Original Article

Evaluation Role of Intravenous Fluids in Prevention of Acute Kidney Injury

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Abstract

Background: Acute kidney injury is a prevalent condition experienced by hospitalized patients, particularly in critically ill adults. The management of optimal fluid balance is necessary to prevent AKI and this can be challenging in patients with trauma. Objective: The aim of this study was to review the recent literature that has discussed the role of fluids in AKI prevention. Method: PubMed database was used for articles selection, and the following keywords were used in the MeSH: fluids role in acute kidney injury prevention, acute kidney injury and intravenous fluids. The total number of 25 papers were reviewed and included in the review. Conclusion: Optimizing fluid management can improve outcomes and if this is not achieved AKI may occur. Therefore, fluid balance monitoring is fundamental to successful AKI management. Regarding therapeutic intervention, 0.9% saline and buffered crystalloids are all acceptable choices for IV fluid management in critically ill patients. Nevertheless, a potentially harmful effect of increased fluid balance has been shown, in which, it may precipitate rather than alleviating AKI. Moreover, renal recovery in patients with fluid overload is significantly lower.

Keywords: Acute Kidney Failure, Intravenous Fluid

Introduction

Acute kidney injury (AKI) is a prevalent condition among hospital inpatients, especially in critically ill adult patients. It leads to morbidity, mortality, and an extended length of stay increase [1-3]. AKI is an increase in serum creatinine 1.5 times baseline or ≥26 µmol/L within 48 hours [4, 5]. The management of fluid balance is critical to prevent AKI and this can be challenging particularly in trauma patients [6]. It is the cardinal key to successful AKI management. Optimal fluid administration depends on the timing of administration and the type of intravenous fluid. In addition, optimizing the amount of fluid is also mandatory in order to avoid any volume overload, which can be associated with poor outcomes [1, 7]. Therefore, in this paper, it was aimed to review the recent literature that has discussed the role of fluids in AKI prevention.

Methodology

PubMed database was used for articles selection, and the following keywords were used in the MeSH: fluids role in acute kidney injury prevention, and acute kidney injury and intravenous fluids. The total number of 25 papers were reviewed and included in the review.

Inclusion criteria: The articles' selection was based on the relevance to the project, which should include intravenous fluids in preventing AKI. Exclusion criteria: All other articles that did not have a related aspect to the role of fluids in preventing AKI as their primary endpoint or repeated studies.

Discussion

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In adult patients with critical illnesses, AKI is a frequently encountered condition. In such patients, AKI is associated with an increase in morbidity and mortality. Due to delays in diagnosis and treatments, few therapeutic interventions successfully treat or prevent AKI. Therefore, increased alertness in such patients can help in the early detection of AKI. Grading the severity of each case helps optimize the intervention.

Table 1: Pathology System Grades of AKI Severity [3, 4]

Grade 1	An increase in serum creatinine ≥1.5 to 1.9 times baseline or increase in serum creatinine of ≥26 μmol/L within 48h
Grade 2	Increase in serum creatinine ≥2 to 2.9 times baseline
Grade 3	Increase in serum creatinine ≥44 μmol/L rise when serum creatinine is ≥354 μmol/L or ≥3.0 times baseline

Fluid balance is a cardinal step for the prevention of AKI and this can be challenging in the specific type of compromised patients [7, 8]. The fluid needs of patients vary during the perioperative period and following acute trauma [7, 9]. Optimizing management of fluid can improve outcomes and if this is not achieved, AKI may occur [8].

In Andrew Davies et al. [7] study, they increased the vigilance regarding the fluid balance of their trauma patient and this was associated with a decrease in the incidence of AKI. The engagement of all members of the multidisciplinary ward team played a crucial role in achieving sustained improvement. There was a decline with regard to the number of AKI alerts from 50 in January to 19 in November 2016. After the invention, 33% was achieved as the average monthly AKI rate. Accordingly, there was an improvement with regard to the completion of fluid balance charts, an increase in 6-hour urine output documentation from 36% to 68% and an increase in running 1-hour output from 80% to 96%. Based on these results, monitoring of the fluid balance is essential for successful AKI management [7].

More than 50% of the human body is fluids distributed in designated compartments. Thus, a 70-kg adult is comprised of 42 kg (liters) body water, 28 liters intracellular fluids and 14 liters extracellular fluids (ECF) [10]. The latter is further distributed to 11 liters interstitial fluids and 3 liters plasma. Despite that these fluids are compartmentalized in the human body, they are dynamically connected. The human body tightly regulates the balance of fluids, acid-base, and electrolytes in each compartment. This regulation is mostly in an energy-dependent manner to obtain their designed functions [10, 11].

There are extensive and dynamic exchanges happen between ECF and gastrointestinal system as well as kidneys. There is a turnover of 8–9 liters/day of gastrointestinal fluids through secretion and absorption and 180 liters/day of glomerular filtrates of which 98–99% is absorbed by renal tubules [12]. Several factors can affect these balances including the use of a large number of medications [10].

Clearly, the endothelial surface layer (ESL) is important in preventing excessive vascular fluid extravasation, which subsequently prevents the formation of tissue edema. Unfortunately, there are some cases where ESL can be compromised, such as, during ischemia-reperfusion injury, hypervolemia, diabetes, inflammation, sepsis, and oxidized lipids [13]. In the inflammatory process, there will be an increase in the permeability of the endothelial glycocalyx layer to polyionic macromolecules. This hyperpermeability allows fluids to move into the interstitium [14].

Hypovolemia is considered as an essential risk factor for AKI and is associated with low urinary output [15]. Regarding the severe hypovolemia, decreased cardiac output may result in compromised renal perfusion. Therefore, fluid replacement therapy is the logical option to increase the cardiac output and stroke volume, renal blood flow, renal oxygen supply, and glomerular filtration rate [16, 17]. Hypovolemia and sepsis are the two most frequent etiologies of AKI, especially in critically ill patients [18]. Timely fluid administration may be a preventive measure against AKI and should be effective both through the restoration of circulating volume and improving impaired renal perfusion [16, 18].

The physiological rationale for the administration of fluids in critically ill patients is to restore tissue perfusion. Crystalloids are now the accepted first-line IV fluid in most ICU patients. Nevertheless, the most appropriate crystalloid to use in patients with AKI is unclear. It has been found that after administration of 2 L of 0.9% saline, the renal cortical tissue perfusion and renal artery blood flow velocity decrease, which has a higher chloride composition than normal plasma [19]. The meta-analysis conducted by Krajewski et al. [20] found that the use of high chloride fluids was associated with a 60% increase in the risk of developing acute kidney injury [20]. However, two observational studies did not report any significant relationship between the AKI risk and choice of intravenous crystalloid [21, 22].

Regarding colloid solutions, it was believed that the administration of colloid solutions, such as albumin or hydroxyethyl starch (HES) to critically ill patients can reduce the overall need for fluid as compared with the administration of crystalloids [16]. However, the Surviving Sepsis Campaign guidelines are recommended against the use of HES [23]. Based on the risk of AKI after the publication of large trials and updated systematic reviews, the Food and Drug Administration (FDA) issued a warning for HES. Those papers showed high AKI rates and an increase in using renal replacement therapy with HES particularly in critically ill patients. This harmful effect of HES is intensified in cases with sepsis and is associated with an increased mortality rate [24-26].

Regarding albumin, it is a natural colloid and it appears to be safe to use in patients with AKI or at risk of developing AKI. However, a limited benefit of albumin has been proven compared to crystalloid solutions [27, 28].

For now, when it comes to the risk of progression or development of AKI, 0.9% saline and buffered crystalloids are all acceptable choices for IV fluid management in critically ill patients. Nevertheless, observational data suggested a potentially harmful effect of increased fluid balance. The risk of AKI rises with increasing central venous pressure. It has been shown that higher fluid inputs did not alleviate AKI but they precipitated the condition [16]. There is a relationship between fluid overload and death in critically ill patients. The rates were higher in patients with AKI, sepsis, acute lung injury, and acute respiratory distress syndrome [29]. Fluid overload is regarded as body weight increase by over 10% [30]. In the study by Bouchard et al. [30], a significant increase was found in respiratory failure, mechanical ventilation, and sepsis in patients with fluid overload. After illness severity adjustment, 60-day and 30-day mortality were observed in AKI patients with fluid overload. Survived AKI patients had a significantly lower level of fluid accumulation during renal replacement therapy than patients who did not survive. Moreover, in patients with fluid overload, renal recovery was considerably lower [30].

Therefore, the optimal evaluation of volume status in patients with severe diseases is highly important especially during the early treatment of these patients. Maintaining hemodynamic stability and optimizing organ function are the keys to managing fluid overload.

Diuretics are still considered as an alternative therapeutic intervention for treating patients with fluid overload including congestive heart failure patients and patients with AKI. Loop diuretics, in particular, are very helpful in treating the symptoms of fluid overload and improving pathophysiological states. However, because of multiple mechanisms, the response to furosemide can decrease in AKI patients. Therefore, AKI patients often require the use of higher doses of furosemide, which unfortunately can lead to ototoxicity in some cases. Moreover, the fact that furosemide clearance is significantly decreased in AKI patients elevates the risk of developing drug adverse effects. In addition, high furosemide doses can lead to impaired myocardial function after furosemide-induced vasoconstriction [31]. Therefore, renal replacement therapies are interventions mostly needed to optimally manage the volume in critically ill patients with fluid overload [30, 32, 33].

Conclusion

The management of optimizing fluid can improve outcomes and if this is not achieved AKI may occur. Therefore, fluid balance monitoring is fundamental to successful AKI management. Regarding therapeutic intervention, 0.9% saline and buffered crystalloids are all acceptable choices for IV fluid management in critically ill patients.

Nevertheless, A potential harmful effect of increased fluid balance has been shown, in which, it may precipitate rather than alleviating AKI. Moreover, renal recovery is significantly lower in patients with fluid overload.

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