rothers.com, for detailed information on nursing books, visit our website www.jaypeebrothers.com, for detailed information on nursing books



# Critical Care NURSING Practice Guide

## A Road Map for Students and New Graduates

2nd Edition

**Elizabeth Simon**

*Forewords*
**Usha Ukande**
**Bennett Schepens**

JAYPEE

# Contents


**1. Eyeballing Your Patient** **1**

- Purpose *2*
- Technology and Your Patient *2*
- Focus on the Patient *2*
- Have a Mental Picture of Your Patient *3*
- Important Points to Remember *4*

**2. Taking and Giving Shift Report** **6**

- Shift Report: What Is It? *6*
- Shift Report: Why Is It Important? *7*
- Does Location Matter? *8*
- Taped versus Bedside *8*
- What Should be in It? (Content) *10*
- What Should not be in It? *10*
- Professional Behaviors *10*
- Documentation Tool *11*
- Important Points to Remember *12*

**3. Assessing Your Patient** **14**

- Head: Nervous System Assessment *15*
- Chest: Respiratory Assessment *15*
- Circulation/Chest: Cardiovascular Assessment *18*
- Blood Pressure Reading *20*
- Mean Arterial Pressure (MAP) *21*
- Abdominal Assessment (GI System) *21*
- Renal System Assessment (Elimination) *26*
- Skin Assessment (Protection) *27*

**4. Machines, Monitors, and Meters** **29**

- Machines *30*
- Understanding Mechanical Ventilation *30*
- Troubleshooting Alarms *37*
- Weaning (Liberation from the ventilators) from the Ventilators *40*
- Pain management, Sedation and Neuromuscular blockade *42*
- Hypothermia Machine *47*

- Continuous Renal Replacement Therapy (CRRT): Renal Machines *49*
- Meters *54*
- Monitors *55*
- Hemodynamic Monitoring *56*

**5. ABCs of Arterial Blood Gas** **65**

- Blood Gas Analysis *65*
- Acid-Base Disorders *67*
- Compensation: Understanding It *72*
- Mixed Acid-Base Disturbances *74*
- Steps in Interpreting ABG *74*
- Interventions in Acid–base Disturbances *76*

**6. Graphs and Waves** **79**

- EKG Waveforms *79*
- Rhythms Originating in Atria *87*
- Rhythms Originating in AV Junction *90*
- Rhythms Originating in Ventricles *92*
- Atrioventricular Blocks (AV Blocks) *97*
- Arterial Pressure Waveform *103*
- Capnography *104*
- Swan-Ganz Catheter Waveforms *104*
- Cardiac Output Waveforms *106*

**7. Drugs, Drips, and Drops** **109**

- Adenosine *110*
- Aminophylline *111*
- Amiodarone *111*
- Amrinone *112*
- Argatroban *113*
- Atropine *113*
- Calcium Gluconate *114*
- Digoxin *114*
- Diltiazem *115*
- Dobutamine *115*
- Dopamine *116*
- Esmolol *117*
- Heparin *117*
- Lidocaine *118*
- Milrinone *118*
- Phenylephrine *119*
- Regular Insulin *119*
- Phytonadione (Vitamin K) *120*
- Prothrombin Complex Concentrate, *4*-factor, Unactivated, from Human Plasma *122*

- Sodium Bicarbonate *122*
- Vasopressin *123*
- Sedatives and Analgesics in Critically Ill Patients *123*
- Cisatracurium *124*
- Dexmedetomidine *124*
- Fentanyl *125*
- Lorazepam *125*
- Midazolam *126*
- Propofol *127*
- Vecuronium *127*
- Drip Calculators *128*

**8. Emergencies in the ICU** **131**

- Adrenal Crisis *131*
- Arrhythmias *133*
- Asthma *137*
- Cardiac Arrest *139*
- Heart Failure *145*
- Pulmonary Edema *148*
- Hypertensive Emergency *149*
- Hypovolemia *149*
- Hypovolemia and Pregnancy *152*
- Rhabdomyolysis *153*
- Thyroid Storm (Thyroid Crisis) *154*
- Shock *155*

**9. Procedures in the ICU** **159**

- Assessment Guide for the Management of the Critical Care Patient *160*
- Protocol for Central Line Catheters *166*
- Flushing Central Venous Access Device *166*
- Hypothermia Protocol *167*
- Hemodynamic Monitoring *169*
- Normal Ranges and Waveforms *171*

**10. Planning Your Day** **184**

- Families *187*
- Nursing Students *189*
- ICU Nurses *189*

**11. Special ICUs** **192**

- Neurological ICU *192*
- Background Information *192*
- Peripheral Nervous System *193*
- Cerebral Perfusion Pressure (CCP) *203*
- Treatment Modalities *205*

- Hypothermia *206*
- Cardiac ICU *207*

**12. Transporting the Critically Ill Patient** **214**

- Phases of Transport *215*
- Special Equipment and Medications *218*

**13. Documentation** **221**

- Components of Documentation *222*
- New Trends in Documentation *222*
- Electronic Medical Record *223*

**14. Excellence in Practice** **228**

**15. Infusions and Transfusions** **236**

- Parenteral Nutrition *242*

**16. Labs, Levels, and Labels** **250**

- Electrolytes *250*
- Calcium-Induced Ischemia *258*
- Interventions *259*
- Replacement Therapy *262*
- Hematology *263*
- Differential Count *266*
- Labs to Evaluate Cardiovascular Integrity and Functions *268*

*Index* 277

# Machines, Monitors, and Meters

CHAPTER 4

*Elizabeth Simon*



In the intensive care unit (ICU), there are more machines, monitors, and meters compared to any other patient care unit. And their number exceeds the number of patients and providers combined. These gadgets give information, perform regulating functions, produce alarms, administers

JAYPEE BROTHERS

therapy, and offer warning during patient care. ICU nurses need to have an average understanding about operations, advantages, and the limitations different types of equipment to provide patient care effectively. It is essential that nurses have an above average competence in troubleshooting problems when needed.

## MACHINES

Among those numerous machines used in the ICU, the mechanical ventilator is the most commonly used and probably the most intimidating one because of its visible presence and frequency of alarms. In fact, the evolution of critical care as a specialty is connected to the invention of positive pressure ventilation. Yet, this critical care modality is only a support not a cure for any ventilatory issues. However, knowledge of the control panel, settings, modes, and troubleshooting is a necessary skill for nurses. Once there is an understanding about the principles behind these modes, it is easy to manage the troubleshooting part.

## UNDERSTANDING MECHANICAL VENTILATION

Mechanical ventilation is required in various conditions related to impaired ventilation, gas exchange, airway clearance, and thoracic cavity structural alteration, and even to reduce metabolic demands. The primary goal is to maintain alveolar ventilation by recruiting vulnerable alveoli, providing oxygenation, and preventing over distention and volutrauma (Burns, 2014, Morton and Fontaine, 2013, Owens, 2014). It is important for a nurse to know about the modes and controls of the machine hooked up to his or her patient.

The mechanical ventilators used now are positive-pressure ventilators, meaning that the air is forced into the alveoli under pressure, whereas normal (spontaneous) breathing is a negative-pressure operation. There are volume ventilators, pressure ventilators, and high-frequency jet ventilators. Before going into the details of the modus operandi of these machines, it is useful to review the basics. Some of the parameters are displayed on the ventilator control panel. The control panel has two areas, one for the set (ventilator) parameters, and the other for the patient data. Comparison of these parameters should begin with eyeballing your patient. Remember to look at the patient first, machines next! A nurse must focus on the following parameters:

### Tidal Volume

Tidal volume is the amount of air inhaled and exhaled in one cycle or each breath. Tidal volume during spontaneous breathing is 4–76 mL/kg. Previously, the practice was to use large tidal volumes for mechanical ventilations, but now the focus in on lower tidal volumes. The primary care provider determines the tidal volume and prescribes in the chart the exact tidal volume to be delivered. For example, if a patient weighs 100 kg, the tidal volume will be set at 400–600 mL/kg. However, patients with obstructive lung diseases

JAYPEE BROTHERS

need slightly higher tidal volume of 7–8 mL/kg to prevent air trapping (Burns, 2014, Parillo and Dellinger, 2014, Owens, 2014). Large volumes can cause injury to the lungs and distant organs because of the inflammatory response and release of cytokines in mechanical ventilation. Now, lung protective ventilation or low volume tidal volumes are preferred.

### Fraction of Inspired Oxygen ($FiO_2$)

Fraction of inspired oxygen is the percentage of oxygen in the inhaled volume. When a patient is intubated, a high $FiO_2$ is used initially and gradually reduced once the patient is stabilized. The goal is to achieve an optimal partial pressure of oxygen ($PaO_2$) or oxygen saturation ($SaO_2$) with minimal $FiO_2$. Concentration above 60% is considered a high $FiO_2$. Oxygen toxicity is a concern when the $FiO_2$ is high for more than 24 hours.

### Respiratory Rate

Both the set rate and the patient's rate can be seen on the control panel. Certain modes have higher rates than others. For example, the patient initially may be placed on a rate of 10–12 bpm, and when the patient is stabilized or placed in intermediate weaning modes, the rate is reduced to allow the patient more spontaneous breaths. You should compare the set rate with the patient's rate. *Respiratory rate multiplied by tidal volume* is the minute ventilation. When minute ventilation increases, partial pressure of carbon dioxide ($PaCO_2$) decreases, and when minute ventilation decreases, $PaCO_2$ increases. Minute ventilation is adjusted to maintain either hypoventilation or hyperventilation. For example, in patients with a head injury, hyperventilation and respiratory alkalosis is used therapeutically to reduce intracranial pressure (ICP). On the other hand, patients with chronic obstructive pulmonary disease are kept slightly hypoventilated to maintain their baseline hypercarbia (high $PaCO_2$).

### Peak Flow (Velocity of Gas per Unit Time)

If peak flow is increased, turbulence and increased airway pressures will result. If auto positive end expiratory pressure (PEEP) develops, adjust the peak flow to decrease the inspiratory time.

### Inspiratory Pressure Limits (IPL)

This feature limits the maximum pressure allowed in the circuit. If this alarm goes off frequently, you need to understand that high pressures have been reached and the inspiration has been cut off, limiting the volume delivered. In this situation, see what is triggering the IPL; anything that causes resistance in the circuit can lead to increased IPL. The most common causes are coughing, the patient biting the endotracheal tube, a kink in the ventilator circuit, secretions, condensed water in the tubing, bronchospasm, stiff lungs, or a pressure limit set too low. Respiratory therapists adjust the control and you have to deal with the rest of the problems. When weaning the patient, IPL is lowered to allow increased work of breathing by the patient.

JAYPEE BROTHERS

## Sensitivity

Sensitivity is a ventilator function measured as a negative inspiratory effort. For example, if the sensitivity increases, the patient has to do less work to initiate a breath. If the sensitivity is lowered, the patient must work harder to initiate a breath.

Knowing these basic control panel features will help you understand the modes of the ventilators. Ventilators currently used in ICUs are volume ventilators, which means that the inspiration of air is cut off when a predetermined volume is delivered. Assist control (AC) and synchronized intermittent mandatory ventilation (SIMV) are the two modes of volume ventilation.

## Volume Modes

- **AC mode:** This mode requires the least amount of work from the patient. All the patient does is open the demand valve and trigger the ventilator to do the rest. In AC mode, the ventilator assists the patient with each breath but controls the tidal volume. The set (prescribed) tidal volume is programmed into the control panel by the respiratory therapist, and the machine delivers the tidal volume. All breaths are machine-assisted breaths. Patients can initiate breaths and increase the rate, but every time they initiate a breath, the machine kicks in the tidal volume. The chances of tachypnea, hyperventilation, and respiratory alkalosis are high. AC is used when the patient is first intubated or is too weak to sustain the work of breathing. AC successfully takes over the work of breathing and is useful when patient is in conditions that prevents patients from meeting their own respiratory needs: acute respiratory distress syndrome (ARDS), pulmonary edema (PE), shock, multisystem trauma (Burns, 2014, Parillo and Dellinger, 2014, Owens, 2014).
- **There are two types of AC ventilation:** Volume assist-control or volume control (VCV) and volume pressure control or pressure control. In positive pressure ventilation, a given pressure is applied to deliver a particular volume or the tidal volume. The VCV mode requires both rate and tidal volume to be ordered by the primary care provider. The product of the rate and tidal volume is the minute ventilation (or minute volume) and this will determine the $CO_2$ elimination. Patient can breathe at different rate than the ventilator; however the full volume is delivered at each breath. Minute ventilation can be augmented by increasing either the rate or tidal volume or both. Normal minute ventilation for a healthy person at rest is 4–5 Liters per minute. Minute ventilation is increased with stress, fever, exercise and so forth when rate increases. (Owens, 2014). It has been observed that high volume (above 8 mL/kg) can cause volutrauma or ventilator induced lung injury (VILI) even in normal lungs. Once the tidal volume is determined, next thing to keep in mind is that plateau pressure should not exceed more than 30–35 cm of $H_2O$. If the plateau pressure exceeds 35 cm the tidal volume should be lowered.

JAYPEE BROTHERS

- **Volume support ventilation (VSV):** In VSV a desired tidal volume and PEEP are programmed in the ventilator and the machine adjusts the pressure up or down to deliver the desirable tidal volume. The computer in the ventilator analyzes and adjusts the tidal volume every three breaths. VSV employs advanced technology in adjusting respiratory compliance and effort while allowing spontaneous breathing. To evaluate the efficacy of the VSV we need to look at the peak airway pressure and Patient's clinical condition. Peak airway pressure is the sum of PEEP and pressure support (PS). Once the pressure support needed to maintain set volume is consistently below.

  On the other hand, in pressure assist control (PCV), a rate and driving pressure is set instead of volume. In addition to the pressure, an inspiratory time also is selected. In PCV the ventilator works with a set pressure and holds it till the time selected is completed and this is known as the I-time. This is the time taken for inspiration and the expiration time is usually double of that. Which means a normal I:E ratio is 1:2 to 1:4. Once this ratio is reversed it is known as inverse ratio ventilation. Inverse ratio ventilation is uncomfortable and when it is therapeutically used in the case of severe ARDS, sedation should be used. The driving pressure is the pressure change during breath. During a breath the peak pressure rises from the end expiratory pressure to the maximum and hold it for the I time and will come back to original pressure. This process will repeat number of breaths set for a minute. The tidal volume generated during this process will depend on the compliance of the respiratory system. If the lung compliance is low the volume would tend towards low and tidal volume will go high when the compliance improves. Therefore, the driving pressure should be adjusted in a range to avail 4–8 mL/kg . The peak airway pressure (driving pressure + PEEP) should not be higher than 35 cm $H_2O$. Because of the possible variations in respiratory compliance in critically ill, many physicians are reluctant to employ this modality (Burns, 2014, Parillo and Dellinger, 2014, Owens, 2014).
- **Synchronized intermittent mandatory ventilation (SIMV) mode:** SIMV is considered a weaning mode, and the patient is placed on this mode when he or she shows evidence of improvement. In SIMV, the machine delivers a set rate, and the patient is allowed to breathe spontaneously. The patient has more freedom, which means that when he takes a breath, the machine allows him/her to take a breath of his/her own tidal volume. Even though the tidal volume is set in the control panel, it does not kick in the tidal volume because the ventilator senses an inspiratory effort by the patient. Conversely, if the machine does not sense an inspiratory effort by the patient, it will deliver the tidal volume set in the machine's control panel. Therefore, you will notice that the patient's tidal volume in the patient data section of the control panel will vary from one breath to another; it will keep changing according to the patient's effort. So, the major difference between the AC and SIMV is that the tidal volume changes from breath to breath in SIMV, whereas in AC, it remains the same (Burns, 2014, Parillo and Dellinger, 2014, Owens, 2014).

JAYPEE BROTHERS

## Pressure Modes

- **Pressure support ventilation (PSV):** The purpose of using pressure early in inspiration and then throughout the inspiratory phase is to reduce patient effort and promote patient comfort. There is no set rate or tidal volume in PSV. Pressure support added to the ventilation enhances the patient's respiratory effort to help the patient during inspiration. Inspiration is cut off when the beginning gas flow reduces to 25% of the initial flow and pressure backs down to PEEP. Then the patient exhales passively. Increasingly, PSV is used in ICUs as the primary ventilation mode. PSV is thought to improve the endurance of respiratory muscles (Morton and Fontaine, 2013). This mode is not for patients who are sedated, or receiving neuromuscular blockade or having any pathological conditions that leads to unreliable breathing PSV is used as a weaning mode, or a recovery mode to boost the patient's effort in maintaining a tidal volume and tidal volume and RR should be monitored to detect any decreased compliance of the lungs. When compliance decreases (stiff lungs), the rate increases, and the tidal volume decreases. Always compare the patient's data with the machine's data. The pressure support needed is based on the patient's condition. When the patient gets stronger the pressure support can be dialed down and vice versa. If the respiratory rate is going high and the tidal volume is coming down patient is becoming tired and in need of more pressure support. When the patient is demonstrating tachypnea, tachycardia, diaphoresis, accessory muscle use and abdominal breathing, the pressure support is inadequate and needs to go higher. Conversely, a lower rate around 10 per minute with an adequate tidal volume shows less pressure support is needed. If the patient is breathing less than 10 per minute, it is time for weaning trial.
- **Pressure**: Controlled ventilation mode (PCV). This mode is the choice when the physical condition of the patient indicates that there is a high risk of barotraumas (damage caused by high airway pressures). PCV mode controls plateau pressures and is used in patients with conditions such as acute respiratory distress syndrome (ARDS) and patients with oxygenation problems such as refractory hypoxia. A set inspiratory pressure is delivered to the patient because the tidal volume can vary with each breath. Inverse ratio ventilation (IRV) is also used in combination with PCV. Sedation may be needed in this mode because of the possibility of dyssynchrony between the patient and the ventilator. IRV is usually used with PCV.
- **High frequency oscillatory ventilation (HFOV):** HFOV aims at accomplishing ultra fast tidal volume that are less than patient's anatomic dead space. A mechanical diaphragm oscillates between 3–15 times a second which creates a push and pull effect on the airway from the endotracheal tube to alveoli. HFOV is useful in severe hypoxic respiratory failure and inpatient with large bronchopulmonary fistula where a tidal volume is lost through the chest tube. The advantage of HFOV is that it can increase the mean airway pressure and oxygenation without high subjecting lung tissue to distending pressures and volume. In essence,

JAYPEE BROTHERS

HFOV can prevent barotrauma as well as volutrauma. Here the ventilation is regulated by number of oscillations (*f*) measured in Hertz or oscillation per second. The higher the frequency the lower the tidal volume that leads to a rise in $PaCO_2$. Likewise, lowering the frequency will lower the $PaCO_2$. Another important factor in HFOV is amplitude; that refers to the pressure of the oscillating diaphragm 8–90 cm $H_2O$. When the amplitude is increased oscillation is increased resulting in improved gas mixing. Increasing the altitude will lower $PaCO_2$ and decreasing the amplitude will increase $PaCO_2$. In spite of the promising therapy the HFOV can provide, there are many drawbacks: (1) need special ventilator, (2) cannot switch from this mode to another (3) there are no alarms in this type of ventilator and therefore frequent assessment is needed, (4) mucous plugging is common, (5) uncomfortable to the patient and usually necessitates sedation and even neuromuscular blockade (Owens, 2014).

- **Inverse ratio ventilation (IRV):** In this mode, the normal pattern expiratory time is almost double that in the inspiratory phase. Usually ventilators are set to deliver inspiration and expiration in a ratio of 1:2 or 1:3. This prolonged exhalation time promotes venous return and passive exhalation (Marino, 2014). In IRV, the ratio is reversed: an equal or longer inspiratory phase and a shorter exhalation phase, such as 1:1 to 4:1. It is useful in patients with ARDS to keep the alveoli open for longer periods, allowing time for gas exchange. PCV is commonly used along with IRV. Major problems you may encounter are auto PEEP and diminished cardiac output. Because the exhalation time is shorter, there is a very high chance of auto PEEP due to hyperinflation of the lungs, and as you know, auto PEEP can lead to barotraumas. Adding PCV itself can cause increase intrathoracic pressure and decrease cardiac output and oxygen delivery. Needless to say, this patient needs close observation for hemodynamic monitoring.
- **Airway pressure release ventilation mode (APRV):** This mode is used in trauma and ARDS patients because it reduces airway pressures, lowers minute volume, and allows spontaneous breathing throughout the inhalation and exhalation cycle. It has time-triggered, pressure-release, and time-cycled modes. The mechanism of operation is to depressurize the airways long enough to allow gas escape from the airways at the same time short enough to avert alveoli collapse. The effect of the APRV in patient is like a combination of CPAP and pressure release. The CPAP will keep the airway open and the release function will allow $CO_2$ to release from lungs periodically. In APRV patient can breathe spontaneously allowing better patient comfort and ventilation/perfusion (V/Q) matching. The terms and parameters of APRV appear unfamiliar and therefore, need explanation here. APRV is called Bi-Vent on Servo ventilators and Bi-Level on Puritan Bennett. P-high is like CPAP, it is the pressure applied to airway during the entire respiratory cycle to keep alveoli opened. A high value means higher airway pressures and better oxygenation and when gas exchange and compliance improve, the patient needs less of a P-high.

JAYPEE BROTHERS

- **T-high:** This is the time spent at the P-high or the time between releases. Improving oxygenation involves longer T-high and at the same time raising $PaCO_2$ by reducing releases per minute.
- **P-low:** This is the pressure that the ventilator drops to during pressure releases. In order to raise mean airway pressure P-LOW should be increased. T-LOW is another value that indicates the time spent at the P-LOW. This is usually 0.4 to 0.8 seconds. Time at T-LOW is important as longer time means more gas escape. For example, patients with COPD need longer T-LOW and patients with stiff lungs need shorter T-LOW. Weaning a patient from APRV is similar to that of from CPAP (Burns, 2014, Parillo and Dellinger, 2014, Owens, 2014).
- **Volume-guaranteed pressure option mode:** In this mode, the machine delivers a guaranteed tidal volume and uses decelerating pressure to deliver that volume. Therefore, it combines the advantages of pressure ventilation and guaranteed tidal volume. It is useful for patients with tidal volume problems such as secretions and weaning at night. Sleep reduces respiratory volume and rate, and secretions increase resistance, reducing spontaneous volume. The machine can provide both control and assist modes and is used for very unstable and weaning patients. The only disadvantage is that the operation demands sophisticated knowledge about the modes and the waveforms.
- **Continuous positive airway pressure (CPAP):** CPAP is the term used when PEEP is added during spontaneous breathing (Morton and Fontaine, 2013). CPAP is a ventilation mode used in intubated and non-intubated patients. For invasive CPAP in intubated patients, it is used as a weaning mode, and noninvasive CPAP is used in patients who have sleep apneas or similar airway problems. Both modalities accomplish the same goal: to keep the airway open during the respiratory cycle. The mode exerts PEEP throughout the cycle and allows the patients better oxygenation. When the patient maintains adequate tidal volume, respiratory rate, and desirable $PaO_2$, he or she is usually extubated. There is no rate or tidal volume set up in the CPAP mode. The patient will breathe at his or her rate and tidal volume with a set $FIO_2$ (low). If the patient stops breathing, the machine will go into rescue breathing mode. If the patient needs nocturnal ventilator support during sleep, a nasal or mask CPAP, called BiPAP, is used.
- **Bi-level positive pressure ventilation mode:** This noninvasive form of mechanical ventilation is used in acute and chronic respiratory failures, sleep apneas, hyperventilation and hypoventilations. There are two levels of support: Inspiratory support and expiratory support. Nasal or face masks or nasal pillows are used to accomplish this noninvasive ventilator support. However, face masks are not suitable for patients with poor cough and thick secretions.
- **Positive end expiratory pressure (PEEP):** PEEP is an adjunct mode that promotes oxygenation. Physiologic PEEP is produced in the body through glottis closure, and this advantage is lost in mechanically ventilated patients. Narrowing and collapse of the alveoli in the dependent lung

JAYPEE BROTHERS

region is a complication of positive pressure ventilation. This alveolar collapse is seen significantly high in conditions where there is small airway collapse (COPD) and reduced lung compliance (ARDS). A PEEP of 5–7 cm of $H_2O$ is used to prevent alveolar collapse at the end of expiration. Low levels of PEEP of 5–10 cm of $H_2O$ prevents collapse of alveoli, high levels of PEEP 20–30 cm of $H_2O$ reopen already collapsed alveoli. This effect of reopening of the alveoli is known as alveolar recruitment that eventually augments oxygenation by providing more gas exchange surface. Thus, the function of PEEP is to deliver pressure at the end of exhalation, especially when the patient suffers from refractory hypoxia, as seen in ARDS and other gas-exchange-compromising problems. To prevent or counterbalance this problem, PEEP is added to the main mode of ventilations. PEEP increases oxygenation and improves functional residual capacity and alveolar recruitment of the collapsed alveoli, thus reducing the need for high $FIO_2$. Keeping the alveoli open can also improve the surfactant regeneration (Morton and Fontaine, 2013). However, it has a negative effect on the cardiac output; PEEP causes ventilator-related lung injury and lowers cardiac output by many mechanisms. Reduction of cardiac output is related to decreased venous return, reduced ventricular compliance, outflow impedance, and hyperinflated lungs. The concept of hyperinflated lungs is easy to understand. The heart and lungs work in synchrony; when the lungs are emptied in exhalation, the heart fills in diastole, and vice versa. When PEEP is added, there is hyperinflation of the lungs at the end of exhalation; this prevents the heart from becoming filled with the stroke volume. This reduced filling related to mechanical or external constraints can reduce cardiac output. This reduction of cardiac output is most pronounced in hypovolemic patients. The positive effects of PEEP are improved gas exchange, and the lung recruitment can be neutralized by the reduction in cardiac output. For example, arterial oxygenation ($SaO_2$) may improve at the expense of systemic oxygenation. A PEEP of 5–7 cm of $H_2O$ is adequate to keep alveoli open with lung-protective ventilation (low tidal volume) (Marino, 2014). As a nurse, it is important to remember to monitor the hemodynamic stability frequently and not to interrupt PEEP, especially high PEEP (> 10 cm of $H_2O$). If high PEEPs (> 10 cm of $H_2O$) are discontinued, it will take a long time to recruit back the alveoli, and the benefits are nullified. Therefore, to suction patients, use inline suction to prevent unnecessary disruption of PEEP.

- **Auto PEEP or intrinsic PEEP (occult PEEP):** The air that remains in the alveoli at the end of exhalation can cause pressure called auto PEEP. This is a result of large tidal volumes and with high rates or the patient breathing rapidly. This auto PEEP can reduce cardiac output and cause barotraumas. Use lower tidal volumes (6–8 mL/kg) to prevent this complication.

## TROUBLESHOOTING ALARMS

When you hear an alarm, you need to go to the bedside and visualize the problem. Look at the patient first because you are there to take care of the

JAYPEE BROTHERS

patient's problem, not the machine's problems. Reassure the patient in a few words, and silence the alarm. Now look at the control panel and identify the type of alarm. The most common are low pressure, high pressure, low rate, high rate, or a combination.

Low-pressure alarms are triggered by situations that cause the delivered volume to leak. Machine senses that the ventilator circuit is not meeting resistance to delivering the volume to the patient. Disconnection is the number one problem to be aware of when low pressure alarm is heard. You can identify disconnection even before looking at the panel; if you eyeball the patient first, you can see this and hear the air escaping out of the tube. In that case, the patient is bagged with 100% oxygen until stabilized. Reassure the patient if the condition allows, and call for needed help. Another cause of low-pressure alarms is an air leak from the tubing. A quick look at the set tidal volume and the tidal volume on the patient data screen can show a leak. The patient's tidal volume will be very low compared with the set tidal volume due to air leak. There are many connections in the ventilator tubing that can get disengaged. You may hear a hissing sound if one of the tubes is leaking. If the tubing appears intact and you cannot identify anything visible, feel for an air leak by moving the dorsal aspect of your hand along the tubing in any direction, from the patient to the machine or the machine to the patient. Sometimes the thermometer port or the port for inhaled medications can leak, and this method of feeling the leaked air with your hand can identify even a small air leak. You can quickly fix that in most situations. Low tracheal cuff pressure another cause of low-pressure alarms. Slowly inflating the pilot balloon will give a tighter seal and would close the air leak. Then you or the respiratory therapist will have to check the tracheal cuff pressure and maintain it around 25 mm Hg or below. Many hospitals have prescribed cuff pressures in their policy manual. A situation seen in patients with a tracheotomy is that low-pressure alarms are triggered by widening stoma in relation to the tracheotomy tube. You can inflate the cuff and try to occlude the leak. If this is not possible after balloon inflation and the alarm is going off with evidence of an air leak, you need to report this and have the tracheotomy tube changed to a larger size. High-pressure alarms are triggered by increased resistance in delivering the preset tidal volume. The circuit is facing pressure due to various causes, such as patient coughing, the patient biting the ET tube, a kink in the ventilator tube, secretions, and condensed water in the tubing, bronchospasm, or stiff lungs. It is important to identify the problem. Anxious patients may be restless and attempt to talk and they may need reassurance and or sedation to calm down. However, secretions are the most common cause and need to be suctioned; water in the tubing can be emptied into a glove by disconnecting from the ventilator end. Do not empty the water back into the humidifier. If the patient is biting the tube, the circuit pressure will build up an oral airway can prevent patient from biting the tube. Look for any kinking of the tubes or tubes caught between the side rails. If you do not see anything that could cause resistance, it must be bronchospasm. Auscultate the patient, and if you hear wheezing or do not hear vesicular breathing, do

JAYPEE BROTHERS

not suction the patient; administer prescribed bronchodilators or call for help. Troubleshooting tips for most common problems are summarized in the Table 4.1.

**Table 4.1:** Tips to troubleshoot ventilator alarms

| *Alarms* | *Underlying problems* | *Corrective measures* | *Additional comments* |
|---|---|---|---|
| High pressure | • Kinked endotracheal tube<br>• Secretions/ mucous plug<br>• Patient talking/ biting the tube<br>• Condensed water in the tubing<br>• Bronchospasm<br>• Small ET tube | • Unkink the tubing<br>• Suction as needed/N–acetylcysteine (NAC) is used for aerosol therapy and tracheal injection<br>• Anxiety reduction, place oral airway<br>• Drain water from the tubing<br>• Bronchodilators<br>• Change ET tube | • Mix 2.5 mL 10% NAC with 2.5 mL of saline for aerosol. (Avoid in asthmatics). For tracheal injection mix 2 mL of 20% NAC with 2 mL of saline and inject into trachea |
| Low pressure alarms | • Disconnection<br>• Air leak<br>• Low ET tube cuff pressure<br>• Large tracheotomy and small tube | • Reconnect and bag the patient with 100% oxygen<br>• Find the leak and tighten connections secure tight seal in all ports (thermometer, medication)<br>• Inflate air to tracheal cuff<br>• Report to physician about the problem and prepare for new tube insertion | • Check cuff pressure and maintain below 25 mm Hg |
| High rate alarm | • Assess the cause, — e.g. dynamic hyperinflation pneumothorax anxiety pain, exhaustion from the ventilator | • Identify the cause pneumothorax—chest tube.<br>• Hyperinflation-reduce rate, adequate tidal volume, shorten inspiratory time<br>• Switch to AC mode if patient is exhausted | • Narcotics and sedation if needed<br>• Provide communication tools |
| Sudden drop in oxygen saturation | • Tube misplacement<br>• Pulmonary embolism<br>• Atelectasis, tension pneumothorax | • Assess tube placement and lung inflation<br>• Assess for pulmonary embolism<br>• Prepare for mucous removal/chest tube insertion | • Disconnect the patient and bag the patient if the assessment is nonconclusive |
| All alarms going off | • Ventilator malfunction<br>• Loose connection from the power outlet | • Assess power source<br>• Disconnect the patient from the ventilator and bag the patient | • Loose connection from the power outlet is common after the house–keeping work |

JAYPEE BROTHERS

## WEANING (LIBERATION FROM THE VENTILATORS) FROM THE VENTILATORS

The new and preferred term for taking the patient out of ventilator support is liberation not weaning. There is some difference in these two terms. During weaning there is a gradual reduction of pressure or volume support and then weaned from the ventilator. Conversely, liberation is a term used for frequent assessment to see whether the patient can breathe spontaneously without support and based on that observation extubated. There are important criteria to be fulfilled before extubation. First of all, we have to be confident the reason for initial intubation needs to be resolved. For example, if a patient was intubated for pneumonia or severe asthma, that pathology is reversed first and lungs appear clear. If the patient was intubated for shock the patient should be free of mental status changes and be from vasopressors to support blood pressure.

Secondly, patient should be able to maintain normocapnia or adequate ventilation without positive pressure ventilation. There will be oxygen therapy under 50% with or without a PEEP of 8 or less.

Adequate cardiovascular strength is another criterion to fulfill. Insufficient cardiac function—this is the third criteria for liberation from ventilators. A weaning trial on a T-piece can assess the patient to see whether he/she will tolerate spontaneous breathing. A stable mental status, to gain cooperation from the patient, is needed for extubation. Rapid shallow breathing index (RSBI) is a parameter used to guide the extubation process. This RSBI is calculated based on the principle that patients' breathing is better when it is deep and slow and worse when it is slow and fast. In order to assess the efficacy of patient's respiratory effort RSBI is calculated from the ratio of tidal volume to the respiratory rate. If the respiratory rate is 12 and the tidal volume is 400 RSBI = 12/0.4 = 30. An RSBI less than 80–100 is considered ready for liberation. However, this index should not be the only criterion.

Experts have developed many clinical parameters or indices to assess the readiness for extubation. They are a maximal inspiratory pressure or negative inspiratory pressure (NIF) of -30, a forced vital capacity of 10–15 mL/kg and minute ventilation of 10 Liters per minute are these parameters. Spontaneous breathing trial (SBT) with T-piece, CPAP-PS should be conducted daily to see if patient is tolerating. SBT is the current approach that replaces weaning parameters. *See* Box 4.1 for SBT.

In spite of optimal ventilator assistance and care about 20% if the patients will not be able to liberate from ventilators after the initial insult is resolved. Preexisting cardiopulmonary anomalies, neurological issues, malnutrition or continuing critical illnesses could be the reasons behind this prolonged respiratory failure. If three SBT fails even after 7 days of recovery from the acute illness, the condition can be called as difficult weaning or prolonged respiratory failure.

### Patient in Mechanical Ventilation—What is Important for Nurses?

It is the primary responsibility of the nurses to take care of the patient attached to a mechanical ventilator as a therapeutic modality. In addition

JAYPEE BROTHERS

for detailed information on nursing books, visit our website **www.jaypeebrothers.com,** for detailed information on nursing books, visit our webs

# Critical Care NURSING
## Practice Guide
### A Road Map for Students and New Graduates

The purpose of this book is to provide a step-by-step practical guide that will help new graduates and nursing students assigned to critical care areas, provide optimal care to their patients with confidence. It will help inexperienced nurses to systematically assess their patients, plan individualized care, implement therapeutic modalities with competence, collaborate effectively and evaluate the effectiveness of nursing actions. 'How and what' to document for prudent practice is also included in this book. In addition, there is a chapter to motivate novices to excel in their areas, engage in lifelong learning, and establish their confidence and competence with certification. In essence, it will be a road map for a novice to become an expert in daily routines and emergencies in the critical care areas. This is a unique approach, and such practical approaches are not seen in textbooks. It is designed to be read as if you are hearing directions from an experienced preceptor in the unit.



**Elizabeth Simon** PhD RN ANP-BC Alumnus-CCRN is a graduate of College of Nursing, Christian Medical College Ludhiana, affiliated to Punjab University, Punjab, India. Following graduation, she had worked at Christian Fellowship Hospital, Oddanchatram, Tamil Nadu, India and Ministry of Health, Kingdom of Saudi Arabia. Upon her arrival to the United States to be employed by the New York City Health and Hospital Corporation, New York, USA, she pursued her higher studies and obtained MS in Critical Care Nursing from the Columbia University School of Nursing, EdM in Nursing Education from Teachers College, Columbia University, New York, USA and PhD in Higher Education from Walden University, Minneapolis, USA. To expand her role as a Nurse Practitioner, she took another MS in Adult Health from Hunter College, New York, USA where she was teaching as a full time faculty.

In the United States, she worked as a Staff Nurse, Staff Development Instructor, Critical Care Nursing Consultant and Adult Nurse Practitioner. She has been board certified both in Emergency Nursing and Critical Care Nursing for more than twenty years and still maintains the certification in Critical Care Nursing. She is an accomplished academic. She has published peer-reviewed articles in clinical and academic journals, written book chapters, reviewed books and presented papers in National and International conferences. She has been teaching Nursing for more than 20 years in the United States. At present, she is the Dean and Professor of School of Nursing, Nyack College, Nyack, New York, USA. She was awarded Fulbright-Nehru Academic Excellence Award for 2015-16 academic year. It was during this time that she decided to publish the revised version of her first book in India in response to the demands of the students and clinicians.

**Available at all medical bookstores**
**or buy online at www.jaypeebrothers.com**

**JAYPEE BROTHERS**
**Medical Publishers (P) Ltd.**
**www.jaypeebrothers.com**

Join us on facebook.com/JaypeeMedicalPublishers

ISBN 978-93-86322-04-3