NURSING PRACTICE & SKILL

Mechanical Ventilation in the Adult: Monitoring

What is Monitoring Mechanical Ventilation in the Adult?

› Mechanical ventilation (MV) is a form of respiratory support used for patients who are experiencing acute or chronic respiratory failure. MV improves gas exchange (i.e., tissue oxygenation and elimination of carbon dioxide) and reduces the patient's work to breathe until the underlying cause of respiratory failure can be treated and resolved. **The information contained in this *Nursing Practice & Skill* lesson is intended to present a brief overview of MV and is not intended to replace facility protocols, clinician orders, or the clinical experience necessary to become proficient in managing MV in an adult patient**

- *What*: The goal of monitoring the adult on MV is to improve ventilation and oxygenation and to provide rest for the patient experiencing respiratory failure. For the purposes of this paper, MV will be used to refer to invasive ventilatory support following endotracheal intubation. For information on noninvasive MV, see the Nursing Practice & Skill series on Noninvasive Assisted Ventilation (NIV)
- *How*: Nursing care of the patient receiving MV includes providing ongoing monitoring of the patient's condition and of the mechanical ventilator settings and alarms, so as to be alert to abnormalities and ventilator problems
- *Where*: MV is used most frequently in the intensive care unit (ICU) and less frequently in other settings (e.g., long-term care facility or the home)
- *Who*: Care for the mechanically ventilated patient is provided for by critical care nurses, physicians, respiratory therapists, and other specialty clinicians

What is the Desired Outcome of Monitoring Mechanical Ventilation in the Adult?

› MV is ordered when a patient is experiencing respiratory insufficiency that is not responsive to less invasive means of treatment

› MV can also be ordered to protect the airway in patients with trauma, patients with impending respiratory failure, and in those who will undergo neuromuscular blockade or general anesthesia during invasive treatments or surgery

Why is Monitoring Mechanical Ventilation in the Adult Important?

› The goal of intensive monitoring of the patient undergoing MV is to provide ventilatory support safely and effectively, while avoiding complications

Facts and Figures

› There have been negative outcomes from prolonged MV. In a retrospective study of 670 patients with existing COPD who were mechanically ventilated, shorter duration of MV was associated with better outcomes and increased overall survival compared to longer MV. The overall ICU mortality rate was 25%. Patients who underwent MV because of exacerbation of their COPD had better outcomes than patients who received MV because of another cause (e.g., sepsis, ARDS, pneumothorax) (Gadre et al., 2018)

› Spontaneous Awakening Trials (SATs) are one of the recommended titration methods used for managing sedatives in critical care units. Researchers conducted a study to determine

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if changing the time of day they performed a daily pairing of SATs and Spontaneous Breathing Trials (SBTs) would improve and decrease duration of mechanical ventilation (DOMV). It was concluded that the change in time of day for SBT showed a significant decrease in DOMV, but no change in the compliance of SAT/SBT screens or number of SBT attempts. (Sanchez Palacios et al., 2016)

› The introduction of an educational intervention and two simple changes in workflow in one emergency department led to improvement in the management of pain and agitation in mechanically ventilated patients. The interventions consisted of stocking fentanyl infusions in the ED and instituting a medication order set for patients receiving MV that led prescribers to order medication consistent with Society for Critical Care Medicine guidelines. Before the changes, 41% of patients receiving MV received an IV opioid; after, up to 71% of patients received an opioid (Isenberg et al., 2018)

What You Need to Know Before Monitoring Mechanical Ventilation in the Adult

› Respiratory failure requiring MV can be caused by conditions which result in hypoxemia or hypercapnia
- Hypoxemia is characterized by diminished oxygen in arterial blood, measured as decreased partial pressure of oxygen (PaO_2). Conditions that can result in hypoxemic respiratory failure include
  - hypoventilation (e.g., caused by medications, sedation, brain injury)
  - diminished cardiac output
  - lung infection, pulmonary edema, or atelectasis
  - lung injury (e.g., pneumothorax)
- Hypercapnia is characterized by elevated carbon dioxide in arterial blood, measured as increased partial pressure of carbon dioxide ($PaCO_2$). Conditions that can result in hypercapnic respiratory failure include
  - exacerbation of restrictive and obstructive airway diseases (e.g., asthma or chronic obstructive pulmonary disease)
  - diminished respiratory drive such as that which occurs with opioid or barbiturate overdose or central nervous system (CNS) infection
  - insufficient respiratory muscle contraction (e.g., caused by paralysis, electrolyte disturbances, or fatigue)

› MV is highly invasive, uncomfortable and distressing to patients, and can potentially lead to life-threatening complications resulting from the ventilator itself (e.g., barotrauma, pneumothorax), use of sedatives and paralytics, and prolonged bed rest (see ***Red Flags*** , below)

› Knowledge of indications for MV and the importance of intensive patient monitoring is important
- See *What is the Desired Outcome of Monitoring Mechanical Ventilation in the Adult?* and *Why is Monitoring Mechanical Ventilation in the Adult Important?*, above

› Knowledge of the basic principles of MV, modes of operation, and common terms is essential
- MV is delivered using one of two control variables: Volume-Controlled(VC), based on tidal volume (TV, i.e., the total amount of air delivered during inspiration) and Pressure-Controlled (PC), based upon peak inspiratory pressure (PIP, i.e., the maximum pressure achieved during inspiration)
  - Whether volume-controlled ventilation or pressure-controlledventilation is used is largely dependent on the equipment that is available, the patient's condition, and clinician preference. Pressure-controlled ventilation is currently used more frequently than volume-controlled ventilation in adults because it allows the tidal volumes to vary based on changes in the patient's lung compliance, which reduce the risk of having airway pressures that are too high and that can lead to pulmonary injury
- Terminology used to refer to how breathing is triggered and controlled include the following:
  - Mandatory – refers to the delivery of mechanical breaths that are controlled solely by the mechanical ventilator
  - Assisted – refers to breaths that are triggered by the patient but controlled by the ventilator
  - Supported – refers to breaths that are triggered by the patient but controlled and supported (e.g., with additional pressure) by the ventilator
  - Spontaneous – refers to breaths that are initiated and controlled by the patient without any assistance from the ventilator
- The three basic methods of MV are continuous mandatory ventilation (CMV), assist-control (A/C), and intermittent mandatory ventilation (IMV). Any of these modes can be delivered using VC or PC
  - *Continuous mandatory ventilation (CMV)*: In this mode, an automatic mechanical breath is delivered at a preset volume/pressure irrespective of the patient's breathing patterns. This is appropriate for patients who are chemically paralyzed, apneic, or undergoing general anesthesia

- *Assist-control (A/C)*: In this mode, a mechanical breath is delivered at the present volume/pressure when the patient takes a spontaneous breath. If a spontaneous breath is not taken, the ventilator will deliver an automatic breath at the preset settings
- *Intermittent mandatory ventilation (IMV)*: In this mode, a preset number of mechanical breaths are synchronized with the patient's spontaneous breaths and delivered at the preset volume/pressure

• Prescribers generally indicate the ventilator mode by writing first the control variable (PC or VC) followed by the mode. For example, PC-CMV indicates that the patient is to receive pressure-controlledcontinuous mandatory ventilation

• Additional MV settings include:

- Rate: This refers to the respiratory rate, which can be programmed by the rate/timing of inspiration (I), expiration (E), and/or the ratio of the two (I/E)
- Positive end-expiratory pressure (PEEP): This refers to airway pressure that is applied at the end of expiration but before inspiration, to keep the alveoli open and permit improved oxygenation. PEEP is measured by noting the airway pressure reading at the end of expiration. Prescribed therapeutic levels range from 10–35 cm H_2O
- Sigh: This refers to a large mechanical breath that is programmed to occur periodically, and it mimics the physiologic sigh that would naturally occur in a spontaneously breathing person
- Pressure support: This refers to supplemental inspiratory pressure that can be used with any mode of MV. Adding pressure support improves tidal volumes in patients who have weak respiratory muscles and who cannot draw in a deep enough breath on their own. Prescribed therapeutic levels range from 5–30 cm H_2O

› Demonstrated competence in patient assessment skills, specifically respiratory, knowledge of advanced cardiac life support (ACLS) techniques, and familiarity with invasive monitoring strategies is important

• Patients typically undergo cardiac monitoring and intra-arterialpressure monitoring, and might undergo pulmonary artery monitoring, which includes measurement of pulmonary capillary wedge pressure (PCWP; i.e., approximate left atrial pressure), pulmonary artery wedge pressure (PAWP) monitoring, mixed venous oxygen saturation (SvO_2), and cardiac output

› Preliminary steps that should be taken prior to monitoring the adult patient receiving MV include the following:

• Review the facility protocol for MV, if one is available

• Verify the patient's identity using two unique identifiers per facility protocol

• Review the patient's medical record for

- any allergies (e.g., to latex, medications); use alternative supplies if necessary
- respiratory disease/illness history
- the treating clinician's orders for MV
- completed facility informed consent documents

• Assemble supplies, which typically include

- Personal protective equipment (PPE; e.g., sterile/nonsterile gloves; use additional PPE [e.g., gown, mask, eye protection] if exposure to body fluids is anticipated)
- syringe (for inflation/deflation of the endotracheal cuff, if necessary)
- endotracheal suctioning set-up
- mechanical ventilator **(Figure 1)**

Figure 1: The bedside mechanical ventilator can assist or replace spontaneous breathing. Copyright© 2014, EBSCO Information Services.

- oxygen analyzer
- distilled water (for humidification)
- emergency airway equipment (e.g., oral airway, laryngoscope, bag-mask device) for emergency ventilation in case of unplanned extubation
- cardiopulmonary monitors
- stethoscope
- equipment for assessment of vital signs
- communication device (e.g., writing tablet, letter board)
- written information, if available, to reinforce verbal education

How to Monitor Mechanical Ventilation in the Adult

› Perform hand hygiene and apply nonsterile gloves
› Don PPE as appropriate to avoid transfer of microorganisms
› Close the door to the patient's room and/or draw the curtain around the bed to provide privacy
› Introduce yourself to the patient and family members, if present, and explain your clinical role in MV
  • Evaluate whether the patient/family requires special considerations regarding communication (e.g., due to illiteracy, language barriers, or deafness); make arrangements to meet these needs, if present
› Assess the patient's level of consciousness, pain level, anxiety level, and ability to cooperate with MV
  • Utilize the Glasgow Coma Scale and a sedation assessment tool (e.g., Richmond Agitation Sedation Scale) to assess level of consciousness and sedation level, respectively
  • Administer sedative, anxiolytic, and analgesic as prescribed, and allow time for therapeutic effect to be reached
› If patient is conscious and their condition permits, assess them for knowledge deficits and coping ability regarding MV
  • Assess patient's understanding of the rationale for MV; explain the procedure and provide emotional support as needed
  • Develop a strategy for communicating with the patient (e.g., using a writing tablet or letter board) and make arrangements to meet specialized needs (e.g., due to illiteracy, foreign language)

– Patients who are intubated cannot communicate their needs through speech because of the presence of the endotracheal tube (ETT). Developing effective alternative communication strategies can help to alleviate some of the patient's fear, reduce feelings of social isolation, and allow the patient to participate in their care. (For more information, see *Nursing Practice & Skill ... Mechanical Ventilation: Patient Communication --Facilitating*)

• Frequently orient the patient to location, day/date, time of day, the reason for hospitalization/treatment, and the location of the nurse call light

– The patient might have impaired cognition caused by sedatives, analgesics, and/or their underlying injury or illness

• When feasible, provide quiet time to allow the patient to get adequate sleep which will promote recovery and reduce confusion/anxiety

› Inspect the MV electrical supply and circuitry

• Verify that the mechanical ventilator is plugged into an electrical outlet or that the portable unit is fully charged

• Verify that the MV tubing is intact and that connections are tight. Make sure that high pressure and low pressure alarms are set to alert the clinician to problems with the MV tubing

• Check that there is adequate water in the humidification reservoir at all times

– Patients with artificial airways require ongoing humidification because they do not receive the humidification provided by breathing normally through the nose, pharynx, and larynx. Drying of the airway results in proliferation of bacteria that can cause ventilator-associated pneumonia (VAP)

• Clear MV tubing of condensate, which could be aspirated or could interfere with ventilation

› Verify that the mechanical ventilator and supplemental oxygen settings are set as prescribed **(Figure 2)**

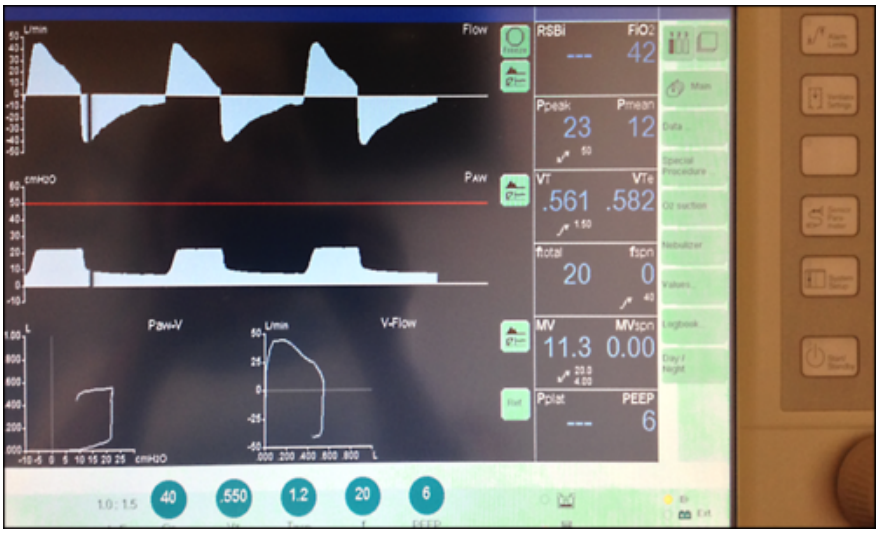

Figure 2: The screen of a ventilator should provide the following minimum information regarding the mode, oxygen concentration (FiO_2), flow rate (liters per minute), and programed respiratory rate. Copyright© 2014, EBSCO Information Services.

• Check the MV mode, oxygen concentration (FiO_2) and flow rate (40–60 L/min), and programmed respiratory rate (e.g., 12–14breaths/min) against the prescriber's orders

• Analyze the oxygen concentration utilizing an oxygen analyzer to ensure that the patient is receiving the correct concentration of supplemental oxygen

› Perform a physical assessment of the patient

• Inspect the positioning of the ETT and check inflation of the cuff, making adjustments if necessary

• Verify that the ETT is properly secured and has not migrated by checking for the mark placed on the distal tip of the tube. Failure to properly secure the ETT can result in accidental dislodgement or removal (see ***Red Flags*** , below)

• Assess the patient's respiratory status by auscultating lung sounds and assessing for equal chest wall movement, amount and characteristics of sputum, and for signs of hypoxia

• Assess the patient's vital signs and check continuous pulse oximetry (SpO_2) and capnography ($EtCO_2$) monitors

• Monitor EKG, intra-arterial pressure, and pulmonary artery monitor readings

• For additional details on patient assessment, see *Nursing Practice & Skill ... Mechanical Ventilation: Patient Assessment*

› Facilitate completion of daily/intermittent laboratory and diagnostic studies, which might include arterial blood gases (ABGs), chest X-ray,echocardiography, EKG, chemistry panel, CBC, and cardiac lab studies. Promptly review results and communicate abnormalities to the treating clinician

- For more information, see *Nursing Practice & Skill ... Mechanical Ventilation: Diagnostic Tests -- Reviewing*

› Administer enteral/parenteral nutrition and intravenous fluids, as prescribed
- Strictly monitor and record intake and output (e.g., every 2–4 hours) and daily weight
- Perform blood glucose checks every 4–6 hours, per treating clinician's order and/or facility protocol; hyperglycemia can be caused by stress and the use of corticosteroids
- Monitor frequency and appearance of stools. Test stools for occult blood (e.g., related to gastric stress ulcers) per facility protocol
- For more details, see *Nursing Practice & Skill ... Mechanical Ventilation: Nutritional Needs -- Managing*

› Perform preventive nursing care to minimize risk for ventilator-associatedcomplications
- Reposition the patient every 2 hours or per facility protocol to reduce risk of pressure ulcers, mobilize secretions, and reduce risk for atelectasis
- Maintain the head of the bed at 30–45 degrees to reduce risk for aspiration. Use duodenal or jejunal tube feeding rather than gastric feeding whenever possible to minimize aspiration risk
- Perform range of motion exercises to help reduce risk of venous stasis and deep vein thrombosis
- Frequently assess the need for endotracheal suctioning to minimize accumulation of secretions and stimulate the cough reflex. Use sterile gloves and adhere to sterile technique during the suctioning procedure. Do NOT instill saline prior to endotracheal suctioning (see ***Red Flags*** , below)
- Indications for suctioning include: sawtooth pattern on the flow volume loop, hearing course crackles over the trachea, increased PIP during volume controlled ventilation and decreased oxygen saturation levels
- Provide pulmonary toileting according to facility respiratory therapy protocols and the treating clinician's orders
  –For details, see *Nursing Practice & Skill ... Mechanical Ventilation: Pulmonary Toileting -- Assisting with*
- Perform oral care every 1–4 hours to prevent aspiration of oral bacteria that can cause ventilator-associated pneumonia and to detect pressure-related sores caused by the ETT
- Administer antithrombotic and peptic ulcer prophylaxis, as prescribed

› Dispose of used materials and perform hand hygiene

› Update the patient's plan of care as appropriate and document the following:
- Time and date of all care performed
- Physical assessment findings including breath sounds, vital signs, cardiopulmonary monitor readings, LOC, and level of cooperation with MV
- The size/depth of the ETT and condition of the cuff
- Ventilator mode and alarm settings, any adjustments in settings that were made, and the patient's response
- Treatments administered, including endotracheal suctioning, postural drainage, and repositioning
- The patient's I & O
- Results of diagnostic and laboratory studies, abnormalities that were found, and treatments administered
- Patient/family/caregiver teaching

Other Tests, Treatments, or Procedures That Can be Necessary Before or After Monitoring Mechanical Ventilation in the Adult

› As appropriate, adjust sedation to promote patient comfort and maintain patient safety

› Promptly communicate any abnormalities in laboratory test results or clinical assessment findings to the treating clinician; administer prescribed treatment

What to Expect After Monitoring Mechanical Ventilation in the Adult

› MV is proficiently and safely administered, and the patient experiences improved ventilation and oxygenation and reduced work of breathing

Red Flags

› In case of unexpected or inadvertent extubation, immediately assess the patient's condition. If the patient remains stable, continue to monitor oxygen saturation and vital signs, and notify the treating clinician. If respiration is insufficient, begin ventilating via bag-mask device until the patient is reintubated

› Long-term MV is associated with an increased incidence of tension pneumothorax, decreased cardiac output, oxygen toxicity, infection, deep vein thrombosis, and gastrointestinal complications such as distention or bleeding from stress ulcers

› The practice of instilling normal saline before endotracheal suctioning is not recommended because it increases risk of VAP, hypoxemia, bronchospasm, cardiac and respiratory arrest, and infection, and does not improve oxygenation in patients receiving MV

What Do I Need to Tell the Patient/Patient's Family?

› Reinforce the treating clinician's explanation of the purpose of MV, how it is administered, and the steps that are taken to monitor the patient's condition while they are mechanically ventilated. Encourage open communication and questions from the patient and/or family member/caregiver

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