Prevalence, Outcomes and Risk factors of Acute Kidney Injury in Surgical Intensive Care Unit: A Multi-Center Thai University-Based Surgical Intensive Care Units Study (THAI-SICU Study)

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Objective: *Acute kidney injury (AKI) is one of the most common problems in critically ill patients. AKI associates with poor outcome in ICU. The recognition of the prevalence and risk factors of AKI is important. This could lead to the prevention of AKI and improve patient's outcome. This study aims to identify the prevalence, outcomes and independent risk factors of AKI in Thai surgical intensive care units.*

Material and Method: *We conducted the prospective cohort study from nine university-based SICUs. The patients were diagnosed AKI by Acute Kidney Injury Network (AKIN) classification. The types of RRT and outcomes including mortality were collected. The risk factors of AKI were identified.*

Results: *A total cohort of 4,652 patients was included for the present study. AKI was diagnosed in 786 (16.89%) patients. The ICU mortality was higher in patients with AKI (29.90% vs. 5.48%, p-value <0.001). Among patients with AKI staging, we found that those with AKIN III had higher ICU mortality compared to patients with AKIN II and AKIN I respectively (47.66% vs. 26.67% vs. 14.69%, p-value <0.001). Patients with AKI had higher 28 day-mortality compared with those without AKI (37.53% vs. 8.98%, p-value <0.001). The independent risk factors of AKI were higher APACHE II scores (OR 1.04, 95% CI 1.01-1.06, p-value = 0.001), lower serum albumin (OR 0.82, 95% CI 0.70-0.97, p-value = 0.020), organ failures which were in the gastrointestinal system (OR 1.53, 95% CI 1.13-2.08, p-value = 0.007), cardiovascular system (OR 1.95, 95% CI 1.34-2.83, p-value <0.001), neurological system (OR 1.37, 95% CI 1.02-1.85, p-value = 0.038) and urinary system (OR 7.00, 95% CI 5.21-9.40, p-value <0.001).*

Conclusion: *Acute kidney injury associates with poor outcomes including increased ICU and 28-day mortality. Independent risk factors of AKI in the present study were higher APACHE II scores, lower serum albumin and organ failures on admission.*

Keywords: *Acute kidney injury, AKIN, Prevalence, Risk factors, Acute renal failure*

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Acute kidney injury (AKI) is one of the most common problems in critically ill patients[1]. This complication has long been realized and the older term is acute renal failure. AKI refers to a condition in which kidney function decline rapidly, which could occur because of several reasons. The severity of AKI is varied from the initial, increasing creatinine levels to anuria, which requires renal replacement therapy. The reported incidence of AKI in critically ill patients varied between 1-25%[2-4] while the non-critically ill hospitalized patients had much lower incidence between 5-7%[3]. The mortality rate in patients who developed AKI was quite high[2,5,6]. The length of ICU stays and hospital stays as well as the hospital costs also increased after AKI[7]. Patients with AKI, who required renal replacement therapy (RRT), had a

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higher risk of death[8]. Some of them developed end stage renal disease and required long-term RRT[9,10].

The authors have reviewed the previous studies and found that the prevalence of AKI and risk factors was diverse. The difference in patient characteristics, for example, medical or surgical patients or the regions of healthcare centers could effect these differences. The understanding of the prevalence and risk factors of the development of AKI in specific group of patients is important. This could lead to the prevention of AKI and improve patient's outcome. Thus, this study aims to identify the prevalence, outcome, and independent risk factors of AKI in surgical patients.

Material and Method

The present study is the further analysis from the previous Thai-SICU study[11]. Thai-SICU study is a multi-center, prospective, observational study conducted in nine university-based SICUs in Thailand between April 2011 to January 2013. A total of 4,652 patients were included in the cohort. Written informed consent was obtained from all patients or their substitute decision makers. This study was approved by our institutional research ethics board.

The inclusion criteria were surgical patients who were diagnosed with AKI by AKIN classification in surgical intensive care units. The follow-up time extended 28 days after AKI or death.

Acute Kidney Injury Network (AKIN) classification was modified from RIFLE classification in 2007 (Table 1)[12]. This criterion was more sensitive to diagnose AKI by inclusion of patients with increased serum creatinine of more than 0.3 mg/dL from baseline within 48 hours. The higher the increase in serum creatinine from baseline the higher the stage of AKIN classification was observed (Table 1).

The patient characteristics such as age, sex, body mass index (BMI), organ failures, pre-admission condition and baseline laboratory investigation were included. The severity of patients on admission was measured by APACHE II and SOFA scores. All these significant variables were adjusted for risk factors of AKI (p-value <0.1 by univariate analysis). The types of RRT and outcomes including mortality were collected and the risk factors of AKI were identified.

Statistical analysis

Continuous variables were expressed as means $\pm$ SDs or median with interquartile range (IQR). Categorical variables were compared using the x^2 test or fisher's exact test, as appropriate. Student's t-test was used to compare continuous variables. A two-sided alpha level of 0.05 was required for statistical significance.

Risk factors identified as significant in the univariate analysis (p<0.10), were investigated further in a multiple regression analysis.

Results

AKI was diagnosed in 786 (16.89%) from the total of 4,652 patients. The BMI, pre-ICU LOS, the history of radio-contrast use in previous 24 hours, blood sugar level on arrival and the chronic conditions which were hypertension, coronary artery disease (CAD), chronic obstructive pulmonary disease (COPD), diabetes mellitus, autoimmune disease, chronic kidney disease, cerebrovascular disease were not different between patients with AKI and those without AKI (Table 2). Patients with AKI had higher ages compared with those without AKI (68 (IQR 56-78) vs. 64 (IQR 50-75), p<0.001) and were more likely to be male gender

Table 1. Acute Kidney Injury Network (AKIN) classification for acute kidney injury by creatinine criteria (Mehta 2007)[15]

	Serum creatinine criteria
Acute kidney injury definition	An abrupt (within 48 hours) increase in serum creatinine of more than or equal to 0.3 mg/dLor increase in serum creatinine of more than or equal to 1.5-times form baseline
AKIN staging	
AKIN stage 1	Increase in serum creatinine at 0.3 mg/dL and over from baseline or increase to more than or equal to 1.5- to 2-times from baseline
AKIN stage 2	Increase in serum creatinine above 2- to 3-times from baseline
AKIN stage 3	Increased in serum creatinine above 3-times from baseline or equal to 4.0 mg/dL with an acute increase of at least 0.5 mg/dL or initiation of renal replacement therapy

Table 2. Baseline Characteristics in patients with acute kidney injury and without acute kidney injury

Baseline characteristics	No AKI (n = 3,866)	AKI (n = 786)	*p*-value
Age, median (IQR)	64 (50-75)	68 (56-78)	<0.001*
Male, n (%)	2,208 (57.11)	521 (66.28)	<0.001*
Body mass index (kg/m^2), median (IQR)	22.31 (19.53-25.26)	22.21 (19.72-24.94)	0.429
SOFA scores, median (IQR)	2 (0-4)	6 (3-9)	<0.001*
SOFA scores (renal excluded), mean $\pm$ SD	2.22$\pm$2.61	5.02$\pm$3.85	<0.001*
APACHE II scores, median (IQR)	10 (6-14)	16 (12-22)	<0.001*
Organ dysfunction/failure on arrival			
Respiratory system, n (%)	1,595 (41.26)	495 (62.98)	<0.001*
Gastrointestinal system, n (%)	716 (18.52)	282 (35.88)	<0.001*
Cardiovascular system, n (%)	447 (11.56)	299 (38.04)	<0.001*
Neurological system, n (%)	1,029 (26.62)	413 (52.54)	<0.001*
Hematological system, n (%)	894 (23.12)	331 (42.11)	<0.001*
Urinary system, n (%)	939 (24.29)	591 (75.19)	<0.001*
Preexisting illness			
Congestive heart failure, n (%)	79 (2.04)	28 (3.56)	0.010*
Hypertension, n (%)	1,873 (48.45)	395 (50.25)	0.356
Coronary artery disease, n (%)	388 (10.04)	72 (9.16)	0.453
Malignancy, n (%)	582 (15.05)	145 (18.45)	0.017*
Autoimmune disease, n (%)	48 (1.24)	8 (1.02)	0.600
Chronic kidney disease, n (%)	357 (9.23)	85 (10.81)	0.169
Cerebrovascular disease, n (%)	235 (6.08)	41 (5.22)	0.351
Smoking, n (%)	440 (11.38)	117 (14.89)	0.006*
Radiocontrast exposure, n (%)	478 (14.04)	110 (15.8)	0.226
Non-operative patients, n (%)	715 (18.49)	288 (36.64)	<0.001*
Operative patients, n (%)	3,151 (81.51)	498 (63.36)	
Laboratory value on arrival			
Serum creatinine (mg/dL), median (IQR)	0.9 (0.7-1.2)	1.7 (1.21-2.8)	<0.001*
PaO_2/FiO_2, median (IQR)	350 (244.45-460)	252 (170-380)	<0.001*
Hemoglobin (g/dL), mean $\pm$ SD	10.71$\pm$2.14	10.06$\pm$2.25	<0.001*
Albumin (g/dL), mean $\pm$ SD	2.82$\pm$0.81	2.54$\pm$0.74	<0.001*
Blood sugar (mg/dl), median (IQR)	152 (123-190)	151 (117-198)	0.713
Abnormal EKG, n (%)	964 (25.22)	298 (38.40)	<0.001*
Abnormal chest x-ray, n (%)	747 (20.07)	285 (37.85)	<0.001*
Cardiac arrest in previous 24 hours, n (%)	78 (2.02)	43 (5.47)	<0.001*
Unplanned readmission, n (%)	91 (2.35)	32 (4.07)	<0.001*

APACHE II = Acute Physiologic and Chronic Health Evaluation II; IQR = interquartile range; SOFA = Sequential Organ Failure Assessment; LOS = length of stay
* *p*-value <0.05

(66.28% vs. 57.11%, *p*<0.001). We found that patients with AKI had more organ failures on arrival than patients without AKI which were respiratory system (62.98% vs. 41.26%, *p*-value <0.001), gastrointestinal system (35.88% vs. 18.52%, *p*-value <0.001), cardiovascular system (38.04% vs. 11.56%, *p*-value <0.001), neurological system (52.54% vs. 26.62%, *p*-value <0.001), hematological system (42.11% vs. 23.12%, *p*-value <0.001) and urinary system (75.19% vs. 24.29%, *p*-value <0.001). The non-operative patients developed AKI more often than operated patients (28.71% vs. 13.64%, *p*-value <0.001). Among operated patients, patients with AKI had significantly lower intra-operative urine output compared to patients without AKI (335.64$\pm$431.27 vs. 510.92$\pm$590.68, *p*<0.001) (Table 4).

Regarding the laboratory investigations on ICU arrival, the patients with AKI had higher creatinine level (1.7 (IQR 1.2-2.8) vs. 0.9 (IQR 0.7-1.2), *p*-value <0.001) but lower PaO_2/FiO_2 ratio (252 (IQR

Table 3. Characteristics of operative patients with acute kidney injury and without acute kidney injury

Characteristics	No AKI (n = 3,151)	AKI (n = 498)	*p*-value
ASA physical status, median (IQR)	3 (2-3)	3 (3-4)	<0.001*
Emergency surgery, n (%)	849 (26.94)	299 (60.04)	<0.001*
Vascular surgery, n (%)	53 (6.74)	215 (5.56)	0.195
Intraoperative data			
Blood loss (ml), mean ± SD	960.65±1570.48	1,495.34±2,781.57	0.386
Positive fluid balance (ml), mean ± SD	2,030.25±1,793.49	2,043.87±2195.05	0.168
Urine output (ml), mean ± SD	510.92±590.68	335.64±431.27	<0.001*
Operative time (min)	277.67±184.14	226.02±170.70	<0.001

* *p*-value <0.05

Table 4. Multivariable analysis for acute kidney injury

	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
APACHE II scores	1.12 (1.11-1.13)	<0.001*	1.04 (1.01-1.06)	0.001*
Albumin	0.64 (0.58-0.72)	<0.001*	0.82 (0.70-0.97)	0.020*
Organ dysfunction/failure on arrival				
Gastrointestinal system	2.46 (2.08-2.90)	<0.001*	1.53 (1.13-2.08)	0.007*
Cardiovascular system	4.69 (3.94-5.59)	<0.001*	1.95 (1.34-2.83)	<0.001*
Neurological system	3.05 (2.60-3.57)	<0.001*	1.37 (1.02-1.85)	0.038*
Urinary system	9.44 (7.90-11.28)	<0.001*	7.00 (5.21-9.40)	<0.001*

APACHE II = Acute Physiologic and Chronic Health Evaluation II; OR = odd ratio; CI = confidence interval
* *p*-value <0.05

170-380) vs. 350 (IQR 244-460), *p*-value <0.001), lower hemoglobin (10.06±2.25 vs. 10.71±2.14, *p*-value <0.001) and lower serum albumin level (2.54±0.74 vs. 2.82±0.81, *p*<0.001).

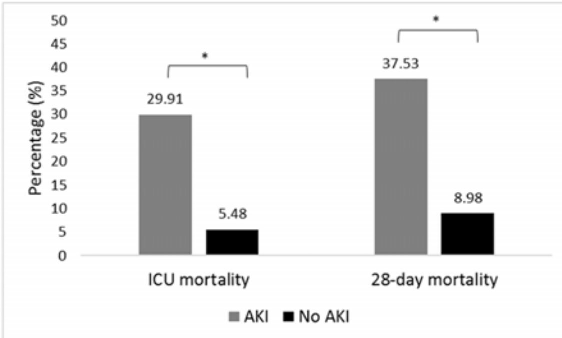
The incidence of previous cardiac arrest within 24 hours were higher in AKI group (5.47% vs. 2.02%, *p*-value <0.001). The unplanned re-admission rate was also higher in patients with AKI (5.85% vs. 2.53%, *p*-value <0.001).

Risk factors of AKI by univariate analysis, which were age, gender, SOFA scores, APACHE II scores, organ dysfunction on admission, congestive heart failure, malignancy, smoking, non-operative patients, serum creatinine, hemoglobin, PaO_2/FiO_2, serum albumin, cardiac arrest in previous 24 hours, unplanned ICU re-admission, were further analyzed by multiple regression analysis. The results showed that higher APACHE II scores (OR 1.04, 95% CI 1.01-1.06, *p*-value = 0.001), lower serum albumin (OR 0.82, 95% CI 0.70-0.97, *p*-value = 0.020), organ failures which were gastrointestinal system (OR 1.53, 95% CI 1.13-2.08, *p*-value = 0.007), cardiovascular system (OR 1.95, 95% CI 1.34-2.83, *p*-value <0.001), neurological system (OR 1.37, 95% CI 1.02-1.85, *p*-value = 0.038), urinary system (OR 7.00, 95% CI 5.21-9.40, *p*-value <0.001) were independent risk factors of AKI (Table 4).

The AKIN classification was recorded for 554 patients. Patients with AKIN I, II and III were 198, 148 and 208 cases, respectively.

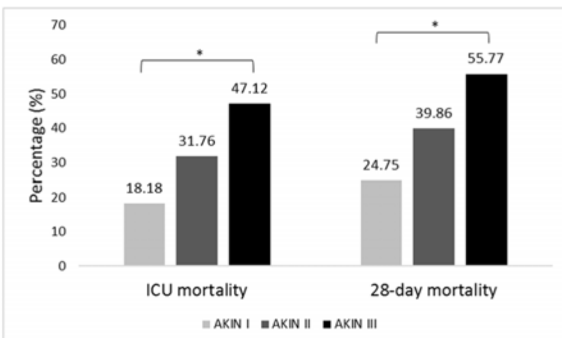
The ICU mortality was higher in patients with AKI (29.91% (235 cases) vs. 5.48% (212 cases), *p*-value <0.001) (Fig. 1). Among patients with AKI, we found that those with AKIN III had higher ICU mortality compared to patients with AKIN II and AKIN I respectively, (47.12% (98 cases) vs. 31.76% (47 cases) vs. 18.18% (36 cases), *p*-value <0.001) (Fig. 2).

At 28 day, patients with AKI had higher mortality rate compared to those without AKI (37.53% (295 cases) vs. 8.98% (347 cases), *p*-value <0.001) (Fig. 1). Patients with AKIN III had higher 28 day mortality compared to patients with AKIN II and AKIN I respectively (55.77% (116 cases) vs. 39.86% (59 cases)



AKI = acute kidney injury, * *p*-value <0.05

Fig. 1 ICU mortality and 28-day mortality in patients with acute kidney injury (AKI) and without acute kidney injury.



AKIN = Acute Kidney Injury Network classifications
* *p*-value <0.05

Fig. 2 ICU mortality and 28-day mortality by AKIN classification.

vs. 24.75% (49 cases), *p*-value <0.001 (Fig. 2). ICU length of stay were increasing in patients with AKI (5 (2-12) days vs. 1 (1-3) day, *p*-value <0.001). Furthermore, hospital length of stay were also increasing in those with AKI (17.5 (9.5-31) days vs. 14 (9-25) days, *p*-value <0.001).

Renal replacement therapy (RRT) was done in 22.26% of patients with AKI divided into intermittent hemodialysis (10.81%), continuous renal replacement therapy (10.43%) and sustained low efficiency dialysis (1.02%).

Among patients with AKI, Patients with AKIN III were significantly correlated with higher risk of deaths compared to AKIN II and I; AKIN III (OR 15.42, 95% CI 11.366-20.943, *p*-value <0.001), AKIN II (OR 8.05, 95% CI 5.551-11.700, *p*-value <0.001) and AKIN I (OR 3.84, 95% CI 2.61-5.66, *p*-value <0.001).

Discussion

Patients who had AKI at any time during ICU stay were 786 cases from 4,652 cases (16.89%). The diagnosis and staging of AKI was done by AKIN classification. The prevalence of AKI in this study is from the surgical intensive care unit which was similar to the prevalence from the previous studies in the surgical ICUs[13]. We found that the prevalence of AKI was varied between different types of patients. One study, which included only major gynecological surgery, reported the prevalence of AKI at 13%[14]. The prevalence of AKI in the mixing ICUs is also different. Wen Y et al conducted the prospective multicenter observational study, which enrolled 3,063 consecutive patients and found that the prevalence of AKI in ICUs was 31.6%[15]. The medical patients were 66.6% of the total patients in this study. The NEFROINTS investigators conducted a prospective observational multicenter study in 10 surgical and medical intensive care units in Italy and demonstrated that the prevalence of AKI in the first 24 hours after admission was 42.7%[16]. The present study found that during operative period, patients who developed AKI had lower urine output compared to patients without AKI. The reason of low urine output was more likely associated with intra-operative hypovolemia which was easier to correct. This might be one of a mechanism of AKI in surgical ICU which is different from medical ICU.

The independent risk factors of acute kidney injury by AKIN classification in this study were higher APACHE II scores, lower serum albumin, organ failures on arrival which were gastrointestinal, cardiovascular, neurological and urinary system. The risk factors of AKI are different between trials. There is one meta-analysis of observational study which includes 504,535 critically ill patients from various ICUs[17]. They found that patients witholder age, diabetes, hypertension, higher baseline creatinine, heart failure, sepsis/systemic inflammatory response syndrome, nephrotoxic drugs use, higher severity of disease scores, vasopressors/ inotropes, high risk surgery, emergency surgery, intra-aortic balloon pump, and longer time in cardiopulmonary bypass pump had the higher risks of AKI. The subjects of this study came from the medical, surgical and cardiac intensive care units, whereas the subjects of the present study were from the surgical intensive care units only. The difference in patient characteristics could explain the difference in risk factors among studies.

Acute kidney injury leads to bad outcomes in critically ill patients. The present study found that ICU and hospital length of stay were increased in patients with AKI. The mortality in patients with AKI was also higher compared to patients without AKI. The numbers of complication in patients with AKI have long been recognized. Therefore, factors that could reduce mortality in these patient groups are much more interested. Kim et al conducted the retrospective observational study in patients underwent thoracic aortic surgery with CPB. They found that potentially modifiable risk factors were pre-operative anemia and hypoalbuminemia and the efforts to minimize operative time and deep hypothermic circulatory arrest time along with transfusion amount may protect patients undergoing aortic surgery against AKI[18]. Karkouti et al also found similar results in cardiac surgery with CPB. They found that patients with the three risk factors which were pre-operative anemia, developed intra-operative anemia, receiving RBC had a 2.6-fold (95% confidence interval 2.0 to 3.3) increase in the relative risk of AKI over an individual with none of these risk factors[19]. Najjar et al also demonstrated that the lowest hematocrit during CPB and pre-operative anemia were potentially modifiable risk factors independently associated with AKI after cardiac surgery in Asian population[20]. The above data are from the patients with surgery under CPB which have more specific physiologic change compared with other patient groups. However, the authors also found that hypoalbuminemia was one of the risk factors of AKI which was similar from one of the above studies. It might be useful knowledge because this risk factor is considered a modifiable risk factor. Thus, we might be able to reduce the incidence of AKI in these patients by raising serum albumin level or considering albumin infusion instead of other types of fluid. Nevertheless, the authors could not confirm this assumption by the finding of this study. Other risk factors that the authors demonstrated in the present study were non-modifiable, which were gastrointestinal, cardiovascular, neurological or urinary system failure on admission and higher APACHE II scores. Non-modifiable risk factors could help physicians to select which patients need special care to protect the development of AKI.

In the present study, patients with higher AKIN classification were associated with higher ICU mortality and 28-day mortality. These findings are similar to other studies[20-22]. Moreover, there was one study from Kork F et al which found that only minor postoperative increase in serum creatinine (25 to 49% above baseline but <0.3 mg/dl) associated with a two-fold increased risk of death (OR, 1.7; 95% CI, 1.3 to 2.4; *p*-value <0.001)[23]. Therefore, the increase in serum creatinine in surgical ICU patients could be one of a marker to predict worse outcome.

Conclusion

AKI in surgical intensive care unit associates with poor outcomes including ICU mortality, 28-day mortality, increased length of ICU stay and hospital stay. Independent risk factors of AKI in the present study were higher APACHE II scores, lower serum albumin and organ failure on admission.

What is already known on this topic?

Acute kidney injury is a significant complication in critically ill patients. It is associated with higher mortality in ICUs. The prevalence of AKI was varied depends on the patient characteristics and the healthcare centers. Patients with AKI may need longer stays in ICU including renal replacement therapy, which consumes more resources. Several modifiable risk factors have been identified to prevent this complication. Risk factors are still different among research studies.

What this study adds?

Mortality of AKI in Thai surgical ICUs was numerically comparable to ICUs in developed countries. However, this study was conducted in a tertiary care center only; this result, however, cannot apply to a lower level of care.

In the present study, risk factors of acute kidney injury were higher APACHE II scores, lower serum albumin and organ failures on admission, which were gastrointestinal, cardiovascular, neurological and urinary systems.

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Potential conflicts of interest

None.

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ความชุก ปัจจัยเสี่ยงและผลการรักษาของภาวะไตวายเฉียบพลันในหออภิบาลผู้ป่วยหนักทางศัลยกรรม: การศึกษาแบบสหสถาบันในประเทศไทย

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วัตถุประสงค์: *ภาวะไตวายเฉียบพลันในหออภิบาลผู้ป่วยหนักทางศัลยกรรมเป็นหนึ่งในภาวะแทรกซ้อนที่สำคัญในผู้ป่วยวิกฤต และมีความสัมพันธ์กับอัตราตายที่สูงขึ้น ความเข้าใจเกี่ยวกับความชุก ปัจจัยเสี่ยง และผลการรักษาของภาวะไตวายเฉียบพลันมีความสำคัญ เพราะทำให้สามารถป้องกันภาวะไตวายเฉียบพลันหรือปรับปรุงผลการรักษาให้ดีขึ้นได้ การวิจัยนี้มีเป้าหมายเพื่อศึกษาถึงความชุก ปัจจัยเสี่ยง และผลการรักษาของภาวะไตวายเฉียบพลันในหออภิบาลผู้ป่วยหนักทางศัลยกรรมในประเทศไทย*

วัสดุและวิธีการ: *ข้อมูลผู้ป่วยที่มีภาวะไตวายเฉียบพลันในการศึกษานี้มาจากการวิจัยโดยการสังเกตแบบไปข้างหน้าในหออภิบาลผู้ป่วยหนักทางศัลยกรรมจากโรงพยาบาลมหาวิทยาลัย 9 แห่ง การวินิจฉัยภาวะไตวายเฉียบพลันใช้เกณฑ์ของ Acute Kidney Injury Network (AKIN) มีการเก็บข้อมูลเกี่ยวกับชนิดของการบำบัดทดแทนไต และผลการรักษา รวมถึงอัตราตาย และวิเคราะห์หาปัจจัยเสี่ยงในการเกิดภาวะไตวายเฉียบพลัน*

ผลการศึกษา: *ผู้ป่วยทั้งหมดในการศึกษาวิจัยมีจำนวน 4,652 คน มีผู้ป่วยไตวายเฉียบพลันเป็นจำนวน 786 ราย (ร้อยละ 16.89) อัตราตายในหออภิบาลของผู้ป่วยที่มีภาวะไตวายเฉียบพลันสูงกว่าผู้ป่วยที่ไม่มีภาวะไตวายเฉียบพลันอย่างมีนัยสำคัญ (ร้อยละ 29.90 เทียบกับร้อยละ 5.48, p<0.001) รวมถึงอัตราตายที่ 28 วัน ในผู้ป่วยที่มีภาวะไตวายเฉียบพลันสูงกว่าผู้ป่วยที่ไม่มีภาวะไตวายเฉียบพลันเช่นเดียวกัน (ร้อยละ 37.53 เทียบกับร้อยละ 8.98, p<0.001) ผู้ป่วยที่มีภาวะไตวายเฉียบพลันตามเกณฑ์ของ AKIN ในระดับ 3 พบว่ามีอัตราตายสูงกว่าระดับ 2 และ ระดับ 1 ตามลำดับ (ร้อยละ 47.66% เทียบกับร้อยละ 26.67 เทียบกับร้อยละ 14.69, p<0.001) ปัจจัยเสี่ยงในการเกิดภาวะไตวายเฉียบพลันได้แก่ คะแนน APACHE II ที่สูงขึ้นระดับอัลบูมินที่ลดลงการล้มเหลวของระบบทางเดินอาหารระบบหัวใจและหลอดเลือด ระบบประสาทและระบบปัสสาวะเมื่อแรกรับ*

สรุป: *ภาวะไตวายเฉียบพลันมีความเกี่ยวข้องกับผลการรักษาที่แย่ลงและเพิ่มอัตราตายของผู้ป่วยในหออภิบาลผู้ป่วยหนักทางศัลยกรรม*