Review Article

Role and Importance of Pulmonary Function test in Pulmonary Involvement of COVID-19: A Review Study

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Abstract

Background: Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is the greatest pandemic in the world. This virus involves the respiratory system, causes pulmonary dysfunction, and causes coronavirus disease (COVID-19). Pulmonary dysfunction due to COVID-19 may be asymptomatic, mild, moderate, and severe/critical. COVID-19 may involve other organs, and its sequelae may be persistent for a long time. The pulmonary function test is a method for evaluating the lungs in people. In this study, we reviewed the results of pulmonary function test (PFT) in patients with a history of COVID-19 involvement based on previous studies.

Materials and Methods: The present review was conducted in 2024 using the keywords COVID-19, pulmonary function test, recovery, and pulmonary involvement in English. Eligible articles (articles containing the mentioned keywords) published during the years 2019 to 2023 were searched in Scopus, Pubmed, Wiley, and Google Scholar international databases. Relevant articles were identified, and after review, the most important and valuable points were presented.

Results: PTF should not be done during COVID-19 involvement because it increases the rate of disease transmission. Small airway dysfunction, restrictive ventilatory dysfunction, and pulmonary diffusion impairment patterns are the most common findings in the PFTs of patients with a history of COVID-19. PFT improves gradually after the recovery of pulmonary involvement of COVID-19 for two years, even in patients with severe or critical forms of COVID-19.

Conclusion: In this review, we summarized the results of studies about pulmonary function tests after COVID-19 involvement in survivors. Small airway dysfunction, restrictive ventilatory dysfunction, and pulmonary diffusion impairment are the most common findings in the PFT of survivors of COVID-19. These patterns are more prevalent among patients with severe or critical forms of COVID-19, and they are associated with the risk factors of COVID-19 severity, such as age, underlying disease, and pulmonary disorders. Forced vital capacity and diffusion capacity of lungs for carbon monoxide decreased in patients with COVID-19, and forced expiratory volume in 1 second (FEV1)/FVC and residual volume (RV) increased in these patients and they were associated with COVID-19 severity. The pulmonary involvement of COVID-19 recovers over time, and after two years, patients return to their baseline PFTs.

Keywords: COVID-19, Pulmonary function test, Lung

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Introduction

The coronavirus disease 2019 (COVID-19) pandemic is the most significant pandemic until now. It was first found in China in 2019. This virus is the second type of the Coronavirus family (SARS-COV-2) and mainly involves the respiratory system[1-3].

SARS-COV-2 is a drop-let-borne virus with a diameter of 60–140 nm that is rapidly spread between hosts. It remains on surfaces for up to 3 days, and one of the important challenging situations is that some patients are asymptomatic and can quickly spread the disease[4-6].

The pathogenesis of the disease is based on an interaction between the angiotensin-converting enzyme 2 (ACE2) receptor of the human body and the surface spike protein (S protein) of the virus [7]. The virus involves all cells with ACE2 receptors, including pneumocytes and airway epithelial cells. The virus enters the host's cells using ACE2 receptors and type II transmembrane serine protease (TMPRSS2), and then the viral activity starts[8,9].

Clinical manifestations of COVID-19 range from asymptomatic to acute respiratory distress syndrome (ARDS). The most common clinical manifestations are fever, cough, and dyspnea. Body pain is also among the common manifestations[6,10,11]. With increasing respiratory system involvement, some presentations such as shortness of breath, chest pain, and hemoptysis are presented, and they can progress to ARDS. It is mentioned that about 15% of patients with mild symptoms progress to severe forms, including the need for oxygen supplementation, and 5% may need intensive unit care (ICU) admission[12-14]. Although SARS-COV-2 involves the lungs and can affect pulmonary functions test, there are few studies about the assessment of COVID-19 effects on pulmonary functions test (PFT) results[15]. In the present study, we aim to review issues about pulmonary function tests in COVID-19 involvement.

Methods

The present review was conducted in 2024 using the keywords COVID-19, pulmonary function test, recovery, and pulmonary involvement in English. Eligible articles published during the years 2019 to 2023 were searched in Scopus, Pubmed, Wiley, and Google Scholar international databases.

Experimental or quasi-experimental articles written in English and relevant to the purpose of the study were included. In contrast, articles whose full text was not available, systematic review studies, and meta-analyses were excluded.

Results

Pulmonary function test during COVID-19 involvement: Although PFT is a good test for the assessment of lung function, there are limitations to PFT's utility. PFT results are affected if a patient has poor understanding, severe or acute disease, or lack of cooperation. The operator should introduce the PFT procedure, and the patient should obey the procedure. If a patient is unable to perform PFT or does not perform PFT well, the results are affected, and unreliable results are seen[16,17].

In patients with COVID-19, prevention recommendations mentioned that PFT for the assessment of COVID-19 involvement should not be done because it increases the risk of the virus transmission. Forced exhalations that are a part of the PFT procedure may induce cough or drop-let throw into the device and increase the risk of transmission for others. So, risk mitigation protocols recommend that non-urgent PFTs should not be done before 14 days of close contact exposure to COVID-19, and only urgent PFTs can be done[18]. With adherence to the protocols, the risk of transmission is low. In a study by Wainstein et al., the incidence rate of COVID-19 involvement after PFT during the pandemic was 0.36%[19]. Although Wainstein et al. found a low incidence rate of COVID-19 after PFT, it was recommended that the test not be performed during COVID-19 involvement, and due to this reason, there is no data in this issue, and studies evaluated post-COVID-19 PFT in COVID-19 survivors.

Pulmonary function test after COVID-19 involvement: Based on our knowledge, there are studies with different results about the PFT after

COVID-19 involvement. Mo et al. performed PFT at the time of discharge of patients who were hospitalized due to COVID-19. They found that impaired diffusion capacity and restrictive ventilation defects were the most prevalent abnormal findings, and they were associated with the disease severity. They mentioned that lung volumes, including total lung capacity (TCL) and residual volume (RV), were significantly associated with the disease severity, and they had worse results in patients with more severe COVID-19 involvements[20].

Lv et al. assessed the PFT of COVID-19 survivors after two weeks of discharge. They evaluated 137 participants and found that 88.9% of patients with severe COVID-19 had forced inspiratory volume (IVC) less than 80% of the predicted value, and 55.6% of these patients had forced vital capacity (FVC) less than 80% of the predicted value. The maximum expiratory flow (MEF)75, MEF50, and MEF25 of less than 70% were found in 25.9%, 40.7%, and 55.6%, respectively. These rates in the non-severe groups were 13.6%, 30%, and 57.3%, respectively, and 79.1% of them had IVC less than 80% of the predicted value, and 16.4% had FVC less than 80% of the predicted value. They concluded that small airway obstruction and restrictive ventilation disorder are associated with COVID-19, and these patterns aggravate severe disease involvement[21].

In a study by Polese et al., 41 severe COVID-19 patients between fifteen to thirty days after discharge were evaluated. Restrictive patterns with a FVC reduction of 54% and a DLCO reduction in 79% of patients were found[22].

Wu et al. evaluated the PFT and lung CT scans of patients with COVID-19 involvement who were discharged six months later. The patients had moderate or severe COVID-19 involvement. They demonstrated that pulmonary dysfunction based on PFT at the sixth-month follow-up included restrictive ventilatory dysfunction, small airway dysfunction, and pulmonary diffusion impairment seen in 7.5%, 18.9%, and 32.1%, respectively [23]. In fact, based on Wu et al.'s results, 58.5% of patients with severe or moderate COVID-19 involvements had impaired PFT after six months of discharge.

van Willigen et al. assessed PFT results in 301 patients 12 months after COVID-19 involvement (hospitalized and nonhospitalized). 25% of patients had impaired PFT after one year of COVID-19 involvement, and impaired PFT was mostly seen in severe and critical types of COVID-19 involvement (48%). They observed that PFT results improved in these patients over one year, and worse results were associated with higher age, underlying disorder, and severe or critical disease[24].

Suppini et al. also evaluated the PFT of one hundred COVID-19 survivors one year after COVID-19. They observed that FVC had a significant association with COVID-19 severity, and with an increase in disease severity, FVC decreased. FEV1/FVC increased, and RV and total lung capacity (TLC) decreased with the severity of COVID-19. TLC, FEV1, FVC, diffusion capacity of lungs for carbon monoxide (DLCO), and RV improved over one year of COVID-19 recovery. Fibrotic change of lung tissue was associated with COVID-19 severity after one year. They mentioned that pulmonary function recovered well, especially in patients with more severe COVID-19 involvements, and it shows that pulmonary damage due to COVID-19 is reversible[25].

Toh et al. evaluated the effects of COVID-19 involvement on PFT results and quality of life. Their results showed that DLCO defects were more prevalent in patients with severe or critical COVID-19 involvement, and these patients had lower quality of life during one year after COVID-19 involvement, based on the Short Form-36 (SF-36) Health Survey. PFT abnormalities had higher rates in patients with older age, underlying disorders, and lung disorders[26]. Quality of life was assessed in this study by the SF-36 Health Survey. With the SF-36 Health Survey, eight health parameters are assessed, including social function, physical function, function limitation because of physical impairments and emotional problems, bodily pain, mental health, general health, and vitality. Each of the parameters is scored from 0 (worst) to 100 (best)[27]. Toh et al. did not mention any data about the recovery of lung function after one year, but they mentioned that the most PFT impairment was observed in the sixth month of follow-up.

Lewis et al. conducted an interesting study on PFT of patients with COVID-19. They compared PFT data of patients before COVID-19 involvement with PFT after one year of COVID-19 involvement. They found that there was no significant difference between the result of

PFT before COVID-19 and PFT after COVID-19. It should be mentioned that their study was done on patients with mild and moderate COVID-19 involvement. They found that age and underlying disease were risk factors for worse results of PFT[28].

Zhang et al. evaluated the effects of COVID-19 on patients after two years. They assessed 288 participants and found that the participants significantly improved from 6 months to one year after COVID-19 involvement. From one year to two years, PFT parameters improved gradually[29]. Huang et al. also concluded that the health status (including PFT) of patients who were hospitalized due to COVID-19 returns to the basic status of each patient after two years. However, it may be weaker than the general population[30]. Li et al. mentioned that after two years of COVID-19 involvement, most organ involvement and disease parameters are resolved, and the most common long-term side effect of the disease is neurological involvement[31]. These studies showed that the PFT of involved participants returned to normal levels during two years.

Discussion

COVID-19 involves all populations over the world. From the start of COVID-19 emergence to July 17, 2021, more than 200 million people were infected, and more than 4 million people died[32,33]. COVID-19 infects the nasopharynx and lungs, and different respiratory manifestations with different severity may be presented, ranging from asymptomatic to pneumonia and even ARDS. Hypoxia is one of the most common symptoms, especially in patients with underlying lung disease. Cytokine storms and lung damage may occur in COVID-19. ARDS and pulmonary fibrosis are the results of lung damage due to COVID-19[34-36].

Respiratory failure occurs in severe COVID-19. Diffuse and bilateral interstitial pneumonia are seen in this stage[37,38]. Older age, diabetes, obesity, cardiovascular disorders, pulmonary disorder, and kidney failure are the risk factors for severe COVID-19 involvement[39,40].

Pulmonary involvement in COVID-19 affects patient outcomes[41]. COVID-19 sequelae may persist in involved people. Studies have mentioned that the pulmonary function test (PFT) is a method to assess the long-term effects of COVID-19 on the lungs[42,43]. In this review, we summarized the results of studies about pulmonary function tests after COVID-19 involvement in survivors.

Due to observing preventive protocols, PFT should not be done during COVID-19 involvement because SARS-Cov-2 is a droplet-borne virus, and one of the main manifestations of patients with COVID-19 is cough. Then, the device can be contaminated by the virus, and the virus may be transmitted between people[44].

Based on the results of studies, the most common findings in the PFT of survivors of COVID-19 are the patterns of small airway dysfunction, restrictive ventilatory dysfunction, and pulmonary diffusion impairment. These patterns are more prevalent among patients with severe or critical forms of COVID-19, and they are associated with the risk factors of COVID-19 severity, such as age, underlying disease, and pulmonary disorders[20-23].

In terms of PFT parameters, it was found that FVC and DLCO decreased in patients with COVID-19, and FEV1/FVC and RV increased in these patients. These parameters were associated with COVID-19 severity[21,22,25,26]. Of the common COVID-19 clinical manifestations are cough, dyspnea, chest pain, and ARDS[45]. These manifestations come from pulmonary dysfunction due to COVID-19 involvement. The findings of PFTs in the studies demonstrated lung injury post-COVID-19 involvement, but these injuries recover gradually.

We summarized studies based on the duration of follow-ups. We classified them from the evaluation of survivors after two weeks to the evaluation after two years of discharge from the hospital. It was found that the pulmonary involvement of COVID-19 based on PFT recovers over time, and after two years, patients return to their baseline PFTs. Although the PFTs of patients with severe forms of the disease were more involved, the recovery rate of these patients was faster, and patients' PFTs became normal for each patient after two years[29-31].

Conclusion

It is concluded that the pulmonary function test is a suitable method for following up on patients after COVID-19 involvement. Prevention protocols for the

restriction of COVID-19 transmission should be obeyed, and this test should be done in participants at least two weeks of recovery. Small airway and restrictive ventilatory dysfunction, as well as pulmonary diffusion impairment patterns, are the most common findings in the PFT. The PFT of recovered participants improves gradually over two years.

Acknowledgment

None.

Conflict of interest

The authors further declare that they have no conflict of interest.

References

1. The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nature microbiology. 2020;5(4):536-44.
2. Gorbalenya AE, Baker SC, Baric RS, et al. Coronaviridae Study Group of the International Committee on Taxonomy of Viruses. The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. Nat. Microbiol. 2020;5(4):536-44.
3. Kim I-H, Kang B-H, Seo SH, et al. Early laboratory preparedness of the Korea Disease Control and Prevention Agency and response to unknown pneumonia outbreak from Wuhan, China, in January 2020. Annals of Laboratory Medicine. 2021;41(6):532-9.
4. Bai Y, Yao L, Wei T, et al. Presumed asymptomatic carrier transmission of COVID-19. Jama. 2020;323(14):1406-7.
5. Van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. New England journal of medicine. 2020;382(16):1564-7.
6. Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China, 2019. New England journal of medicine. 2020;382(8):727-33.
7. Li Y, Zhou W, Yang L, You R. Physiological and pathological regulation of ACE2, the SARS-CoV-2 receptor. Pharmacological research. 2020;157:104833.
8. Hoffmann M, Kleine-Weber H, Schroeder S, et al. SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. cell. 2020;181(2):271-80.
9. Guan W-j, Ni Z-y, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. New England journal of medicine. 2020;382(18):1708-20.
10. Xu X, Chen P, Wang J, et al. Evolution of the novel coronavirus from the ongoing Wuhan outbreak and modeling of its spike protein for risk of human transmission. Science China Life Sciences. 2020;63:457-60.
11. Nicastri E, D'Abramo A, Lepore L, et al. The evolution of clinical and scientific evidence-based management guidelines for Covid-19 disease: A longitudinal descriptive analysis. Available at SSRN 3672327. 2020.
12. Pau A, Aberg J, Baker J, et al. National Institutes of Health COVID-19 Treatment Guidelines Panel. Convalescent plasma for the treatment of COVID-19: perspectives of the National Institutes of Health COVID-19 Treatment Guidelines Panel. Ann Intern Med. 2021;174(1):93-5.
13. Health NIo. National Institutes of Health COVID-19 treatment guidelines. Therapeutic Management of Nonhospitalized Adults With COVID. 2021;19.
14. Lu R, Zhao X, Li J, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. The lancet. 2020;395(10224):565-574.
15. Hull JH, Lloyd JK, Cooper BG. Lung function testing in the COVID-19 endemic. The Lancet Respiratory Medicine. 2020;8(7):666-7.
16. Ponce M, Sankari A, Sharma S. Pulmonary Function Tests. 2022 Sep 3. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. 2023.
17. Contini M, Conte E, Agostoni P. Lung function evaluation in heart failure: possible pitfalls. Breathe. 2020;16(1).
18. Borg BM, Osadnik C, Adam K, et al. Pulmonary function testing during SARS-CoV-2: An ANZSRS/TSANZ position statement. Respirology. 2022;27(9):688-719.
19. Wainstein EJ, Peroni HJ, Ferreyro BL, et al. Incidence of COVID-19 after pulmonary function tests: a retrospective cohort study. Revista de la Facultad de Ciencias Médicas. 2021;78(4):367.
20. Mo X, Jian W, Su Z, et al. Abnormal pulmonary function in COVID-19 patients at time of hospital discharge. European Respiratory Journal. 2020;55(6).
21. Lv D, Chen X, Mao L, et al. Pulmonary function of patients with 2019 novel coronavirus induced pneumonia: a retrospective cohort study. 2020.
22. Polese J, Sant'Ana L, Moulaz IR, et al. Pulmonary function evaluation after hospital discharge of patients with severe COVID-19. Clinics. 2021;76.
23. Wu Q, Zhong L, Li H, et al. 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;2021:1-7.
24. van Willigen HD, Wynberg E, Verveen A, et al. One-fourth of COVID-19 patients have an impaired pulmonary function after 12 months of disease onset. Plos one. 2023;18(9):e0290893.
25. Suppini N, Fira-Mladinescu O, Traila D, et al. Longitudinal Analysis of Pulmonary Function Impairment One Year Post-COVID-19: A Single-Center Study. Journal of Personalized Medicine. 2023;13(8):1190.
26. Toh MR, Teo YR, Poh LCR, et al. Impact of COVID infection on lung function test and quality of life. Scientific Reports. 2023;13(1):17275.
27. Ware Jr JE, Gandek B. Overview of the SF-36 health survey and the international quality of life assessment (IQOLA) project. Journal of clinical epidemiology. 1998;51(11):903-12.
28. Lewis KL, Helgeson SA, Tatari MM, Mallea JM, Baig HZ, Patel NM. COVID-19 and the effects on pulmonary function following infection: A retrospective analysis. EClinicalMedicine. 2021;39.
29. Zhang H, Li X, Huang L, et al. Lung-function trajectories in

COVID-19 survivors after discharge: A two-year longitudinal cohort study. EClinicalMedicine. 2022;54.
30. Huang L, Li X, Gu X, et al. Health outcomes in people 2 years after surviving hospitalisation with COVID-19: a longitudinal cohort study. The Lancet Respiratory Medicine. 2022;10(9):863-76.
31. Li D, Liao X, Liu Z, et al. Healthy outcomes of patients with COVID-19 two years after the infection: a prospective cohort study. Emerging Microbes & Infections. 2022;11(1):2680-8.
32. Togami E, Griffith B, Mahran M, et al. The World Health Organization's public health intelligence activities during the COVID-19 pandemic response, December 2019 to December 2021. Eurosurveillance. 2022;27(49):2200142.
33. Čivljak R, Markotić A, Kuzman I. The third coronavirus epidemic in the third millennium: what's next? Croatian medical journal. 2020;61(6):1-4.
34. Catanzaro M, Fagiani F, Racchi M, Corsini E, Govoni S, Lanni C. Immune response in COVID-19: addressing a pharmacological challenge by targeting pathways triggered by SARS-CoV-2. Signal transduction and targeted therapy. 2020;5(1):84.
35. Jacobs M, Van Eeckhoutte HP, Wijnant SR, et al. Increased expression of ACE2, the SARS-CoV-2 entry receptor, in alveolar and bronchial epithelium of smokers and COPD subjects. European Respiratory Journal. 2020;56(2).
36. Zhou P, Yang X-L, Wang X-G, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. nature. 2020;579(7798):270-3.
37. Raut ER, Raut AR. A Review on Coronavirus Disease-A Future Challenge for Mankind (Focusing on Indian Situation). Coronaviruses. 2021;2(8):9-13.
38. Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The lancet. 2020;395(10229):1054-62.
39. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. Boletim Epidemiológico: Ministério da Saúde Brasília; 2020.
40. Lighter J, Phillips M, Hochman S, et al. Obesity in patients younger than 60 years is a risk factor for Covid-19 hospital admission. Clinical Infectious Diseases. 2020;71(15):896-7.
41. Rusu I, Turlacu M, Micheu MM. Acute myocardial injury in patients with COVID-19: Possible mechanisms and clinical implications. World Journal of Clinical Cases. 2022;10(3):762.
42. Scappaticcio L, Pitoia F, Esposito K, Piccardo A, Trimboli P. Impact of COVID-19 on the thyroid gland: an update. Reviews in endocrine and metabolic disorders. 2020:1-13.
43. Davis HE, McCorkell L, Vogel JM, Topol EJ. Long COVID: major findings, mechanisms and recommendations. Nature Reviews Microbiology. 2023;21(3):133-46.
44. Franczuk M, Przybyłowski T, Czajkowska-Malinowska M, et al. Spirometry during the SARS-CoV-2 pandemic. Guidelines and practical advice from the expert panel of Respiratory Physiopathology Assembly of Polish Respiratory Society. Advances in Respiratory Medicine. 2020;88(6):640-50.
45. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The lancet. 2020;395(10223):497-506.