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Caring for Patients on Mechanical Ventilation

What research indicates is best practice.

Barbara Liston, a 65-year-old retired social worker, has been diagnosed with ventilator-associated pneumonia after 10 days on a positive-pressure mechanical ventilator. A chest X-ray shows bilateral infiltrates with increased densities that are worse on the right side. Her ventilator settings include fractional concentration of oxygen in inspired gas (FiO_2), 80% (increased from 40% in response to a rise in nighttime hypoxemia); tidal volume, 500 mL; ventilation rate, 12 breaths per minute; and positive end-expiratory pressure (PEEP), 8 cm H_2O. Values for her arterial blood gases, drawn two hours earlier, are pH, 7.35; partial pressure of arterial oxygen (PaO_2), 75 mmHg; partial pressure of arterial carbon dioxide ($PaCO_2$), 55 mmHg; and serum bicarbonate, 20 mmHg. Thus, Ms. Liston's PaO_2–FiO_2 ratio, an indicator of oxygenation status, is 94. She has an extensive history of chronic obstructive pulmonary disease and supplemental oxygen use at home. She has an enteral feeding tube in place, but feeding has been suspended because her gastric residual volumes have been greater than 100 mL per hour. She is lying flat in bed with a temperature of 103°F. Heavily sedated, she responds only to suctioning.

What are the most important interventions to consider, and what are the best, evidence-based nursing practices to help Ms. Liston be liberated from the ventilator? This article addresses several integral areas of care, including weaning from mechanical ventilation, preventing ventilator-associated pneumonia, providing nutritional support, managing anxiety, timing tracheostomy, preventing aspiration, and promoting sleep. (In this article, *mechanical ventilation* refers to the use of positive-pressure ventilators that deliver air invasively through endotracheal or tracheal tubes.)

The longer a patient remains on mechanical ventilation, the greater the risk of complications, which increase the likelihood that the patient will require a longer hospital stay. Patients on mechanical ventilation are occupying beds not only in ICUs, where its use is typical, but also on intermediate care and step-down, medical–surgical, pulmonary rehabilitation, and long-term care units.

WEANING FROM MECHANICAL VENTILATION

The length of time spent on a mechanical ventilator (ventilator length of stay) varies among patients. Weaning should occur without undue delay, in order to reduce the risk of complications (such as

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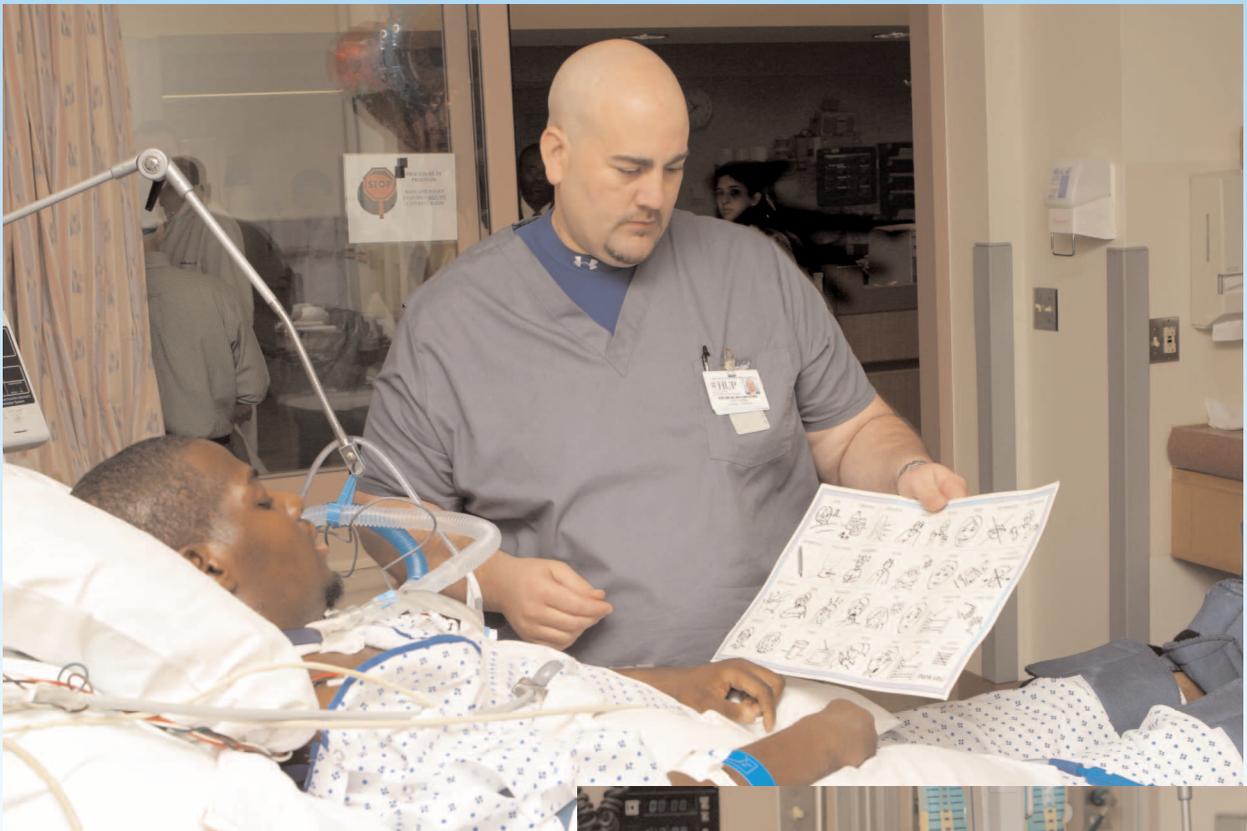
As shown here, picture and alphabet boards can be part of a communication plan for a patient on mechanical ventilation. All photographs were taken in a critical care unit at the Hospital of the University of Pennsylvania in Philadelphia.

pneumonia and airway trauma) and their associated costs.[1] But premature weaning can also have undesirable results, such as compromised gas exchange and, if the patient must be reintubated, difficulty reestablishing an airway. In some cases, tracheostomy may become necessary. For these reasons, investigators have sought criteria that would help predict a patient's weaning potential.

In 1991 Yang and Tobin developed the frequency–tidal volume ratio (also known as the rapid shallow breathing index); most weaning protocols today incorporate it. The ratio is expressed as frequency of respiration (f, given in breaths per minute) divided by tidal volume (VT, given in liters) as measured during spontaneous, unsupported respiration. They reported it to be an accurate predictor of both weaning failure, if the result was greater than 105, and success, if the result was less than or equal to 105.[2] A later study evaluated the frequency–tidal volume ratio and four other indices and determined that although none was a strong predictor of weaning success, they were all useful in predicting failure (unsuccessful weaning trials).[3]

Regular suctioning removes the secretions that increase the risk of pneumonia.

As an indicator of oxygenation status, the PaO_2–FiO_2 ratio has had its proponents and detractors; studies of its reliability and validity have yielded mixed results. However, in comparison with other such indicators, it appears to be among the more useful ones and often is used to assess acute lung injury. One 2003 study compared the accuracy of the PaO_2–FiO_2 ratio and the Murray lung injury score as measures of lung injury severity.[4] The researchers determined that the PaO_2–FiO_2 score predicted death better and recommended that it

"replace more complex and potentially therapy-dependent scores." The PaO_2–FiO_2 ratio can be calculated readily from arterial blood gas results and the prescribed FiO_2 ventilator setting.

In 1995 a multicenter study published in the *New England Journal of Medicine* reported that "a once-daily trial of spontaneous breathing led to [successful] extubation about three times more quickly than intermittent mandatory ventilation and about twice as quickly as pressure-support ventilation."[5] Another study of 300 adult patients on mechanical ventilation demonstrated that daily assessment of respiratory function using several indices, including the PaO_2–FiO_2 ratio, followed by a trial of spontaneous breathing when appropriate, significantly reduced complications and critical care costs.[6]

Studies have shown that weaning is most successful when a multidisciplinary team collaborates.[7, 8] In one study of a collaborative weaning plan, the team used weaning boards (dry-erase boards kept at the bedside to communicate to the team, patient, and family) and flow sheets (paper sheets kept at the bedside to record the weaning process and the patient's responses to each trial).[7] The intervention decreased medical ICU lengths of stay by an average of 3.6 days and ventilator lengths of stay by an average of 2.7 days.

Best nursing practice. Guidelines published in the December 2001 issue of *Chest* (www.chestjournal.org/cgi/content/full/120/6_suppl/375S) recommend that patients be formally assessed to determine their readiness for discontinuation of mechanical ventilation.[1] Nurses can ensure that such assessment occurs daily—checking for evidence that the underlying cause of respiratory failure has been reversed, for adequate oxygenation and inspiratory effort, and for hemodynamic stability—and can discuss the findings with physicians. The patient's progress in attempting to breathe spontaneously should also be considered.

The nurse should monitor patients for signs of respiratory intolerance, such as thoracoabdominal asynchrony, the use of accessory muscles to breathe, tachypnea, decreased oxygen saturation, hypertension, tachycardia, and diaphoresis, and for symptoms such as dyspnea, discomfort, and anxiety. Respiratory muscle fatigue may occur during weaning; it usually takes about 24 hours for a patient to recover from such fatigue, although some may recover more quickly. Dyspnea is common in patients on ventilators and should be evaluated. Powers and Bennett studied five dyspnea-rating scales and determined all five to have reliability and validity in critically ill patients on mechanical ventilation; of the five, the numeric scale was easiest for patients to use.[9] Such a scale typically allows patients to rate their dyspnea on a scale from 0 (no breathlessness) to 10 (most severe breathlessness)

(some versions use a 4-point or other range).

The guidelines recommend that the following values be met before weaning: PEEP, less than or equal to 5 to 8 cm H_2O; FiO_2, less than or equal to 0.4 to 0.5 (40% to 50%); pH, 7.25 or greater; and PaO_2–FiO_2 ratio, greater than 150 to 200.[1] (Generally, a PaO_2–FiO_2 ratio of greater than 300 is considered normal, although lower levels may be acceptable.) The pH level and PaO_2–FiO_2 ratio are based on arterial blood gas results and can be calculated easily by the nurse. The frequency–tidal volume ratio is also easily calculated and can be useful in predicting weaning failure.

The guidelines define hemodynamic stability as "the absence of active myocardial ischemia and the absence of clinically important hypotension"[1]; accordingly, patients receiving very-low-dose vasopressor therapy or none at all may be considered for weaning. The patient's ability to initiate an inspiratory effort should be evaluated as well. This is done by measuring negative inspiratory force, using a gauge attached to the endotracheal or tracheostomy tube. The patient exhales as completely as possible, then breathes in with as much force as possible for about five to 10 seconds. A negative inspiratory force of –20 cm H_2O or greater indicates readiness for weaning.[10]

PREVENTING VENTILATOR-ASSOCIATED PNEUMONIA

Nosocomial pneumonia is most commonly caused by aspiration of oropharyngeal secretions. Risk factors include critical illness, immunosuppression, use of an artificial airway or mechanical ventilation, lengthy hospitalization, and long ventilator length of stay.[11] Patients on mechanical ventilation are six to 21 times more likely to develop nosocomial pneumonia than those not on mechanical ventilation.[12]

One study found that clinically suspected nosocomial pneumonia occurred less often in patients in a semirecumbent position (45° angle) than in those in a supine position (8% versus 34%).[13] The researchers also concluded that the risk of nosocomial pneumonia increased with "long-duration mechanical ventilation and decreased consciousness."

Oral microorganisms, which tend to concentrate in dental plaque, can migrate to and colonize the lungs.[14] In patients who are critically ill and on mechanical ventilation, this can cause ventilator-associated pneumonia. Dental plaque and associated microbes can be managed through toothbrushing and oral rinsing, administering an antimicrobial agent, or both.[14] Proper oral care is essential in this population. Yet a recent study of patients on mechanical ventilation found that toothbrushing, which is effective in removing plaque, was not performed routinely, and that sponge toothettes, which are ineffective for plaque removal, were used instead.[15]

Monitoring patients for signs and symptoms of aspiration includes auscultation of the lungs for rales or wheezing.

Dependence on a machine for breathing can bring about anxiety. A nurse can help manage a patient's anxiety by communicating with him about upcoming procedures.

In a recent pilot study, 34 intubated trauma and surgical patients were randomly assigned either to receive a single application of 2 mL of a 0.12% chlorhexidine solution by spray or swab to cover all oral surfaces or to a control group.[16] Patients in both treatment groups (spray and swab) showed decreased oral bacterial growth; patients in the control group did not. The researchers concluded that the use of chlorhexidine soon after intubation may delay or prevent the development of ventilator-associated pneumonia. An oral rinse of chlorhexidine (Peridex) was shown to be effective in preventing nosocomial pneumonia in patients intubated after cardiovascular surgery.[17]

Best nursing practice. Weaning and extubation should occur as soon as the patient is ready.

Elevating the head of the patient's bed to a 45° angle will reduce the likelihood of aspiration of oral secretions. Oral care should include toothbrushing at least every 12 hours. The use of sponge toothettes every two to four hours to stimulate the oral mucosa is also recommended, but it should not replace toothbrushing. Subglottic secretions should be suctioned regularly, and proper cuff pressure should be maintained to prevent leakage of contam-

inated secretions.[18] Application of chlorhexidine by spray or swab to cover all oral surfaces may also be useful, but further studies in patients on long-term ventilation are needed.

MANAGING ANXIETY

Having to depend on a machine to breathe and being unable to speak can bring about anxiety, which can result in sleep disturbances, increased myocardial oxygen consumption, and increased sympathetic output; the last can lead to tachypnea, tachycardia, or hypertension, making weaning

more difficult.[19] A patient's inability to speak may also make it harder for nurses to meet his needs.

In our experience, the most commonly used anxiolytics in adult critical care are the benzodiazepines midazolam (Versed) and lorazepam (Ativan). Midazolam, a short-acting drug, has a more rapid onset of action and a shorter half-life than does lorazepam, an intermediate-acting drug.[20] In a randomized, controlled study, Swart and colleagues evaluated the drugs' effectiveness in 64 patients on mechanical ventilation who required long-term sedation.[21] Patients received either midazolam or lorazepam by continuous infusion. The researchers found that with lorazepam it was "significantly easier" to attain and manage the desired sedation level; there were no differences in recovery between the two groups during the 24 hours immediately after discontinuing the drug. Propofol (Diprivan), a hyp-

Sedation by continuous IV infusion has been associated with prolonged ventilator lengths of stay.

notic agent with rapid onset and a short half-life, is delivered intravenously and is often used for short-term sedation of patients on mechanical ventilation. But it's recommended for short-term use only; high-dose infusions have been associated with "propofol syndrome," a rare but "potentially fatal complication characterized by severe metabolic acidosis and circulatory collapse."[22]

According to recently published clinical guidelines on the use of sedatives in critically ill adults, the development and use of sedation guidelines by a multidisciplinary team can reduce ventilator and ICU lengths of stay by about half (from 317 to 167 hours and from 19.1 to 9.9 days, respectively) without a change in mortality rate; direct patient care costs may be reduced even more dramatically.[20]

Sedation by continuous IV infusion has been associated with prolonged ventilator lengths of stay.[23] There is evidence that a daily interruption "to allow patients to 'wake up'" may be advisable.[24] Kress and colleagues studied 128 adults on mechanical ventilation who were receiving either midazolam or propofol through continuous infusion. In the intervention group, infusion was stopped daily until the patient awakened or seemed uncomfortable, at which point a physician decided whether to resume infusion; in the control group, infusion was interrupted only at a clinician's discretion. The researchers found that daily interruption reduced the median ventilator length of stay by 2.4 days and the critical care length of stay by 3.5 days. This was accomplished with no difference in the rate of adverse events (such as self-extubation or tracheostomy) in the two groups.

The initiation of sedation can cause hemodynamically unstable patients to develop hypotension.[20] Some clinicians believe it's safer to administer benzodiazepines in small-bolus doses rather than by continuous infusion.[19]

Nonpharmacologic interventions may be useful as well, although little research in this area has been conducted in patients on mechanical ventilation. In a literature review, White reported that music therapy has been shown to reduce anxiety and pain levels, heart and respiratory rates, and blood pressure in critical care and perioperative populations.[25] One study of 54 patients on mechanical ventilation tested the effects of a single 30-minute music therapy session. The researchers found that those in the intervention group had less anxiety and were more relaxed, as evidenced by decreased heart and respiratory rates, than did those in the control group.[26]

Happ and colleagues recently studied communication methods in patients on mechanical ventilation in an ICU and found that they communicated primarily through head nods and mouthed words.[27] Other methods used, although less common, were gesturing and writing. More research is needed to determine the most effective means of communication with this population.

Best nursing practice. In patients who are alert and oriented, anxiety can be assessed using a Likert scale. In patients who are not alert and oriented, assess for behaviors associated with anxiety, such as pulling on tubes or catheters, restlessness, and agitation. When a patient exhibits anxiety, first rule out possible clinical causes such as hypoxemia, metabolic abnormalities, cerebral hypoperfusion, adverse drug reactions, and alcohol or drug withdrawal.

If sedation is needed, the minimum amount that will achieve the sedation goal should be given, preferably either as small-bolus doses or, if through continuous IV infusion, with daily interruption and reassessment of the patient's need.[20] Work with an interdisciplinary team to develop an algorithm or guideline for sedation administration at your facility. If a patient's gastrointestinal tract is functioning properly, the gastrointestinal route is preferred. Determine whether the sedative can be administered orally rather than intravenously, as the latter route carries a higher risk of infection.

Sedation assessment tools that have validity and reliability, such as the Riker Sedation–Agitation Scale or the Motor Activity Assessment Scale, may be useful for titration of sedative dosage,

whether administration is continuous or intermittent.[20] A newer scale, the Richmond Agitation–Sedation Scale, has demonstrated both validity and reliability and is the first scale capable of "detect[ing] changes in sedation status over consecutive days of [ICU] care."[28] Ongoing monitoring and frequent reassessment with regard to sedation can reduce a patient's ventilator length of stay.

Another intervention is developing a communication plan. Nurses should assess each patient to determine which communication methods are best and share this information with team members and the patient's family. Give the patient paper and pencil to determine whether the handwriting is legible. Picture and alphabet boards can be useful as well. The American Association of Critical-Care Nurses has endorsed one such tool, the EZ Board (manufactured by Vidatak, LLC), a portable, nonelectronic communication board with preprinted letters, phrases, and pictures; it's available in English and Spanish versions. Music therapy may also help reduce anxiety.

MALNUTRITION AND NUTRITIONAL SUPPORT

Protein-energy malnutrition, which is common in critically ill patients, decreases muscle mass and thickness and results in diminished strength and endurance. When respiratory muscles such as the sternocleidomastoid and the diaphragm are affected, diminished pulmonary function, shortness of breath, fatigue, and decreased response to hypoxia can result. Malnutrition also suppresses immune system function and increases susceptibility to infectious disease, including nosocomial pneumonia.

For patients on mechanical ventilation, experts recommend starting nutritional support by the third day of intubation.[29] If the patient is malnourished, this should begin within 24 hours of intubation. Nutritional support helps sustain the immune system, promote wound healing, and maintain muscle mass. In a recent study of 200 hospitalized critically ill adults, the use of an evidence-based nutrition management protocol significantly decreased the mean ventilator length of stay.[30]

Underfeeding and overfeeding. For critically ill patients, enteral nutrition is preferred to total parenteral nutrition because it provides adequate calories and more nutrients, preserves gut integrity and immune function, is associated with fewer complications, and is less expensive.[29, 31] But it's important to feed the patient the correct amount. Underfeeding can lead to loss of lean body mass, poor wound healing, and diminished immunity, thereby increasing the risk of infection.[29] In a prospective study of 44 adult patients who were critically ill and on enteral feeding, it was determined that patients were receiving only about half of the nutritional goal amounts set by a dietitian.[32] Physicians ordered a daily mean feeding volume that was 65.6% of the recommended amount. Moreover, only 78.1% of the volume ordered was actually given, mainly because of feeding interruptions prompted by diagnostic or surgical procedures, routine nursing care, high gastric residual volumes, or displaced tubes. The researchers determined that withholding enteral nutrition was avoidable 66% of the time.

Similarly, a recent prospective study of 187 patients in intensive care found that average caloric intake was only about half that recommended by the American College of Chest Physicians (ACCP).[33] However, the researchers noted that "moderate caloric intake (for example, 33% to 65% ACCP targets; approximately 9 to 18 kcal/kg per day)" was associated with better outcomes than higher caloric intake, especially among patients with more severe illness (including those on mechanical ventilation). Overfeeding can increase physiologic stress, worsen hyperglycemia, cause "fatty liver," and increase respiratory demand by elevating carbon dioxide production.[29, 34, 35]

Gastroparesis, which frequently occurs in critically ill patients, impairs drug absorption, leads to higher gastric residual volumes, and increases the likelihood of gastroesophageal reflux and aspiration.[36] The cause of gastroparesis often remains unknown.

Best nursing practice. Although there's no single indicator for nutritional status, several measures can be useful. Nurses can also request assessment by a dietitian to determine nutritional needs and establish feeding goals.

Indirect calorimetry allows accurate estimation of a patient's daily resting energy expenditure from measurements of variables such as oxygen consumption and carbon dioxide production. It's useful for determining a patient's nutritional needs and can help prevent both overfeeding or underfeeding. In one study, researchers compared indirect calorimetry with other energy estimation methods and concluded that it should be "an integral part of all nutrition support regimens."[37] Drawbacks include the fact that it requires trained personnel and specialized, expensive equipment. If indirect calorimetry is an option, nurses can suggest that it be used.

Other indicators of nutritional status include *serum prealbumin, urine urea nitrogen,* and *electrolyte levels.* Because serum prealbumin has a shorter half-life than serum albumin (three days versus 21 days), it's a better indicator of possible protein-energy malnutrition. (However, serum prealbumin levels may be higher in patients with renal insufficiency.) Decreased protein intake diminishes the body's nitrogen store, causing nitrogen deficiency, which a 24-hour urinalysis can reveal. Some electrolyte imbalances can impair ventilatory muscle function. Low magnesium levels have been associated

Gastric residual volumes are monitored to assess tolerance of tube feeding and the risk of aspiration.

with muscle weakness, as has hypophosphatemia; the latter has also been associated with weaning failure.[1]

Monitoring gastric residual volumes is often done to assess a patient's tolerance of tube feeding and risk of aspiration. Normal rates of gastric secretion are about 100 to 150 mL/hr.[29] One study found that nurses often stopped tube feedings if a patient's residual volume was either greater than twice the hourly rate or greater than 200 mL.[38] But although there's some evidence that residual volume levels correlate to feeding tube intolerance, it's not known what specific level increases the risk of aspiration.[38] The recently validated *Canadian Clinical Practice Guidelines for Nutritional Support in Mechanically Ventilated, Critically Ill Adult Patients* states that "a protocol that incorporates prokinetics at initiation and tolerates a higher gastric residual volume (250 mL) should be considered as a strategy to optimize delivery of [enteral nutrition] in critically ill adult patients."[39] Feeding tube placement is a factor. According to a literature review by Swanson and Winkelman, when the feeding tube is placed in the noncontracting portion of the stomach, residual volume can be as great as 800 mL without adverse effects because the stomach has reserve capacity and can distend easily.[40] But if the tip of the feeding tube is in the duodenum, a residual volume of only 200 mL can cause discomfort and possibly result in intestinal perforation.[40]

A variety of enteral feeding tubes are available. Small-bore feeding tubes can be placed through the oral or nasal cavity into either the stomach or the transpyloric area; larger-bore tubes can be placed through the oral or nasal cavity into the stomach. Nasogastric tubes are generally used for no longer than six to eight weeks, in part because prolonged use can result in nasal septal or esophageal erosion, sinusitis, or distal esophageal stricture. Gastrostomy, duodenostomy, and jejunostomy tubes enter percutaneously through the stomach or abdominal wall; these types are used when longer-term enteral nutrition is required. A gastrostomy tube permits bolus as well as continuous feedings; this type is most appropriate for patients with intact gag and cough reflexes and adequate gastric emptying. Duodenostomy and jejunostomy tubes require slow, continuous feeding over the course of 12 to 24 hours, because the small bowel cannot buffer osmotic loads as effectively as the stomach.[41] (For more on feeding tube types, see "Enteral Tube Flushing," March.) If underfeeding is a concern and if it's appropriate, consider switching the patient from continuous to bolus feedings, as this may allow procedures and interventions to be scheduled when they won't disrupt feeding.

Until research can establish at what residual volume level enteral feedings should be withheld, a specific recommendation cannot be made. If a patient's residual volume level is high enough to cause con-

cern, the following recommendations by Parrish and McCray, drawn from the American Association of Critical-Care Nurses *Protocols for Practice: Care of the Mechanically Ventilated Patient,* may help.[29] Position the patient on the right side for 15 to 20 minutes before checking residual volume levels; this helps the patient to avoid aspirating secretions from the fundus gastricus. In some cases transpyloric placement of the feeding tube might help. Confer with the dietitian about using a more calorie-dense formula at a reduced rate (less volume per hour). Monitor glucose levels because hyperglycemia may lead to gastroparesis; if glucose levels rise above 200 mg/dL, the physician should be notified. Opioids should be avoided when possible because these drugs tend to cause constipation. Gastroparesis can usually be managed with prokinetic agents such as metoclopramide (Reglan).

TRACHEOSTOMY

There is no consensus on when a tracheostomy should be performed. When patients cannot be weaned and noninvasive, positive-pressure ventilation cannot be used, a tracheostomy should be considered; if weaning attempts fail repeatedly, it may be necessary. If in such cases the patient will need ventilation for longer than three weeks, a tracheostomy should be performed as soon as possible.[42]

Recent studies have suggested that early tracheostomy leads to better outcomes and decreases ventilator lengths of stay. In one prospective, randomized study, 124 patients in medical ICUs received either early (within 48 hours) or delayed (at days 14 to 16) tracheostomies.[43] The patients in the early-tracheostomy group had shorter ventilator and ICU lengths of stay and experienced less mouth and larynx trauma than did the patients in the delayed-tracheostomy group. Another study in patients with severe head injuries found that early tracheostomy (at day 5 or 6) was associated with fewer total days on ventilation than was prolonged endotracheal intubation.[44]

Both endotracheal and tracheostomy tubes can lead to complications. With an endotracheal tube, potential complications include upper airway injury such as glottic and subglottic ulcerations, chronic glottic incompetence, laryngeal stenosis, vocal cord paralysis, and tracheal stenosis. Both endotracheal and tracheostomy tubes can lead to complications. With an endotracheal tube, potential complications include upper airway injury such as glottic and subglottic ulcerations, chronic glottic incompetence, laryngeal stenosis, vocal cord paralysis, and tracheal stenosis. Problems such as hoarseness, laryngeal erythema and ulceration, and granulomas can remain long term (still present after six months) in a small subset of this population.[45] Many of these complications will not be apparent until the patient

is extubated or, if the patient has a tracheostomy tube, until he can use a speaking valve.

The benefits of tracheostomy include greater patient comfort, a more secure airway, more effective airway suctioning, decreased airway resistance, better patient mobility, and greater opportunity to speak and eat normally.[1]

Best nursing practice. When a patient's condition warrants it, the nurse can suggest that a tracheostomy be considered. There is no standard guideline for changing a tracheostomy tube routinely. It is usually changed when a functional problem (such as a cuff rupture) occurs or when a design change (such as a different size) is warranted. The first tube change should not be performed until seven to 10 days after the initial tracheostomy, in order to allow the stoma and tract to mature.[45, 46]

Immediate posttracheostomy complications (within the first 24 hours) can include pneumothorax, subcutaneous emphysema, and bleeding at the insertion site. It's important to prevent accidental decannulation during the first 72 hours, because during reinsertion there is greater risk of tissue damage and unsuccessful ventilation. Most tracheostomy tubes are sutured in place with purse-string sutures that prevent such displacement. Check suture integrity and call for assistance immediately if the sutures are found not to be intact or the tube becomes dislodged.

RISK OF ASPIRATION

Any artificial airway increases the risk of aspiration. Potential complications of aspiration include hypoxemia, chemical pneumonitis, pulmonary infection, mechanical obstruction, atelectasis, abscess, fibrosis, and respiratory distress syndrome; death also can result.[47]

A speech therapist can perform a bedside swallowing evaluation to look for signs of aspiration; if necessary, videofluoroscopy can be performed. One recent study compared the reliability of the bedside colored dye test with that of videofluoroscopy for detecting aspiration in patients with tracheostomies. Both tests indicated aspiration reliably, but the colored dye test had a high false-negative rate.[48]

Silent aspiration (aspiration without the normal cough reflex) can occur. Moreover, the presence of dysphagia appears to have poor predictive value. In a study of 93 patients with neurologic disorders, silent aspiration occurred in 20% of patients who had no complaints of swallowing difficulties and in 49% of those with dysphagia.[49] Patients who require prolonged endotracheal intubation or tracheostomies tend to develop decreased sensation of the airway, and that too may increase the risk of silent aspiration, as a literature review conducted by Pannunzio has suggested.[11]

Best nursing practice. Monitor patients closely for signs and symptoms of aspiration. These include sudden onset of coughing and shortness of breath, as well as increased heart and respiratory rates. You may hear rales or wheezing, or draw feeding matter from the endotracheal tube when suctioning. The patient may become cyanotic and develop a fever.

It's important to bear in mind the possibility of silent aspiration. Preventive measures include keeping the head of the bed raised at a 45° angle. If appropriate, request an order for a swallowing evaluation to be made by a speech therapist. Nasogastric feeding tubes should be marked at the entry point upon placement; after initial insertion, proper placement should be verified (preferably by abdominal X-ray). Tube placement should be reassessed periodically by checking the mark to make sure the tube hasn't shifted.

> Because disrupted sleep affects oxygen consumption, carbon dioxide production, and other aspects of respiration, it's likely to inhibit weaning.

SLEEP

Sleep is crucial to physical and psychological well-being, yet disrupted sleep is common among patients in ICUs. Patients may experience sleep deprivation, sleep fragmentation (abnormal sleep–wake cycles), abnormal patterns of rapid eye movement (REM) and non-REM sleep, or a combination of these. Possible causes include environmental factors (such as excessive light and noise), diagnostic and other procedures, routine patient care, and pain. Possible consequences of disrupted sleep include upper airway collapse,[50] endocrine and immune system dysfunction,[51] cognitive impairment,[52] changes in the brain's metabolic functioning,[53] and behavioral effects such as disorientation and agitation. However, there has been little research into the effects of disrupted sleep in patients on mechanical ventilation.

Some studies indicate that almost all patients on mechanical ventilation experience disrupted sleep. Using 24-hour polysomnography, Cooper and colleagues analyzed sleep patterns in 20 critically ill and ventilated patients.[52] None of them had normal sleep; 12 didn't sleep "as it is conventionally measured" at all, and eight had severely fragmented sleep patterns. The researchers hypothesized that, because disrupted sleep affects oxygen consumption, carbon dioxide production, and other aspects of respiration, it's likely to inhibit weaning. Freedman and colleagues studied 22 patients in a medical ICU (20 were on mechanical ventilation) and found they were "qualitatively, but not necessarily quantitatively, sleep deprived."[54] All had sleep–wake cycle abnormalities.

Excessive noise has often been suggested as a leading cause of disrupted sleep. There is evidence that reducing it can help (see "Noise Control: A Nursing Team's Approach to Sleep Promotion," February 2004). In another study, Olson and colleagues tested a nursing intervention designed to reduce both excessive noise and light in a neurocritical care unit.[55] During twice-daily "quiet times," lights were dimmed, televisions were turned off, and visits by family members and clinicians were minimized. Patients were 1.6 times more likely to sleep during the intervention than during the control period.[55] However, Freedman and colleagues determined that environmental noise was responsible for only 17% of awakenings overall.[54] They concluded that other factors must play a larger role than previously thought in disrupting sleep.

A recent retrospective study of 50 patients in four ICUs examined patterns of nocturnal care-related interactions.[56] The researchers found that "the high frequency [of such activity] left patients few uninterrupted periods for sleep." They suggested that clustering nocturnal care-related interactions could help remedy this.

Best nursing practice. Until more is known about sleep disruption in patients on mechanical ventilation, interventions used in critical care populations should be tried. For example, nurses can mitigate excessive noise and light using the methods outlined above. Dines-Kalinowski recently described four other nursing interventions, including[57]
- assessing for and managing pain.
- promoting comfort at bedtime through such measures as good oral care and proper positioning.
- reducing anxiety by communicating with the patient about upcoming procedures.
- coordinating care with team members to minimize nighttime interruptions.

Listening to soft music or reading may help some patients relax. One study of critically ill patients found that back massage improved the quality of sleep.[58]

If these measures are ineffective, the nurse can ask a physician to order a sleeping agent at bedtime. However, many drugs commonly administered to patients in ICUs can interfere with sleep. Agents that combine a benzodiazepine and an opioid are frequently used to sedate patients on mechanical ventilation. Both benzodiazepines and opioids are known to decrease REM sleep and stage 2 sleep.[59]

If sleep disruptions occur, review the patient's medications and, if possible, limit any that may interfere with sleep. Drugs that increase total sleep time may not improve the quality of sleep.

Melatonin, a naturally occurring hormone, appears to maintain normal sleep patterns. But as of this writing only one pilot study with eight patients has been conducted in a critical care population[60]; more research is needed before it can be recommended for patients on mechanical ventilation. ᵼ

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CE 3.5 HOURS

Continuing Education

GENERAL PURPOSE: To provide registered professional nurses with current information on the care of patients on mechanical ventilation.

LEARNING OBJECTIVES: After reading this article and taking the test on the next page, you will be able to

- outline the assessment procedures for determining a mechanically ventilated patient's readiness for weaning.
- discuss the recommended approaches to identifying and managing the complications of mechanical ventilation.
- plan appropriate interventions for ensuring the safety of patients on mechanical ventilation.

To earn continuing education (CE) credit, follow these instructions:

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