

Fluid and Electrolyte Imbalance in Critical Care: A Review of Pathophysiology, Clinical Impact, and Nursing Management

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Abstract: Fluid and electrolyte balance is essential for maintaining cellular homeostasis and organ function. Critically ill patients are particularly vulnerable to fluid and electrolyte imbalances due to underlying disease processes, aggressive therapeutic interventions, and altered physiological responses. Imbalances such as hyponatremia, hypernatremia, hypokalemia, hyperkalemia, hypocalcemia, and fluid overload are frequently observed in intensive care units (ICUs) and are associated with increased morbidity and mortality. This review explores the pathophysiology, clinical manifestations, diagnostic considerations, and evidence-based nursing management strategies for fluid and electrolyte disturbances in critically ill patients. Emphasis is placed on the pivotal role of critical care nurses in early identification, monitoring, and timely intervention to improve patient outcomes.

Keywords: fluid imbalance, electrolyte disorders, critical care, intensive care unit, nursing management

1. Introduction

Maintenance of fluid and electrolyte homeostasis is fundamental to survival. In critically ill patients, this balance is often disrupted due to sepsis, trauma, renal dysfunction, cardiac failure, endocrine disturbances, and extensive surgical procedures. Mechanical ventilation, vasopressors, diuretics, intravenous fluids, and renal replacement therapy further contribute to instability.

Fluid and electrolyte imbalances are not merely laboratory abnormalities; they significantly influence neurological status, cardiovascular stability, respiratory function, and renal perfusion. Early recognition and prompt correction are essential components of critical care nursing practice.

Pathophysiology of Fluid and Electrolyte Imbalance in Critical Illness

- Critical illness triggers complex neurohormonal responses involving:
- Activation of the renin–angiotensin–aldosterone system (RAAS)
- Increased antidiuretic hormone (ADH) secretion
- Inflammatory cytokine release
- Capillary leak syndrome

These mechanisms lead to:

Fluid shifts between intravascular and interstitial compartments
Sodium and water retention
Altered potassium and calcium distribution
Acid–base disturbances
Sepsis and systemic inflammatory response syndrome (SIRS) further exacerbate vascular permeability, causing third-spacing and hypovolemia despite total body fluid overload.

Common Electrolyte Imbalances in Critical Care

1) Sodium Imbalances

- Hyponatremia is frequently seen in ICU patients due to SIADH, heart failure, renal dysfunction, or excessive hypotonic fluid administration. Severe hyponatremia can result in cerebral edema, seizures, and coma.
- Hypernatremia often occurs due to dehydration, inadequate free water intake, or osmotic diuresis. It may lead to neurological impairment and increased mortality.

2) Potassium Imbalances

- Hypokalemia may result from diuretics, gastrointestinal losses, insulin therapy, or metabolic alkalosis. It increases the risk of arrhythmias and muscle weakness.
- Hyperkalemia is common in renal failure, acidosis, and tissue breakdown. It is life-threatening due to its potential to cause cardiac arrest.

3) Calcium and Magnesium Disorders

Hypocalcemia is common in sepsis and massive transfusion, contributing to hypotension and impaired myocardial contractility. Magnesium imbalance often coexists with potassium abnormalities and affects neuromuscular stability.

4) Fluid Overload and Fluid Deficit

Excessive fluid resuscitation can lead to:

- Pulmonary edema
- Acute respiratory distress syndrome (ARDS)
- Increased intra-abdominal pressure
- Delayed wound healing
- Conversely, inadequate fluid replacement leads to hypoperfusion, shock, and multi-organ failure.

Clinical Impact and Prognosis

Multiple studies indicate that both hypo- and hypernatremia are associated with increased ICU mortality. Fluid overload exceeding 10% of body weight has been linked to prolonged

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mechanical ventilation and longer ICU stays. Electrolyte disturbances may serve as independent predictors of poor outcomes.

Thus, electrolyte monitoring is not only therapeutic but also prognostic in critical care settings.

Assessment and Diagnostic Monitoring

Critical care nurses play a central role in early detection through:

- Continuous hemodynamic monitoring
- Strict intake and output charting
- Daily weight assessment
- Serum electrolyte analysis
- Arterial blood gas (ABG) interpretation
- ECG monitoring for potassium abnormalities
- Timely communication with the multidisciplinary team ensures rapid intervention.
- Evidence-Based Management Strategies

Management principles include:

Individualized fluid therapy (restrictive vs. liberal strategies)
Balanced crystalloids over high-chloride solutions where appropriate

Careful correction of sodium to prevent osmotic demyelination

Protocol-based potassium replacement

Use of diuretics or renal replacement therapy when indicated

Gradual correction is essential to avoid complications.

Role of the Critical Care Nurse

The critical care nurse is pivotal in:

Early identification of subtle changes

Accurate documentation

Prevention of medication errors during electrolyte replacement

Patient and family education

Implementation of ICU fluid protocols

Nurse-led monitoring systems and standardized electrolyte replacement guidelines have demonstrated improved patient safety outcomes.

Gaps in Current Research

Although electrolyte disorders are common, there remains variability in fluid resuscitation strategies and correction protocols. Further research is needed to establish standardized nursing-driven electrolyte management guidelines and outcome-based interventions.

2. Conclusion

Fluid and electrolyte imbalances are common and potentially life-threatening complications in critically ill patients. Their presence significantly affects patient prognosis and length of ICU stay. Early recognition, vigilant monitoring, and evidence-based management are essential components of critical care nursing practice. Strengthening nursing protocols and continuing education can improve patient safety and clinical outcomes in intensive care settings.

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