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Association Between Intraoperative Oliguria and Acute Kidney Injury After Major Noncardiac Surgery

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BACKGROUND: Acute kidney injury (AKI) occurs in 6.1%–22.4% of patients undergoing major noncardiac surgery. Previous studies have shown no association between intraoperative urine output and postoperative acute renal failure. However, these studies used various definitions of acute renal failure. We therefore investigated the association between intraoperative oliguria and postoperative AKI defined by the serum creatinine criteria of the Risk, Injury, Failure, Loss, and End-stage kidney disease (RIFLE) classification.

METHODS: In this single-center, retrospective, observational study, we screened 26,984 patients undergoing elective or emergency surgery during the period September 1, 2008 to October 31, 2011 at a university hospital. Exclusion criteria were age <18 years; duration of anesthesia <120 minutes; hospital stay <2 nights; local anesthesia only; urologic or cardiac surgery; coexisting end-stage kidney disease; and absence of serum creatinine measurement, intraoperative urine output data, or information regarding intraoperative drug use. Multivariable logistic regression analysis was used as the primary analytic method.

RESULTS: A total of 5894 patients were analyzed. The incidence of postoperative AKI was 7.3%. By multivariable analysis, ≥120 minutes of oliguria (odds ratio = 2.104, 95% CI, 1.593–2.778; $P < .001$) was independently associated with the development of postoperative AKI. After propensity-score matching of patients with ≥120 and <120 minutes of oliguria on baseline characteristics, the incidence of AKI in patients with ≥120 minutes of oliguria (n = 827; 10%) was significantly greater than that in those with <120 minutes of oliguria (n = 827; 4.8%; odds ratio = 2.195, 95% CI, 1.806–2.668; $P < .001$).

CONCLUSIONS: Contrary to previous studies, we found that intraoperative oliguria is associated with the incidence of AKI after major noncardiac surgery. (Anesth Analg 2018;127:1229–35)

KEY POINTS

- **Question:** We investigated the association between intraoperative oliguria and postoperative acute kidney injury (AKI).
- **Findings:** Intraoperative oliguria, defined as <0.5 $mL\cdot kg^{-1}\cdot hour^{-1}$ for ≥120 minutes, was significantly related to the development of postoperative AKI, which was confirmed by multivariable regression analysis and propensity-score matching.
- **Meaning:** Intraoperative urine output might be a useful marker for predicting the development of postoperative AKI.

Development of postoperative acute kidney injury (AKI) is associated with extended duration of hospital stay and increased morbidity and mortality.[1–7] AKI occurs in 6.1%–22.4% of patients who undergo major noncardiac surgery.[4,8–14] Several baseline risk factors (eg, advanced age, hypertension, diabetes mellitus) for and perioperative contributors (eg, systemic inflammation, hemodynamic alterations, nephrotoxins) to postoperative AKI have been recognized, which may help identify patients at high risk of postoperative AKI.[3–17]

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Although recorded religiously in clinical practice, intraoperative urine output remains a controversial marker of renal function. Urine output is a functional marker that can be influenced by many nonrenal factors. Previous studies found no association between intraoperative urine output and postoperative acute renal failure (ARF).[5,18–26] However, those studies used various definitions of ARF. The concept of AKI has been developed in the past decade, and 3 consensus criteria for AKI have been published (Risk, Injury, Failure, Loss, End-stage kidney disease [RIFLE], Acute Kidney Injury Network [AKIN], and Kidney Disease: Improving Global Outcomes [KDIGO] criteria) such that different severity stages of AKI can be diagnosed.[27–29] In the present study, we investigated the association of oliguria in major noncardiac surgery with postoperative AKI as defined by the serum creatinine criteria of the RIFLE classification.

METHODS

This study was approved, and the requirement for written informed consent was waived, by the Institutional Review Board of Jikei University School of Medicine (#24–308). In this single-center, retrospective, observational study by a database

analysis, we screened 26,984 patients undergoing elective or emergency surgery during the period September 1, 2008 to October 31, 2011 at Jikei University Hospital, a 1074-bed tertiary care center in Tokyo, Japan. Exclusion criteria were age <18 years; duration of anesthesia <120 minutes; hospital stay <2 nights; under local anesthesia only, including nerve block anesthesia, infiltration anesthesia, and topical anesthesia; urologic (including renal transplant) or cardiac surgery; absence of serum creatinine measurement before surgery or during the week after surgery; absence of intraoperative urine output data; coexisting end-stage kidney disease; and absence of information regarding intraoperative drug use.

Baseline serum creatinine level was defined according to the most recent value obtained at our outpatient clinic 1–12 months before admission. Coexistent chronic kidney disease (CKD) and end-stage kidney disease were defined as a baseline estimated glomerular filtration rate (eGFR) of <60 and <15 mL·minute^{-1}·1.73 m^{-2}, respectively, using the Japanese Modification of Diet in Renal Disease equation.[30,31] Patients were classified into 3 groups according to baseline eGFR as follows: ≥60; ≥30, and <60; and <30 mL·minute^{-1}·1.73 m^{-2}. Emergency surgery was defined according to the American Society of Anesthesiologists (ASA) designation of "E." Intraoperative red cell concentrate transfusion included allogeneic transfusion, preserved autotransfusion, and recovered autotransfusion. Intraoperative urine output was measured every 30 minutes during anesthesia.

Exposure of Interests

Oliguria was defined as <0.5 mL·kg^{-1}·hour^{-1} for ≥120 minutes (given that one of the exclusion criteria was duration of anesthesia <120 minutes), as primary exposure.

For assessment of the association between intraoperative oliguria duration and incidence/severity of postoperative AKI, patients were classified into 7 groups according to oliguria duration as follows: none; 1–59 minutes; 60–119 minutes; 120–179 minutes; 180–239 minutes; 240–299 minutes; and ≥300 minutes, as secondary exposure.

Definition of AKI

The criteria for postoperative AKI were based on the serum creatinine criteria of the RIFLE classification.[27] The 3 severity grades (risk, injury, failure) were defined based on changes in serum creatinine level. The risk criterion corresponds to an increase in serum creatinine to 1.5–1.9 times baseline within 7 days; the injury criterion corresponds to an increase in serum creatinine to 2–2.9 times baseline within 7 days; and the failure criterion corresponds to an increase in serum creatinine to 3 times baseline level or greater or an increase to >4 mg/dL with an acute increase of at least 0.5 mg/dL within 7 days. Urine output criteria were not used in the present study, owing to lack of information regarding postoperative urine output.

Statistical Analysis

Data are presented as median and interquartile range (25th–75th percentile) or number and percentage. Univariate analysis was performed by the Mann-Whitney *U* test and Pearson χ^2 test to investigate the association between clinical variables and oliguria for ≥120 minutes. A *P* value of <.05 was considered statistically significant.

Multivariable logistic regression analysis was conducted to investigate the association between intraoperative oliguria (<0.5 mL·kg^{-1}·hour^{-1}) for ≥120 minutes and postoperative AKI while adjusting for potential cofounding variables (model 1). A logistic regression model with a backward-elimination stepwise approach was used. Variables included in the analysis were as follows: age; sex; weight; baseline serum creatinine level; coexistent CKD; ASA physical status (PS); emergency surgery; surgical department (orthopedic surgery as reference); type of anesthesia (general anesthesia as reference); intraoperative blood loss; intraoperative red cell concentrate, fresh-frozen plasma, and platelet concentrate transfusion; intraoperative albumin preparation, crystalloid, and hydroxyethyl starch infusion; and intraoperative use of furosemide, mannitol, atrial natriuretic peptide, radiocontrast agent, and nonsteroidal anti-inflammatory drugs. For sensitivity analysis, the 7 groups according to oliguria duration were entered instead of oliguria for ≥120 minutes into the multivariable regression analysis for postoperative AKI (model 2). Results are presented as odds ratios (ORs) with 95% CIs. A *P* value of <.05 was considered statistically significant. A commercially available statistical package (SPSS 20.0; IBM Corp, Armonk, NY) was used for all statistical analyses.

As a sensitivity analysis to our main method of multivariable regression, we further investigated the association between oliguria and the development of postoperative AKI using the propensity-score (PS) matching. We first constructed a logistic regression model for calculating the PS for each subject to be oliguric for ≥120 minutes intraoperatively based on the same variables of multivariable logistic regression analysis. PS matching was performed in a one-to-one fashion between the ≥120 minutes of oliguria group and the <120 minutes of oliguria group using calipers of width equal to 0.2 of the standard deviation of the logit of the PS.[32] Covariate balances after matching were checked by comparing standardized differences.[33] A standardized difference >10% was considered to have imbalance after PS matching. The Pearson χ^2 test was used to compare the incidence of postoperative AKI between the 2 groups.

A 2-tailed $P < .05$ was considered to have statistical significance for all analyses. Statistical analyses with PS matching were performed using JMP Pro 11.2.0 (SAS Institute Inc, Cary, NC).

RESULTS

Of the 26,984 patients undergoing elective or emergency surgery during the study period, 21,090 were excluded for various reasons (Figure 1); thus, data for 5894 patients were analyzed.

The incidence of postoperative AKI in the study patients was 7.3% (429 patients): 5.1% (298 patients) in the risk category, 1.4% (80 patients) in the injury category, and 0.9% (51 patients) in the failure category according to the serum creatinine criteria of the RIFLE classification. Baseline patient characteristics, intraoperative variables, and outcomes classified by patients with and without oliguria for ≥120 minutes are presented in Tables 1 and 2. With respect to baseline patient characteristics (Table 1), body weight was significantly ($P < .001$) greater in patients with ≥120 minutes of oliguria. The relative percentage of male versus

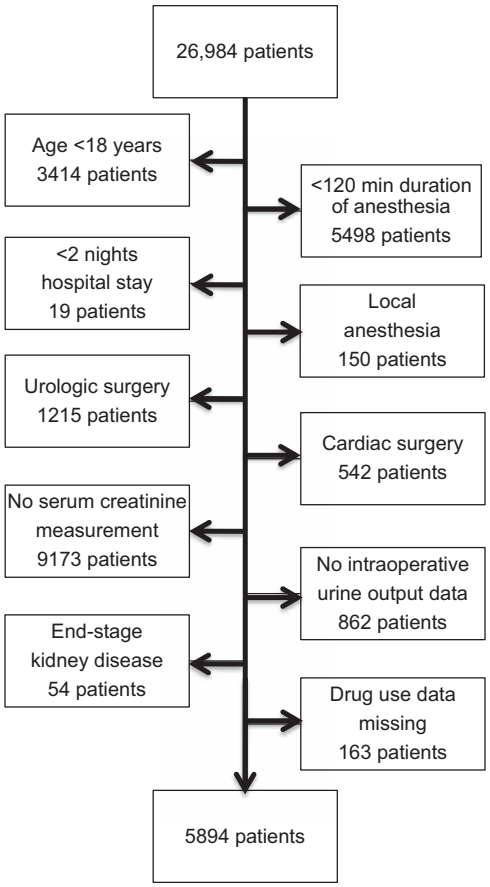

Figure 1. Patient flowchart.

Table 1. Baseline Patient Characteristics in Relation to Intraoperative Oliguria

	Oliguria <120 min (n = 5041)	Oliguria ≥120 min (n = 853)	*P* Value
Age (y)	62 (46–73)	61 (46–71)	.126
Sex (male)	2277 (45.2%)	545 (63.9%)	<.001
Height (cm)	160 (154–167)	165 (158–171)	<.001
Weight (kg)	57 (50–65)	63 (54–73)	<.001
Body mass index	22.2 (20.1–24.4)	23.3 (21–26.3)	<.001
Hospital stay before surgery (d)	2 (1–3)	2 (1–4)	.028
Baseline serum creatinine (mg/dL)	0.73 (0.61–0.9)	0.79 (0.67–0.93)	<.001
Baseline eGFR ($mL \cdot min^{-1} \cdot 1.73\ m^{-2}$)			.664
≥60	3841 (76.2%)	645 (75.6%)	
<60, ≥30	1089 (21.6%)	185 (21.7%)	
<30	111 (2.2%)	23 (2.7%)	
ASA PS ≥3	459 (9.1%)	84 (9.8%)	.488
Emergency surgery	225 (4.5%)	29 (3.4%)	.157
Department			<.001
Orthopedic surgery	990 (19.6%)	122 (14.3%)	
Gastrointestinal surgery	695 (13.8%)	168 (19.7%)	
HBP surgery	402 (8%)	151 (17.7%)	
Neurosurgery	583 (11.6%)	53 (6.2%)	
Obstetrics and gynecology	844 (16.7%)	123 (14.4%)	
Otorhinolaryngology	142 (2.8%)	37 (4.3%)	
Thoracic surgery	340 (6.7%)	50 (5.9%)	
Vascular surgery	800 (15.9%)	113 (13.2%)	
Other[a]	245 (4.9%)	36 (4.2%)	

Data are presented as median and interquartile range (25th–75th percentile) or number and percentage.

Abbreviations: ASA PS, American Society of Anesthesiologists physical status; eGFR, estimated glomerular filtration rate; HBP, hepato-biliary-pancreatic.

[a]Plastic surgery, oral surgery, pediatric surgery, breast surgery, dermatology, and internal medicine.

female patients was significantly ($P < .001$) greater in the ≥120-minute oliguria group. With respect to intraoperative variables and outcomes (Table 2), duration of anesthesia was significantly ($P < .001$) longer, and there was significantly ($P < .001$) more blood loss in the ≥120-minute oliguria group. Hydroxyethyl starch infusion ($P < .001$), use of furosemide ($P < .001$), postoperative renal replacement therapy requirement during hospital stay ($P < .001$), postoperative intensive care unit admission ($P = .001$), and incidence of hospital mortality ($P = .001$) were also more common in the ≥120-minute oliguria group.

Figure 2 shows the relation between incidence of postoperative AKI and oliguria. In patients with ≥120 minutes of oliguria duration, the incidence of postoperative AKI was 15.6% compared to 5.9% in those with <120 minutes of oliguria (Figure 2A). The incidence of postoperative AKI increased with duration of oliguria, from 5.4% in patients with no oliguria to 41.4% in those with oliguria for ≥300 minutes (Figure 2B).

By multivariable logistic regression analysis, ≥120 minutes of oliguria (OR = 2.104, 95% CI, 1.593–2.778; $P < .001$) was independently associated with the development of postoperative AKI after adjusting for potential confounding factors (weight; baseline serum creatinine level; coexistent CKD; type of anesthesia; intraoperative albumin preparation infusion; intraoperative fresh-frozen plasma and platelet concentrate transfusion; and radiocontrast agent) (Table 3, model 1). In the sensitivity analysis, the OR increased steadily with increasing oliguria duration compared to those with zero duration (Table 3, model 2).

Table 4 shows patient characteristics and intraoperative variables after PS matching on oliguria. We obtained standardized differences within 10% for all variables, indicating successful balancing between the 2 groups. After PS matching, the incidence of postoperative AKI (10%) in patients with ≥120 minutes of oliguria was significantly greater than that in patients with <120 minutes of oliguria (4.8%; OR = 2.195, 95% CI, 1.806–2.668; $P < .001$).

DISCUSSION

Key Findings

We performed a retrospective database analysis of almost 6000 surgical cases to assess the association between intraoperative oliguria and postoperative AKI in the context of major noncardiac surgery. AKI according to the serum creatinine criteria of the RIFLE classification occurred in 7.3% of all surgical cases. Intraoperative oliguria, defined as <0.5 $mL \cdot kg^{-1} \cdot hour^{-1}$ for ≥120 minutes, was significantly related to the development of postoperative AKI, which was confirmed by multivariable regression analysis and PS matching. In addition, longer duration of intraoperative oliguria correlated positively with the severity of postoperative AKI.

Table 2. Intraoperative Variables and Outcomes in Relation to Intraoperative Oliguria

	Oliguria <120 min (n = 5041)	Oliguria ≥120 min (n = 853)	*P* Value
Type of anesthesia			<.001
GA (±SA, EA, or LA)	4148 (82.3%)	766 (89.8%)	
TIVA (±SA, EA, or LA)	621 (12.3%)	78 (9.1%)	
CSEA, SA, or EA	272 (5.4%)	9 (1.1%)	
Duration of anesthesia (min)	237 (182–330)	316 (225–478)	<.001
Blood loss (100 g)	1.1 (0–3.1)	2 (0.3–6.3)	<.001
Crystalloid infusion (100 mL)	18 (13–25)	21 (15–31)	<.001
Hydroxyethyl starch infusion (100 mL)	5 (0–10)	5 (0–10)	<.001
Intraoperative fluid balance (100 mL)	15.3 (10.5–21.8)	22.2 (15.3–33.3)	<.001
RCC transfusion	897 (17.8%)	214 (25.1%)	<.001
FFP transfusion	147 (2.9%)	75 (8.8%)	<.001
PC transfusion	67 (1.3%)	43 (5%)	<.001
Albumin preparation infusion	295 (5.9%)	115 (13.5%)	<.001
Intraoperative medication			
Furosemide	78 (1.5%)	63 (7.4%)	<.001
Mannitol	97 (1.9%)	25 (2.9%)	.056
Atrial natriuretic peptide	108 (2.1%)	40 (4.7%)	<.001
Radiocontrast	1070 (21.2%)	78 (9.1%)	<.001
NSAIDs	1049 (20.8%)	254 (29.8%)	<.001
Peak serum creatinine (mg/dL)	0.72 (0.59–0.91)	0.81 (0.66–1.07)	<.001
RRT during hospital stay	28 (0.6%)	24 (2.8%)	<.001
ICU admission	1679 (33.3%)	335 (39.3%)	.001
Total hospital stay (d)	12 (7–24)	14 (8–26)	<.001
Hospital mortality	72 (1.4%)	26 (3%)	.001

Data are presented as median and interquartile range (25th–75th percentile) or number and percentage.

Abbreviations: CSEA, combined spinal-epidural anesthesia; EA, epidural anesthesia; FFP, fresh-frozen plasma; GA, general anesthesia (inhalation anesthesia); ICU, intensive care unit; LA, local anesthesia; NSAIDs, nonsteroidal anti-inflammatory drugs; PC, platelet concentration; RCC, red cell concentration; RRT, renal replacement therapy; SA, spinal anesthesia; TIVA, total intravenous anesthesia.

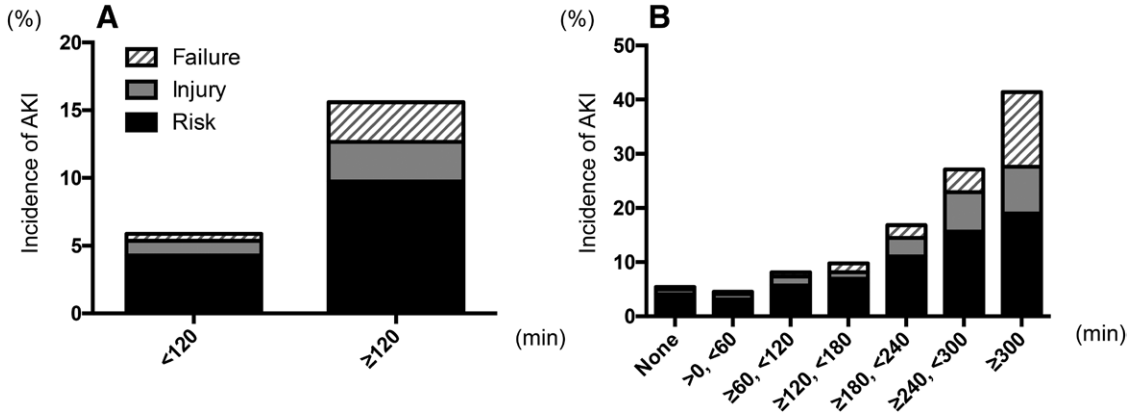

Figure 2. Relation between the incidence of postoperative acute kidney injury (AKI) and oliguria duration. A, Patients were classified into 2 groups (oliguria for <120 or ≥120 min). B, Patients were classified into 7 groups according to oliguria duration.

Comparison to Previous Studies

Miller's Anesthesia (7th ed), the common textbook of anesthesiology, states, "in the operating room, patients are often hemodynamically unstable; decreased blood volume or cardiac output, fluctuating hormone levels (eg, aldosterone, renin, antidiuretic hormone), nervous system reflexes, and increased catecholamine concentrations, added to the effects of general anesthesia, can alter GFR. The data do not support oliguria as a reliable intraoperative sign of pending renal dysfunction."[34] Indeed, previous studies have found no association between intraoperative urine output and development of postoperative ARF.[5,18–26] For example, Alpert et al[22] investigated oliguric patients during aortic surgery (urine output <0.125 mL·kg^{-1}·hour^{-1}) treated with additional crystalloid solution, intravenous mannitol, furosemide, or no intervention and found no association between intraoperative average or lowest urine output per hour and the following ARF. However, definitions of ARF used in previous studies were quite varied and included histologic evidence of acute tubular necrosis, creatinine clearance, GFR, or changes in preoperative to postoperative concentrations of blood urea nitrogen and creatinine.[5,18–25] Study subjects were also varied and included burn injury,[18] trauma,[19,20] shock status,[21] cardiovascular surgery,[22,23] bariatric surgery,[24] or video-assisted lung surgery.[25]

Since the beginning of this century, the concept of AKI has been developed, and 3 consensus criteria for defining AKI have been published (RIFLE, AKIN, and KDIGO criteria).[27–29] In addition, dramatic improvements in anesthetic and monitoring techniques have been made, making

Table 3. Multivariable Logistic Regression Model for Association Between Oliguria and Postoperative Acute Kidney Injury

	Odds Ratio	95% CI	*P* Value
Model 1, primary exposure			
Oliguria ≥120 min	2.104	1.593–2.778	<.001
Age (5 per years)	1.073	1.022–1.127	.005
Sex (male)	1.424	1.075–1.887	.014
ASA PS ≥3	1.902	1.413–2.561	<.001
Emergency surgery	4.194	2.878–6.113	<.001
Department			<.001
Orthopedic surgery	1.0	—	—
Gastrointestinal surgery	2.573	1.642–4.03	<.001
HBP surgery	1.33	0.774–2.283	.302
Neurosurgery	0.44	0.198–0.978	.044
Obstetrics and gynecology	1.416	0.784–2.56	.249
Otorhinolaryngology	0.929	0.405–2.13	.862
Thoracic surgery	1.970	1.091–3.557	.025
Vascular surgery	2.249	1.425–3.551	.001
Other[a]	0.337	0.079–1.431	.14
Blood loss (100 g)	1.011	1.0–1.023	.046
Crystalloid infusion (100 mL)	1.014	1.004–1.023	.005
Hydroxyethyl starch infusion (100 mL)	1.035	1.014–1.055	.001
RCC transfusion	2.021	1.516–2.692	<.001
Furosemide	2.989	1.908–4.68	<.001
Mannitol	2.816	1.467–5.407	.002
Atrial natriuretic peptide	3.721	2.387–5.799	<.001
NSAIDs	0.695	0.497–0.973	.034
Model 2, secondary exposure			
Duration of oliguria (min)			<.001
None	1.0	—	—
>0, <60	0.827	0.59–1.16	.272
≥60, <120	1.542	1.185–2.007	.001
≥120, <180	1.896	1.35–2.663	<.001
≥180, <240	3.54	2.377–5.273	<.001
≥240, <300	6.5	4.027–10.493	<.001
≥300	12.353	7.145–21.357	<.001

Model 2 adjusts for same variables as model 1.

Abbreviations: ASA PS, American Society of Anesthesiologists physical status; CI, confidence interval; HBP, hepato-biliary-pancreatic; NSAIDs, nonsteroidal anti-inflammatory drugs; RCC, red cell concentration.

[a]Plastic surgery, oral surgery, pediatric surgery, breast surgery, dermatology, and internal medicine.

Table 4. Propensity-Score Matching of Patient Characteristics and Intraoperative Variables

	Oliguria <120 min (n = 827)	Oliguria ≥120 min (n = 827)	Standardized Difference
Age (y)	58.7 ± 15.3	58.6 ± 15.8	0.0064
Sex (male)	519 (62.8%)	521 (63%)	0.0041
Weight (kg)	64.6 ± 13.3	64.4 ± 13.5	0.0149
Baseline serum creatinine (mg/dL)	0.85 ± 0.34	0.86 ± 0.41	0.0266
Baseline eGFR ($mL \cdot min^{-1} \cdot 1.73\ m^{-2}$)			
≥60	625 (75.6%)	630 (76.2%)	0.014
<60, ≥30	183 (22.1%)	174 (21%)	0.0268
<30	19 (2.3%)	23 (2.8%)	0.0317
ASA PS ≥3	75 (9.1%)	80 (9.7%)	0.0206
Emergency surgery	24 (2.9%)	27 (3.3%)	0.0231
Department			
Orthopedic surgery	127 (15.4%)	122 (14.8%)	0.0168
Gastrointestinal surgery	161 (19.5%)	165 (20%)	0.0126
HBP surgery	132 (16%)	139 (16.8%)	0.0216
Neurosurgery	58 (7%)	53 (6.4%)	0.024
Obstetrics and gynecology	141 (17%)	122 (14.8%)	0.0628
Otorhinolaryngology	33 (4%)	37 (4.5%)	0.0248
Thoracic surgery	48 (5.8%)	49 (5.9%)	0.0043
Vascular surgery	91 (11%)	104 (12.6%)	0.0496
Other[a]	36 (4.4%)	36 (4.4%)	0
Type of anesthesia			
GA (±SA, EA, or LA)	739 (89.4%)	740 (89.5%)	0.0033
TIVA (±SA, EA, or LA)	77 (9.3%)	78 (9.4%)	0.0034
CSEA, SA, or EA	11 (1.3%)	9 (1.1%)	0.0184
Blood loss (100 g)	4.9 ± 10.6	5.3 ± 10	0.0388
RCC transfusion (100 mL)	2.8 ± 11.2	3.4 ± 10.7	0.0548
Albumin preparation infusion (100 mL)	1.1 ± 4.7	1.3 ± 4.9	0.0417
Crystalloid infusion (100 mL)	24.4 ± 14.8	23.7 ± 12.8	0.0506
Hydroxyethyl starch infusion (100 mL)	7.5 ± 7.8	7.6 ± 7.8	0.0128
FFP transfusion (100 mL)	0.6 ± 4.2	0.9 ± 4	0.0582
PC transfusion (100 mL)	0.1 ± 0.8	0.2 ± 0.9	0.0726
Intraoperative medication			
Furosemide	39 (4.7%)	48 (5.8%)	0.0493
Mannitol	17 (2.1%)	23 (2.8%)	0.0453
Atrial natriuretic peptide	31 (3.7%)	34 (4.1%)	0.0154
Radiocontrast	71 (8.6%)	78 (9.4%)	0.028
NSAIDs	249 (30.1%)	248 (30%)	0.0022

Data are presented as number and percentage or mean ± standard deviation.

Abbreviations: ASA PS, American Society of Anesthesiologists physical status; CSEA, combined spinal-epidural anesthesia; EA, epidural anesthesia; eGFR, estimated glomerular filtration rate; FFP, fresh-frozen plasma; GA, general anesthesia (inhalation anesthesia); HBP, hepato-biliary-pancreatic; LA, local anesthesia; NSAIDs, nonsteroidal anti-inflammatory drugs; PC, platelet concentration; RCC, red cell concentration; SA, spinal anesthesia; TIVA, total intravenous anesthesia.

[a]Plastic surgery, oral surgery, pediatric surgery, breast surgery, dermatology, and internal medicine.

optimal intraoperative management of fluid, blood pressure, respiration, and anesthetic depth possible.[35] Using one of the AKI consensus criteria and a current patient database including various noncardiac surgeries, we found that the incidence of postoperative AKI increased with longer duration of oliguria.

Implications for Clinicians

We found that intraoperative urine output was an independent factor for the incidence of postoperative AKI. Given that urine output can be measured simply, easily, immediately, and without added cost, intraoperative urine output can be recognized as a useful marker to predict the development of postoperative AKI.

However, the impact of intraoperative oliguria on postoperative AKI may differ among various patient conditions and surgery types. For example, abdominal laparoscopic surgery induces intraoperative oliguria, owing to a prolonged increase in intraabdominal pressure during pneumoperitoneum. A randomized controlled trial found that in morbidly obese patients who undergo laparoscopic bariatric surgery, intraoperative urine output was low despite the amount of fluid therapy, and the average serum creatinine concentration was always within normal limits.[24] In another single-center, observational study of postoperative ARF after major noncardiac surgery, intraoperative oliguria (<0.5 $mL \cdot kg^{-1} \cdot hour^{-1}$) was not related to postoperative ARF as defined as eGFR <50 $mL \cdot minute^{-1}$.[5] However, in that study, only patients with previously normal renal function (eGFR >80 $mL \cdot minute^{-1}$) were included. Combining these findings

and those of the present study, it appears that the impact of intraoperative oliguria depends on the existence of other risk factors for postoperative AKI. Indeed, our multivariable logistic regression analysis found several independent factors associated with the development of postoperative AKI including age, sex, ASA PS, emergency surgery, surgery type (gastrointestinal surgery, neurosurgery, thoracic surgery, vascular surgery), and intraoperative blood loss. For patients with these factors, perioperative management (eg, avoiding nephrotoxins; hemodynamic optimization such as goal-directed therapy) might reduce the development of postoperative AKI.[36]

Strengths and Limitations

The present study has several strengths. To the best of our knowledge, this is the first report focusing on the relation between postoperative AKI and oliguria using one of the recently developed consensus criteria for the definition and classification of AKI among patients undergoing major noncardiac surgery. The present study included a large number of patients undergoing major noncardiac surgery in a tertiary hospital. Our inclusion criteria minimized selection bias, and our results were confirmed by multivariable regression analysis and PS matching on oliguria. However, this study was performed at a single center, which might affect external validity. Comorbid conditions, preoperative information regarding drug use, intraoperative vital signs, and postoperative urine output were not available. This limited further assessment of the characteristics and causation of postoperative AKI. In addition, we were able to use only serum creatinine data to define postoperative AKI according to the RIFLE criteria. Recent studies have reported that patients meeting both serum creatinine and urine output criteria have a worse prognosis than patients meeting only 1 of the 2 criteria, and intensive monitoring of urine output improved detection of AKI and therapeutic outcome.[37,38] Furthermore, our retrospective database included more than 26,000 patients; however, only 5894 patients were included in the study. The majority of excluded patients had no creatinine measurement and duration of anesthesia <120 minutes, with a low risk of postoperative AKI.

CONCLUSIONS

Contrary to dated literature reports, we found that intraoperative oliguria is related to the incidence of AKI after major noncardiac surgery. Intraoperative urine output might be a useful marker for predicting the development of postoperative AKI, especially in high-risk patients. ■

DISCLOSURES

Name: Ayako Shiba, MD.
Contribution: This author helped with patient recruitment, data collection, data analysis, writing of the first draft, and final approval of the manuscript.
Name: Shigehiko Uchino, MD.
Contribution: This author helped with study design and writing and final approval of the manuscript.
Name: Tomoko Fujii, MD.
Contribution: This author helped with propensity-score matching analysis and writing and final approval of the manuscript.
Name: Masanori Takinami, MD.
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Name: Shoichi Uezono, MD.
Contribution: This author helped with writing and final approval of the manuscript.
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