in the airway?
      - Yes: Suction the patient
      - No:
What do I do?

↑ pressure or PEEP alarm

Always check the patient first!

- Is the patient biting the ETT?
  - Yes: Insert a bite block
  - No:
    - Is the ETT/trach tube position incorrect?
      - Yes: Reposition artificial airway
      - No:
        - ↑ $R_{AW}$ or ↓ $C_L$?
          - Yes: Potential causes:
            - Secretions
            - Bronchospasm
            - Mucosal edema
            - Pneumonia
            - Pulmonary edema
            - Pneumothorax
            - Pleural effusion
          - No:
            - No
↑ pressure or PEEP alarm worsening $C_L$

Pressure Ventilation

Volume Ventilation
↑ pressure or PEEP alarm worsening $R_{AW}$

Much longer expiratory time; increased $R_{AW}$ = takes longer to exhale

Reduced expiratory flow (speed of exhalation)

Area within the loop (hysteresis) is much larger

(From Pilbeam SP: Mechanical ventilation: physiological and clinical applications, ed 3, St Louis, 1998, Mosby.)

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What do I do?

↑ pressure or PEEP alarm

Always check the patient first!

Asynchrony?

1. Check gas flow
2. Check sensitivity
3. Check ventilator settings
4. Check mode
5. Consider sedation

Auto-PEEP?

1. Check and correct for increased $R_{AW}$
2. Decrease $T_1$

Call RT
↑ pressure or PEEP alarm

Asynchrony

Auto-PEEP
What did I do?
Inverse I:E Ratio alarm

- Anything that would cause a change in the RR
- Patient has an increased drive to breathe
  - Pain
  - Need for sedation
What do I do?
Inverse I:E Ratio alarm

Always check the patient first!

Do you want an inverse I:E?
- Yes: Activate the function to allow inverse I:E ratio
- No

Is the RR too high?
- Yes: Decrease RR
- No

Is volume ventilation being used and VT too up or down?
- Yes
  1. If VT too high, decrease volume
  2. If VT too low, increase flow
- No: Call RT
What did I do? Apnea alarm

• Over sedated
• Disconnected
• Patency of tube
What did I do?

Apnea alarm

Always check the patient first!

Is the patient actually apneic?  
No  
Can the ventilator sense patient effort?  
No  
Is there a leak?  
No  
Call RT

Yes  
Ensure appropriate ventilatory support or manually ventilate

Yes  
Adjust the sensitivity until the ventilator senses patient effort

Yes  
Eliminate source of leak
Apnea alarm

**Sensitivity**
Pressure drops below baseline because patient has to pull to trigger breath

**Air Leaks**
Exhaled volume does not reach baseline

(From Pilbeam SP: Mechanical ventilation: physiological and clinical applications ed 3, St Louis, 1999, Mosby.)

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Case Study

- 23 year old male
- Acute asthma exacerbation secondary to viral infection
- Intubated in ED with 7.5 ETT
- Currently receiving:
  - Midazolam
  - Fentanyl
  - Albuterol via nebulizer

- Ventilator settings:
  - VT = 600 mL (6ml/kg PBW)
  - RR = 10 breaths/min
  - FiO2 = 1.0 (100%)
  - PEEP = 0
  - Flow = 90 L/min
Case Study: After Initiation of Mechanical Ventilation

- **Blood gases:**
  - \( \text{pH} = 7.35 \)
  - \( \text{PaCO}_2 = 47 \text{ mm Hg} \)
  - \( \text{PaO}_2 = 186 \text{ mm Hg} \)
  - \( \text{HCO}_3^- = 25 \text{ mEq/L} \)
  - \( \text{SaO}_2 = 91\% \)

- **Measured Ventilator Parameters:**
  - \( \text{PIP} = 65 \text{ cm H}_2\text{O} \)
  - \( \text{Plateau} = 25 \text{ cm H}_2\text{O} \)
  - \( \text{AutoPEEP} = 8 \text{ cm H}_2\text{O} \)
Take-Home Points

• Always look at the patient first
• Don’t fall victim to alarm fatigue
  • Know your ventilators (capabilities, sounds, etc.)
  • Know your established protocols
  • Confirm ventilator settings and alarm settings at the
    when you first accept the patient for your shift
• When in doubt and the patient is in distress,
  manually ventilate the patient and call for help
References

References

- Papadakos PJ. Electronic distractions of the respiratory therapist and their impact on patient safety. Respir Care 2014;59(8):1306-1309.
Free Alarm Resources

• **Safety Innovations Series**
  • White Papers
  • Patient Safety Seminar Recordings

• **Alarms Management Patient Safety Seminars**
  • Webinar Recordings
  • Webinar Slides
  • Key Points Checklists
Mark Your Calendars!

• 2015 AAMI Annual Conference and Expo
  • June 5-8, 2015; Denver, CO

• Next Patient Safety Seminar: June 15, 2015
  • *Clinical Alarms: Do You Know Your Number?*
  • To register: [https://attendee.gotowebinar.com/register/3188749012882322690](https://attendee.gotowebinar.com/register/3188749012882322690)
Questions?

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**Slides & Recording:**