

MULTIORGAN FAILURES IN COVID-19 PATIENTS AND THEIR ASSOCIATION WITH ADVERSE OUTCOMES

**Parastoo Moradi Choghakabodi¹,
Razieh Pazhouhan Far², Elham
Fattahinezhad³**

¹ School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

² Department of Obstetrics and Gynecology, School of Medicine, Abadan University of Medical Sciences, Abadan, Iran.

³ Department of Pediatrics, School of Medicine, Dezful University of Medical Sciences, Dezful, Iran.

ABSTRACT

Objectives: Organ and kidney failures often occur in patients with severe COVID-19. This study set out to assess organ and kidney failures in COVID-19 patients and their correlation with poor outcomes.

Methods: This retrospective analytical study involved 311 unvaccinated COVID-19 patients admitted at hospital between April and August 2021. Patients' clinical and laboratory information were statistically analyzed. Severity of organ dysfunction was examined using the sequential organ failure assessment (SOFA) score, and kidney dysfunction was assessed using renal parameters and Kidney Disease: Improving Global Outcomes (KDIGO) criteria.

Results: Of the COVID-19 patients, 20.6% (n=64) had kidney dysfunction with common signs of albuminuria [68 (21.8%)] and hematuria [56 (18%)]. Older age, comorbidities, need of mechanical ventilation, chronic kidney disorders, higher SOFA scores, hypoxemia, lymphopenia, albuminuria, and hematuria all associated with COVID-19 severity (P<0.05). The mortality rate was 10%, noting a higher mortality risk in pa-

tients with severe infection. The mentioned factors, especially older age, chronic liver/biliary disease, higher SOFA, and lower PaO₂/FiO₂ ratio were independently related to high risk of mortality (P<0.05). However, the zero mortality rate in non-severe group indirectly highlights the dominant role of infection severity for patients' outcomes and the link between the survival and organ failures.

Conclusions: Organ and kidney failures were key indicators of severe COVID-19 and risk of death. However, the severity of COVID-19 remained the paramount factor influencing both survival status and its association with organ and kidney dysfunction. Monitoring these factors can help the sorting and management of patients according to risk.

Keywords: COVID-19 Severity; Kidney Failure; Organ Failure

1. INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of COVID-19 pandemic, has dramatically affected global health, resulting in organ failure and negative consequences [1, 2]. Entering cells through ACE2 receptor, the virus induces cell damage, hyperinflammation, endothelial dysfunction, microvascular thrombosis, and tissue hypoxia, impacting several organs simultaneously. Particularly in patients with pre-existing conditions, systemic inflammation can cause multi-organ failure resulting from oxidative stress, coagulation and metabolic abnormalities [2-4]. Activation of the renin-angiotensin-aldosterone system adds to vasoconstriction and renal ischemia, thus worsening organ failure [5-7]. The Sequential Organ Failure Assessment (SOFA) score, which includes renal function, is useful for predicting patient outcomes [8].

Given the major impacts of *SARS-CoV-2* on various organs, this study aimed to examine organ and kidney dysfunction in COVID-19 patients and its correlation with negative outcomes and laboratory results. The results can help us better understand the pathophysiology of COVID-19 and find predictors of serious complications, enabling more efficient management, improving clinical outcomes, and lower the mortality rate.

2. METHODS

2.1. Study design and population

Data taken from the medical records of COVID-19 patients who visited the Emergency Department of Sina

ADDRESS FOR CORRESPONDENCE:

Parastoo Moradi Choghakabodi
School of Medicine, Ahvaz Jundishapur University of
Medical Sciences, Ahvaz, Iran
phone: +98 9059676090, Fax: 061-3311
email: parastoomoradi40@yahoo.com

Hospital in Ahvaz, Iran, between April 19, 2021, and August 20, 2021, were used in this retrospective, single-center cohort study. The study was authorized by the ethics committee of university and Sina Hospital in Ahvaz, and adhered to the guidelines set forth in the 2018 Declaration of Helsinki and its subsequent revisions (1401.1.20).

2.2. Inclusion and exclusion criteria

The study included unvaccinated patients with confirmed SARS-CoV-2 infection, determined by positive results on the real-time reverse transcription polymerase chain reaction (RT-PCR) test and chest CT scan, and typical COVID-19 symptoms. Patients with incomplete medical records or those transferred to other hospitals were excluded from the study.

2.3. Study approach and measured parameters

Simple random sampling was applied using the lottery method whereby the main investigator assigned each patient's medical record a unique code to minimize bias. Those codes were placed in a box, and samples were drawn randomly. Investigators gathered patients' information daily for statistical analysis, including demographics, comorbidities, clinical/vital signs, and laboratory results upon admission.

All COVID-19 patients were categorized into two groups: critically ill patients and non-severe cases, based on the World Health Organization (WHO) severity criteria. Those criteria included: severe involvement of lung lobes or a CT severity score greater than 4, acute respiratory distress syndrome (PaO₂/FiO₂ ≤100 mmHg), multiple organ failure, prolonged hospitalization lasting more than seven days, significantly elevated WBC and neutrophil counts, lymphopenia, cytokine storm, severe dyspnea, fatigue, and, in some cases, diarrhea and anorexia [9].

Acute kidney injury (AKI) was described using the Kidney Disease Improving Global Outcomes (KDIGO) clinical practice guidelines as an increase in serum creatinine of ≥0.3 mg/dL within 48 hours or serum creatinine elevation to ≥1.5 times baseline within seven days or urine output less than 0.5 mL/kg/hour for six hours for all patients. The diagnosis of AKI in instances where urine output information was unavailable depended solely on serum creatinine alterations [10].

The Sequential Organ Failure Assessment (SOFA) score evaluates six organ systems: respiratory (PaO₂/FiO₂), coagulation (Platelets), liver (Bilirubin), cardiovascular, renal (Creatinine/Urine Output), and neuro-

logical system. The score ranges from 0 to 24, with a higher score indicating more severe organ failure. A SOFA score above 18 is indicative of multi-organ failure [11, 12].

2.4. Main and secondary outcomes

The main outcomes were the evaluation of organ and kidney dysfunction, the relationship between the degree of organ dysfunction (SOFA score) and survival, as well as assessment of the significant predictors of mortality related to COVID-19. The secondary objective was to explore the relationship of medical markers with the disease severity which enables assessment of disease progression.

2.5. Sample size calculation

Given the proportion of acute kidney injury (AKI: 37.2%) in a recent analogous study by Milani et al [13], a margin of error (d) equal to 0.08 with α= 0.05, N≈ 141 patients here calculated with the following formula: $N = ((Z_{1-\alpha/2})^2 \times P(1-P)) / d^2$

Where: $Z_{1-\alpha/2}=1.96$ (for 95% confidence), $P=0.372$ (prevalence of AKI)

Yet, to maximize the validity of the results, all eligible patients who presented to the hospital were included, giving a final sample of 311 participants.

2.6. Statistical analysis

Statistical analysis was conducted using SPSS 26 (SPSS, Inc., IL, USA). Variables were presented as mean and standard deviation (SD) or frequency. The chi-square test for categorical or t-test for numerical parameters were employed to assess differences between subgroups. Univariate and multivariate logistic regression analyses were utilized to explore the associations between variables. Additionally, univariate and multivariable Cox models were applied to identify independent prognostic factors of survival. A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

Out of the total 426 patients who presented with COVID-19 symptoms to the Emergency Department of Razi Hospital, 311 unvaccinated patients met the inclusion criteria for clinical and laboratory evaluation.

3.1 Demographics and baseline clinical and laboratory characteristics

Among 311 patients, 44.7% (n=172) were male and 55.3% (n=139) were female, 62.7% (n=195) had comorbidities, 28% (n=87) had severe infection, while

Table 1. Baseline clinical and laboratory characteristics of COVID-19 patients and initial comparative analyses between subgroups.

Variables	All patients (n=311)	Min_Max range	Non-Severe Group (n=224)	Severe Group (n=87)	P-value1	Alive Group (n=280)	Deceased Group (n=31)	P-value2
	Mean ± SD / Frequency (%)		Mean ± SD /Frequency (%)			Mean ± SD /Frequency (%)		
Gender:								
Male	172 (55.3)	—	121 (54.0)	51 (58.6)	0.545	152 (54.3)	20 (64.5)	0.37
Female	139 (44.7)	—	103 (46.0)	36 (41.4)	—	—	—	—
Age	55.33± 16.54	15_95	52.19 ± 15.70	63.44 ± 15.95	0.0001*	53.73 ± 15.72	69.81 ± 16.97	0.0001*
Comorbidities:								
Hypertension	195 (62.7)	—	117 (52.2)	78 (89.7)	0.0001*	169 (60.4)	26 (83.9)	0.018
	103 (33.2)	—	59 (26.3)	44 (50.6)	0.001*	77 (27.5)	26 (25.2)	0.7
Cardiovascular diseases	94 (30.3)	—	40 (17.9)	54 (62.1)	0.0001*	74 (26.4)	20 (64.5)	0.001*
Diabetes	73 (23.6)	—	30 (13.4)	43 (49.4)	0.0001*	55 (19.6)	18 (58)	0.0001*
Chronic kidney disorders	64 (20.6)	—	24 (10.7)	40 (46.0)	0.0001*	45 (16.1)	19 (61.3)	0.0001*
Neurological Disorders (Migraine headaches, Encephalitis, Epilepsy and Seizures, Stroke)	61 (19.5)	—	20 (8.9)	41 (47.1)	0.0001*	50 (17.9)	11 (35.5)	0.0001*
Chronic liver and biliary disease	20 (6.4)	—	10 (4.5)	10 (11.5)	0.05	13 (4.6)	7 (22.6)	0.0001*
Asthma	15 (4.7)	—	4 (1.78)	11 (12.6)	0.001*	10 (3.6)	5 (16.1)	0.005
COPD	4 (1.3)	—	0 (0)	4 (4.6)	0.03*	0 (0)	4 (13)	0.001*
Cancer	3 (≈1)	—	0 (0)	3 (≈3.5)	0.04*	1 (0.35)	2 (6.45)	0.02*
Severity of Disease:								
Severe	87 (28)	—	—	—	—	57 (20.35)	30 (96.77)	0.0001*
Non severe	224 (72)	—	—	—	—	—	—	—
Mechanical ventilation	107 (34.4)	—	20 (8.9)	87 (100.0)	0.0001*	77 (27.5)	30 (96.8)	0.0001*
Albuminuria		—	32 (14.3)	36 (41.4)	0.0001*	53 (18.9)	15 (48.4)	0.0001*
No	243 (78.1)	—	—	—	—	—	—	—
Moderately increased	44 (14.1)	—	—	—	—	—	—	—
Severely increased	24 (7.7)	—	—	—	—	—	—	—
Hematuria		—	16 (7.1)	40 (46.0)	0.0001*	37 (13.2)	19 (61.3)	0.0001*
non	255 (82)	—	—	—	—	—	—	—
Microscopic hematuria	47 (15.1)	—	—	—	—	—	—	—
Gross hematuria	9 (2.9)	—	—	—	—	—	—	—
Mortality rate	31 (10)	—	1 (0.45)	30 (34.50)	< 0.0001*	—	—	—
Hospital Stay (Day)	6.44± 4.02	1_22	6.16 ± 3.72	7.18 ± 4.64	0.067	6.65 ± 4.09	4.55 ± 2.72	0.0001*
GCS	14.39 ± 1.087	11_15	14.92 ± 0.27	13.06 ± 1.24	0.0001*	14.67 ± 0.70	11.94 ± 0.81	0.0001*
SOFA Score:	3.33± 2.24	1_12	2.44 ± 1.29	5.64 ± 2.51	0.0001*	2.82 ± 1.55	8.00 ± 2.14	0.0001*
Minimal organ dysfunc- tion	283 (91)	—	—	—	—	—	—	—
Mild organ dysfunction	18 (5.8 %)	—	—	—	—	—	—	—
Moderate organ dys- function	10 (3.2 %)	—	—	—	—	—	—	—
eGFR	81.19± 23.52	15_103	88.01 ± 13.42	63.63 ± 33.10	0.0001*	84.17 ± 20.21	54.32 ± 33.07	0.0001*
PaO2: 75 to 100 mm Hg	69± 7.64	50_85	72.40 ± 5.21	60.24 ± 5.70	0.0001*	70.64 ± 6.00	54.23 ± 4.30	0.0001*
FiO2	0.25± 0.066	0.21_0.55	0.23 ± 0.02	0.33 ± 0.08	0.0001*	0.24 ± 0.03	0.41 ± 0.09	0.0001*
PaO2/FiO2 ratio	286.88± 75.49	90.91_404.76	321.99 ± 48.64	196.51 ± 54.21	0.0001*	303.14 ± 58.80	140.07 ± 44.77	0.0001*
WBC (10*3µL)	8± 4.80	1.30_50.50	7.11 ± 3.48	10.32 ± 6.65	0.0001*	7.72 ± 4.03	10.61 ± 8.90	0.084
RBC (µL)	4.28± 0.67	2.21_6.29	4.36 ± 0.63	4.07 ± 0.75	0.001*	4.31 ± 0.67	4.04 ± 0.72	0.058
Neutrophiles (%)	69.05± 11.97	26.30_93.80	66.34 ± 11.14	76.08 ± 11.14	0.0001*	68.45 ± 11.76	74.60 ± 12.41	0.012*
Lymphocytes (%)	24.33± 11.45	1.80_67.90	27.15 ± 10.80	17.07 ± 9.79	0.0001*	25.05 ± 11.23	17.83 ± 11.51	0.002*
Hb (g/dL)	12.25± 1.99	7.30_17.90	12.52 ± 1.94	11.58 ± 1.98	0.0001*	12.34 ± 1.96	11.48 ± 2.10	0.037*
Hct (%)	35.41± 5.56	20.60_48.80	36.07 ± 5.35	33.73 ± 5.76	0.001*	35.60 ± 5.51	33.72 ± 5.82	0.095
MCV (fl)	83.07± 7.2	56.60_112.80	82.86 ± 7.04	83.64 ± 7.62	0.407	82.98 ± 7.24	83.95 ± 6.87	0.464
PLT (10*3/uL)	203.96± 90.38	33_614	206.99 ± 91.31	196.20 ± 88.00	0.338	207.34 ± 90.63	173.48 ± 83.45	0.04*
ESR (Ml/heart beat)	43.68± 25.83	5_140	40.68 ± 24.87	51.41 ± 26.79	0.002*	43.43 ± 25.64	45.97 ± 27.82	0.631
AST	43.76± 29.88	10_261	41.86 ± 29.60	48.66 ± 30.23	0.076	42.87 ± 29.58	51.84 ± 31.89	0.143
ALT	30.15± 37.23	6_430	30.17 ± 38.90	30.13 ± 32.77	0.993	30.77 ± 38.90	24.55 ± 14.56	0.079
Direct bilirubin	0.31± 0.42	0.08_5.20	0.26 ± 0.20	0.46 ± 0.72	0.012*	0.28 ± 0.25	0.65 ± 1.09	0.067
Total Bilirubin (TSB) mg/dl	1.08± 0.56	0.10_3.90	1.04 ± 0.52	1.20 ± 0.67	0.046*	1.07 ± 0.55	1.17 ± 0.74	0.471
BUN, serum (mg/dl)	25.41± 22.56	5_151	21.32 ± 17.78	35.95 ± 29.31	0.0001*	23.18 ± 19.57	45.61 ± 35.07	0.001*
Creatinine (mg/dl)	1.19± 0.82	0.30_9.50	1.06 ± 0.50	1.53 ± 1.27	0.001*	1.11 ± 0.58	1.94 ± 1.78	0.016*

* P-value <0.05 is significant. eGFR: estimated Glomerular Filtration Rate; GCS: Glasgow Coma Scale; Sequential Organ Failure Assessment (SOFA) Score. COPD: Chronic Obstructive Pulmonary Disease
P-value1 signifies comparison of variables between severe and non-severe COVID-19 patients using t-test or chi-square tests.
P-value2 signifies comparison of variables between alive and deceased patients using t-test or chi-square tests.
Some patients had more than one underlying condition.

72% (n=224) had non-severe infection. The most common comorbidities in COVID-19 patients were hypertension, cardiovascular disease, diabetes, chronic kidney disease, and neurological disorders, and these diseases were more evident in patients with severe infection (p<0.05). Also, 34.4% (n=107) required mechanical ventilation, and 20.6% (n=64) had kidney dysfunction. The majority of patients [283 (91%)] had minimal organ dysfunction, indicating mild or no significant organ failure, while a smaller proportion [18 (5.8%)] experienced mild dysfunction and 3.2% (n=10) had moderate organ dysfunction. Albuminuria was observed in 21.8% (n=68) and hematuria in 18% (n=56) of patients. Thirty patients [31 (~10%)] died. The average length of hospital stay was 6.44 ± 4.02 days. (Table 1).

3.2 Gender-based differences in clinical profile and outcomes

There was no significant difference in mean age between the two sexes (p = 0.915). Overall, 58.6 % (n=51) of males and 41.4 % (n=36) of females had severe infection without any significant difference (p= 0.526). The rate of comorbid conditions was significantly higher in females [97 (~70%)] than males [98 (57%); p=0.025, OR (95% CI):1.744 (1.088_2.794)]. However, there was no significant difference in the rates of kidney disorders (p= 0.999), liver biliary disease (p= 0.361), mechanical ventilation (p=0.9), and Glasgow Coma Scale (GCS) score (p = 0.428) between the two sexes. At the same time, the mean SOFA score was significantly higher in males (3.66 ± 2.33) compared to females (2.93 ± 2.07; p= 0.004). There

was no significant differences in the rates of albuminuria (p= 0.95) and hematuria (p= 0.784) between the two sexes. The mortality rate was higher in males (11%) as compared to females (8%), but without significance (p= 0.441). There was no significant difference in the length of hospitalization between the two sexes, either (p= 0.604).

3.3 Indicators of disease severity

In order to determine the significant variables associated with COVID-19 severity and mortality, the status of variables was first examined between subgroups using initial comparative analyses (e.g., t-test; chi-square; Table 1). Then, a set of variables for inclusion in the logistic and Cox regression models was chosen based on a few criteria: significance in the primary comparison (p< 0.05), no significant multicollinearity (VIF < 5), clinical relevance or importance, and possibility for interpretation. When some multiple variables were correlated to one another, only the most clinically meaningful variable was selected in order to minimize redundancy and enhance the clarity of the model.

Based on the univariate logistic regression analyses, several factors were associated with disease severity including: older age, comorbidities, use of mechanical ventilation, chronic kidney disorders (CKD), higher SOFA Score, hypoxemia, lymphopenia, albuminuria, and hematuria. However, multivariate logistic regression analyses revealed that only comorbidities (OR [95% CI]: 12.0 [4.16 – 34.82], p <0.0001), use of mechanical ventilation (OR [95% CI]: 129.0 [25.8 – 645.8], p= 0.0001), higher SOFA Score (OR [95% CI]:

Table 2. Univariate and multivariate Cox regression analyses for identifying factors associated with overall survival in COVID-19 patients.

Variables	Univariate analysis			Multivariate analysis		
	HR	95% CI	P-value	Adjusted HR	95% CI	P-value
Age, yr	1.06	1.03 – 1.08	< 0.0001*	1.01	0.99 – 1.02	0.344
Comorbidities (any)	2.81	1.08 – 7.33	0.034*	0.94	0.51 – 1.70	0.829
Severity of Disease	71.39	9.73 – 523.86	< 0.0001*	19.152	2.261 – 162.254	0.007*
Chronic kidney disorders	6.12	2.96 – 12.64	< 0.0001*	1.13	0.55 – 2.33	0.748
Chronic liver/biliary disease	6.51	2.78 – 15.21	< 0.0001*	3.06	1.26 – 7.44	0.014*
Mechanical ventilation	45.61	6.21 – 335.27	< 0.0001*	1.34	0.69 – 2.59	0.387
SOFA Score (per point)	1.80	1.60 – 2.02	< 0.0001*	1.25	1.11 – 1.40	0.0001*
PaO ₂ /FiO ₂ ratio	0.95	0.94 – 0.97	< 0.0001*	0.99	0.99 – 1.00	0.0001*
Hematuria	7.23	3.50 – 14.95	< 0.0001*	1.19	0.56 – 2.53	0.644
Albuminuria	3.42	1.68 – 6.94	< 0.0001*	0.86	0.46 – 1.63	0.648
Lymphocyte % (per %)	0.94	0.91 – 0.98	0.0035*	1.00	0.98 – 1.02	0.916
Hb (g/dL)	0.846	0.707 – 1.012	0.067			
PLT (10*3/uL)	0.995	0.990 – 1	0.053			
Serum Creatinine (mg/dL)	1.72	1.39 – 2.11	< 0.0001*	1.05	0.83 – 1.34	0.672
BUN (mg/dL)	1.02	1.01 – 1.03	< 0.0001*	1.00	0.99 – 1.02	0.562

* P-value <0.05 is significant.

The wide CI reflects the fact that one group (the non-exposed group to specific variable) has no events (deaths) or only a few, which leads to a very large HR and a wide confidence interval. This is a typical issue in survival analysis when a group has no events.

2.03 [1.21 – 3.40], $p= 0.007$), and lymphopenia (OR [95% CI]: 0.86 [0.79 – 0.94], $p= 0.001$) were independently associated with disease severity.

3.4 Predictors of mortality

Overall, 30 patients died during hospitalization. The majority of deaths occurred between days 5 and 15 of the hospital stay (Figure 1). Cox regression analyses showed that in addition to disease severity, advanced age, chronic liver/biliary disease, a greater SOFA score, and lower PaO₂/FiO₂ ratio were strongly associated with a higher risk of mortality (Table 2). At the same time, the limited number of deceased cases in non-severe group indirectly highlighted the importance of disease severity as a dominant factor influencing survival.

ly emphasizes that disease severity is the dominant factor influencing survival. Other medical risk factors tend to be present in critically ill patients, rather than independently predicting death. Nonetheless, early identification of kidney and organ dysfunction in COVID-19 patients could serve as a valuable tool for risk stratification. Although many studies have looked at organ or kidney failure in COVID-19, our study is concentrated on a well-defined hospitalized cohort and uses standard, validated criteria such the SOFA score and KDIGO criteria to accurately assess multi-organ and acute renal injury. Furthermore, we examined particular renal markers including hematuria and albuminuria, which are less reported in the current literature. The relatively large sample size

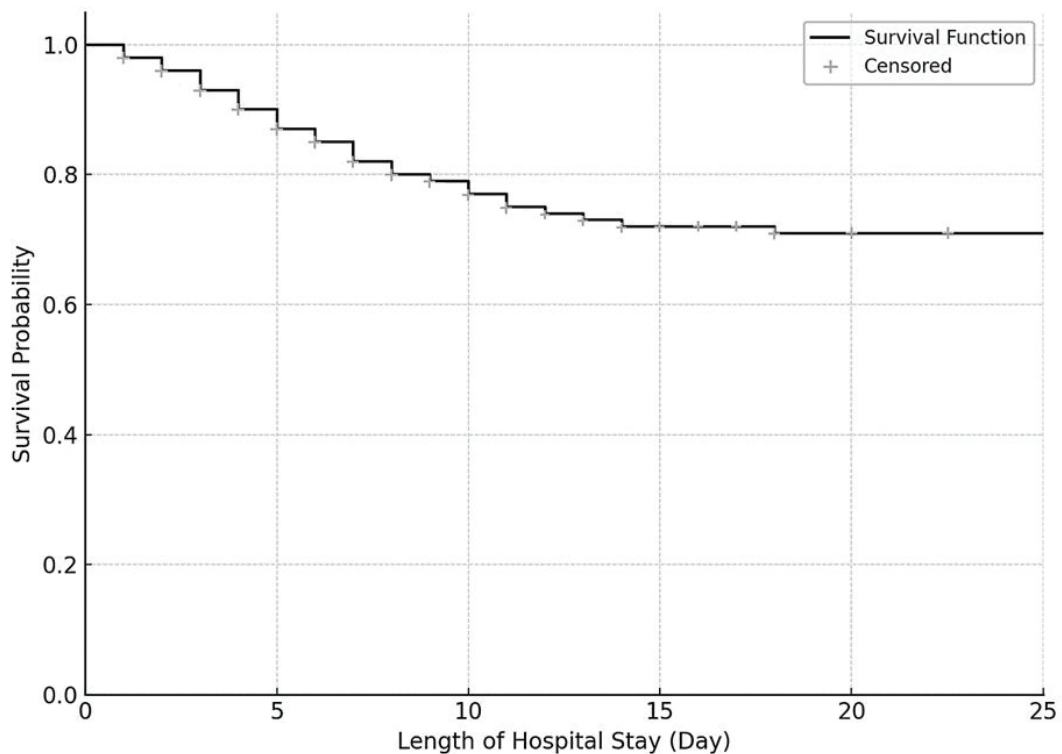


Figure 1. Probability of survival of COVID-19 patients according to time. Cum Survival: Cumulative survival.

4. DISCUSSION

This research revealed a high incidence of kidney dysfunction in COVID-19 patients (20.6%), as indicated by albuminuria and hematuria. Nine percent of them also had mild to moderate organ failure. Older age, comorbidities, mechanical ventilation, kidney problems, a higher SOFA score, hypoxemia, and laboratory abnormalities, especially hematuria and albuminuria were linked to severe illness. Importantly, only one death reported among non-severe cases indirect-

and strict statistical techniques help to better characterize organ dysfunction, and may be useful for risk stratification and medical management in comparable groups.

Chen et al. (2021) reported renal impairment in 15–30% of COVID-19 patients, particularly based on serum creatinine and urine protein levels [14]. Our study confirms these results, emphasizing the strong association between kidney dysfunction and disease severity. While Chen et al. focused on serum creati-

nine and AKI, our study emphasized on both KDIGO and albuminuria/hematuria, which offers earlier insights into kidney dysfunction and may better predict poor outcomes. Hematuria (18%) was higher in our patients' cohort than in Chen et al.'s study, possibly because of differences in the sampled population. Our cohort was from one hospital, and therefore potentially included more severe cases, while Chen's cohort recruited a more general sample from multiple hospitals. Although both studies found that older age and comorbidities were linked to disease severity and poor prognosis, our findings identified the dominant role of disease severity for survival.

Similarly to us, Schnabel et al. found out that kidney dysfunction was common among COVID-19 patients and related to severe disease and higher mortality [15]. Both studies concluded that age, comorbidities, and mechanical ventilation were the key risk factors for kidney dysfunction. Furthermore, while both studies agreed that disease severity and kidney dysfunction were significant factors influencing mortality, our results suggested that disease severity played a superior role in patients' outcomes.

Our findings align with Fukui et al. and Karras et al.'s reports [16, 17] with the observation of high rates of AKI in COVID-19 patients, with AKI being related to poor prognosis. All studies pointed out the role of pre-existing diseases in forecasting adverse outcomes; however our findings showed that the link between these impairments and mortality was actually affected by the severity of disease. While Karras et al. conclusions depended on serum creatinine, our research also employed albuminuria and hematuria for early identification of kidney damage. Furthermore, Karras et al. strongly emphasized on chronic kidney disease (CKD) as a key comorbidity worsening clinical outcome, while our study indicated that chronic liver/biliary disease was more significantly related to mortality.

Study strengths and limitations

Our research stands out for its rigorous data gathering, the usage of often overlooked albuminuria and hematuria markers, and its emphasis on both renal and multiple organ failure. Employing the SOFA score aids to a more objective risk assessment in a moderate-sized population. At the same time, the study is limited and possibly biased by the lack of post-discharge long-term outcome analysis, and the single-center retrospective approach.

CONCLUSION

Our study revealed that kidney and organ dysfunction, along with advanced age, comorbidities, hypoxemia, and greater SOFA score, are significantly correlated with COVID-19 severity and mortality. Disease severity plays the dominant role in survival and its association with other risk factors. Nonetheless, further large-scale, multicenter studies are needed to validate these results and explore the long-term effects of kidney dysfunction among coronavirus survivors.

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