RESEARCH ARTICLE

The aetiology, risk factors and outcome of Acute Kidney Injury in patients requiring Kidney Replacement Therapy: A prospective single center experience

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Abstract

Objective: To find out the causes, associated leading factors and impact of kidney replacement therapy on patients hospitalised for acute kidney injury in a tertiary care setting.

Method: The prospective, cross-sectional study was conducted at the Sindh Institute of Urology and Transplantation, Karachi, from January 1 to March 31, 2022, and comprised patients of either gender aged 18 or more years presenting with acute kidney injury as per the Kidney Disease Improving Global Outcomes criteria and required kidney replacement therapy. Complete, partial or no recovery was the main outcome parameter noted at the end of 90 days. Possible aetiologies were identified and categorised as pre-renal, renal and post-renal aetiologies. Risk factors for acute kidney injury were recorded, including age, gender and co-morbidities. Data was analysed using SPSS 22.

Results: Of the 210 patients with mean age 46.1±14.24 years, 109(52%) were males and 101(48%) were females (p>0.05). Hypertension was the most common comorbidity 98(46.8%), followed by diabetes mellitus 75(35.7%) and underlying chronic kidney disease 55(26.2%). Multiple therapeutic interventions were required, including vasopressors in 101(48.1%) patients and mechanical ventilation in 31(14.8%). Renal failure due to intrinsic renal aetiology was the most common 98(46.7%), followed by post-renal aetiology 61(29%). There was no significant association between outcomes and aetiologies (p>0.05). There was increase in chronic kidney disease cases from 55(26.2%) patients at baseline to 107(50.9%) at the end of 90 days. Complete recovery was noted in 71(33.8%) patients, partial in 73(34.76%), no recovery in 34(16.1%) patients who required maintenance kidney replacement therapy, and 32(15.2%) patients died.

Conclusion: Complete recovery after 90 days of kidney replacement therapy was observed in one-third of the patients. Intrinsic renal aetiology was the most prevalent, and hypertension was the most common comorbidity.

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Introduction

Acute kidney injury (AKI) is a frequently occurring acute syndrome characterised by an abrupt decrease and impairment in the glomerular filtration rate (GFR).[1] AKI poses a significant health concern to the population, as it affects 13.3 million individuals worldwide, and results in 2 million deaths each year.[2] Reports indicate that 85% of individuals affected by AKI are part of the developing regions of the world.[3] Patients with multiple comorbidities are more susceptible to AKI, which can result in adverse outcomes, such as chronic kidney disease (CKD) and even death.[3,4] The incidence and prevalence of AKI within a community are greatly influenced by local factors and prevalent diseases, which differ significantly between developed and underdeveloped nations. In the developing world, community-acquired AKI is more prevalent than hospital-acquired AKI.[5,6] A study in Pakistan also reported that 82% of patients with AKI required kidney replacement therapy (KRT) on arrival, indicating the severity of the kidney injury on arrival.[7] A study in southern India, aiming to establish the epidemiology of community-acquired AKI, demonstrated dialysis dependency in 83% patients, with overall in-hospital mortality being 26.20%.[8]

The rate of renal recovery varies in the literature, possibly because of the lack of a consistent definition for renal recovery.[9-12] Some studies[9,10] reported that recovery rates ranged 36-99% based on the definition of recovery as dialysis independence at discharge. Furthermore, to reduce the severity and improve recovery in AKI cases, it is important to identify the underlying causes and risk factors of AKI.

The studies conducted in Pakistan[6,7] regarding AKI have mostly been retrospective, with little prospectively collected data. Additionally, none of the studies have comprehensively examined the aetiology, risk factors and outcomes of AKI in a single setting. The current study was planned to fill the gap by analysing the causes, associated leading factors and impact of kidney replacement therapy (KRT) on AKI inpatient in a tertiary care setting.

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Patients and Methods

The prospective, cross-sectional study was conducted at the Sindh Institute of Urology and Transplantation, Karachi, from January 1 to March 31, 2022. After approval from the institutional ethics review committee, the sample size was calculated using EpiInfo.[13] The estimated mortality rate for AKI patients was taken as 4.2%[6] with margin of error 3% and confidence interval (CI) 95%. The sample was inflated by >20% to account for the risk of loss to follow-up. All patients of either gender aged 18 or more years presenting with AKI and requiring KRT were included if they had length of hospital stay (LOS) >24 hours. Patients with chronic liver disease, end-stage renal diseases (ESRD), and those who had received renal transplantation were excluded. All patients who survived were followed up for 90 days after discharge from the hospital.

After taking informed consent from all the subjects or their attendants, data was collected using a study proforma. Demographic and clinical variables included age, gender, duration of symptoms, chronic medical conditions, regular medications, reason for intensive care unit (ICU) admission, and drugs prescribed during hospitalisation. Data was also collected on mechanical ventilation (MV), vasopressors and KRT requirement. Serum creatinine levels were tested during hospitalization, at discharge and 3 months thereafter.

AKI was defined and stratified as per the Kidney Disease Improving Global Outcomes (KDIGO) criteria.[14] Baseline creatinine (Cr) was defined as the average of all values observed between 8 and 365 days prior to hospitalisation.[14] In the absence of previous serum Cr records, the lowest Cr level during hospitalisation was considered.[14] The estimated GFR (eGFR) was calculated using the CKD-Epidemiology Collaboration Cr equation.[15] Application of the KDIGO criteria was done at two different times; within 48h of presentation, and at the time of discharge. Thereafter, the patients were classified into pre-renal, renal and post-renal categories according to the identified aetiology. Oliguria was defined as urine output <400mL/day, and anuria was defined as urine output <100mL/day.

All patients were treated according to the institutional standard operating procedures (SOPs) for both wards and ICUs. All routine tests and patient management were done at the discretion of the attending physician. Dialysis prescription was decided according to the volume status, and the dose was calculated according to laboratory parameters on admission which was subsequently modified as and when needed.

The primary outcome was in-hospital mortality. The outcome of renal function was defined 90 days post-discharge by the values of eGFR as full recovery (eGFR >90ml/min/1.73m^2 after AKI, or in pre-existing CKD patients, <20% reduction in baseline eGFR), partial recovery (eGFR ≥15-<90ml/min/1.73m^2 after AKI, or in pre-existing CKD patients >20% reduction in baseline eGFR), no recovery (eGFR <15ml/min/1.73m^2 requiring KRT) or mortality.

Data was analysed using SPSS 22. Data was expressed as mean ±standard deviation, median with interquartile range, or frequencies and percentages, as appropriate. Categorical variables were compared using chi-square test. P<0.05 was considered statistically significant.

Results

Of the 210 patients with mean age 46.1±14.24 years, 109(52%) were males and 101(48%) were females. Hypertension (HTN) was the most common comorbidity 98(46.8%), followed by diabetes mellitus (DM) 75(35.7%) and underlying CKD 55(26.2%). There were 98(46.7%) patients who presented with renal type of AKI. Mean eGFR on arrival was 6.1± 2.8 ml/min/m2. Multiple therapeutic interventions were required, including vasopressors in 101(48.1%) patients and MV in 31(14.8%). Overall, 51(24,3%) patients underwent renal biopsy, 45(21.4%) required steroids, 37(17.6%) cytotoxic agents, and 13(6.2%) plasmapheresis (Table 1).

Table-1: Demographic characteristic of the patients (n=210).

Characteristics	AKI cases [n (%)]
Mean Age (years)	46.1±14.24
Gender	
Male	109 (51.9)
Female	101 (48.1)
DM	75 (35.7)
HTN	98 (46.8)
CKD	55 (26.2)
CHF	36 (17.1)
Malignancy	24 (11.4)
Aetiology	
Pre-renal	51 (24.3)
Renal	98 (46.7)
Post-renal	61 (29)
Vasopressors	101 (48.1)
Mechanical ventilation	31 (14.8)
Renal biopsy	51 (24.3)
Cytotoxic agents	37 (17.6)
Steroids	45 (21.4)
Plasmapheresis	13 (6.2)
Hospital stay	
Ward	62 (29.5)
ICU	31 (14.8)
Both	117 (55.7)

DM: Diabetes mellitus, HTN: Hypertension, CKD: Chronic kidney disease, CHF: Congestive heart failure, ICU: Intensive care unit.

Renal failure due to intrinsic renal aetiology was the most common 98(46.7%), followed by post-renal aetiology 61(29%). Sepsis was the most common aetiology 29(13.8%). (Table 2).

The risk of post-renal AKI was more in patients aged >45 years, while pre-renal and renal AKI were more prevalent in younger age (p<0.05). There was no significant gender difference between pre-renal and renal groups (p>0.05), while significant male predominance was found in post-renal patients (p<0.05). Patients with pre-existing HTN, DM and CKD mostly presented with pre-renal and post-renal aetiologies (p<0.05). Patients with underlying malignancy were mostly in the post-renal group, and more cardiac patients were noted in the pre-renal group (p<0.05) (Table 3).

Table-3: Risk factors for acute kidney injury (AKI) (n=210).

	Pre-renal (n=51) n (%)	**Renal** (n=98) n (%)	**Post-renal** (n=61) n (%)	***p*-value**
Age (years)				
≥18 - 30	9 (17.6)	20 (20.4)	9 (14.7)	0.05
31 - ≤45	13(25.5)	35 (35.7)	14 (23)	
45 - ≤60	21 (41.2)	32 (32.7)	19 (31.1)	
>60	8 (15.7)	11 (11.2)	19 (31.1)	
Gender				
Male	26 (51)	44 (44.9)	39 (63.9)	0.06
Female	25 (49)	54 (55.1)	22 (36.1)	
Co-morbids				
DM	28 (54.9)	28 (28.6)	19 (31.1)	0.004
HTN	26 (51)	45 (45.9)	27 (44.3)	0.76
CHF	22 (43.1)	8 (8.2)	6 (9.8)	<0.05
CKD	21 (41.2)	13 (13.3)	21 (34.4)	<0.05
Malignancy	1 (2)	1 (1)	22 (36.1)	<0.05

DM: Diabetes mellitus, HTN: Hypertension, CKD: Chronic kidney disease, CHF: Congestive heart failure.

Table-2: Aetiological characteristics of the patients (n=210).

Aetiology	**n (%)**
Pre-renal	51 (24.3)
Acute gastroenteritis	18 (8.6)
Blood loss	16 (7.6)
Heart Failure	17 (8.1)
Renal	98 (46.7)
Sepsis	29 (13.8)
Acute GN	18 (8.6)
AIN	13 (6.2)
Toxin induced ATN	7 (3.3)
Pigment induced ATN	9 (4.3)
Vasculitis	12 (5.7)
Pregnancy induced HUS	5 (2.4)
Pre-eclampsia	2 (0.9)
Eclampsia	3 (1.4)
Post-renal	61 (29)
Obstruction due to stone	26 (12.4)
Bladder growth	20 (9.5)
BPH	15 (7.1)

GN: Glomerulonephritis, ATN: Acute tubular necrosis, AIN: Acute interstitial nephritis, HUS: Haemolytic uraemic syndrome, BPH: Benign prostatic hyperplasia.

Table-4: Renal outcomes at 90 days (n=210).

	Total n (%)	**Pre-renal** n (%) (n=51)	**Renal** n (%) (n=98)	**Post-renal** n (%) (n=61)	***p*-value**
Complete recovery	71(33.8)	20 (39.2)	31 (31.6)	20 (32.8)	0.74
Partial recovery	73 (34.76)	15 (29.4)	37 (37.8)	21 (34.4)	
No recovery	34 (16.1)	7 (13.7)	14 (14.3)	13 (21.3)	
Death	32 (15.2)	9 (17.6)	16 (16.3)	7 (11.5)	

There was increase in CKD cases from 55(26.2%) patients at baseline to 107(50.9%) at the end of 90 days. Complete recovery was noted in 71(33.8%) patients, partial in 73(34.76%), no recovery in 34(16.1%) patients who required maintenance KRT, and 32(15.2%) patients died (Table 4).

Discussion

The current study had majority of young patients (mean age 46.1±14.24 years) and most were males (51.9%). Epidemiological data confirmed that these finding were consistent with earlier reports[6,16-18] with respect to a younger age group. Male gender was considered a significant factor associated with AKI probably due to more frequent vascular diseases.[19] A meta-analysis found that the development of hospital-acquired AKI was 2.2 times more likely to occur in males.[19]

As the current cohort comprised patients requiring KRT on arrival or thereafter, the eGFR was expected to be <15ml/min/1.73m^2. The current sample's mean eGFR on arrival was <10ml/min/m^2. In the study, 46.7% patients were detected with intrinsic type of AKI, while pre-renal and post-renal AKI was seen in 24.3% and 29% patients, respectively. The prevalence of intrinsic causes was similar to the occurrence of renal causes in earlier studies as well[20,21] while pre renal AKI was less frequent. The fact that there were more intrinsic AKI cases and fewer with post-renal causes may explain the relatively young age of the current sample.

In the present study, the main aetiological factors of AKI were sepsis (13.8%), obstructive nephropathy due to stone disease (12.4%), genitourinary cancer (9.5%), benign prostatic hyperplasia (BPH) (7.1%), and acute glomerulonephritis (GN), gastroenteritis and heart failure (about 8% each), followed by blood loss (7.6%) and acute interstitial nephritis (AIN) (6.2%), with other aetiologies having a prevalence of <5%. Sepsis and heart failure were among the four most common causes of AKI in earlier studies,[22,23] which is consistent with the current findings. In contrast, AIN was the most common cause of AKI in one study,[21] while obstetrical causes were predominant in

studies conducted in Pakistan.[6,7]

The current data supported evidence that in addition to age and gender, DM, HTN, CKD, congestive heart failure (CHF) and malignancy were also significant risk factors for AKI.[24] Pre-existing CKD was present in approximately one-fourth of the current patients (26.2%) and almost 50% of them had some kind of comorbid condition. In line with recent reports,[25] the current results confirmed that the most common comorbidities were HTN (46.8%) and DM (35.7%), followed by CHF (17.1%) and malignancy (11.4%).

The chance of recovery from AKI is largely dependent on aetiology as well as stage of AKI on arrival (26-27). According to KDIGO criteria[14] all the current patients were in stage 3 as they required KRT. The recovery not only depends on aetiology, but also on how early they presented, and were subsequently hospitalised and treated. The current study noted complete recovery in almost one-third of the patients, which was almost equal in all three AKI categories. This was contrary to a Pakistani study[6] in which 67.7% patients had complete recovery. The discrepancy may have been because 70% of the patients underwent RRT in the other study[6] as opposed to the current study in which all patients underwent KRT. Moreover, the most common aetiologies were obstetric complications, followed by obstructive uropathy, in the study,[6] which was contrary to the current study.

AKI is associated with short- and long-term mortality. The risk factors identified have been hypotension and need for vasoactive drugs, septic shock, use of nephrotoxic drugs, respiratory insufficiency and need for MV, multiple organ dysfunction, metabolic acidosis and anaemia.[28] The current results showed 15.2% mortality for AKI survivors after 90 days of follow-up. Studies have reported mortality rate ranging from 20% to 50%.[29-31] The low mortality in the current study could have been because of younger age of the sample, and short duration of the follow-up post-discharge, as complications may take time to manifest.

In the current study, the highest death rate was associated with pre-renal aetiology. This was possibly due to increased presence of pre-existing comorbidities that have been reported to be associated with high mortality after AKI.[25] Post-renal AKI was associated with a higher recovery rate, which was most likely because kidney damage caused by obstruction is transient and mild, and is reversible after removal of the obstruction.

The current study has several limitations. First, the study specifically focussed on AKI patients who underwent KRT. Second, given the observational nature of the study, a cross-sectional design has inherent weaknesses, such as lack of long-term follow-up. Third, the study was conducted at a single centre with a limited sample size, and, as such, the findings may not be generalisable. Fourth, follow-up time was 90 days, and a more extensive follow-up should be done in patients with kidney diseases. Fifth, the study did not focus on AKI treatment interventions and therapies in depth.

Conclusion

Complete recovery after 90 days of kidney replacement therapy was observed in one-third of the patients. Intrinsic renal aetiology was the most prevalent and HTN was the most common comorbidity.

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Conflict of Interest: None.

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Author Contribution:

RA: Data collection, analysis, and deriving the result.
TE: Concept, design of work, revision of final draft.
SM: Result, discussion, revision.
SY: Data collection, analysis