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# Role of Spirometry in Lung Function Assessment in Post COVID-19 Pneumonia Cases

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**Abstract** **Original Research Article**

***Background*:** Most COVID-19 patients recover without hospitalization, although a significant percentage needs hospitalization for pneumonia and other sequelae. Corona viral disease-19 (COVID-19) targets the lung, however its effects on lung function are unknown. ***Objective*:** This analysis aims to explore the significance of Spirometry in evaluating lung function in individuals who have recovered from COVID-19 and developed pneumonia. ***Materials and Methods*:** Prospective observational study conducted in the Department of Pulmonary Medicine, Gazi Medical College (GMC), Khulna, Bangladesh, during May 2021 to June 2022, to find out lung function assessment of post-COVID-19 recovered pneumonia cases after 12 weeks of discharge from hospital. Total 50 cases were enrolled in study after IRB approval and written informed consent of patient. ***Results*:** A restrictive pattern was observed in 43.6% of the patients, while 21.8% had normal lung function, 14.7% had obstructive patterns, and 19.9% displayed mixed patterns. In the abnormal lung function group, a majority of patients (60.7%) were aged 50 years or older. In the normal lung function group, a single patient (2.9%) exhibited an oxygen saturation level below 75%, but in the abnormal lung function group, 34 patients (27.9%) demonstrated the same. There was a statistically significant difference ($p<0.05$) seen between the two groups. ***Conclusion*:** Age above 50 years, male gender, Diabetes mellitus, High CT severity, longer duration of illness, proper timing of initiation of BIPAP/NIV therapy, has documented significant impact on post- COVID lung functions.

**Keyword:** Pulmonary functions, spirometry, post-COVID-19.



## INTRODUCTION

COVID-19 pneumonia is a diverse disease with varying effects on lung parenchyma, airways, and vasculature, resulting in long-term implications on lung functioning. Spirometry is a low-cost, non-invasive, easily accessible, and sensitive method for monitoring lung function in the post-COVID care scenario, and it will aid in the management of these cases by assessing treatment response. Pulmonary function abnormalities have been described in post-COVID-19 pneumonia cases and should be evaluated with caution to ensure a satisfactory therapeutic outcome [1].

Early epidemiological reports showed that 8.2% of total cases presented with rapid and progressive respiratory failure, similar to acute respiratory distress syndrome (ARDS) [2].

Approximately 25.4% post-COVID-19 patients had abnormal pulmonary function at three months following hospital discharge [3]. Restrictive lung defect was in 50% of post-COVID-19 patients [4]. Another study showed 42% post-COVID-19 patients had impaired lung function after three months of hospital discharge [5]. Only 6.4% post-COVID-19 patients had restrictive defect in another study [6].

Infectious COPD exacerbations are characterized by obstruction, hyperinflation, air trapping, and increased respiratory effort and central respiratory drive. Blood pCO2 rises in particular, and because of its high lipid solubility, it easily passes the blood-brain barrier, causing acidosis in the cerebrospinal fluid and cerebral interstitial tissue [7, 8].

Spirometry is among the most significant and popular techniques pulmonologists have employed in recent years to assess patients and carry out pulmonary function testing (PFT) [9]. During spirometry, significant pulmonary function indices, such as forced expiratory volume (FEV1), forced vital capacity (FVC),

and FEV1/FVC, are evaluated. The pulmonary function of patients with severe COVID-19 has been carefully examined in the present study 6 to 12 weeks after recovery and discharge because PFT is crucial for evaluating respiratory health and diagnosing situations like asthma, chronic obstructive pulmonary disease (COPD), and severe respiratory failure [10].

The parameters of maximum inspiratory pressure (PI max) and maximum expiratory pressure (PE max), diffusion capacity of carbon monoxide (DLCO), residual volume (RV), total lung capacity (TLC), RV/TLC, COPD assessment test (CAT) score, MRC score, airway obstruction pressure (P=0.1), and oxygen saturation percentage were also looked at. Since there is limited information on the respiratory function in individuals with symptomatic COVID-19 pneumonia after recovery, we intend to analyse the PFT results, trends of lung involvement and finding the correlation of spirometric findings with CTSS values in patients having COVID-19 pneumonia following discharge.

## MATERIALS AND METHODS

Prospective observational study conducted in Department of Pulmonary Medicine, Gazi Medical College (GMC), Khulna, Bangladesh, during May 2021 to June 2022, to find out lung function assessment of post-COVID-19 recovered pneumonia cases after 12 weeks of discharge from hospital. Total 156 cases were enrolled in study after IRB approval and written informed consent of patient.

**Inclusion Criteria**

1. All treated and recovered COVID-19 pneumonia cases over the age of 18 admitted to an indoor unit have been included in the study.
2. The study included recovered instances with COVID-19 pneumonia regardless of oxygen saturation.
3. The study included recovered COVID-19 pneumonia cases who were willing to take a spirometry test.

**Exclusion Criteria**

1. Recovered COVID-19 pneumonia cases are unwilling to undertake spirometry testing.
2. Patients with COVID-19 pneumonia who have recovered are unable to undergo a spirometry test.
3. Recovered COVID-19 pneumonia cases with neurological difficulties such as hemiparesis or hearing difficulty, as well as co-ordination challenges during spirometry
4. Excluded from the study were recovered COVID-19 pneumonia cases with tachypnea or tachycardia, as well as cases requiring oxygen at rest.
5. Cases of COVID-19 pneumonia recovered in children under the age of 18
6. Cases of COVID-19 pneumonia recovered in pregnant women (any trimester was excluded)

All study cases were undergone following assessment before enrolling in study clinical assessment as-vital parameters like heart rate, respiratory rate, blood pressure and documentation of respiratory adventitious sounds, laboratory parameters- hemoglobin, renal functions, blood sugar level, kidney functions, ECG, Spirometry. Subsequently spirometry evaluation was done by a portable spirometer, SPIROLAB II and meets American Thoracic Society and European Respiratory Society standards (ATS & ERS), before and fifteen minutes after administration of 400 microgram salbutamol using pressurized metered-dose inhaler (pMDI) with small-volume spacer device. All patients were instructed not to use any bronchodilator on the preceding night and on day of procedure. Spirometry procedure was carried out as per ATS/ERS task force recommendation for standardization of lung function testing. Subjects who were found to have post-bronchodilator FEV1 (Forced Expiratory Volume in first second)/FVC (Forced Vital Capacity) <0.7 were taken up for final analysis as this value indicates the cut-off for diagnosis of obstructive airway disease according to GOLD guideline. Bronchodilator Reversibility (BDR) was defined as an improvement in FEV1 by at least 12% and 200 ml over pre-bronchodilator value. FEV1/FVC ≥0.7 were excluded as those patients had either a normal spirometry or a purely restrictive ventilatory abnormality. Also, the individuals who failed to fulfil acceptability and reproducibility criteria of spirometry were excluded. FVC, FEV1, and FEV1/FVC ratio values for case patients were compared with lung function normal and abnormal adult predicted normative population values group.

## RESULTS

**Table 1: Spirometry assessment of post-COVID 19 pneumonia cases at 3 months of discharge from hospital**

| | Frequency | Percentage |
|---|---|---|
| Normal | 34 | 21.8 |
| Obstructive | 23 | 14.7 |
| Mixed | 31 | 19.9 |
| Restrictive | 68 | 43.6 |

Table 1 shows that restrictive pattern was found in 43.6% patients followed by normal lung function in 21.8%, obstructive in 14.7% and mixed in 19.9% patients.

**Table 2: CT severity grade of post-COVID 19 pneumonia cases**

| CT severity grade | Frequency | Percentage |
|---|---|---|
| Mild (≤8 score) | 34 | 21.8 |
| Moderate (9-15 score) | 23 | 14.7 |
| Severe (>15 score) | 68 | 43.6 |

Table 2 shows that majority (43.6%) patients had severe CT severity, 23(14.7%) had moderate and 34(21.8%) had mild CT severity.

**Table 3: Association between demographic characteristics with lung function of post-COVID 19 pneumonia**

| Variables | Lung function | | | | P value |
|---|---|---|---|---|---|
| | Normal (n=34) | | Abnormal (n=122) | | |
| | n | % | n | % | |
| Age (years) | | | | | |
| <50 | 23 | 67.6 | 48 | 39.3 | 0.003 |
| ≥50 | 11 | 32.4 | 74 | 60.7 | |
| Gender | | | | | |
| Male | 28 | 82.4 | 82 | 67.2 | 0.087 |
| Female | 6 | 17.6 | 40 | 32.8 | |

P value reached from chi square test

Table 3 shows that 11(32.4%) patients belonged to age ≥50 years in normal lung function group and 74(60.7%) in abnormal lung function group. Which was statistically significant (p<0.05) between two groups.

**Table 4: Association between CT severity grades with lung function of post-COVID 19 pneumonia**

| CT severity grade | Lung function | | | | P value |
|---|---|---|---|---|---|
| | Normal (n=34) | | Abnormal (n=122) | | |
| | n | % | n | % | |
| Mild | 10 | 29.4 | 13 | 10.7 | |
| Moderate | 16 | 47.1 | 21 | 17.2 | 0.001 |
| Severe | 8 | 23.5 | 88 | 72.1 | |

P value reached from chi square test

Table 4 shows that 8(23.5%) patients had severe CT severity in normal lung function group and 88(72.1%) in abnormal lung function group. The difference was statistically significant (p<0.05) between two groups.

**Table 5: Association between hospital stay at entry point with lung function of post-COVID 19 pneumonia**

| Hospital stay (days) | Lung function | | | | P value |
|---|---|---|---|---|---|
| | Normal (n=34) | | Abnormal (n=122) | | |
| | n | % | n | % | |
| ≤7 | 27 | 79.4 | 34 | 27.9 | |
| 8-14 | 6 | 17.6 | 45 | 36.9 | 0.001 |
| >14 | 1 | 2.9 | 43 | 35.2 | |

P value reached from chi square test

Table 5 shows that 1(2.9%) patients was found hospital stay >14 days in normal lung function group and 43(35.2%) in abnormal lung function group. The difference was statistically significant (p<0.05) between two groups.

**Table 6: Association between oxygen saturation at entry point with lung function of post-COVID 19 pneumonia**

| Oxygen saturation (%) | Lung function | | | | P value |
|---|---|---|---|---|---|
| | Normal (n=34) | | Abnormal (n=122) | | |
| | n | % | n | % | |
| <75 | 1 | 2.9 | 34 | 27.9 | |
| 75-90 | 10 | 29.4 | 83 | 68.0 | 0.001 |
| >90 | 23 | 67.6 | 5 | 4.1 | |

P value reached from chi square test

Table 6 shows that 1(2.9%) patients was found oxygen saturation level <75% in normal lung function group and 34(27.9%) in abnormal lung function group. The difference was statistically significant ($p<0.05$) between two groups.

## DISCUSSION

In this study, the most common spirometric abnormality was a restrictive defect, which was more severe in severe instances. COVID-19 pneumonia can advance to fibrotic changes, resulting in a restricted lung deformity [11]. The majority of restrictive lung defects were modest. In parenchymal pathology, restrictive lung defect is associated with decreased lung capacity and DLCO. Reduced TLC was the most prevalent anomaly in this investigation, followed by reduced DLCO.

In this study observed that restrictive pattern was found in 43.6% patients followed by normal lung function in 21.8%, obstructive in 14.7% and mixed in 19.9% patients. Shital *et al*., [1], reported In Spirometry assessment of post-COVID 19 pneumonia cases at 12 weeks post discharge form hospital, restrictive pattern was predominant type documented in 43.33% cases, normal lung functions were documented in 22.5% cases. Torres-Castro *et al*., [12], done systematic review and meta-analysis of Respiratory function in post-COVID-19 cases and observed altered diffusion capacity, restrictive pattern and obstructive pattern were found in 39%, 15% and 7% of patients, respectively. Fumagalli *et al*., [13], found a significant incidence of a restrictive pattern in 10 (76%) out of 13 patients after 6 weeks from recovery in COVID pneumonia cases. Eksombatchai *et al*., [14], reported overall abnormalities in spirometry were seen in 15 cases (17.2%). In the severe pneumonia group, there were 71.4% having abnormal spirometry. Meanwhile, abnormal spirometry was found at 10.2% and 15.6% in the mild symptom and non-severe pneumonia groups, respectively. There were restrictive defects in 2 patients (28%) in the severe pneumonia group. There were also 3 patients (42.9%) in the severe pneumonia group having obstructive defects in which 2 out of the 3 were small airway disease. Regarding patients in the mild symptom and non-severe pneumonia groups, only 2 (4.3%) and 3 patients (9.1%), respectively, had obstructive defects.

Current study observed that majority (43.6%) patients had severe CT severity, 23(14.7%) had moderate and 34(21.8%) had mild CT severity. CT severity was graded as mild (grade 1) as ≤8 score, moderate (grade 2) as 9-15 score, and severe (grade 3) as > 15 score [15], Sharma *et al*., [16], reported 58% of sample population had grade 3 severity followed by moderate severity in 27.3% patients and grade 1 severity was present in only 14.7% patients.

Present study observed that 11(32.4%) patients belonged to age ≥50 years in normal lung function group and 74(60.7%) in abnormal lung function group. Which was statistically significant ($p<0.05$) between two groups. Shital *et al*., [1], revealed abnormal lung function in 77.5% post covid-19 pneumonia cases and statistically significant association in males (90/150) versus females (45/315) normal and abnormal lung functions respectively [$p<0.00001$]; similar observation also documented in age of population in study cases as below 50 years (110/300) versus above 50 years (25/165) [$p<0.0001$]. Salem *et al*., [4], observed that the female sex was an independent predictor for impaired lung diffusion using multivariable logistic regression ($P = 0.024$), and No significant predictor for the restrictive pattern was detected.

In this study showed that 8(23.5%) patients had severe CT severity in normal lung function group and 88(72.1%) in abnormal lung function group. The difference was statistically significant ($p<0.05$) between two groups. Shital *et al*., [1], reported CT severity score has shown negative impact on lung function after recovery at 12 weeks post-discharge; cases with score <8, 8-15 and >15 documented normal and abnormal lung functions as in 36/54, 60/80 and 39/331 respectively of total 600 study cases [$p<0.00001$]. Lewis *et al*., [17], in their study included mild and moderate disease with 20% of patients being severe or critical disease. Patra *et al*., [10], reported majority of the patients, HRCT severity score during course of illness had strong correlation with spirometric findings after 6-10 weeks of follow up and

the association was statistically significant (p value 0.000). 33% had mild, 22% had moderate and 4% patients had severe lung disease. 41% patients had normal findings on spirometry. Correlations exist between the severity of a disease or persistent imaging alterations and the deterioration of lung function, with studies by wan *et al*., [18], showing comparable results.

In this study observed that 1(2.9%) patients was found hospital stay >14 days in normal lung function group and 43(35.2%) in abnormal lung function group. The difference was statistically significant ($p<0.05$) between two groups. Shital *et al*., [1], reported duration of illness has associated negative impact on lung function; <7 days, 8-15 days and >15 days of onset of symptoms documented normal and abnormal lung functions in 108/132, 22/168 and 5/165 cases respectively [$p<0.00001$].

According to the current study, 1 (2.9%) individuals in the group with normal lung function and 34 (27.9%) in the group with impaired lung function had oxygen saturation levels below 75%. The difference between the two groups was statistically significant (p 0.05). Low oxygen saturation at the entrance site, as noted by Shital *et al*., [1], has a detrimental effect on the overall outcome of lung function; cases with oxygen saturations of 75%, 75-90%, and >90% were identified as having normal and abnormal lung functions, respectively, in 92/18, 35/135, and 6/314 instances, respectively (p0.00001).

## CONCLUSION

In conclusion, our study showed that pulmonary abnormalities, especially reduced diffusion capacity, are common in discharged COVID-19 patients at three to five months after hospital discharge. COVID-19 pneumonia is heterogeneous disease with variable effect on lung parenchyma, airways and vasculature leading to long term effects on lung functions. Spirometry is cost effective, non-invasive, easily available, sensitive tool for assessment lung function in post COVID care setting and it will help management of these cases by assessing response to treatment. Pulmonary functions abnormality in post-COVID-19 pneumonia cases has been documented and should be assessed cautiously to have successful treatment outcome. Age above 50 years, male gender, Diabetes mellitus, High CT severity, longer duration of illness, proper timing of initiation of BIPAP/NIV therapy, has documented significant impact on post- COVID lung functions.

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## REFERENCE

1. Shital, P., Dhumal, U., & Acharya, A. (2021). Role of spirometry in lung function assessment in post COVID-19 pneumonia cases: correlation with CT severity, duration of illness, oxygen saturation and ventilatory support in critical care setting in tertiary care setting in India. *Saudi J Med*, *6*(12), 441-448.
2. Cypel, M., & Keshavjee, S. (2020). When to consider lung transplantation for COVID-19. *The Lancet Respiratory Medicine*, *8*(10), 944-946.
3. Zhao, Y. M., Shang, Y. M., Song, W. B., Li, Q. Q., Xie, H., Xu, Q. F., ... & Xu, A. G. (2020). Follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors three months after recovery. *EClinicalMedicine*, *25*.
4. Salem, A. M., Al Khathlan, N., Alharbi, A. F., Alghamdi, T., AlDuilej, S., Alghamdi, M., ... & Sabit, H. (2021). The long-term impact of COVID-19 pneumonia on the pulmonary function of survivors. *International journal of general medicine*, 3271-3280.
5. Liang, L., Yang, B., Jiang, N., Fu, W., He, X., Zhou, Y., ... & Wang, X. (2020). Three-month follow-up study of survivors of coronavirus disease 2019 after discharge. *Journal of Korean medical science*, *35*(47). doi:10.3346/jkms.2020.35.e418
6. Liao, X., Wang, Y., He, Z., Yun, Y., Hu, M., Ma, Z., ... & Liu, L. (2021, September). Three-month pulmonary function and radiological outcomes in COVID-19 survivors: a longitudinal patient cohort study. In *Open forum infectious diseases* (Vol. 8, No. 9, p. ofaa540). US: Oxford University Press. doi: 10.1093/ofid/ofaa540
7. Zhu, G. F., Zhang, W., Hua, Z., Xu, Q. F., & Liang, Y. (2007). Effectiveness and safety of noninvasive positive-pressure ventilation for severe hypercapnic encephalopathy due to acute exacerbation of chronic obstructive pulmonary disease: a prospective case-control study. *Chinese medical journal*, *120*(24), 2204-2209.
8. Briones, K., Briones, M., Chung, M. (2008). Noninvasive mechanical ventilation in patients with chronic obstructive pulmonary disease and severe hypercapnic neurological deterioration in the emergency room. *Eur J Emerg Med*, *15*, 127–133.
9. Mo, X., Jian, W., Su, Z., Chen, M., Peng, H., Peng, P., ... & Li, S. (2020). Abnormal pulmonary function in COVID-19 patients at time of hospital discharge. *European Respiratory Journal*, *55*(6).
10. Patra, S., Khyalappa, R. A. (2023). correlation of the spirometric outcomes of follow up patients of COVID-19 pneumonia with their admission time computed tomography severity score on high resolution computed tomography thorax. *Int J Res Med Sci*, *11*, 558-61.
11. Guler, S. A., Ebner, L., Aubry-Beigelman, C., Bridevaux, P. O., Brutsche, M., Clarenbach, C., ... & Funke-Chambour, M. (2021). Pulmonary function

and radiological features 4 months after COVID-19: first results from the national prospective observational Swiss COVID-19 lung study. *European respiratory journal*, *57*(4). doi: 10.1183/13993003.03690-2020

12. Torres-Castro, R., Vasconcello-Castillo, L., Alsina-Restoy, X., Solís-Navarro, L., Burgos, F., Puppo, H., & Vilaró, J. (2021). Respiratory function in patients post-infection by COVID-19: a systematic review and meta-analysis. *Pulmonology*, *27*(4), 328-337.
13. Fumagalli, A., Misuraca, C., Bianchi, A., Borsa, N., Limonta, S., Maggiolini, S., ... & Colombo, D. (2021). Pulmonary function in patients surviving to COVID-19 pneumonia. *Infection*, *49*, 153-157.
14. Eksombatchai, D., Wongsinin, T., Phongnarudech, T., Thammavaranucupt, K., Amornputtisathaporn, N., & Sungkanuparph, S. (2021). Pulmonary function and six-minute-walk test in patients after recovery from COVID-19: A prospective cohort study. *PloS one*, *16*(9), e0257040.
15. Yang, R., Li, X., Liu, H., Zhen, Y., Zhang, X., Xiong, Q., ... & Zeng, W. (2020). Chest CT severity score: an imaging tool for assessing severe COVID-19. *Radiology: Cardiothoracic Imaging*, *2*(2), e200047. https://doi.org/10.1148/ryct.2020200047
16. Sharma, S., Aggarwal, A., Sharma, R. K., Patras, E., & Singhal, A. (2022). Correlation of chest CT severity score with clinical parameters in COVID-19 pulmonary disease in a tertiary care hospital in Delhi during the pandemic period. *Egyptian Journal of Radiology and Nuclear Medicine*, *53*(1), 1-8.
17. Lewis, K. L., Helgeson, S. A., Tatari, M. M., Mallea, J. M., Baig, H. Z., & Patel, N. M. (2021). COVID-19 and the effects on pulmonary function following infection: A retrospective analysis. *EClinicalMedicine*, *39*.
18. Wu, Q., Zhong, L., Li, H., Guo, J., Li, Y., Hou, X., ... & Xing, Z. (2021). A follow-up study of lung function and chest computed tomography at 6 months after discharge in patients with coronavirus disease 2019. *Canadian Respiratory Journal*, *2021*, 1-7.