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ORIGINAL ARTICLE

CLINICO-LABORATORY CHARACTERISTICS, RISK FACTORS AND OUTCOME OF ACUTE KIDNEY INJURY

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ABSTRACT

OBJECTIVE: To determine the clinico-laboratory characteristics, risk factors and outcome related to acute kidney injury (AKI) in hospitalized patients.

METHODS: This prospective study on 101 consecutive patients admitted to the Northwest General Hospital & Research Centre, Peshawar, Pakistan was carried out from January-March 2019. Patients were staged according to Kidney Disease Improving Global Outcomes (KDIGO) guidelines and outcomes were measured in terms of in-hospital mortality and change in KDIGO staging.

RESULTS: Majority (n=57/101; 56.43%) were males. Mean age of patients was 57.90±16.93 years. Twenty-seven (26.73%) patients were in AKI stage-I, 29 (28.71%) in stage-2 and 45 (44.55%) were in stage-3. Hypertension (n=74/101; 73.27%) was the commonest co-morbid condition. Sepsis (n=39/101; 38.61%) and hypovolemia (n=21/101; 20.8%) were most common risk factors for AKI. There was complete recovery in 43 (42.57%) patients. In-hospital mortality was 6.9% (n=7/101) and 57.1% (n=4/7) of these patients had KDIGO stage-3. Serum creatinine levels declined in 22 (21.78%) cases, remained static in 23 (22.8%) and worsened in 06 (5.9%) cases. Male gender and presence of hypovolumia ($p<0.05$) significantly differed in survivors compared to non-survivors. Furthermore, factors associated with declined in serum creatinine included stage-II AKI and length of hospital stay, while stage-II and III AKI on admission, absence of oliguria crude odd ratio (cOR: 2.681, p=0.027, 95% CI: 1.12-6.44) and lower serum creatinine levels on admission (cOR: 0.668, $p<0.001$, 95% CI: 0.54-0.83) were associated with complete recovery.

CONCLUSION: Sepsis and hypovolemia constituted the major risk factors. Gender and hypovolemia were the significant factors between the survivors and non-survivors.

KEYWORDS: Acute Kidney Injury (MeSH); Patient Outcome Assessment (MeSH); KDIGO (Non-MeSH); Fatal Outcome (MeSH); Mortality (MeSH); Sepsis (MeSH); Oliguria (MeSH).

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INTRODUCTION

Acute kidney injury (AKI) is a common complication which physicians come across in daily practice and is associated with serious adverse outcomes. It is defined according to Kidney Disease Improving Global Outcomes (KDIGO) criteria as an increase in serum creatinine of ≥ 0.3mg/dl (≥ 26.5mol/l) within 48 hours and is due to multiple factors including comorbidities, hemodynamic compromise, and the drugs causing direct injury to the kidneys.[1] AKI has significant long-term implications on patient health leading to recurrent hospital admission and long-term mortality.[2-6]

The incidence of AKI has greatly increased in the last few years and differs according to the criteria used to diagnose AKI with poor prognosis having morbidity from 3/1000 to 5/1000 in the United States.[6] In a study done in China, it was concluded that there were 1.4 to 2.9 million patients diagnosed with AKI in 2013 alone.[6] AKI results in serious events needing multidisciplinary approach and has amortality rate of 58% in intensive care units.[7] The incidence of AKI has not been well established till now and very few studies have pointed out the burden caused by AKI. In a meta-analysis performed in 2012, the incidence of AKI was reported to be 21.6% in adults worldwide with 23.7% incidence in Southern Asia using KDIGO guidelines.[8] Hospital associated AKI is more common in men as compared to women especially among those who undergone non-cardiac surgery.[9] Sepsis is the leading cause of AKI in critically ill patients, accounting for 50% of cases. AKI is also an independent and strong risk factor in ST elevation myocardial infarction patients.[10] There is very limited data available in Pakistan on AKI despite the fact that it hinder the physician's approach in managing their patients. Our study aimed to find possible risk factors and outcomes related to AKI by applying KDIGO criteria among hospitalized patients.

METHODS

This prospective study was conducted on patients who were admitted to Department of Medicine and Allied, Northwest General Hospital & Research Centre, Peshawar, Pakistan, from January 2019 to March 2019. The facility is a tertiary care referral center in Peshawar and has a patient population from throughout Khyber Pakhtunkhwa and Afghanistan region. Informed consent was taken from all the patients and their families. The patients were

TABLE I: PATIENTS CHARACTERISTICS AMONG BETWEEN SURVIVORS AND NON-SURVIVORS

Variable		Total (n=101)	Survivors (n=94) N (%)	Non-survivors (n=7) N (%)	p-value
Gender	Male	57 (56.43)	50 (87.71)	7 (12.28)	0.018#
	Female	44 (43.56)	44 (100)	0 (0)	
KDIGO stage on admission	Stage 1	27 (26.73)	26 (96.30)	1 (3.70)	0.703*
	Stage 2	29 (28.71)	27 (93.1)	2 (6.9)	
	Stage 3	45 (44.55)	41 (91.1)	4 (8.89)	
Co-morbid conditions	Hypertension	74 (73.27)	69 (93.24)	5 (6.76)	1.000*
	Diabetes mellitus	58 (57.43)	53 (91.380	5 (8.62)	0.696*
	Coronary artery disease	41(40.59)	39 (95.12)	2 (4.88)	0.698*
	Congestive heart failure	34 (33.66)	33 (97.06)	1 (2.94)	0.418*
	Chronic Kidney disease	21 (20.79)	20 (95.24)	1 (4.76)	1.000
Previous hospitalization	Yes	61 (60.39)	58 (95.08)	3 (4.92)	1.000#
	No	40 (39.60)	36 (90)	4 (10)	
Dialysis	No	83 (82.18)	77 (92.77)	6 (7.23)	1.000#
	Yes	18 (17.82)	17 (94.44)	1 (5.56)	
Oliguria	Yes	36 (35.64)	31 (86.11)	5 (13.89)	0.094#
	No	65 (64.36)	63 (96.92)	2 (3.08)	
Risk factors for acute kidney disease	Sepsis	39 (38.61)	35 (89.74)	4 (10.26)	0.425*
	Hypovolemia	21 (20.79)	17 (80.95)	4 (19.05)	0.033*
	Acute fluid overload	18 (17.82)	17 (94.44)	1 (5.56)	1.000*
	Acute Coronary Syndrome	10 (9.91)	9 (90)	1 (10)	0.529*
	Obstructive Uropathy	09 (8.91)	9 (100)	0 (0)	1.000*
	Drugs	07 (6.93)	7 (100)	0 (0)	1.000*
	Glomerulonephritis	04 (3.96)	4 (100)	0 (0)	1.000*
	Respiratory failure	04 (3.96)	4 (100)	0 (0)	1.000*
	Pigment nephropathy	01 (0.99)	1 (100)	0 (0)	1.000*
	Contrast induced	02 (1.98)	2 (100)	0 (0)	1.000*
Reasons for admission	Infectious Disease	23 (22.8)	21 (22.3)	2 (28.6)	0.480*
	Cardiovascular disorders	21 (20.79)	20 (95.24)	1 (4.76)	
	Chronic kidney disease	18 (17.82)	17 (94.44)	1 (5.56)	
	Neurological diseases	15 (14.85)	15 (100)	0	
	Respiratory diseases	9 (8.91)	7 (77.78)	2 (22.22)	
	Obstructive uropathy	5 (4.95)	5 (100)	0	
	Liver disorders	04 (3.96)	4 (100)	0	
	Gastrointestinal disorders	04 (3.96)	3 (75)	1 (25)	
	Obstetric related acute kidney injury	2 (1.98)	2 (100)	0	

¶; Student independent t test , §; Mann whiteny test , *; Chi square test ,#; Fischer exact test

thoroughly examined and detailed history was taken from everyo subject. Demographic variables and clinico-laboratory parameters were collected on a structured format. Outcomes were defined in terms of KDIGO staging and in-hospital mortality. A patient was staged to Stage I, Stage II and Stage III according to rise or fall in serum creatinine levels.

Patients fulfilling KDIGO criteria for AKI were enrolled via non-probability consecutive sampling. Patients with age less than 14 years age and chronic kidney disease (CKD) patients who were on renal replacement therapy were not included in the final data set.

Ethical approval was taken from the Ethics Committee of the Northwest general Hospital & Research Center, Peshawar, Pakistan.

Descriptive statistics such as frequency (%) and mean with standard deviation or median (IQR) where appropriate were computed for categorical and numerical variable respectively. Proportions differences were tested using Chi-square statistics or Fischer exact test where applicable. For non-normally distributed numerical variable median differences was calculated using the Mann Whitney test while in contrast, student independent t-test was used for the normally distributed numerical variable. Logistic regression was used to determine the factors associated with the changes in serum creatinine [declined and resolved]. The analysis was performed using the Statistical Package for Social Sciences (SPSS) V 20.0. Statistical significance was set at $P < 0.05$.

OPERATIONAL DEFINITIONS

1. AKI was defined as per KDIGO guidelines as follow:[1]

Stage 1: 1.5-1.9 times baseline odds ratio (or) =0.3mg/dL (=26.5 ìmol/L) increase in the serum creatinine, (and/or) urine output, 0.5 mL/kg/h for 6-12hour.

Stage 2: 2.0-2.9 times baseline in the serum creatinine (and/or) urine output <0.5mL/kg/h for =12hr.

Stage 3: 3.0 times baseline increase in the serum creatinine to =4.0mg/dL (=353.6 ìmol/L) (and/or) urine output of <0.3 mL/kg/h for =24h, or anuria for =12h or the initiation of renal replacement therapy or in patients, 18years, decrease in estimated GFR to <35 mL/min/1.73 m^2.[1,11]

2. Obstructive uropathy was defined as the cause of AKI with radiological evidence and improvement after the relief of obstruction.

3. Drugs were labeled as the cause of AKI where there was clinical relation in the absence of other factors causing AKI.

4. Contrast-induced nephropathy was defined as a rise in serum creatinine of 25% or an absolute increase of serum creatinine of 0.5 mg/dl within 48 hours after the procedure.[12]

5. Sepsis was defined as patients with suspected or confirmed bacterial infection and presence of ≥2 of the following variables[13] i.e

a) Glasgow Coma Scale <15 or Altered mental status

b) Respiratory rate >22/minute

c) Systolic BP <100mmHg

d) White cell count >12000/μL or <4000/μL.

6. Hypovolemia is defined as:[13]

a) Decrease in blood pressure less than 90/60mmHg

b) Delayed capillary refill

c) Improvement after normalization of blood flow

7. CKD was defined as patients persistent reduction in eGFR of less than 60 mL/min per 1.73 m^2 or with

TABLE II: OUTCOME OF ACUTE KIDNEY INJURY IN TERMS OF KDIGO STAGING AND IN-HOSPITAL MORTALITY

¶KDIGO stage on admission	Outcome in terms of KDIGO staging					
	Declined (n=22) N (%)	Static (n=23) N (%)	Resolved (n=43) N (%)	Worsened (n=6) N (%)	Death (n=7) N (%)	Total (n=121) N (%)
Stage 1	1 (3.70)	2 (7.40)	21 (77.78)	2 (7.40)	1 (3.70)	27 (26.73)
Stage 2	8 (27.59)	5 (17.24)	11 (37.93)	3 (10.35)	2 (6.89)	29 (28.71)
Stage 3	13 (28.89)	16 (35.56)	11 (24.44)	1 (2.22)	4 (8.89)	45 (44.56)

¶Kidney Disease Improving Global Outcomes

radiological and biochemical evidence of chronic kidney disease for more than 03 months.[13]

RESULTS

All patients were classified as per KDIGO guidelines. Twenty seven (26.73%) patients were in AKI stage I, 29 (28.71%) patients were in stage II and 45 (44.55%) patients were in stage III (Table I). Hypertension (n=74/101; 73.27%) was the most common co-morbid condition followed by diabetes mellitus (n=58/101; 57.43%). Of the total, 36(35.64%) patients were oliguric at presentation. Dialysis was required in 18 (17.82%) cases. Sepsis (n=39/101; 38.61%) and hypovolemia (n=21/101; 20.8%) were the most common risk factors for AKI. Infectious diseases (n=23/101; 22.8%), cardiovascular disorders (n=21/101; 20.8%) and chronic kidney disease (n=18/101; 17.8%) were the common causes for hospitalization.

The mean serum creatinine on admission was 4.50±3.10 mg/dL in all patients with 4.35±2.96 mg/dL and 6.46±4.56 mg/dL in survivors and non-survivors respectively (p=0.085). Baseline median (IQR)] serum K^+ was 4.71 (4.72) mmol/L, 4.65 (1.68) mmol/L and 4.99 (1.55) mmol/L in all patients, survivors and non-survivors respectively (p=0.211).

Mean (SD) length of hospital stay was 5.37±3.37, 5.49±3.356 and 3.71±3.302 days in all patients, survivors and non-survivors respectively (p=0.180). Data regarding the outcome showed that 43 (42.57%) patients completely recovered from AKI at the time of discharge. Serum creatinine levels declined in 22 (21.78%) cases, remained static in 23 (22.8%) cases and worsened in 06 (5.9%) cases. The outcome was good in KDIGO stage I. Out of 43 cases with fully recovery, 21 (48.8%) cases were in KDIGO stage I. About 77.78% (n=21/27) cases of KDIGO stage I had complete resolution of serum creatinine level at discharge (Table II). Median (IQR)] serum creatinine at discharge was 1.8 (10.41) mg/dL, 1.52 (2.34) mg/dL and 2.30 (4.2) mg/dL in all patients, survivors and non-survivors respectively (p=0.071). In-hospital mortality was observed in 7 (6.9%) cases and 57.1% (n=4/7) of these patients had KDIGO stage 3. Common factors contributing for mortality were hypovolumia and sepsis (n=4/7;57.14% each). Out of 21 cases of hypovolumia, 23.8% (n=5) required dialysis and 19.05% (n=4) died. While in patients with sepsis 17.94% (n=7/39) required dialysis and 10.25% (n=4/39) died. Out of 18 cases requiring dialysis, 7 (38.88%) had sepsis, 5 (27.77%) had hypovolumia and 3 (16.66%) had acute circulatory overload (Table III).

Crude Odd ratios (cOR) along with 95% CI were calculated for factors affecting the outcome: change in serum creatinine. Factors associated with declined in serum creatinine included Stage 2 AKI (cOR: 0.095, 95% CI: 0.01-0.77, p=0.028) and length of hospital stay (cOR: 1.152, , 95% CI: 1.01-1.38, p =0.039). Patients with CKD, stage II , stage III, AKI on admission, absence of oliguria and low serum creatinine on admission were associated with complete recovery in terms of serum creatinine (Table IV).

DISCUSSION

The term of AKI has been described from time to time using various criteria. Most of the times in literature, serum creatinine level is the most frequently used marker by the researchers in defining and staging AKI. It can also be defined based on urinary output. The criterion implemented in our study was based on the KDIGO guidelines 2012, stating that an increase in serum creatinine of = 0.3mg/dl (= 26.5mol/l) within 48 hours.[1,14]

It has been observed that a slight increase in Cr level can increase the relative mortality. AKI is a common cause of an increase in morbidity and mortality among hospitalized patients that also results in an increased hospital stay and a financial burden.[15] Patients with AKI have three to seven times higher odds for deaths compared to non-AKI admissions.[8] The presence of CKD and other concomitant condition raises the risk of AKI.

Studies have been done to predict the possible causes and outcomes of patients having AKI.[2,15,16] To our knowledge, it is the first study in this area conducted outside ICU settings to estimate the risk factors and outcomes in AKI patients, using KDIGO definitions.

Hypertension followed by diabetes was the most common co-morbids in our study population. A previous study described the same medical co-morbids in their hospital-acquired acute kidney injury patients. In patients requiring hospitalization for acute health associated problems, several factors such as age-linked changes and accompanied co-morbidity renders elder population prone to develop AKI.[13]

Primary reasons for admission of the study patients to the hospital included infectious diseases (n=23, 22.8%), cardiovascular disease (n=21, 20.8%), chronic kidney disease (n=18, 17.8%), neurological disease (n=15, 14.9%) and respiratory disease (n=9, 8.9%). Park et al. reported pulmonary disease, gastrointestinal disease, and malignancies to be the primary reason for admission in their study patients.[17] Previous hospitalization was higher in non-survivors (75%) as compared to survivors (61.7%). Previous health status was normal in 39.6% of patients which is similar to a study conducted in an ICU setting (41%).[7]

Studies from India reported that the

TABLE III: CAUSES AND MANAGEMENT OF ACUTE KIDNEY INJURY

Cause and Management of Acute Kidney Injury		Need for Dialysis				Death (n=7)	
		No (n=83)		Yes (n=18)			
		N	%	N	%	N	%
Hypovolumia	Yes	16	19.27	5	27.77	4	57.14
	No	67	80.72	13	72.22	3	42.85
Sepsis	Yes	32	38.55	7	38.88	4	57.14
	No	51	61.44	11	61.11	3	42.85
Acute circulatory overload	Yes	15	18.07	3	16.66	1	14.28
	No	68	81.92	15	83.33	6	85.71
Acute coronary syndrome	Yes	9	10.84	1	5.55	1	14.28
	No	74	89.15	17	94.44	6	85.71
Obstructive uropathy	Yes	9	10.84	0	0	0	0
	No	74	89.15	18	100	7	100
Drugs	Yes	6	7.22	1	5.55	0	0
	No	77	92.77	17	94.44	7	100
Glomerulonephropathies	Yes	2	2.40	2	11.11	0	0
	No	81	97.59	16	88.88	7	100
Respiratory Failure	Yes	4	4.8	0	0.0	0	0.0
	No	79	95.2	18	100.0	7	100.0
Contrast induced	Yes	2	2.40	0	0	0	0
	No	81	97.59	18	100	7	100
Pigment Nephropathy	Yes	1	1.20	0	0	0	0
	No	82	98.79	18	100	7	100

etiology of the AKI haschanged in recent times from drug-induced to sepsis and volume depletion.[13,18,19] In these studies, sepsis was the most frequently associated factor (n=39, 38.6%) found among AKI patients, which was 48% and 34.88% in other studies.[7,13] This high incidence of sepsis in our patients may be because most of our patients were from medical units. It is well documented that sepsis attributed to AKI carries high mortality.[7,13] The presence of AKI is an independent risk factor in these patients corresponds to in-hospital mortality. Rangel-Frausto et al described that in culture-positive patients, AKI was recorded in 51% with septic shock, 23% with severe sepsis, and 19% with mild to moderate sepsis.[20] Despite medical advancement the death ratio of severe sepsis has continued to spike.[13] Compared to non-septic (45%) AKI, sepsis-related AKI has a very high mortality (74%).[16] Mortality noted in present study was 6.9%, which is less than the reported 10.8%42.8% globally.[16,21,22] The reason could be the low number and non-ICU status of the patients in this study. The other possible reasons include a decreased number of days spent in the hospital,the high number of patients in stage I and II AKI according to KDIGO and relatively young population with absence of multiple comorbidites. Sepsis was followed by intravascular volume depletion (21, 20.8%) and acute fluid overload (18, 17.8%) as the most frequently associated factors among our AKI patients. The likelihood of the progression of hospital-acquired AKI increases from 9.2 to 9.4 times in the presence of factors such as volume depletion and congestive cardiac failure.[23] Poor prognosis was seen in these patients.

Thirty six patients were oliguric of whom, 5 patients died in our study. Such patient tends to have longer hospitalization and need more regular dialysis sessions. Oliguria has been recognized as a poor prognostic sign in AKI. Oliguria and high creatinine levels when combined have been presented to estimate the highest mortality in a sample of 32,000 patients.[24]

According to KDIGO staging, the majority of patients (45, 44.55%) progressed to Stage III and mortality was also highest in stage III (4, 57.1%). Among those who recovered completely most of them (21, 48.8%) belonged to stage I according to KDIGO guidelines. These results resemble the one concluded in data collected from Asia-Africa.[13]

Gender was found to be associated with in-hospital mortality in AKI patients in our results, all of them were males which supported results of a meta-analysis of studies providing sex-stratified incidence of hospital-acquired acute kidney injury (HAAKI) demonstrates that female sex is associated with protection from AKI. It also concluded that it is male sex that is associated with HAAKI.[9]

Factors affecting the outcome [change in serum creatinine] were determined. Stage II AKI and length of hospital stay were the factors associated with decline in serum creatinine. On the other hand, patients with stage II, III AKI on admission, absence of oliguria, and lower serum creatinine on admission were associated with complete recovery in terms of serum creatinine. Stage II had a significant decline in serum creatinine levels than stage III which may be due to early approach in the management of progressing AKI patients. Similarly, an increase in hospital stay also had a significant decline in serum creatinine levels which support a prolonged monitored approach for AKI patients inside the hospital.. Keeping stage I as a reference, the odds ratio of stage II and stage III was 0.175 and 0.092 respectively. These results can be due to low baseline serum creatinine levels and early renal replacement therapy to these patients. Patients who had mildly functioning kidneys initially with urinary output >500ml/24hr had significant recovery than those with oliguria at the time of presentation which shows oliguria a bad prognostic sign. Lower serum creatinine levels on admission were statistically significant regarding complete recovery among AKI patients which means lower baseline serum creatinine can be used as a good prognostic marker among AKI patients.

Strength and Limitation of the Study

To our knowledge, it is the first study in this region using KDIGO guidelines and estimating in-hospital mortality. The limitation of this study is single center and lack of follow up after discharge from the hospital. Moreover, we acknowledge that our sample size is small, large sample would yield more meaningful insight.

TABLE IV: FACTOR PREDICTING OUTCOME (CHANGES IN SERUM CREATINE)

Parameters			Crude Odd ratios (95% CI)	p-value
Factors affecting decline in serum creatinine	¶KDIGO stage on admission	Stage 1	1	
		Stage 2	0.095 (0.01-0.77)	0.028
		Stage 3	0.935 (0.33-2.65)	0.903
	Length of hospital stay		1.152 (1.01-1.32)	0.039
	Respiratory failure	Yes	1	0.340
		No	0.81 (0.01-0.83)	
Factors affecting good outcome [Recovery]	Chronic Kidney Disease	Yes	0.100 (0.02-0.46)	0.003
		No	1	
	KDIGO stage on admission	Stage 1	1	
		Stage 2	0.175(0.54-0.57)	0.004
		Stage 3	0.092(0.03-0.29)	<0.001
	Oliguria	Yes	1	0.027
		No	2.681 (1.12-6.44)	
	Baseline serum Creatinine (mean)		0.668 (0.54-0.83)	<0.001

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CONCLUSION

The majority of our study patients were in KDIGO stage III and sepsis and hypovolemia constituted the major risk factor. AKI resulted with in-hospital mortality of 6.9%. Male gender and presence of hypovolemia were the significant factors between survivors and non-survivors. Stage II, III AKI on admission, absence of oliguria, and lower serum creatinine levels on admission were associated with complete recovery.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

NS: Analysis and interpretation of data, drafting the manuscript, critical review, approval of final version to be published

SA & ANA: Conception and study design, critical review, approval of final version to be published

RS & KH: Acquisition of data, drafting the manuscript, approval of final version to be published

AH: Analysis and interpretation of data, critical review, approval of final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest

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