Acute Kidney Injury in Pediatric Patients with COVID-19; Clinical Features and Outcome

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Abstract

Background:

Renal disorders are reported as both underlying conditions and complications in critical pediatric COVID-19 infection. Herein, we investigated the pattern of renal involvement, particularly acute kidney injury (AKI), among pediatric patients with COVID-19.

Methods

We prospectively enrolled hospitalized pediatric patients with the clinical diagnosis of COVID-19 infection. Demographic, clinical, and laboratory findings were gathered and analyzed, using a mixed method of qualitative and quantitative approaches and descriptive statistics.

Results

187 patients including 120 (64.2%) male and 67 (35.8%) female with COVID-19 infection at a median (interquartile range) of 60 (24-114) months were enrolled in this study.

Most patients (n=108, 58.1%) were suffered from one or two underlying comorbidities, mainly malnutrition (77.4%), neurologic/learning disorders (21.4%) and malignancy (10.2%). Kidney was the third organ involved in 30 patients (16%) during hospital admission, after lung (53.5%) and gastrointestinal tract (39%). According to the KDIGO definition and classification, AKI was detected in 38.5% of patients (stage 1: 55.6%, stage 2: 36.1%, stage 3: 8.3%) at presentation or during follow up. Nine patients (4.8%) required hemodialysis and 16 (8.6%) patients were eventually died. There was no significant association between AKI and pediatric intensive care unit (PICU) admission ($p=0.079$), multisystem inflammatory syndrome in children (MIS-C) ($p=0.051$), comorbidities ($p=0.067$), and mortality rate ($p=0.789$).

Conclusions

Kidneys are one of the major organs affected by COVID-19 infection. Although kidney abnormalities resolve in the majority of pediatric COVID-19 infection, particular attention should be given to kidney involvement in COVID-19 patients, particularly children with history of malnutrition and renal disorders.

Introduction

The prevalence of SARS-CoV-2 infection (Severe-acute-respiratory-syndromecoronavirus-2) or COVID-19 (Coronavirus disease 2019) among children is 2.0-7.4% [1-5], categorized as mild to moderate in the majority, asymptomatic in 24.0-26.0%, and severe in 5.9% of patients [6, 7].

Although less frequent than adults, the preexisting medical condition may influence disease severity and outcome [8]. Among others, renal disorders are reported as both underlying conditions (such as

hydronephrosis, chronic kidney disease, kidney anomalies) and complication (acute kidney injury, hematuria, proteinuria, hypertension) of COVID-19 infection, particularly in critically ill pediatric patients [9-11]. However, this might be an underestimation as the reports are based on hospitalized patients mainly at the beginning of the pandemic when the pediatric population was considered to be at low risk of infection and not evaluated systematically [12, 13]. Furthermore, the early stages of acute kidney injury may be asymptomatic and preadmission kidney function may not be available in most patients [14].

In virtue of the longer incubation period and milder symptoms compared with adults [3, 15], internal organ complications may progress insidiously. Therefore, early diagnosis of kidney involvement and application of appropriate treatment can help prevent long-term complications and may be a determining factor in reducing the mortality rate. In this viewpoint, we aimed to investigate the pattern of renal involvement among pediatric patients with COVID-19 with particular attention to acute kidney injury.

Methods

II.A. Participants

From March 1 to December 30, 2020, we prospectively enrolled 187 pediatric patients who were admitted to Mofid Children's Hospital, a tertiary teaching and referral pediatric hospital in Tehran, with the clinical diagnosis of COVID-19 infection. Patients were selected/excluded based on the COVID-19 infection status, history of renal disorders, and creatine level at the admission (**Figure 1**). During the study time, 8283 out of 29367 patients with suspected COVID-19 infection were admitted to the hospital and the diagnosis of COVID-19 infection was established in 576 patients according to the Iranian Ministry of Health COVID-19 consensus. 362 patients with mild COVID-19 manifestations and outpatient management, 16 patients with history of renal disorder and high serum creatinine in admission, and 11 patients without available serum creatinine level were excluded.

Acute kidney injury was defined based on the KDIGO guideline (Kidney Disease Improving Global Outcomes) [16-18]. The COVID-19 infection was considered severe if the patient needed intensive care unit (ICU) stay or mechanical ventilation.

II.B. Data collection and qualitative analysis

A data sheet was developed and patient demographic characteristics, medical comorbidities, clinical presentations, laboratory findings (complete blood count, serum electrolytes, urinalysis, urine culture, blood culture, liver function tests, blood urea nitrogen, first and serial serum creatinine, biochemistry, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) and lactate dehydrogenase), COVID-19 reverse transcription polymerase chain reaction (RT-PCR), chest X-ray (CXR), chest computed tomography (CT) scan, and outcome were gathered by a pediatric nephrology fellowship.

All statistical analyses were performed using SPSS software (v. 26.0, Chicago, IL); Descriptive statistics included means and standard deviation (SD) for normally distributed or medians and interquartile range (IQR) for skewed measures, and proportions for categorical variables. Analytic tests including Mann-Whitney, Chi-square, or Fisher exact tests were applied for comparison. The associations between indicators of kidney involvement and in-hospital death were examined using Cox proportional hazard regression analysis. A P value < 0.05 was considered statistically significant.

Results

Overall, 187 pediatric patients including 120 (64.2%) male and 67 (35.8%) female with COVID-19 infection were enrolled in this study. The median (Interquartile range: IQR) age of the study population was 60 (24-114) months and the median (IQR) hospital admission duration was 5 (3-8.25) days.

The median (IQR) body mass index (BMI) was 16.0 (13.0-18.6). Based on the BMI, patients were categorized as underweight (n=127, 68.3%), normal (n=42, 22.6%), overweight (n=13, 7%), and obese (n=4, 2.2%).

The COVID-19 evidence was observed in CXR of 73.8% (79 of 107) and chest CT scan of 74.6% (85 of 114) of patients. The COVID-19 RT-PCR was evaluated in 84 patients with positive result in 30 (35.7%) and negative result in 54 (64.3%) patients.

The blood pressure at the presentation was evaluated in 148 patients, who were normal in 126 (85.1%), low in 12 (8.1%) and high in 10 (6.8%) patients. At discharge, the blood pressure was in the normal range for 111 out of 116 (95.7%) patients and high in 5 (4.3%) patients.

Underlying comorbidities consisted of malnutrition (n=144, 77.4%), neurologic/learning disorders (n=40, 21.4%), malignancy (n=19, 10.2%), inborn errors of metabolic (n=14, 7.5%), cardiovascular disorder (n=13, 7%), gastrointestinal/hepatic disorders (n=10, 5.3%), chronic pulmonary disorders (n=9, 4.8%), inborn errors of immunity (n=9, 4.8%), and hematologic disorder (n=8, 4.3%).

Positive nephrotoxic drug history was reported in 20 cases (10.7%); angiotensin-converting enzyme inhibitor (n=10, 5.3%), nonsteroidal anti-inflammatory drugs (n=5, 2.7%), trimethoprim/sulfamethoxazole (n=5, 2.7%), calcineurin inhibitors (n=2, 1.1%) and vancomycin (n=1, 0.5%).

Reduced urine volume before admission was detected in 26 (14.3%) patients, edema in 13 (7.1%), urine discoloration in 3 (1.6%), and dysuria in 2 (1.1%) patients.

During hospital admission, organ involvements were as follows: lung (n=100, 53.5%), gastrointestinal tract (n=73, 39%), kidney (n=30, 16%), skin (n=7, 3.7%), heart (n=5, 2.7%), and central nervous system (n=4, 2.1%). In addition, 20 (10.7%) patients developed multisystem inflammatory syndrome (MIS-C).

According to the normal range for age, the serum creatinine level at the presentation was in the AKI range in 72 (38.5%) of 187 evaluated patients. Based on the KDIGO classification, patients with AKI were

categorized as stage 1 (n=40, 55.6%), stage 2 (n=26, 36.1%), and stage 3 (n=6, 8.3%). The comparison of the demographic data, clinical and laboratory findings of patients in AKI or non-AKI groups is presented in **Table 1**.

Most of the patients (n=115, 65.7%) had normal level of leukocytes. Leukocytosis and leukopenia were reported in 32 (18.3%) and 28 (16%) patients, respectively. Majority of patients had normal neutrophil (n=100, 68.5%), lymphocytes (91, 70%), and platelets (73, 51%). While, lymphopenia (n=19, 14.6%), neutropenia (n=12, 8.2%), and thrombocytopenia (n=33, 23.1%) were found in minor groups. Inflammatory markers including ESR (35 of 53, 66%) and lactate dehydrogenase (LDH) (56 of 59, 94.9%), were elevated in most of the evaluated patients.

There was no significant correlation between AKI staging and white blood cell (WBC) ($p=0.888$), neutrophil ($p=0.228$), lymphocyte ($p=0.420$), or LDH ($p=0.218$) count at presentation.

Severe COVID19 disorder was detected in 66 (35.3%) patients. Electrolyte abnormalities was reported in 95 (72.5%) patients. The most frequent electrolyte abnormalities included hyponatremia (46, 35.4%), hypernatremia (4, 3.1%), hypokalemia (11, 8.5%), hyperkalemia (22, 16.9%), hypocalcemia (40, 52.6%), hypophosphatemia (38, 59.4%), and hypermagnesemia (38, 62.3%).

44 patients (23.5%) were admitted in the pediatric intensive care unit (PICU) setting and 27 (14.4%) patients required intubation. There was no significant association between AKI and PICU admission ($p=0.079$), MIS-C ($p=0.051$), and comorbidities ($p=0.067$). Nine patients (4.8%) required hemodialysis. 16 (8.6%) patients were eventually died. The mortality rate was approximately equal in patients with AKI and without AKI (9.7% vs. 7.8%, $p=0.789$). (**Table 2**)

Discussion

In this study, we investigated the pattern of kidney involvement among pediatric patients with COVID-19 with particular attention to acute kidney injury.

Most patients (n=108, 58.1%) were suffered from one or two underlying comorbidities, mainly malnutrition (77.4%), neurologic/learning disorders (21.4%) and malignancy (10.2%). The association between preexisting comorbidities and the risk of severe COVID-19 infection is well established among the adult but not pediatric population. In adults, comorbidities (such as cardiovascular disorders, diabetes, and malignancy) are significantly correlated with severe COVID-19 infection [19, 20]. Few studies have reported severe COVID-19 in 5.1% and 0.2% of patients with and without comorbidities, respectively [21], and underlying comorbidities in about two-thirds of patients with the severe form of infection [22]. Therefore, particular attention should be given to children with underlying comorbidities, in terms of protective measurements and diagnostic approach.

The high level of AKI (38.5%), at presentation or during follow up, and electrolyte abnormalities (72.5%) in this study population is interesting, in part due to the fact that kidney was not expected to this much get

involved in the pathogenesis of COVID-19, as expected for the lungs and gastrointestinal tract.

In our previous pilot study at the beginning of COVID-19 outbreak, AKI was reported in 34.5% of patients [23], half of which were complicated by the stage III AKI. High level of AKI in COVID-19 infection might be explained by the high expression of ACE2 in renal tubular cells [24]. However, the data regarding COVID-19-related kidney complications in children are lacking, which may suggest that COVID-19 mainly affects kidneys in an indirect unmeasurable manner (e.g., dehydration, hypoxia, sepsis-induced cytokine storm, disseminated intravascular coagulation (DIC), rhabdomyolysis, or even inappropriate use of non-steroidal anti-inflammatory drugs (NSAIDs)) [25, 26].

The epidemiological features of AKI among pediatric patients with COVID-19 infection are unknown. According to recent studies, kidney involvement in patients with COVID-19 typically occurs in associations with some critical situations like acute respiratory distress syndrome (ARDS) or multi-organ failure. The incidence of COVID-19 associated AKI varies from 0.5% to 23.0%, these differences may be due to an interval of 7–15 days from baseline visit to the onset of AKI and the hospital that performed the study, as tertiary referral hospitals are more likely to admit complicated patients [27-29].

Wang F. et al. evaluated 275 adults with COVID-19 and observed AKI in 49.5% of patients during their hospital stay. They showed that in comparison with patients without AKI, patients who developed AKI were older, tended to have some degree of chronic kidney disease, and had sepsis-related multi-organ failure [28]. Bowe. B. et al. reported the results of their query in the epidemiology of AKI in 5216 patients with COVID-19 infection and showed an incidence of 32% for AKI in their study group. In their study, 58%, 13%, and 16% met KDIGO definitions of stage 1, 2, and 3 AKI, respectively, and 12% received renal replacement therapy [30].

We did not find any specific correlation between laboratory parameters (such as WBC, lymphocyte count, and LDH) and AKI stage. However, another study found factors that were predictive of stage 2 or 3 AKI including admission respiratory rate, WBC, lymphocyte count, and LDH level [31]. They also demonstrated that patients with COVID-19 and AKI were more likely to require renal replacement therapy (RRT) than those without this viral infection and were less likely to recover kidney function [31]. A study from UK, 29% of 52 pediatric patients developed AKI, as part of MIS-C without any need for RRT [32]. In a recent broad survey from 41 centers, AKI was reported in 106 (44%) critically ill patients [33]. In a systematic review on twenty-four studies, the AKI incidence among 1247 patients at the median age of 9.1 years was estimated about 30.5% and RRT was applied in only 0.56% of patients [34].

Conclusively, AKI seems to complicated one out of three hospitalized patients and whether the kidney injury is going to persist is not clear. In a cohort of 1612 patients with AKI with post-hospitalization follow-up, patients with COVID-19 associated AKI had 11.3 mL/min/1.73 m per year faster decline in GFR. However, further studies are required to provide long-term follow up of COVID-19 patients in terms of post-infectious renal function.

Overall, this study has some limitations. The research was designed with observational and only evaluated hospitalized patients from a single pediatric hospital, thus the prevalence of AKI may not reflect their prevalence among all pediatric COVID-19 patients. Nevertheless, given the rarity of studies on COVID-19 associated AKI in children, this study could be at the forefront to elucidate the prevalence of AKI among these patients. The authors aim to continue this survey with greater sample size including variable underlying disorders, drug history, and severity of COVID-19 infection, and also assessment of renal function in patients complicated with AKI.

Conclusions

Kidneys are one of the major organs affected by COVID-19 infection. Although kidney abnormalities resolve in the majority of pediatric COVID-19 infection, particular attention should be given to kidney involvement in COVID-19 patients, particularly children with history of malnutrition and renal disorders.

Abbreviations

AKI: Acute kidney injury

BMI: Body mass index

COVID-19: Coronavirus Disease 2019

CRP: C-reactive protein

ESR: Erythrocyte sedimentation rate

GFR: Glomerular filtration rate

IQR: Interquartile range

KDIGO: Kidney Disease Improving Global Outcomes

LDH: Lactate dehydrogenase

MIS-C: Multisystem inflammatory syndrome in children

PICU: Pediatric Intensive Care Units

RRT: Renal replacement therapy

RT-PCR: Reverse transcription polymerase chain reaction

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2

Declarations

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Conflicts of interest/Competing interests: The authors declare that they have no conflict of interest.

Availability of data and material: Not applicable.

Code availability: Not applicable.

Authors' contributions

Masoumeh Mohkam, Mahbube Mirzaee, and Mahnaz Jamee developed the original concept and protocol of the study, designed the study and collected the data. Mahnaz Jamee and Fatemeh Abdollah Gorji wrote the manuscript and designed the statistical tests and analyzed the data. Zahra Pournasiri, Seyed Mohammad taghi Hosseini Tabatabaei, Nasrin Esfandiar, and Reza Dalirani contributed to writing the manuscript. Sedigheh Rafiei Tabatabaei, Abdollah Karimi, Shahnaz Armin, Roxana Mansour Ghanaie, Mina Alibeik and Seyed Alireza Fahimzad collected the data, conceived the project, and supervised and coordinated the study.

Ethics approval

The present study was conducted according to the principles expressed in the Helsinki Declaration and the ethic committee of Pediatric Nephrology Research Center and Research Institute for Children's Health of Shahid Beheshti University of Medical Sciences (Ethical code: IR.SBMU.MSP.REC.1399.330).

Consent to participate

The informed consent was obtained from all individual participants (their parents) included in the study.

Consent for publication

Consent for publication was given by each author.

References

1. Wu Z, McGoogan JM (2020) Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. *Jama* 323(13):1239–1242. doi:10.1001/jama.2020.2648
2. Kalantari H, Tabrizi AHH, Foroohi F (2020) Determination of COVID-19 prevalence with regards to age range of patients referring to the hospitals located in western Tehran, Iran. *Gene Rep* 21:100910. doi:10.1016/j.genrep.2020.100910
3. She J, Liu L, Liu W (2020) COVID-19 epidemic: Disease characteristics in children. *J Med Virol* 92(7):747–754. doi:10.1002/jmv.25807

4. Lee PI, Hu YL, Chen PY, Huang YC, Hsueh PR (2020) Are children less susceptible to COVID-19? *J Microbiol Immunol Infect* 53(3):371–372. doi:10.1016/j.jmii.2020.02.011
5. Bi Q, Wu Y, Mei S, Ye C, Zou X, Zhang Z et al (2020) Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study. *Lancet Infect Dis* 20(8):911–919. doi:10.1016/s1473-3099(20)30287-5
6. Chang TH, Wu JL, Chang LY (2020) Clinical characteristics and diagnostic challenges of pediatric COVID-19: A systematic review and meta-analysis. *J Formos Med Assoc* 119(5):982–989. doi:10.1016/j.jfma.2020.04.007
7. Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z et al. Epidemiology of COVID-19 Among Children in China. *Pediatrics*. 2020;145(6). doi:10.1542/peds.2020-0702
8. Mehta NS, Mytton OT, Mullins EWS, Fowler TA, Falconer CL, Murphy OB et al (2020) SARS-CoV-2 (COVID-19): What Do We Know About Children? A Systematic Review. *Clin Infect Dis* 71(9):2469–2479. doi:10.1093/cid/ciaa556
9. Alsohime F, Tamsah MH, Al-Nemri AM, Somily AM, Al-Subaie S (2020) COVID-19 infection prevalence in pediatric population: Etiology, clinical presentation, and outcome. *J Infect Public Health* 13(12):1791–1796. doi:10.1016/j.jiph.2020.10.008
10. Mahmoudi S, Mehdizadeh M, Shervin Badv R, Navaeian A, Pourakbari B, Rostamyman M et al (2020) The Coronavirus Disease 2019 (COVID-19) in Children: A Study in an Iranian Children's Referral Hospital. *Infect Drug Resist* 13:2649–2655. doi:10.2147/idr.S259064
11. Chen F, Liu ZS, Zhang FR, Xiong RH, Chen Y, Cheng XF et al (2020) [First case of severe childhood novel coronavirus pneumonia in China]. *Zhonghua Er Ke Za Zhi* 58(0):E005. doi:10.3760/cma.j.issn.0578-1310.2020.0005
12. Terrie YC (2020) One Impact of the COVID-19 Pandemic on the Pediatric Population: MIS-C. *US Pharmacist* 45(7/8):41–45
13. Buonsenso D, Zampino G, Valentini P. Novel Coronavirus Disease 2019 Infection in Children: The Dark Side of a Worldwide Outbreak. *Frontiers in Pediatrics*. 2020;8(215). doi:10.3389/fped.2020.00215
14. Pei G, Zhang Z, Peng J, Liu L, Zhang C, Yu C et al (2020) Renal Involvement and Early Prognosis in Patients with COVID-19 Pneumonia. *J Am Soc Nephrol* 31(6):1157–1165. doi:10.1681/asn.2020030276
15. Guo CX, He L, Yin JY, Meng XG, Tan W, Yang GP et al (2020) Epidemiological and clinical features of pediatric COVID-19. *BMC Med* 18(1):250. doi:10.1186/s12916-020-01719-2
16. John A, Kellum NL et al. KDIGO Clinical Practice Guideline for Acute Kidney Injury. *Official Journal of the International Society of Nephrology*. 2012;2. doi:10.1038/kisup.2012.2
17. Laycock J, Baum M, Rees L (2020) KDIGO nomenclature glossary for Pediatric Nephrology. *Pediatric Nephrology* 35(12):2201–2203. doi:10.1007/s00467-020-04633-0
18. Levey AEK, Dorman N, Christiansen S, Hoorn E, Ingelfinger J, Inker L, Levin A, Mehrotra R, Palevsky P, Perazella A, Tong A, Allison S, Bockenhauer D, Briggs J, Bromberg J, Davenport A, Feldman H, Fouque

- D, Gansevoort R, Gill J, Greene E, Hemmelgarn B, Kretzler M, Lambie M, Lane P, Laycock J, Leventhal S, Mittelman M, Morrissey P, Ostermann M, Rees L, Ronco P, Schaefer F, St. Clair Russell J, Vinck C, Walsh S, Weiner D CM, Jadoul M, Winkelmayer W. Nomenclature for kidney function and disease: report of a kidney disease: improving global outcomes (KDIGO) consensus conference. *Kidney Int* 2020;97: 1117–1129. doi:10.1016/j.kint.2020.02.010
19. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM et al. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. *Eur Respir J*. 2020;55(5). doi:10.1183/13993003.00547-2020
 20. Li X, Xu S, Yu M, Wang K, Tao Y, Zhou Y et al (2020) Risk factors for severity and mortality in adult COVID-19 inpatients in Wuhan. *J Allergy Clin Immunol* 146(1):110–118. doi:10.1016/j.jaci.2020.04.006
 21. Tsankov BK, Allaire JM, Irvine MA, Lopez AA, Sauvé LJ, Vallance BA et al (2020) Severe COVID-19 Infection and Pediatric Comorbidities: A Systematic Review and Meta-Analysis. *Int J Infect Dis* 103:246–256. doi:10.1016/j.ijid.2020.11.163
 22. Williams N, Radia T, Harman K, Agrawal P, Cook J, Gupta A. COVID-19 Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in children and adolescents: a systematic review of critically unwell children and the association with underlying comorbidities. *Eur J Pediatr*. 2020:1–9. doi:10.1007/s00431-020-03801-6
 23. Mohkam M, Mirzaee M, Abdollah Gorgi F, Rafiei Tabatabaei S, Karimi A, Armin S et al (2021) Renal Involvement in COVID-19 Among Iranian Children. *Arch Pediatr Infect Dis* 9(1):e106597. doi:10.5812/pedinfect.106597
 24. Pan XW, Xu D, Zhang H, Zhou W, Wang LH, Cui XG (2020) Identification of a potential mechanism of acute kidney injury during the COVID-19 outbreak: a study based on single-cell transcriptome analysis. *Intensive Care Med* 46(6):1114–1116. doi:10.1007/s00134-020-06026-1
 25. Valizadeh R, Baradaran A, Mirzazadeh A, Bhaskar LV (2020) Coronavirus-nephropathy; renal involvement in COVID-19. *J Renal Inj Prev* 9(2):e18-e. doi:10.34172/jrip.2020.18
 26. Asgharpour M, Zare E, Mubarak M, Alirezaei A (2020) COVID-19 and Kidney Disease: Update on Epidemiology, Clinical Manifestations, Pathophysiology and Management. *J Coll Physicians Surg Pak* 30(6):19–25. doi:10.29271/jcpsp.2020.Supp1.S19
 27. Gagliardi I, Patella G, Michael A, Serra R, Provenzano M, Andreucci M. COVID-19 and the Kidney: From Epidemiology to Clinical Practice. *J Clin Med*. 2020;9(8). doi:10.3390/jcm9082506
 28. Wang F, Ran L, Qian C, Hua J, Luo Z, Ding M et al. Epidemiology and Outcomes of Acute Kidney Injury in COVID-19 Patients with Acute Respiratory Distress Syndrome: A Multicenter Retrospective Study. *Blood Purif*. 2020:1–7. doi:10.1159/000512371
 29. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z et al (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet* 395(10229):1054–1062. doi:10.1016/s0140-6736(20)30566-3

30. Bowe B, Cai M, Xie Y, Gibson AK, Maddukuri G, Al-Aly Z (2020) Acute Kidney Injury in a National Cohort of Hospitalized US Veterans with COVID-19. Clin J Am Soc Nephrol 16(1):14–25. doi:10.2215/cjn.09610620

31. Fisher M, Neugarten J, Bellin E, Yunes M, Stahl L, Johns TS et al (2020) AKI in Hospitalized Patients with and without COVID-19: A Comparison Study. J Am Soc Nephrol 31(9):2145–2157. doi:10.1681/asn.2020040509

32. Stewart DJ, Hartley JC, Johnson M, Marks SD, du Pré P, Stojanovic J (2020) Renal dysfunction in hospitalised children with COVID-19. The Lancet Child adolescent health 4(8):e28–e29. doi:10.1016/s2352-4642(20)30178-4

33. Bjornstad EC, Krallman KA, Askenazi D, Zappitelli M, Goldstein SL, Basu RK (2021) Preliminary Assessment of Acute Kidney Injury in Critically Ill Children Associated with SARS-CoV-2 Infection. A Multicenter Cross-Sectional Analysis 16(3):446–448. doi:10.2215/cjn.11470720

34. Raina R, Chakraborty R, Mawby I, Agarwal N, Sethi S, Forbes M. Critical analysis of acute kidney injury in pediatric COVID-19 patients in the intensive care unit. Pediatric nephrology (Berlin, Germany). 2021:1–12. doi:10.1007/s00467-021-05084-x

Tables

Table 1. Baseline characteristics of the study population

Baseline characteristics	COVID19 case n=187	AKI n=72	Non-AKI n=115	P- Value
Age group (years)				
Infants 0–1	35 (18.7%)	14 (19.4%)	21 (18.3%)	0.573
Toddlers 1–5	63 (33.7%)	27 (37.5%)	36 (31.3%)	
Children 5–13	60 (32.1%)	23 (31.9%)	37 (32.2%)	
Adolescents ≥13	29 (15.5%)	8 (11.1%)	21 (18.3%)	
Median age (years) (IQR)	5 (2-9.5)	5 (1.9-8.8)	6 (2-11)	0.102
Sex				
Male	120 (64.2%)	45 (62.5%)	75 (65.2%)	0.706
Female	67 (35.8%)	27 (37.5%)	40 (34.8%)	
All comorbidity				
Common comorbidities	108 (58.1%)	35 (49.3%)	73 (63.5%)	0.067
Neurologic disorders	40 (21.4%)	14 (19.4%)	26 (22.6%)	0.715
Hematologic disorders	8 (4.3%)	2 (2.8%)	6 (5.2%)	0.422
Malignancies	19 (10.2%)	5 (6.9%)	14 (12.2%)	0.249
Cardiovascular disorders	13 (7%)	6 (8.3%)	7 (6.1%)	0.743
Pulmonary disorders	9 (4.8%)	3 (4.2%)	6 (5.2%)	>0.999
Malnutrition	144 (77.4%)	52 (72.2%)	92 (80.7%)	0.209
GI/hepatic disorders	10 (5.3%)	3 (4.2%)	7 (6.1%)	0.570
Inborn errors of metabolic	14 (7.5%)	4 (5.6%)	10 (8.7%)	0.572
Inborn errors of Immunity	9 (4.8%)	2 (2.8%)	7 (6.1%)	0.304
Nephrotic syndrome	3 (1.6%)	0 (0%)	3 (2.6%)	–
Serum laboratory findings (Quantitative)				
Total leukocyte count	8.6 (5.7-11.8)	8.5 (5.5-12.7)	8.6 (5.9-11.5)	0.957
Absolute neutrophilic count	5.2 (2.7-8.1)	5.1 (2.5-8.0)	5.3 (3.0-8.5)	0.529
Absolute lymphocyte count	3 (1.8-4.8)	2.9 (2.1-4.6)	3.0 (1.7-4.8)	0.662

Hemoglobin (g/dl)	11 (9.9-12.4)	10.9 (9.9-12.6)	11.3 (10-12.4)	0.878
Platelet count	222 (145-342)	233 (144-343)	222 (145-345)	0.781
CRP	5 (2-25)	5 (1.2-24)	5 (2-34)	0.621
ESR	35 (11-56)	29.5 (6.8-48)	36 (15-60)	0.475
Admission serum creatinine (mg/dl), median (IQR)	0.6 (0.5-0.8)	0.8 (0.6-1.1)	0.5 (0.5-0.6)	<0.001
Discharge serum creatinine (mg/dl), median IQR	0.5 (0.4-0.7)	0.6 (0.4-0.8)	0.5 (0.4-0.6)	0.008
BUN	10 (7.8-15)	12 (8.3-17.7)	10 (7-12.8)	0.020
LDH	608 (475-944)	620 (479-936)	593 (466-968)	0.709
Sodium	136 (134-138)	136 (134-139)	136 (134-138)	0.494
Potassium	4 (3.7-4.4)	4 (3.8-4.4)	4 (3.7-4.3)	0.273
Calcium	8.7 (8.2-9.5)	8.9 (8.2-9.5)	8.7 (8.2-9.4)	0.390
Magnesium	2.2 (1.9-2.3)	2.2 (2-2.3)	2.2 (1.8-2.3)	0.528
Phosphorus	3.9 (3.1-5)	4.2 (3.7-4.9)	3.6 (2.9-5)	0.114
Duration of hospital stay, median (IQR)	5 (3-8.25)	6 (3-9)	5 (3-8)	0.869
Duration of hospital stay <14 days	162 (89%)	63 (91.3%)	99 (87.6%)	0.477
Duration of hospital stay ≥14 days	20 (11%)	6 (8.7%)	14 (12.4%)	

Table 2- Comparison of qualitative variables in COVID-19 Patients

Parameters	Total case	AKI	Non-AKI	OR	95% CI	P-value
Leukocytosis	32 (18.3%)	15 (22.1%)	17 (15.9%)	1.498	0.692-3.245	0.322
Leukopenia	28 (16%)	13 (19.1%)	15 (14%)	1.450	0.642-3.273	0.402
Neutrophilia	34 (23.3%)	12 (20.7%)	22 (25%)	0.783	0.352-1.738	0.689
Neutropenia	12 (8.2%)	8 (13.8%)	4 (4.5%)	3.360	0.962-11.730	0.047*
Lymphopenia	19 (14.6%)	4 (7.4%)	15 (19.7%)	0.325	0.102-1.043	0.050*
Thrombocytopenia	33 (23.1%)	13 (22.4%)	20 (23.5%)	0.999	0.466-2.141	>0.999
High ESR	35 (66%)	11 (61.1%)	24 (68.6%)	0.720	0.220-2.359	0.760
Organ's involvement	157 (84%)	61 (84.7%)	96 (83.5%)	1.098	0.489-2.465	>0.999
Comorbidities	108 (58.1%)	35 (49.3%)	73(63.5%)	0.559	0.307-1.020	0.067
MIS-C	20 (10.7%)	12 (16.7%)	8 (7%)	2.675	1.036-6.909	0.051
Electrolyte disturbance	95 (72.5%)	36 (73.5%)	59 (72%)	1.080	0.487-2.394	>0.999
Admission at PICU	44 (23.5%)	22 (30.6%)	22 (19.1%)	1.860	0.939-3.685	0.079
Need to intubation	27 (14.4%)	14 (19.4%)	13 (11.3%)	1.894	0.833-4.304	0.138
Mortality	16 (8.6%)	7 (9.7%)	9 (7.8%)	1.268	0.451-3.570	0.789

**P-value<0.05 is considered significant.*

Figures

Figure 1

Patient selection process.