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A Study About Characteristics Of Acute Kidney Injury In Covid 19 Patients In A Tertiary Referral Hospital.

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ABSTRACT

AKI is an important complication of COVID-19 and is related to higher in-hospital mortality. It has also been observed that AKI is an important prognostic marker of disease severity and survival. This study aimed to assess the significance of acute kidney injury in COVID 19 infected individuals. Study included patients aged more than 18 years diagnosed with COVID 19 infection and having AKI. RFT levels, inflammatory markers levels, demographic details are used to assess its significance in diagnosis and prognosis of illness in patients. Characteristics and outcomes of acute kidney injury in hospitalized covid19 patients is observed. Amongst the causes of AKI in the study group, most common cause at the time of admission and during the hospital stay was pre renal, followed by renal. Sepsis was most common specific cause of AKI during the hospital stay followed by dehydration. Patients who had earlier incidence of AKI had greater incidence of RRT initiation and frequency. subjects who were diagnosed with AKI at the time of admission had better survival (79.1%) compared to those who developed during the hospital stay (20.9%) with statistically significant p value <0.001. The study concluded no significant correlation between creatinine levels and HRCT severity scores, biomarkers including ferritin, CRP, d dimer. However, patients who had multiple RRT had increased mean D DIMER levels (4.89).
Keywords: AKI (Acute Kidney Injury), COVID19 (Corona virus disease), RRT (Renal replacement therapy), HRCT (High-resolution computed tomography).

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INTRODUCTION

AKI is an important complication of COVID-19 and is related to higher in-hospital mortality. Furthermore, it is not clear whether AKI in patients with COVID-19 is causally related to a cytopathic effect of the virus or to the systemic inflammatory response and cytokine storm. The pathogenetic mechanisms leading to AKI are complex and include prerenal AKI due to hypovolemia or cardiorenal syndrome and renal AKI secondary to cytokine release syndrome or rhabdomyolysis leading to acute tubular necrosis, virus-mediated injury, drug nephrotoxicity, and intravascular coagulation. COVID-19 AKI has been associated first with sepsis (cytokine storm) and septic shock (hypoxia), second with the use of nephrotoxic drugs, and third with direct cell damage caused by SARS-CoV-2[1, 2]. It has also been observed that AKI is an important prognostic marker of disease severity and survival. The incidence of AKI is higher in patients who require intensive care support.

Review Of Literature

Coronaviruses are enveloped viruses. Inside the envelope, nucleocapsid proteins (N protein) are wrapped with a single-stranded, non-segmented, positive-sense RNA [3]. Coronaviruses are a large family of viruses that are known to cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and severe acute respiratory syndrome (SARS) [4]. The SARS-CoV-2 is causing worldwide outbreak of infection (COVID-19) [4, 5]. COVID-19 patients at disease onset usually present with fever, cough, myalgia and fatigue. In severe cases they presented with breathlessness, pneumonia, acute respiratory distress syndrome, myocarditis and multiple organ failure [6, 7]. RT PCR from nasopharyngeal swab or BAL is the gold standard for diagnosis of COVID19[8]. In case of false negative results and in high suspicion of COVID19, HRCT chest shows high sensitivity in detecting early pulmonary abnormalities suggesting COVID 19. Common findings are ground glass opacities, crazy pavement pattern with bilateral and peripheral distribution [9]. A unique finding associated with SARS-CoV-2 infection is rise in inflammatory markers like CRP [9-12].

The severity of AKI was also related to the mortality rate, which was higher in those with AKI stage 2–3 or with high serum urea and creatinine levels at presentation [13], particularly in those who require RRT. The mortality rate was increased approximately 1.73-fold (74.8%) in the intensive care unit (ICU) patients who received RRT [14]. In summary, AKI affects the prognosis of patients with COVID-19, increases the morbidity and mortality rates and the need for RRT.

AKI is associated with remarkably high mortality among hospitalized COVID-19 patients. The risk factors reportedly associated with mortality in patients with COVID-19, were older age, male gender, and comorbidities, including diabetes mellitus, were also valid among patients with COVID-19 and AKI. Renal problems continue in a significant portion of discharged patients, though few patients depend on dialysis. As AKI stage increases, the complete recovery rate decreases. The complete recovery rate of AKI is lower in patients with CKD than in patients with non-CKD [15]. Objectives of the study was to assess the significance of acute kidney injury in COVID 19 infected individuals. To find the correlation between acute kidney injury and severity of COVID19 at the day of admission and till the day of discharge. To find an association between COVID 19 mortality and Acute kidney injury.

Materials

Source of data were the patients admitted in COVID wards and ICU under department of general medicine, KIMS hospital, Bangalore. Collection of data for the study was done over a period of 24 months. Patients who were more than 18 years diagnosed as COVID 19 positive either by RT PCR or through radiological imaging having AKI during the time period from January 2021 to January 2023 were included in the study. AKI was defined as per KDIGO definition as change in serum creatinine of 0.3mg/dl over 48 hours period or 50% rise in baseline creatinine. Patient aged less than 18yrs, pregnant patients and patients referred to other hospitals or discharged against medical advice were excluded from study.

METHODOLOGY

67 patients fulfilling the inclusion criteria were enrolled for the study. The data collected from patients include age sex, vitals parameters, time of onset of symptoms, routine biochemical and hematological profile, inflammatory markers, RTPCR for COVID 19. RFT levels were analyzed on day of

admission and further followed up till discharge or death. patients were categorized based on severity of illness as per clinical management protocol. RFT levels, inflammatory markers levels, demographic details were collected and values were used to assess its significance in diagnosis and prognosis of illness in patients. Characteristics and outcomes of acute kidney injury in hospitalized COVID19 patients were observed. Data was entered in a pretested proforma. Data recorded were statistically analyzed.

RESULTS

The subjects in study group belong to the age group 26-89 years and included 54 males and 13 females. Majority belonged to age group of 61-80 years. The most common symptom observed in study group was breathlessness followed by fever and cough. Most of the patients were diagnosed with covid-19 within 7 days of symptom onset. Most common comorbidity among study groups was type 2 DM (46 %) and hypertension (31%), followed by IHD (12 %).Mean hematological parameters in study group at admission were as follows: Mean sodium is 135.75, Mean potassium is 5.16, Mean aspartate aminotransferase is 49.79, Mean alanine aminotransferase is 82.33, Mean LDH is 391.52, Mean albumin is 2.95, Mean ferritin is 616.62, Mean D dimer is 3.51, Mean procalcitonin is 1.55, Mean Hb is 10.65, Mean leukocyte count is 12384.5.Mean neutrophil count 82.33%, lymphocyte 7.65%, thrombocyte 0.96%, mean CRP levels 17.46.Mean urea on day of admission is 131.56 and during the stay in hospital is 143.83.Mean creatinine on the day of admission is 5.32 and during the stay in the hospital is 3.64.Mean sodium on the day of admission is 131.98 and during the stay in the hospital is 142.50.Mean potassium on the day of admission is 5.14 and during the stay in hospital is 5.20..Mean LDH on the day of admission is 376.09 and during the stay in hospital is 419.17.Mean ferritin on the day of admission is 573.69 and during the stay in hospital is 693.54.Mean hemoglobin on the day of admission is 10.4 and during the stay in hospital is 11.09.Mean leukocyte count on the day of admission is 12154.19 and during the stay in hospital is 12797.08.Mean neutrophil count on the day of admission is 80.05 and during the stay in hospital is 86.43.Majority of the subjects in study group had HRCT score less than 10 on the day of admission and mean HRCT score during the stay in hospital remained less than 10 followed by score in range of 16-20.

In this study, most of the patients did not have any unfavorable prognostic signs such as Respiratory Distress, Tachycardia, Bradycardia, Tachypnoea, Dehydration, Hypotension.

Oliguria at any time during stay in hospital or at the time of admission. Patients had Lymphopenia (46.3%,31), at the time of admission (58.1%, n25) compared to stay in hospital (25%, n6). Patients also had thrombocytopenia (25.4%, n17), statistically significant number (p- 0.02) at the time of admission (34.9%, n15) compared to stay in hospital (8.3%, n17). Mean lymphocyte count on the day of admission is 11.97 and during the stay in hospital is 8.23. Patients also had elevated levels of AST levels and ALT levels. Mean AST on the day of the admission is 41.84 and during the stay in hospital is 64.04. Mean ALT on the day of admission is 52.35 and during the stay in hospital is 136.04. Most of the people in study group also had hypoalbuminemia. Mean albumin at admission is 3.02 and during hospital stay is 2.83. Also most of the patients had elevated D DIMER levels. Mean D DIMER on the day of admission is 3.35 and during the stay in hospital is 3.80. Procalcitonin was elevated at the time of Admission and during the hospital stay. Mean procalcitonin on the day of admission is 1.67 and during the stay in hospital is 1.32. Amongst the causes of AKI in the study group, most common cause at the time of admission and during the hospital stay is pre renal, followed by renal and sepsis is the most common specific cause of AKI during the hospital stay followed by dehydration. CRP was significantly elevated among the patients. Mean CRP levels on the day of admission is 13.42 and during the stay in hospital is 24.69. Majority patients HRCT score is less than 10 at admission(65.1%) and during hospital stay(54.2%).Most of the patients received glucocorticoid therapy(80.6%),at admission (83.7%) and during hospital stay(75%).Most common cause for AKI was pre renal(88.1%).Specific cause in majority of people is sepsis(n49,73.1%) and majority of them had sepsis at the time of admission(n36,83.7%).

Most of the patients who had AKI at admission required dialysis(n36,83.7%) compared to patients who developed AKI during hospital stay(n14,58.3%) which is statistically significant(p=0.02)

Incidence of AKI was earlier amongst the patients who needed ICU care, intubation and mechanical ventilation. Patients who had earlier incidence of AKI had greater incidence of RRT initiation and frequency.

Most common indication for RRT(n66,98.5%) at the time of admission(n42,97.7%) and during the hospital stay(n24,100.0%) was increasing blood urea, serum creatinine levels with Anuria/Oliguria

followed by metabolic acidosis and refractory hyperkalemia. Majority of the subjects in the study did not have complete recovery of AKI at the time of discharge (Complete Recovery 25.4%, Partial Recovery 6.0%, No Improvement 68.7%) and lost follow up after discharge. 40 patients survived out of 67 patients. Subjects who were diagnosed with AKI at the time of admission had better survival (79.1%) compared to those diagnosed during the hospital stay (20.9%) with statistically significant p value <0.001. 27 patients (40.3%) did not survive. The hematological and biochemical parameters such as urea (Mean 164.70, p value<0.001), AST (Mean 63.85, p value 0.01), ALT (Mean 126.78, p value<0.009)), albumin (Mean 2.72, p value 0.002) had significant correlation among non survivors. In this study neutrophilia, increased Ferritin, CRP, D dimer, LDH were not statistically significant indicator in determining survival outcomes. Mean procalcitonin was more in survivors (1.73) compared to non survivors (1.27). Though most common cause for AKI was sepsis. Majority of subjects in the study group among both the survivors and non survivors had HRCT score less than 10. Among the non survivors 22.2% of subjects had HRCT score 16-20, compared to 12.5% among the survivors. Thus HRCT score may not determine the survival outcomes among these patients. Amongst the subjects, early initiation of Remdesivir and glucocorticoid had favorable outcomes. Lymphopenia is common among survivors group (60.0%, n24) compared to non survivors(25.9%,n7).Even thrombocytopenia is common in survivors(35.0%,n14) group compared to non survivor(11.1%,n3) group. Patients with poor survival outcomes had hypotension(n7,26.9%,p=0.03*), secondary bacterial infection(48.1%,n13,p=0.03*), mechanical ventilation or ECMO requirement (85.2%,n23,p<0.001*).There was no statistically significant difference in cause for AKI among survivors and non survivors as the most common among both was prerenal. Among survivors patients who underwent dialysis for Hypervolemia(n5,12.5%,p=0.04*)) and Severe uremic symptoms (n16,40.0%,p=0.03*) had statistically significant survival rate compared to non survivors. The study concluded significant correlation between LDH levels and creatinine values(p=0.03) by spearman's correlation test. The study concluded no significant correlation between creatinine levels and HRCT severity scores. The study concluded no significant correlation between creatinine values and biomarkers including ferritin, CRP, D dimer. Study did not conclude significant correlation between HRCT score, d dimer, CRP levels and frequency of RRT. However, patients who had multiple RRT had increased mean D DIMER levels (4.89).

Descriptive for Renal & Other Laboratory Parameters among study patients at Admission

Parameters	Category	N	Mean	SD	Median	Min	Max
Renal	Urea(mmol/L)	67	135.96	55.08	144	30	240
	Creatinine(mg/dl)	67	4.72	2.49	4.17	1.1	10.6
Inflammatory, Lipid, Electrolyte, Haematological & CRP	Na(mmol/L)	67	135.75	8.91	135	116	153
	K(mmol/L)	67	5.16	0.95	5.2	3.2	6.6
	AST(UL)	67	49.79	47.22	37	11	210
	ALT(UL)	67	82.33	203.71	27	5	1075
	LDH(UL)	67	391.52	130.86	356	230	900
	Albumin	67	2.95	0.51	2.8	2.2	4.1
	Ferritin(ng/dl)	67	616.62	408.22	546	179.7	2500
	D dimer(mg/L)	67	3.51	4.2	1.8	0.09	20
	Procalcitonin(ng/L)	67	1.55	1.02	1.2	0.23	4.5
	Hb(g/dl)	67	10.65	2.17	10.4	7.5	14.9
	Leucocyte count	67	12384.5	7621.48	11320	1270	49780

Descriptive for Renal & Other Laboratory Parameters among study patients at Admission

Parameters	Category	N	Mean	SD	Median	Min	Max
	Neutrophil count	67	82.33	17.03	88	1	96.7
	Lymphocyte count	67	10.63	7.65	8	0.9	35
	Thrombocyte count	67	2.07	0.96	1.92	0.29	4.55
	CRP levels	67	17.46	14.99	14.2	0.99	80.7

Comparison of mean values of different study parameters based on the Timing of AKI using Mann Whitney Test						
Parameters	AKI Timing	N	Mean	SD	Mean Diff	p-value
Urea(mmol/L)	At admission	43	131.56	54.61	-12.28	0.37
	During Hospital stay	24	143.83	56.21		
Creatinine(mg/dl)	At admission	43	5.32	2.64	1.69	0.01*
	During Hospital stay	24	3.64	1.79		
Na(mmol/L)	At admission	43	131.98	7.09	-10.52	<0.001*
	During Hospital stay	24	142.50	7.86		
K(mmol/L)	At admission	43	5.14	0.92	-0.06	0.61
	During Hospital stay	24	5.20	1.01		
AST(UL)	At admission	43	41.84	39.04	-22.21	0.04*
	During Hospital stay	24	64.04	57.32		
ALT(UL)	At admission	43	52.35	123.63	-83.69	0.04*
	During Hospital stay	24	136.04	294.08		
LDH(UL)	At admission	43	376.09	116.31	-43.07	0.30
	During Hospital stay	24	419.17	152.30		
Albumin	At admission	43	3.02	0.50	0.19	0.11
	During Hospital stay	24	2.83	0.53		
Ferritin(ng/dl)	At admission	43	573.69	253.80	-119.85	0.60
	During Hospital stay	24	693.54	592.41		
D dimer(mg/L)	At admission	43	3.35	3.94	-0.45	0.91
	During Hospital stay	24	3.80	4.71		

Comparison of mean values of different study parameters based on the Timing of AKI using Mann Whitney Test						
Parameters	AKI Timing	N	Mean	SD	Mean Diff	p-value
Procalcitonin(ng/L)	At admission	43	1.67	0.98	0.35	0.04*
	During Hospital stay	24	1.32	1.08		
Hb(g/dl)	At admission	43	10.40	1.99	-0.69	0.32
	During Hospital stay	24	11.09	2.45		
Leucocyte count	At admission	43	12154.19	8141.50	-642.90	0.46
	During Hospital stay	24	12797.08	6735.52		
Neutrophil count	At admission	43	80.05	20.00	-6.38	0.14
	During Hospital stay	24	86.43	8.65		
Lymphocyte count	At admission	43	11.97	8.03	3.74	0.008*
	During Hospital stay	24	8.23	6.39		
Thrombocyte count	At admission	43	2.07	1.00	-0.01	0.78
	During Hospital stay	24	2.07	0.92		
CRP levels	At admission	43	13.42	9.41	-11.26	0.003*
	During Hospital stay	24	24.69	19.96		

Comparison of mean values of different study parameters based on the Timing of AKI using Mann Whitney Test						
Parameters	AKI Timing	N	Mean	SD	Mean Diff	p-value
Urea(mmol/L)	At admission	43	131.56	54.61	-12.28	0.37
	During Hospital stay	24	143.83	56.21		
Creatinine(mg/dl)	At admission	43	5.32	2.64	1.69	0.01*
	During Hospital stay	24	3.64	1.79		
Na(mmol/L)	At admission	43	131.98	7.09	-10.52	<0.001*
	During Hospital stay	24	142.50	7.86		
K(mmol/L)	At admission	43	5.14	0.92	-0.06	0.61
	During Hospital stay	24	5.20	1.01		
AST(UL)	At admission	43	41.84	39.04	-22.21	0.04*
	During Hospital stay	24	64.04	57.32		
ALT(UL)	At admission	43	52.35	123.63	-83.69	0.04*
	During Hospital stay	24	136.04	294.08		
LDH(UL)	At admission	43	376.09	116.31	-43.07	0.30
	During Hospital stay	24	419.17	152.30		
Albumin	At admission	43	3.02	0.50	0.19	0.11
	During Hospital stay	24	2.83	0.53		
Ferritin(ng/dl)	At admission	43	573.69	253.80	-119.85	0.60
	During Hospital stay	24	693.54	592.41		
D dimer(mg/L)	At admission	43	3.35	3.94	-0.45	0.91
	During Hospital stay	24	3.80	4.71		

Comparison of mean values of different study parameters based on the Timing of AKI using Mann Whitney Test						
Parameters	AKI Timing	N	Mean	SD	Mean Diff	p-value
Procalcitonin(ng/L)	At admission	43	1.67	0.98	0.35	0.04*
	During Hospital stay	24	1.32	1.08		
Hb(g/dl)	At admission	43	10.40	1.99	-0.69	0.32
	During Hospital stay	24	11.09	2.45		
Leucocyte count	At admission	43	12154.19	8141.50	-642.90	0.46
	During Hospital stay	24	12797.08	6735.52		
Neutrophil count	At admission	43	80.05	20.00	-6.38	0.14
	During Hospital stay	24	86.43	8.65		
Lymphocyte count	At admission	43	11.97	8.03	3.74	0.008*
	During Hospital stay	24	8.23	6.39		
Thrombocyte count	At admission	43	2.07	1.00	-0.01	0.78
	During Hospital stay	24	2.07	0.92		
CRP levels	At admission	43	13.42	9.41	-11.26	0.003*
	During Hospital stay	24	24.69	19.96		

Comparison of Radiographic & other relevant findings based on Timing of AKI among study patients using Chi Square Test

Variable	Category	At admission		During Hospital stay		Total		p-value
		n	%	n	%	n	%	
Glucocorticoid	Yes	36	83.7%	18	75.0%	54	80.6%	0.39
	No	7	16.3%	6	25.0%	13	19.4%	
Unfavourable prognostic signs at any time during hospital stay	Respiratory Distress	3	7.0%	5	20.8%	8	11.9%	0.11
	Tachycardia	2	4.7%	2	8.3%	4	6.0%	
	Bradycardia	2	4.7%	0	0.0%	2	3.0%	
	Tachypnea	0	0.0%	2	8.3%	2	3.0%	
	Dehydration	2	4.7%	0	0.0%	2	3.0%	
	Hypotension	2	4.7%	0	0.0%	2	3.0%	
	Oliguria	1	2.3%	2	8.3%	3	4.5%	
	Nil	31	72.1%	13	54.2%	44	65.7%	
Relevant Findings	Lymphopenia	25	58.1%	6	25.0%	31	46.3%	0.009*
	Anemia	21	48.8%	11	45.8%	32	47.8%	0.81
	Thrombocytopenia	15	34.9%	2	8.3%	17	25.4%	0.02*
	Shock severe hypotension	6	14.0%	4	17.4%	10	15.2%	0.71
	Secondary bacterial infection	11	25.6%	8	33.3%	19	28.4%	0.50
	Intensive care unit admission	38	76.0%	11	24.0%	49	73.1%	0.01*
	Intubation/ ECMO	9	21.4%	16	66.7%	25	37.9%	<0.001*
	Slow continuous dialysis	34	79.1%	10	41.7%	44	65.7%	0.002*
Duration of stay in intensive care unit(days)	Nil	9	20.9%	9	37.5%	18	26.9%	0.11
	< 3 days	14	32.6%	10	41.7%	24	35.8%	
	3 days - 1 week	14	32.6%	5	20.8%	19	28.4%	
	> 1 week	6	14.0%	0	0.0%	6	9.0%	

Comparison of Suspected & extended causes for AKI, based on Timing of AKI among study patients using Chi Square Test

Variable	Category	At admission		During Hospital stay		Total		p-value
		n	%	n	%	n	%	
Suspected Causes	Pre-renal	38	88.4%	21	87.5%	59	88.1%	0.92
	Renal	11	25.6%	2	8.3%	13	19.4%	0.09
	Post renal	4	9.3%	0	0.0%	4	6.0%	0.12
	Others	10	23.3%	1	4.2%	11	16.4%	0.04*
Suspected Specific Causes	Dehydration	9	20.9%	0	0.0%	9	13.4%	0.02*
	GI loss	2	4.7%	0	0.0%	2	3.0%	0.28
	Heart failure	2	4.7%	0	0.0%	2	3.0%	0.28
	Sepsis	36	83.7%	13	54.2%	49	73.1%	0.009*
	Thrombotic microangiopathy	2	4.7%	0	0.0%	2	3.0%	0.28
Extended causes	Nephrotoxic drugs	2	4.7%	1	4.2%	3	4.5%	0.93
	Post renal Urological	6	14.0%	2	8.3%	8	11.9%	0.50

Comparison of Dialysis requirement & Indications for RRT based on Timing of AKI among study patients using Chi Square Test							
		At admission		During Hospital stay		Total	
Variable	Category	n	%	n	%	n	%	p-value
Dialysis requirement	Yes	36	83.7%	14	58.3%	50	74.6%	0.02*
	No	7	16.3%	10	41.7%	17	25.4%	
Frequency of haemodialysis	Once	2	4.7%	3	12.5%	5	7.5%	0.10
	Twice	7	16.3%	9	37.5%	16	23.9%	
	Thrice	14	32.6%	4	16.7%	18	26.9%	
	Multiple	20	46.5%	8	33.3%	28	41.8%	

Comparison of Dialysis requirement & Indications for RRT based on Timing of AKI among study patients using Chi Square Test							
		At admission		During Hospital stay		Total	
Variable	Category	n	%	n	%	n	%	p-value
Indications for Renal Replacement Therapy	Increase in serum BUN creatinine levels	42	97.7%	24	100.0%	66	98.5%	0.45
	Hyperkalaemia	14	32.6%	7	29.2%	21	31.3%	0.77
	Metabolic acidosis	26	60.5%	0	0.0%	26	38.8%	<0.001*
	Hypervolemia	4	9.3%	1	4.2%	5	7.5%	0.44
	Severe uremic symptoms	18	41.9%	2	8.3%	20	29.9%	0.004*
Renal Improvement	Complete Recovery	11	25.6%	6	25.0%	17	25.4%	0.29
	Partial Recovery	4	9.3%	0	0.0%	4	6.0%	
	No Improvement	28	65.1%	18	75.0%	46	68.7%	

Comparison of Survival Status based on Timing of AKI among study patients using Chi Square Test							
		At admission		During Hospital stay		Total	
Variable	Category	n	%	n	%	n	%	p-value
Survival Status	Survivor	34	79.1%	6	25.0%	40	59.7%	<0.001*
	Non-survivor	9	20.9%	18	75.0%	27	40.3%	

CONCLUSION

Patients with Covid19 and AKI had significant incidence of Lymphopenia and thrombocytopenia during the admission and stay in hospital. Most common cause for AKI at the time of admission and during the hospital stay was pre renal, followed by renal. Sepsis was most common specific cause of AKI during the hospital stay. most common indication for RRT at the time of admission and during the hospital stay

was increasing blood urea, serum creatinine levels with Anuria/Oliguria followed by metabolic acidosis and refractory hyperkalemia.

Subjects who were diagnosed with AKI at the time of admission had better survival (79.1%) compared to those diagnosed during the hospital stay (20.9%) with statistically significant p value <0.001. The study concluded no significant correlation between creatinine levels and HRCT severity scores. Study did not conclude significant correlation between HRCT score, d dimer, CRP levels and frequency of RRT. However patients who had multiple RRT had increased mean D DIMER levels(4.89).

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