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Pulmonary Function Assessment with Spirometry in Symptomatic Post-COVID-19 Patients: A Cross-Sectional Study at Dhaka Medical College Hospital

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Abstract

Background: *The emergence of COVID-19 has posed challenges in managing the disease and mitigating its long-term effects, particularly on the respiratory system. This study assessed lung function abnormalities through spirometry in symptomatic post-COVID-19 patients in a tertiary care hospital in Bangladesh.*

Materials & Methods: *This cross-sectional study was conducted at Dhaka Medical College Hospital over one year. A total of 100 post-COVID-19 patients with shortness of breath and/or cough 6-8 weeks post-discharge were included. Patients underwent face-to-face interviews, clinical history reviews including previous investigations findings and spirometry tests. Spirometry assessments were classified as normal or restrictive. The severity of restrictive changes were graded from mild to very severe. FEV1 and FVC were measured, and the FEV1/FVC ratio was calculated. Data were analyzed using SPSS Version 25.*

Results: *The mean age of participants was 51.3±7.27 years, with a male predominance (70% male). Common symptoms included cough (86%), shortness of breath (54%), and weakness (41%). Spirometry showed that 66% had restrictive changes, with mean FEV1 at 61.04±10.69% and FVC at 73.02±12.73%. Restrictive changes in spirometry were significantly predominant in severe COVID-19 cases ($p<.05$) and were associated with pre-existing conditions like hypertension, diabetes, and smoking history ($p<.05$). Logistic regression revealed higher odds of restrictive changes with older age, smoking history, disease severity, and the presence of diabetes and hypertension.*

Conclusion: *This study reported a high prevalence of restrictive changes in spirometry in post-COVID-19 patients, associated with disease severity and pre-existing comorbidities.*

Keywords: *Post-COVID-19, COVID-19, Respiratory sequalae, Shortness of Breath, Spirometry, Restrictive pulmonary function.*

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Introduction:

Corona Virus Disease 2019 (COVID-19) presents as a heterogeneous disease, affecting individuals from asymptomatic to severe illness and death[1]. Acute COVID-19 commonly presents with respiratory symptoms like cough, shortness of breath (SOB), and pneumonia, occasionally advancing to acute respiratory distress syndrome (ARDS)[2]. Post-recovery, long-term

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complications, particularly affecting the respiratory system, may persist, including SOB and cough, significantly impacting quality of life[3].

Respiratory sequelae of post-COVID-19 have been widely reported through abnormal spirometry findings[3–9]. However, most follow-ups are conducted 3-6 months post-infection while early screening could prompt necessary interventions. In Bangladesh, 16% of COVID-19 patients reported with long-term complications[10], but little studies focused on pulmonary function in post-COVID patients. Symptomatic post-COVID-19 patients refer to individuals who continue to experience persistent or new symptoms after recovery. Restrictive lung disease, marked by reduced lung volumes, may result from post-COVID sequelae or factors like interstitial lung diseases, obesity, neuromuscular disorders, or thoracic deformities[11].

Spirometry, a non-invasive pulmonary function test, measures lung air volume and flow, providing diagnostic information on lung function. This study aims to investigate lung function abnormalities and associated factors in symptomatic post-COVID-19 patients 6-8 weeks post-discharge using spirometry which might initiate early intervention and thus improve quality of life.

Materials & Methods:

Study site, design and patients

This study was a cross-sectional study conducted over a period of twelve months in Department of Respiratory Medicine, Dhaka Medical College Hospital (DMCH). Post-COVID-19 patients aged 18 years or over attending for follow up after 6-8 weeks of discharge from hospital admission and presenting with respiratory symptoms (shortness of breath and/or cough) were approached for inclusion in this study. Following inclusion and exclusion criteria a total of 100 patients were included in this study. Patients with history of any pre-existing lung disease and who are undergoing radiotherapy or chemotherapy were excluded from this study.

Data collection

All enrolled patients were subjected to face-to-face interview, clinical examination and spirometry assessment. A semi-structured questionnaire was developed including all necessary information- demographic features (age, gender, socio-economic features), clinical history (severity of COVID-19 disease, comorbidities) and spirometry findings (forced expiratory volume in one second, FEV1; forced vital capacity, FVC and FEV1/FVC ratio). For clinical information, previous hospital records (discharge paper, investigation files of RT PCR, Chest Xray, Complete blood count reports) were checked thoroughly. Severity of COVID-19 disease was assessed from history, investigation reports and prescriptions according to the National Guidelines on Clinical Management of Coronavirus Disease 2019[12]. Patients who exhibited mild symptoms without shortness of breath and no pneumonia on imaging were considered as mild cases. Patients with signs of pneumonia and SpO_2 ≥90% on room air were considered as moderate cases. Severe cases presented with pneumonia along with respiratory distress or SpO_2<90% on room air. Critical cases included respiratory failure requiring mechanical ventilation, shock, or other organ failure necessitating intensive care unit (ICU). Each patient had a dedicated case record form.

Spirometry assessment of pulmonary function

Each patient underwent standard spirometry test through a computer-based spirometer (microQuark), using the new generation software designed by COSMED. Subjected patient was explained regarding the test procedure prior the test. FEV1, FVC and FEV1/FVC ratio were measured. Normal Reference ranges for both are >80% predicted[13]. The ratio of FEV1 to FVC was also calculated and >0.7 was considered as normal[13].

Spirometry findings indicated a restrictive lung disease with reduced levels of both FEV1 (<80% predicted) and FVC (<80% predicted) with a normal level of FEV1/FVC ratio (>0.7)[14]. Severity of restrictive lung disease was also assessed where a FVC level ≥70% was considered as mild, <70% to ≥60% as moderate, <60% to ≥50% as moderately severe, <50% to ≥35% as severe and <35% as very severe[14].

Patients with abnormal spirometry findings (FEV1 or FVC <80% predicted) were referred for further evaluation, including Chest X-ray (CXR), to identify potential underlying conditions, which could have influenced lung function. CXR was not systematically performed for all patients but was used selectively in cases of abnormal spirometry to assist in identifying structural lung abnormalities.

Statistical analysis

The statistical analysis was performed using the IBM Statistical Package for the Social Sciences (SPSS) for Windows, Version 25.0. Descriptive statistics were utilized to calculate measures of the variables, which were then presented using tables and charts. The association between spirometry findings and patient characteristics was assessed using the chi-square test. Additionally, univariate logistic regression analysis was conducted to evaluate the risk factors associated with restrictive lung disease. Statistical significance was determined at a two-sided p-value of less than 0.050.

Result:

The mean age of the post covid patients presenting with respiratory sequalae was 51 years where almost two-third of the patients were aged over 50 years. Male predominance was observed with 70% male and 30% female. Most participants resided in urban areas and had attained highest education from primary or secondary school. Regarding occupation, the most common were businessman and housewife. Almost nine-tenth of the patients' monthly income was below 20,000 Bangladesh Taka per month. Among the reported symptoms during follow-up, cough was the most prevalent (86%), followed by shortness of breath (54%) and weakness (41%). About 57% of the participants were smokers. (Table-I)

Nearly half of the participants experienced mild COVID-19 disease followed by moderate and severe disease. Critical cases were observed in 5% of the patients. A significant proportion had pre-existing comorbidity where hypertension and diabetes mellitus were most common. Other notable comorbidities include dyslipidemia, nonalcoholic fatty liver disease, and chronic kidney disease (Table-II).

The spirometry results indicate two-thirds of the patients, exhibited restrictive changes in spirometry. Among these individuals, the severity of the restrictions varied, with 24% classified as having mild restrictive changes, 22% as moderate, 15% as moderately severe, 4% as severe, and 1% as very severe. The mean FEV1 and FVC were 61.04±10.69 % (SD) and 73.02±12.73 (%) (SD). Mean FEV1/ FVC ratio was .836±.001 (SD). (Table-III)

A significant association has been demonstrated between the more severe form of COVID-19 disease and restrictive lung function abnormalities ($p<.05$).

Table-I

Socio-demographic characteristics and presenting post covid symptoms of the study participants (n=100)

Variables	%
Age (years)	
≤50	35
>50	65
Mean±SD	51.3±7.27 years
Maximum-minimum	67-25 years
Gender	
Male	70
Female	30
Residence	
Urban	60
Rural	40
Highest educational attainment	
No formal education	5
Primary school	45
Secondary school	42
Higher secondary college/above	8
Occupation	
Government job	4
Non-government job	5
Business	46
Housewife	26
Unemployed	3
Others	16
Monthly income (BDT)	
< 10,000	42
10,000-20,000	49
21,000-40,000	5
>40,000	4
Smoking history	
Smoker	57
Non smoker	43
Presenting symptoms*	
Cough	86
SOB	54
Weakness	41
Headache	34
Anorexia	19
Anosmia	15
Nasal congestion	14
GIS	13
Chest pain	13
Muscle pain	10
Fever	5

*Multiple response considered. BDT: Bangladesh Taka, SOB: Shortness of Breath, GIS: Gastrointestinal symptoms

Table-II

Severity of COVID-19 disease and pre-existing co-morbidity among the study participants (n=100)

Variables	%
Severity of COVID-19	
Mild	48
Moderate	27
Severe	20
Critical case	5
Pre-existing co-morbidity	
Hypertension	55
Diabetes mellitus	44
Dyslipidemia	12
Nonalcoholic fatty liver disease	8
Hypothyroidism	9
Chronic kidney disease	11
Ischemic heart disease	10

Table-III

Spirometry findings of the study participants (n=100)

Findings	%
Lung function status	
Normal lung function	44
Restrictive lung function	66
Mild	24
Moderate	22
Moderately severe	15
Severe	4
Very severe	1
FEV1 (%) *	61.04±10.69
FVC (%) *	73.02±12.73
FEV1/FVC ratio*	.836±.001

FEV1: forced expiratory volume in one second
FVC: forced vital capacity

Additionally, several pre-existing comorbidities, such as hypertension, diabetes, and dyslipidemia, show significant associations with restrictive lung function abnormalities ($p<.05$). Moreover, a history of smoking was also observed as associated with restrictive lung function ($p<.05$). (Table-IV)

Univariate logistic regression demonstrates that older age (>50 years), a history of smoking, and the presence of diabetes mellitus and hypertension as comorbidity are significant risk factors for developing restrictive lung function abnormalities as respiratory sequalae in post covid patients. (Table-V)

Table-IV

Association of restrictive changes in spirometry with severity of COVID-19 disease, pre-existing comorbidity and history of smoking (n=100)

	Spirometry		
	Normal(n=34)n (%)	Restrictive(n=66)n (%)	p value*
Severity of COVID-19 disease			**<.001**
Mild	30 (88.2)	14 (21.2)	
Moderate	3(8.8)	27 (40.9)	
Severe	1(2.9)	20 (30.3)	
Critical case	0	5 (7.6)	
Pre-existing comorbidity			
Hypertension	12 (35.3)	43 (65.2)	0.004
Diabetes	7 (20.6)	37 (56.1)	0.001
Dyslipidemia	0 (0)	12 (18.2)	0.008
Nonalcoholic fatty liver disease	0 (0)	8 (12.1)	0.034
Hypothyroidism	3 (8.8)	6 (9.1)	0.965
Chronic kidney disease	0 (0)	11 (16.7)	0.012
Ischemic heart disease	0 (0)	10 (15.2)	0.017
History of smoking	11 (32.4)	46 (69.7)	0.05

*chi-square test

Table-V

Factors responsible for restrictive changes in spirometry among post covid patients (n=100)

Variables	Odds ratio	95% CI(lower-upper)	p value*
Age (>50 years)	3.24	1.36-7.74	0.008
Sex (Male)	1.18	0.48-2.89	0.713
Smoking history (Smoker)	4.81	1.97-11.71	0.001
Diabetes (Present)	4.92	1.88-12.89	0.001
Hypertension (Present)	3.43	1.44-8.15	0.005
Hyperlipidemia (Present)	1.03	0.29-3.72	0.959

*univariate analysis of logistic regression

Discussion:

The emergence of COVID-19 has posed significant challenges not only in the acute management of the disease but also in combating its long-term impact on various organ systems, particularly the respiratory system. This study aims to shed light on the prevalence of restrictive changes in spirometry as post-COVID-19 complications.

The patients included in this study were experiencing shortness of breath and/or cough after 6-8 weeks of discharge from the hospital following admission for COVID-19 and two-third of them were found with restrictive changes in spirometry. Restrictive changes in pulmonary function have also been reported in certain previous studies focusing on post-COVID-19 patients[15,16]. There are several reasons behind the development of respiratory sequelae following COVID-19 disease. Many patients develop acute respiratory distress syndrome (ARDS) and pneumonia from COVID-19 infection, leading to severe inflammation and damage. This residual damage might persist even after the recovery of the infection, affecting respiratory function[17]. Moreover, COVID-19 disease may cause pulmonary fibrosis may impair lung function and cause breathing difficulties in long term[18]. Ventilation-induced lung injury[19], thromboembolic complications[20], neuromuscular weakness[21] may also result in lung function impair and respiratory complications. The average level of forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) were below than normal reference levels where average FEV1/FVC ratio was normal- suggesting ongoing respiratory sequelae as restrictive changes in spirometry following COVID-19 infection.

The severity of COVID-19 disease was significantly associated with the presence of restrictive lung function abnormalities, supported by previous studies[22] highlight the impact of disease severity on long-term respiratory outcomes.

In this study, all patients were systematically screened for pre-existing comorbidities. Hypertension, diabetes mellitus, dyslipidemia, nonalcoholic fatty liver disease, chronic kidney disease, and ischemic heart disease were identified as significantly associated with restrictive lung function abnormalities. Notably, no patients with pre-existing neuromuscular conditions or diaphragmatic paralysis were included, as these factors can profoundly impact spirometry findings. Existing evidence suggests that post-COVID complications are more pronounced in individuals with comorbid conditions, likely due to their increased vulnerability to respiratory sequelae and systemic inflammation[23]. Identifying and accounting for such comorbidities is essential in understanding the multifactorial nature of lung function impairments in post-COVID-19 patients.

Patient demographics of this study represents a clear male predominance with an average age of 51 years while majority residing in urban areas. Similar demographic patterns were reported in previous studies[13,24]. Over half of the patients were presented current history of smoking. Both age and smoking history were identified as independent risk factors for restrictive lung function abnormalities in post-COVID-19 patients in logistic regression. Older age (>50 years) was associated with a significantly higher risk of developing restrictive lung function abnormalities, emphasizing the vulnerability of older individuals to long-term respiratory sequelae following COVID-19.

History of smoking also significantly increased the odds of experiencing restrictive lung function abnormalities, highlighting the impact of smoking in the context of COVID-19 recovery.

The findings of our study point out to the importance of comprehensive respiratory assessment, including spirometry, in post-COVID-19 follow-up care to detect and manage respiratory sequelae effectively. Early identification of restrictive changes in spirometry can facilitate timely interventions, such as pulmonary rehabilitation programs, respiratory therapies, and lifestyle modifications, to optimize respiratory function and quality of life in affected individuals. These findings also highlight the need for integrated management approaches that address not only the acute manifestations of COVID-19 but also its long-term consequences, particularly in individuals with pre-existing comorbidities and older age. However, given the broader scope of pulmonary function assessments, future studies should integrate additional investigations, such as total lung capacity (TLC) and lung volume analysis, to achieve a more holistic understanding of post-COVID-19 respiratory sequelae.

Conclusion:

This study reported a high prevalence of restrictive changes in pulmonary function abnormalities among post-COVID-19 patients through spirometry assessment which was associated with severity of COVID-19 disease, pre-existing comorbidities, age, and smoking history. These findings indicate the necessity of implementation of targeted respiratory assessment and integrated management approaches in post-COVID-19 care to mitigate long-term respiratory complications and improve patient outcomes.

Limitations:

The limitations of our study include its cross-sectional design, which limited our ability to assess long-term respiratory outcomes. While we ensured rigorous screening during enrollment by excluding patients with known lung diseases and reviewing prior imaging (e.g., CXR) to rule out abnormalities, we acknowledge the absence of detailed documentation on factors such as body mass index (BMI), which could influence spirometry findings. Additionally, although all patients with abnormal spirometry results were referred for CXRs to identify potential underlying causes, incorporating more systematic imaging data, including HRCT findings (e.g., fibrosis), would have strengthened our analysis.

Future research incorporating longitudinal follow-ups, multicenter involvement, and a more detailed collection of clinical parameters, such as BMI and comorbid conditions, is necessary to enhance our understanding of post-COVID-19 respiratory outcomes and develop targeted interventions for comprehensive post-acute care

Declarations:

Ethics approval: The study protocol was reviewed and approved by the Ethical Review Committee of Dhaka Medical College. Ethical issues were maintained in accordance with the Helsinki Declaration.

Conflict of interest: None

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