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Original Article

Acute Kidney Injury in Pediatric Intensive Care Unit: Incidence, Risk Factors, and Outcome

Awatef Elbeunishi, Fadila Algadban*, Widad Al Alajilani

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Department of Pediatric, Faculty of Medicine, University of Tripoli, Libya
**** Correspondence***: *maigetso@gmail.com*

Abstract

Acute kidney injury is a common complication in critically ill patients and it is commonly associated with high mortality and morbidity with adverse short and long-term outcomes. The main objective of this study was to determine the incidence of acute kidney injury in Intensive Care Unit (ICU) patients in Al Khadra Teaching Hospital, also to assess the risk factors associated with the development of Acute Kidney Injury (AKI) in a critically ill patient. A retrospective medical record review was performed using the medical records for all patients who were admitted to the ICU at Al- Khadra Hospital, between 1 June 2021 to 31 January 2022. Datasheet was used to extract the clinical data and investigation from the hospital records. About 147 patients were included. Their baseline demographic, clinical, biological, and operative characteristics were analyzed. AKIs developed in 43 (29.25%) patients, with 16 patients in stage 1 (37.2%), 14 patients with stage II (32.6%), and 13 patients with stage III (30.2%), older age (6- 15 years were more prone to develop AKI) (P0.039), Most common etiologies were Infections, including pneumonia, sepsis, acute gastroenteritis with hypovolemic shock, and UTI accounted for the majority of all infections. While Pneumonia constituted one-third of all infections associated with AKI and was associated with high mortality 54.7%. Major PICU related risk factors were use of vasoactive drugs, nephrotoxic drugs, the need for mechanical ventilation (P≤0.05). Length of hospital and PICU stay was significantly longer than non-AKI patients (P ≤0.05). Total renal function recovery occurred in 56.3% of cases, partial recovery in 28.1%, and 18.6% of cases did not recover, the mortality in AKI (18.6%) was higher (p=0.002) in comparison to non- AKI (4.8%) with a relative risk (RR-3.9) higher in AKI patient. Development of AKI in ICU is an important risk factor for poor outcomes in critically setting. Prevention is the best method for avoiding AKI, with the early identification and recognition of high-risk patients, KDIGO is a better diagnostic criterion for early detection of AKI and reduction of their morbidity and mortality.

Key words: *Acute Kidney Injury; Children; Pediatric Intensive Care; Risk Factors*.

Introduction

Acute Kidney Injury (AKI) is one of several conditions that affect the kidney structure and function. It encompasses a broad clinical syndrome including different etiologies, such as specific kidney diseases (e.g., acute interstitial nephritis, acute glomerular and vasculitis renal diseases), non-specific conditions (e.g. ischemia, toxic injury), as well as extrarenal pathology (e.g., prerenal azotemia, and acute postrenal obstructive nephropathy)". It is a very common condition affecting about 5% of non-critically ill and 27% of critically ill children Acute kidney injury is a common complication in critically ill patients and it is commonly associated with high mortality and morbidity with adverse short and long- term outcomes [1-3].

Although acute kidney injury is preventable and treatable, in most cases it carries a high mortality rate in a critical care setting, especially in developing countries, therefore, the early recognition of AKI patients and dealing with the risk factors associated with the development of acute kidney injury will help in providing and establishing preventive measure that could improve survival in those patients, and decrease the long term morbidity, and developing steps and guidelines help in prevention, diagnosis, and treatment of AKI [4].

The exact incidence of pediatric AKI is not known; the overall incidence of AKI is thought to be increasing and depends on the clinical setting and the patient's clinical condition. About 27% percent of the critically Ill children at the PICU developed AKI with 10% of them developing severe AKI (AKI stage 2 and stage 3), and 1% requiring renal replacement therapy. 12% of severe AKI develops within 7 days after ICU admission [2].

Multiorgan dysfunction, need for mechanical ventilation, documented infection, extracorporeal membrane oxygenation, and nephrotoxic medication exposure are identified as risk factors for developing AKI in critically ill children, while nephrotoxic medication exposure has the greatest independent risk [5,6].

Development of AKI is associated with higher mortality, PICU length of stay, and duration of mechanical ventilation [7,8]. Severe AKI (stage II or III) has the highest association with mortality. Patients with resolved AKI or those who have an improvement in their severity of AKI stage tend to have lower mortality; however, patients with any degree of AKI, even mild, despite the complete resolution, still have higher rates of mortality than patients who do not develop AKI at all in the ICU setting [9]. Outside of the PICU, 25% of the non-critically ill children who are exposed to three or more nephrotoxic medications developed AKI [10,11].

AKI rates of 30% have been reported in infants; whereas, 48% of extremely preterm infants (less than 28 weeks of gestation) develop AKI [12]. The incidence increases to 40-65% in the infants undergoing cardiac surgery depending on the definition used, the rate increasing with lower age at surgery, longer cardiopulmonary bypass, type of repair, and lower gestational age [13,14]. The main objective of this study was to determine the frequency of acute kidney injury in the pediatric ICU at AL Khadar teaching hospital. We also aimed to assess the risk factors and outcomes associated with the development of AKI in critically ill patients.

Methods

Study design and setting

A retrospective cross-sectional analysis was performed in the pediatric ICU of an Alkhadra Teaching Hospital located in Tripoli, Libya. All pediatric patients aged one month or older, admitted to the ICU department for more than 24 hours.

Inclusion and exclusion criteria

Pediatric patients aged one month or older, admitted to the ICU department for more than 24 hours were included. Patients with multiple admissions to the ICU, the admission with the longest stay was considered for the analysis, those patients that complete 28 days in ICU and passed the neonatal period, were also included in the study.

We had excluded neonates (aged less than 28 days) and children with a history of, or evidence of, chronic kidney disease, those patients who stayed in ICU less than 24 hours, and patients with no paper records.

Data collection

The data of patients admitted to the ICU between 1 June 2021 and 31 January 2022 was collected, and retrieved between June and September 2022 from the patient's paper records. A checklist, and datasheet were used to collect data from files and medical records and extract the information of interest. All data were collected at the time of ICU admission and included the patients' baseline characteristics (age, sex, and race), comorbidities (hypertension, diabetes, cardiovascular disease, cancer, and other comorbidities), in-hospital admission motive (surgical or clinical), the reason for admission to PICU, ICU-admission conditions (need for mechanical ventilation, nosocomial infection, sepsis, shock or polytrauma), for the UOP.

We calculated urine output (UOP) in children with available UOP data, and length of stay (in the hospital and the ICU). Data about the hemodynamic parameters (heart rate, respiratory rate, blood temperature, systolic and diastolic blood pressure, and laboratory parameters (serum creatinine, urea, sodium, potassium, chloride, lactate, and albumin concentrations) were also retrieved. Additionally, the following biochemical imbalances were verified at ICU admission, hypernatremia (serum concentration of sodium <135 mEq/L); hypernatremia (serum concentration of sodium 145 mEq/L); hypokalemia (serum concentration of potassium 3.5 mEq/L); hyperkalemia (serum concentration of potassium >5.5 mEq/L); hypochloraemia (serum concentration of chloride <97 mEq/L); hypoalbuminemia (serum concentration of albumin <3.5 g/dL) and metabolic acidosis (arterial blood pH 7.35 and serum concentration of bicarbonate <22 mEq/L), All laboratory workups were recorded and followed for identification of significantly associated hematological and or laboratory abnormalities, such as significant anemia, leucopenia or leukocytosis, neutropenia or neutrophilia, thrombocytopenia, and disturbed coagulation profiles. Other associated laboratory abnormalities, such as hypernatremia, hyperkalemia, and high troponin levels were reported. Evidence of any associated infection (blood and urine culture) and the high acute phase reactants (C reactive protein and ferritin), and procalcitonin were recorded and highlighted.

Criteria for an AKI diagnosis

AKI was defined and classified by the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines, which use serum creatinine and urinary volume values for the AKI diagnosis (1). To identify the cases of AKI, both KDIGO criteria (worst sCr and urine output) were considered. To apply the KDIGO criteria, as the majority of patients have not had the previous measurement of serum creatinine, we considered the first s.Cr at ICU-ad as the baseline value. However, for those patients that had a high sCr on admission, AKI identified if the baseline sCr at ICU admission had increased by more than 0.3mg/dL. To convert to micromoles per liter, multiply by 88.4) over 2 days, or increased or decreased 1.5-fold or more from a nadir value over 7 days.

Statistical analysis

The data were coded, entered, and processed on a computer using SPSS (version 22). The results were represented in tabular and diagrammatic forms and then interpreted, Continuous variables were given as means (with standard deviations) or medians (with interquartile ranges) according to nonmality or skewed distributions. Normality was tested using the Kolmogorov-Smimov test, Categorical variables were summarized by percentages and frequencies, t-tests for normally distributed variables and Mann-

Whitney tests for non-parametric variables for between-group comparisons, Chi-square tests have been used for categorical variables. To compare the summary statistics of categorical variables across groups, we used the x2-test or Fisher's exact test, if at least one of the cells in any contingency table contained an expected count of 5, and ($P<0.05$) was considered significant

Ethical considerations

To maintain the confidentiality of records during the study and in the publication of results, data about the study participants were de-identified. Personal identification information, such as names and addresses, was removed. Only the principal researcher and supervisors had access to the data.

Results

General patient demographic characteristics

During the study period, from I June 2021 to 30 January 2022, 210 patients were admitted to the AL Khadra Hospital ICU, and 147 patients were included in the final study. Table 1 shows the demographic and clinical characteristics of the PICU patient population. During this study, 147 patients were included, out of them 60.5% male (89 Patients), and 39.5% female (58 patients) the minimum age was one-month (30 days) and the maximum was 15years with a median and IQR of 1.25 (0.45-5.90) years. Weight was documented with a median of 10 and IQR (6-16).

All comorbidities were included and analyzed in this study. Of the 147 patients, 40.8% (n=60) presented with a previous comorbid condition, that was observed in both groups 75%(n-45) in non-AKI, 15%(n-25) in AKI patient, (p=0.347), which distributed as the following; 17.7%(26 patients) were reported a respiratory condition mainly asthma, 12.9% (19 patients) were known case of neurological disease, 4.1% (6 patients) reported as CHD, 4.1%(6 patient) had the gastrointestinal condition, 3.4%(5 patient) with the endocrinal disease, 3.4% (5 patient) reported with a definitive syndrome, 3%(2 patient) with a metabolic disease, 1.4%(2 patient) with nephrologic disease (neurogenic bladder), 1.4%(2 patients) had hematological abnormality and only one patient had neoplastic disease on chemotherapy. The median of total days spent in ICU was 4 (IQR 2-4) days. In this study minimal stays as short as 1 day and maximum stays as long as 101 days. The most common cause of admission to ICU was sepsis and reported in 38.8% (57 patients) followed by admission due to respiratory failure in 32.7% (48 patients) and post-operative observation in 6.1% (9 patients) and Hyperglycemic state (DKA, HHS) in 6.1% (9 patient), CNS disease in 4.8% (7 patient), multiple trauma 4.8%(7patient) and severe anemia in 2.7% (4 patient). Other causes like drug toxicity, scorpion bite, and liver impairment contribute 4.1% (6 patients). The outcome in ICU admission showed that 91% (134 patients) showed signs of improvement after admission and discharged from ICU, 8.8% (13 patients) passed away.

Table 1. Demographic, clinical characteristics, and outcomes of the general population

Variable	**All cases, N 147**
Gender(M/F)n	89/58
Age, years, Median, (IQR)	1.25 (0.45-5.90)
Weight, Median, (IQR)	10(6-16)
Comorbidities	
Respiratory disease, n (%)	26(17.7%)
Neurological disease, n (%)	19(12.9%)
CHD, n (%)	6 (4.1%)
GIT, n (%)	6(4.1%)
Diabetic, n (%)	5(3.4%)
Syndromic, n (%)	5(3.4%)
Metabolic, n (%)	3 (2%)
Hematological (%)	2 (1.4%)
Neurogenic bladder (%)	2(1.4%)
Neoplastic, n (%)	1 (0.7%)
Total days spent in ICU, (P25-P75)	
Median	4(2-6)
Minimum	1
Maximum	101
Cause of admission, n (%)	
Sepsis	57(38.8%)
Respiratory condition	48(32.7%)

Post-operative	9(6.1%)
Hyperglycemic state (DKA, HHS)	9(6.1%)
Trauma	7(4.8%)
Post-surgical observation	10(6.8%)
CNS condition	7(4.8%)
Severe anemia	4(2.7%)
Others	6(4.1%)
ICU outcome, n (%)	
Improved & discharged	131(89%)
Discharged with impaired RFT	3(2%)
Passed away	13(8.8%)

Development of AKI

During this period 147 patients were included in the final study, of these patients, 43 (29.3%) had AKI, according to KDIGO staging criteria 37.2% (16) of the them had stage I, 32.6%(n-14) had stage II, and 30.2% (n=13) had stage III (Figure 1).

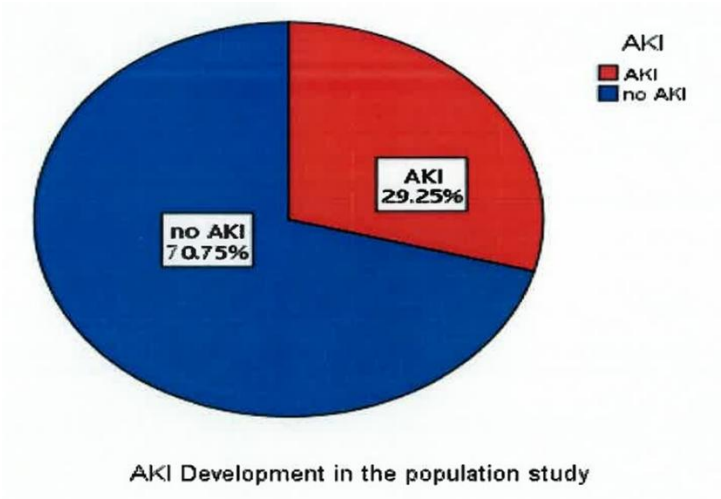

Figure 1. AKI incidence in patients admitted to intensive care unit

Among 43 patients with AKI, 12.2% (18 patients) had AKI on admission and 15% (25 patients) developed AKI in the first seven days of PICU admission, and 1.4% (2 patients) AKI occurs beyond 7 days from ICU admission.

Regarding the diagnostic criteria, 41 cases (95.3%) fulfilled the creatinine criterion, one case (0.7%) the urinary output criterion, and one child (0.7%) fulfilled both criteria.

Table 2. KDIGO classification and outcomes of AKI.

Variable	number (%)
AKI stages	
Stage 1	16 (37.2%)
Stage 2	14 (32.6%)
Stage 3	13 (30.2%
Diagnostic criteria	
S.cr	41 (95.3%)
UOP	1 (0.7%)
S.er, UOP	1 (0.7%)
AKI starting time	
At admission	18 (12.2%)
D1-D7	23 (15%)

>D8	2(1.4%)
Outcomes	
Complete recovery	32(74.4%)
Partial recovery	3 (7%)
Arrested	6(14%)
Relapse & Arrested	2 (4.7%)

Statistical Comparison Between AKI & Non-AKI Groups regarding Demographic Data, Risk Factors, Etiology, Clinical Conditions & Outcome.

Patients in population study was categorized in two groups based on their development of AKI and compared according their demographic data, risk factors, etiology, clinical conditions & outcome (Table 3). To understanding the epidemiology of the disease, patients were classified to three groups based on their age: infant group<1 year (n=67, 45.6%), the second group from 1 to 6 years old (n50, 34%), and the third group were age from 6 up to 15 years old counting (n=30, 20.4%) AKI incidence was 28.4% in the infant group, 20% in the age group of 1-6 years old, and 46.7% in the 6-15-year-old group. The percentage was high in this age group (p=0.039). Feature of AKI by age group are shown in (figure 2), Both groups had approximately equal proportions of male and female patients, there is no association was observed between the gender of the patients, and increasing the incidence of acute renal injury, (p>0.05).

Table 3. Statistical comparison between AXI & Nos-AKI groups regarding demographic data, risk factors, etiology, clinical conditions & outcome

Character	Aki	Non-AKI	P value
Age years. n(%)			
<1Y	19(28.4%)	48(71.6%)	0.039
1-6y	10(20%)	40(80%)	
6-15y	14(46.7%)	16(53.3%)	
Gender			0.105
Male, n (%)	29(32.6%)	60(67.4%)	
Famle, n (%)	14(24.1%)	44(75.9%)	
Cause of ICU admission			
Sepsis, n (%)	23(33.3%)	46(66.7%)	
Post-operative, n (%)	4(44.4%)	5(55.6%)	
Trauma, n (%)	2(28.6%)	5(71.4%)	0.289
Respiratory condition, n (%)	6(17.1%)	29(82.9%)	
Neurological disorder, n (%)	1(14.3%)	6(85.7%)	
DKA, n (%)	2(28.6%)	5(71.4%)	
HHS, n (%)	2(100%)	0(0.0%)	
Others, n (%)	2(28.6%)	5(71.4%)	
Length of ICU stay median, (IQR)	9(1-12)	7.5 (4-11)	0.00
Length of hospital stay median, (IQR)	5(6-17)	3(2-5)	0.03
Need to MV support, n (%)	14(53.8%)	12(46.2%)	0.002
Need to inotrope support, n (%)	16(48.5%)	17(51.7%)	0.006
Need to blood transfusion, n (%)	26(47.3%)	29(52.7%)	0.000
Basal Cr at admission, Ma (SD)	0.50(0.27)	0.11% (0.11)	0.000
Highest s, Cr within ICU M(SD)	0.73 (0.33)	0.29% (0.11)	0.000
Lowest eGFR in ICU, MA (SD)	56.8%(23.7)	68.8(35.5)	0.263
Crude mortality rate, n (%)	18.6%	4.8%	0.002

Interquartile range (IQR), mean standard deviation (MSD)

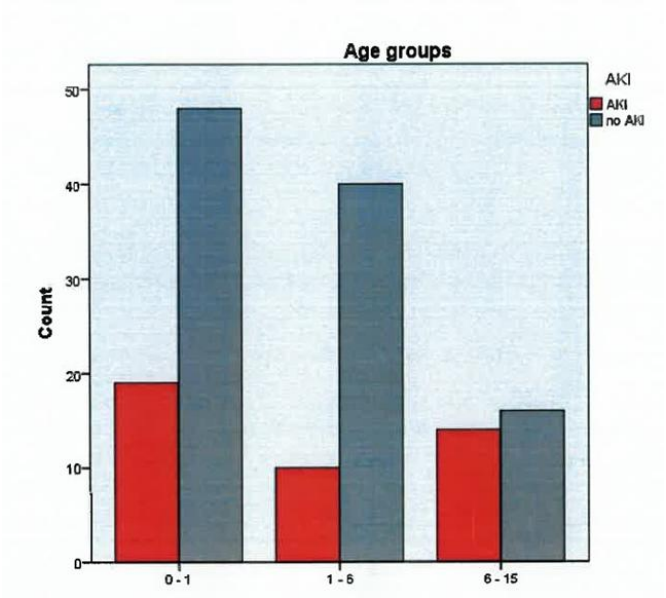

Figure 2. Incidence of AKI among different age groups.

In the comparison between 2 groups (AKI) & (non-AKI) regarding risk factors that may predispose to AKI, patient with AKI was significantly associated with mechanical ventilation, inotrope use, nephrotoxic drugs, basal serum creatinine, need to blood transfusion, and age group 6-15 years old ($p<0.05$), (Table 4). The median serum creatinine was greater in AKI patients than in those without AKI ($p<0.05$), and AKI patients had more hyperkalemia, hypernatremia, hyperuricemia, and hypoglycemia. Regarding the duration of PICU admission, there was a significant difference between the two groups, in the AKI group the median value of the duration of PICU admission was 7 days while in non-the AKI Group was five days. the AKI group was associated with longer PICU admission ($P<0.05$). Also, for total days spent in the hospital, the median in AKI group was 5 days (IQR, 9) & for non-AKI was 3 days; (IQR, 3) respectively, it was longer for AKI patient as observed ($p=0.03$).

Table 4. Biochemical instance and complication during AKI and non-AKI

Biochemical imbalance	Aki	Non-AKI Total	Total	P-value
Urea normal, (%)	33(24.8%)	100(75%)	133	0.001
High, n (%)	10(71.4%)	4(28.4%)	14	
Serum potassium				
Normal	24(22.4%)	83(77.6%)	107	0.01
Hyperkalaemia	7(53.8%)	6(46.2%)	13	
Hypokalaemia	12(44.4%)	15(55.6%)	27	
Serum sodium				
Normal	31(25.8%)	89(74.2%)	120	0.032
Hyponatremia	10(15%)	15(60%)	25	
Hypernatremia	2(100%)	0(0.0%)	2	
Blood glucose				
Normal range 70-140	27(22.9%)	91(77%)	118	0.001
Hyperglycemia >180	13(50%)	13(50%)	26	
Hypoglyvenia <50	3(100%)	0(0%)	3	

Regarding the use of nephrotoxic drugs AKI occurrence was increased by increasing the number of the nephrotoxic drugs used from 15.8% for children who had not taken any nephrotoxic drugs to 21.7% for who take 1- 2 drugs to 41.7% for 3-6 drugs to 83.3% for those taking more than 7 drugs, the p-value (0.00).

Table 5. AKI and nephrotoxic drugs exposure

Number of nephrotoxic drugs	AKI	Non-AKI	Total	P-value
Not taken	3(15.8%)	16(84.2%)	19	0.000
1-2 drugs	20(21.7%)	72(78.3%)	92	
3-6 drugs	10(41.7%)	14(58.3%)	24	
>7 drugs	10(83.3%)	2(16.7%)	12	
Total n, (100%)	43(29.3%)	10(70.7%)	147 (100)	

Outcomes

Of the 147 patients included in the period of study 43 (29.3%) had AKI and 104 (70.7%) with ne AKI. Total renal recovery was reported in 32 cases (74.4%), partial recovery in 3 cases (7%). No recovery and arrest in 6 cases (14%), and 2 cases (4.7%) showing relapsing and then arrested. Of all AKI patients during the period of this study, no one (n= 0) required RRT during the study period, the total mortality rate for PICU was 8.84% (13 deaths) reported, 8 deaths (61.5%) of which corresponding to AKI cases & was as follow; two deaths (25%) AKI stage 1, four deaths (50%) AKI stage II and two deaths (25%) AKI stage III. Of all AKI patients during the period of this study, no one (n=0) required RRT (Figure 3).

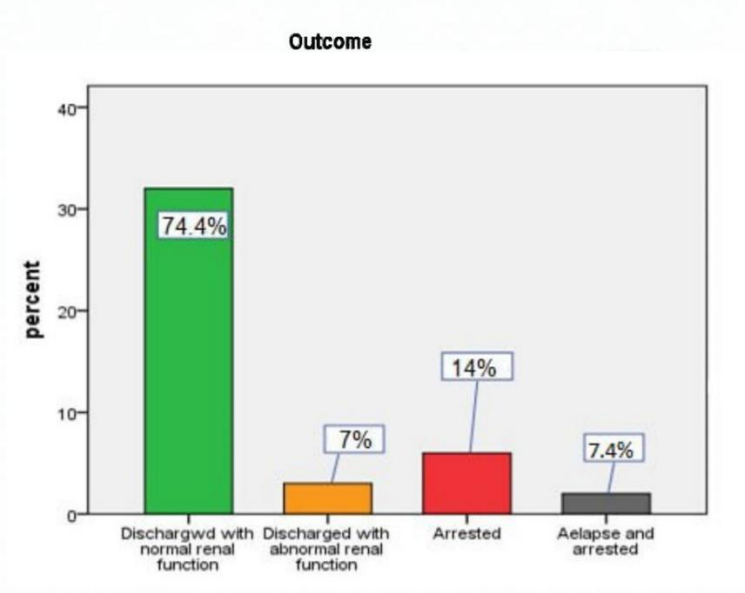

Figure 3. Short-term outcomes and mortality among AKI stages

Discussion

This study was conducted in a retrospective cohort of pediatric patients hospitalized in intensive pediatric care services, aimed to assess the incidence of acute kidney injury, associated risk factors, and outcomes in the pediatric intensive care unit. To date, no similar studies have been developed in Libya, to enable a comparison with characteristics described in the national population, consequently, only comparisons with international data are possible, which is considerably variable among studies, extending from 5% to 82%. This variation probably results from differences in case mix, illness severity, coexisting conditions, and definitions of acute kidney injury.

The incidence of AKI in our study was 29.3%, in which (43 cases) out of 147 cases were admitted to the PICU. In comparison to the incidence of AKI, our results were lower than study conducted in Egypt by Abdulsames et al., reported 33% [15]. Another Indonesian study in pediatric critically ill patients revealed by Prasetyo et al., [16] shows an incidence of 58.3%. Sutherland et al. [17] reported a 40.3% incidence of AKI at the Lucile Packard Children's Hospital, California. Also, a study run in India by Gupta et al., shows an incidence of 42,9% AKI in patients admitted to the intensive care unit [18]. While the incidence of 29.3% in our study was higher than 25.1%, as reported by Krishnamurthy et al., in a prospective observational study conducted in India using (AKIN) classification in critically ill pediatric patients admitted to the PICU; aged from 1 month to 13 years [19].

Regarding diagnosis, this study reinforces the importance of using both serum creatinine, and urine output as criteria for AKI diagnosis, as previously described. Several previous studies depend only on changes in serum creatinine, and the urinary output has not been considered due to its difficult measurement accuracy, although it may allow a higher diagnostic sensitivity, and can predict mortality as observed by many studies. In our study, urine output was documented in a few patient records, because of this restriction in data resources, the U.O.P criterion was fulfilled for only two cases out of 34 cases with available data, and they met the stage III AKI at the time of diagnosis. As described in adult studies, oliguria, when established allows AKI diagnosis before an increase in serum creatinine is

detected. This usually occurs later or may not even occur, particularly in malnourished children with poor muscle mass, or due to a dilution effect related to volume expansion [21].
Regarding KDIGO stages at diagnosis, (37.2%) of cases fulfilled stage 1 criteria, (32.6%) stage II criteria, and (30.2%) stage III. This was comparable with Higuita-Serna et al., that report the incidence according to (KDIGO) classification, (38.6%) as stage 1; (29.6%) as stago II; and (31.8%) as stage III [21]. While other studies report variable incidences [22,23].
Regarding the time of AKI onset on admission, stage 1 cases of AKI were (6) cases out of 16 (37.5%), stage 2 were (5) cases out of 14 (35.7%), and stage 3 were (7) cases out of 13 (53.8%). In comparison between subgroups, stage III was associated with a larger number of cases of AKI onset on admission than in other classes, but this was not statistically significant ($p>0.05$). In contrast to that reported by Abdulsamea et al., who observe significant differences among the AKI classes using pRIFLE criteria [15].
We found that the common etiologies in our study were infections, including pneumonia, sepsis, acute gastroenteritis with hypovolemic shock, and UTI accounted for the majority of all infections. Pneumonia constituted one-third of all infections associated with AKI and was associated with high mortality 54.7%, this agrees with a prospective observational study from a tertiary center in southern India done by Krishnamurthy & colleagues that report an increased risk of developing AKI and mortality found quite common in pneumonia (66.7%) [19].
Regarding Invasive ventilation and association with AKI in our study 26 patients needs MV, 53.8% (14) of them develop AKI ($P=0.003$) and most of them had stage 3 (38.5%) AKI. This was comparable to another retrospective study from the Netherlands, among 103 children requiring mechanical ventilation, 58% developed AKI [24].
Regarding the use of inotropes, these drugs are generally used for the treatment of systemic hypotension refractory to fluid therapy, often in the context of shock, hemorrhage, or MOF. However, they also act on the renal vasculature, with its mechanism not fully understood yet. In this study, inotropic support was required by 16 of (43 children) with AKI. Of these, (3 patients) had stage 1, (5 patients) had stage II, and (8 patients) had stage III AKI. Only 17 of (104 children) without AKI required inotropic support P-value< (0.006). Several studies [20,25] reported the use of inotropic drugs as a risk factor for AKI, Hemodynamic instability, which leads to inotropic drug use, is associated with renal hypoperfusion, resulting in renal damage of prerenal cause, making it difficult to understand the role of inotropic drugs in AKI), This is most likely due to the patient's severity of illness. Similarly, patients in an unstable hemodynamic state are at increased risk for both inotrope use and ischemic AKI in the setting of multi-organ damage.
The complications and co-morbidities that significantly observed More in AKI than non-AKI patients included hyperuricemia in 10 (71.4%), hyponatremia in 10 (40%), hypernatremia in 2 (100%) & Hypokalemia in 12 (44.4%), hyperkalemia in 7 (53.8%) hyperglycemias in 13 (50%), hypoglycemia in 3 (100%), and need to blood transfusion in 26 (47.3%) of AKI patient. During this study period, no patients underwent renal replacement therapy in the ICU. Safder et al., showed that RRT was required in 11.4% of pediatric patients with AKI [26]. This may be explained that the clear protocols developed to predict RRT in risky patients, and low resources as the RRT requires a multidisciplinary team approach that is facilitated by a pediatric nephrologist in conjunction with intensivists and skilled nursing staff.
The present study has some limitations that can be avoided in future studies, including single-center study, and reduced sample size. Although, our PICU receives critically ill patients from 1 month of age up to 18 years of age who have various surgical, medical, and traumatic Conditions. Hence, its results can probably give an insight into these problems for the entire territory, but a large multicenter study, including several pediatric intensive care units, will potentially enable a better disease characterization and confirm the results obtained. On the other hand, a more accurate and detailed regression analysis of some variables of interest -including detailed drug dosage, and duration, inotropic drug support, and accurate calculation of UOP, may improve the biased strength of identified risk factors and explain their temporal relation with AKI development. Another limitation is that we examined only short-term outcomes of hospitalized children with AKI. Lack of information on the long-term outcome e.g, microalbuminuria, hypertension, or elevated creatinine levels, is needed to evaluate the impact of mild AKI on renal function Regardless of these limitations, to the best of our knowledge, this is the first Libyan study on AKI in the pediatric intensive care setting with retrospective data collection, and maybe a preliminary analysis for future research in the area.

Conclusion

In this study, the incidence of AKI in critically ill patients was high. AKI was directly related to increased mortality, with a four times higher risk of Death in AKI *versus* Non-AKI Patients. The time of hospital and PICU Stay was determinant. It was seen that patient with AKI stayed longer than the KDIGO Criteria were shown to be important for early AKI risk patients' detection, suggesting that, with its use, earlier diagnosis will improve more careful and less delayed therapy, which in long term will lead to a reduction in this disease-related morbidity and mortality.

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