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Identifying Risk Factors for Impaired Pulmonary Function in COVID-19 Patients: A Cross-Sectional Study

Odonchimeg Bayaraa[1,2], Allabyergyen Myeryemkhaan[3], Gaamaa Jamsran[1], Norjmaa Boldbaatar[1,4], Sarantuya Jav[5], Munkhbayarlakh Sonomjamts[6], Ichinnorov Dashtseren[3,6]

[1]School of Medicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia;
[2]Center of Pulmonology and Allergology, The First Central Hospital, Ulaanbaatar, Mongolia;
[3]Mongolia-Japan Hospital, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia;
[4]Gurvan Gal Hospital, Ulaanbaatar, Mongolia;
[5]Department of Molecular Biology and Genetics, School of Biomedicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia;
[6]Department of Pulmonology and Allergology, School of Medicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia.

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Corresponding Author:
Ichinnorov Dashtseren (M.D., Ph.D., Prof)
Department of Pulmonology and Allergology, School of Medicine, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia
E-mail: ichinnorov@mnums.edu.mn
ORCID: https://orcid.org/0000-0001-6413-4794

Objective: COVID-19 has an impact on various organs, including heart, kidney, lung, and liver. However, respiratory system has been the primary organ mostly affected, ranging from asymptomatic to critical stages of the disease. The risk of developing impaired pulmonary function depends on multiple factors, including demographic and clinical manifestations such as severity of the disease, comorbidities, and treatment options. As the number of new COVID-19 cases declines, public health experts and medical doctors are increasingly interested in conditions after COVID-19 and are working to improve the quality of life for affected patients. Our study aim was to investigate risk factors associated with impaired pulmonary function in individuals recovered from severe COVID-19. **Method:** The study was conducted using a hospital-based, cross-sectional study design. A total of 268 participants who visited the Pulmonology and Allergology Center of The First Central Hospital of Mongolia for a follow-up examination one year after contracting COVID-19 between 2022 and 2023. Demographic data, comorbidities, severity of initial infection, hospitalization history, and spirometry were analyzed to determine their association with post-COVID-19 impairment of pulmonary function. **Results:** This study identified the risk factors significantly associated with altered pulmonary function in post-COVID-19. 50.4% of individuals with initial severe infection had altered pulmonary function. Severe group had higher odds of decreasing FVC (predicted %) compared to the asymptomatic group (OR=3.69; 95% CI; P =0.003). For comorbidities, patients with cardiovascular disease were significantly more likely to decrease FVC (predicted %) compared to participants who had no comorbidities (OR=4.22; 95% CI; P =0.040). Moreover, patients with chronic lung diseases had a significantly high of impaired FVC (%), with an adjusted odds ratio of 2.46 (95% CI, P =0.005) **Conclusion:** Patients with pre-existing cardiovascular and chronic lung diseases, and severe initial infection have a significantly higher likelihood of impaired pulmonary function compared to those with other comorbidities, and non-severe COVID-19.

Keywords: COVID-19, Comorbidities, Impaired pulmonary function, Severity of disease

Introduction

Coronavirus disease 2019 (COVID-19) is a disease caused by a new coronavirus named

severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] According to the World Health Organization (WHO), more than 777 million COVID-19 cases and 7 million deaths have been reported on February 2025.[2] COVID-19 has an impact on various organs, including heart, kidney, lung and liver.[3-5] However, the respiratory system has been the primary organ mostly affected, ranging from asymptomatic to critical stages of the disease. In previous SARS infection, various studies examined survivors and observed fibrotic features in up to 36% of the patients.[6,7] Moreover, early studies following SARS showed that 27.8% of survivors had decreased lung function. Similarly, 100 days after COVID-19, 22% of survivors showed impairment of forced vital capacity (FVC) and/or forced expiratory volume in 1 second (FEV1).[8] Impaired pulmonary function and quality of life have a significant association, particularly it is related to impaired physical activity. As the number of new COVID-19 cases declines, public health experts and medical doctors are increasingly interested in conditions after COVID-19 and are working to improve the quality of life for affected patients.

The risk of developing impaired pulmonary function depends on multiple factors, including demographic and clinical manifestations such as severity of the disease, comorbidities, and treatment options.[9] A previous study from Mongolia reported that certain demographic information, such as older age, male participants, and comorbidities such as active TB and/or COPD, significantly affected the severity of COVID-19. Additionally, some laboratory measurements and serum vitamin D concentrations were studied among the patients with various severity stages of the disease.[10] Although certain studies show us the risk factors affect the severity of the disease, there is limited data about pulmonary function in patients after COVID-19. Understanding the possible factors associated with impaired pulmonary function is highly needed for preventing declined pulmonary function among COVID-19 patients.

Materials and Methods

The study was conducted using a hospital-based, cross-sectional study design. A total of 268 participants who visited the Pulmonology and Allergology Center of The First Central Hospital of Mongolia for a follow-up examination one year after contracting COVID-19 between 2022 and 2023 were included voluntarily in this study. In the current study, we excluded participants with critical COVID-19. The research study was approved by the Research Ethics Committee of the Mongolian National University of Medical Sciences (№2022/3-06). All participants were provided with the study protocol and gave their written informed consent.

Independent Variables

Data were collected through interviews using questionnaires. Demographic information including age, sex, smoking status, and education level, with smoking status categorized as non-smokers or active and former smokers. Clinical factors included comorbidities, severity of COVID-19, and steroid treatment. Previous studies have not clearly identified a specific age cutoff for FVC impairment. However, some findings suggest that impaired pulmonary function after COVID-19 tends to appear around the age of 50.[11,12] We classified age into two categories: below and equal to 50, and above 50. The total number of participants with comorbidities was divided into four main groups: arterial hypertension (AH), chronic lung diseases (CLD), cardiovascular diseases (CVD), and diabetes mellitus (DM). For the severity of COVID-19, participants were divided into three groups: Asymptomatic, Non-severe, and Severe, with severity stages based on the World Health Organization's "Living Guidance for Clinical Management of COVID-19".

Dependent Variables

Pulmonary function, especially forced expiratory volume (FVC), was assumed as the outcome variable. The dummy variable was categorized as its cut-off point. According to previous studies and guidelines, FVC 80% is used as a cut-off point in our study. According to the 2019 update of the Standardization of Spirometry by the American Thoracic Society and European Respiratory Society, spirometry tests is performed by a specialized nurse and independently evaluated by a pulmonologist.[13]

Statistical Analysis

Descriptive statistics summarize the distribution of demographic and clinical manifestations, which are presented as frequencies and percentages for three groups according to their COVID-19 severity. All data were assessed for normal distribution by the Kolmogorov-Smirnov test. The Kruskal-Wallis test was employed to detect differences in pulmonary function test outcomes among the three groups for continuous variables, while the Chi-square test was used for categorical

variables, including dyspnea scales. Logistic regression analysis was conducted to explore the relationship between demographic and clinical factors and the pulmonary function test. A logistic regression model included the above dummy variables to examine their association with pulmonary function tests. Multicollinearity analysis among variables was assessed using variance inflation factors, and no significant issues were noticed. The final multivariate model included sex, age, smoking status, severity of disease, comorbidities, and steroid treatment. Odds ratios (ORs) with 95%, Confidence intervals (CIs) were estimated to quantify these associations. A P-value of <0.05 was considered statistically significant. Data were analyzed using IBM SPSS version 26.0.

Results

In our study, a total of 268 participants were included, with 87 categorized as asymptomatic, 91 as non-severe, and 90 as severe groups. Table 1 shows the number and percentage of demographic and clinical characteristics among the three groups. The median age was 58 years (IQR: 48–65), and the median BMI was 27.5 (IQR: 24.6–32.0). Participants of all groups were predominantly female: 59.8%, 64.8%, and 56.7%, respectively. In the asymptomatic group, 27.6% were current and past smokers, but they were the majority compared to other groups. For participants with comorbidities, cardiovascular disease was a small portion of the comorbidities, representing only 5.7%, 7.7%, and 7.8%, respectively. However, DM had a higher prevalence in the severe group (24.4%) compared to the asymptomatic (10.3%) and non-severe (15.4%) groups. Corticosteroids and oxygen therapy were not administered to the asymptomatic

Table 1. Characteristics of the study population of 268 COVID-19 patients divided by disease severity

Characteristics	Total (n=268)	Asymptomatic (n=87)	Non-severe (n=91)	Severe (n=90)
Age, median (IQR)	58 (48–65)	58 (42–66)	58 (51–65)	57 (49–64)
Sex (%)				
Male	106 (39.6)	35 (40.2)	32 (35.2)	39 (43.3)
Female	162 (60.4)	52 (59.8)	59 (64.8)	51 (56.7)
BMI, median (IQR)	27.5 (24.6–32.0)	26.4 (22.9–31.8)	28.6 (25.0–32.3)	28.1 (25.1–32.7)
Smoker, n (%)				
Never	212 (79.1)	63 (72.4)	75 (82.4)	74 (82.2)
Current/past	56 (20.9)	24 (27.6)	16 (17.6)	16 (17.8)
Education, n (%)				
Lower	52 (19.4)	20 (23.0)	18 (19.8)	14 (15.6)
Medium	96 (35.8)	33 (37.9)	30 (33.0)	33 (36.7)
Higher	120 (44.8)	34 (39.1)	43 (47.3)	43 (47.8)
Comorbidity, n (%)				
AH	146 (54.5)	46 (52.9)	44 (48.4)	56 (62.2)
CLD	93 (34.7)	30 (34.5)	29 (31.9)	34 (37.8)
CVD	19 (7.1)	5 (5.7)	7 (7.7)	7 (7.8)
DM	45 (16.8)	9 (10.3)	14 (15.4)	22 (24.4)
Treatment, n (%)				
Corticosteroids	101 (37.7)	-	33 (36.3)	68 (75.6)
Oxygen supply	63 (23.5)	-	15 (16.5)	48 (53.3)

*0- Pre-treatment performance, 30-Results 30 days after treatment, 60- Results days after treatment, *P < 0.05*

Table 2 shows the spirometry test results and functional assessment outcomes among the three groups. In our study, 50.4% of patients had altered pulmonary function. The median FVC as a percentage of predicted values was significantly different between groups (P <0.05). Asymptomatic group had median of 85% (IQR: 66–100), the non-severe group had 79% (IQR: 66–95), and the severe group had 70% (IQR: 62–81), with the severe group showing a lower percentage of predicted FVC. Although there were no significant differences between the three groups for other measurements, the results consistently decreased with their severity. Functional assessments, including 6 MWT distance, Borg scores, and Fatigue Severity Scales, show significant differences between the three groups (P <0.05).

Table 2. Characteristics of the study population of 268 COVID-19 patients divided by disease severity

Characteristics	Asymptomatic (n=87)	Non-severe (n=91)	Severe (n=90)	P-value
Spirometry, median (IQR)				
FVC, L	2.84 (1.97–3.34)	2.53 (1.93–3.23)	2.34 (1.70–3.01)	0.065
FVC, % of predicted	85 (66–100)	79 (66–95)	70 (62–81)	0.000
FEV1, L	2.37 (1.74–2.82)	2.19 (1.63–2.72)	2.17 (1.63–2.67)	0.646
FEV1, % of predicted	86 (67-101)	81 (65–96)	80 (59–97)	0.382
FEV1 /FVC, L	84 (75.59–91.33)	80 (76.16–88.87)	81 (78.02–90.92)	0.053
Borg scores, median	1	2	3	0.001
6 MWT, median (IQR)	288 (252–309)	280 (231–294)	264 (201–294)	0.001
FSS, median (IQR)	29 (20–35)	38 (35–42)	45 (40–50)	0.000

IQR: interquartile range; FVC: forced vital capacity; FEV1: forced expiratory volume in 1 second; 6 MWT: 6-minute walk test; FSS: fatigue severity score, Statistical test: Kruskal-Wallis Test for continuous variables and chi-square test for categorical variables among the three groups

In multivariate analysis (Table 3), the severe group had higher odds of decreasing FVC (predicted %) compared to the asymptomatic group (OR =3.69; 95% CI; P <0.05). For comorbidities, patients with cardiovascular disease were significantly more likely to decrease FVC (predicted %) compared to participants who had no comorbidities (OR =4.22; 95% CI, P< 0.05). Moreover, patients with chronic lung diseases had a significantly high of impaired FVC (%), with an adjusted odds ratio of 2.46 (95% CI, P< 0.05).

Discussion

This study identified the prevalence of severity of COVID-19 patients, with 50.4% had altered pulmonary function. Key factors associated with impaired FVC were cardiovascular diseases including congestive heart failure, and ischemic heart diseases, chronic lung diseases, and severe COVID-19. Moreover, age groups above 50 years do not show a significant impact on impaired FVC (OR= 1.13; 95% CI) and patients who had not received corticosteroids were not found to have impaired pulmonary function (OR= 1.02; 95% CI).

A previous study showed that among the patients diagnosed with COVID-19, 57.7% had comorbidities. Major comorbidities were cardiovascular disease, hypertension, diabetes, COPD, cancer, CKD, and others.[14] Furthermore, a significant portion of hospitalized COVID-19 patients, around 12.2%, require mechanical ventilation during pandemic years. Among those patients had cardiac injury, a serious complication, can occur in as many as 20%. Notably, individuals with pre-existing cardiovascular conditions appear to be more vulnerable to COVID-19 infection and unfortunately experience higher rates of illness and health.[15-17] Particularly, patients with cardiovascular diseases exhibited significantly impaired pulmonary function such as DLCO.[9] However, our study demonstrated that patients with CVD had a higher risk of impaired FVC compared to other comorbidity groups.

However, our study showed that the age group above 50 years was not significantly associated with impaired pulmonary function. Some study, which conducted a 2-year follow-up after

Table 1. Characteristics of the study population of 268 COVID-19 patients divided by disease severity

Variables	Univariate			Multivariate*		
Sex	OR	(95% CI)	P-value	OR	(95% CI)	P value
Female	1.00	-	-	1.00	-	-
Male	1.34	(0.81–2.21)	0.240	1.08	(0.59–1.99)	0.788
Age						
≤50 years	1.00	-	-	1.00	-	-
>50 years	1.68	(0.99–2.87)	0.055	1.13	(0.59–2.15)	0.709
Smoking						
None	1.00	-	-	1.00	-	-
Current/past	1.06	(0.58–1.92)	0.842	0.91	(0.43–1.91)	0.813
Severity						
Asymptomatic	1.00	-	-	1.00	-	-
Non-severe	0.87	(0.52–1.46)	0.616	1.75	(0.88–3.45)	0.107
Severe	2.84	(1.64–4.91)	0.000	3.69	(1.56–8.72)	0.003
Comorbidities						
Non-comorbidities	1.00	-	-	1.00	-	-
Hypertension	1.38	(0.85–2.24)	0.192	1.33	(0.73–2.40)	0.342
CLD	2.85	(1.66–4.90)	0.000	2.46	(1.32–4.59)	0.005
CVD	4.57	(1.30–16.10)	0.018	4.22	(1.06–16.72)	0.040
DM	1.52	(0.78–2.97)	0.211	1.11	(0.52–2.34)	0.778
Steroid treatment						
Received	1.00	-	-	1.00	-	-
Not-received	0.50	(0.30–0.83)	0.008	1.02	(0.49–2.11)	0.944

*OR: odds ratio; CI: confidence interval; CLD: chronic lung disease; CVD: cardiovascular disease; DM: diabetes mellitus *Adjusted for sex, age, smoking status, severity of COVID-19 (asymptomatic, non-severe, and severe), comorbidities, and steroid treatment*

COVID-19, observed that persistent FVC decline was significantly associated with age above 45 years.[18] Contrastingly, other studies have shown that younger patients (18–29 years) had significantly lower mean FVC compared to older age groups (30–39 and 50–65 years). The natural age-related lung function impairment, which progressess with older age.[19,20] This suggests that younger patients with post-COVID-19 symptoms may experience lower FVC compared to older individuals.[21] Corticosteroid treatment helps to maintain the cytokine storm, leads to tissue damage and massive fibrosis in lung tissue. Because of above reason, some reports showed that corticosteroid treatment had efficacy of significant improvement and recover of pulmonary functions tests, including FVC, FEV1 and DLCO, during long-term follow-up.[22] According to previous studies, corticosteroid doses were generally categorized into low, moderate and high doses based on their administration during COVID-19. Efficacy improvement of pulmonary function results was noticed in high-dose corticosteroid treatments.[22] A part of limitation in our study was that we were unable to estimate the doses of corticosteroid treatment and clarify their association with pulmonary function.

Conclusion

Patients with pre-existing cardiovascular and chronic lung diseases, and severe initial infection have a significantly higher likelihood of impaired pulmonary function compared to those with other comorbidities, and non-severe COVID-19.

Conflict of Interest

There were no conflicts and interest.

Authors Contribution

O.B. was responsible for data collection, data analysis, and writing the manuscript. A.M. supported data analysis and the manuscript. G.J. and N.B. contributed to data collection. S.J., M.S., and I.D. provided advisory guidance and conceptualized the study.

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