ORIGINAL ARTICLE

Incidence and Risk Factors of Postoperative Acute Kidney Injury in Non-Cardiovascular Surgery: A Retrospective Cohort Study

Warinporn Kuawatcharawong, MD[1], Thanaporn Jitpakdee, MD[1], Kawisara Potranun, MSc[1], Papassorn Wankhan, MD[1]

[1] Panyananthaphikkhu Chonprathan Medical Center, Srinakharinwirot University, Nonthaburi, Thailand

Objective: To identify the incidence, risk factors, and outcome of postoperative acute kidney injury (AKI) in non-cardiovascular surgery.

Materials and Methods: A single-center retrospective cohort study included patients who underwent non-cardiovascular surgeries such as general, orthopedics, gynecology, neurosurgery, ENT, plastic, and endoscopy, between January 1, 2019 and December 31, 2020. The primary outcome was the incidence of AKI within seven days after surgery, as defined by the Kidney Disease: Improving Global Outcomes (KDIGO) criteria. The secondary outcomes were risk factors and the outcome of AKI.

Results: From 2,898 cases, the incidence of postoperative AKI was 2% (57 cases). Twenty-two out of 57 cases (38.6%) had diagnosis of acute renal failure in the discharge summary. Independent risk factors of postoperative AKI by multivariate logistic regression analysis were the American Society of Anesthesiologists (ASA) classification of 3 or greater, emergency surgery, atrial fibrillation, preoperative use of a mechanical ventilator, eGFR of less than 60 mL/minute/1.73 m^2, hypoalbuminemia, intraoperative urine output of less than 0.5 mL/kg/hour, vasopressor infusion, and intraoperative blood transfusion. Patients with postoperative AKI had higher mortality rates and postoperative complications included pneumonia, surgical site infection, sepsis, respiratory failure, and severe arrhythmia.

Conclusion: Postoperative renal function should be monitored in patients with risk factors associated with postoperative AKI to improve patient outcomes.

Keywords: Acute kidney injury (AKI); Postoperative AKI; Surgery; Surgical complication; KDIGO creatinine criteria; Kidney function

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Perioperative acute kidney injury (AKI) is a complication associated with increased morbidity, mortality, length of stay, and hospital cost[1,2]. The incidence of AKI in surgical patients varied from 1% to 31% depending on the type of surgery and definition of AKI[3-5]. Many risk factors such as old age, hypertension, diabetes mellitus, and chronic kidney disease (CKD) are associated with AKI[5]. Most of the previous studies in Thailand related to perioperative AKI were done in patients undergoing cardiovascular surgery[6-8] or in critical patients[9-12] with an incidence of AKI from 8.5% to 65%. However, there was limited data on perioperative AKI in other types of surgery or in non-critical patients.

A previous study of AKI in gynecologic surgery found only 14% of the patients with AKI by the RIFLE definition had a diagnosis of AKI listed in discharge summaries[13], raising the concern that perioperative AKI might be overlooked in less complex surgeries.

The present study aimed to investigate the incidence, risk factors, and outcome of postoperative AKI in common surgeries to increase awareness of this complication.

Materials and Methods

This retrospective study was conducted in Panyananthaphikkhu Chonprathan Medical Center, Srinakharinwirot University, a 400-bed teaching hospital in Thailand with more than 3,000 operations performed each year. The study was approved by the Ethics in Human Research Review Committee of Panyananthaphikkhu Chonprathan Medical Center,

Correspondence to:

Wankhan P.

Panyananthaphikkhu Chonprathan Medical Center, Srinakharinwirot University, 222 moo 2, Tiwanon Road, Bang Talat, Pakkred, Nonthaburi 11120, Thailand.

Phone: +66-85-9183295, **Fax:** +66-2-5022345 ext. 3651

Email: papassornw@g.swu.ac.th

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The lists of 7,035 operations under anesthesia between January 1, 2019 and December 31, 2020 from the electronic databases were reviewed. Participants over 18 years old who underwent surgery under general or regional anesthesia were included. Vascular and urologic surgery were excluded. The former because it was already an extensive study, the latter due to the high probability of mechanical obstruction. Obstetric surgery was excluded considering that postoperative serum creatinine (sCr) was rarely obtained, and most patients are healthy, whereas, eye surgery was excluded due to very small numbers in the present study hospital.

The medical records of the remaining 3,227 cases were reviewed for additional exclusion criteria, which were patients with end-stage renal disease, patients without preoperative sCr within three months before surgery, patients with preoperative AKI, operation involving urinary tract, tracheostomy due to prolonged intubation, length of stay less than 48 hours, patients who were referred to other hospitals, and patients with missing anesthetic records. For the patients who received more than one operation in the same admission, only the first operation was included in the present study. The final population included in the present study was 2,898 cases.

Manually written medical records and electronic medical databases were reviewed. Comorbidities and complications were collected from the discharge summary and progress notes. Intraoperative data were collected from anesthetic records and operative notes.

Definitions

The definition of AKI from the Kidney Disease: Improving Global Outcomes (KDIGO)[14] was used in the present study. The most recent preoperative sCr was used as a baseline. The estimated glomerular filtration rate (eGFR) was calculated by the EPI-GFR method based on baseline sCr. AKI was defined by an increase in sCr of more than 0.3 mg/dL within 48 hours or an increase of more than 1.5 times within seven days postoperatively. AKI stage was calculated from the highest sCr in the same admission. If postoperative sCr was not presented, the patients were considered as not having AKI. For other preoperative laboratory data, the most recent preoperative values were used for analyses.

Intraoperative blood pressure was manually recorded every five minutes. Intraoperative hypotension was defined by the recorded systolic blood pressure (SBP) less than 90 mmHg or mean arterial pressure (MAP) less than 60 mmHg at least two times consecutively.

The diagnoses of acute renal failure by ICD-10-CM, which were N17.0 Acute renal failure with tubular necrosis, N17.1 Acute renal failure with acute cortical necrosis, N17.2 Acute renal failure with medullary necrosis, N17.8 Other acute renal failure, and N17.9 Acute renal failure unspecified, were obtained from discharge summary to compare with the findings from investigators.

Statistical analysis

Data were analyzed using Stata Statistical Software, version 18 (StataCorp LLC, College Station, TX, USA). Continuous variables were reported as mean and standard deviation (SD) for normally distributed data, or median and interquartile range (IQR) for non-normally distributed data. Categorical data were reported as count (n) and percentages (%). Mean and median were compared between these two groups using independent samples t-test or Mann-Whitney test, when appropriated. Proportions were compared using the chi-square test or Fisher's exact test as appropriate. A p-value (p) less than 0.05 was considered statistically significant.

In logistic regression analysis, ordinal and continuous variables except operative time were recategorized into two groups, using cut points commonly used in clinical practice, which were American Society of Anesthesiologists (ASA) classification 3, hemoglobin 10 g/dL, serum albumin 3.5 g/dL, eGFR 60 mL/minute/1.73 m^2, blood loss of 500 mL, and urine output (UO) 0.5 mL/kg/hour. Preoperative and intraoperative risk factors with $p<0.2$ from univariate analysis were included in multivariate analysis using logistic regression to identify independent risk factors.

Results

Of the 2,898 cases, postoperative sCr was presented in 24.4% of cases. The incidence of postoperative AKI was 2% (57 cases), 1.4% (40 cases) were AKI stage 1, 0.4% (12) were stage 2, and 0.2% (5) were stage 3. In 57 cases that fit the criteria of AKI by KDIGO definition, 22 cases (38.6%) had a diagnosis of acute renal failure as a complication in discharge summary, three patients received renal replacement therapy during admission. The highest incidence of AKI occurred in neurosurgery at 10.8%, followed by general surgery at 3.0%, gynecology

Table 1. Incidence of postoperative AKI by surgery type

Surgery type	Number	AKI; n (%)				Diagnosis of ARF in d/c sum† n (%)	Postoperative sCr presented n (%)
		All stage	Stage 1	Stage 2	Stage 3		
General	1,232	37 (3.0)	25 (2.0)	9 (0.7)	3 (0.2)	12 (32.4)	289 (23.5)
Orthopedics	975	9 (0.9)	9 (0.9)	0 (0.0)	0 (0.0)	5 (55.6)	242 (24.8)
Gynecology	401	4 (1.0)	2 (0.5)	1 (0.2)	1 (0.2)	3 (75.0)	96 (23.9)
Neurosurgery	65	7 (10.8)	4 (6.2)	2 (3.1)	1 (1.6)	2 (28.6)	51 (78.5)
ENT	159	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	14 (8.8)
Plastic	40	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (20.0)
Endoscopy	26	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (30.8)
All	2,898	57 (2.0)	40 (1.4)	12 (0.4)	5 (0.2)	22 (38.6)	708 (24.4)

AKI=acute kidney injury; ARF=acute renal failure; d/c sum=discharge summary; sCr=serum creatinine
† Compared to incidence of AKI by KDIGO

at 1%, and orthopedic at 0.9%. Detailed results are shown in Table 1.

The baseline characteristics of patients with AKI and without AKI are presented in Table 2. Patients with postoperative AKI were older, at 67.6±15.1 versus 53.1±18.2 ($p<0.001$), and had higher ASA classification ($p<0.001$). There is no difference in body mass index (BMI) between the two groups. The incidence of AKI was higher in patients who underwent emergency surgery at 57.9% versus 23.5% ($p<0.001$).

Comorbidities found associated with post-operative AKI were hypertension with 64.9% versus 39.5%, $p<0.001$), diabetes mellitus at 36.8% versus 19% ($p<0.001$), dyslipidemia at 38.6% versus 25.8 ($p=0.03$), coronary artery disease at 14% versus 3.5% ($p=0.001$), sepsis at 12.3% versus 1.7% ($p<0.001$), cirrhosis at 5.3% versus 0.8% ($p=0.015$), atrial fibrillation at 15.8% versus 1.7% ($p<0.001$), and need of preoperative mechanical ventilator at 22.8% versus 1.3% ($p<0.001$).

For laboratory factors, patients with AKI had lower eGFR at 78.2±26.9 versus 96±22.7 ($p<0.001$), lower hemoglobin at 11.4±2.1 versus 12.7±1.9 ($p<0.001$), and lower serum albumin at 3.27±0.8 versus 3.98±0.55 ($p<0.001$).

Intraoperative factors associated with post-operative AKI were longer operative time at 135 minutes (IQR 85 to 220) versus 80 minutes (IQR 50 to 120) ($p<0.001$), higher blood loss at 350 mL (IQR 100 to 1,000) versus 50 mL (IQR 5 to 200) ($p<0.001$), less UO at 1 mL/kg/hour (IQR 0.38 to 1.62) versus 1.56 mL/kg/hour (IQR 0.9 to 2.8) ($p=0.003$), higher intraoperative hypotension at 42.1% versus 7.9% ($p<0.001$), more use of vasopressor infusion at 22.8% versus 1.1% ($p<0.001$), and greater need of blood transfusion at 63.2% versus 9.9% ($p<0.001$).

Preoperative risk factors with $p<0.2$ from univariate analysis were further analyzed by multivariate logistic regression (Table 3). The results show that ASA class 3 or greater (OR 18.63, 95% CI 4.16 to 83.48, $p<0.001$), emergency surgery (OR 3.31, 95% CI 1.7 to 6.47, $p<0.001$), atrial fibrillation (OR 2.68, 95% CI 1.08 to 6.65, $p=0.034$), need of preoperative mechanical ventilator (OR 4.89, 95% CI 2.08 to 11.52, $p<0.001$), hypoalbuminemia (OR 2.81, 95% CI 1.32 to 5.98, $p=0.007$), and eGFR of less than 60 mL/minute/1.73 m² (OR 2.33, 95% CI 1.17 to 4.61, $p=0.015$) were independent risk factors of postoperative AKI.

Multivariate analysis by logistic regression model adjusting for age, gender, and ASA classification of 3 or greater was used for intraoperative risk factors (Table 4). The remaining independent intraoperative risk factors were UO of less than 0.5 mL/kg/hour (OR 2.79, 95% CI 1.33 to 5.82, $p=0.006$), vasopressor infusion (OR 2.62, 95% CI 1.04 to 6.59, $p=0.04$), and blood transfusion (OR 4.46, 95% CI 1.98 to 10.04, $p<0.001$).

Postoperative outcomes

The mortality rate was higher in patients with postoperative AKI at 31.6% versus 1.1% ($p<0.001$). Patients with postoperative AKI were more likely to have postoperative complications, which include pneumonia at 22.8% versus 1.2% ($p<0.001$), surgical site infection at 14% versus 1.4% ($p<0.001$), sepsis at 24.6% versus 1.1% ($p<0.001$), respiratory failure at 21.1% versus 1.1% ($p<0.001$), and severe arrhythmia at 14% versus 0.8% ($p<0.001$) (Table 5). Three patients without AKI had acute coronary syndrome, while none occurred in patients with AKI.

The length of hospital stay was significantly longer in patients with postoperative AKI at 19 days

Table 2. Patient characteristics and intraoperative data

Variables	All patients (n=2,898)	AKI (n=57)	Non-AKI (n=2,841)	p-value	% cases with complete data
Male; n (%)	1,248 (43.1)	30 (52.6)	1,218 (42.9)	0.141	100
Age (years); mean±SD	53.4±18.3	67.6±15.1	53.1±18.2	<0.001	100
ASA classification; n (%)				<0.001	100
ASA I	334 (11.5)	0 (0.0)	334 (11.8)		
ASA II	1,493 (51.5)	2 (3.5)	1,491 (52.5)		
ASA III	942 (32.5)	29 (50.9)	913 (32.1)		
ASA IV	124 (4.3)	24 (42.1)	100 (3.5)		
ASA V	5 (0.2)	2 (3.5)	3 (0.1)		
BMI (kg/m^2); mean±SD	24.46±4.92	24.49±4.57	24.46±4.93	0.956	100
Department; n (%)				<0.001	100
General surgery	1,232 (42.5)	37 (64.9)	1,195 (42.1)		
Orthopedics	975 (33.6)	9 (15.8)	966 (34.0)		
Gynecology	401 (13.8)	4 (7.0)	397 (14.0)		
Neurosurgery	65 (2.2)	7 (12.3)	58 (2.0)		
ENT	159 (5.5)	0 (0.0)	159 (5.6)		
Plastic	40 (1.4)	0 (0.0)	40 (1.4)		
Endoscope	26 (0.9)	0 (0.0)	26 (0.9)		
Emergency surgery; n (%)	701 (24.2)	33 (57.9)	668 (23.5)	<0.001	100
Hypertension; n (%)	1,158 (40.0)	37 (64.9)	1,121 (39.5)	<0.001	100
Diabetes mellites; n (%)	560 (19.3)	21 (36.8)	539 (19.0)	<0.001	100
Dyslipidemia; n (%)	756 (26.1)	22 (38.6)	734 (25.8)	0.030	100
Coronary artery disease; n (%)	108 (3.7)	8 (14.0)	100 (3.5)	0.001	100
Cerebrovascular disease; n (%)	122 (4.2)	5 (8.8)	117 (4.1)	0.089	100
Asthma; n (%)	68 (2.3)	2 (3.5)	66 (2.3)	0.389	100
COPD; n (%)	34 (1.2)	1 (1.8)	33 (1.2)	0.493	100
Sepsis; n (%)	54 (1.9)	7 (12.3)	47 (1.7)	<0.001	100
Cirrhosis; n (%)	27 (0.9)	3 (5.3)	24 (0.8)	0.015	100
Atrial fibrillation; n (%)	57 (2.0)	9 (15.8)	48 (1.7)	<0.001	100
Mechanical ventilator; n (%)	50 (1.7)	13 (22.8)	37 (1.3)	<0.001	100
Hemoglobin (g/dL); mean±SD	12.7±1.9	11.4±2.1	12.7±1.9	<0.001	99.6
Hemoglobin <10 g/dL; n (%)	199 (6.9)	13 (22.8)	186 (6.5)	<0.001	99.6
Serum albumin; mean±SD	3.95±0.58	3.27±0.82	3.98±0.55	<0.001	24.2
Serum albumin <3.5 g/dL; n (%)	127 (4.4)	17 (29.8)	110 (3.9)	<0.001	24.2
eGFR (mL/minute/1.73 m^2); mean±SD	95.6±22.9	78.2±26.9	96.0±22.7	<0.001	100
eGFR <60 mL/minute/1.73 m^2; n (%)	228 (7.9)	18 (31.6)	210 (7.4)	<0.001	100
Total bilirubin (mg/dL); mean±SD	1.03±0.09	1.54±1.82	1.01±2.25	0.240	22.4
Intraoperative					
General anesthesia; n (%)	2,122 (73.2)	51 (89.5)	2,071 (72.9)	0.005	100
Operative time; median (IQR)	80 (50 to 125)	135 (85 to 220)	80 (50 to 120)	<0.001	100
Total blood loss (mL); median (IQR)	50 (5 to 200)	350 (100 to 1,000)	50 (5 to 200)	<0.001	100
Blood loss ≥500 mL; n (%)	354 (12.2)	27 (47.4)	327 (11.5)	<0.001	100
Urine (mL/kg/hour); median (IQR)	1.53 (0.9 to 2.8)	1 (0.38 to 1.62)	1.56 (0.9 to 2.8)	0.003	52
Urine <0.5 mL/kg/hour; n (%)	153 (10.2)	14 (28.0)	139 (9.5)	<0.001	52
Hypotension; n (%)	249 (8.6)	24 (42.1)	225 (7.9)	<0.001	100
Vasopressor infusion; n (%)	44 (1.5)	13 (22.8)	31 (1.1)	<0.001	100
Blood transfusion; n (%)	318 (11.0)	36 (63.2)	282 (9.9)	<0.001	100

SD=standard deviation; IQR=interquartile range; AKI=acute kidney injury; ASA=American Society of Anesthesiologists; BMI=body mass index; COPD=chronic obstructive pulmonary disease; eGFR=estimated glomerular filtration rate

p-value corresponds to independent samples t-test, Mann-Whitney U test, chi-square test, or Fisher's exact test

Table 3. Univariate and multivariate analysis to determine preoperative risk factors of postoperative acute kidney injury

Variables	Univariable analysis		Multivariable analysis	
	Unadjusted OR† (95% CI)	p-value	Adjusted OR‡ (95% CI)	p-value
Age	1.05 (1.03 to 1.07)	<0.001	1.01 (0.99 to 1.04)	0.176
Male	1.48 (0.88 to 2.50)	0.143	0.97 (0.53 to 1.78)	0.919
ASA classification ≥3	49.40 (12.02 to 202.93)	<0.001	18.63 (4.16 to 83.48)	<0.001
Emergency surgery	4.47 (2.63 to 7.62)	<0.001	3.31 (1.7 to 6.47)	<0.001
Hypertension	2.84 (1.64 to 4.92)	<0.001	0.88 (0.43 to 1.81)	0.729
Diabetes mellitus	2.49 (1.44 to 4.30)	0.001	1.22 (0.64 to 2.31)	0.550
Coronary artery disease	4.48 (2.06 to 9.70)	<0.001	1.69 (0.71 to 4.01)	0.236
Cerebrovascular disease	2.24 (0.88 to 5.71)	0.092	0.48 (0.16 to 1.44)	0.189
Sepsis	8.32 (3.59 to 19.31)	<0.001	0.69 (0.24 to 2.01)	0.501
Cirrhosis	6.52 (1.91 to 22.31)	0.003	1.47 (0.34 to 6.26)	0.603
Atrial fibrillation	10.91 (5.07 to 23.49)	<0.001	2.68 (1.08 to 6.65)	0.034
Preoperative mechanical ventilator	22.39 (11.13 to 45.02)	<0.001	4.89 (2.08 to 11.52)	<0.001
Hemoglobin <10 g/dL	4.22 (2.23 to 7.97)	<0.001	1.52 (0.72 to 3.20)	0.270
Serum albumin <3.5 g/dL	10.55 (5.80 to 19.20)	<0.001	2.81 (1.32 to 5.98)	0.007
eGFR <60 mL/minute/1.73 m^2	5.78 (3.25 to 10.29)	<0.001	2.33 (1.17 to 4.61)	0.015

CI=confidence interval; OR=odds ratio; ASA=American Society of Anesthesiologists; eGFR=estimated glomerular filtration rate

† Crude odds ratio estimated by Logistic regression model, ‡ Adjusted odds ratio estimated by Logistic regression model

Table 4. Univariable analysis and multivariable analysis of intraoperative factors for postoperative AKI

Variables	Univariable analysis		Multivariable analysis	
	Unadjusted OR† (95% CI)	p-value	Adjusted OR‡ (95% CI)	p-value
Age	1.05 (1.03 to 1.07)	<0.001	1.01 (0.99 to 1.03)	0.268
Male	1.48 (0.88 to 2.50)	0.143	1.47 (0.77 to 2.79)	0.242
ASA classification ≥3	49.40 (12.02 to 202.93)	<0.001	13.32 (3.04 to 58.44)	0.001
Operative time	1.01 (1.00 to 1.01)	<0.001	1.00 (0.999 to 1.004)	0.130
Blood loss >500 mL	6.92 (4.06 to 11.79)	<0.001	1.14 (0.49 to 2.64)	0.767
Urine <0.5 mL/kg/hour	3.69 (1.94 to 7.00)	<0.001	2.79 (1.33 to 5.82)	0.006
Intraoperative hypotension	8.46 (4.91 to 14.56)	<0.001	1.85 (0.92 to 3.71)	0.085
Vasopressor infusion	26.78 (13.13 to 54.63)	<0.001	2.62 (1.04 to 6.59)	0.040
Blood transfusion	15.560 (8.96 to 27.02)	<0.001	4.46 (1.98 to 10.04)	<0.001

CI=confidence interval; OR=odds ratio; ASA=American Society of Anesthesiologists

† Unadjusted odds ratio estimated by Logistic regression model, ‡ Adjusted odds ratio estimated by Logistic regression model adjusting for gender, age, ASA classification ≥3

Table 5. Postoperative complications, length of stay, and postoperative ICU

Variables	All patients (n=2,898)	AKI (n=57)	No AKI (n=2,841)	p-value
Postoperative complications; n (%)				
Dead	50 (1.7)	18 (31.6)	32 (1.1)	<0.001
Pneumonia	48 (1.7)	13 (22.8)	35 (1.2)	<0.001
Surgical site infection	47 (1.6)	8 (14.0)	39 (1.4)	<0.001
Sepsis	44 (1.5)	14 (24.6)	30 (1.1)	<0.001
Respiratory failure	42 (1.4)	12 (21.1)	30 (1.1)	<0.001
Severe arrhythmia	30 (1.0)	8 (14.0)	22 (0.8)	<0.001
Heart failure	12 (0.4)	1 (1.8)	11 (0.4)	0.111
Length of stay (days); median (IQR)	5 (3 to 9)	19 (9 to 33)	5 (3 to 9)	<0.001
ICU admission; n (%)	275 (9.5)	44 (77.2)	231 (8.1)	<0.001

IQR=interquartile range; AKI=acute kidney injury; ICU=intensive care unit

p-value corresponds to independent samples t-test, Mann-Whitney U test, chi-square test, or Fisher's exact test

(IQR 9 to 33) versus five days (IQR 3 to 9) (p<0.001) and required postoperative intensive care unit (ICU) admission at 77.2% versus 8.1% (p<0.001).

Discussion

The present study included a group of surgical patients to represent a population that is more commonly found in surgical wards of general hospitals. The authors focus on preoperative and intraoperative factors that might be associated with postoperative AKI to help identify patients at risk and increase awareness of this complication. The present study included patients with CKD up to stage IV, which differed from previous studies that usually include only patients with normal renal function[4,15,16].

The incidence of postoperative AKI was 2%, consistent with previous studies of postoperative AKI in non-cardiac surgery, with a range of incidence from 0.8% to 13.2%[4,15,16]. The varied incidence was caused by differences in inclusion criteria and definition of AKI. For example, a retrospective study by Kheterpal et al.[15] reported an incidence of postoperative AKI in patients with GFR of 80 mL/minute/1.73 m² or greater at 0.8% while using a decrease in GFR below 50 mL/minute/1.73 m² as a definition of AKI. Biteker et al. report an incidence of AKI at 6.7% in a prospective study of postoperative AKI in non-cardiac nonvascular surgery[16] using RIFLE criteria in male patients with sCr of less than 1.6 mg/dL and female patients with sCr of less than 1.4 mg/dL. The lower incidence observed in the present study compared to Biteker et al. may be attributed to the fact that postoperative sCr was measured in only 24.4% of the present study patients, whereas, it was measured in every patient in the Biteker et al. study. Consequently, the true incidence of AKI in the present study might be underestimated.

While KDIGO criteria use both sCr and UO for diagnosis of AKI, the authors used only sCr to identify patients with AKI because UO was not routinely monitored postoperatively. However, monitoring of UO in high-risk patients is recommended, as reported by Boonchai et al.[17], that a decrease in UO is more sensitive than sCr for AKI detection. In the presented, intraoperative UO less than 0.5 mL/kg/hour was associated with postoperative AKI, while data from a retrospective study by Mizota et al.[18] found that intraoperative UO less than 0.3 mL/kg/hour was independently associated with postoperative AKI in major abdominal surgery rather than the conventional 0.5 mL/kg/hour and less fluid resuscitation is required to maintain adequate UO. This suggested that intraoperative UO monitoring should be used to identify patients at risk, but the optimal threshold of UO that decreases the risk of AKI should be further investigated. Considering that UO data were collected retrospectively, there may be inconsistencies in how UO was monitored or recorded, which could impact the result.

The independent risk factors of AKI from multivariate analysis, which were ASA class 3 or greater, emergency surgery, eGFR of less than 60 mL/minute/1.73 m², hypoalbuminemia, and intraoperative blood transfusion are consistent with previous studies[9,19]. These factors should be used to identify high-risk patients, and postoperative renal function should be monitored for early detection of AKI.

The association between intraoperative hypotension and postoperative AKI has been reported by Louise et al.[20], in a retrospective cohort study of 5,127 patients undergoing non-cardiac surgery. AKI was associated with MAP less than 60 mmHg for 11 to 20 minutes and MAP less than 55 mmHg for more than 10 minutes by invasive blood pressure monitoring. In addition, a meta-analysis by An et al.[21] found that intraoperative MAP of less than 60 mmHg for more than one minute was significantly associated with postoperative AKI and the risk of AKI was increased when hypotension lasted longer. In the present study, intraoperative hypotension or SBP of less than 90 mmHg or MAP of less than 60 mmHg for more than six minutes, was associated with AKI by univariate analysis (OR 8.46, 95% CI 4.91 to 14.56, p<0.001) but not from multivariate analysis. These findings suggest that early treatment of intraoperative hypotension may reduce the risk of postoperative AKI.

The present study data showed that patients with postoperative AKI had a higher rate of mortality and other complications. Comparing the incidence of AKI in the present study to the diagnosis of acute renal failure listed in the discharge summary, only 22 out of 57 cases (38.6%) were diagnosed. This raises a concern that perioperative AKI might be a neglected problem, which might cause detrimental effects on patient outcomes.

There are limitations in the present study. First, it was conducted at a single center, which may limit the generalizability of the findings to other settings. The patient characteristics, surgical protocols, and resources available at different institutions may result in varying incidences of AKI, affecting the applicability of the results to broader clinical practice.

Second, the retrospective design limits the ability to infer causality between identified risk factors and the development of postoperative AKI. Variables may have been overlooked or misclassified, introducing potential bias in the reported associations. Third, while the authors attempted to adjust for confounding variables through multivariate analysis, unmeasured confounding factors may influence the association between identified risk factors and postoperative AKI. These factors could include the patient's baseline health status, medications, and postoperative care measures, which were not thoroughly controlled in the analysis. Finally, the authors only assessed outcomes within seven days of surgery. Longer-term renal function and the true long-term impact of AKI on patient health and recovery were not evaluated, which is crucial for understanding the full consequences of postoperative AKI.

Conclusion

Postoperative AKI is associated with morbidity and mortality and might be neglected in non-critical patients. Postoperative renal function should be monitored in patients with high risk for AKI to improve patient outcomes.

What is already known on this topic?

Postoperative AKI is a common complication in major abdominal surgery, cardiovascular surgery, and critical patients, and associated with morbidity and mortality.

What does this study add?

Postoperative AKI is under-recognized in non-critical surgical patients.

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Conflicts of interest

The authors declare no conflict of interest.

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