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The Determinants and Outcome of Acute Kidney Injury in Critically Ill Patients in Zagazig University Hospitals

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Abstract: ***Background: Acute kidney injury (AKI) is a common and serious complication in hospitalized patients particularly in patients in the intensive care unit (ICU). The mortality rate in patients with AKI remains very high, despite significant advances in the care of critically ill patients. The identification of risk factors associated with AKI and its poor prognosis is required, so preventive and early diagnostic measures can be taken, aiming to reduce patients' mortality and to improve the outcome. Objective: This study was to evaluate the prevalence of AKI in patients admitted to ICU as well as to identify the risk factors that affect the occurrence and the outcome of AKI in those patients. Methods: We screened 238 patients admitted to Zagazig university hospitals ICU for the occurrence and determinants of AKI during their period of admission. All patients were subjected to full history taking with special attention to hypertension (HTN), diabetes mellitus (DM), underlying chronic kidney disease (CKD) and drug intake, thorough clinical examination with special attention to the presence of sepsis, Acute Physiology And Chronic Health Evaluation (APACHE II score) during the first 24 hours of admission, time of nephrology consultation and the need for renal replacement therapy (RRT). Laboratory investigations included complete blood count, liver function tests, renal function tests, coagulation profile (PT, PTT, and INR), ABG, serum Mg, Calcium and Phosphorus levels and complete urine analysis. Results: The prevalence of AKI in critically ill patients admitted to Zagazig University ICU was 35.3%; of them 14.2% developed end stage renal disease (ESRD) and the mortality rate was 13%. Sepsis was the most common cause of AKI and its prevalence was 51.2%. Hypomagnesaemia, oliguria, late nephrology consultation, duration of AKI >2weeks, need for RRT, underlying CKD, Age>60years, APACHE II score >15, patients with stage 3 AKI according to acute kidney injury network (AKIN) criteria, oliguria and sepsis, all are risk factors associated with increased risk of non-recovery of renal function. Thrombocytopenia<100.000/ul, stage 3 AKI, oliguria, duration of AKI >2weeks, need for RRT, late nephrology consultation, sepsis, age>60years and APACHE II score >15 are risk factors associated with increased risk of mortality. Late nephrology consultation and stage 3 AKI were the most important risk factors for overall unfavorable outcome (ESRD and death). Conclusion: AKI is very prevalent in critically ill patients with sepsis being the most common cause. Late nephrology consultation and stage 3 AKI are the most important independent risk factors for unfavorable outcome in those patients.***

Keywords: Acute kidney injury, Hypomagnesaemia, critically ill patients.

1. Introduction

AKI is acute decline in renal function that occurs over period of hours to days. This acute decline is usually manifested by accumulation of nitrogenous end products including urea and creatinine in blood and it is sometimes accompanied by oliguria **(1).** In critical care settings, patients with AKI constitute an important subgroup, in that they have higher short and long-term mortality, prolonged hospital length of stay, and more resource consumption (2**).**

The incidence of AKI in ICU patients ranges between 20-70% and among those, patients who undergo RRT portend even worse outcome **(3).** RRT-treated AKI patients have an average of 50-70% in-hospital mortality (depending on AKI etiologies) and 25-50% patients develop chronic kidney disease (CKD) there after without complete recovery of renal function **(2).** Consequently, better understanding of the precipitating factors of AKI in those critically ill patients is of paramount importance for clinicians to reduce the incidence of AKI in ICUs **(3).**

Risk factors for AKI in patients with severe illnesses are often multiple rather than single. These factors can be grouped into several categories: first, certain underlying background predisposes patients to the development of AKI. Aged patients tend to acquire AKI more frequently than their younger counterparts, owing to the physiologic ageing of kidneys, multiple morbidities, and impaired renal recoverability **(4).** Comorbidities include those with underlying DM, HTN, CKD, and heart failure; all reportedly set the backstage of subsequent renal injury through the interplay of disrupted renal auto-regulation, pre-existing renal damage, and concomitant use of nephrotoxic medications **(5).** Interestingly, as CKD often leads to AKI, AKI at its end begets CKD **(6).** Second, the insult can be the precipitant of AKI through different mechanisms. For example, sepsis or systemic inflammatory response syndrome (SIRS) contributes to AKI development, by means of its glomerular hemodynamic alterations, induction of reactive oxygen species and oxidative stresses, and tubular ischemic injury (which is now considered as secondary event) **(1).** Hypotension, shock at presentation, and use of vasopressors/inotropes, also account in part for the clinical settings that subsequently spawn AKI **(7).** Third, medications are often the one neglected component of the preludes for AKI. Angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin receptor blockers (ARBs) constitute

one important example. Their use during coronary angiography is reported to increase risk of subsequent contrast induced nephropathy by nearly 50%. Prolonged diuretics use in patients with heart failure or CKD can cause volume depletion and secondary renal ischemia, with resultant AKI susceptibility **(8).** Non steroidal anti-inflammatory drugs (NSAIDS) also predispose one to AKI through their selective renal hemodynamic changes, especially for hypoalbuminemic and anemic patients **(9).**

The combination of the above agents further raises the AKI risk up to 30%, especially within the initial one month of starting these medications; consequently, patients in current use of any combination of the above drugs should be attended to, especially during periods of potential renal Insults, in order to reduce the incidence of subsequent AKI **(10).**

The aim of this work was to evaluate the prevalence of AKI in critically ill patients admitted to Zagazig University hospitals ICU as well as to identify the risk factors that affect the occurrence and the outcome of AKI in those patients.

2. Patients and Methods

The current study was a prospective cohort study and was conducted in the medical ICU, Zagazig university hospitals in the period from February 2014 to July 2014. The study included 238 patients divided into two major groups; group A (patients with AKI) and group B (patients without AKI). Group A was subdivided into three subgroups according to stage of AKI according to AKIN criteria (stage 1, stage 2 and stage 3) **(13)**. An informed written consent was obtained from all participants.

2.1 Exclusion criteria

- Age < 18 years
- Patients refuse to enter the study.
- Presence of advanced liver disease
- Those with ESRD on regular haemodialysis (HD) or peritoneal dialysis (PD)
- Pregnant females
- Patients admitted to ICU for less than 48 hours.

All patients were subjected to thorough history taking with special emphasis on the age, sex, body mass index (BMI), use of the following drugs (diuretics, NSAIDS, ACEIs and ARBs), duration of kidney disease and presence of other systemic diseases specially DM, HTN and CKD. We evaluated all patients for the presence of AKI and its duration, presence of oliguria, Hypomagnesaemia (serum Mg<0.7mmol/L), time of nephrology consultation and use of RRT in the form of HD or PD.

We depended on the international sepsis definitions conference criteria for diagnosis of sepsis which is defined as the presence of infection (probable or documented) together with systemic manifestations of infection **(11)**. Assessment of severity of clinical condition was done using **APACHE II** score **(12).**

Patients were subjected to routine investigations as fasting blood glucose, complete blood count, urine analysis, arterial blood gases, BUN, serum creatinine (S.Cr), liver function tests, coagulation profile (PT, PTT and INR), serum Magnesium, Calcium, ionized Calcium and Phosphorus and pelvi-abdominal ultrasound with special comment on both kidneys and urinary tract**.** We depended on AKIN criteria **(13)** for diagnosis of AKI as follow:

1. **Stage 1 AKI:** S.Cr increase≥0.3 mg/dl (≥26.5 µmol/l) or increase to 1.5–2.0-fold from baseline or urine output <0.5 ml/kg/h for 6 h.
2. **Stage 2 AKI:** S.Cr increase >2.0–3.0-fold from baseline or urine output <0.5 ml/kg/h for 12 h.
3. **Stage 3 AKI:** S.Cr increase >3.0-fold from baseline OR S.Cr ≥4.0mg/dl (≥354 µmol/l) with an acute increase of at least 0.5 mg/dl (44 µmol/l) or urine output <0.3 ml/kg/h for 24 h OR Anuria for 12 h OR need for RRT.

2.2 Statistical Analysis

The collected data were presented, summarized, tabulated & analyzed by using computerized software statistical packages (SPSS version 19). P<0.05 was considered to be statistically significant at 95% confidence interval. Chi-square test was used to compare proportions. Analysis of variance (ANOVA or F test) was used to compare means among more than two groups. The descriptive statistics were presented with mean ± standard deviation (SD) for quantitative variables. All qualitative data was expressed by frequency (number) and percent

3. Results

DM and CKD were significantly more prevalent in group **A** compared to group B (P<0.05) and (P<0.05) respectively; while, no significant difference between the two main groups regarding age, gender, BMI and presence of smoking or HTN, (**table 1)**.

The mean ±SD of APACHE II score and platelet count were significantly higher in group B compared to group A (P<0.05) and (P<0.05) respectively, while the prevalence of sepsis and hypomagnesaemia was significantly higher in group A compared to group B (P<0.05) and (P<0.05), respectively. Also, the prevalence of unfavorable outcome (death or the development of ESRD) was significantly higher in group **A** compared to group B (P<0.05) (**table1**).

Furthermore, there was significant difference between the three subgroups of group A (AKI patients) regarding the mean ±SD of age (P<0.05), presence of CKD (P<0.05), APACHE II score (P<0.05) and hypomagnesemia (P<0.05). Also, there was a significant difference between three subgroups of group A in the prevalence of oliguria, initial rise in S.Cr, basal S.Cr, S.Cr level at time of nephrology consultation, late nephrology consultation, duration of AKI, need for RRT and unfavorable outcome (ESRD) (P<0.05), (**table 2).** On the other hand, no significant difference between the three subgroups of group A was found regarding the mean±SD of gender, presence of smoking, sepsis, HTN, DM and platelet count **(table 2).**

On multivariate analysis, we calculated the risk of different clinical and laboratory variables and the outcome of AKI and we found that high APACHE II score, history of HTN, underlying CKD, presence of oliguria, stage 3 AKI, late nephrology consultation, duration of AKI>2 weeks and thrombocytopenia, all increase the need for RRT in AKI patients, **table (3).** Furthermore, old age (>60 years), high APACHE II score, sepsis, underlying CKD, stage 3 AKI, oliguria, late nephrology consultation, duration of AKI > 2 weeks, hypomagnesaemia, thrombocytopenia and need for RRT all increase the risk of non recovery of renal function, **(table 4)**. Moreover, old age (>60 years), high APACHE II score, sepsis, stage 3 AKI, oliguria, duration of AKI > 2weeks, late nephrology consultation, thrombocytopenia and need for RRT all increase the risk of death in AKI patients **(table 5)**.

Cox regression analysis was done to estimate the hazard ratio of all these factors on the overall outcome and showed that late nephrology consultation, stage 3 AKI, oliguria, advanced age (>60 years), thrombocytopenia, high APACHE II score and sepsis increase the hazard of the overall unfavorable outcome (ESRD and death) in the same descending order **(table 6)**.

Table 1: Demographic data and parameters of patients of the two groups of the study

variable	Group A (with AKI)	Group B (Non AKI)	t	P
Number (%)	84 (35.3%)	154 (64.7)		
Age(years): mean ±SD	56.57 (15)	59.29 (12.7)	-1.2	0.2
Gender: Male, n (%) Female, n (%)	 41 (48.8%) 43 (51.2%)	 84(54.5%) 70 (45.5%)	0.02	0.8
BMI: mean ±SD	28.48 (4.06)	27.9 (4.52)	2.8	0.68
Smoking, n (%)	27 (32.1%)	46 (29.8%)	0.11	0.72
HTN, n (%)	49 (58.3%)	68 (44%)	3.4	0.06
DM, n (%)	34 (40.5%)	16 (10.7%)	19.5	0.00
CKD, n (%)	22 (26.2%)	16 (10.7%)	6.6	0.01
APACHE II: mean ±SD	10.16 ±4.48	29.02 ± 4.11	- 28.4	0.000
Sepsis, n (%)	43 (51.2%)	22 (14.3%)	45.8	0.00
Hypomagnesaemia, n(%):	42 (50%)	68 (44%)	75.3	0.00
Platelet count, mean ±SD×10³ :	200.79 ± 98.5	253.2 ± 79.91	-3.7	0.000
Favorable outcome	61 (72.6%)	139 (90.5%)	13.4	0.001
Unfavorable outcome	23 (27.4%)	15 (9.5%)		

BMI: body mass index, CKD: chronic kidney disease, APACHE: Acute Physiology And Chronic Health Evaluation
HTN: hypertension, DM: diabetes mellitus,

Table 2: Demographic data and parameters of patients of the three subgroups of group A

variable	**Stage 1**	**stage 2**	**stage 3**	**P**
Number (%)	15 (17.8%)	31(37%)	38 (45.2)	
Age(years): mean ±SD	61.1 (12.1)	60.1(11.6)	51.8 (17.3)	0.031
Gender: Male, n (%) Female, n (%)	 8 (46.7%) 7 (53.3%)	 16 (51.6%) 15 (48.4%)	 17 (44.7%) 21 (55.3%)	0.8
BMI: mean ±SD	28.63±3.79	28.48±4.06	27.78±4.49	0.717
Smoking, n (%)	6 (40%)	11(35.5%)	10 (32.1%)	0.55
HTN, n (%)	10 (66.7%)	20 (64.5%)	19 (50%)	0.3
DM, n (%)	8 (53.3%)	14 (45.2%)	12 (31.6%)	0.2
CKD, n (%)	0(0.0%)	6 (19.4%)	16 (42.1%)	0.004
APACHE II: mean ±SD	7.26±3.32	8.7±3.23	12.5±4.65	0.000
Sepsis, n (%)	4 (26.7%)	18 (58.1%)	21 (55.3%)	0.1
Hypomagnesaemia, n (%):	5 (33%)	11 (35.5%)	26 (68.4%)	0.04
Platelet count, mean ±SD×10³	201.66±44.58	205.41±53.81	196.68±136.49	0.93
Basal S.Cr: mean±SD	1.05±0.27	1.25±0.56	1.92± 1.46	0.007
Initial rising S.Cr: mean ±SD	1.64±0.37	2.40±0.64	3.81±1.68	0.000
S.Cr at time of consultation mean ±SD:	2.21±0.48	3.48±1.15	5.68±2.32	0.000
Oliguria, n (%):	0 (0.0%)	2 (6.5%)	33 (86.8%)	0.000
Time of nephrology consultation Early <2days Late ≥2days	 15 (100%) 0 (0.0%)	 31 (100%) 0(0.0%)	 15(39.5%) 23(60.5%)	0.000
Duration of AKI (days): mean ±SD	7.06±2.82	7.06±3.18	21.21±17.63	0.000
RRT, n (%)	0(0.0%)	0(0.0%)	29(74.3%)	0.000
Favorable outcome , n (%) ESRD, n (%) Mortality, n (%)	15(100%) 0(0.0%) 0(0.0%)	31(100%) 0(0.0%) 0(0.0%)	15(39.5%) 12(31.5%) 11(29%)	0.00

BMI : body mass index, APACHE: Acute Physiology And Chronic Health Evaluation S.Cr: serum creatinine, RRT: renal replacement therapy, ESRD: end stage renal disease.

Table 3: Multivariate analysis of clinical and laboratory variables related to RRT in patients with AKI

Variables	OR	95% CI		P
		lower	upper	
Age >60 years	0.7836	0.317	1.932	0.5
APACHE score >15	4.55	1.732	11.9918	0.002
Diabetes mellitus	0.679	0.267	1.728	0.4
Hypertension	3.325	1.295	8.532	0.01
Chronic kidney disease	5.483	1.928	15.594	0.000
Stage 3 (AKIN criteria)	288.7	16.192	5149.9	0.000
Hypomagnesaemia	2.113	0.8422	5.304	0.11
Thrombocytopenia <100.000/ul	3.755	1.218	11.576	0.02
Duration of AKI >2 weeks	280.0	31.138	2517.7	0.000
Late nephrology consultation≥2days	24.22	6.778	86.57	0.000
Sepsis	0.836	0.3401	2.059	0.69
Oliguria	7.68	2.784	21.223	0.000

APACHE: Acute Physiology And Chronic Health Evaluation, AKIN: acute kidney injury network, AKI: acute kidney injury, OR: Odds Ratio

Table 4: Multivariate analysis of clinical and laboratory variables related to non-recovery of renal function in patients with AKI.

Variable	*OR*	*95% CI*		*P*
		lower	*upper*	
Age > 60 years	5.445	1.101	27.017	0.03
APACHE score>15	9.2105	1.12	75.69	0.03
Diabetes mellitus	1.269	0.352	4.529	0.71
Hypertension	0.837	0.233	2.996	0.78
Chronic kidney disease	11.238	2.638	47.87	0.001
Stage 3 (AKIN criteria)	38.89	2.204	686.23	0.01
Hypomagnesaemia	3.5	1.384	8.95	0.008
Thrombocytopenia<100.000/ul	2.904	0.734	11.495	0.02
Duration of AKI > 2 weeks	11.92	2.368	60.03	0.002
Sepsis	0.73	0.035	0.859	0.03
Late Nephrology consultation≥2days	10.31	2.435	43.663	0.005
Oliguria	19.200	2.323	158.64	0.006
Renal replacement therapy	11.925	2.368	60.031	0.002

APACHE: Acute Physiology And Chronic Health Evaluation,
AKIN:acute kidney injury network, AKI: acute kidney injury

Table 5: Multivariate analysis of clinical and laboratory variables related to death in patients with AKI.

Variable	*OR*	*95% CI*		*P*
		lower	*upper*	
Age > 60 years	3.0263	1.225	7.474	0.01
APACHE score>15	25	0.649	438.17	0.02
Diabetes mellitus	0.70	0.193	2.53	0.5
Hypertension	1.000	0.289	3.454	1
Chronic kidney disease	2.31	0.649	8.229	0.19
Stage 3 (AKIN criteria)	43.86	2.495	771.16	0.009
Hypomagnesaemia	1.233	0.34	4.40	0.74
Thrombocytopenia <100.000/ul	9.8	2.557	37.557	0.000
Duration of AKI >2 weeks	7.8	1.914	31.781	0.004
Late nephrology consultation≥2days	7.6	2.013	28.684	0.002
Sepsis	13.75	1.68	112.202	0.01
Oliguria	9.4	1.909	46.27	0.005
Renal replacement therapy	7.8	1.914	31.781	0.004

APACHE: Acute Physiology And Chronic Health Evaluation,
AKIN: acute kidney injury network, AKI: acute kidney injury

Table 6: Cox regression analysis with estimation of hazard ratio for risk factors associated with unfavorable outcome(ESRD and death) in patients with AKI.

Risk factor	Hazard ratio	95% CI		P
		Lower	upper	
Age> 60 years	3.2	2.14	38.131	0.03
BMI>30		0.415	4.824	0.58
Smoking		0.478	7.488	0.36
DM		0.327	4.353	0.789
HTN		0.784	37.38	0.087
CKD		0.046	1.824	0.187
APACHE sore II >15	2.6	0.297	1.539	0.02
Sepsis	2.1	1.313	15.059	0.01
Hypomagnesaemia		0.573	2.942	0.5
Platelet count <100.000/ul	2.8	0.77	1.784	0.01
Oliguria	3.6	0.011	2.079	0.03
Duration of AKI>2 weeks		0.292	1.539	0.35
Late nephrology consultation≥2days	5.3	0.077	2.725	0.002
Stage 3 according to AKIN	4.9	3.54	19.94	0.001

BMI: body mass index, DM: diabetes, HTN: hypertension, CKD: chronic kidney disease, APACHE:Acute Physiology And Chronic Health Evaluation, AKIN: acute kidney injury network, AKI: acute kidney injury

4. Discussion

AKI is characterized by a rapid fall in GFR, accompanied or not by nitrogen product retention, water and electrolyte disturbances. It is a complex pathology with multiple and varied etiologies and with no consensus definition. Currently, classifications are based on increased serum creatinine and urine output fall, such as *RIFLE* and *AKIN* are used **(14).** Several studies show the incidence of this syndrome has increased over the decades, being associated with a longer life expectancy and multiple co-morbidities in the population **(15).** AKI is less frequent in the community (0.4% to 0.9%) than in hospitalized patients (4.9% to 7.2%). In hospitals, AKI became an important complication when associated with other comorbidities **(12).** The identification of risk factors associated with AKI and its poor prognosis is required so that preventive and early
diagnosis measures can be taken, aiming to reduce patients' mortality**.**

In the present study, AKI was prevalent in critically ill patients (84/238, 35.3%). This prevalence is almost equal to that reported in UK and Germany by **Ostermann and Chang** (35.8%) **(15)** and to that reported in Australia/New Zeeland ICUs (36.1%) (**5**). while a lower incidence was reported by **Cruz et al** in Italy(10.8%) **(16)** . This difference may be related to different patient characteristics, number of co-morbid conditions and the criteria used to define and stratify AKI. In our study, we found that old age >60y is risk factor for occurrence of AKI, non-recovery of renal function and higher mortality rate among critically ill patients with AKI. Similarly, **Gong Y et al** found that 99/189 (52.38%) of AKI patients were elderly **(17)**. In addition, **Schmitt et al,** found that recovery from AKI was 28% lower in patients older than 65 years **(18) .** On the other hand, **Lameire et al** did not find any relation between older age and non-recovery from AKI **(19).** This contradiction can be related to

the difference in number and degree of comorbid conditions as DM, HTN, CKD and cardiovascular disease. Several other individual studies have not been able to show that age is specifically associated with impaired renal recovery **(18).**

Furthermore, we found that the risk of mortality was higher in elderly patients with AKI. Similar results were found by **Sesso et al**, they reported a mortality rate of 42% in elderly AKI patients compared to 24% in younger age groups **(20).** Similarly, **Kohli et al** reported a mortality rate of 61% in elderly patients with AKI in a tertiary care center in India **(21).** It is believed that the aging process impairs the renal epithelial cell proliferation as well as the function of progenitor and stem cells that are critical for tubular repair.

In our study we found that underlying CKD is risk factor for occurrence and non-recovery from AKI in critically ill patients. Similarly, **Hsu et al** found that the risk of ESRD and death 30 days after hospital discharge were increased by 30% in 39805 patients with underlying CKD (stage 3b or higher) after an episode of AKI **(22)** . Similar results were found on long term observations after hospital acquired AKI **(23).**
In addition, we found that preexisting HTN or DM is a risk factor for occurrence of AKI. These findings are not different than those reported by **Drawz et al(24)** . Moreover, **Liangos et al** reported increased mortality in diabetic and hypertensive patients when they develop AKI **(25).**

We found also that APACHE II score>15 is risk factor for the occurrence and non-recovery from AKI as well as increased risk of mortality among patients with AKI in the ICU**.** Similar results were found by **Guo-en et al** and **Ahlstrom et al.** They added also that high APACHE II score was an independent risk factor for death **(26,27) .**

We found that sepsis the most common cause of AKI in ICU and is a predictor of non-recovery and increased mortality among those patients. Similarly, the multicenter European Sepsis Occurrence in Acutely Ill Patients (SOAP) study found that 51% of septic patients with sequential organ failure score above 2 developed AKI **(28)**. In addition, **Neveu et al** found a near linear increase in mortality in AKI patients when they categorized as non-septic or associated with either sepsis syndrome or septic shock **(29).**

In this study we found that hypomagnesaemia is in a risk factor for non-recovery of renal function among critically ill patients with AKI. Similarly, **Sarah et al**, found that hypomagnesaemia is an independent risk factor for non-recovery of renal function among AKI patients in the ICU**(30)**. Also **Santos et al** , found that hypomagnesaemia is a risk factor for non-recovery of renal function in AIDS patients with AKI. Magnesium is well known to have vasodilator properties **(31).** In addition, it increases the red blood cell deformability, reduces platelet aggregation, and has anti-inflammatory effects that maintain endothelial integrity **(32).** Meanwhile, we did not find any differences in ICU mortality rates between hypomagnesaemic and normomagnesaemic patients with AKI**.** Similar results were found by **Chernow et al and Guerin et al (33,34)**. In contrast, **Rubeiz et al** reported nearly doubled mortality rates in hypomagnesaemic versus normomagnesaemic patients (46 versus 25%, respectively**)(35).** Similar results were also observed by **Safavi and Honarmand (36)**. This might be related to the greater frequency of other electrolyte abnormalities that accompany hypomagnesemia (especially hypokalemia) and cardiac arrhythmias, and to a strong association of hypomagnesaemia with sepsis and septic shock **(37).**

In our study we found that thrombocytopenia is risk factor for the need for RRT, non-recovery of renal function and higher mortality rate among patients with AKI in the ICU. It had been found that patients with thrombocytopenia had significant morbidity as evidenced by higher incidence of AKI and longer ICU stay, compared to the patients with higher platelet count **(38).** Indeed**,** patients with thrombocytopenia tend to be sicker and are more likely to develop major bleeding episodes and to receive more blood product transfusions with a higher incidence of acute lung injury or ARDS**(39)**.

We found also that patients presented with oliguria are at high risk for the need of RRT, non-recovery of renal function and mortality**.** Oliguria at initiation of RRT was found to be undisputedly associated with higher short and long-term mortality as well as non-recovery of renal function or development of end-stage renal disease **(40)**. The presence of oliguria represents a surrogate for more significant renal injury and occurs more often in critically ill patients with severe underlying disease**(41)**.

In our study we found that late nephrology consultation is another risk factor for the need for RRT, non-recovery of renal function after AKI and an independent risk factor of increased mortality among patients with AKI in the ICU. Similarly, **Perez-Valdivieso et al** reported that patients who had an increase in serum creatinine greater than 100% at the time of nephrology consultation is a portent of increased mortality and worse renal function at hospital discharge **(42)**. Also, **Ponce et al** have found that nephrology consultation was delayed (≥48 hours) in 62.3%, which was associated with increased ICU mortality (88.2% *versus* 65.4%, $P< 0.001$) **(43).** Studies have demonstrated that nephrologists are more skilled at recognizing and managing these complications according to evidence-based guidelines at an earlier stage as compared with general practitioners **(44)**.

In our study we found that AKI duration of more than 2 weeks is an additional risk factor for the need for RRT, non-recovery of renal function and higher mortality among patients with AKI in the ICU. Similar results were found by **Seung Seok et al (45).** The more severe and treatment-resistant an AKI case is (e.g., non-recovery case), the longer the duration of AKI become**.** In contrast, **Coca et al** assessed a large cohort of patients with DM undergoing cardiac surgery in the Veterans Administration system. Both severity and duration of AKI were linked to long-term mortality. However, the duration of AKI was not linked to CKD progression **(23).**

Lastly, we found that patients with stage 3 AKI according to AKIN criteria are at increased risk of non-recovery of renal function and mortality**.** Similarly, **Mandelbaum et al** found

that in-hospital mortality rates were: 13.9%, 16.4%, 33.8% for AKI of stages 1, 2 and 3, respectively **(46)**. Also, **Ostermann and Chang** found that AKI III was an independent risk factor for ICU mortality **(15)**.

5. Conclusion

AKI is very prevalent in the ICU setting with sepsis being the most common cause. Late nephrology consultation and stage 3 AKI are the most important independent risk factors for unfavorable outcome in those patients. Early nephrology consultation is mandatory to improve the outcome.

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