Characteristics of Acute Kidney Injury in Hospitalized COVID-19 Patients in an Urban Academic Medical Center

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AKI is a recognized complication of coronavirus disease 2019 (COVID-19) (1). In this study, we characterized the AKI incidence and outcomes in patients with COVID-19 and AKI.

We conducted a retrospective cohort study of 1002 patients admitted from March 1 to April 19, 2020 through the Emergency Department at NewYork-Presbyterian/Weill Cornell Medical Center. Patient follow-up was until at least June 20, 2020, at which time 22 patients were still hospitalized and nine were transferred to another hospital facility. Baseline creatinine was defined as the closest creatinine prior to March 1, 2020 or, if none was available, the creatinine at time of hospital presentation. The Weill Cornell Institutional Review Board approved this study.

AKI, defined by the Kidney Disease Improving Global Outcomes criteria (2), occurred in 294 (29%) of the 1002 patients: stage 1 AKI (n=182, 18%); stage 2 AKI (n=29, 3%); and stage 3 AKI (n=83, 8%). KRT was performed in 59 patients (6%); 53 received hemodialysis and/or continuous venovenous hemodialysis, five received a combination of acute peritoneal dialysis and hemodialysis/continuous venovenous hemodialysis, and one received acute peritoneal dialysis. The time from hospitalization to AKI was a median of 2.2 days in stage 1 AKI, 2.4 days in stage 2 AKI, and 1.6 days in stage 3 AKI.

We evaluated the urine electrolytes and microscopy associated with the AKI event within 3 days. Among those available, the fractional excretion of sodium (FENa) was <1% in 76%, and urine microscopy had granular casts in 21%. The presumed etiology of stage 3 AKI on the basis of manual chart review was acute tubular necrosis (ATN) in 28%, prerenal in 13%, prerenal/ATN in 11%, other causes in 4%, and unknown in 45% of patients. Granular casts were observed more frequently in stage 3 AKI than stage 1 AKI and stage 2 AKI (33% versus 16%, P=0.006).

We compared clinical characteristics of the patients with AKI with those without AKI (Table 1). Patients who developed AKI were older and more frequently had a history of hypertension, diabetes mellitus, congestive heart failure, CKD, and kidney transplantation than patients without AKI (P<0.001). Proteinuria and hematuria were more frequent in patients with AKI than in patients without AKI (P<0.001). Baseline creatinine, admission creatinine, peak creatinine, white blood cells, procalcitonin, troponin I, C-reactive protein, D-dimer, ferritin, lactate dehydrogenase, lactate, and creatine kinase were significantly higher in patients with AKI than in patients without AKI (P<0.001), whereas hemoglobin and albumin levels were significantly lower in patients with AKI than in those without AKI (P<0.001). Patients with AKI were also more likely to have usage of nonsteroidal anti-inflammatory drugs, diuretics, and hydroxychloroquine during hospitalization; intensive care unit admission; mechanical ventilation; use of vasopressors; and longer hospital length of stay than patients without AKI (P<0.001).

Patients with AKI had higher mortality than patients without AKI (40% versus 8%, P<0.001). Among the patients with AKI, 140 (48%) recovered to their baseline kidney function. Among the 154 (52%) who did not recover to their baseline kidney function, 43 received dialysis, among which 34 were dialysis dependent and 26 died (60%), and 111 did not receive dialysis, among which 80 (72%) died (P=0.18). Patients with AKI who did not recover to their baseline kidney function were older; had more congestive heart failure; had less anticoagulation use; and had higher D-dimer, troponin I, and peak creatinine levels than patients with AKI who recovered to their baseline kidney function (P<0.001).

Within the AKI group, we found that the FENa was <1% in a majority of patients, and granular casts were present in 21% of patients. However, another study found that FENa was <1% in 38% of cases of patients with AKI and COVID-19 (3), and therefore, FENa evaluation needs to be interpreted with due caution and may not reflect the AKI etiology. As for potential etiology for the AKI, limited data from patient series of kidney biopsies support ATN as the most common cause of AKI (4). Further studies are needed to better understand the basis for kidney dysfunction.

In this study, we found several laboratory parameters that are significantly different between patients with AKI and patients without AKI. D-dimer level was significantly higher in patients with AKI without

Table 1. For continuous variable, the numbers of measurements are listed (*n* = number in total cohort/number in AKI group/number in the no AKI group)

Characteristics	Total Cohort, *n*=1002, No. (%) or Median (Interquartile Range)	AKI Group, *n*=294, No. (%) or Median (Interquartile Range)	No AKI Group, *n*=708, No. (%) or Median (Interquartile Range)
Demographics and comorbidities			
Age, median, yr	66 (53–76)	69 (59–79)	63 (51–74)
Men	619 (62%)	208 (71%)	411 (58%)
Race			
White	354 (35%)	112 (38%)	242 (34%)
Black	119 (12%)	41 (14%)	78 (11%)
Other	272 (27%)	86 (29%)	186 (26%)
Unknown/declined	257 (26%)	55 (19%)	202 (29%)
Hypertension[a]	597 (60%)	211 (72%)	386 (55%)
Diabetes mellitus[a]	378 (38%)	138 (47%)	240 (34%)
Congestive heart failure[a]	131 (13%)	67 (23%)	64 (9%)
COPD[a]	81 (8%)	36 (12%)	45 (6%)
Obesity[a]	184 (18%)	71 (24%)	113 (16%)
CKD[b]	138 (14%)	66 (22%)	72 (10%)
Kidney transplant recipient	33 (3%)	20 (7%)	13 (2%)
Laboratory parameters[c]			
Baseline creatinine, mg/dl, *n*=1002/294/708	0.9 (0.8–1.2)	1.1 (0.9–1.4)	0.9 (0.8–1.1)
Admission creatinine, mg/dl, *n*=1002/294/708	1.0 (0.8–1.3)	1.2 (0.9–1.9)	0.9 (0.8–1.1)
Peak creatinine, mg/dl, *n*=1002/294/708	1.1 (0.8–1.8)	2.8 (1.8–5.0)	0.9 (0.8–1.2)
WBC$\times 10^3/\mu$l, *n*=1002/294/708	6.9 (5.1–9.6)	7.6 (5.5–10.7)	6.7 (4.9–9.3)
Hemoglobin, g/dl, *n*=1002/294/708	13.4 (12.2–14.8)	13.1 (11.5–14.5)	13.6 (12.4–14.8)
Platelets $\times 10^3/\mu$l, *n*=1000/294/706	207 (156–270)	200 (146–258)	213 (160–273)
ALT, U/L, *n*=995/294/701	34 (22–57)	34 (21–54)	35 (23–59)
AST, U/L, *n*=986/291/695	42 (28–65)	46 (30–70)	41 (27–63)
Alkaline phosphatase, U/L, *n*=995/294/701	74 (59–100)	78 (59–105)	73 (58–99)
Total bilirubin, mg/dl, *n*=995/294/701	0.6 (0.4–0.8)	0.6 (0.4–0.9)	0.6 (0.4–0.8)
Albumin, g/dl, *n*=995/294/701	3.2 (2.8–3.5)	3.1 (2.7–3.4)	3.2 (2.9–3.6)
Prothrombin time, s, *n*=878/284/594	13.3 (12.3–14.6)	13.4 (12.6–15)	13.2 (12.3–14.4)
Procalcitonin, ng/ml, *n*=930/278/652	0.17 (0.09–0.42)	0.32 (0.16–0.69)	0.14 (0.08–0.30)
Troponin I, ng/ml, *n*=845/262/583	0.03 (0.03–0.05)	0.04 (0.03–0.12)	0.03 (0.03–0.03)
ESR, mm/h, *n*=716/216/500	73 (49–99)	76 (49–101)	72 (48–97)
CRP, mg/dl, *n*=748/228/520	11 (6–19)	14 (7–22)	10 (5–17)
D-dimer, ng/ml, *n*=686/211/475	442 (273–900)	636 (339–1845)	391 (248–772)
Ferritin, ng/ml, *n*=784/240/544	732 (339–1392)	965 (500–1566)	611 (292–1278)
IL-6, pg/ml, *n*=181/91/90	26 (10–58)	33 (14–63)	18 (9–50)
LDH, U/L, *n*=866/263/603	417 (319–545)	478 (353–608)	399 (311–515)
Lactate, mmol/L, *n*=619/197/422	1.6 (1.1–2.2)	1.9 (1.3–3)	1.5 (1.1–2.0)
Creatine kinase, U/L, *n*=582/199/383	144 (76–308)	186 (86–409)	130 (71–255)
Urine protein, 1+, 2+, 3+, *n*=748/269/479	505 (68%)	207 (77%)	298 (62%)
Hematuria, 1+, 2+, 3+, *n*=748/269/479	362 (48%)	174 (65%)	188 (39%)
Fractional excretion of sodium <1%, *n*=148		112 (76%)	
Urine granular casts >0/hpf, *n*=220		46 (21%)	
Hospital characteristics/outcomes			
NSAID usage in hospital	278 (28%)	104 (35%)	174 (25%)
Diuretic usage in hospital	277 (28%)	178 (61%)	99 (14%)
Anticoagulation usage in hospital	675 (67%)	201 (68%)	474 (67%)
Hydroxychloroquine usage in hospital	695 (69%)	231 (79%)	464 (66%)
ICU admission	274 (27%)	183 (62%)	91 (13%)
Mechanical ventilation	261 (26%)	179 (61%)	82 (12%)
Vasopressor usage	261 (26%)	183 (62%)	78 (11%)
Length of stay, d, *n*=971/281/690	7 (3–17)	17 (7–39)	6 (3–12)
Mortality	172 (17%)	118 (40%)	54 (8%)

Among the laboratory parameters, WBCs, hemoglobin, platelets, ALT, AST, alkaline phosphatase, total bilirubin, albumin, procalcitonin, ESR, CRP, D-dimer, ferritin, and LDH were measured similarly in the AKI group and in the no AKI group ($P>0.05$), whereas prothrombin time, troponin I, IL-6, lactate, urine protein, and hematuria were measured more frequently in the AKI group than the no AKI group ($P<0.05$). *P* values were calculated using the Wilcoxon rank sum test for analysis of continuous variables and using the Fisher's exact test for analysis of dichotomous variables. All statistical analyses were performed using R 3.3.3. CKD indicates baseline creatinine of ≥1.5 mg/dl. COPD, chronic obstructive pulmonary disease; WBC, white blood cell; ALT, alanine aminotransferase; AST, aspartate aminotransferase; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein; LDH, lactate dehydrogenase; hpf, high-power field; NSAID, nonsteroidal anti-inflammatory drug; ICU, intensive care unit.

[a]Obtained using International Classification of Diseases-9 and International Classification of Diseases-10 codes.

[b]A baseline creatinine prior to Emergency Department presentation was used in 320 patients (32%).

[c]All laboratory values were the first values obtained after Emergency Department presentation except for the fractional excretion of sodium <1% and urine granular casts >0/hpf, which were obtained within 3 days of the AKI event. Urine granular casts were detected using an automated system (iRiCELL; Beckman Coulter, Brea, CA), and they were manually verified by laboratory technicians.

kidney function recovery than in patients with AKI and kidney function recovery. A recent study in patients with COVID-19 admitted to the intensive care unit reported D-dimer as predictive of the need for dialysis (5), and it is likely that D-dimer is a predictor of disease severity. We also found a higher IL-6 level in patients with AKI than in patients without AKI. Whether cytokine storm also played a role in kidney injury is unknown. Disease severity may also be linked to men, and further evaluation is needed to understand the relationship between sex and AKI. An important limitation of our study is that the incidence of community-acquired AKI may have been underestimated because only one-third of patients had a baseline creatinine prior to admission.

In conclusion, our study identified a high incidence of AKI in hospitalized patients with COVID-19. We found that a significant proportion did not have complete kidney function recovery, supporting the importance of CKD follow-up in patients with COVID-19.

Disclosures

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