

critical care nursing monitoring basics

Mastering Critical Care Nursing Monitoring Basics: A Comprehensive Guide

critical care nursing monitoring basics are the cornerstone of patient safety and effective treatment in high-acuity settings. Within the intensive care unit (ICU), the nurse's ability to meticulously observe, interpret, and respond to a patient's physiological status can mean the difference between life and death. This crucial role involves a deep understanding of various monitoring systems, vital signs, and subtle clinical cues. In this article, we will delve into the fundamental aspects of critical care nursing monitoring, covering everything from the essential physiological parameters to advanced hemodynamic monitoring techniques, ensuring you have a solid grasp of this vital skill set. We will explore the rationale behind each monitoring modality, the interpretation of data, and the timely interventions that follow.

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Foundational Physiological Monitoring

The bedrock of critical care nursing monitoring lies in the continuous and vigilant assessment of fundamental physiological parameters. These are the vital signs that provide a snapshot of a patient's immediate status and their ability to maintain homeostasis. Without a thorough understanding and accurate measurement of these basics, more advanced interventions would be haphazard and ineffective. Think of these as the essential alarm system for the body; a change in their readings can signal a developing problem long before more overt symptoms appear.

Heart Rate and Rhythm Assessment

Heart rate, representing the number of times the heart beats per minute, is a

primary indicator of cardiovascular function. A normal resting heart rate for adults typically falls between 60 and 100 beats per minute. However, in critical care, this range can be influenced by numerous factors, including medications, underlying conditions, and the patient's physiological stress response. Deviations from the expected range, whether an abnormally high rate (tachycardia) or a low rate (bradycardia), necessitate immediate investigation. Tachycardia can indicate hypovolemia, fever, pain, anxiety, or sepsis, while bradycardia might suggest cardiac issues, certain medications, or electrolyte imbalances. Equally important is the assessment of heart rhythm, which describes the pattern of the electrical impulses that cause the heart to contract. An irregular rhythm can point to arrhythmias, which can impair the heart's ability to pump blood effectively, leading to reduced cardiac output and potential organ hypoperfusion.

Blood Pressure Monitoring and Interpretation

Blood pressure (BP) is the force exerted by circulating blood against the walls of the arteries. It is typically measured as systolic pressure (the pressure during heart contraction) over diastolic pressure (the pressure when the heart relaxes between beats). In critical care, maintaining adequate blood pressure is paramount to ensuring sufficient perfusion to vital organs like the brain, heart, and kidneys. Hypotension (low blood pressure) can lead to inadequate tissue oxygenation and organ damage, while hypertension (high blood pressure) can increase the risk of bleeding, stroke, and myocardial infarction. Continuous blood pressure monitoring, often via an arterial line, provides real-time data that allows for rapid adjustments in therapy. Understanding the nuances of BP readings, including the pulse pressure (the difference between systolic and diastolic pressure), is also critical.

Respiratory Rate and Oxygenation Saturation

The respiratory rate, the number of breaths a person takes per minute, is a crucial indicator of ventilatory status. A normal adult respiratory rate is typically between 12 and 20 breaths per minute. Tachypnea (an increased respiratory rate) can signal respiratory distress, hypoxia, fever, or metabolic acidosis, while bradypnea (a decreased respiratory rate) might suggest respiratory depression due to medications, head injury, or severe illness. Beyond the rate, the depth and pattern of breathing offer further insights. Oxygenation saturation, commonly measured by pulse oximetry, reflects the percentage of hemoglobin saturated with oxygen. A normal SpO₂ is usually 95% or higher. A drop in oxygen saturation can indicate impaired gas exchange, airway obstruction, or a decrease in lung compliance, requiring prompt assessment of the respiratory system and potential interventions such as supplemental oxygen or ventilatory support.

Temperature Monitoring and its Significance

Body temperature is a vital sign that reflects the body's metabolic state and its ability to regulate its internal environment. A normal body temperature typically hovers around 98.6°F (37°C), but can fluctuate slightly. Fever (hyperthermia) is a common response to infection or inflammation, indicating the body's immune system is active. However, sustained high temperatures can lead to increased metabolic demand, dehydration, and cellular damage. Conversely, hypothermia (low body temperature) can occur in cases of prolonged exposure to cold, severe illness, or certain medical conditions, and can slow down bodily functions, potentially leading to organ dysfunction. Accurate and regular temperature monitoring is essential for identifying these conditions and guiding appropriate treatment, such as antipyretics or warming measures.

Cardiovascular Monitoring Essentials

The cardiovascular system is the engine that drives oxygenated blood throughout the body. In critical care, understanding its complex workings and monitoring its performance is paramount. This involves not just tracking the basic vital signs, but also delving into more specific assessments to ensure adequate cardiac output and tissue perfusion. Any compromise in this system can have rapid and devastating consequences for all other organ systems.

Electrocardiogram (ECG) Interpretation

The electrocardiogram (ECG) is an indispensable tool in critical care, providing a graphical representation of the heart's electrical activity. A continuous 12-lead ECG, or at least a 3- or 5-lead continuous monitor, allows nurses to detect and interpret a wide range of arrhythmias, ischemia, and infarction. Understanding the basic components of an ECG waveform—the P wave, QRS complex, and T wave—and their significance is crucial. Nurses must be able to identify common life-threatening arrhythmias such as ventricular tachycardia, ventricular fibrillation, atrial fibrillation with rapid ventricular response, and asystole, and be prepared to initiate immediate interventions according to established protocols. Regular rhythm strips are essential for trending changes and assessing the effectiveness of treatments.

Central Venous Pressure (CVP) Monitoring

Central venous pressure (CVP) monitoring involves measuring the pressure within the superior vena cava, which reflects the pressure in the right atrium. This parameter provides valuable information about the patient's

fluid status and the effectiveness of right ventricular function. A normal CVP typically ranges from 2 to 6 mmHg. Elevated CVP can indicate fluid overload, right ventricular failure, or increased intrathoracic pressure, while a low CVP may suggest hypovolemia or decreased circulating volume. Accurate CVP readings require proper catheter placement, leveling of the transducer at the phlebostatic axis, and ensuring no air bubbles are in the line. It is a key indicator for guiding fluid resuscitation and vasopressor therapy.

Pulmonary Artery Catheter (PAC) Monitoring

While less commonly placed now than in previous decades due to advancements in less invasive techniques, the pulmonary artery catheter (PAC), also known as a Swan-Ganz catheter, offers a comprehensive view of hemodynamic status. It allows for the measurement of pulmonary artery pressure, pulmonary capillary wedge pressure (PCWP), cardiac output, and mixed venous oxygen saturation (SvO₂). PCWP, in particular, is a surrogate measure of left ventricular end-diastolic pressure and left atrial pressure, providing insight into left ventricular preload and filling pressures. SvO₂ reflects the balance between oxygen delivery and oxygen consumption by the tissues; a decrease in SvO₂ indicates increased oxygen extraction, often due to inadequate oxygen delivery (hypoperfusion) or increased oxygen demand.

Arterial Line Monitoring

Arterial lines, typically inserted into the radial, brachial, or femoral artery, provide continuous, real-time measurement of arterial blood pressure. This is considered the gold standard for BP monitoring in critically ill patients, especially those who are hemodynamically unstable or receiving potent vasoactive medications. Beyond systolic and diastolic pressures, arterial lines also provide waveform analysis, which can reveal information about cardiac contractility and systemic vascular resistance. They also allow for frequent arterial blood gas sampling without repeated venipunctures, minimizing patient discomfort and risk of complications. Proper waveform transduction, waveform calibration, and transducer leveling are critical for accurate readings.

Respiratory Monitoring Techniques

The lungs are responsible for the vital exchange of oxygen and carbon dioxide, a process that can be severely compromised in critically ill patients. Comprehensive respiratory monitoring is therefore a non-negotiable aspect of critical care nursing. It's about ensuring the patient can effectively breathe and that their tissues are receiving the oxygen they

desperately need.

Ventilator Management and Settings

For patients requiring mechanical ventilation, understanding and managing the ventilator settings is a core nursing responsibility. This includes parameters such as tidal volume (the amount of air inhaled with each breath), respiratory rate, fraction of inspired oxygen (FiO_2), and positive end-expiratory pressure (PEEP). Each setting plays a crucial role in supporting or replacing the patient's spontaneous breathing efforts and optimizing gas exchange while minimizing ventilator-induced lung injury (VILI). Nurses must be proficient in interpreting ventilator alarms, troubleshooting common issues, and making appropriate adjustments under physician orders to ensure patient safety and comfort. Regularly assessing the patient's tolerance to the prescribed settings is also essential.

Blood Gas Analysis (ABG/VBG)

Arterial blood gas (ABG) analysis is a powerful diagnostic tool that provides detailed information about a patient's acid-base balance, ventilation, and oxygenation. It measures pH, partial pressure of carbon dioxide (PCO_2), partial pressure of oxygen (PO_2), bicarbonate (HCO_3), and oxygen saturation. Venous blood gas (VBG) analysis, while less informative about oxygenation, can still provide valuable data on pH and PCO_2 , and is less invasive. ABGs help diagnose and monitor respiratory acidosis, respiratory alkalosis, metabolic acidosis, metabolic alkalosis, and hypoxemia or hypercapnia. Understanding how to interpret these values in conjunction with clinical findings is critical for guiding treatment strategies, particularly in patients with respiratory failure or metabolic derangements.

Peak Expiratory Flow and Spirometry

While peak expiratory flow (PEF) and spirometry are more commonly associated with outpatient management of respiratory conditions like asthma, they can have limited utility in certain critical care scenarios, particularly for spontaneously breathing patients with neuromuscular weakness or during weaning from mechanical ventilation. PEF measures the maximum speed of exhalation, providing an objective assessment of airway obstruction. Spirometry measures lung volumes and capacities, offering a more detailed picture of pulmonary function. Though less frequently employed in the immediate critical phase, these tools can provide objective data for assessing reversibility of bronchoconstriction or the progress of lung recovery.

Chest X-rays and Imaging Interpretation

Regular chest X-rays are a vital component of respiratory monitoring in the ICU. They allow for the assessment of lung fields for signs of pneumonia, atelectasis, pulmonary edema, pneumothorax, and the correct placement of endotracheal tubes, central lines, and chest tubes. Critical care nurses must be able to identify significant findings on chest X-rays, such as infiltrates, effusions, or changes in lung volume, and communicate these findings promptly to the physician. Understanding the normal radiographic appearance of the lungs is essential for recognizing abnormalities and tracking the progression or resolution of lung pathology.

Neurological Monitoring Principles

The brain is the central command center of the body, and its function can be severely impacted by critical illness. Neurological monitoring in the ICU is essential for detecting changes in brain function, assessing the adequacy of cerebral perfusion, and identifying potential neurological emergencies before they lead to irreversible damage.

Glasgow Coma Scale (GCS)

The Glasgow Coma Scale (GCS) is a standardized, objective assessment tool used to evaluate a patient's level of consciousness. It assesses three components: eye opening, verbal response, and motor response, with a total score ranging from 3 (deep coma) to 15 (fully awake). A declining GCS score is a critical indicator of neurological deterioration, suggesting increased intracranial pressure, brain injury, or metabolic encephalopathy. Regular and accurate GCS scoring by nurses is vital for tracking changes over time and alerting the medical team to potential problems. It provides a common language for describing neurological status across different healthcare providers.

Pupillary Light Reflex Assessment

The size, equality, and reactivity of the pupils to light are crucial neurological indicators. Normal pupils are typically 2-4 mm in diameter, equal in size, and constrict briskly and symmetrically when exposed to light. Asymmetrical pupils or a fixed and dilated pupil can indicate significant intracranial pressure, herniation, or direct brainstem injury. Nurses must meticulously assess pupillary response to light, noting any deviations from normal. The documentation of pupillary findings is essential for monitoring trends and evaluating the effectiveness of interventions aimed at reducing

intracranial pressure.

Intracranial Pressure (ICP) Monitoring

For patients with severe traumatic brain injury, subarachnoid hemorrhage, or other conditions that can lead to elevated intracranial pressure (ICP), invasive ICP monitoring is often implemented. This involves placing a transducer within the cranial vault to directly measure the pressure inside the skull. Normal ICP is typically between 5 and 15 mmHg. Elevated ICP can impede cerebral blood flow, leading to ischemia and secondary brain injury. Critical care nurses play a vital role in monitoring ICP readings, identifying trends, recognizing alarm parameters, and implementing nursing interventions to help reduce ICP, such as elevating the head of the bed, managing sedation, and ensuring adequate ventilation.

Cerebral Perfusion Pressure (CPP) Calculation

Cerebral perfusion pressure (CPP) is the mean arterial pressure (MAP) minus the intracranial pressure (ICP). It represents the pressure gradient that drives blood flow to the brain. A CPP of 60-80 mmHg is generally considered adequate for maintaining cerebral perfusion in most adult patients. If CPP falls too low, cerebral ischemia can occur. If CPP is too high, it can lead to increased ICP. Critical care nurses are responsible for calculating CPP, monitoring its trends, and collaborating with the medical team to adjust MAP and ICP to maintain CPP within the target range. This calculation highlights the interplay between systemic blood pressure and intracranial dynamics.

Renal and Metabolic Monitoring

The kidneys play a critical role in maintaining fluid and electrolyte balance, filtering waste products, and regulating blood pressure. Metabolic processes are fundamental to cellular function. In critical care, these systems are often compromised, necessitating diligent monitoring to prevent or manage serious complications.

Urine Output Monitoring and Significance

Urine output is a direct indicator of renal perfusion and kidney function. In critical care, a Foley catheter is often in place to allow for continuous monitoring of urine output. A normal urine output is typically 0.5 to 1 mL/kg/hour. A significant decrease in urine output (oliguria) can signal hypovolemia, acute kidney injury (AKI), or impaired renal perfusion, while

excessive urine output (polyuria) might indicate fluid overload or certain endocrine disorders. Nurses must meticulously track urine output, noting its color, clarity, and any presence of sediment or blood, and report any significant changes promptly. This data is crucial for guiding fluid management and assessing the response to therapies.

Electrolyte Balance and Monitoring

Electrolytes such as sodium, potassium, chloride, calcium, and magnesium are essential for cellular function, nerve impulse transmission, and muscle contraction. Critical illness can disrupt electrolyte balance due to various factors, including fluid shifts, kidney dysfunction, and medications. Imbalances can lead to serious consequences, such as cardiac arrhythmias (especially with potassium abnormalities), seizures, and muscle weakness. Nurses must monitor electrolyte levels through laboratory results and be aware of the clinical signs and symptoms of common electrolyte disturbances, facilitating timely intervention with electrolyte replacement or removal.

Blood Glucose Levels and Control

Maintaining stable blood glucose levels is crucial for optimal cellular function and wound healing, especially in critically ill patients. Stress hyperglycemia is common in the ICU due to the release of stress hormones, and uncontrolled hyperglycemia can lead to impaired immune function, increased risk of infection, and poor outcomes. Conversely, hypoglycemia (low blood glucose) can cause neurological deficits and cardiac events. Critical care nurses are responsible for monitoring blood glucose levels, often using point-of-care glucometers, and implementing insulin therapy protocols to maintain blood glucose within the target range, as prescribed by the medical team.

Acid-Base Balance Interpretation

As discussed with ABGs, acid-base balance is a critical aspect of metabolic and respiratory monitoring. The body tightly regulates pH through respiratory and metabolic mechanisms. Deviations from the normal pH range (7.35-7.45) can have profound effects on enzyme function and cellular processes. Critical care nurses must understand how to interpret acid-base status, identifying whether the primary problem is respiratory or metabolic in origin and whether it is compensated or uncompensated. This understanding is fundamental for diagnosing and managing a wide range of critical illnesses.

Advanced Hemodynamic Monitoring

Beyond the basic vital signs, advanced hemodynamic monitoring allows for a deeper understanding of the forces at play within the cardiovascular system. This sophisticated level of assessment is vital for managing patients with complex cardiac conditions, shock, or those requiring aggressive vasoactive support.

Cardiac Output (CO) and Cardiac Index (CI)

Cardiac output (CO) is the volume of blood pumped by the heart per minute, typically measured in liters per minute (L/min). Cardiac index (CI) is the CO adjusted for body surface area, providing a more individualized measure of cardiac performance. A normal CO for an adult at rest is generally 4-8 L/min, and a normal CI is 2.5-4 L/min/m². Monitoring CO and CI helps assess the heart's ability to meet the body's metabolic demands. Decreased CO/CI indicates inadequate tissue perfusion and can be a sign of heart failure, hypovolemia, or severe sepsis. Various methods, including thermodilution via a PAC or echocardiography, are used to measure CO and CI.

Systemic Vascular Resistance (SVR)

Systemic vascular resistance (SVR) is a measure of the resistance to blood flow in the systemic circulation. It is a key determinant of blood pressure and reflects the degree of vasoconstriction or vasodilation in the peripheral vasculature. High SVR can impede blood flow and increase the workload on the left ventricle, while low SVR can lead to hypotension and inadequate organ perfusion. SVR is typically calculated using MAP, CVP, and CO. In critical care, SVR is frequently monitored to guide the titration of vasoactive medications, such as vasopressors and vasodilators, to achieve optimal circulatory status.

Mixed Venous Oxygen Saturation (SvO₂)

Mixed venous oxygen saturation (SvO₂) is a measure of the amount of oxygen remaining in the blood returning to the right atrium after circulating through the body's tissues. It reflects the balance between oxygen delivery and oxygen consumption. A normal SvO₂ is typically between 60% and 80%. A decreased SvO₂ (<60%) indicates that tissues are extracting more oxygen than usual, suggesting inadequate oxygen delivery (due to low CO, anemia, or hypoxemia) or increased oxygen demand (due to fever, sepsis, or hypermetabolism). An elevated SvO₂ (>80%) can indicate impaired oxygen utilization, such as seen in cyanide poisoning or severe sepsis.

Non-Invasive Cardiac Output Monitoring

Recent advancements have led to the development of non-invasive cardiac output monitoring devices that utilize technologies like impedance cardiography, bioreactance, or pulse contour analysis. These methods aim to provide continuous or intermittent CO and hemodynamic parameter estimations without the need for invasive catheterization. While they offer advantages in terms of safety and patient comfort, their accuracy can be influenced by various factors, and validation against more invasive methods is often required. Nonetheless, these technologies are increasingly being integrated into critical care settings to aid in hemodynamic assessment and management.

The Art of Data Interpretation and Integration

Collecting data from various monitoring devices is only the first step; the true skill in critical care nursing lies in the ability to interpret and integrate this information into a coherent clinical picture. This requires a deep understanding of physiology, pathophysiology, and the complex interplay between different organ systems.

Recognizing Trends and Patterns

Single data points are often less informative than observing trends over time. Critical care nurses must be adept at recognizing subtle changes in vital signs, hemodynamic parameters, and laboratory values. Is the patient's heart rate gradually increasing? Is their urine output declining consistently? Are their blood gases slowly deteriorating? Identifying these trends allows for proactive intervention before a patient's condition becomes acutely unstable. It's about seeing the forest for the trees, understanding the overall trajectory of the patient's health.

Synthesizing Information from Multiple Sources

No single monitoring parameter tells the whole story. Effective critical care nursing involves synthesizing data from the ECG, arterial line, ventilator, laboratory results, and physical assessments. For example, a patient with a rising heart rate and falling blood pressure could be experiencing hypovolemia, sepsis, or cardiac tamponade. The nurse must integrate all available data to differentiate between these possibilities and guide appropriate diagnostic workup and treatment. It's like piecing together a complex puzzle where each monitor provides a vital clue.

Anticipating and Preventing Complications

With a thorough understanding of the patient's baseline status and ongoing monitoring data, skilled nurses can often anticipate potential complications. For instance, a patient with a falling SvO₂ and rising lactate might be developing septic shock, prompting early initiation of resuscitation measures. Similarly, a patient with increasing ICP and decreasing CPP may be at risk for cerebral herniation, necessitating prompt interventions to reduce ICP. This anticipatory approach is a hallmark of expert critical care nursing and significantly contributes to improved patient outcomes.

The Nurse's Role in Collaborative Decision-Making

Critical care nursing is a team sport. Nurses are invaluable members of the multidisciplinary team, and their insights derived from continuous patient monitoring are crucial for collaborative decision-making. They are the frontline observers, often the first to detect subtle changes or emergent situations. Effective communication with physicians, respiratory therapists, pharmacists, and other members of the care team ensures that patient care is coordinated, timely, and evidence-based, leading to the best possible outcomes.

Technology and Future Trends in Monitoring

The field of critical care monitoring is constantly evolving, driven by technological advancements aimed at improving accuracy, reducing invasiveness, and providing more comprehensive data for better patient management.

Wearable and Continuous Non-Invasive Sensors

The development of wearable sensors and advanced non-invasive monitoring technologies is transforming how patients are assessed. These devices can continuously track parameters like ECG, respiration, SpO₂, and even some hemodynamic indicators, providing a more holistic and real-time picture of a patient's status. This can reduce the need for frequent manual checks and allow for earlier detection of subtle physiological changes.

Artificial Intelligence and Machine Learning in Data

Analysis

Artificial intelligence (AI) and machine learning (ML) are increasingly being applied to analyze the vast amounts of data generated by critical care monitoring systems. AI algorithms can identify complex patterns, predict patient deterioration, and alert clinicians to potential risks with greater speed and accuracy than traditional methods. This promises to enhance diagnostic capabilities and personalize treatment strategies.

Tele-ICU and Remote Monitoring Capabilities

Tele-ICU services, leveraging advanced monitoring technology and high-speed communication, allow for remote oversight of critically ill patients by intensivists and expert nurses. This can extend specialized care to underserved areas, improve response times, and support bedside nurses in complex decision-making. The ability to remotely access and interpret real-time patient data is a significant step forward.

Integration of Multi-Modal Data for Predictive Analytics

The future of critical care monitoring involves the seamless integration of data from all sources – physiological monitors, electronic health records, imaging, and genomics. By analyzing this multi-modal data, predictive analytics can offer even more sophisticated insights into patient risk stratification, treatment efficacy, and the potential for adverse events. This comprehensive approach promises to revolutionize proactive and personalized critical care.

Frequently Asked Questions

Q: What are the most critical vital signs to monitor in a critical care setting?

A: The most critical vital signs in critical care are heart rate, blood pressure, respiratory rate, and temperature. These fundamental indicators provide an immediate snapshot of the patient's physiological stability and are the first line of defense in detecting deterioration.

Q: Why is continuous ECG monitoring so important in the ICU?

A: Continuous ECG monitoring is crucial in the ICU because it allows for the immediate detection of potentially life-threatening arrhythmias that can compromise cardiac output and lead to sudden cardiac arrest. Early identification and intervention for abnormal rhythms are paramount.

Q: How does urine output help assess a patient's condition?

A: Urine output is a direct reflection of kidney perfusion and overall circulatory status. A significant decrease in urine output can indicate hypovolemia, impaired renal function, or inadequate blood flow to the kidneys, signaling a potential problem that requires immediate attention and fluid management.

Q: What is the significance of monitoring electrolyte levels in critical care?

A: Electrolyte imbalances, such as abnormal levels of potassium, sodium, or calcium, can have severe consequences for cardiac function, neurological activity, and muscle function. Monitoring and correcting these imbalances are vital for preventing serious complications like arrhythmias and seizures.

Q: How does a critical care nurse use data from an arterial line?

A: A critical care nurse uses data from an arterial line to continuously monitor a patient's blood pressure with high accuracy. This allows for precise adjustments of vasoactive medications and provides real-time information on the patient's hemodynamic stability, crucial for managing shock or administering potent drugs.

Q: What is the role of PEEP in mechanical ventilation monitoring?

A: Positive End-Expiratory Pressure (PEEP) is a setting on a mechanical ventilator that helps keep the small airways and alveoli open at the end of exhalation. Critical care nurses monitor PEEP to ensure adequate lung inflation, improve oxygenation, and prevent alveolar collapse, while also watching for potential adverse effects like reduced venous return.

Q: When would a Glasgow Coma Scale (GCS) score be particularly concerning for a critical care nurse?

A: A declining GCS score, especially a drop of 2 or more points, is highly concerning and indicates neurological deterioration. This could be due to increased intracranial pressure, bleeding in the brain, or other neurological insults, requiring immediate further assessment and intervention.

Q: How does mixed venous oxygen saturation (SvO2) inform patient care?

A: SvO2 reflects the balance between oxygen delivery and consumption. A low SvO2 suggests that tissues are not receiving enough oxygen, indicating potential issues with cardiac output, anemia, or hypoxemia, prompting the nurse to advocate for interventions to improve oxygen delivery.

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