Managing Fluid Balance in the Critically Ill Patient
Overview

• Importance of optimizing patient fluid balance
• Fluid overload in critical illness
• Renal replacement therapy for fluid management
• Impact of fluid removal rate on hemodynamics
• Monitoring patient fluid status during treatment
• Advantages of continuous renal replacement therapy
• Guideline recommendations for hemodynamically unstable patients
• Managing fluid overload: Septic shock
• Managing fluid overload: Acute decompensated heart failure
• PRISMAFLEX CRRT system
• Summary and conclusions
• References
Optimizing Patient Fluid Balance
Optimum Fluid Balance Is Central To Critical Care

Fluid Management in Critical Illness Is Challenging

Critical illness characteristics can make optimizing fluid balance difficult

- Hemodynamic compromise
- Leaky capillary beds
- Multi-organ failure
- Large volumes of IV fluids

Fluid Overload in Critical Illness
Causes of Fluid Overload in the ICU

IV fluids
• Fluid resuscitation and continuous intravenous administration of fluid can lead to fluid accumulation and overload

Acute kidney injury
• ICU populations are at increased risk for acute kidney failure (AKI) and oliguria, which often lead to fluid accumulation

Sepsis
• Risk of fluid overload is increased with systemic inflammation, reduced oncotic pressure, and increased capillary permeability

Congestive heart failure
• Congestion, or fluid overload, is a classic clinical feature of patients presenting with heart failure

Clinical Indicators of Fluid Overload

- 10% or greater increase in body weight\(^1,2\)
- Pitting edema, anasarca\(^1,2\)
- Lung crackles, rales\(^1,2\)
- Chest x-ray\(^2\)
  - Congestion
  - Pulmonary edema
  - Pleural effusions

Fluid Overload Is Extremely Common in the ICU

ICU patients with severe sepsis or septic shock (N = 405)

- Day 1: 67% evidenced fluid overload
- Day 3: 48% evidenced fluid overload

Fluid Overload Is Associated with Poor Outcomes

- Increased mortality¹
- Pulmonary edema¹,²
- Myocardial dysfunction²
- Impaired coagulation²
- Delayed wound healing²
- Acute kidney injury²
- Impaired bowel function²
- Reduced liver function²
- Prolonged mechanical ventilation³


Image source: O’Connor & Prowle et al. 2015

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Managing Fluid Balance with Renal Replacement Therapy

- Renal replacement therapy (RRT) may be utilized for volume management in critically ill patients with fluid overload.\(^1\)

- Large volumes of fluid required to treat underlying condition can result in fluid accumulation that is often difficult to correct in the absence of renal support.\(^2\)

- Effectiveness of medical management alone can be limited by diuretic-resistance and acute kidney injury.\(^3\)

Choice of Appropriate RRT Modality

Considerations\textsuperscript{1-3}

- Total amount of fluid required to be removed to achieve clinical goals
- Rate at which fluids need to be removed
- Ongoing fluid administration needs
- Patient’s illness and comorbidities
- Patient’s hemodynamic status
- Need for solute removal, electrolyte correction or control of uremia
- Available resources and expertise

Plasma Refilling Rate and Hemodynamic Stability

- During RRT, fluid is primarily removed from the intravascular compartment\(^1\)
- The rate of change in intravascular blood volume is determined by plasma refilling rates from the interstitial compartment\(^1\)
- When the rate of fluid removal exceeds that of plasma refilling, the decrease in circulating blood volume can lead to hemodynamic instability, hypotension and hypoperfusion\(^1\)
- A slow, sustained rate of fluid removal allows time for vascular refilling and promotes hemodynamic stability\(^1,2\)

Optimal Fluid Removal Rate

- Safe rate of fluid removal varies by patient condition and may change over the course of treatment
- The rate at which fluid should be removed requires consideration of
  - Expected fluid inputs and losses
  - Expected speed of vascular refilling
  - Patient’s physiological tolerance to transient reduction in intravascular volume
- Slow, sustained fluid removal is more likely to achieve net negative fluid balance with greater hemodynamic stability

Rapid early fluid removal may be indicated in cardio-renal syndrome but a slower removal may be required for hemodynamic tolerability after resolution of pulmonary edema (A)\(^1\)

Patients with single organ renal failure (B) may tolerate more rapid fluid removal than those with AKI complicating severe sepsis (C) or septic shock (D)\(^1\)

Monitoring Patient Fluid Status

• Meticulous monitoring of patient fluid status is critical for effective fluid removal\(^1\)

• Fluid losses or gains outside the control of RRT treatment system must be accounted for\(^2\)
  – IV fluids, nutrition, medications, blood products
  – Urine output, drain outputs

• Patient fluid status is monitored by\(^2\)
  – Accurate charting of all fluid intakes and outputs
  – Daily weighing
  – Physical assessment

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Continuous Renal Replacement Therapy for Fluid Management
Advantages of CRRT for Fluid Management

- **Hemodynamic stability**
  - Slow, gradual fluid removal allows adequate time for the vascular space to refill, reducing the impact on hemodynamics and organ perfusion

- **Precise fluid balance control**
  - Accurate measurements of fluid removal and infusion volumes help facilitate precise control of patient fluid balance

- **Flexibility to tailor treatment to clinical needs**
  - Continuous and gradual process allows fluid removal rates to be customized to varied clinical scenarios and fine-tuned on an ongoing basis

### Guidelines: CRRT for Hemodynamic Stability

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<th>Acute Dialysis Quality Initiative (ADQI)</th>
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<td>“We suggest using CRRT to facilitate management of fluid balance in hemodynamically unstable septic patients.”</td>
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Fluid Overload: Septic Shock
Fluid Overload in Septic Shock

Causes of fluid overload

- Initial fluid resuscitation aimed at restoring intravascular volume
- Administration of large volumes of fluid as drug diluents, artificial nutrition and maintenance fluids
- Further fluid administration to counter relative hypovolemia resulting from capillary leak
- Interstitial edema induces organ dysfunction that contributes to further fluid accumulation

RRT in Septic Shock

- Aggressive fluid removal can cause hemodynamic deterioration, which may result in hypoperfusion and worsening organ failure\(^1\)

- Slow, continuous removal of fluid supports hemodynamic stability\(^1\)

- Sepsis clinical guidelines recommend use of CRRT in hemodynamically unstable patients\(^2\)

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Fluid Overload: Acute Decompensated Heart Failure
Volume Overload in Acute Decompensated Heart Failure

- Congestion is the primary reason for hospitalization in patients with acute decompensated heart failure.\(^1\)
- Diuretic resistance is common in advanced heart failure and limits the efficacy of fluid removal by medical management alone.\(^2\)
- Nearly 40% of patients treated with conventional diuretic-based regimens still have congestive symptoms at discharge.\(^1\)
- Incomplete decongestion is associated with increased post-discharge events and hospital readmission.\(^3\)
- 2013 ACCF/AHA guideline for the management of heart failure recommend that RRT be considered in patients with obvious volume overload, diuretic resistance and/or impaired renal function.\(^4\)

RRT in Acute Decompensated Heart Failure

- Multiple trials have demonstrated the detrimental effect of hypotension in ADHF\textsuperscript{1}
- Maintenance of hemodynamic stability is key to avoiding hypotension and worsening renal function\textsuperscript{1}
- Desirable volume status should be achieved without causing a rapid reduction in intravascular volume\textsuperscript{1}
- CRRT results have demonstrated improved hemodynamics and better fluid balance control compared with intermittent RRT\textsuperscript{2}

Prismaflex CRRT System
PRISMAFLEX CRRT System

Highly accurate, scale-based fluid management system

- Fluid removal accuracy is provided through algorithms and self-calibrating fluid scales
- Monitors accumulated fluid balance/imbalance and adjusts accordingly to help reduce risk of patient injury
- Allows for easier dose tracking

Scale-based system enables accurate fluid management

Summary and Conclusions
Summary and Conclusions

- Optimizing fluid balance in the ICU is challenging
- Fluid accumulation and overload are common in critically ill patients
- Fluid overload is associated with increased morbidity and mortality
- Effective fluid management strategies can help mitigate fluid accumulation and improve outcomes
- Diuretic resistance and acute kidney injury may limit the efficacy of medical diuresis
- Renal replacement therapy may be considered to help achieve fluid removal goals
- Hemodynamic stability is essential to preserving organ perfusion and optimizing recovery
- Fluid removal with CRRT is slow and sustained, and has demonstrated hemodynamic tolerance
- CRRT may facilitate precise control over patient fluid balance by enabling accurate, ongoing measures of fluid removal and replacement volumes
- CRRT allows customization of fluid removal rates to varied clinical scenarios and changing patient needs
- Fluid inputs and outputs outside the CRRT system must be accounted for during treatment
- CRRT is the suggested modality for mechanical fluid removal in hemodynamically unstable patients with considerable fluid accumulation

References


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