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ORIGINAL ARTICLE

Acute Kidney Injury in Hospitalized Patients with COVID-19: Evolution and Mortality

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ABSTRACT

Background: COVID-19 infection is commonly complicated by acute kidney injury (AKI) in up to 60-80 % of patients, however, data characterizing the severity and evolution of AKI, are limited. The aim of this study was to describe risk factors associated with AKI severity, in-hospital mortality, and short-term renal recovery in hospitalized COVID-19 patients.

Methods: A prospective cohort study that included Covid-19 patients, who developed AKI during hospitalization. Demographic, clinical, and laboratory data were recorded, and patients were followed up for 3 months. The study included 80 hospitalized COVID-19 patients who developed AKI. AKI stage 1, stage 2 and stage 3 occurred in 27(33.8%), 29(36.2%), and 24(30%) patients, respectively, whereas mortality was higher in stage 3 AKI (58.3%) compared to AKI stage 1(18.5%) and stage 2 (17.2%) p= 0.01. Of the 56 discharged patients, renal recovery occurred in AKI stage 1(100%), compared to AKI stage 2 (79%), and AKI stage 3 (50%). On multivariable analysis, age > 59 years, CKD, requiring dialysis, were associated with higher risk of mortality (Odd ratio: 1.9, 2.3, and 12.3, respectively).

Conclusions: Stage 3 AKI patients had more ICU admissions, more patients required dialysis, less renal recovery, and higher mortality compared to AKI stage 1 and 2. CKD, age > 59 years, and requiring dialysis, were all independently associated with in-hospital mortality. After 3 months follow up renal recovery was the role in mild kidney injury; stage 1 AKI compared to stage 2 and 3.

Key words: COVID-19, Acute kidney injury, AKI, mortality, renal recovery

INTRODUCTION

Coronavirus disease 2019 (COVID 19) is caused by infection with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) **[1]**. The outbreak began in China, in December 2019, then the disease spread rapidly all over the world and was declared a global pandemic in March 2020, by World health organization (WHO) **[2]**. As of September 5, 2022, WHO estimated that SARS-CoV-2 has infected ~600.3 million people and caused ~6.4 million deaths across the globe **[3].**

COVID-19 infection triggers inflammatory processes associated with the release of inflammatory cytokines, that can infiltrate the lungs, leading to severe inflammation and destruction of lung parenchyma **[4]**. In COVID-19 cases, the kidney may be a target for organ injury due to Angiotensin-converting enzyme-2 (ACE-2), the coupling site for SARS-COV2 that is highly expressed in proximal tubule cells and podocytes **[5]**. AKI has been identified as an extreme COVID-19 inflammation with a higher risk of death in critically ill patients. AKI associated with COVID-19 has not been fully elucidated but may be explained by inflammation, tubular damage associated with a viral infection, volume depletion, hemodynamic changes, thrombotic vascular processes, rhabdomyolysis, and glomerular diseases **[6,7]**. AKI patients with COVID-19 were more likely to require KRT than AKI patients without COVID-19 **[8].**

Acute kidney injury (AKI) is a common complication of COVID 19 infection with an incidence rate of 20% in hospitalized patients and more than 50% in critically ill patients **[9]** and up

to 80% in critically ill patients in one study **[10]**. Up to one-third of patients with AKI associated with COVID-19 may require renal replacement therapy **[9]**. And in those patients; The risk of death is increased 3 folds in patients with COVID-19 and severe AKI **[11]**.

In hospitalized COVID-19 patients who developed AKI; risk factors associated with severity of AKI are not well characterized, also data are limited, regarding renal recovery and mortality outcomes in those patients.

The aim of this study was to describe demographic and clinical characteristics of AKI among COVID-19 patients, to define factors associated with the severity of AKI, and to explore the short-term outcome including renal recovery and in-hospital mortality.

METHODS

Study design

This prospective cohort study included COVID-19-infected patients isolated and admitted to the general ward and ICU of Ahmed Galal military Hospital, Egypt. During the study period from May to August 2021, this 120 beds-hospital was an isolation hospital for Covid 19 infected patients.

Study Population: The study included All patients hospitalized with COVID-19 infection associated with AKI; COVID-19 was diagnosed by the positive result of real-time polymerase chain reactions (PCR) for SARS-CoV-2 from a nasopharyngeal swab. All patients were >18 years old. Chronic kidney disease (CKD) patients were included, except those with End stage renal disease, or kidney transplant. During the study period, 80 patients with COVID-19 who developed AKI during admission (41 male & 39 female) were followed up during their hospital stay and after discharge for a total period of 3 months. The study population flowchart is shown in (Figure S1).

The data collected included demographic and clinical variables (age, gender, and history of comorbid conditions; hypertension, diabetes mellitus, ischemic heart disease, chronic obstructive pulmonary disease, and chronic kidney disease (CKD), and laboratory data; complete blood count (CBC), serum electrolyte, serum creatinine; baseline (up to 12 months prior to hospitalization), on admission, peak serum creatinine during hospitalization, and on follow-up; after one month, and after 3 months. Acute phase reactants were obtained at the time of hospital admission including C-reactive protein (CRP), ferritin, D-dimer, liver function tests; serum aspartate aminotransferase (AST), alanine transaminase (ALT), serum Albumin, and total bilirubin. Non-enhanced chest computed tomography (CT) scans were performed **on** all patients on admission, and patients were managed as per Egyptian guidelines for COVID-19 treatment **[12]**. Treatment during hospitalization included Remdesivir, Tocilizumab**,** and steroids. Data regarding requirement of dialysis and number of hemodialysis sessions were also documented.

Definitions

As per the kidney disease: Improving Global Outcomes (**KDIGO**) **[13**] guidelines for AKI:

Baseline serum creatinine was defined as the most recent serum creatinine level that was available within 7–365 days before admission. If baseline creatinine was not available during that period; an estimated glomerular filtration rate (eGFR) of 75 ml/min per 1.73 m^2 was presumed to be the baseline eGFR (as per KDIGO guidelines), then the baseline creatinine was calculated on the basis of a Modification of Diet in Renal Disease study (**MDRD**) equation **[14]**.

Chronic kidney disease (CKD) was defined based on a baseline eGFR of less than 60 mL/min/1.73 m^2 for > 3 months **[13]**.

AKI was diagnosed using the highest serum creatinine during hospitalization.

AKI stages were defined according to KDIGO guidelines for AKI; AKI **stage 1** was defined by an absolute increase of ≥ 0.3 mg/dL within 48 hours or 1.5 to 2 folds increase (within 7 days) of baseline serum creatinine during hospitalization; **stage 2** (>2- 3 folds increase), and **stage 3 (**≥3 folds increase, or serum creatinine ≥4.0 mg/dL with an acute increase of >0.5 mg/dL, or requiring dialysis). Recovery of kidney function was defined as the return of serum creatinine to less than 0.3 mg/dL above baseline **[13]**.

Outcome:

patients were followed up during hospitalization and after discharge for a total period of 3 months; for in-hospital mortality, and to document AKI outcomes either recovery to baseline serum creatinine or not.

Ethical Approvals

The study was approved by "Institutional Review Board" (IRB) committee at Faculty of Medicine, Zagazig University (IRP No.9175-9-6-2019). A written informed consent was taken from all subjects for ethical consideration. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis:

All data were collected, tabulated, and statistically analyzed using SPSS 22.0, IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Continuous Quantitative variables e.g., age were expressed as the mean ± SD, and categorical qualitative variables were expressed as absolute frequencies "number" & relative frequencies (percentage). One-way ANOVA test was used to compare more than two groups of normally distributed data. Categorical data were compared using the Chi-square ($\chi 2$) test. $P < 0.05$ was considered statistically significant (S), $p < 0.001$ was considered highly statistically significant (HS), and $p \geq 0.05$ was considered non statistically significant (NS). Multivariate logistic regression analysis was performed to examine risk factors associated with both AKI and in-hospital mortality after adjustment for age, and sex.

RESULTS

This study included 80 COVID-19 patients who developed AKI during hospital stay.

Table 1 shows age, sex, comorbidities, treatments, frequency of AKI stages, and number of patients who required dialysis. 41(51.3%) patients were male, and 39 (48.8%) were female, their ages ranged from 31 to 73 years (mean of 55.44 years). Regarding the co-morbidities, 50% of our patients were diabetic, 43.8% were hypertensive, 32.5% had ischemic heart disease (IHD), 21.2% had chronic obstructive pulmonary disease (COPD), 38.8% had bronchial asthma and 36.2% well known chronic kidney disease (CKD) patients. 60 (75%) patients were treated with Remdesivir, and 33(41.2%) patients received Tocilizumab. Regarding Oxygen support, 26.2% were on Oxygen (O2) mask, 20 % received continuous positive airway pressure (CPAP), 20 % of patients required mechanical ventilation (MV), and 33.8% required only 2 liters of nasal oxygen. All patients received corticosteroids; 33.8% low dose, 50% moderate dose, and 16.2% high dose as per the Egyptian COVID protocol[12].

Table 2 shows 27(33.8%) patients developed AKI stage 1, 29 (36.2%) patients stage 2, and 24 (30.0%) patient stage 3. AKI stage 3 patients were more commonly to receive Tocilizumab, Remdesivir, moderate or high dose steroids, and receive CPAP ventilation, and mechanical ventilation compared to AKI stage 1, or stage 2, with all variables, showed statistically significant differences.

Table 3 shows the comparison between AKI stage 1, 2, and 3 regarding disease course:

AKI stage 3 showed worst course compared to stage 1 and stage 2. Patients with AKI stage 3 had more ICU admissions (91%), need for dialysis therapy (58%), higher mortality (58%), and less renal recovery at 3 months after discharge (50 % of the discharged patients).

Table 4 compares serum creatinine in hospital and on follow-up in all patients, and **Table 5** compares serum creatinine between AKI stages during follow-up; serum creatinine improved and there was highly statistically significant difference in serum creatinine at; baseline (AKI), after 1month and 3 months of follow up.

Table 6 shows multivariate logistic regression analysis for predictors for in-hospital mortality, shows that; Age >59, having CKD, and, requiring dialysis; were independently associated with increased risk of mortality; Odd ratio :1.9, 2.3, and 12.3, respectively, and all were statistically significant. Other statistically non-significant variables were not shown in multivariate analysis (other chronic diseases, MV , remdesivir….).

Table 7 shows multivariate logistic regression analysis for predictors of severe AKI (stage 3 AKI): requiring mechanical ventilation, having CKD, and admission serum creatinine >2.2 mg/dl; were all significantly associated with increased risk of progression to severe AKI; Odd ratio (OR) 1.4, 3.01, and 2.5 respectively. Other statistically non-significant variables were not shown in multivariate analysis (age, other chronic diseases, MV, remdesivir….).

Table S1 shows the comparison of laboratory and clinical data between survivors and non-survivors.

Table S2 shows the comparison between survivors (N. =56) and non-survivors (N. =24) regarding Age, Sex, co-morbidities, and treatment.

Table 1 Distribution of the studied cases according to Age and Sex

		No. = 80
Age (years)	**Mean ± SD**	
	55.44 ± 11.10	
Sex	Female	39 (48.8%)
	Male	41 (51.3%)

		No. = 80
Age (years)	**Mean ± SD**	
	55.44 ± 11.10	
Comorbidities		
Diabetes	40	50.0%
Hypertension	35	43.8%
Ischemic heart disease	26	32.5%
Chronic obstructive lung disease	17	21.2%
Bronchial asthma	31	38.8%
Chronic Kidney disease (CKD)	29	36.2%
Treatment		N (%)
Remdesivir	Yes	60 (75.0%)
Tocilizumab	Yes	33 (41.2%)
Oxygen support	O2 mask CPAP MV Nasal O2 2L	21 (26.2%) 16 (20%) 16 (20%) 27 (33.8%)
Corticosteroids	Low dose Moderate dose High dose	27(33.8%) 40 (50.0%) 13(16.2%)

CPAP: Continuous positive airway pressure; O_2: oxygen

Table 2 Comparison of AKI stages regarding treatments

		Stage of AKI			**Test value**	***p*-value**
		Stage 1	**Stage 2**	**Stage 3**		
		No. = 27	**No. = 29**	**No. = 24**		
Remdesivir	Yes	19 (70.4%)	19 (65.5%)	22 (91.7%)	5.255*	**0.04**
Tocilizumab	Yes	5 (18.5%)	6 (20.7%)	22 (91.7%)	35.988*	**0.001**
O2 support	O2 mask	7 (25.9%)	12 (41.4%)	2(8.3%)	13.410*	**0.01**
	CPAP	2 (7.4%)	2(6.9%)	12(50%)	18.495*	**0.001**
	MV	3 (11.1%)	3(10.3%)	10 (41.6%)	22.912*	**0.001**
	Nasal O2 2L	15 (55.6%)	12 (41.4%)	--	13.723*	**0.01**
Corticosteroids	Low dose	15 (55.6%)	12(41.4%)	--	17.536*	**0.005**
	Moderate dose	9 (33.3%)	13 (44.8%)	18 (75.0%)		
	High dose	3 (11.1%)	4 (13.8%)	6 (25.0%)		

MV: Mechanical ventilation; CPAP: continuous positive airway pressure**;** O_2: oxygen.

Table 3 Comparison between AKI stage 1 , 2 , and 3 regarding disease course

		AKI stage			Test value	*p*-value
		Stage 1	Stage 2	Stage 3		
		No. = 27	No. = 29	No. = 24		
Time from illness to hospital admission (days)	Median (IQR)	6 (5 – 6)	5 (4 – 6)	5 (4 – 6)	3.488	0.175
	Range	4 – 8	3 – 7	3 – 8		
Timing of AKI since admission (days)	Median (IQR)	2 (2 – 3)	2 (2 – 3)	3 (2 – 4)	10.551	**0.005**
	Range	2 – 6	1 – 7	1 – 6		
Patients required dialysis	No	27	29	10 (41.7%)	11.736	**0.003**
	Yes	--	--	14 (58.3%)		
Number of hemodialysis sessions	Median (IQR)	--	--	6 (4 – 9)	--	--
	Range	--	--	3 – 13		
ICU admission	No	16 (59.3%)	15 (51.7%)	2 (8.3%)	15.657	**0.005**
	Yes	11 (40.7%)	14 (48.3%)	22 (91.7%)		
Prognosis of COVID	Death	5 (18.5%)	5 (17.2%)	14 (58.3%)	23.302	**0.001**
	Cured	22 (81.5%)	24 (82.8%)	7 (29.2%)		
	Cured on O2 nasal 2L	--	--	3 (12.5%)		
Discharged N.	56	22	24	10	37.374	**0.001**
AKI recovery N (%)	39(69.5%)	22(100%)	14 (58.3%)	3 (30.%)	13.231	**0.02**
After one month (56 patients)	40 (71.4%)	22(100%)	15(62.5%)	3(30%)	25.3	**0.005**
After 3 months (56 patients)	46 (82%)	22(100%)	19(79%)	5(50%)	15.41	**0.01**

ICU: intensive care unit; AKI: acute kidney injury; IQR: interquartile range.

Table 4 Comparison between base, Post 1month and Post 3 month Regarding serum creatinine

		AKI	1 month	3 month	Test value	*p*-value
		No. = 80	No. = 56	No. = 56		
S.Creatinine mg/dl	**Mean ± SD**	3.18 ± 1.61	1.71 ± 0.52	1.32 ± 0.49	54.168	**0.001**
	Range	1.3 – 8	0.8 – 3.1	0.7 – 2.8		

Table 5 Comparison between AKI stages regarding peak serum creatinine, after 1month and after 3 months

	stage of AKI			Test value	*p*-value
	stage 1	Stage 2	Stage 3		
Peak S.Creatinine mean ±SD in hospital (N) total 80	2.11 ± 1.10 1.3-3.5 (27)	2.85 ± 1.31 1.9 – 5.5 (29)	4.27 ± 1.03 2.9 – 8 (24)	9.76	**0.05**
After 1 month (N) total 56	1.35 ± 0.44 0.8 – 2.2 (22)	1.91 ± 0.41 1.5 – 3.1 (24)	2.20 ± 0.24 1.8 – 2.5 (10)	20.32	**0.01**
After 3 months (N) total 56	1.02 ± 0.36 0.7 – 2.1 (22)	1.50 ± 0.50 0.9 – 2.8 (24)	1.74 ± 0.24 1.4 – 2.1 (10)	14.61	**0.01**

Table 6 Multivariate logistic regression analysis for predictors for in-hospital mortality

	p-value	Odds ratio (OR)	95% C.I. for OR	
			Lower	Upper
Age >59	0.04	1.9	1.1	3.01
CKD	0.03	2.35	1.6	4.2
Requiring dialysis	0.001	12.33	6.59	24.207

CKD: chronic kidney disease.

Table 7 Multivariate logistic regression analysis for predictors for severe AKI (Stage 3 AKI)

	p-value	Odds ratio (OR)	95% C.I. for OR	
			Lower	Upper
Mechanical ventilation	0.01	1.4	1.1	2.51
CKD	0.001	3.01	1.6	6.24
Admission S.Creatinine >2.2	0.01	2.5	1.71	5.6

CKD: chronic kidney disease.

DISCUSSION

AKI is described as the second most common complication after severe acute respiratory distress syndrome (ARDS) in COVID-19 patients **[15];** AKI occurs in up to 80% of COVID-19 patients admitted to the ICU **[16]**.

In our study, we included 80 patients with COVID-19-associated AKI, those patients were followed up during hospitalization and for 3 months post-discharge; 41 patients were male, and 39 were female, and age of the study group ranged from 31 to 73 years (mean 55.44 years). Our AKI patients were frequently diabetic, hypertensive, CKD, and IHD patients; all those factors were previously identified in COVID-related studies as predisposing factors for AKI associated with COVID-19 infection **[16, 17]**.

29 patients (36.2%) of our AKI patients had prehospitalization CKD; A similar prevalence of CKD, was reported by **Portolés et al [18]** as they reported that 43.5% of AKI patients were well known to have chronic kidney disease (CKD), also **Almenara-Tejederas et al [19]** found that 34% of COVID 19 patients developed AKI, and 22% of those AKI patients had prehospitalization CKD and in these studies, CKD was associated with a higher incidence of AKI, and mortality.

In this cohort, stages of AKI were found to be distributed evenly 27(33.8%), 29(36.2%), and 24(30%), similarly; **Chan et al** showed that stages 1, 2, or 3 AKI occurred in 39%, 19%, and 42%, respectively[16]. Comparable results, (AKI stage 1; 48% stage 2; 21% stage 3; 31% with some predominance of AKI stage 1), were shown by **Almenara-Tejederas et al [19]**. Meanwhile, another group identified AKI KDIGO stage 1 as the most frequent stage, representing 70% of AKI cases **[20],** on the contrary; another analysis by **Tejederas et al [21]** who included 196 patients, showed that AKI stage 3 represented 66% of AKI patients, 17% AKI stage 2 and 15% stage 1 AKI**.**

Patients with severe AKI; AKI stage 3 were more commonly to receive remdesivir, and tocilizumab, to be admitted to ICU (91.7%), with higher mortality (58.3%) compared to stage 1 and stage 2 AKI (18.5%), and (17.2%) respectively. In our study, patients with severe AKI (stage 3) had worse in-hospital course, as they were more commonly admitted to ICU compared to AKI stage 1 and stage 2; (91% vs 40 %, and 48%; respectively), to required CPAP ventilation (50%,7.4%, and 6.9%; respectively), and to require mechanical ventilation (41%, 11%, and 10%; respectively), and all showed statistically significant difference. This association between AKI severity and in-hospital mortality was reported in most studies and is considered to be a determining prognostic factor for COVID-19 infection **[15, 17]**.

24 (30%) of our patients died during hospitalization, similarly many studies reported high mortality in COVID patients who developed AKI**. Almenara-Tejederas et al [19]** reported 34.2 % mortality, which was especially higher in AKI stage 3(56% mortality), **Hirsch et al [17]** reported in-hospital mortality of 35% in COVID-associated AKI in a Norwegian nationwide study that included COVID-19 patients admitted to ICU; **Aukland et al [22]** showed that in-hospital mortality was 30% whereas 90 days mortality was 38.5% in patients with COVID associated AKI, also they concluded that AKI was related to acute

circulatory failure and that mortality was associated with age and AKI at ICU admission**.** In another study by **Morieri et al [23]**, in-hospital mortality was 39.3% in COVID patients with AKI compared to only 4.3% in COVID patients without AKI**.**

In our study, the non-survivors were more commonly older compared to those who survived (p= 0.005), had more comorbidities, all (100% were admitted to ICU, and more commonly (45%) required dialysis (Tables S1 and S2)**.**

In our study, multivariate analysis showed that; age > 59, CKD, and requiring dialysis, all were associated with increased mortality risk. All studies agreed that the occurrence of AKI during hospitalization in COVID-19 patients is as an independent predictor of mortality, and that severity of AKI was associated with higher mortality **[24**, **25].** Also in another study, multivariate regression analysis showed that; hypertension, diabetes mellitus, CKD stage 3–5, male gender, AKI, and malignancy were found to be significantly independent variables increasing mortality **[26]**. Contrary to these data, **Almenara-Tejederas et al [19]** could not detect any influence of the presence of CKD on mortality in their study, and they attributed this to the small number of analyzed population in their study.

In our study, Remdesivir was not shown in multivariate analysis to be associated with an increased risk of developing severe AKI. In their Analysis of data from 850 patients hospitalized with COVID-19, **Wong et al [27]** investigated the effect of remdesivir on AKI and showed that the risk of AKI significantly increased both prior and after remdesivir initiation, but compared together, the risk of AKI was not significantly different, so authors concluded that there is no significant association between remdesivir initiation with the risk of AKI[27]. Similarly, in a propensity score–matched study, **Seethapathy** et al showed that even in patients with eGFR <30 ml/min per 1.73 m^2 remdesivir is well tolerated **[28]**.

In this study, 56(70%) patients were discharged, and at the time of hospital discharge, no patient was maintained on dialysis, as most patients who required dialysis died (11 of 14 (78.5%) patients), whereas the remaining 3 patients could be weaned from dialysis.

At hospital discharge 39 (69.5%) of the survivors recovered baseline kidney function, 22 (100%) of AKI stage 1, 14 (58.3%) of the 24 patients with AKI stage 2, and 3 (30%) of the 10 AKI stage 3 patients, recovered to baseline creatinine on discharge. After 3 months of follow-up, AKI recovery increased to 82% of discharged patients, 79% of AKI stage 2, and 50 % of AKI stage 3. Data regarding follow-up for renal recovery post-COVID-19 associated AKI in hospitalized patients are sparse one study reported that 65% of the survived COVID patients with AKI, recovered baseline kidney function at the time of hospital discharge; and after a mean follow-up of 21 days, this percentage increased to over 69% [16], also **Almenara-Tejederas et al [19]** showed consistent data 62.5% of patients recovered baseline renal function at hospital discharge, and after 128 days of follow up, the percentage of renal recovery increased to 77.0% of the survivors**.** In a retrospective analysis of the 266 COVID-19-associated AKI patients, 71.8% had renal recovery (RR) at hospital discharge; however, there was no follow-up after hospital discharge **[29].** Similar to these studies, we showed that recovery among survivors of COVID-19 infection is common and especially increases with time after hospital discharge.

Our study has limitations. First, it is a single-center study with a small sample size, which may not permit extrapolation of the results. Second, the etiology of AKI was not identified, urine studies were not done, and also we did not evaluate data regarding ICU severity scores that are commonly associated with AKI and mortality. But the strength of this study is that it was a prospective study with 3 months follow up which may give insight into the short-term prognosis of COVID-associated AKI.

CONCLUSIONS

In this study, stage 3 AKI patients had worse hospital course and prognosis with more ICU admissions, more patients required dialysis, less renal recovery, and higher mortality compared to AKI stage 1 and 2. Having CKD, age > 59 years, and requiring dialysis, were all independently associated with in-hospital mortality. After 3 months of follow-up renal recovery was the role in mild kidney injury; stage 1 AKI, compared to stage 2 and 3.

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SUPPLEMENTARY FILES

Supplementary Tables

Table S1 Comparison of laboratory data between survivors and non-survivors

		Prognosis of COVID		Test value	*p*-value
		Survivors	Non-survivors		
		No. = 56	No. = 24		
Time from illness to hospital admission (days)	Median (IQR)	5 (4 – 6)	6 (5 – 7)	-2.090	**0.037**
	Range	3 – 7	3 – 8		
Timing of AKI since admission (days)	Median (IQR)	2 (2 – 2.5)	3.5 (3 – 4)	-4.937	**0.01**
	Range	1 – 4	2 – 7		
AKI stage	stage 1	22 (39.3%)	5 (20.8%)	13.117	**0.001**
	stage 2	24 (42.9%)	5 (20.8%)		
	stage 3	10 (17.9%)	14 (58.3%)		
Patients needed dialysis (N)	No	53 (94.6%)	13 (54.2%)	58.251	**0.001**
	Yes	3 (5.4%)	11 (45.8%)		
Hemodialysis sessions (N)	Median (IQR)	3 (3 – 3)	8 (4 – 10)	-2.105	**0.035**
	Range	3 – 3	3 – 13		
Hemoglobin g/dl	Mean ± SD	10.86 ± 2.10	10.62 ± 1.76	0.494	0.622
	Range	6.2 – 17	7.9 – 14.5		
WBCS × 1000 / mm^3	Median (IQR)	11.2 (8.85 – 11.6)	17.05 (15.5 – 19.95)	-6.005	**0.01**
	Range	3.4 – 26.2	13.4 – 27.2		
Platelet × 1000 / mm^3	Median (IQR)	228 (153.5 – 281.5)	150 (96.5 – 212)	-3.151	**0.002**
	Range	80 – 422	65 – 320		
Lymphocyte / mm^3	Median (IQR)	625 (425 – 790)	690 (470 – 800)	-1.020	0.308
	Range	340 – 980	360 – 920		
	Range	57 – 98	52.6 – 94.4		
Urea mg/dl	Median (IQR)	55 (50 – 65)	180 (162.5 – 190)	-6.838	**0.005**
	Range	45 – 160	100 – 290		
Creatinine mg/dl	Mean ± SD	2.29 ± 0.73	5.25 ± 1.12	-14.034	**0.001**
	Range	1.5 – 5.3	3.5 – 8		
Na mmol/L	Mean ± SD	134.77 ± 4.82	136.42 ± 5.58	-1.336	0.185
	Range	124 – 145	129 – 146		
K mmol/L	Mean ± SD	4.01 ± 0.62	4.79 ± 1.01	-4.257	**0.05**
	Range	2.9 – 5.4	3.1 – 6.5		
ALT IU/L	Median (IQR)	29 (29 – 44)	32.5 (29 – 43.5)	-1.223	0.221
	Range	24 – 65	33 – 131		
AST IU/L	Median (IQR)	29 (24 – 39)	30.5 (25 – 38)	-0.495	0.62
	Range	26 – 65	29 – 94		
Ferritin ng/ml	Median (IQR)	427.5 (330.5 – 728)	509.5 (310 – 1000)	-0.657	0.511
	Range	215 – 2000	11.7 – 3000		
CRP mg/dl	Median (IQR)	57.5 (48 – 85.5)	48 (38.5 – 84)	-1.081	0.279
	Range	18 – 174	8.8 – 143		
D.dimer mcg/ml	Median (IQR)	0.46 (0.33 – 0.62)	0.53 (0.29 – 1.28)	-0.568	0.57
	Range	0.12 – 1.3	0.12 – 4.1		
Total bilirubin mg/dl	Median (IQR)	0.8 (0.7 – 0.1.1)	1.1 (0.9 – 1.4)	-2.531	**0.011**
	Range	0.7 – 1.3	0.8 – 1.6		
Albumin g/dl	Mean ± SD	3.46 ± 0.55	2.86 ± 0.55	4.457	**0.01**
ICU admission	No	33 (58.9%)	0 (0.0%)	24.073	**0.001**
	Yes	23 (41.1%)	24 (100.0%)		

ALT: alanine transaminase, AST: aspartate transaminase, CRP: C-reactive protein, K: potassium Na: sodium, ICU: intensive care unit, WBCs: white blood cell count, AKI: acute kidney injury

Table S2: Comparison between survivors (no. =56) and non-survivors (no. =24) regarding Age, Sex, Co-morbidities, and treatment

		Prognosis of COVID		Test value	*p*-value
		Survivors	Non-survivors		
		No. = 56	No. = 24		
Age	**Mean ± SD**	53.20 ± 10.89	60.67 ± 9.96	-2.883•	**0.005**
	Range	31 – 73	33 – 73		
Sex	Female	24 (42.9%)	15 (62.5%)	2.594*	0.107
	Male	32 (57.1%)	9 (37.5%)		
Co-morbidity	DM	21 (37.5%)	19 (79.2%)	11.667*	**0.001**
	HTN	18 (32.1%)	17 (70.8%)	10.219*	**0.001**
	IHD	12 (21.4%)	14 (58.3%)	10.430*	**0.001**
	COPD	8 (14.3%)	9 (37.5%)	5.410*	**0.02**
	CKD	13 (23.2%)	16 (66.7%)	13.726*	**0.001**
	Bronchial asthma	19 (33.9%)	12 (50.0%)	1.828*	0.176
Treatment					
Remdesivir	Yes	37 (66.1%)	23 (95.8%)	7.937*	**0.005**
Tocilizumab	Yes	10 (17.9%)	23 (95.8%)	42.150*	**0.001**
O2 support	O2 mask	21 (37.5%)	--	54.095*	**0.001**
	CPAP	8 (14.3%)	8 (33.3%)		
	MV	--	16 (66.6%)		
	Nasal O2 2L	27 (48.2%)	--		
Corticosteroids	Low dose	27 (48.2%)	--	25.678*	**0.001**
	Moderate dose	26 (46.4%)	14 (58.3%)		
	High dose	3 (5.4%)	10 (41.7%)		

MV: Mechanical ventilation, CPAP: continuous positive airway pressure**,** $\mathbf{O_2}$: oxygen.

Supplementary Figures

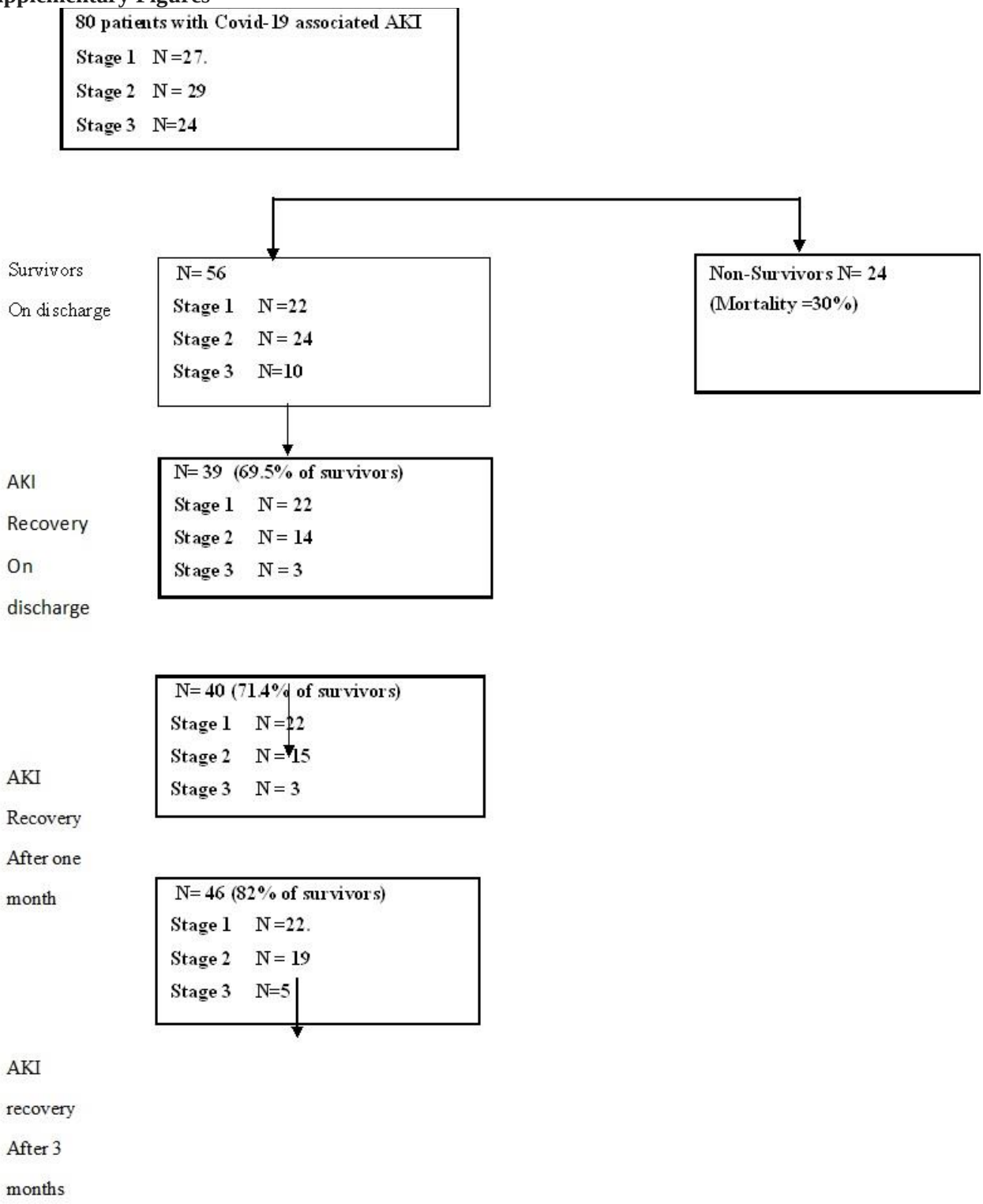

Fig. S1 Study population flowchart. AKI, acute kidney injury