Risk factors of acute kidney injury and dialysis among patients attending intensive care units in China

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Abstract: Acute Kidney Injury (AKI) in intensive care unit (ICU) is highly morbid and fatal conditions and patients who received dialysis portend even worse outcomes. Current prospective observational study was aimed to evaluate the risk factors associated with AKI and dialysis among patients attending ICU during predefined period of six months. Predisposing factors were evaluated by using logistic regression. Out of total 1544 patients, 748 (48.4%) had AKI while 244 (16%) patients received renal replacement therapy (RRT). Among patients receiving dialysis, 231 were having AKI. Old age, diabetes mellitus, mechanical ventilation, use of vasopressors, sepsis, SOFA score >9 and high APACHE-II score were significant risk factors of AKI in current study. AKI patients with old age, female gender, mechanical ventilation, use of vasopressors, sepsis, score >9 and high APACHE-II were found to be at high risk of receiving dialysis in study cohort. ROC curve analysis demonstrated excellent prediction accuracy of regression model for AKI (AUC: 0.845, P<0.001) and dialysis (AUC: 0.785, P<0.001). Moreover, AKI and dialysis use was associated with higher mortality and prolonged hospital stay present study. Overall mortality in current study was 30.1% while mortality among AKI patients receiving RRT was 42.5%. A substantial number of patients attending ICU had AKI. Dialysis was initiated among significant proportion of study participants and most of them had AKI. High risks patients should be managed aggressively in the first instance. Early identification may cause a dramatic decrease in mortality and morbidity could be expected in these high-risk patients.

Keywords: Acute kidney injury, renal failure, intensive care units, renal replacement therapy, dialysis, mortality

Introduction

Acute kidney injury (AKI) encompasses a wide spectrum of injury to the kidneys, not just kidney failure. The definition of AKI has changed in recent years, and detection is now mostly based on monitoring serum creatinine levels, with or without urine output. AKI is increasingly being seen in primary care in people without any acute illness, and awareness of the condition needs to be raised among primary care health professionals [1]. In critical care settings, patients with AKI constitute an important subgroup and subjected to higher short and long-term mortality, prolonged hospital stay, and more resource consumption [2]. Incidence of AKI in intensive care unit (ICU) varies from 20% to 70% according to hospital settings, and, among these, patients who undergo renal replacement therapy (RRT) portend even worse outcome [3]. The in hospital mortality rate among AKI patients receiving RRT ranges 50-70%, depending on AKI etiologies. On the other hand 25-50% patients with develop chronic kidney disease (CKD) after AKI episodes without complete recovery of renal function [2-4]. Consequently, better understanding of the precipitating factors of AKI in these critically ill patients is of paramount importance for clinicians to reduce the incidence of AKI in ICUs.

About 70% critically ill patients with AKI require renal replacement therapy (RRT). There is some evidence that early high flux renal replacement therapy (RRT) may improve clinical outcomes in critically ill patients [5], however there is still lack of consensus on definition of AKI and on timing of acute RRT initiation [6, 7]. Usually AKI patients in ICU are often managed conservatively with intravenous fluids, mechanical ventilation, inotropes and diuretics because of limited health resources and complications related to RRT. In such cases, RRT is only initiated when major complications of acidosis, fluid overload, hyperkalemia or uremia develop. Although RRT causes a considerable escalation in the com-
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Complexity of treatment and associated with inherent risks for adverse effects and increases cost of care for those with severe AKI but still a key component of modern critical care [8]. Early prediction of the requirement for RRT will useful to intensivists in managing critically ill patients. Additionally, data regarding risk factors of dialysis are sparse. In this context, current study was conducted to evaluate factors associated with AKI and dialysis among patients attending ICU.

Methods

Ethical approval

Current study was approved by institutional research review committee (Reference: SXT. GICU/134532/2016). Board specifically approved the informed consent waiver due to the anonymous, observational and non-interventional nature of the study.

Study location and participants

This prospective monocentric observational study was performed among patients attending intensive care unit (ICU) of Shanghai 9th People’s Hospital, Shanghai, China. A total 5772 patients were admitted to ICU during the period of six months (January 2015 to December 2015). Patients with chronic renal insufficiencies (CRI), severe hypovolemia, missing demographic and laboratory data or having stay less than 48 hours or on renal replacement therapy were excluded preliminary stage of the study. A total 1544 patients were included in final analysis and were followed up until discharge or death, whichever occurred first. Study process flow diagram with inclusion and exclusion criteria is shown in Figure 1.

Data collection

The data collected for each participant included demographics, co-morbidities, ICU diagnosis, surgical and non-surgical procedures, clinical and laboratory parameters, discharge outcomes and modalities of RRT. Patients with missing data required for the purpose of analysis were excluded from the study. Demographics included age, gender and other baseline standard characteristics. Clinical data included patient’s sign and symptoms on hospital ad-

![Figure 1. Study Flow with patient’s Exclusion and Inclusion criteria (classification of patients based upon AKI and dialysis treatment).]
mission, co-morbidities and need of mechanical ventilation. Laboratory data included complete blood count (CBC), arterial blood gases (ABGs), renal function tests (RFTs) and liver function tests (LFTs). Kidney functions were assessed by serum creatinine (SCr), urine output and urea while severity of illness was assessed using Sequential Organ Failure Assessment (SOFA), APACHE-II and GSC scores. Demographics and clinical data were recorded on the day of admission while laboratory data were recorded for each day of hospitalization until discharge or death, whichever occurred first. All the data was collected by trained researchers by using electronic case report form (CRF). All the completed CRFs were sent to the principle investigator on daily basis via email to check the integrity of data collection. All the collected data were screened for missing values, incomplete details or any further queries before inclusion into statistical analysis. Patients with missing data required for analysis were excluded from the study (Figure 1).

**AKI diagnostic criterion**

Acute Kidney Injury Network (AKIN) criterion [9] was used to stratify AKI among studied participants (Table 1). Baseline SCr was estimated with Modification of Diet in Renal Disease (MDRD) equation by assuming glomerular filtration rate as 75 ml/min/1.73 m² for patients without baseline SCr and having no history of chronic renal insufficiency (CRI). All the patients were stratified into AKI on the basis of SCr and urine output (UO), whichever led to worst classification of AKI. In case of progressive AKI, the severe stage of AKI during ICU stay was considered in final analysis. For patients having recovery of AKI during ICU stay, the worst stage of AKI was recorded as final stage. Baseline SCr values were calculated in approximately 45% of studied population.

**Terminologies**

The primary diagnosis of patients was subjected to cause of ICU admission, recorded by treating clinician on ICU admission. Definitions of primary diagnosis used in current study are described in Table 2 [10].

**Statistical analysis**

The statistical package SPSS (version 20.0) was used for all statistical analyses. Continuous variables were expressed as mean ± standard deviation (SD) or as median with inter quartile range (IQR), while as categorical variables were expressed frequency along with

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**Table 1. Acute Kidney Injury Network (AKIN) criterion for AKI classification**

<table>
<thead>
<tr>
<th>AKI severity staging</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>AKIN-I</td>
<td>Increase in serum creatinine ≥26.2 μmol/L or increase to ≥150-199% (1.5- to 1.9-fold) from baseline OR urine output &lt;0.5 mL/kg/h for ≥6 h</td>
</tr>
<tr>
<td>AKIN-II</td>
<td>Increase in serum creatinine to 200-299% (&gt;2-2.9 fold) from baseline OR urine output &lt;0.5 mL/kg/h for ≥12 h</td>
</tr>
<tr>
<td>AKIN-III</td>
<td>Increase in serum creatinine to ≥300% (≥3-fold) from baseline or serum creatinine ≥354 μmol/L with an acute rise of at least 44 μmol/L or initiation of RRT or urine output &lt;0.3 mL/kg/h ≥24 h or anuria ≥12 h</td>
</tr>
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</table>

**Table 2. Primary diagnosis of patients recorded by treating clinician on ICU admission**

<table>
<thead>
<tr>
<th>Primary diagnosis</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septic and septic shock</td>
<td>If sepsis related diagnosis was present</td>
</tr>
<tr>
<td>Sepsis</td>
<td>Due to infections, pneumonia and gastrointestinal disease or unknown cause of sepsis</td>
</tr>
<tr>
<td>Cardiac diagnosis</td>
<td>Cardiogenic shock (systolic blood pressure &lt;90 mmHg; absence of hypervolemia and clinical signs of poor tissue perfusion i.e. oliguria, cyanosis, cool extremities, altered mentation) Cardiac arrest or acute myocardial infarction (rise in troponin and either ischemic chest pain, new ST-T wave changes or pathological Q waves on ECG)</td>
</tr>
<tr>
<td>Respiratory diagnosis</td>
<td>Aspiration syndrome, exacerbation of chronic obstructive pulmonary disease (COPD) or asthma, pulmonary embolism, non-cardiogenic pulmonary edema, primary respiratory arrest and aspiration syndrome</td>
</tr>
<tr>
<td>Gastrointestinal hemorrhage</td>
<td>Bleeding due to peptic ulcer, varices and diverticulosis</td>
</tr>
<tr>
<td>Neurological diagnosis</td>
<td>Epidural hematoma, stroke, intra-cerebral hemorrhage, subarachnoid hemorrhage and other neurological causes for coma</td>
</tr>
<tr>
<td>Metabolic or poisoning causes</td>
<td>Non-operative causes of metabolic coma, diabetic ketoacidosis, drug overdose and other endocrinopathies</td>
</tr>
</tbody>
</table>
proportion (percentage). For the purpose of comparison all the patients were grouped into AKI/non-AKI and dialysis dependent/dialysis independent. Groups were compared by stu-
dent t test, Kolmogorov-Smirnov test, Chi-Square test or Mann-Whitney U test, where appropriate. Logistic regression analysis was applied to determine independent risk factors of AKI and dialysis. In univariate analysis, the variables having $P$ values <0.25 were considered as candidates multivariate regression analysis [11, 12]. Variables with $p$ values <0.05 were considered final predictors of AKI and dialysis in current study. All the variables were deemed to be significant if $p$ values were less than 0.05.

Results

A total 4228 out of 5772 patients were excluded due to the various reasons (2129 patients staying less than 48 hours in ICU, 697 patients with age less than 18 years, 78 patients with hypovolemia, 320 patients with CKD, 121 patients having dialysis before getting admit to ICU, 4 patients with renal transplant and 879 patients with missing data required for analysis) (Figure 1). After applying exclusion criteria, 1544 patients (mean age: 48.2 ± 9.6 years) were included into the final analysis. Most of the patients had sepsis (40.2%) as primary diagnosis on ICU admission followed by cardiovascular (23.8%), gastrointestinal (22.3%) and respiratory (20.9%) reasons of ICU admission (Table 3).

The incidence of AKI in current study was 48.4% (n=748/1544). Based upon AKIN criterion, most of the patients had AKIN-III (382/748, 18.9%) followed by AKIN-II (225/748, 30.1%) and AKIN-I (141/748, 51.1%). Out of total patients with AKI, 42 patients developed AKI by AKIN criterion on elevation of SCr within 48 hours and these patients were belonged to AKIN-I stage. Among AKI patients, about 90 had AKI on ICU admission while remaining 10% developed AKI during their stay in ICU. Approximately, 18% with AKIN-II on ICU admission were progressed to AKIN-III during ICU stay and only 3% (n=22) patients with AKIN-I progressed to AKIN-II (n=16) and AKIN-III (n=6). Patients with AKIN-II had higher risks (Odds ratio: 3.9, $P<0.001$) of disease progression in while patients with AKIN-I had 1.5 ($P=0.025$) times more odds of developing AKIN-I and AKIN-II in current study. In order to evaluate factors significantly associated with AKI, a comparison between patients with and without AKI was performed (Table 3).

Patients having AKI were older ($P<0.001$) than those who did not develop AKI, while gender was equally distributed among patients with and without AKI ($P=0.221$). Likewise, patients with AKI had higher proportion of comorbidities and among them hypertension, diabetes mellitus (DM), coronary heart disease (CHD), congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD) was significantly associated with AKI. Most of the patients in current study were diagnosed with sepsis (40.2%) on ICU admission and AKI was found to be significantly associated with sepsis. Moreover, gastrointestinal and malignancies diagnosis on ICU admission were prominent among patients with AKI. Patients with higher SOFA, APACHE-II and GSC scores were also associated with AKI in our study cohort.

Mean duration of ICU stay was 13 days and patients with AKI had significantly prolonged ICU stay as compared to non-AKI ($P<0.001$). Similarly, mortality rate in AKI group was more than twice as compared to non-AKI group ($P<0.001$). Patients with AKI had worse clinical presentations and poor prognoses during ICU stay compared to the patients without AKI. We found abnormal recordings of renal functions tests, hepatic function tests, complete blood count, arterial blood gases and urinalysis were significantly higher in AKI patients than non-AKI. Similarly, prevalence of multiple organ

### Table 4. Predisposing factors of AKI according to multivariate logistic regression

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
<th>$P$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old age*</td>
<td>0.989</td>
<td>2.5</td>
<td>1.6-4.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.672</td>
<td>2.7</td>
<td>1.2-6.3</td>
<td>0.023</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>0.433</td>
<td>1.6</td>
<td>0.6-4.7</td>
<td>0.031</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>1.321</td>
<td>3.2</td>
<td>2.1-8.4</td>
<td>0.047</td>
</tr>
<tr>
<td>Inotropes</td>
<td>0.532</td>
<td>2.2</td>
<td>0.9-3.9</td>
<td>0.071</td>
</tr>
<tr>
<td>Malignancies</td>
<td>0.401</td>
<td>1.9</td>
<td>1.1-6.5</td>
<td>0.062</td>
</tr>
<tr>
<td>Sepsis</td>
<td>2.561</td>
<td>7.2</td>
<td>5.7-11.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>SOFA score &gt;9</td>
<td>0.882</td>
<td>4.4</td>
<td>2.9-7.3</td>
<td>0.040</td>
</tr>
<tr>
<td>High APACHE II score</td>
<td>1.041</td>
<td>3.0</td>
<td>1.4-4.8</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Hypertension, coronary heart disease, CHF, COPD, cardiac arrhythmia, use of vasodilators and aminoglycosides, gastrointestinal reasons of ICU admission, multiple Organ dysfunctions (MODs) and high GSC on baseline had $P>0.25$, hence excluded from multivariate analysis. *Age greater than 60 years.
dysfunctions (dysfunctions of more than 2 organs) was also significantly higher among AKI patients ($P=0.033$).

The variables that were statistically significant and clinically relevant were subjected to logistic regression. Univariate analysis was performed on 19 variables and among them 9 variables with $p$ values less than 0.25 were included in multivariate analysis. Out of these nine variables, 7 were found to be independent predictors of AKI in present study (Table 4).

Multivariate logistic regression analysis showed that patients with old age, diabetes mellitus, mechanical ventilation, use of vasopressors, sepsis, high SOFA and APACHE II scores on ICU admission had more likelihood of development of AKI in our study. Use of inotropes and malignancies were significantly associated with AKI in unadjusted analysis but failed to demonstrate any association in multivariate adjusted analysis. We also performed sub group analysis of these variables to determine risk factors of severe AKI (AKIN-III) in our study. Multivariate analysis showed presence showed that presence of old age [OR (95% CI): 2.2 (1.3-4.5), $P=0.001$], mechanical ventilation [OR (95% CI): 3.1 (2.3-7.3), $P<0.001$], sepsis [OR (95% CI): 4.2 (1.8-6.3), $P<0.001$] and multiple organ dysfunctions [OR (95% CI): 2.4 (1.4-5.5), $P=0.002$] was associated with AKIN-III. ROC curve analysis demonstrated excellent prediction (area-under-curve: 0.915, 95% CI: 0.901-0.981, $P<0.001$) accuracy of regression model for AKI (Figure 2).

Approximately 16% patients (n=244) received RRT in current study and among them 231 were belonged to AKI. Most of the patients (217/244) received continuous renal replacement therapy (CRRT) while intermittent hemodialysis (IHD) was used in 27/244 patients. Only 13 patients without AKI received RRT due to various reasons including hypervolemia, acidosis, hyperkalemia and symptomatic uremia. Approximately 95% patients with AKI received dialysis, so the comparison between patients with and without dialysis was not performed because it would be same comparison as we did in Table 3. Therefore, we compared only AKI patients with and without dialysis in Table 5.

Most of the patients receiving dialysis (225/231) were belonged to AKIN-III stage, while dialysis was initiated in 6 patients with AKIN-II due to accompanied complications. AKI patients who received dialysis were older and have higher preponderance of female gender than non-dialysis dependent AKI. Diabetes mellitus, CHF and COPD were more common among AKI patients receiving dialysis. AKI patients who had sepsis as primary diagnosis on ICU admission were associated with dialysis treatment ($P<0.001$). Similarly, patients receiving dialysis were more severe as indicated by high SOFA, APACHE II and GSC scores as compared to AKI patients without dialysis. Dialysis led to longer ICU stays and higher mortality among AKI patients ($P<0.001$) (Table 5).
A total twelve variables were analyzed in univariate analysis, among them 9 variables with $P<0.25$ were subjected to adjusted analysis. Final logistic regression model showed 7 significant variables associated with dialysis among AKI patients (Table 6). Among these, presence of sepsis, mechanical ventilation, high SOFA and APACHE scores were significant predictors of dialysis among AKI patients. Though diabetes mellitus (OR 2) and MODs (OR 1.6) showed association with dialysis in univariate analysis but failed to demonstrate such association in multivariate adjusted analysis. ROC curve analysis demonstrated excellent prediction (area-under-curve: 0.847, 95% CI: 0.793-0.900, $P<0.001$) accuracy of regression model for AKI (Figure 3).

The overall mortality in current study was 30.1% (465/1544). Patients with AKI were significantly associated with mortality in our study (Table 3). Similarly, AKI patients with dialysis had higher mortality rate as compared to AKI patients without dialysis (Table 5). We did not perform logistic analysis to evaluate predictors of mortality because it was beyond the study scope. However, in a separate series, we are assessing several factors associated with ICU related mortality and results will be shared once completed.

Discussion

We conducted single center study with ICU patients to characterize AKI, stratified by AKIN
classification and evaluate various factors associated with the development of AKI and dialysis. In the present study, 48.4% patients developed AKI, which was associated with prolonged ICU stay and increased mortality, compared with those who did not develop AKI. The prevalence of AKI varies according to methodology and location of the studies. Additionally, AKI diagnostic criteria, availability of baseline SCr values and heterogeneous population of studies are some other factors related to variability of AKI incidence and characteristics across studies [13]. Various studies reported AKI among 41.3% [14] and 53.2% [15] patients attending ICU by using RIFLE (Risk, Injury, Failure, Loss of Function, End stage) criterion. Lou et al. compared three diagnostic criteria of AKI and found highest incidence (51%) by using KDIGO (Kidney disease improving global outcomes) criterion, followed by 46.9% by RIFLE and 38.4% by AKIN criteria [16]. Despite availability of vast literature, true incidence of AKI in ICU is still unknown that warrants need of randomized controlled trials. However, current study demonstrated high incidence of AKI in patients seeking medical care in ICU. Such high proportion of patients is not only related to increased morbidity or mortality but also to increased hospital expenditure and burden on health care system [17].

A recent increase in reported incidence of AKI can be observed and it might be contributed to availability of aggressive diagnostic criteria, efforts made to estimate baseline SCr and therapeutic interventions [18]. We used AKIN criterion in current study because it also identified patients with an abrupt increase in SCr (26.4 umol/L) during hospital stay and identified patients with slight increase in creatinine levels [19, 20]. On the
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other hand, RILFE criterion does not classify such small increase in SCr and may lead to under-estimation of AKI cases [21].

It has been documented that transient increase in serum creatinine is associated with increased mortality and poor outcomes [21, 22]. Therefore, early identification of AKI cases will be of paramount importance to reduce morbidity and mortality. We found that patients with AKI were severely ill as demonstrated by high SOFA, APACHE-II and GCS scores on ICU admission (Table 3) and had higher mortality rate (42.5%) and prolonged ICU stay (17 ± 3 days). Early identification of these patients will not only reduce morbidity and mortality but also economic burden on health care system. Logistic regression analysis showed that patients with old age (≥60 years), diabetes mellitus, mechanical ventilation, vasopressors use, sepsis and high SOFA and APACHE-II scores on ICU admission were significantly associated with AKI (Table 4). Old age is well defined risk factor of occurrence of AKI and related to compromised kidney function due to aging induced physiological and pharmacokinetic changes. Moreover, elderly patients have comorbid conditions for which they are using medications including nephrotoxic drugs and it make them more susceptible of AKI [1]. The need of mechanical ventilation and vasopressors is associated with severity of illness as denoted by high SOFA and APACHE-II scores. Such patients also had multiple organ dysfunctions in our study and it might be reasons that these patients had higher odds of AKI in present study [23]. The predisposing factors in current study are consistent with various other similar studies evaluating predictors of AKI in ICU [23, 24].

Sepsis as primary diagnosis on ICU admission was present in most of the studied participants (40.2%) followed by cardiovascular, gastrointestinal and respiratory diagnoses. Gastrointestinal, malignancies and sepsis as primary diagnosis on ICU admission were associated with the development of AKI (Table 4). However, only sepsis was found to be a strongest risk factor of AKI where patients with sepsis diagnosis had 7.2 times more risk of AKI while malignancies and gastrointestinal diagnosis failed to demonstrate any risk prediction in logistic regression (Table 3). The findings are consistent with the results reported by Wijewickrama et al. [9]. AKI in ICU is multifactorial and true etiology is still needed to be evaluated [14, 15, 25]. Primary diagnosis on ICU admission may vary from clinicians to clinicians; therefore we suggest studies with well-defined diagnostic criteria in order to determine the exact cause of AKI.

Patients with AKI in ICU are usually managed with conservative treatments or RRT. Conservative treatment includes management of volume, electrolyte and acid-base homeostasis and specific drug management. Renal replacement therapy (RRT) is indicated for management of specific problems such as volume overload, hyperkalemia, acidosis and symptoms of uremia [26]. Because of limited health resources and complications associated with RRT, many critically ill patients with AKI are often managed conservatively with mechanical ventilation, inotropes, diuretics and intravenous fluids; RRT is usually initiated when major complications of fluid overload, acidosis, uraemia or hyperkalaemia develop. Early prediction of the requirement for acute RRT will be useful in ICU where physicians have excessive workload. Therefore, we determine several risk factors of dialysis treatment in current study. In present study, most of the patients who received RRT had AKI and only 13 patients without AKI required RRT during ICU stay. However, we excluded these 13 patients from analysis and comparison was performed among AKI patients with and without dialysis (Table 5). If we compare patients receiving dialysis therapy (n=244) with those without dialysis (n=1300), then it would be more or less same comparison as we performed in Table 3 (AKI versus non-AKI). In this context, current study determined risk factors of dialysis treatment among AKI patients.

AKI patient with old age were found to be significantly associated with dialysis treatment where the risk of dialysis initiation was 2.3 times as compared to their younger counterparts (Table 6). Similar findings were reported by Elsevier and co-workers that AKI patients requiring RRT were significantly older than those who did not need RRT in ICU [26, 27]. We also identified that female patients were associated with a higher risk of dialysis requiring AKI and similar findings have been reported by Doddakula et al. [27]. Other risk factors of dialysis initiation were mechanical...
ventilation, vasopressors and high disease severity scores (Table 6). The severity of disease, as evaluated by recognized prognostic scales in ICU, considerably affects the risk of dialysis treatment [28]. The results of current study also showed increased risk of dialysis with high SOFA (OR: 3.9) and APACHE-II (OR: 2.6) scores. These results are also in concordance with the findings of Czempik et al. where odds of dialysis increased 1.12 times with each 5 score increase [29]. Need of mechanical ventilation and vasopressors denote seriously ill patients as evidenced by the high GSC, APACHE-II and SOFA scores and these patients had 2.1 to 3.8 times higher risks of dialysis in present study. These findings are consistent with other studies conducted in ICU [27]. It is worthwhile to mention that ventilation duration is correlated with development of AKI as well as with dialysis initiation. Doddakula et al., found that ventilator duration and pulmonary complications are significantly associated with RRT risk [27]. Impact of nor-adrenalin, furosemide, antibiotic, activated protein C and intubation on development of AKI and dialysis initiation has also been evaluated by various studies [29, 30]. Unfortunately, these variables were not assessed in current study. We suggest the evaluation of different treatment modalities for their association with the development of AKI and dialysis initiation.

Presence of congestive heart failure and COPD was associated with dialysis in present study. However, these variables failed to predict dialysis treatment among AKI patients in logistic regression. These results are in agreement with other findings evaluating different factors of RRT need among AKI patients [27]. Diabetes mellitus were found to be significantly associated with dialysis need in unadjusted analysis but failed to demonstrate such association in adjusted model (Table 6). Faulke et al. have also reported association of diabetes mellitus with RRT but the results of their logistic regression were in accordance with our findings (OR: 18.3, P=0.08) [30].

AKI patients who received RRT were found to be associated with higher mortality rate and prolonged hospital stay in our study. These findings suggest that dialysis initiation is associated with not only dialysis-related complications but also with higher costs to the patients as well as to the health care system. Therefore, decision to start RRT should be considered with great care by taking into account the patient’s conditions. However, there is still controversy regarding timing of dialysis initiation that needs further studies to make final conclusion in clinical practice. Karvellas and colleagues in a meta-analysis suggested that earlier institution of RRT in critically ill patients with AKI may have a beneficial impact on survival [31]. However, their conclusion is based on heterogeneous studies of variability quality, recommending dire need of suitably designed studies to draw definitive treatment recommendation.

Overall mortality in present study was 30.1%. Presence of AKI and need of dialysis were found to be significantly associated with mortality and these findings are consistent with other studies [14, 15]. Out of 465 fatal cases, 318 (68.4%) patients had AKI and among them 278 patients had AKIN-II, 38 had AKIN-II and 2 had AKIN-I. A total 138 out of 465 patients were on dialysis therapy [32]. These findings suggest strong association of AKI and dialysis need with mortality. We did not perform analysis on death cases due to the scope of study but we strongly suggest early identification of predictors of death will be of great value in reducing mortality in ICU. However, we are currently working on a series evaluating predisposing factors of mortality among ICU patients.

There are some potential limitations accompanied by the study. Being an observational study, it is prone to biases. We used two independent investigators to collect data from both electronic and clinical records to reduce selection and detection biases. However, we cannot exclude significant performance bias in this study. Initiation of dialysis treatment is usually at discretion of attending physician, so the result of current study might be biased toward clinician’s decision of RRT initiation. Hence, there is no definite criterion to start RRT and it only depends on patient's entire condition. On the other hand, in our institution, nephrologists follow KDIGO guidelines to manage AKI patients taking into account of good clinical practices (KDIGO). We used the simplified MDRD formula to estimate baseline serum creatinine for patients without values. This can lead to under or over estimation of AKI cases and may affect true incidence of AKI in our study. We did not evaluate impact of several treatment modalities in current study.
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Additionally, our study lacks post-discharge follow-up of patients. However, current study is strengthening by population size and extensive analysis of possible variables to predict AKI and dialysis.

In conclusion, half of the patients attending ICU in current study had AKI defined by AKIN criterion. Severely ill elderly patients with diabetes mellitus diagnosed with sepsis on ICU admission and receiving mechanical ventilation and vasopressors at baseline were at high risk of AKI development. Dialysis was initiated among substantial proportion of study participants and most of them had AKI. Old age, female gender, need of mechanical ventilation and vasopressors, sepsis as primary diagnosis on ICU admission and high disease severity scores were independent predisposing factors of dialysis treatment. Both AKI and dialysis therapy were associated with high mortality rate and prolonged ICU stay. High risk patients should be managed aggressively in the first instance. Early identification may cause a dramatic decrease in mortality and morbidity could be expected in these high-risk patients.

Disclosure of conflict of interest

None.

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