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EDITORIAL

Fluid stewardship and fluid restriction: do think of maintenance and fluid creep

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Intravenous (IV) fluids remain among the most frequently administered interventions in the intensive care units (ICU). Around 80-90% of all hospitalized patients receive IV fluids and about one out of five patients suffer from deleterious effects of inappropriate fluid management. While greater attention is given to their role in acute resuscitation, the cumulative burden of IV fluids—particularly maintenance fluids and fluid creep—has emerged as a key contributor to iatrogenic harm in critical care.[1] A positive cumulative fluid balance after 72 hours of ICU stay was found to be associated with increased morbidity such as pulmonary edema, impaired gastrointestinal motility, intra-abdominal hypertension and abdominal compartment syndrome, delayed wound healing, and mortality.[2] Moreover, a dose-dependent relation between fluid overload and mortality was noted.[2,3] Despite growing evidence for the adverse effects of the injudicious use of IV fluids, the awareness and knowledge of clinicians on IV fluids is suboptimal.[4,5]

Fluid stewardship, a concept analogous to antimicrobial stewardship, offers a structured, physiology-based, and patient-centric framework to optimize fluid therapy throughout the hospital stay of critically ill patients, aiming to improve outcomes and reduce costs.[5,6] By integrating appropriate diagnostics, physiologic monitoring, and daily reassessment into fluid prescription, fluid stewardship transitions fluid administration from a passive default to a deliberate clinical decision.

RETHINKING THE PURPOSE OF FLUIDS: FROM DIAGNOSTIC TO DISCHARGE

Traditionally, IV fluids have been administered reflexively, under the assumption that they are beneficial and essentially just an innocuous bag of water and electrolytes. However, evidence increasingly highlights the need to classify fluids as pharmacologic agents with indications, contraindications, potential complications, and adverse effects. The 4Ds model-Drug, Dose, Duration, and De-escalation-has served as a foundational framework for fluid stewardship.[5] This has recently evolved into the more nuanced 10 Ds model, which offers a comprehensive and systematic guide to rational fluid administration in critically ill patients. This involves clear terminology for fluid management, and its physiological effects such as fluid balance and fluid accumulation (definitions); the reason and indication for IV fluids (diagnosis); distribution of IV fluids in different body compartments (distribution); specific type of IV fluid (drug); volume and rate of infusion (dose), time over which fluids need to be administered (duration), stopping or reducing fluids when no longer required (de-escalation), recording your fluid practices (documentation); auditing and reflecting on the carefulness of the fluid prescription (diligence); and finally advocacy, leadership, change management and discussion on fluids (discussion) (Figure 1).[7]

Figure 1. *10 Ds of fluid stewardship.*

MAINTENANCE FLUIDS AND FLUID CREEP

While attention has historically focused on resuscitative fluids, maintenance fluids-often administered as background therapy constitute a substantial and often inconspicuous source of fluid and sodium overload.[1] These fluids are frequently prescribed to patients who are nil enterally, unable to tolerate enteral fluids, for drug diluents, or sometimes just “to keep the line open”. However, maintenance fluids once prescribed, are rarely audited or de-escalated unless overt fluid accumulation is evident. “Fluid creep” refers to the unintentional and unmonitored delivery of fluids from sources such as drug infusions, intravenous flushes, and electrolyte-replacement therapy (Figure 2).[8] These hidden inputs are not always captured in fluid charts but may account for up to 50% of total daily fluid intake in some ICU patients.[8]

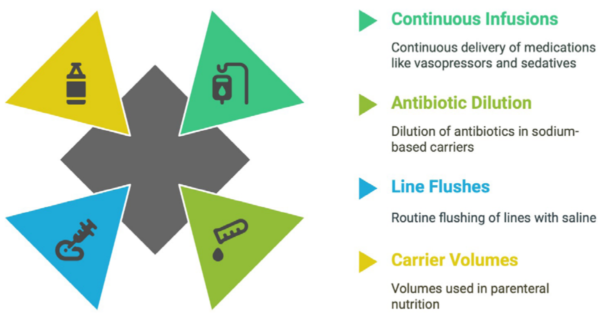

Figure 2. *Factors contributing to fluid creep.*

The issue is further compounded by the widespread improper use of isotonic crystalloids solutions, such as 0.9% saline or balanced crystalloids, for maintenance purposes.[4] Even at modest rates (e.g., 100 mL/hr), these infusions deliver over 2 L/day and upwards of 300 mmol of sodium—a quantity far exceeding physiologic requirements of an adult critically ill patient that is around 1-1.5 mmol Na/kg/day). Unlike dietary sodium, which is excreted gradually and metabolically neutral, IV sodium is retained in the interstitium, drives water retention, and increases the work of renal sodium excretion.[1] A single one-liter bag of 0.9 % sodium chloride delivers roughly 3.5 g of elemental sodium—already more than the recommended daily limit of 2.3 g.

This practice not only contributes to volume overload but also to hypernatremia (sodium overload), hyperchloremia and adverse outcomes such as delayed ventilator weaning, and interstitial edema (especially in patients with impaired renal function or non-osmotic ADH release), increased need for ICU resources (longer duration mechanical ventilation), increased vasopressor need, increased risk for AKI, and even mortality.[8] The sodium burden, derived largely from maintenance fluids and fluid creep, is usually hidden in plain eyesight and contributes to fluid accumulation in the critically ill.[9]

Mitigating fluid creep requires coordinated changes in prescribing practices (fluid stewardship), limiting fluid volume, sodium and chloride intake, hypotonic fluids as drug diluents, optimizing medication delivery with volumetric infusions and reducing unnecessary IV flushes, monitoring the daily body weight, fluid balances and electrolytes, assessment of body fluid composition, and nursing protocols.[10] Switching to glucose-based drug diluents, using higher drug concentrations to reduce carrier volumes (e.g. administration of concentrated drugs via a slow IV bolus through a syringe rather than a 50- or 100-ml bag), and auditing non-resuscitative inputs are effective steps toward mitigation.

FLUID ACCUMULATION SYNDROME

Fluid accumulation is common in critically ill patients because of capillary leak associated with systemic inflammation from various etiologies and/or injudicious fluid administration. Fluid accumulation syndrome (FAS) is defined as any percentage of fluid accumulation with the presence of new-onset organ dysfunction because of the accumulated fluids and is associated with adverse patient outcomes.[9,11] In patients with limited fluid tolerance, continuing fluid administration push the patient toward venous hypertension and congestion, pulmonary edema, and intra-abdominal hypertension—manifestations that develop without a clear clinical trigger and are often misattributed to disease progression or multiple organ dysfunction syndrome.[12]

However, there is scarce evidence on diagnosing, monitoring, and preventing FAS. Clinical signs such as peripheral edema and respiratory distress without clear lung/cardiac diseases are non-specific, especially in critically ill. Rising oxygen requirements, new B-lines on lung ultrasound, portal vein pulsatility, and increasing intra-abdominal pressure may signal subclinical volume-related harm. Advanced monitoring tools such as transpulmonary thermodilution with PICCO (Getinge, Solna, Sweden) or Volume View (Edwards, Irvine, USA) can also be used to assess extravascular lung water and pulmonary vascular permeability index. The non-invasive bioelectrical impedance analysis (BIA) is another tool to assess total body water (TBW), extracellular water content (ECW), intracellular water content (ICW), the ECW/ICW ratio and overhydration (OH, volume excess).[13] Since these tools are not prospectively validated in a critically ill, a combination of such tools and a clinical assessment of fluid accumulation is currently recommended.[9,14]

There is no established evidence-based strategy for the management of FAS and recently a 3-pillar management has been proposed: 1) Prevention, 2) Care, and 3) Cure (Figure 3). Prevention starts with the identification of patients at risk for FAS who may benefit from active fluid removal (hemodynamically stable, fluid unresponsive, and shows no signs of tissue hypoperfusion). Fluid restriction and fluid withholding when IV fluids are not needed is a logical first step (e.g., when the patient is not in shock– resuscitation fluids are not indicated, when the patient receives enough fluids from other sources to cover the daily needs– maintenance fluids are not indicated, etc.) and limiting creep fluids (reduce sodium and chloride and dilute drugs in hypotonic glucose 5%). It is important to avoid wrong indications (e.g., isotonic solutions as maintenance).[9]

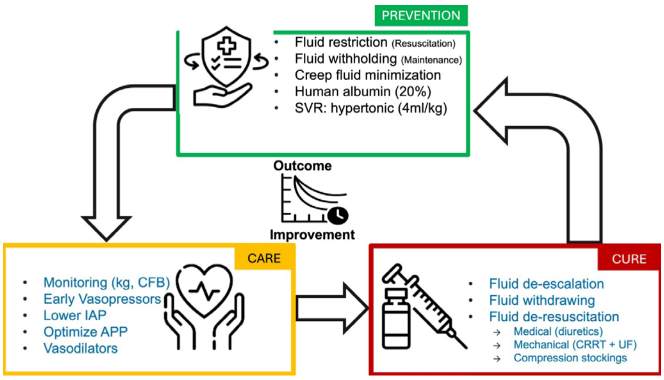

Figure 3. *The 3 pillars of FAS management with prevention, care and cure. Adapted with permission from Pfortmueller et al. under the Open Access CC BY License 4.0.*[9]

The care for patients with FAS consists of careful monitoring of IAP, daily body weight and BIA, daily and cumulative fluid balance, initiation of early vasopressors to recruit stressed volume from the unstressed. It further involves monitoring and reduction of IAP by improvement of abdominal wall compliance, reduction of intra-luminal content, reduction of intra-abdominal content, and optimization of abdominal perfusion pressure.

A definitive cure for FAS can be achieved by de-escalation, fluid withdrawal, and mechanical or medical fluid removal. Loop diuretics are the initial mainstay of therapy for the management of such patients, but a combination with other diuretics such as acetazolamide, spironolactone, or indapamide may be considered. The active fluid removal using diuretics also contributes to the risk of electrolyte disturbances or hemodynamic instability.[9,15] Thus, the dosing of diuretics needs to be individualized based on the renal function, previous exposure to diuretics and patient tolerance. Combination therapy of PEEP, and/or albumin preceding diuretics has shown a synergistic effect.[16,17] Renal replacement therapy can be considered in patients with associated renal dysfunction, and/or who are refractory or intolerant to diuretics. Finally, venous compression stockings have shown a beneficial effect on fluid clearance in patients with sepsis and liver failure.

BEYOND FLUID RESPONSIVENESS AND EMBRACING FLUID TOLERANCE: INTO MAINTENANCE REALM

The concept of fluid tolerance—originally developed for resuscitative fluid decision-making—holds equal relevance for maintenance fluid practices.[18] While bolus infusions are typically reassessed using dynamic tests (e.g., passive leg raising test, stroke volume variation), maintenance fluids are often initiated and continued without considering evolving physiologic tolerance.

Yet, in critically ill patients with right heart strain, capillary leak, or compromised renal and lymphatic clearance, even low-volume isotonic infusions may exceed tolerance thresholds. Thus, fluid stewardship includes not only to assess whether a patient will respond to fluids, but also whether they can tolerate ongoing fluid delivery without incurring FAS with organ dysfunction or worsening existing condition (Figure 4). For many, particularly those in the stabilization or recovery phase, the safest fluid may be none at all.[12,18]

Figure 4. *Clinical and haemodynamic indicators of fluid tolerance.*

UNIFIED MODEL OF FLUID STEWARDSHIP

A practical implementation of fluid stewardship in the ICU begins with a deliberate shift in mindset: diagnose and don't drip. Fluids should no longer be considered benign defaults, but pharmacologic interventions should be initiated only when true hypovolemia is identified, and fluid tolerance is assured. In shock, the six conditions that should be met before administering a drop of fluids are: 1) patient in acute circulatory failure, 2) presence of tissue hypoperfusion (lactate, increased CRT), 3) hypovolemia, 4) fluid responsiveness, 5) fluid tolerance, 6) no risk for FAS. Static parameters such as central venous pressure or urine output thresholds are insufficient; instead, clinicians should rely on physiologic tools including the Venous Excess Ultrasound Score (VExUS), lung ultrasound, functional hemodynamics, dynamic volumetric preload assessments, and fluid challenge responses.

The second pillar involves minimizing the sodium and chloride burden. Balanced hypotonic solutions should be preferred over isotonic crystalloids for maintenance therapy whenever feasible. Concurrently, fluid creep must be rigorously audited and minimized, particularly by eliminating unnecessary line flushes and diluent volumes in continuous infusions.[19] In the post-resuscitation phase, (hypercaloric) early enteral feeding and hydration using potable water should be considered in hemodynamically stable, sedated patients. Finally, change and transformation must be adopted and a culture of documentation and de-resuscitation must be cultivated using the 10 Ds checklist. IV fluids should be promptly discontinued when enteral nutrition and oral medications suffice, and de-resuscitation therapy—via diuretics or renal replacement therapy—should be initiated in the presence of clinical or sonographic evidence of volume intolerance and FAS.[9] Together, these strategies embody a modern, precision-based approach to fluid stewardship in critical care (Figure 5).

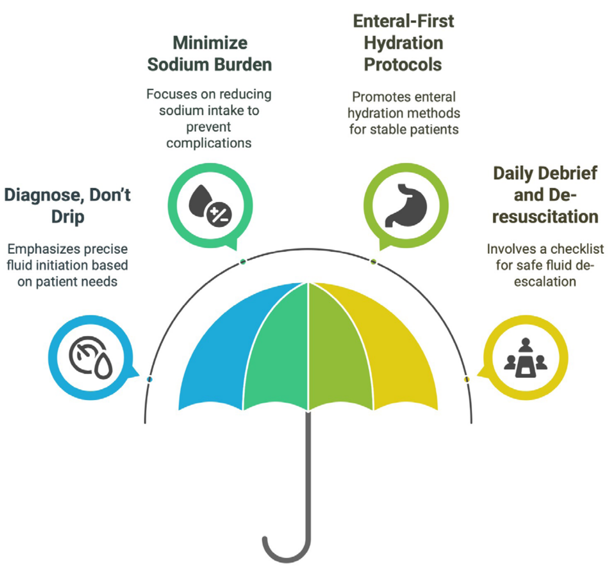

Figure 5. *Strategies for fluid stewardship in the context of maintenance fluid and fluid creep.*

CONCLUSION

Fluid stewardship represents a natural evolution in critical care—integrating physiology, precision, and individualization into fluid therapy. It acknowledges that the harms of fluid administration extend beyond volume to include sodium toxicity, venous congestion, intra-abdominal hypertension, and cumulative burden via fluid creep. Critical care teams can optimize therapy, minimize harm, and improve outcomes by adopting structured frameworks such as the 10 Ds, embracing the concept of fluid tolerance, and reevaluating the role of maintenance fluids and administration routes.

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