Original Article

Impact of 10% Intra-operative Fluid Overload on Patients Undergoing Major Non-cardiac Surgery and Admitted to General Surgical ICU: A Prospective Observational Study

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Objective: To examine the incidence and effects of intra-operative fluid overloads [IFO] >10% of admission body weight on the incidence of prolonged intensive care unit [ICU] stays (>72 hr); ICU and 90-day mortality rates and perioperative complications.

Materials and Methods: A prospective, observational study was conducted on 800 patients admitted to the general surgical ICU from January 2014 to December 2015. Gathered data included patients' demographic data; admitted and pre-operative serum albumin, hemoglobin [Hb] and creatinine up to 72 hrs; the American Society of Anesthesiologists physical status; surgery type and urgency; anesthesia type and duration; type and amount of intake and output; perioperative complications; septic shock on ICU admission; ventilator days, ICU and hospital lengths of stay, the Acute Physiology and Chronic Health Evaluation II score on postoperative day 1, ICU and 90-day mortality rates.

Results: The incidence of IFO was 7.4%. Patients with IFO had significantly longer anesthetic times, lower pre-operative and admitted serum albumin levels; higher preoperative Hb level, fluid balances; longer ICU and longer hospital length of stay. Significantly higher combined general and neuraxial block and septic shock on ICU admission was seen in the IFO patients. Significantly higher perioperative major complications (e.g. congestive heart failure, serious cardiac arrhythmias, intra-abdominal hypertension and wound infection) were found in IFO patients. Acute kidney injury was the most organ dysfunction (32.2%) found in IFO patients and 12% needed renal replacement therapy from fluid overload. Ten percent IFO was a significant predictor of prolonged ICU stay (OR 8.87; 95% CI 4.65 to 16.90, $p<0.001$) and who had intra-operative fluid balances more than 115 mL/kg were significantly associated with higher 90-day mortality.

Conclusion: Ten percent IFO had a high impact in critically ill patients undergoing major non-cardiac surgery in terms of prolonged ICU stay, increasing perioperative major complications, and mortality. Care should be taken to prevent IFO.

Keywords: Fluid overload, Intra-operation, Non-cardiac surgery, Prolonged ICU stay

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Patients undergoing major surgery typically experience a high physiological stress response that usually necessitates additional fluid replacement and a resulting accumulation of fluid[1,2]. A high intra-operative fluid intake (>15 mL/kg/hr) in patients with a serum albumin level ≤3 g/dL has been associated with increased complications and 30-day mortality[3]. Fluid overload which is an increase in body weight or fluid equivalent to more than 10% of the admission body weight, has been associated with increased respiratory complications, more sepsis, and organ dysfunction[4]. Acute kidney injury [AKI] patients with fluid overload

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have shown an increase in their 30- and 60-day mortality rates[5]. In esophageal surgery, fluid balance above average on the operation day was associated with a higher postoperative mortality rate and severe respiratory and cardiac complications, including surgical complications of anastomosis leakage[6]. A positive fluid balance on day 4 increased the rate of complications, including wound infections and renal complications[4]. Intraoperative fluid overload in cardiothoracic surgery has also been associated with poor outcomes[7,8]. Recent studies have showed that fluid overload particularly crystalloid overload can cause shading of the endothelial glycocalyx, leading to microvascular dysfunction, especially in the presence of hypoalbuminemia[9,10]. Fluid overload can affect tissue edema, delay wound healing, and increase the risk of anastomosis leaking[11,12]. Flap thrombosis has been reported with in intra-operative crystalloid overload[13].

To date, there has been very little published information about intraoperative fluid overload in patients undergoing major non-cardiac surgery; this is the most stressful period for surgical patients, and it can be affected by both the anesthetic and the decisions of the anesthesiologist.

The primary objective of this study was to study the incidence of 10% intra-operative fluid overload [IFO] among patients who were undergoing major, non-cardiac surgery and had been admitted to the general surgical intensive care unit [ICU]. The secondary objectives were to study the impact of 10% IFO on ICU resource utilization (ventilator days and ICU length of stay), perioperative complications occurring within 3 days of ICU admission and mortality (ICU and 90-day).

Materials and Methods

Hospital setting

The present study was part of a prospective ICU database of the 14-bed general surgical ICU [SICU] in the Department of Anesthesiology, Siriraj Hospital, which is Thailand's largest, tertiary-referral university hospital. Approval for the research was given by the Siriraj Institutional Review Board (Si 227/2011). This study was conducted on 800 consecutive surgical patients who were undergoing major, noncardiac surgery under anesthesia and had been admitted to the general surgical SICU January 2014 to December 2015.

Excluded were patients who were younger than 18 years; were undergoing cardiac, neurosurgical, traumatic, or transplant surgery; or died within 3 days of ICU admission.

Data collection

The data obtained were comprised of patients' demographic data, pre-operative body weight and height, the American Society of Anesthesiologists [ASA] physical status; pre-operative comorbidities, including stroke, hypertension, coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, diabetes mellitus, urgency and type of surgery, anesthetic technique and duration, all intra-operative fluid intake and output, pre-operative and admitted hemoglobin [Hb] and serum albumin levels, baseline and admitted serum creatinine level up to 72 hours, septic shock on ICU admission, the Acute Physiology and Chronic Health Evaluation [APACHE] II score on postoperative day 1, ventilator days, ICU and the hospital lengths of stay, perioperative complications, ICU and 90-day mortality[14].

The following definitions were used. Fluid balance was defined as all intake minus all output[6], a 10% IFO was a fluid balance at the end of surgery >10% of hospital admission body weight[5,15], ventilator day was the time period (in days) of ventilator use, the ICU length of stay was the time from the ICU admission to the time of the physician's order to discharge, a prolonged ICU length of stay was a staying in the ICU >72 hours[16,17], an acute kidney injury was as per the KDIGO criteria within 72 hours of ICU admission[18], septic shock was as per the Society of Critical Care Medicine [SCCM] guideline criteria[19], severity of illness was the ASA physical status[20], and the APACHE II score[21] was the score on postoperative day 1. The perioperative complications included airway congestion, pulmonary edema, acute respiratory distress syndrome[22], pleural effusion, congestive heart failure, intra-abdominal hypertension, acute kidney injury, anastomosis leakage, wound disruption, and complications of the type of fluid replacement, such as anaphylaxis and transfusion-related lung injuries [TRLI][23].

Statistical analysis

The present study aimed to estimate the incidence of fluid overload in patients undergoing major non-cardiac surgery who had been admitted to general SICU. Our 3-month pilot study revealed an incidence of fluid overload of 23% using same definition[5,15]. However, based on recent knowledge about fluid management the incidence of fluid overload was

supposed to be lower. With an expected incidence of 15% and a 95% confidence interval [CI] of 15±2.5%, a sample of 800 patients was needed.

The patients' demographic were presented using descriptive statistics. The incidence of fluid overload was reported as percentage. The difference between the patients with and without fluid overload was tested using Chi-square test for qualitative variables and 2-sample t-test and Mann-Whitney U test for quantitative variables with and without normal distribution respectively. For the secondary outcomes to determine the impact of fluid overload on ventilator days, ICU and hospital lengths of stay, perioperative complications and mortality (in the ICU, and 90 days after ICU admission), the Mann-Whitney U test and Chi-square test were employed. The factors associated with a prolonged ICU stay (>3 days) were analyzed using binary logistic regression and reported as adjusted OR, 95% CI, and *p*-value. All statistical data analyses were analyzed using IBM SPSS Statistics for Windows, version 21.3 (IBM Corp, Armonk, NY, USA).

Results

The 800 patients in this study, most of the comorbidities were hypertension, diabetes mellitus and ASA physical status III. The pre-operative and admission serum albumin levels were 3.2±1.9 and 2.9±0.9 g/dL, respectively. Baseline serum creatinine was 1.4±1.2 mg/dL. The median of pre-operative and admitted Hb levels were 10.6 and 11.0 g/dL, respectively. 9.8% had combined general and regional anesthesia, one-fourth were undergoing major abdominal surgery and emergency surgery, respectively. 13.1% had septic shock on ICU admission and the APACHE II score on postoperative day 1 was 9.0±5.4 (Table 1). The median intra-operative intake was 2,400 mL, intra-operative crystalloid was 2,000 mL, blood loss was 300 mL, and intra-operative fluid balance was 1,515 mL.

In the present study, 59 patients (7.4%) had 10% IFO. Forty percent underwent major abdominal surgery and one forth had septic shock on ICU admission. IFO patients were significantly younger than non-IFO patients, had lower co morbidities, and their preoperative and admission serum albumin level were lower (Table 1).

IFO patients had a significantly higher intake (crystalloid, synthetic colloid, albumin, blood and blood components), blood loss, and fluid balance (Table 2). Most of the fluids were from crystalloid solution with a median of >6,000 mL or 15 mL/kg/hr. Six percent hydroxyl ethyl starch was the commonly used synthetic colloid whereas albumin solution was rarely used.

The secondary outcomes of this study were the effects of a 10% IFO on ICU resource utilization (ventilator days and ICU length of stay), perioperative complications and mortality (ICU and 90-day mortality). A univariate analysis comparing the 10% IFO and others factors associated with a prolonged ICU stay showed that a patient age >80 years, an ASA physical status >III, undergoing emergency surgery, an admitted serum albumin level <3 g/dL, an admitted Hb level <9 g/dL, septic shock on ICU admission, acute kidney injury [AKI], and an APACHE II score on postoperative day 1 >10 were significantly associated with a prolonged ICU stay[15,16] (Table 3).

From the multivariate analysis, 10% IFO, an ICU admitted serum albumin level <3 g/dL, septic shock on ICU admission were significant predictors of prolonged ICU stay. AKI and an APACHE II score on day 1>10 had a tendency to be predictors of prolonged ICU stay (Table 4). A significantly longer hospital length of stay was also found in 10% IFO patients (Table 5).

Significantly higher complications were found in 10% IFO patients including, congestive heart failure, serious cardiac arrhythmias, liver dysfunction, intra-abdominal hypertension[23], wound infections. Moreover, the incidence of AKI and ventilator associated pneumonia [VAP] had a tendency to be higher in 10% IFO patients (Table 5) along with other complications associated with fluid overload (such as airway congestion needing reintubation, severe pulmonary congestion, pulmonary edema, flap thrombosis, anastomosis leakage, wound disruption, anaphylaxis from 6% hydroxy ethyl starch and transfusion related lung injury [TRLI] from plasma transfusion. AKI was the most common organ dysfunction (32.2%) in IFO patients, and 12% needed emergency renal replacement therapy [RRT] from fluid overload.

Ten percent IFO patients had a tendency to have a higher ICU and 90-day mortality (Table 5). From subgroup analysis, patients who had a total intra-operative balance more than the median of balance fluid (115 mL/kg) were significantly associated with 90-day mortality.

Discussion

With the need for higher fluid replacement in patients undergoing major surgery, miss understanding of third space fluid losses and over estimation of intra-operative losses, most patients had a positive fluid balance at the end of surgery[1,2,25]. Poor surgical

Table 1. Demographic data and detail of the study patients

Data	Study patient (n = 800)	10% IFO (no) (n = 741)	10% IFO (yes) (n = 59)	*p*-value
Age (year)	64.2±17.3	64.6±17.2	59.4±18.9	0.027*
Body weight (kg)	61.3±16.1	61.4±17.9	58.1±12.0	0.144
Body mass index (kg/m^2)	23.7 (5.8)	23.9±6.2	22.9±4.9	0.209
Gender: female	357 (44.6)	331 (44.7)	26 (44.1)	0.929
Preadmission co-morbidity				
Hypertension	397 (49.6)	383 (51.7)	14 (23.7)	<0.001*
Coronary artery disease	107 (13.4)	105 (14.2)	2 (3.4)	0.019*
Stroke	57 (7.1)	57 (7.7)	0 (0)	0.027*
Diabetes mellitus	150 (18.8)	144 (19.4)	6 (10.2)	0.079
Chronic obstructive pulmonary disease	41 (5.1)	41 (5.5)	0 (0)	0.064
Chronic kidney disease	136 (17)	131 (17.7)	5 (5.5)	0.070
Smoking	232 (29)	216 (29.1)	16 (27.1)	0.741
ASA				0.125
I-II	269 (33.6)	246 (33.2)	23 (20.4)	
III	468 (58.5)	438 (59.1)	30 (50.8)	
>III	63 (7.9)	57 (7.7)	6 (10.2)	
Preoperative serum albumin (g/dL)	3.2±1.9	3.4±0.6	3.1±0.8	0.040*
Admitted serum albumin (g/dL)	2.9±0.9	3.2±1.9	2.6±0.8	0.026*
Preoperative hemoglobin (g/dL)	10.6 (5 to 16)	10.0 (5 to 18)	11 (7.1 to 16.0)	<0.001*
Admitted hemoglobin (g/dL)	11.0 (6 to 17.9)	11.0 (6 to 17.9)	11.0 (7.1 to 16.0)	0.946
Baseline serum creatinine (mg/dL)	1.4±1.2	1.5±1.3	1.3±0.9	0.241
Combined GA and neuraxial block	78 (9.8)	67 (9.0)	11 (18.6)	0.019*
Emergency surgery	229 (28.6)	211 (28.5)	18 (30.5)	0.739
Type of surgery				0.098
Abdominal surgery	224 (28.0)	200 (27.0)	24 (40.7)	
Vascular surgery	183 (22.9)	174 (23.5)	9 (15.2)	
Maxillofacial surgery	142 (17.8)	129 (17.4)	13 (22.0)	
Orthopedic surgery	116 (14.5)	112 (15.1)	4 (6.8))	
Urological surgery	78 (9.8)	74 (10.0)	4 (6.8)	
Obstetric and gynecological surgery	57 (7.1)	52 (7.0)	5 (8.5)	
Anesthetic time (min)	240 (15 to 1,050)	240 (10 to 1,050)	410 (165 to 840)	<0.001*
Septic shock on ICU admission	105 (13.1)	89 (12.0)	16 (27.1)	<0.001*

The data are presented as mean ± standard deviation, median (min-max) and n (%)
* $p<0.05$ indicates statistical significance
IFO = Intraoperative fluid overload; BMI = Body mass index; ICU = Intensive care unit; ASA = American Society of Anesthesiologists; GA = General anesthesia

outcomes and increased postoperative complications have been reported for cardiac surgery with a high intra-operative balance as well as and in noncardiac surgery with a high positive balance on the first up to 4 days of ICU admission especially in the presence of low serum albumin levels[4-8,10]. The questions had been raised about the impact of only the 10% IFO on perioperative outcome.

In the present study of 800 patients, the incidence of 10% IFO was 7.4% (59 patients), which was less than the figure of 23% in our pilot study. Most of the higher fluid intake in the 10% IFO patients in our study came from the need for fluid resuscitation due to severe bleeding (up to 15,200 mL), septic shock (a quarter of the IFO patients had septic shock on ICU admission) and during the first phase of combined general and neuraxial block and during lengthy surgery. Over-aggressive fluid resuscitation was found in these patients, especially crystalloid solution which is the recommended initial resuscitation fluid[18,23,26]. Total intake up to 16,411 ml and crystalloid up to 11,600 mL or 41 mL/kg/hr were found in this study, which was

Table 2. Data of intraoperative fluid management

	10% IFO (no) (n = 741)	10% IFO (yes) (n = 59)	*p*-value
Total intake (mL)	2,150 (500 to 14,120)	9,528 (3,976 to 16,411)	<0.001*
Total intake (mL/hr)	546 (30 to 4,406)	1,299 (62 to 2,970)	<0.001*
Total intake (mL/kg/hr)	10 (2 to 47)	21 (4 to 49)	<0.001*
Total crystalloid solution^{+} (mL)	1,950 (500 to 8,860)	6,300 (2,400 to 11,600)	<0.001*
Total crystalloid solution^{+} (mL/hr)	477 (4 to 2,798)	815 (57 to 2,798)	<0.001*
Total crystalloid solution^{+} (mL/kg/hr)	8 (2 to 77)	15 (1 to 41)	<0.001*
Total synthetic colloid^{++} (mL)	500 (100 to 2,500)	1,000 (400 to 2,720)	<0.001*
Total blood loss (mL)	250 (5 to 15,200)	2,465 (20 to 15,000)	<0.001*
Total blood and blood component replacement^{+++} (mL)	598 (50 to 9,993)	1,323 (100 to 6,102)	<0.001*
Total albumin solution (mL)	250 (100 to 1,067)	0	N/A
Total balance^{++++}	1,390 (-1,955 to 6,657)	6,449 (3,716 to 15,381)	<0.001*
Total balance^{++++} (mL/kg)	20 (-35 to 110)	115 (57 to 236)	<0.001*

The data are presented as median (min-max)
*p<0.05 indicates statistical significance.
IFO = Intraoperative fluid overload; N/A = Not applicable
$^{+}$ Crystalloid solution included all kind of crystalloid solution; $^{++}$ Synthetic colloid included 6% Hydroxy ethyl starch solution and 4% gelatin solution; $^{+++}$ Blood component included fresh frozen plasma, cryoprecipitate and platelet; $^{++++}$ Total balance included all intake minus all output

Table 3. Data from univariate analysis of patients with prolonged and not-prolonged ICU length of stay

	Not prolonged ICU stay (n = 563)	Prolonged ICU stay (n = 237)	Crude odds ratio (95% confidence interval)	*p*-value
Age >80 year	78 (13.9)	48 (20.3)	1.58 (1.06 to 2.35)	0.023*
ASA >III	33 (5.9)	30 (12.7)	2.33 (1.38 to 3.92)	<0.001*
Emergency surgery	133 (23.6)	96 (40.5)	2.20 (1.59 to 3.04)	<0.001*
10% IFO	16 (2.8)	43 (18.1)	7.58 (4.17 to 13.76)	<0.001*
Admitted serum albumin <3.0 g/dL	267 (47.4)	171 (72.2)	2.87 (2.07 to 3.99)	<0.001*
Admitted Hb <9 g/dL	81 (14.4)	48 (20.3)	1.51 (1.02 to 2.24)	0.039*
Septic shock on ICU admission	76 (13.5)	120 (50.6)	6.57 (4.63 to 9.34)	<0.001*
Acute kidney injury	119 (21.1)	108 (45.6)	3.12 (2.26 to 4.33)	<0.001*
APACHE II score on postoperative day 1 >10	138 (22.9)	106 (45.6)	2.82 (2.04 to 3.89)	<0.001*

The data are presented as n (%), crude odds ratio
* p<0.05 indicates statistical significance
ASA = American Society of Anesthesiologists, IFO = Intraoperative fluid overload; Hb = Hemoglobin; ICU = Intensive care unit; APACHE II = The Acute Physiology and Chronic Health Evaluation

much higher than the previous report of 6,000 ml or >15 mL/kg/hr that was associated with poor outcomes especially in the presence of low serum albumin <3 g/dL[3,4]. With the high cost of albumin solution, very few patients received this external albumin solution replacement during surgery despite the high oncotic and high benefit of albumin on cellular and microvascular function[27]. In this study, the mean $\pm$ SD of admission serum albumin in IFO patients was 2.6$\pm$0.8 g/dL which was significantly lower than that for the non-IFO patients (3.2$\pm$1.9 g/dL, p = 0.026).

Complications of fluid overload in the presence of low intravascular oncotic pressure were also found, including airway edema, pulmonary edema, severe pulmonary congestion, and intra-abdominal hypertension. Synthetic colloids, especially 6%

Table 4. Data from multivariate analysis of patients with prolonged and not-prolonged ICU length of stay

	Adjusted odds ratio (95% confidence interval)	*p*-value
Age >80 year	1.53 (0.97 to 2.41)	0.065
ASA >III	0.95 (0.50 to 1.78)	0.862
Emergency surgery	1.02 (0.68 to 1.53)	0.928
10% IFO	8.87 (4.65 to 16.90)	<0.001*
Admitted serum albumin <3.0 g/dL	1.86 (1.28 to 2.71)	0.001*
Admitted Hb <9 g/dL	1.05 (0.66 to 1.67)	0.848
Septic shock on ICU admission	4.92 (3.26 to 7.04)	<0.001*
Acute kidney injury	1.54 (1.00 to 2.37)	0.053
APACHEII score on postoperative day 1>10	1.55 (1.00 to 2.40)	0.052

The data are presented as adjusted odds ratio and 95% CI
* $p<0.05$ indicates statistical significance
ASA = American society of Anesthesiologists; IFO = Intraoperative fluid overload; Hb = Hemoglobin; ICU = Intensive care unit; APACHEII = The Acute Physiology and Chronic Health Evaluation score

Table 5. Data of outcome of 10% intraoperative fluid overload (IFO)

Data	10% IFO (no) (n = 741)	10% IFO (yes) (n = 59)	*p*-value
APACHE II score postoperative day 1	9.1±5.5	8.3±4.8	0.272
Major perioperative complications			
Stroke	7 (0.9)	0 (0.0)	0.453
Myocardial infarction	10 (1.3)	0 (0.0)	0.369
Congestive heart failure	23(3.1)	5 (8.5)	0.043*
Cardiac arrhythmias	55 (7.4)	9 (15.3)	0.033*
Acute respiratory distress syndrome	71 (9.6)	6 (10.2)	0.883
Acute kidney injury	197 (26.6)	19 (32.2)	0.350
Gastrointestinal bleeding	30(4.0)	3 (5.1)	0.700
Liver dysfunction	27 (3.6)	7 (11.9)	0.048*
Abdominal hypertension	20 (3.8)	6 (10.2)	0.049*
Disseminated intravascular coagulation	50 (6.7)	7(11.9)	0.141
Ventilator associated pneumonia	28 (3.8)	3 (5.1)	0.617
Wound infection	12 (1.6)	4 (6.8)	0.038*
Ventilator day	2 (1 to 37)	3 (1 to 28)	0.090
ICU length of stay (days)	1 (1 to 37)	3 (1 to 30)	0.011*
ICU stay >72 hr	194 (26.2)	27 (45.8)	0.001*
Hospital day	15 (1 to 67)	20 (5 to 65)	0.047*
ICU mortality	33 (4.5)	5 (8.5)	0.201
90-day mortality	87 (11.7)	12 (20.3)	0.102

The data are presented as mean ± standard deviation, median (min-max) and n (%)
* $p<0.05$ indicates statistical significance
APACHE = Acute Physiology and Chronic Health Evaluation score; ICU = Intensive care unit

hydroxyethy starch (up to 2,720 mL or 50 mL/kg), along with blood and blood components (up to 9,993 mL) were also given in the present study. Moreover, complications such as anaphylaxis and TRLI were found. Careful intra-operative evaluation of fluid and, blood losses and replacement are important. Goal directed therapy may help decrease the severity of IFO[28].

Ten percent IFO was significantly associated with perioperative major complications; such as congestive heart failure, cardiac arrhythmias, liver dysfunction, intra-abdominal hypertension, and wound infections. AKI was the most frequent organ dysfunction (32.2%) found in IFO patients and 12% needed RRT from fluid overload in the presence of AKI. There was no significant difference in the incidence of AKI in patients with and without IFO, despite the significant effect of a positive fluid balance of 10% admission body weight. This might have been due to an inadequate sample size[29,30].

In addition, ten percent IFO had a significant impact on ICU resource utilization. The present study showed that 10% IFO was a predictor of prolonged ICU length of stay and a tendency for higher number of ventilator days. In addition, a prolonged hospital stay was found more often in IFO patients. More complications and the increase times needed to clear fluid overloads might be the major causes of this prolonged ICU stay[31].

The ICU and 90-day mortality tended to be higher in IFO patients. These IFO patients who had a total intra-operative balance more than 115 mL/kg were significantly associated with 90-day mortality. Consequent-care should be taken with this group of patients to prevent fluid overload, for example, by using goal-directed fluid therapy strategies[27] not only to provide good tissue perfusion but also to prevent fluid overload.

Limitation

One limitation was that the total number of study patients might not have been enough because of the overestimated IFO incidence of 23%, compared with the acute incidence of 7.4% that led to some interesting results such as AKI and mortality, which did not show statistical significance. In addition, the purpose of the present study was to examine the effects of IFO for all surgical procedures, this meant that the results for each group of procedures was too small to show a clinically significant difference between each group of patients. In addition, as this was an observational study, there might be some errors in measurement (especially in the estimation of blood losses), which might interfere with the results of the study. Despite the small number of index cases in this study, the effects of IFO on resource utilization (such as ICU and hospital lengths of stay), and major complications (such as congestive heart failure, serious cardiac arrhythmias, liver dysfunction, intra-abdominal hypertension, and wound infections) showed a significant difference from patients who did not have IFO and the other factors associated with a prolonged ICU stay. The results of this exploratory study also need further study for each group of surgical patients such as patients with septic shock and patients undergoing major abdominal surgery.

Conclusion

Ten percent IFO had a high impact in critically ill patients undergoing major non-cardiac surgery in terms of ICU resource utilization and increased in perioperative major complications and mortality. IFO occurred significantly more often in patients with lower pre- and postoperative serum albumin levels, in patients undergoing surgery with high risks of blood and fluid loss, in lengthy surgery, and septic shock. AKI was the most common organ dysfunction found in the IFO patients.

What is already known on this topic?

High intra-operative fluid infusion and perioperative positive fluid balance have been associated with poor outcomes. Fluid over more than 10% of admission body weight has been associated with organ dysfunction. Intra-opertaive fluid overload in during cardiothoracic surgeries has been associated with poor outcomes.

What this study adds?

The current incidence of IFO >10% admission body weight in major non-cardiac surgery patients admitted to the general surgical SICU has been established. This IFO was associated with poor outcomes both in terms of increased ICU and, hospital lengths of stay, as well as a higher incidence of perioperative complications and mortality; it was also and was a significant predictor of a prolonged ICU length of stay >72 hours. The high incidence of IFO was particularly prevalent among in patients undergoing surgery involving high risk of blood and fluid loss, lengthy surgery and patient who had clinical sign of septic shock.

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Trial registration

Clinical Trials.gov registration as NCT0136 1477.

Potential conflicts of interest

The authors declare no conflict of interest.

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