Supplemental material table of contents

Supplemental Table 1. Characteristics of the discovery cohort according to studied ordinal outcome.

Variables	No AKI (N=48,304)	Low stage AKI (N=2,132)	Critical AKI (N=605)	P
Demographics				
Age	55 [44; 66]	63 [53; 71]	65 [55; 73]	<0.001
<40	9,016 (18.7%)	152 (7.1%)	38 (6.3%)	
≥40 and <60	19,990 (41.4%)	698 (32.7%)	189 (31.2%)	
≥60 and <80	18,194 (37.7%)	1,158 (54.3%)	332 (54.9%)	
≥80	1,104 (2.3%)	124 (5.8%)	46 (7.6%)	
Sex				<0.001
female	27,402 (56.7%)	706 (33.1%)	198 (32.7%)	
male	20,902 (43.3%)	1,426 (66.9%)	407 (67.3%)	
Body mass index (kg/m^2)	23.8 [21.6; 26.0]	24.0 [21.9; 26.3]	23.7 [21.3; 26.1]	0.005
<18.5 (underweight)	1,802 (3.9%)	77 (3.8%)	40 (7.1%)	
≥18.5 and <30 (normal range)	42,743 (91.5%)	1,854 (90.4%)	501 (88.5%)	
>30 (obesity)	2,150 (4.6%)	119 (5.8%)	25 (4.4%)	
Preexisting comorbidities				
Heart disease	1,445 (3.0%)	132 (6.2%)	52 (8.6%)	<0.001
Hypertension	8,989 (18.6%)	653 (30.6%)	182 (30.1%)	<0.001
Diabetes mellitus	3,494 (7.2%)	357 (16.7%)	105 (17.4%)	<0.001
Surgery characteristics				
Departments				<0.001
General surgery	20,962 (43.4%)	1,167 (54.7%)	318 (52.6%)	
Neurosurgery	4,920 (10.2%)	106 (5.0%)	37 (6.1%)	
Obstetrics and gynecology	7,802 (16.2%)	61 (2.9%)	31 (5.1%)	
Orthopedics	10,834 (22.4%)	476 (22.3%)	62 (10.2%)	
Urologic surgery	3,786 (7.8%)	322 (15.1%)	157 (26.0%)	
Surgery duration (hours)	2.2 [1.4; 3.2]	3.8 [2.2; 5.8]	3.9 [2.3; 6.2]	<0.001
Expected surgery duration (hours)	2.5 [2.0; 3.0]	3.0 [2.5; 5.0]	3.0 [2.5; 5.0]	<0.001
Anesthesia type				<0.001
General	41,480 (86.4%)	1,878 (88.6%)	563 (93.5%)	
Non-general	6,508 (13.6%)	242 (11.4%)	39 (6.5%)	
Emergency operation	613 (1.3%)	74 (3.5%)	45 (7.8%)	<0.001
BP before operation				
SBP	123 [113; 135]	126 [114; 138]	125 [113; 137]	<0.001
DBP	77 [70; 85]	76 [69; 84]	75 [68; 83]	<0.001
Normotensive	35,199 (75.2%)	1,389 (69.4%)	388 (72.4%)	
Hypertensive (SBP ≥ 140 or DBP ≥ 90)	9,601 (20.5%)	493 (24.6%)	112 (20.9%)	
Hypotensive (SBP < 90 or DBP < 60)	1,978 (4.2%)	120 (6.0%)	36 (6.7%)	
Preoperative RAAS blockade	2,482 (5.1%)	294 (13.8%)	105 (17.4%)	<0.001
Laboratory findings				
eGFR (mL/min/1.73 m^2)	82.3 [71.8; 95.1]	76.9 [61.9; 93.6]	74.0 [57.6; 92.9]	<0.001
No CKD or CKD stage 1 or 2 (≥60)	44,900 (93.0%)	1,633 (76.6%)	438 (72.4%)	
CKD stage 3A (≥45 and <60)	2,836 (5.9%)	311 (14.6%)	79 (13.1%)	
CKD stage 3B (≥30 and <45)	459 (1.0%)	132 (6.2%)	50 (8.3%)	
CKD stage 4 (≥15 and <30)0	109 (0.2%)	56 (2.6%)	38 (6.3%)	
Presence of albuminuria (dipstick ≥ 1+)	4,060 (8.6%)	427 (20.5%)	195 (33.2%)	<0.001
White blood cell count (1000/mm^2)	6.1 [5.0; 7.5]	6.3 [4.9; 7.9]	6.6 [4.9; 8.9]	<0.001
Reference range (4000~10000)	41,211 (85.3%)	1,627 (76.3%)	424 (70.3%)	
Leukopenia (<4000)	3,581 (7.4%)	278 (13.0%)	75 (12.4%)	
Leukocytosis (≥10000)	3,493 (7.2%)	226 (10.6%)	104 (17.2%)	
Hemoglobin (g/dL)	13.3 [12.1; 14.4]	12.6 [10.9; 14.0]	12.1 [10.4; 13.8]	<0.001
Anemia (<12 for female, <13 for male)	12,819 (26.6%)	1,010 (47.4%)	348 (57.6%)	<0.001
Platelet (10^3/μL)	200 [152; 255]	206 [140; 294]	207 [135; 324]	<0.001
Thrombocytopenia (<10)	3,807 (7.9%)	263 (12.6%)	90 (15.2%)	<0.001
Albumin (g/dL)	4.2 [3.9; 4.5]	3.9 [3.3; 4.3]	3.7 [3.0; 4.2]	<0.001
Hypoalbuminemia (<3.5)	4,322 (9.0%)	591 (27.7%)	235 (38.8%)	<0.001
Sodium (mEq/L)	140 [139; 142]	140 [138; 142]	140 [137; 142]	<0.001
Normonatremia (135~145)	45,900 (95.2%)	1,881 (88.2%)	507 (83.8%)	
Hyponatremia (<135)	1,028 (2.1%)	190 (8.9%)	73 (12.1%)	
Hypernatremia (>145)	1,275 (2.6%)	61 (2.9%)	25 (4.1%)	
Potassium (mEq/L)	4.2 [4.0; 4.4]	4.2 [4.0; 4.5]	4.2 [3.9; 4.5]	<0.001
Normokaleima (3.5~5.5)	47,108 (97.7%)	2,041 (95.7%)	562 (92.9%)	
Hypokalemia (<3.5)	920 (1.9%)	64 (3.0%)	32 (5.3%)	
Hyperkalemia (>5.5)	175 (0.4%)	27 (1.3%)	11 (1.8%)	

Supplemental Table 2. Cumulative logistic regression analysis result for variable selection.

	(Low stage AKI + Critical AKI) vs. (No AKI)			(Critical AKI) vs. (Low stage AKI + No AKI)		
	Coefficient	95% CI	P	Coefficient	95% CI	P
Age <40	Reference			Reference		
≥40 and <60	0.745	0.588, 0.906	<0.001	0.790	0.453, 1.154	<0.001
≥60 and <80	1.357	1.207, 1.513	<0.001	1.420	1.098, 1.773	<0.001
≥80	1.989	1.772, 2.205	<0.001	2.201	1.769, 2.640	<0.001
Male sex (vs. female)	0.978	0.896, 1.060	<0.001	0.951	0.782, 1.123	<0.001
Departments						
General surgery	Reference			Reference		
Neurosurgery	-0.891	-1.069, -0.720	<0.001	-0.669	-1.027, -0.341	<0.001
Obstetrics and gynecology	-1.793	-2.012, -1.587	<0.001	-1.293	-1.683, -0.941	<0.001
Orthopedics	-0.355	-0.457, -0.255	<0.001	-0.964	-1.246, -0.698	<0.001
Urologic surgery	0.580	0.470, 0.688	<0.001	0.978	0.782, 1.170	<0.001
BMI category						
Underweight (vs. reference range)	0.164	-0.032, 0.351	0.093	0.639	0.299, 0.951	<0.001
Obesity (vs. reference range)	0.195	0.017, 0.365	0.028	-0.019	-0.449, 0.362	0.925
Heart disease (vs. none)	0.849	0.688, 1.005	<0.001	1.069	0.769, 1.348	<0.001
Hypertension (vs. none)	0.652	0.567, 0.737	<0.001	0.599	0.422, 0.772	<0.001
Diabetes mellitus (vs. none)	0.957	0.850, 1.062	<0.001	0.932	0.714, 1.141	<0.001
Expected surgery duration (hours)	0.539	0.515, 0.563	<0.001	0.458	0.417, 0.500	<0.001
Non-general anesthesia (vs. general)	-0.310	-0.438, -0.185	<0.001	-0.810	-1.151, -0.499	<0.001
Emergency operation (vs. non-emergency)	1.277	1.073, 1.474	<0.001	1.803	1.477, 2.105	<0.001
BP category						
Hypotensive before surgery (vs. normotensive)	0.222	0.126, 0.316	<0.001	0.045	-0.170, 0.253	0.675
Hypertensive before surgery (vs. normotensive)	0.446	0.273, 0.613	<0.001	0.481	0.120, 0.811	0.006
Preoperative RAAS blockade use (vs. no use)	1.148	1.033, 1.260	<0.001	1.282	1.064, 1.492	<0.001
eGFR ≥60	Reference			Reference		
≥45 and <60	1.092	0.977, 1.206	<0.001	0.981	0.732, 1.217	<0.001
≥30 and <45	2.151	1.972, 2.327	<0.001	2.196	1.881, 2.490	<0.001
≥15 and <30	2.928	2.648, 3.207	<0.001	3.197	2.819, 3.551	<0.001
Leukopenia (vs. reference range)	0.683	0.564, 0.800	<0.001	0.675	0.420, 0.916	<0.001
Leukocytosis (vs. reference range)	0.641	0.518, 0.761	<0.001	1.039	0.817, 1.251	<0.001
Anemia (vs. none)	1.004	0.926, 1.081	<0.001	1.280	1.118, 1.443	<0.001
Hypoalbuminemia (vs. none)	1.481	1.393, 1.568	<0.001	1.772	1.605, 1.937	<0.001
Hyponatremia (vs. reference range)	1.593	1.450, 1.733	<0.001	1.731	1.472, 1.976	<0.001
Hypernatremia (vs. reference range)	0.260	0.030, 0.475	0.022	0.567	0.136, 0.950	0.006
Hypokalemia (vs. reference range)	0.636	0.416, 0.844	<0.001	1.045	0.664, 1.390	<0.001
Hyperkalemia (vs. reference range)	1.369	1.002, 1.710	<0.001	1.561	0.888, 2.125	<0.001
Urine albuminuria (vs. none)	1.175	1.079, 1.270	<0.001	1.605	1.429, 1.778	<0.001
Thrombocytopenia (vs. none)	0.564	0.446, 0.680	<0.001	0.707	0.475, 0.928	<0.001

AKI = acute kidney injury, CI = confidence interval, BMI = body mass index, BP = blood pressure, RAAS = renin-angiotensin-aldosterone system, eGFR = estimated glomerular filtration rate
The grey colored variables (surgical departments, underweight/obesity, blood pressure categories and hypernatremia) were not included in further model construction due to significant difference of coefficients in each threshold, suggesting that parallel assumption is hardly assumed with the variables.

Supplemental Table 3. Proportional odds model for variable selection.

	Model coefficient	95% CI	P
Age <40	Reference		
≥40 and <60	0.473	0.302, 0.644	<0.001
≥60 and <80	0.787	0.617, 0.956	<0.001
≥80	1.120	0.875, 1.366	<0.001
Male sex (vs. female)	0.714	0.624, 0.804	<0.001
Heart disease (vs. none)	0.190	0.006, 0.374	0.042
Hypertension (vs. none)	0.176	0.069, 0.282	0.001
Diabetes mellitus (vs. none)	0.263	0.135, 0.391	<0.001
Expected surgery duration (hours)	0.451	0.424, 0.478	<0.001
Emergency operation (vs. non-emergency)	0.690	0.448, 0.931	<0.001
Preoperative RAAS blockade use (vs. none)	0.473	0.338, 0.608	<0.001
eGFR ≥60			
≥45 and <60	0.663	0.532, 0.794	<0.001
≥30 and <45	1.321	1.113, 1.528	<0.001
≥15 and <30	1.921	1.607, 2.235	<0.001
Leukopenia (vs. reference range)	0.395	0.254, 0.536	<0.001
Leukocytosis (vs. reference range)	0.027	-0.117, 0.172	0.712
Anemia (vs. none)	0.292	0.192, 0.392	<0.001
Hypoalbuminemia (vs. none)	0.683	0.563, 0.802	<0.001
Hyponatremia (vs. reference range)	0.307	0.162, 0.452	<0.001
Hypokalemia (vs. reference range)	0.169	-0.080, 0.418	0.184
Hyperkalemia (vs. reference range)	0.270	-0.155, 0.696	0.212
Urine albuminuria (vs. none)	0.533	0.421, 0.646	<0.001
Thrombocytopenia (vs. none)	0.041	-0.090, 0.172	0.543

CI = confidence interval, RAAS = renin angiotensin aldosterone system, eGFR = estimated glomerular filtration rate

The grey colored variables (leukocytosis, hypokalemia, hyperkalemia, and thrombocytopenia) were not included in the further model construction due to significant difference of coefficients in each threshold.

Supplemental Table 4. Comparing model coefficients for variable selection.

	Model coefficient	95% CI	P
Age (vs. <40)			
≥40 and <60	0.502	0.332, 0.672	<0.001
≥60 and <80	0.807	0.638, 0.976	<0.001
≥80	1.136	0.892, 1.379	<0.001
Male sex (vs. female)	0.705	0.616, 0.794	<0.001
Heart disease (vs. none)	0.187	0.004, 0.370	0.040
Hypertension (vs. none)	0.171	0.065, 0.276	< 0.001
Diabetes mellitus (vs. none)	0.275	0.148, 0.401	<0.001
Expected surgical duration (continuous, hours)	0.458	0.432, 0.484	<0.001
Emergency operation	0.669	0.432, 0.906	<0.001
Preoperative RAAS blockade use (vs. none)	0.453	0.319, 0.588	<0.001
eGFR (vs. ≥ 60 mL/min/1.73 m^2)			
≥45 and <60	0.680	0.551, 0.809	<0.001
≥30 and <45	1.331	1.127, 1.536	<0.001
≥15 and <30	2.021	1.714, 2.328	<0.001
Leukopenia (vs. none)	0.204	0.097, 0.310	<0.001
Anemia (vs. none)	0.305	0.206, 0.404	<0.001
Hypoalbuminemia (vs. none)	0.667	0.550, 0.784	<0.001
Hyponatremia (vs. none)	0.296	0.153, 0.438	<0.001
Albuminuria (vs. none)	0.505	0.394, 0.617	<0.001

CI = confidence interval, RAAS = renin angiotensin aldosterone system, eGFR = estimated glomerular filtration rate

As additional simple model consisted with age and additional ten variables according to the size of the model coefficients, the grey colored variables (heart disease, hypertension, and leukopenia) were not included in the further model construction due to relatively small model coefficients.

Supplemental Table 5. The model coefficients of the finally selected variables in the proportional odds model.

	Model coefficients	95% CI	P
Age (vs. <40)			
≥40 and <60	0.522	0.353, 0.691	<0.001
≥60 and <80	0.852	0.686, 1.019	<0.001
≥80	1.203	0.962, 1.443	<0.001
Male sex (vs. female)	0.705	0.616, 0.794	<0.001
Diabetes mellitus (vs. none)	0.347	0.227, 0.467	<0.001
Expected surgical duration (continuous, hours)	0.459	0.433, 0.484	<0.001
Emergency operation	0.678	0.441, 0.915	<0.001
RAAS blockade use (vs. none)	0.506	0.375, 0.638	<0.001
eGFR (vs. ≥ 60 mL/min/1.73 m^2)			
≥45 and <60	0.690	0.561, 0.818	<0.001
≥30 and <45	1.345	1.141, 1.549	<0.001
≥15 and <30	2.012	1.705, 2.319	<0.001
Anemia (vs. none)	0.319	0.221, 0.418	<0.001
Hypoalbuminemia (vs. none)	0.705	0.590, 0.820	<0.001
Hyponatremia (vs. none)	0.298	0.156, 0.441	<0.001
Albuminuria (vs. none)	0.510	0.399, 0.621	<0.001

CI = confidence interval, RAAS = renin angiotensin aldosterone system, eGFR = estimated glomerular filtration rate

Model coefficients were multiplied for 11.0306 and rounded to integers to construct the SPARK index.

Supplemental Table 6. Sensitivity and specificity for PO-AKI and critical AKI in discovery and validation cohorts according to suggested threshold values.

	Sensitivity	Specificity	Negative predictive value	Positive predictive value
PO-AKI				
Discovery cohort				
Cutoff = 20	96.0 %	27.2 %	99.2 %	6.8 %
Cutoff = 40	51.0 %	88.6 %	97.0 %	20.0 %
Validation cohort				
Cutoff = 20	95.9 %	16.0 %	98.6 %	5.9 %
Cutoff = 40	38.5 %	85.8 %	96.2 %	13.0 %
Critical AKI (among SPARK index ≥ 40)				
Discovery cohort				
Cutoff = 60	25.8 %	91.7 %	96.0 %	13.9 %
Validation cohort				
Cutoff = 60	18.2 %	94.9 %	96.0 %	14.8 %

PO-AKI = postoperative acute kidney injury, AKI = acute kidney injury, SPARK = simple postoperative acute kidney injury risk

Supplemental Table 7. Distribution of the selected variables in the composite complete-case dataset according to the surgery departments.

	General surgery (N=31,810)	Orthopedic surgery (N=24,873)	Obstetrics and gynecology (N=8,351)	Neurosurgery (N=7,280)	Urologic surgery (N=7,204)	P
Age (years)	58 [49; 68]	59 [44; 69]	45 [36; 52]	56 [45; 65]	66 [57; 72]	<0.001
<40	3,023 (9.5%)	5,171 (20.8%)	2,827 (33.9%)	1,186 (16.3%)	692 (9.6%)	
≥40 and <60	13,949 (43.9%)	7,559 (30.4%)	4,332 (51.9%)	3,185 (43.8%)	1,473 (20.4%)	
≥60 and <80	13,869 (43.6%)	11,149 (44.8%)	1,133 (13.6%)	2,813 (38.6%)	4,780 (66.4%)	
≥80	969 (3.0%)	994 (4.0%)	59 (0.7%)	96 (1.3%)	259 (3.6%)	
eGFR (mL/min/1.73 m^2)	82.7 [71.7; 95.2]	85.7 [72.6; 98.0]	86.5 [75.4; 100.8]	85.5 [72.8; 99.4]	76.6 [64.7; 88.2]	<0.001
≥60	29,432 (92.5%)	22,516 (90.5%)	8,042 (96.3%)	6,740 (92.6%)	5,936 (82.4%)	
≥45 and <60	1,895 (6.0%)	1,830 (7.4%)	250 (3.0%)	440 (6.0%)	963 (13.4%)	
≥30 and <45	366 (1.2%)	401 (1.6%)	43 (0.5%)	74 (1.0%)	226 (3.1%)	
≥15 and <30	117 (0.4%)	126 (0.5%)	16 (0.2%)	26 (0.4%)	79 (1.1%)	
Dipstick albuminuria	2,806 (8.8%)	1,459 (5.9%)	699 (8.4%)	402 (5.5%)	1,316 (18.3%)	<0.001
Male sex	16,900 (53.1%)	11,025 (44.3%)	0 (0.0%)	3,366 (46.2%)	6,455 (89.6%)	<0.001
Expected surgery duration (hours)	3.0 [2.0; 3.5]	2.5 [2.0; 3.0]	2.0 [2.0; 3.0]	4.0 [3.0; 5.0]	3.0 [2.0; 4.0]	<0.001
Emergency department	444 (1.4%)	296 (1.2%)	164 (2.0%)	233 (3.2%)	58 (0.8%)	<0.001
Diabetes mellitus	2,705 (8.5%)	2,522 (10.1%)	255 (3.1%)	595 (8.2%)	597 (8.3%)	<0.001
RAAS blockade use	1,647 (5.2%)	1,756 (7.1%)	235 (2.8%)	712 (9.8%)	472 (6.6%)	<0.001
Albumin (g/dL)	4.2 [3.9; 4.5]	4.4 [4.1; 4.6]	4.3 [4.1; 4.5]	4.2 [3.9; 4.5]	4.4 [4.2; 4.6]	<0.001
Hypoalbuminemia (<3.5)	3,126 (9.8%)	1,478 (5.9%)	554 (6.6%)	683 (9.4%)	197 (2.7%)	
Hemoglobin (g/dL)	13.3 [12.0; 14.4]	13.6 [12.5; 14.9]	12.7 [11.6; 13.5]	13.4 [12.4; 14.5]	14.3 [13.2; 15.2]	<0.001
Anemia (<12 for female, <13 for male)	9,425 (29.6%)	4,444 (17.9%)	2,555 (30.6%)	1,631 (22.4%)	1,280 (17.8%)	
Sodium (mEq/L)	141 [139; 142]	141 [139; 142]	140 [139; 141]	141 [139; 142]	141 [139; 142]	<0.001
Hyponatremia (<135)	933 (2.9%)	545 (2.2%)	102 (1.2%)	169 (2.3%)	111 (1.5%)	

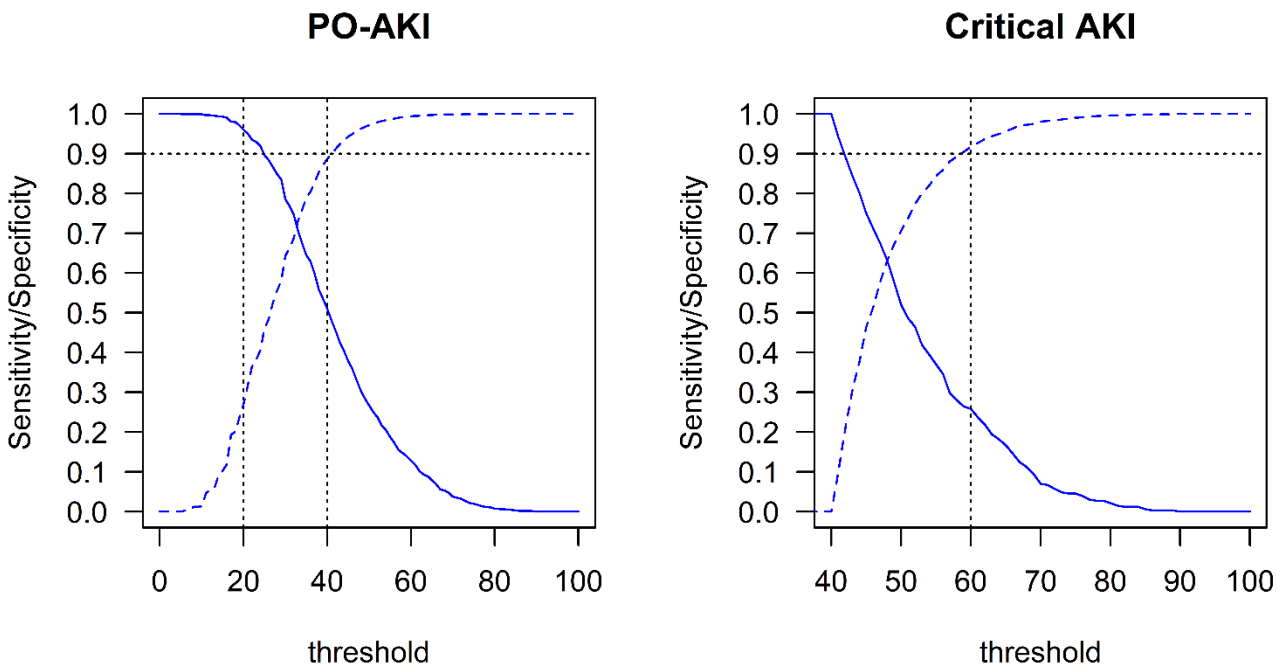
eGFR = estimated glomerular filtration rate, RAAS = renin-angiotensin-aldosterone system

Supplemental Table 8. Distribution of studied outcomes in each surgical department in the composite dataset.

	Class A	**Class B**	**Class C**	**Class D**	**P**
General surgery	(N=6,228)	(N=19,988)	(N=4,988)	(N=606)	
Any AKI	47 (0.8%)	785 (3.9%)	827 (16.6%)	347 (57.3%)	<0.001
Low-stage AKI	41 (0.7%)	606 (3.0%)	610 (12.2%)	259 (42.7%)	<0.001
Critical AKI	6 (0.1%)	179 (0.9%)	217 (4.4%)	88 (14.5%)	<0.001
Orthopedic surgery	(N=6,119)	(N=16,776)	(N=1,908)	(N=70)	
Any AKI	78 (1.3%)	604 (3.6%)	219 (11.5%)	14 (20.0%)	<0.001
Low-stage AKI	71 (1.2%)	539 (3.2%)	169 (8.9%)	8 (11.4%)	<0.001
Critical AKI	7 (0.1%)	65 (0.4%)	50 (2.6%)	6 (8.6%)	<0.001
Obstetrics and gynecology	(N=4,300)	(N=3,900)	(N=145)	(N=6)	
Any AKI	26 (0.6%)	68 (1.7%)	20 (13.8%)	1 (16.7%)	<0.001
Low-stage AKI	17 (0.4%)	44 (1.1%)	13 (9.0%)	0 (0.0%)	<0.001
Critical AKI	9 (0.2%)	24 (0.6%)	7 (4.8%)	1 (16.7%)	<0.001
Neurosurgery	(N=287)	(N=5,133)	(N=1,781)	(N=79)	
Any AKI	7 (2.4%)	91 (1.8%)	76 (4.3%)	15 (19.0%)	<0.001
Low-stage AKI	6 (2.1%)	71 (1.4%)	52 (2.9%)	6 (7.6%)	<0.001
Critical AKI	1 (0.3%)	20 (0.4%)	24 (1.3%)	9 (11.4%)	<0.001
Urologic surgery	(N=552)	(N=4,935)	(N=1,603)	(N=114)	
Any AKI	10 (1.8%)	526 (10.7%)	361 (22.5%)	57 (50.0%)	<0.001
Low-stage AKI	6 (1.1%)	376 (7.6%)	240 (15.0%)	37 (32.5%)	<0.001
Critical AKI	4 (0.7%)	150 (3.0%)	121 (7.5%)	20 (17.5%)	<0.001

AKI = acute kidney injury

Supplemental Figure 1. Sensitivity and specificity plot for SPARK index



Sensitivity and specificity plot for risk of PO-AKI and critical AKI according to threshold values in the discovery cohort. Blue linear lines were the sensitivity curves and the blue dotted lines were the specificity curves. Vertical dotted lines indicated the suggested threshold values SPARK classification. The horizontal dotted lines indicated the sensitivity/specificity value of 0.9.

Supplemental Method 1. Detailed information regarding the collected variables.

The following demographic data were collected from the discovery and validation cohorts: age, sex, and baseline body mass index (BMI) at the time of admission. Age was categorized as < 40, ≥ 40 and < 60, ≥ 60 and < 80, or ≥ 80 years, and the interval was determined to limit the number of categories for simplicity.[1,2] BMI was categorized as underweight (< 18.5 kg/m^2), reference range (≥ 18.5 and < 25 kg/m^2), and obese (≥ 25 kg/m^2).[3,4] Comorbidities of heart disease,[2,5] including a history of admission-requiring heart failure or coronary artery disease (e.g. angina or myocardial infarction), hypertension, and diabetes mellitus, were collected.[1,2,5,6] The comorbidity histories were identified mainly by reviewing anesthesiologists' records, relevant medication usage, and diagnostic codes. Data on the actual surgery duration (hours) and expected surgery duration (hours), which were input by the attending surgeons before performing surgery to schedule anesthesia and reserve operating rooms, were collected. Only the expected surgery duration was included in the model, as it was a preoperatively collectable variable.[6,7] Anesthesia type (general or non-general), and whether the operation was performed as scheduled or as an emergency operation were collated. Systolic blood pressure (BP) and diastolic BP before surgery were recorded.[8] Among well-known PO-AKI-related medications,[9,10] preoperative use of renin-aldosterone-angiotensin-system blockade was included in the study variables. Diuretics, non-steroidal anti-inflammatory drugs or nephrotoxic antibiotics were not collected because those medications are frequently newly initiated after performing surgery to control volume overload, pain or infection. The collected laboratory values were the last examination results within 3 months prior to surgery. Baseline eGFR was calculated based on sCr levels using the CKD-EPI equation and stratified into four categories (reference range, ≥ 60; CKD 3A, ≥ 45 and < 60; CKD 3B, ≥ 30 and < 45; or CKD 4, ≥ 15 and < 30 mL/min/1.73 m^2).[1,8,11] The presence of baseline albuminuria, another direct kidney function parameter, was identified by a simple dipstick test.[12,13] Abnormalities in white blood cell count were categorized as leukopenia (< 4,000/μL) and leukocytosis (≥ 10,000/μL).[14] Anemia was defined as a hemoglobin level of < 12 g/dL for female and < 13 g/dL for male patients.[8,15] A serum albumin level < 3.5 g/dL was the definition for hypoalbuminemia.[16,17] Baseline electrolyte imbalances, including hyponatremia (serum sodium < 135 mEq/L), hypernatremia (serum sodium > 145 mEq/L), hypokalemia (serum potassium < 3.5 mEq/L), and hyperkalemia (serum potassium > 5.5 mEq/L), were recorded.[18,19]

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Supplemental Method 2. Supplemental statistical analysis method.

Categorical variables were shown as frequencies (percentage) and continuous variables as medians (interquartile ranges). The chi-squared test and Mann-Whitney U test were implemented to compare the baseline characteristics of the discovery and validation cohorts. Model calibration was first inspected visually with calibration plots, both for the estimated low-stage AKI and critical AKI probabilities. As our study included large (> 25,000) number of patients, plainly applying the Hosmer-Lemeshow test was not recommended.[1,2] Therefore, we calculated the P values of the Hosmer-Lemeshow tests in thousand random subsamples with a fixed subsample sizes (n = 1,000), and identified the median values.[1,2] Model discriminatory power was checked with the c-stat. The final inspection of the predictive power of the SPARK index was performed for PO-AKI and critical AKI outcomes, with receiver operating characteristics (ROC) curve analysis, and an area under curve (AUC) ≥ 0.7 was considered acceptable. To inspect whether a significant bias was present due to our exclusion criteria, sensitivity analyses were performed. In the analyses, the final SPARK index's discriminative power for the ordinal outcome was calculated with 1) an imputed dataset using nonlinear additive transformation and imputation, 2) inputting the actual surgery duration rather than the expected ones, 3) datasets which were divided according to three eras (2004-2007, 2008-2011, 2012-2015) after merging the study and validation cohorts, and 4) a dataset after additionally excluding the patients who had preoperatively increased sCr for ≥ 0.3 mg/dL or ≥ 1.5-fold relative to the minimum level within 3 months before the surgeries, regardless of the intervals between those, to strictly control the possible inclusion of those with unassessed AKI before surgery. In addition, the performance of the SPARK index and classification was inspected in each surgical department, after combining the discovery and validation cohorts. All analyses were performed with complete-cases without missing values except for the sensitivity analysis with the imputed dataset. Statistical analyses were performed with R (version 3.4.3, the R foundation) and two-sided P-values < 0.05 were considered statistically significant.

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