Actionable Patient Safety Solutions (APSS):

Ventilation Management

How to use this guide

This guide gives actions and resources for Ventilation Management. In it, you'll find:

Patient Safety MOVEMENT

Executive Summary

The Problem

Because mechanical ventilation is one of the most common interventions for patients in the ICU, hospital protocols should be standardized, strong, and frequently reassessed for utmost quality. Furthermore, the tangential adverse effects of poor ventilation management, such as infection and unplanned extubation, are plentiful, expensive, and readily exacerbated.

The Cost

The importance of strong ventilator management policies and workflows is evident in the magnitude of mechanically-ventilated patients per year, with nearly 800,000 hospitalizations involving mechanical ventilation, costing $27 billion and representing 12% of all hospital costs (Kirton, 2011). The lack of strong ventilation management workflows is detrimental to the organization, with ventilator-associated infections alone representing 36,000 annual deaths exclusively in the US (AHRQ, 2017).

The Solution

Many healthcare organizations have successfully implemented and sustained improvements and reduced death from ventilation management. These organizations have focused on projects that included **implementing a ventilation management bundle.**

This document provides a blueprint that outlines the actionable steps organizations should take to successfully improve outcomes for patients on a ventilator and summarizes the available evidence-based practice protocols. This document is revised annually and is always available free of charge on our website. Hospitals who make a formal commitment to improve ventilator safety and share their successes on the PSMF website have access to an additional level of consulting services.

Leadership Checklist

On a monthly basis, or more frequently if a problem exists, the executive team should review the outcomes of patients on a ventilator. Use this checklist as a guide to determine whether current evidence-based guidelines are being followed in your organization:

- ☐ Measure and report ventilation management compliance monthly (ventilator days/total inpatient bed days). Note trends in areas with low compliance and high ventilator-associated harm or death. Routinely reassess outcomes.
- ☐ If ventilator-associated outcomes indicate room for improvement, initiate a PI (performance improvement) project. If a problem is not indicated, routinely reassess to identify gaps, and ensure integrity of the data collected.
- ☐ Ensure frontline involvement in ventilation management improvement activities. Maintain their engagement and remove barriers to progress.
- ☐ If a PI plan is put in place, measure the associated process outcomes.
- ☐ Ensure that adopted ventilation management protocols and standards are embedded into clinical workflows, whether electronic or paper, and are aligned with education, training, and policy throughout the organization.
- ☐ Ensure there are enough staff to effectively manage necessary preventive care.
- ☐ Devise strict guidelines for individuals allowed to change ventilator settings.
- ☐ Ensure adequate training and documentation of ventilator management competencies and skills.
- ☐ Eliminate barriers to making rapid changes to documentation templates and order sets.
- ☐ Debrief on a regular basis to solicit team feedback about barriers to sustained compliance. Adjust the plan quickly and nimbly as needed.
- ☐ Hold staff accountable for providing the standard of care and reward success.
- ☐ Ensure that leaders have a simple process to oversee ventilator management improvement work while also considering how it aligns with other initiatives across the organization.
- ☐ Devise a streamlined discharge process which incorporates pre-discharge planning, follow up, and thorough education for the patient and family members.

Clinical Workflow Infographic

ADMISSION

Do a risk assessment, including an assessment of airway stability and respiration rate. Is this patient at risk for being on a ventilator? Patients at risk include those with obstruction of the trachea, obstructive pulmonary disease, pneumonia, ARDS, weakness of breathing muscles, and/or damage to the surrounding tissue and bones. See here for a comprehensive guide to airway assessment.

INTUBATION

Proper positioning and confirmation are essential for stabilization. Position the endotracheal tube within the trachea at the proper depth with the tip of the ETT within the optimal target range at 2-6 cm above the carina. This positioning will minimize the opportunity for UE if the ETT moves (See APSS: Unplanned Extubation). Many endotracheal tubes have depth positioning markers on the ETT which will facilitate proper depth positioning.

- Confirm proper tracheal position by use of waveform EtCO2 and proper depth position by CSR/US.
- Record the tube depth at the upper incisors.

Verify who is able to adjust the ventilator settings and ensure that this point person is constantly aware of any changes to patient status.

Ensure that the patient has infection prevention protocols embedded in their plan of care. Patients on a ventilator are at risk for ventilator-associated pneumonia. See APSS: Ventilator-Associated Pneumonia for infection prevention strategies.

ROUTINE CARE

If the patient is not on a ventilator, routinely assess for risk. Assess for breathing difficulties and airway compromise (such as low oxygen saturation, labored breathing, increased respiratory rate etc.). Not all patients will have a compromised airway but early recognition and anticipation of potential airway complications can be pivotal for readiness to treat. In short, look for cyanosis, obtundation, agitation, and asymmetry in chest rise upon inhalation. Listen to patient complaints and breath sounds. Be particularly mindful for breath sounds with crackling, stridor, and gurgling. See here for a comprehensive guide to airway assessment. Refer to APSS: Safer Airway Management for more information.

Always conduct a pre-operational check before the use of a ventilator. This check should include assessment of the ventilator circuit, humidifier system, and tubing.

If patient is on a ventilator:

Conduct routine assessments. Assessment should include the following components:

- Understand the reason for the need for mechanical ventilation.
- Check the respiratory rate. Compare the rate on the screen with a manual evaluation.
- Check the tidal volume.
- Investigate changes in peak inspiratory pressure. Peak inspiratory pressure, in general, is usually kept below 40 cmH2O. If the alarm sounds, indicating an increased peak inspiratory pressure, assess the cause. Causes can include, but are not limited to, a kinked tube or sudden pneumothorax.
- Monitor plateau pressure. This pressure should be below 30 cm H20.
- Be vigilant about a tension pneumothorax on a ventilated patient.
- Continuously monitor carbon dioxide and watch for sudden increases or decreases, which may suggest a complication.
- Conduct a thorough pain assessment using both validated objective and subjective measures, including, but not limited to, Critical Care Pain observation tool (CPOT) and Behavioral Pain Scale (BPS).
- Perform suctioning routinely, based on patient need. Decreased SPO2, increased PEEP, and an increasing FiO2 are indications that lend to suctioning. Limit suctioning attempts to 10 seconds. For adults, the appropriate level of the suction vacuum should be between 80 to 120 mmHg.
- Frequently assess the position of the endotracheal tube and auscultate for equal breath sounds. See APSS: Safer Airway Management.
- Ensure cuff pressure is in a range that delivers a clinically-determined tidal volume and reduces aspiration risk. While the pressure range is determined by the hospital, it is typically between 20 to 30 cmH2O.
- Anticipate and proactively plan for hemodynamic instability. Monitor cardiac and respiratory status closely, using continuous pulse oximetry and blood pressure. Determine need for continuous intravenous fluids or pressor drugs.

Understand the ventilator modes and how each impacts the patient.

Limit the number of individuals allowed to make changes to the ventilator.

Determine the optimal way to meet nutritional needs based on the individual patient. 40% of critically ill patients experience malnutrition (Seron-Arbeloa et al., 2013). The route chosen should depend on the patient's illness and gastrointestinal function. Enteral nutrition is the preferred method due to the reduction in septic risk and lower cost. The choice of enteral access is determined by the aspiration risk of the patient. See here for full guidelines to meet nutritional requirements for ventilated patients.

Ensure that every patient on a ventilator has a bag valve mask within reach of their bed at all times for use in an emergency, such as an unplanned extubation or patient-ventilator dyssynchrony.

Determine readiness for appropriate weaning procedures and begin weaning as soon as possible. Assess for capacity to wean daily to reduce the unnecessary ventilation and associated complication risk.

- See here for clinical criteria involved in readiness assessments.
- See here for a table of objective, actionable criteria for weaning.

EXTUBATION

Extubate the patient as soon as possible. Conduct frequent readiness testing to determine those who are ready to wean to reduce the unnecessary ventilation and the associated risks for complications. Readiness testing is also used to determine those who are not ready to wean to protect against premature removal. See here for clinical criteria involved in readiness assessments. See here for a table of objective, actionable criteria for weaning.

DISCHARGE

Transitioning patients who were on a ventilator in the hospital to home:

- Patients are usually discharged from the ICU to a ward for independent breathing when they no longer require mechanical ventilation. ICU staff should follow the patient's progress on the next unit to ensure that complications have not developed and to ensure continuity of care. Once the patient is ready to be discharged from the ward, the following recommendations should be considered to ensure a safe transition home from previously being on a ventilator:
  - Explain the reality of debilitation and the timeline of expected recovery when returning home. Patients will often not understand how tired or weak they will be upon returning home. Providing a realistic timeline for recovery can help the patient in setting goals and can reduce anxiety, confusion, or frustration.
  - Ensure the patient is receiving some form of rehabilitation. This could be physical, occupational, pharmacological, or psychological.
  - Help the patient understand what appointments and medications will be necessary and why. Provide a timeline of when each appointment should happen and how long they will need to take each medication. Provide contact information for all post-discharge appointments and explain instructions for medication use clearly.
  - Help the patient understand what their responsibilities are for their recovery. Aid in goal-setting for the patient.
  - Give practical, specific, and actionable advice on nutrition, mobility, and rehabilitation.
  - Follow up with the patient frequently post-discharge.
  - Ensure thorough and proper communication with all outpatient care team members. This will include background of patient, treatment in the hospital, medications, allergies, current state at discharge, and recommendations for continued care.

In addition to the above considerations, the following should also be included in transitioning the ventilator-dependent patient from hospital to home:

- Train home care givers thoroughly and integrate training into the multiple days leading up to discharge to ensure time for competency checks and questions. Document the caregiver competency in the patient's record. Training should include:
  - Overview of pulmonary anatomy
  - Description of physiological implications of the patient's condition or disease
  - Overview of ventilator settings and how to troubleshoot
  - How to change the ventilator circuit
  - How to perform suctioning and airway care
  - What to do in an emergency
  - How to perform CPR and bagging
  - How to perform infection control and sterilization procedures.

Performance Improvement Plan

Follow this checklist if the leadership team has determined that a performance improvement project is necessary:

- [ ] **Gather the right project team.** Be sure to involve the right people on the team. You'll want two teams: an oversight team that is broad in scope, has 10-15 members, and includes the executive sponsor to validate outcomes, remove barriers, and facilitate spread. The actual project team consists of 5-7 representatives who are most impacted by the process. Whether a discipline should be on the oversight team or the project team depends upon the needs of the organization. Patients and family members should be involved in all improvement projects, as there are many ways they can contribute to safer care.

Complete this Lean Improvement Activity:
Conduct a SIPOC analysis to understand current state and scope of the problem. A SIPOC is a lean improvement tool that helps leaders to carefully consider everyone who may be touched by a process, and therefore, should have input on future process design.

RECOMMENDED VENTILATION MANAGEMENT IMPROVEMENT TEAM	
• Nurses	• Infection control specialists
• Respiratory therapists	• Clinical educators
• Physicians	• Information technology
• Physical and occupational therapists	• Patient and family members
• Environmental service staff	• Admitting and registration staff
• Engineering staff	• Quality and safety specialists
• Dietary staff	

Table 1: Understanding the necessary disciplines for a ventilation management improvement team

- [ ] **Understand what is currently happening and why.** Reviewing objective data and trends is a good place to start to understand the current state, and teams should spend a good amount of time analyzing data (and validating the sources), but the most important action here is to go to the point of care and observe. Even if team members work in the area daily, examining existing processes from every angle is generally an eye-opening experience. The team should ask questions of the frontline during the observations that allow them to understand each step in the process and identify the people, supplies, or other resources are needed to improve patient outcomes.

Create a process map once the workflows are well understood that illustrates each step and the best practice gaps the team has identified (IHI, 2015). Brainstorm with the advisory team to understand why the gaps exist, using whichever root cause analysis tool your organization is accustomed to (IHI, 2019). Review the map with the advisory team and invite the frontline to validate accuracy.

VENTILATION MANAGEMENT PROCESSES TO CONSIDER ASSESSING	
• Hand hygiene	• Suctioning protocols
• Intubation protocols	• Patient positioning
• Ventilator-associated pneumonia protocols	• Sedation vacations
• Environmental cleaning	• Weaning protocols
• Equipment disinfection	• Patient and family education
• Freque and routine oral care	

Table 2: Consider assessing these processes to understand where the barriers contributing to ventilation management may be in your organization

☐ **Prioritize the gaps to be addressed and develop an action plan.** Consider the cost effectiveness, time, potential outcomes, and realistic possibilities of each gap identified. Determine which are a priority for the organization to focus on. Be sure that the advisory team supports moving forward with the project plan so they can continue to remove barriers. Design an experiment to be trialed in one small area for a short period of time and create an action plan for implementation.

The action plan should include the following:

- Assess the ability of the culture to change and adopt appropriate strategies
- Revise policies and procedures
- Redesign forms and electronic record pages
- Clarify patient and family education sources and content
- Create a plan for changing documentation forms and systems
- Develop the communication plan
- Design the education plan
- Clarify how and when people will be held accountable

TYPICAL GAPS IDENTIFIED IN VENTILATION MANAGEMENT	
• Inappropriate setting changes	• Failed or delayed identification of ARDS
• Failure to change alarms	• Excessively high fraction of inspired oxygen
• Unrecognized asynchrony	• Changing settings without appropriate orders
• Inattentiveness to dynamic needs	• Failure to communicate changes to the medical team

Table 3: By identifying the gaps in ventilation compliance, organizations can tailor their project improvement efforts more effectively

☐ **Evaluate outcomes, celebrate wins, and adjust the plan when necessary.** Measure both process and outcome metrics. Outcome metrics include the rates outlined in the leadership checklist. Process metrics will depend upon the workflow you are trying to improve and are generally expressed in terms of compliance with workflow changes. Compare your outcomes against other related metrics your organization is tracking.

Routinely review all metrics and trends with both the advisory and project teams and discuss what is going well and what is not. Identify barriers to completion of action plans, and adjust the plan if necessary. Once you have the desired outcomes in the trial area, consider spreading to other areas (IHI, 2006).

It is important to be nimble and move quickly to keep team momentum going, and so that people can see the results of their labor. At the same time, don't move so quickly that you don't consider the larger, organizational ramifications of a change in your plan. Be sure to have a good understanding of the other, similar improvement projects that are taking place so that your efforts are not duplicated or inefficient.

Read this paper **from the Institute for Healthcare Improvement to understand how small local steps can integrate into larger, system changes**

VENTILATION MANAGEMENT COMPARATIVE OUTCOMES
• Hand hygiene compliance
• Ventilator-associated pneumonia
• ICU LOS
• Readmission rate

Table 4: Consider evaluating related metrics to better understand ventilation management presence and contributing factors

What We Know About Ventilation Management

It is important to recognize that, although ventilator-associated pneumonia cases have gained significant attention in the past, primarily due to their consideration by the U.S. Centers for Medicare and Medicaid (CMS) as 'never-events', there are risks beyond just that of infections for patients on a ventilator. Since CMS announced it would stop reimbursing hospitals for ventilator-associated pneumonia, there was a decrease in the number of cases reported. While this could be due to genuine improvement efforts, it has been suggested that articulating diagnostics differently has contributed to the reported decline. It is important to remain vigilant for any ventilator-associated event while patients are on a ventilator, instead of matching the metrics to what is set forth by the payer. In summary, whenever patients are on a ventilator, they are at significant risk for complications and should be monitored closely, regardless of the metrics set forth.

Complications of Poor Ventilation Management (NIH , n.d.)

- Pneumonia
- Sinus infection
- Antibiotic resistance
- Atelectasis
- Blood clots
- Pulmonary edema
- Lung damage
- Muscle weakness
- Vocal cord damage

Populations at Risk

Those with respiratory problems, such as, but not limited to, obstruction in the trachea, obstructive pulmonary diseases (e.g. asthma, chronic bronchitis, etc.), pneumonia, acute respiratory distress syndrome (ARDS), weakness of breathing muscles, and/or damage to surrounding tissues/bones, are at a higher risk for being on a ventilator (NIH, n.d.).

Other conditions that may lend to ventilation risk include drug overdose, neonatal respiratory distress syndrome, sepsis, spinal cord injuries, polio, and/or amyotrophic lateral sclerosis (ALS). Those undergoing surgery may receive mechanical ventilation to deliver anesthetic drugs, prevent aspiration, and control levels of oxygen and carbon dioxide in the blood (NIH, n.d.).

Patient Assessment and Ventilator Settings

Upon ventilation initiation, it is important to understand the individual patient's circumstance, including medical history, reason for the need for mechanical ventilation, and the goal, as some ventilators default to the last operational setting, which may pose a risk for the current patient.

When assessing a patient on a ventilator, start in standardized sequence as follows (Williams & Sharma, 2020):

- **Check the respiratory rate.** The machine's screen will display the rate. Manually evaluate the patient's respiratory rate and determine if he or she is breathing at a rate above the ventilator setting.
    - The ventilator will also highlight the fraction of inspired oxygen. In a freshly intubated patient, this is usually 100%, and then it can be weaned down based upon the Po2 on the ABG or merely following the pulse oximetry.
- **Check the tidal volume.** The tidal volume is about 6-8 mL/kg of ideal body weight for patients with healthy lungs. For unhealthy lungs, such as in ARDS or ALI, 4-6 mL/kg is used as a protection strategy for the lungs.
- **Investigate changes in peak inspiratory pressure.** Peak inspiratory pressure, in general, is usually kept below 40 cmH2O. Peak inspiratory pressures increase with increased resistance. If the peak inspiratory pressure is high, the machine will sound an alarm. It could be that the endotracheal tube is kinked or the patient is biting down on the tube. It can also mean a mucus plug, bronchospasm, or a sudden pneumothorax.
- **Monitor plateau pressure.** Plateau pressure is pressure applied to the alveoli during positive pressure ventilation. This is measured during a breath-hold when there is no gas exchange occurring. This pressure should be below 30 cm H20. High plateau pressures indicate a problem with compliance of the lungs, such as in ARDS, restrictive diseases, or even obesity.
- **Be vigilant about a pneumothorax on a ventilated patient.** Prompt recognition and treatment of a pneumothorax is significant in reducing harm and death. A delay in treatment can lead to life threatening tension pneumothorax. This can cause a drop in blood pressure and result in respiratory arrest. Tension pneumothorax is more common in ventilated patients and occurs in 30 to over 95% of all pneumothoraces (Hsu & Sun, 2014).
- **Prevent ventilator-associated lung injury (VALI) and mitigate alveolar overdistension by using small tidal volumes (6mL/kg) by body weight and maintaining a plateau pressure of ≤30 cm H2O** (Hyzy & Slutsky, 2019). Lung protective strategies include low tidal volume ventilation and moderate positive end-expiratory pressure (Kimura et al., 2016).

Ventilator Modes

The ventilator mode will depend on patient factors but the usual modes of ventilation include (Williams & Sharma, 2020):

- **Assist control:** The ventilator administers breaths in parallel with the respiration by the patient. Upon inspiration, the ventilator will administer a full assisted tidal volume. Spontaneous breathing is allowed. Assist control is advantageous because it is often used for patients who are unable to take spontaneous breaths due to weakness, recent resuscitation, sedation, and/or ARDS. However, because it delivers a set tidal volume and flow, patients can sometimes become uncomfortable and/or it can lead to patient-ventilator dyssynchrony. This result, known as Auto-PEEP, is associated with poor oxygenation, ventilation, and hemodynamic instability.
- **Controlled mechanical ventilation:** The ventilator will deliver a preset tidal volume and respiration rate. As such, the ventilator breathes completely for the patient and the patient must be paralyzed or heavily sedated. Controlled mechanical ventilation does not allow for independent, spontaneous breathing and if the patient is not paralyzed, this can be problematic. The patient cannot adjust to the PaC02 demand. If this mode of ventilation is used long term, the patient can experience atrophy of the respiratory muscles. This mode of ventilation should not be used outside of the OR.
- **Synchronized intermittent mandatory ventilation:** Unlike controlled mechanical ventilation, this mode allows spontaneous breathing and delivers a set number of breaths in parallel with the patient's respiratory efforts. This allows for movement of the respiratory muscles to improve cardiac function and output. However, this may have a causal relationship with respiratory acidosis and respiratory muscle fatigue. This mode is helpful in the weaning process.
- **Intermittent mandatory ventilation:** The ventilator administers a set, fixed rate tidal volume on the lowest setting to support an appropriate arterial blood gas. The ventilator will deliver the set tidal volume with or without patient effort, therefore, this setting allows the patient to partially engage in independent breathing. As such, it decreases barotrauma risk. However, this mode can lend itself to stacking of breathing, which may cause barotrauma if the ventilator peak inspiratory pressure is not set appropriately.
- **Pressure-supported ventilation:** This mode decreases the burden of breathing for the patient and limits barotrauma. The level of support pressure is set to aid each spontaneous patient effort. This mode can improve oxygenation while lowering the burden of breathing. However, there's no volume guarantee, as the lungs are ever changing. This method is useful for weaning or to manage patients with neuromuscular disorders.

Note that continuous positive airway pressure (CPAP) is not technically classified as a mode of ventilation. Continuous positive pressure is administered to a spontaneously breathing patient, but it is the patient's responsibility to begin and sustain the breaths. Therefore, the rate of respiration and tidal volume are dependent on the patient's efforts, independent of the ventilator. This patient must be closely monitored for fatigue (Williams & Sharma, 2020).

Carbon Dioxide Monitoring

Capnography measures the quantity of exhaled carbon dioxide and is often used to confirm placement of endotracheal tube, to ensure continuous monitoring of the mechanically ventilated patients, and to monitor ventilation during sedation in patients without mechanical ventilation. A sudden decrease may indicate a drop in pulmonary blood flow, thereby suggesting a pulmonary embolism. An increase may indicate cardiogenic shock, cardiac arrest, high ventilation/perfusion lung scan ratios, use of positive end-expiratory pressure, and/or inaccurate calibration of the capnometer (Williams & Sharma, 2020). Therefore, continuous carbon dioxide monitoring is a pillar in safety of mechanically-ventilated patients.

Pain Assessment

- Critical Care Pain observation tool (CPOT): Includes facial expressions, movements, muscle tension, and ventilator compliance.
- Behavioral Pain Scale (BPS): Commonly used in ICUs and considers facial expressions, movement of upper limbs, and ventilator compliance.
- Other methods include objective methods such as electroencephalogram (EEG), auditory evoked potential and signal-processed EEG - bispectral index (BIS) monitors and subjective methods such as Riker sedation-agitation scale (SAS), motor activity assessment scale (MAAS), richmond agitation-sedation scale (RASS), Adaptation to the intensive care environment scale (ATICE), and Ramsay Sedation Scale.

Infection Prevention

See APSS: Ventilator-Associated Pneumonia for infection prevention strategies. In general,:

- Practice good hand hygiene.
- Disinfect the ventilator equipment, including the resuscitation bags, spirometers, and oxygen analyzers.
- Change the condensate fluid regularly.
- Maintain air humidity with a heat moisture exchange humidifier.
- Use closed suctioning systems.
- Use non-invasive ventilation, when possible.
- Apply topical antibiotics on ET tubes.
- Practice good oral care.
- Assess patient daily for readiness to extubate and perform sedation vacations.

- Perform peptic ulcer prophylaxis with PPI or H2-blocker.
- Perform as much mobility as possible, even if that means only turning and repositioning.

Suctioning

Patients may require suctioning to maintain their airway. Patients may be unable to clear their own airway due to problems such as neuromuscular disease, sedation, or neurologic complications. Those who have been intubated typically require suctioning. Indications for suctioning are directly related to respiratory distress due to increased secretions and include high respiratory rate, high heart rate, and gasping. In intubated patientsdecreased SPO2, increased PEEP, and an increasing FiO2 are indications that lend to suctioning. Suctioning attempts should be limited to 10 seconds to allow patient time to recover. For adults, the appropriate level of the suction vacuum should be between 80 to 120 mmHg. For children, this should be between 60 to 80 mmHg to avoid tissue damage.

Endotracheal Tube Positioning

The position of the endotracheal tube should be frequently assessed and the chest should be auscultated for equal breath sounds. See APSS: Safer Airway Management.

Hemodynamic stability: One of the key reasons for admission into the ICU is hemodynamic instability. Mechanical ventilation can alter cardiac output and blood pressure. Potential effects of mechanical ventilation include increased pulmonary vascular resistance, ventricular interdependence, and altered autonomic responses (David et al., 1999). It is important to be able to predict, anticipate, and proactively plan for hemodynamic instability in the ventilated or potentially future ventilated patients.

- Monitor cardiac and respiratory status closely, using continuous pulse oximetry and blood pressure (Williams & Sharma, 2020).
- Determine need for continuous intravenous fluids or pressor drugs (i.e. norepinephrine) (Williams & Sharma, 2020).

Ventilator Alarms

Do not ignore or silence a ventilator alarm without first understanding the cause for alarm.

- Hospital alarm policies should include (Williams & Sharma, 2020):
    - Functionality tests and meaning
    - Competency tests in response to an alarm
    - Tutorials for how to extract and evaluate alarm data
    - Education regarding alarm modification
    - Formal reporting procedures
    - Criteria outlining those allowed to change the alarm

Other Considerations for Ventilator Safety

- Limit the number of individuals allowed to make adjustments to the ventilator.
    - If adjustments are made, notify the respiratory therapist immediately.
- Ensure that every patient on a ventilator has a bag valve mask within reach of their bed at all times for use in an emergency, such as an unplanned extubation or patient-ventilator dyssynchrony.
- Always conduct a pre-operational check before the use of a ventilator. This check should include assessment of the ventilator circuit, humidifier system, and tubing.
- Ensure cuff pressure is in a range that delivers a clinically-determined tidal volume and reduces aspiration risk. While the pressure range is determined by the hospital, it is typically between 20 to 30 cmH2O.

Discontinuation

Discontinuation should consist of readiness testing to determine appropriate weaning procedures.

- **Readiness testing:** The purpose of readiness testing is to determine those who are ready to wean to reduce the unnecessary ventilation and associated complication risk. The second purpose of readiness testing is to determine those who are not ready to wean to protect them against risks of premature weaning (Epstein, 2018).
- See here for clinical criteria involved in readiness assessments.
- See here for a table of objective, actionable criteria for weaning.
    - Although subjective readiness assessments can vary by individual, they are still useful in understanding the present state. Subjective assessment include cough, presence of neuromuscular blocking agents, presence of excessive trachea-bronchial secretion, status of underlying cause for respiratory failure, continuous sedation infusion, and mental status on sedation.

Resources

For ventilator management:

- Sedation in Intensive Care Unit Patients: Assessment and Awareness
- Weaning from Mechanical Ventilation: Readiness Testing
- Patient and Family Education on Mechanical Ventilation Toolkit
- Weaning Predictors: Criteria
- Extubation Management in the Adult Intensive Care Unit
- Enteral Nutrition in Critical Care

For patients and family members:

- Questions to Ask Your Doctor about ARDS
- 10 Things to Know if Your Loved One is On a Ventilator

For general improvement:

- CMS: Hospital Improvement Innovation Networks
- IHI: A Framework for the Spread of Innovation
- The Joint Commission: Leaders Facilitating Change Workshop
- IHI: Quality Improvement Essentials Toolkit
- SIPOC Example and Template for Download
- SIPOC Description and Example

Education for Patients and Family Members

The outline below illustrates all of the information that should be conveyed to the patient and family members by someone on the care team in a consistent and understandable manner.

Explain why ventilation is needed. A member of the healthcare team should elaborate on the need for ventilation and should provide a basic overview of the methods of ventilation preparation and management. The healthcare professional should help the family understand what to expect before, during and after ventilation, as well as the risks of mechanical ventilation, such as pneumonia.

Indicate what to watch out for. Family members can serve as an extra pair of eyes and ears and can alert medical staff if something might be wrong. Family members should have an understanding of what to look for that may indicate infection and other complications of mechanical ventilation, such as coughing up mucus or fevers and chills. In order to adequately welcome patients and family members into the care team, it is not enough to explain "what" patients and family members should look for or "what" is going to happen in their care. The "what" must always be followed with a "why" to aid in genuine understanding.

Additionally, family members should know exactly when to call for help, where to go for help, and with whom they should speak. It is essential that patients and family members understand that they should not be ashamed to ask any questions and that many patients in similar situations often have similar questions.

Instead of employing a directive conversation style, an active, engaging conversation should take place, leaving capacity for questions and repeat-back strategies. When patients and family members understand the signs and symptoms that could be indicative of a problem, they are able to serve as an extra set of eyes in order to elevate this concern as early as possible.

Describe what can be anticipated. In addition to explaining when to call for help in the case of a potential emergency, healthcare providers should also thoroughly explain the typical treatment that can be expected before, during, and after ventilation. Additionally, it is important to discuss potential ventilation complications.

Clinicians should provide a high-level overview of the processes in place at their organization to ensure safety of the ventilation during the hospital stay, upon weaning, and upon discharge. This demonstrates competence of the organization, will likely bolster patient and family comfort, and will provide the patient and family members with information for which to reference if they may be suspicious of any complications.

By engaging in these conversations before a problem arises, family members can be prepared in the circumstance of necessary treatment and will have an understanding of where to go to find out more information about their loved one's condition.

Explain what is expected of them during their care. By giving patients and family members a "job" while they are in the hospital, they can be immersed fully in the routine care, can hold other team members accountable, can feel more confident voicing their concerns or opinions, and can serve as an extra set of informed and vigilant eyes to ensure successful ventilation management. This team involvement can also reduce their anxiety by transforming concern into proactive action.

Patients and family members can:

- Keep an eye on having the head of the bed elevated 35 to 45 degrees at all times.
- Ask for clarification of ventilation safety standards and ventilator weaning timeline.
- Follow up with the healthcare team on delirium prevention.
- Encourage participation in early exercise and mobility after extubation to help recovery.
- Ensure that a pain assessment is conducted for the patient regularly.
- Assist in personal hygiene and skincare to prevent infections and pressure ulcers.
- Remain vigilant about ventilator cleaning procedures.
- Monitor for hand hygiene in all healthcare providers and visitors.
- Watch for any signs of an infection, including, cough, shortness of breath, chest pain or fever, and elevate to care team.

Explore next steps. Planning for life after the hospital, whether in assisted living, returning home, or another option, should begin as early as possible between the healthcare providers and the patient and family.

Patients and family members should understand what can be anticipated in the patient after discharge regarding both physical and cognitive functioning.

- Try to understand what specific barriers that patient as an individual may face upon discharge.
- Explain the lifestyle modifications that may be necessary post-discharge.
- Illustrate the recovery process and help the patient and family members set realistic goals for recovery.

Describe the organization's ventilation management standards that were followed.

- If any of the protocols changed due to this specific patient's circumstance, articulate that to the patient and family members.

Have a discussion with the patient and family around end of life care and advanced directives.

- Make an attempt to thoroughly understand the religious or cultural nuances in any of the patient's or family members' decisions or questions.

Ensure thorough explanation of necessary post-discharge appointments, therapies, and medications.

- Assess for patient preference in time and location of follow-up appointments, if possible.

Provide patients and family members resources, including direct contact phone numbers, to the hospital for post-discharge questions.

- Make sure the resources are in their own language.

Provide thorough instructions to the patient and family members in the days leading up to discharge regarding ventilation weaning process and recovery after discharge.

- If home ventilation is required after discharge, set aside time with the patient and family member more than once to ensure their understanding and confidence regarding equipment, resources, psychosocial, spiritual and teaching needs, etc. (See Clinical Workflow Infographic).

Each conversation with a patient and family member should be inclusive and void of bias. Additionally, these conversations should leave ample time for discussion and the facilitator should encourage questions from the patient and family members.

Patients and family members should understand that, although all clinicians in the hospital do their best, no one is ultimately coordinating their care. Patients and family members should understand that they are the managers of their care and as such, should demand to be an active part of the care team including conversations and decisions.

Measuring Outcomes

While each organization will likely have or opt to devise their own metrics for project improvement, below are examples of process and outcomes metrics that would be helpful to consider:

Process metrics: Spontaneous breathing trial performance, spontaneous awakening trial performance, pain assessment documentation, goal setting for patients throughout stay and before discharge

Outcome metrics: Ventilator days/total inpatient bed days

Endnotes

Conflicts of Interest Disclosure

The Patient Safety Movement Foundation partners with as many stakeholders as possible to focus on how to address patient safety challenges. The recommendations in the APSS are developed by workgroups that may include patient safety experts, healthcare technology professionals, hospital leaders, patient advocates, and medical technology industry volunteers. Workgroup members are required to disclose any potential conflicts of interest.

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