

Effect of positive fluid balance on acute kidney injury and in-hospital mortality in patients admitted to ICU after major surgery or trauma

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Abstract

Objective: Objective: To evaluate whether or not positive fluid balance is associated with the development and severity of acute kidney injury in intensive care patients admitted after major surgery or trauma, and to examine its relationship with in-hospital mortality.

Method: The retrospective, analytical, cross-sectional study was conducted at the General Surgery Department of Shifa International Hospital, Islamabad, Pakistan, and comprised data from April 2021 to May 2021 of patients aged >16 years admitted to intensive care unit after major trauma. Demographic and clinical data was noted, and serum creatinine levels and fluid balance were recorded. Mortality rate and incidence of acute kidney injury were the two outcomes of interest. Data was analysed using SPSS 20.

Results: Of the 132 patients with mean age 36.77 ± 17.69 years, 84(63.64%) were males and 48(36.36%) were females. Positive fluid balance was noted in 26(19.7%) patients and negative fluid balance in 29(21.9%). In terms of acute kidney injury, stage 1 was noted in 103(78%) patients, stage 2 in 12(9.1%) and staged 3 in 11(8.3%). Fluid overload was significantly associated with stage 3 acute kidney injury ($p < 0.05$). Overall fluid overload-related mortality was 2(1.5%).

Conclusion: Positive fluid balance was significantly associated with stage 3 acute kidney injury. Intravenous fluids in post-traumatic or post-surgical intensive care patients should be carefully handled to avoid overloading.

Key Words: Fluid resuscitation, Acute kidney injury, Positive fluid balance, Intravenous fluids, Major trauma. (JPMA 76: 1015; 2026) DOI: <https://doi.org/10.47391/JPMA.21676>

Introduction

Acute kidney injury (AKI) is frequently observed in patients who are admitted to the intensive care unit (ICU), and is a considerable cause behind organ or system dysfunction.¹ Generally, these patients belong to the old age group^{2,3} with pre-existing comorbidities and prior kidney dysfunction and who may have often undergone invasive therapeutic procedures before hospitalisation.⁴

Intravenous (IV) fluid therapy is given to those patients who are at a high risk of acute renal injury. Fluid overload can lead to serious and potential consequences. Some of its detrimental effects include delayed wound healing, increased chance of nosocomial infections, and ultimately can lead to organ or system dysfunction.

In critically ill patients, fluid balance is often disrupted, especially in those with acute kidney injury (AKI). These patients may have positive or negative fluid balance (FB). Up to 40% of patients admitted to ICU have been

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reported to have positive FB⁵, but there is no conclusive study to understand the association between exposure to positive FB and long-term outcome. While some studies showed an increased risk of short-term mortality in patients with positive FB of >10% of their body weight, other studies showed no such association.^{5,6}

IV fluid therapy is considered a cornerstone therapy for critically ill patients, especially who are already diagnosed with AKI, or have the potential to develop AKI. It improves renal blood supply and corrects underlying hypovolaemia, thus improving cardiac output.^{6,7} In recent times, the concept of overzealous fluid therapy and its beneficial effects on the kidney has been questioned. Positive FB has been linked with the development of AKI, especially if it is administered before initiating the renal replacement therapy (RRT).⁵ However, only a few studies have interpreted the association between positive FB and mortality during RRT.^{8,9} The current study was planned to correlate the incidence of AKI in critically ill patients admitted in surgical ICU after trauma or major surgery, and to explore its association with FB.

Materials and Methods

The retrospective, analytical, cross-sectional study was conducted at the General Surgery Department of Shifa International Hospital, Islamabad, Pakistan, and

comprised data from April 2021 to May 2021. The sample size was calculated using the World Health Organisation (WHO) calculator based on $n = d^2 Z^2 p / (1-p) 10$ formula with 95% confidence interval (CI) and 5% margin of error while keeping expected positive FB to be 40%.¹¹

The sample was raised using non-probability consecutive sampling technique. Those included were patients aged >16 years admitted to ICU after major trauma or surgery. Patients who died within 48 hours of admission were excluded due to the competing outcomes of AKI and mortality. Patients with congestive cardiac failure, end-stage renal dysfunction, severe burns involving >20% of total body surface area and rhabdomyolysis were also excluded. Demographic and clinical data, including age, gender, diagnosis, serum creatinine level, and FB, was recorded on a proforma. Consent had been obtained from all the patients.

The two outcomes of interest were mortality rate and incidence of AKI. The AKI diagnosis was established and AKI stages were classified in accordance with the Kidney Disease Improving Global Outcomes (KDIGO) group guidelines.¹¹ Patients with an increase in serum creatinine 7 days were diagnosed as having AKI. Patients were classified as stage 1 AKI when serum creatinine was 1.5-1.9 times the initial value, 2.0-2.9 times was classified as stage 2 AKI, and at least 3 times as stage 3 AKI with dialysis requirement. The highest rise in serum creatinine value within one week of admission was compared to the first creatinine value to establish the increase in length of hospital stay (LOS). Fluid overload was defined as a positive net FB, meaning total fluid intake exceeded output within the first 24 hours of ICU admission.

Data was retrieved from the electronic medical records (EMR) system using codes for acute kidney injury, trauma and major abdominal/thoracic surgery. Additional variables were extracted manually from clinical notes and laboratory reports.

Data was analysed using SPSS 20. Data was expressed as mean \pm standard deviation (SD) or frequencies and percentages as appropriate. Data was stratified for gender, AKI stage and mortality rate. Post-stratification, chi-square test was applied to compare positive and negative FB between the groups. $P < 0.05$ was taken as statistically significant.

All patients were followed up for 30 days after ICU admission to determine in-hospital mortality.

Results

Of the 132 patients with mean age 36.77 ± 17.69 years, 84(63.64%) were males and 48(36.36%) were females.

Table-1: Patient characteristics (n=132).

Characteristics	Total (n=132)	Male (n=84)	Female (n=48)
Mean Creatinine (mg/dL)			
Baseline	1.09 \pm 0.86	–	–
Raised	1.71 \pm 1.16	–	–
Fluid Balance			
Normal	77 (58.4%)	50	27
Positive	26 (19.7%)	16	10
Negative	29 (21.9%)	18	11
Acute Kidney Injury (AKI)			
No Injury	6 (4.6%)	1	5
Stage 1	103 (78%)	60	43
Stage 2	12 (9.1%)	7	5
Stage 3	11 (8.3%)	6	5

Mean baseline creatinine level was 1.09 ± 0.86 mg/dL which rose to 1.71 ± 1.16 mg/dL. Positive FB was noted in 26(19.7%) patients and negative fluid balance in 29(21.9%), while normal FB was found in 77(58.4%) patients. Overall, 126(95.4%) patients developed AKI. In terms of AKI, stage 1 was noted in 103(78%) patients, stage 2 in 12(9.1%) and stage 3 in 11(8.3%). Fluid overload was significantly associated with stage 3 acute kidney injury ($p < 0.05$). Overall fluid overload-related mortality was 2(1.5%) (Table 1).

The most common AKI cause of patients' presentation was peritonitis 49(37%), while 39(30%) patients presented with combined abdominothoracic blunt trauma (Figure).

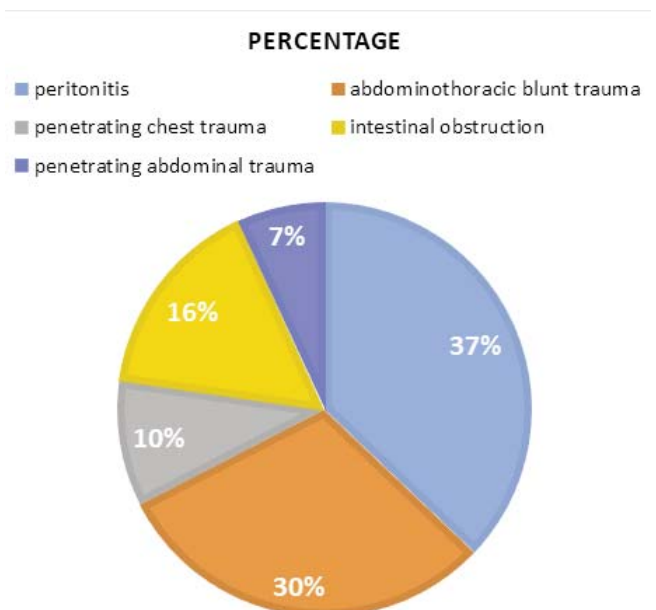


Figure: Causes of admission to intensive care unit (ICU).

Table-2: Comparison of fluid balance with respect to gender, acute kidney injury (AKI) and mortality rate.

A. Gender × Fluid Balance (n = 132)				
Gender	Positive	Negative	Normal	Total
Male (84)	16 (19.0%)	18 (21.4%)	50 (59.6%)	84 (100%)
Female (48)	10 (20.8%)	11 (22.9%)	27 (56.3%)	48 (100%)
Total	26 (19.7%)	29 (22.0%)	77 (58.3%)	132 (100%)

B. AKI Stage × Fluid Balance (n = 132)

Values shown as total patients per cell (M/F) with % of row total

AKI Stage	Positive	Negative	Normal	Total	P value
No AKI (6)	1/0 1 (16.7%)	1/0 1 (16.7%)	3/1 4 (66.6%)	6 (100%)	0.0049
Stage 1 (103)	12/8 20 (19.4%)	13/10 23 (22.3%)	35/25 60 (58.3%)	103 (100%)	
Stage 2 (12)	2/1 3 (25.0%)	2/1 3 (25.0%)	3/4 6 (50.0%)	12 (100%)	
Stage 3 (11)	1/1 2 (18.2%)	2/0 2 (18.2%)	2/5 7 (63.6%)	11 (100%)	
Total	26 (19.7%)	29 (22.0%)	77 (58.3%)	132 (100%)	

C. Mortality × Fluid Balance (n = 132)

Values shown as total patients per cell (M/F) with % of row total

Outcome	Positive	Negative	Normal	Total	P value
Deaths (15)	1/1 2 (13.3%)	3/2 5 (33.3%)	5/3 8 (53.4%)	15 (100%)	0.003
Survivors (117)	15/9 24 (20.5%)	15/9 24 (20.5%)	45/24 69 (59.0%)	117 (100%)	
Total	26 (19.7%)	29 (22.0%)	77 (58.3%)	132 (100%)	

Median follow-up duration was 30 days. The 30-day mortality was 15(11.4%). Positive FB was found in 2(1.5%) cases.

Positive FB was significantly associated with a AKI stage 3 compared to patients without fluid overload ($p=0.0049$). Mortality was higher in patients with negative FB than in those with positive FB ($p=0.003$) (Table 2).

Discussion

AKI incidence in hospitals' emergency departments worldwide is independent of different underlying causes. The role of certain antibiotics in causing AKI, thereby causing a rapid loss of kidney's ability to remove wastes and maintaining fluid and electrolytes balance in children is well-known, and far from uncommon.^{12,13}

It is common in severely injured trauma patients, and is associated with poor outcomes. A positive FB is associated with AKI and poor long-term renal outcomes among general ICU and cardiac surgery patients. Currently, the optimal endpoint of resuscitation of severely injured trauma patients is unknown, which may result in excess fluid administration. Positive FB is common after severe trauma, and is associated with increased AKI development.¹³ This was also seen in the current study where positive FB was significantly associated with AKI stage 3 ($p=0.0049$).

Among critically ill patients, positive and negative FB is not associated with higher risk of death within 30 days, and, among patients receiving RRT, neither negative nor positive FB is associated with renal recovery.¹⁴ Positive FB of >2L at 48 hours occurs in half of severely injured trauma patients, and fluid positivity is independently and incrementally associated with AKI development.¹⁵

Persistence of a positive FB over time has been associated with increased mortality.¹⁶ FB is a practice-dependent and potentially modifiable risk factor for poor outcomes, which has been demonstrated in the current study as well. Currently, there is little evidence about goal-directed care and optimal endpoints of resuscitation in the severely injured trauma population.¹⁷

Bouchard et al. found that positive FB resulting in AKI was independently associated with mortality, regardless of the requirement of dialysis.¹⁸ This was in line with the current results. In another study, 48.32% patients had positive FB and 52.8% had negative FB, and there was significantly higher mortality rate due to AKI in patients with positive FB compared to negative FB (43.5% vs 7.4%). This was in contrast to the current study, in which only 2 patients had positive and 13 had negative FB.¹⁹

The current study has limitations of being a single-centre research. Further multicentre studies on the topic are recommended. Besides, the association between AKI stages and cause of surgical ICU admission was not explored in the current study, which might be independently associated with AKI.

Conclusion

FB in surgical patients is a sensitive and controversial topic and needs meticulous attention. Overzealous fluid therapy can cause more harm than good as it was found associated with late stages of AKI.

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Conflict of Interest: None.

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AUTHORS' CONTRIBUTIONS:

SN: Concept, design, data acquisition, analysis and interpretation.

SL: Drafting, revision, final approval and agreement to be accountable for all aspects of the work.