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ORIGINAL ARTICLE

Renal Involvement in Hospitalized COVID-19 Patients without Pre-existing Kidney Disease

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Abstract

Introduction: *COVID 19, caused by the highly contagious SARS CoV 2 virus, has resulted in over 6 million deaths worldwide since December 2019. While primarily affecting the pulmonary system, the infection also impacts kidneys. Increasing evidence shows increasing renal impairment among hospitalized COVID-19 patients, highlighting the importance of monitoring renal functions and its association with COVID-19 disease severity.*

Materials & Methods: *This prospective observational study was conducted at Bangladesh Medical University (BMU), from September 2020 to August 2021, involving 231 adult COVID-19 patients with normal baseline serum creatinine. Patients with pre-existing conditions or unwilling to consent were excluded. Relevant data were collected and statistical analysis was conducted.*

Results: *The study population had a mean age of 53.5 ± 14.5 years, with 48.1% participants aged 51–70 years; males comprised 57.1%, and mean BMI was 23.3 kg/m². Fever was the predominant symptom (93.9%), followed by cough (68.8%), loss of smell (50.2%), shortness of breath (45%), diarrhea (37.7%), and body ache (22.5%). Mean SpO, was 93.17 ± 4.21%. Hypertension (29.9%) and diabetes (22.1%) were the most common comorbidities. HRCT revealed 26–50% lung involvement in 44.5% and 51–75% in 35.5% of patients. Average time from symptom onset to admission was 5.9 ± 2.3 days, with hospital stay averaging 13.1 ± 5.3 days. COVID-19 disease severity was moderate in 66.2%, severe in 16.9%, and critical in 5.2%. Renal complications were frequent: AKI occurred in 11.7%, proteinuria and hematuria each in 25.1%, and overall renal involvement in 55.8%. Critical cases showed the highest renal involvement (77.8%), followed by severe (76.9%) and moderate (51%).*

Conclusion: *There is significant impact of COVID-19 on renal function and monitoring renal involvement in hospitalized COVID-19 patients is vital for good prognosis.*

Keywords: *COVID-19, AKI, Renal Involvement.*

Introduction

COVID-19, caused by the highly contagious SARS-CoV-2 virus, has had a devastating global impact, leading to over 6 million deaths since its emergence in late December 2019[1]. COVID-19 infection presents in various clinical forms and is recognized as a multisystem inflammatory syndrome, creating significant challenges for primary physicians. It can range from asymptomatic cases to those requiring outpatient treatment or hospitalization. While the disease primarily impacts the pulmonary system, leading to

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respiratory distress and hospital admissions, it also affects other systems, including the kidneys[2,3]. Several studies have observed and documented an increasing incidence of renal involvement (elevated serum creatinine, hematuria and proteinuria) in COVID-19 patients, particularly among those admitted in hospital[4-7]. Studies have indicated that COVID-19 impacts the kidneys' vascular, tubular, and glomerular compartments[8]. Acute kidney injury (AKI) has also been found to correlate with complications and clinical outcomes. In a systematic review, AKI was found to be associated with increased mortality (relative risk: 13.38), severe disease (RR: 4.43), and the need for ICU support for hospitalized COVID-19 patients (RR: 5.90)[6]. Recent study has also shown in COVID-19 patients, renal involvement to be highly correlated with disease severity and increased risk of mortality during treatment[7].

The SARS-CoV-2 uses the angiotensin II-converting enzyme (ACE2) and the transmembrane serine 2 protease (TMPRSS2) to enter cells. These enzymes are expressed in kidney cells, making them targets for infection[7]. This can lead to alterations in renal function tests and acute renal failure. The presence of virus antigens in kidney tissue and urine of COVID-19 patients supports this theory[9,10]. In addition to its direct cytopathic effects, SARS-CoV-2 triggers a severe immune response, causing macrophage and lymphocyte infiltration, fibrosis, and microvascular changes, leading to acute tubular necrosis and AKI[9]. The virus also disrupts the renin-angiotensin-aldosterone system by occupying ACE2, increasing angiotensin II levels, which may cause nephron vasoconstriction and reduced glomerular filtration rate. This process also raises blood volume and sodium levels due to increased aldosterone activity and decreased angiotensin[11].

Bangladesh was hit by COVID-19 at March 2020, and ever since we have witnessed a high rate of renal involvement and related complications in COVID-19 patients. In depth data regarding renal involvement among hospitalized COVID-19 patients is needed to ensure better prognosis, but there is scarce evidence that evaluate renal involvement among such patients. Therefore, present study aimed to focus on the epidemiology of renal involvement among COVID-19 hospitalized patients, the predictors of this involvement and its association with disease severity.

Materials and Methods

This prospective observational study was conducted in the COVID unit of BMU, Dhaka from September 2020 to August 2021, among adult (age ≥18 years) admitted COVID-19 patients with normal baseline serum creatinine. Patients with pre-existing proteinuria, pre-existing hematuria, on maintenance hemodialysis, renal transplant recipient, pregnant and lactating women, with structural kidney disease like stone or tumor, patients with urinary tract infection or unwilling to give written consent for the study, were excluded. Using purposive sampling technique, 231 respondents were enrolled in the study as per selection criteria. Before starting the study, formal ethical approval was taken from the Institutional review board (IRB) of BMU. Patients' history and clinical examination were done with proper personal protection by wearing personal protective equipment (PPE). Drug history, laboratory and radiological findings, disease course and pre-existing comorbidities were obtained and recorded in data sheet.

The severity of COVID 19 was classified according to BMU clinical case management guidance (2020) into four categories. Mild cases presented with nonspecific symptoms such as fever, cough, sore throat, malaise, headache, myalgia, anosmia, conjunctival redness, or rash, without dyspnea or radiological evidence of pneumonia. Moderate cases included patients with mild symptoms plus radiological findings of pneumonia, respiratory distress with a rate <30 breaths/min, or oxygen saturation >93% on room air. Severe cases were defined by respiratory distress with a rate ≤30 breaths/min, oxygen saturation ≤93% at rest, or arterial partial pressure of oxygen (PaO_2)/ fraction of inspired oxygen (FiO_2) ≤300 mmHg. Critical cases encompassed patients with respiratory failure requiring mechanical ventilation, shock, acute respiratory distress syndrome (ARDS), or other organ dysfunction necessitating intensive care. AKI was diagnosed according to the definition by the KDIGO 2012 Clinical Practice Guidelines[12].

Baseline serum creatinine and previous urine analysis reports were collected if available. When not available prior to the diagnosis of COVID-19, serum creatinine measured on admission was used as the baseline value. Routine investigations including renal function test were done. Patients were followed up at regular interval. For all the respondents, repeat renal function test including urine routine microscopic examination and serum creatinine was done at 48 hours, on day 7 and at discharge. Three months after discharge patients with renal involvement (proteinuria, hematuria, AKI) were followed up. Data were collected using a preformed semi structured data collection sheet (questionnaire). Demographic data of the patients including their age and gender were collected. All information regarding clinical features was recorded. All the reports of the investigations were recorded in the data sheet.

Statistical analysis was performed using Windows® based software program Statistical Packages for Social Sciences 25 (SPSS-25) (Chicago, IL, USA). After collection, all the

data were checked and cleaned. Quantitative data were expressed as percentage, mean and standard deviation and qualitative data were expressed as frequency distribution and percentage. To determine statistical significance, Chi-squared test and Independent Sample T-test were considered according to applicability. P value of < 0.05 was considered statistically significant.

Results

Mean age of the study population was 53.5 ± 14.5 years, with 26.0% respondents from age group 51 – 60 years, followed by 22.1% respondents from 61 – 70 years (Table I). Study population was male (57.1%) predominant. Mean BMI was 23.3 ± 3.2 kg/m^2. Most of the respondents (93.9%) had fever on presentation. Other complaints included cough (68.8%), shortness of breath (45.0%), loss of smell (50.2%), diarrhea (37.7%) and body ache (22.5%). Mean SpO_2 was 93.17 ± 4.21%. Hypertension was the most prevalent comorbidity at 29.9% respondents, followed by DM at 22.1% respondents. In HRCT reports, 44.5% respondents had 26 - 50% lung involvement, followed by 35.5% having 51 - 75% lung involvement. Average time from symptoms onset to admission was 5.9 ± 2.3 days. Average length of hospital stay was 13.1 ± 5.3 days.

COVID-19 disease severity was assessed and 66.2% had moderate disease, followed by 16.9% with severe disease (Figure 1a). AKI status of the study population was assessed (Figure 1b). AKI was found among 27 (11.7%) respondents, of which stage 1 AKI was found among 14 (51.9%) respondents, stage 2 AKI was found among 6 (22.2%) respondents and stage 3 AKI was found among 7 (25.9%) respondents.

Table-I

Descriptive statistics of the study population. (n = 231)

Characteristics		Data
Age (in years)	53.5 ± 14.5	
Age group (in years)	<30	15 (6.5%)
	31 – 40	33 (14.3%)
	41 – 50	48 (20.8%)
	51 – 60	60 (26.0%)
	61 – 70	51 (22.1%)
	>70	24 (10.4%)
Gender	Male	132 (57.1%)
	Female	99 (42.9%)
BMI (kg/m^2)		23.3 ± 3.2
Comorbidities	Diabetes Mellitus (DM)	51 (22.1%)
	Hypertension (HTN)	69 (29.9%)
	Ischemic Heart Disease (IHD)	34 (14.7%)
	Cerebrovascular Disease (CVD)	9 (3.9%)
	Obstructive Airway	19 (8.2%)
Clinical presentation during admission	Fever	217 (93.9%)
	Cough	159 (68.8%)
	Shortness of breath	104 (45.0%)
	Body ache	52 (22.5%)
	Diarrhoea	87 (37.7%)
	Loss of smell	116 (50.2%)
	SpO_2 (%)	93.17 ± 4.21
HRCT findings (percentage of lung involvement)	0%	8 (3.5%)
	1 - 25%	17 (7.4%)
	26 - 50%	103 (44.5%)
	51 - 75%	82 (35.5%)
	>75%	21 (9.1%)
Time from symptoms onset to admission (in days)	5.9 ± 2.3	
Length of hospital stay (in days)	13.1 ± 5.3	

Data presented as n (%) or mean ± SD.

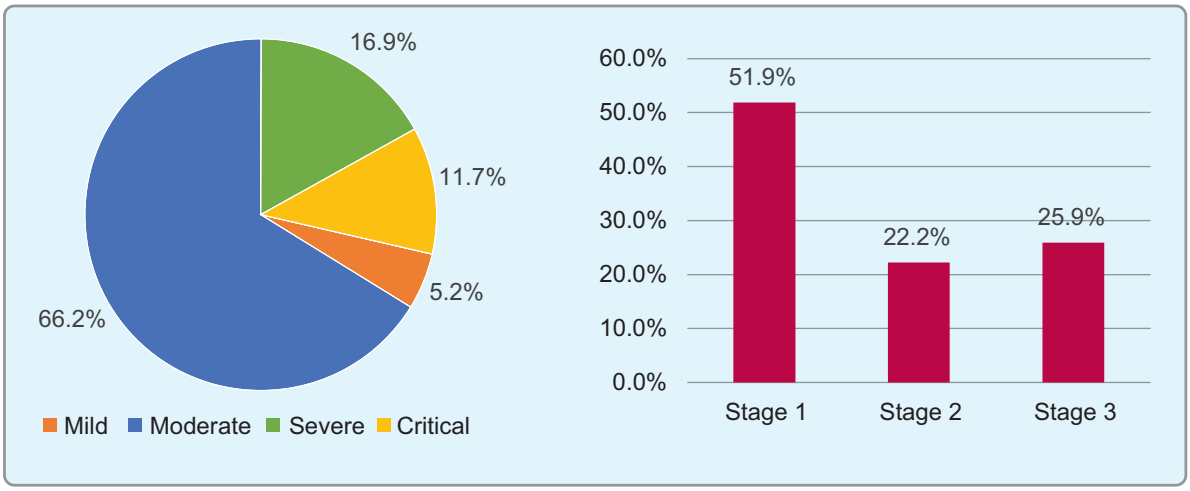

Figure 1: *a: Distribution of study population according to COVID-19 severity. (n = 231). b: Distribution of study population according AKI Stages. (n = 27)*

Respondents were found to suffer from proteinuria, hematuria, AKI and renal involvement (Table II). Proteinuria +1 was found among 58 (25.1%) respondents, of which 37 (16.0%) had moderate disease. Proteinuria +2 to +3 was found among 23 (10.0%) respondents, of which 11 (4.8%) had moderate disease. Hematuria was found among 58 (25.1%) respondents, of which 30 (13.0%) had moderate disease. Among the 27 (11.7%) respondents with AKI, 11 (4.8%) had moderate disease. Renal involvement was found among 129 (55.8%) respondents, of which 78 (33.8%) had moderate disease.

Study population was assessed according to renal involvement relative to disease severity (Table III). Among the study population, respondents with critical COVID-19 disease showed highest (77.8%) renal involvement, followed by 76.9% severe COVID-19 patients with renal involvement and 51.0% moderate COVID-19 patients with renal involvement.

Among the study population, 129 (55.84%) respondents had renal involvement (Table IV). Mean age of patients with renal involvement was 55.3 ± 16.1 years and patients without renal involvement was 51.3 ± 12.0 years, but this difference was not statistically significant. No statistically significant difference was found in terms of gender distribution related to renal involvement. Statistically significant ($p < 0.05$) difference was also observed regarding diabetes status and hypertension among patients with renal involvement

Table-II

Clinical findings according to COVID-19 severity. (n = 231)

Variables		Severity of COVID-19				Total
		Mild	Moderate	Severe	Critical	
Proteinuria	1+	0	37 (16.0%)	11 (4.8%)	10 (4.3%)	58 (25.1%)
	2+ to 3+	0	11 (4.8%)	7 (3.0%)	5 (2.2%)	23 (10.0%)
Hematuria		0	30 (13.0%)	15 (6.5%)	13 (5.6%)	58 (25.1%)
AKI		0	11 (4.8%)	7 (3.0%)	9 (3.9%)	27 (11.7%)
Renal involvement		0	78 (33.8%)	30 (13.0%)	21 (9.1%)	129 (55.8%)

Data presented as n (%).

Table III

Distribution of study population according to renal involvement. (n = 231)

Disease severity	Renal Involvement	
	Frequency	Percentage
Mild (n = 12)	0/12	0
Moderate (n = 153)	78/153	51.0%
Severe (n = 39)	30/39	76.9%
Critical (n = 27)	21/27	77.8%
Total (n = 231)	129/231	55.8%

Table-IV

Distribution of study population according to renal involvement. (n = 231)

Variables		Renal Involvement		P Value
		Present (129, 55.84%)	Absent (102, 44.16%)	
Age (in years)	55.3 ± 16.1	51.3 ± 12.0	0.036[b]	
Gender	Male	81 (35.1%)	51 (22.1%)	0.051[a]
	Female	48 (20.8%)	51 (22.1%)	
Diabetes mellitus	35 (27.1%)	16 (15.7%)	< 0.05[a]	
Hypertension	48 (37.2%)	21 (20.6%)	< 0.05[a]	

Data presented as n (%) or mean ± SD.

[a] Chi-squared test was conducted, P < 0.05 was considered statistically significant.

[b] Independent Sample T-test was conducted, P < 0.05 was considered statistically significant.

Discussion

Mean age of the study population was 53.5 ± 14.5 years. Study population was 57.1% male and 42.9% female. These results are consistent with Pei et al., 2020 study showing mean age of hospitalized COVID-19 patients to be 56.3 years with 54.7% male predominance[13]. Hachim et al., 2021 also showed similar finding among hospitalized COVID-19 patients, which further supports present study findings[14]. Highest prevalence of COVID-19 was observed among respondents in age group 51 – 60 years at 26.0%. This is consistent with Kalantari, Tabrizi and Foroohi, 2020 study showing highest prevalence of COVID-19 patients from the age group of 50–59 years[15]. Present study showed fever (93.9%), cough (68.8%), dyspnoea (45%) and diarrhea (32.4%) to be the most common clinical presentations during admission for COVID-19 patients. Other studies have also shown similar findings[13,16]. Mean SpO_2 in present study was 93.2 ± 4.2% which is consistent with the SpO_2 value (93%) shown in Pei et al., 2020 study[13]. Hypertension (29.9%) and diabetes mellitus (22.1%) were the most frequent comorbidities in present study. Other studies have also revealed hypertension and diabetes mellitus to be the most prevalent comorbidities among COVID-19 hospitalized patients, which supports present study findings[13,17,18]. Present study showed time from symptoms onset to admission to be 5.9 ± 2.3 days, which is consistent with d" 7 days found for most patients in other studies[19,20]. mean length of hospital stay in present study was 13.1 ± 5.3 days, slightly higher than Figueroa et al., 2024 showing 9 days[20].

Among the study population, 66.2% had moderate disease, 16.9% had severe and 5.2% had critical disease. Hong et al., 2020 showed among COVID-19 patients, 60.1% had moderate disease, 14.3% had severe and 6% had critical disease, which is consistent with current study finding [21]. Present study showed 35.1% respondent developed proteinuria and 25.1% developed hematuria during their stay at hospital. Among hospitalized COVID-19 patients, incidents of proteinuria were shown to be 18.4-65.8% and incidents of hematuria were shown to be 17.4-41.7% in other studies[13,21,22]. In present study, 11.7% developed AKI, which is consistent with other studies showing 10.5% to 20.7% COVID-19 patients developing AKI[13,23]. Present study showed 51.9% of the respondents with AKI to have stage 1 disease, followed by 25.9% with stage 3 and 22.2% having stage 3 disease. Alfano et al., 2021 showed similar

findings of 57.9% of the AKI patients having stage 1 disease, 24.6% having stage 2 and 17.3% having stage 3 disease[24].

Present study showed 55.8% of the respondents having renal involvement. Other studies among hospitalized COVID-19 patients have also shown renal involvement to develop among 60-75.4% respondents, supporting present study finding (13,25). In present study, among respondents with critical COVID-19 disease, 77.8% had renal involvement, followed by 76.9% severe COVID-19 patients with renal involvement and 51.0% moderate COVID-19 patients with renal involvement. This is higher than Yang et al., 2020 findings, showing 29% renal involvement among critically ill COVID-19 patients, which is lower than present study findings[26]. Zheng et al., 2020 also suggested increasing prevalence of renal involvement with increasing disease severity among hospitalized COVID-19 patients[27]. Among the study population, statistically significant ($p < 0.05$) difference was observed regarding diabetes status and hypertension among patients with renal involvement. This is corroborated by Abdulaziz Al-Muhanna et al., 2022 study showing substantial increase in disease severity for diabetes mellitus and hypertension among COVID-19 patients with renal involvement[28].

Conclusions

Present study findings highlight the significant impact of COVID-19 on renal function and the importance of monitoring renal involvement in hospitalized COVID-19 patients. Although this was a single center based prospective study, since COVID-19 pandemic is over at the time of publication of this study, a multicenter based retrospective study on the admitted COVID-19 patients' data could be conducted for better understanding the impact of COVID-19 on renal system.

References

1. Sharma A, Ahmad Farouk I, Lal SK. COVID-19: A Review on the Novel Coronavirus Disease Evolution, Transmission, Detection, Control and Prevention. Viruses [Internet]. 2021 Jan 29;13(2):202. Available from: https://www.mdpi.com/1999-4915/13/2/202
2. Ooi SH, Ng KP, Sthaneshwar P, Lim SK, Khor PY, Lim JY, et al. A study of hospitalized COVID-19 patients with AKI in a setting of multiracial developing country. BMC Nephrol [Internet]. 2024 Apr 5;25(1):122. Available from: https://bmcnephrol.biomedcentral.com/articles/10.1186/s12882-024-03498-x
3. Agbuduwe C, Basu S. Haematological manifestations of COVID 19: From cytopenia to coagulopathy. Eur J Haematol [Internet]. 2020 Nov;105(5):540–6. Available from: https://onlinelibrary.wiley.com/doi/10.1111/ejh.13491
4. Hirsch JS, Ng JH, Ross DW, Sharma P, Shah HH, Barnett RL, et al. Acute kidney injury in patients hospitalized with COVID-19. Kidney Int [Internet]. 2020 Jul;98(1):209–18. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0085253820305329
5. Chen YT, Shao SC, Hsu CK, Wu IW, Hung MJ, Chen YC. Incidence of acute kidney injury in COVID-19 infection: a systematic review and meta-analysis. Crit Care [Internet]. 2020 Dec 16;24(1):346. Available from: https://ccforum.biomedcentral.com/articles/10.1186/s13054-020-03009-y
6. Lim MA, Pranata R, Huang I, Yonas E, Soeroto AY, Supriyadi R. Multiorgan Failure With Emphasis on Acute Kidney Injury and Severity of COVID-19: Systematic Review and Meta-Analysis. Can J Kidney Heal Dis [Internet]. 2020 Jan 7;7. Available from: https://journals.sagepub.com/doi/10.1177/2054358120938573
7. Pan X wu, Xu D, Zhang H, Zhou W, Wang L hui, Cui X gang. 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 [Internet]. 2020 Jun;46(6):1114–6. Available from: http://link.springer.com/10.1007/s00134-020-06026-1
8. Sharma P, Uppal NN, Wanchoo R, Shah HH, Yang Y, Parikh R, et al. COVID-19–Associated Kidney Injury: A Case Series of Kidney Biopsy Findings. J Am Soc Nephrol [Internet]. 2020 Sep;31(9):1948–58. Available from: https://journals.lww.com/10.1681/ASN.2020050699
9. Diao B, Wang C, Wang R, Feng Z, Zhang J, Yang H, et al. Human kidney is a target for novel severe acute respiratory syndrome coronavirus 2 infection. Nat Commun [Internet]. 2021 May 4;12(1):2506. Available from: https://www.nature.com/articles/s41467-021-22781-1
10. Naicker S, Yang CW, Hwang SJ, Liu BC, Chen JH, Jha V. The Novel Coronavirus 2019 epidemic and kidneys. Kidney Int [Internet]. 2020 May;97(5):824–8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0085253820302519
11. Kurbel S. The renin angiotensin system in COVID 19: Why ACE2 targeting by coronaviruses produces higher mortality in elderly hypertensive patients? BioEssays [Internet]. 2021 Mar 18;43(3). Available from: https://onlinelibrary.wiley.com/doi/10.1002/bies.202000112
12. Foreword [Internet]. Vol. 2, Kidney International Supplements. 2012. 7 p. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2157171615310455
13. Pei G, Zhang Z, Peng J, Liu L, Zhang C, Yu C, et al. Renal Involvement and Early Prognosis in Patients with COVID-19 Pneumonia. J Am Soc Nephrol [Internet]. 2020 Jun;31(6):1157–65. Available from: https://journals.lww.com/10.1681/ASN.2020030276

14. Hachim brahim Y, Hachim MY, Naeem K Bin, Hannawi H, Al Salmi I, Al-Zakwani I, et al. Kidney Dysfunction among COVID-19 Patients in the United Arab Emirates. Oman Med J [Internet]. 2021 Jan 15;36(1):e221–e221. Available from: http://omjournal.org/articleDetails.aspx?coType=1&aId=2843

15. Kalantari H, Tabrizi AHH, Foroohi F. Determination of COVID-19 prevalence with regards to age range of patients referring to the hospitals located in western Tehran, Iran. Gene Reports [Internet]. 2020 Dec;21:100910. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2452014420303241

16. Li Z, Wu M, Yao J, Guo J, Liao X, Song S, et al. Caution on Kidney Dysfunctions of COVID-19 Patients. SSRN Electron J. 2020;1–25.

17. Trabulus S, Karaca C, Balkan II, Dincer MT, Murt A, Ozcan SG, et al. Kidney function on admission predicts in-hospital mortality in COVID-19. Lazzeri C, editor. PLoS One [Internet]. 2020 Sep 3;15(9):e0238680. Available from: https://dx.plos.org/10.1371/journal.pone.0238680

18. Keivani Boroujeni E, Kellner SJ, Pezeshgi A. Covid-19 and kidney; a mini-review on current concepts and new data. J Nephropharmacology [Internet]. 2020 May 27;10(1):e01–e01. Available from: http://jnephropharmacology.com/Article/npj-8315

19. Peng L, Lv QQ, Yang F, Wu XM, Zhang CC, Wang YQ, et al. The interval between onset and admission predicts disease progression in COVID-19 patients. Ann Transl Med [Internet]. 2021 Feb;9(3):213–213. Available from: https://atm.amegroups.com/article/view/61500/html

20. Figueroa R, Molina P, Villalobos A, Cecilia Canto-Costal A, Patrón D, Aguilar I, et al. 541: IMPACT OF TIME INTERVAL FROM COVID-19 SYMPTOM ONSET TO HOSPITALIZATION: AN OUTCOME ANALYSIS. Crit Care Med [Internet]. 2024 Jan 14;52(1):S244–S244. Available from: https://journals.lww.com/10.1097/01.ccm.0001000340.98841.9f

21. Hong D, Long L, Wang AY, Lei Y, Tang Y, Zhao JW, et al. Kidney manifestations of mild, moderate and severe coronavirus disease 2019: a retrospective cohort study. Clin Kidney J [Internet]. 2020 Jun 1;13(3):340–6. Available from: https://academic.oup.com/ckj/article/13/3/340/5835359

22. Cheng Y, Luo R, Wang K, Zhang M, Wang Z, Dong L, et al. Kidney disease is associated with in-hospital death of patients with COVID-19. Kidney Int [Internet]. 2020 May;97(5):829–38. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0085253820302556

23. Hamilton P, Hanumapura P, Castelino L, Henney R, Parker K, Kumar M, et al. Characteristics and outcomes of hospitalised patients with acute kidney injury and COVID-19. den Uil C, editor. PLoS One [Internet]. 2020 Nov 3;15(11):e0241544. Available from: https://dx.plos.org/10.1371/journal.pone.0241544

24. Alfano G, Ferrari A, Fontana F, Mori G, Magistroni R, Meschiari M, et al. Incidence, risk factors and outcome of acute kidney injury (AKI) in patients with COVID-19. Clin Exp Nephrol [Internet]. 2021 Nov 1;25(11):1203–14. Available from: https://link.springer.com/10.1007/s10157-021-02092-x

25. Kaye AD, Okeagu CN, Tortorich G, Pham AD, Ly EI, Brondeel KC, et al. COVID-19 impact on the renal system: Pathophysiology and clinical outcomes. Best Pract Res Clin Anaesthesiol [Internet]. 2021 Oct;35(3):449–59. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1521689621000094

26. Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med [Internet]. 2020 May;8(5):475–81. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2213260020300795

27. Zheng X, Yang H, Li X, Li H, Xu L, Yu Q, et al. Prevalence of Kidney Injury and Associations with Critical Illness and Death in Patients with COVID-19. Clin J Am Soc Nephrol [Internet]. 2020 Nov;15(11):1549–56. Available from: https://journals.lww.com/10.2215/CJN.04780420

28. Abdulaziz Al-Muhanna F, Ibraham Ali Albakr W, Subbarayalu AV, Cyrus C, Ahmed Aljenaidi H, Ali Alayoobi L, et al. Impact of COVID-19 on Kidney of Diabetic Patients. Medicina (B Aires) [Internet]. 2022 May 6;58(5):644. Available from: https://www.mdpi.com/1648-9144/58/5/644