Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical Anaesthesia

Journal homepage: www.ijca.in

Original Research Article

Pulmonary functions under general anaesthesia in patients recovered from COVID-19

Harun Özmen[1*], Serkan Doğru[1], Bahar Aydınlı[1], Erdi Hüseyin Erdem[1], Çiğdem Yalçın[1], Handan Heybeli[1], Lale Titiz[1]

[1]Dept. of Anaesthesiology and Reanimation, Mersin Şehir Hastanesi, Turkey

Abstract

Background: COVID-19, which caused a global pandemic, has exhibited a wide spectrum of clinical manifestations, ranging from asymptomatic cases to severe hyperinflammatory responses, respiratory failure, and ARDS. Long-term complications in the post-acute stage of COVID-19 are predominantly associated with the respiratory system. This study aimed to evaluate the long-term pulmonary functions of patients who either managed their COVID-19 infection at home or were discharged after short-term hospital care.

Materials and Methods: In this retrospective study, peripheral oxygen saturation (SaO2), end-tidal carbon dioxide (ETCO2), inspiratory maximum pressure (IMP), and plateau pressure (PP) were measured. Driving pressure (P drive) and compliance (C) values were calculated under general anaesthesia in patients who had mild COVID-19 or had no history of COVID-19.

Results: No significant differences were observed in the respiratory dynamics between patients with a history of mild COVID-19 and those without, when evaluated under general anaesthesia.

Conclusion: This study demonstrated that mild COVID-19 does not lead to long-term deterioration in respiratory dynamics under anaesthesia. However, additional post-stress evaluations are necessary to identify potential latent respiratory dysfunction in patients recovering from mild COVID-19.

Keywords: COVID-19, Anaesthesia, Respiratory function, Compliance.

Received: 07-06-2024; **Accepted:** 20-01-2025; **Available Online**: 16-04-2025

1. Introduction

Coronavirus acute respiratory syndrome (SARS-COV-2) emerged in Wuhan, China in December 2019. After initial spread of the disease, World Health Organization admitted COVID-19 as pandemics in the World in March 2020. It's a communicable disease which is mainly by droplet infection, respiratory secretions and direct contact in human beings. The patient could be appeared in several types ranged from symptomatic carriage to atypical pneumonia, hyperinflammatory response, respiratory failure and ARDS during the pandemics.[1] COVID-19 also significantly increased the risk of hypercoagulability and thromboembolism. Besides those who have the disease at home, there were severe number of patients who admitted to the hospital. Most of those patients (80%) were followed at regular service with viral pneumonia, 20% of them were followed in intense care with approximately 5% were intubated.[2-4] With the infection agent in the lungs the inflammatory cells (neutrophile, macrophage and monocyte) intravenously pass to alveolar area. Alveolar capillary membrane structure is damaged and the exudation of the plasma proteins rich in coagulation factors-fibrinogen occurs. The tissue factor (TF) on the damaged endothelium, monocyte and macrophage causes the formation of the fibrin.[3] COVID-19's long term complications are predominantly considered to be in the form of respiratory system complications. This study aims to investigate the long term pulmonary functions of the patients who contracted COVID-19 infection at home or went back home after a short term hospital surveillance.

*Corresponding author: Harun Özmen
Email: hrnozmn@gmail.com

https://doi.org/10.18231/j.ijca.2025.038

2. Materials and Methods

The study analysed the medical records of patients who received general anaesthesia in 2022 and 2023 at Mersin City Training and Research Hospital. This was conducted after obtaining approval from the Mersin University Clinical Research Ethics Committee (Grant number: 28.07.2021-523). The records reviewed included patients who either had no history of COVID-19 infection or had contracted mild COVID-19, managed either at home or through a short-term hospital stay.

Patients were excluded from the study if they were younger than 18 years or older than 60 years. Additionally, those with a history of allergy, chronic obstructive pulmonary disease, bronchial asthma, or malignancy were not included. The study also excluded patients who had undergone surgeries in the prone, Trendelenburg, or lateral decubitus positions, as well as those who had thoracic surgery, laparoscopic abdominal surgery, obstetric, or non-obstetric procedures.

For both groups, demographic data, types of operations, and operation durations were collected from anaesthesia records. During the maintenance phase of anaesthesia, specific parameters were carefully standardized to ensure consistency across all cases. The tidal volume was set at 7 mL/kg, the inspiratory pause was 10%, positive end-expiratory pressure (PEEP) was 5 mmHg, and the respiratory rate was 12 breaths per minute. The peripheral oxygen saturation (SaO2), end-tidal carbon dioxide (ETCO2), inspiratory maximum pressure (IMP), and plateau pressure (PP) were recorded at 1, 15, and 30 minutes after endotracheal intubation. Additionally, compliance (C) and driving pressure (P drive) were calculated from these values.

Lung images of all patients were reviewed, and the presence of dyspnoea was assessed from preoperative records. This comprehensive approach ensured the inclusion of relevant data to assess the long-term pulmonary effects of mild COVID-19 in patients undergoing general anaesthesia.

2.1. Statistical analysis

Qualitative data was presented as numbers and percentage with quantitative values as mean and standard deviation. The distribution of the data was analyzed using one-sample Kolmogorov-Smirnov test. Comparisons were made between groups by Mann-Whitney U test. All analyses were completed using Statistical Package for social Sciences program (SPSS Inc, Chi, IL) version 20. Statistical significance was accepted as $p<0.05$.

3. Results

A total of 70 patients were included in the study, of which 24 (34.4%) were female. The comparison of spirometry measurements between patients with a history of mild COVID-19 and those without COVID-19 showed no significant differences in any parameters, including inspiratory maximum pressure (IMP), plateau pressure (PP), compliance (C), and driving pressure (P drive) (**Table 1**, **Figure 1**).

Table 1: Comparison of spirometry measurements

	COVID-19 (-) (Mean±SD) (n=35)	COVID-19 (+) (Mean±SD)(n=35)	P
Gender (Female) (n/%)	10 (28.6)	14 (40)	0.314[a]
Duration of anaesthesia (min)	76.48±33.03	74.42±44.02	0.543[b]
Pi-1st min	17.34±3.53	16.74±2.75	0.597[b]
Pi-15th min	18.05±3.24	17.45±3.12	0.409[b]
Pi-30th min	18.11±3.15	18.02±3.22	0.967[b]
PPlt-1st min	14.11±2.32	13.34±3.08	0.122[b]
PPlt-15th min	14.97±1.88	14.31±2.90	0.165[b]
PPlt-30th min	14.85±2.34	14.55±3.11	0.444[b]
C-1st min	51.11±15.26	58.80±21.48	0.076[b]
C-2nd measurement	48.71±10.24	52.11±14.42	0.269[b]
C-3rd measurement	48.65±9.82	51.57±16.30	0.738[b]
$EtCO_2$-1st measurement	34.94±5.49	35.77±4.08	0.878[b]
$EtCO_2$-2nd measurement	32.51±5.15	33.20±4.27	0.873[b]
$EtCO_2$-3rd measurement	32.22±5.25	32.76±4.67	0.700[b]
DP-1st measurement	9.08±2.41	8.17±3.04	0.072[b]
DP-2nd measurement	9.97±1.88	9.00±3.19	0.082[b]
DP-3rd measurement	9.88±2.34	9.71±3.20	0.541[b]

Pi, inspiratory pressure; PPlt, plateau pressure; C, compliance; $EtCO_2$, end-tidal carbon dioxide; DP, driving pressure
*$p<0.05$, [a]Chi-square test, [b]Mann-Whitney U test

Table 2: Lung images (Chest X-ray and CT of all patients)

	Previous imaging findings of Preop COVID-19 (+) normal pathological		Preop COVID-19 (+) normal pathological		Preop COVID-19 (-) normal pathological	
Lung X-RAY	13	-	35	-	35	-
Lung CT	2	-	-	-	-	-
Dyspnea during preoperative period	-	-	-	-	-	-

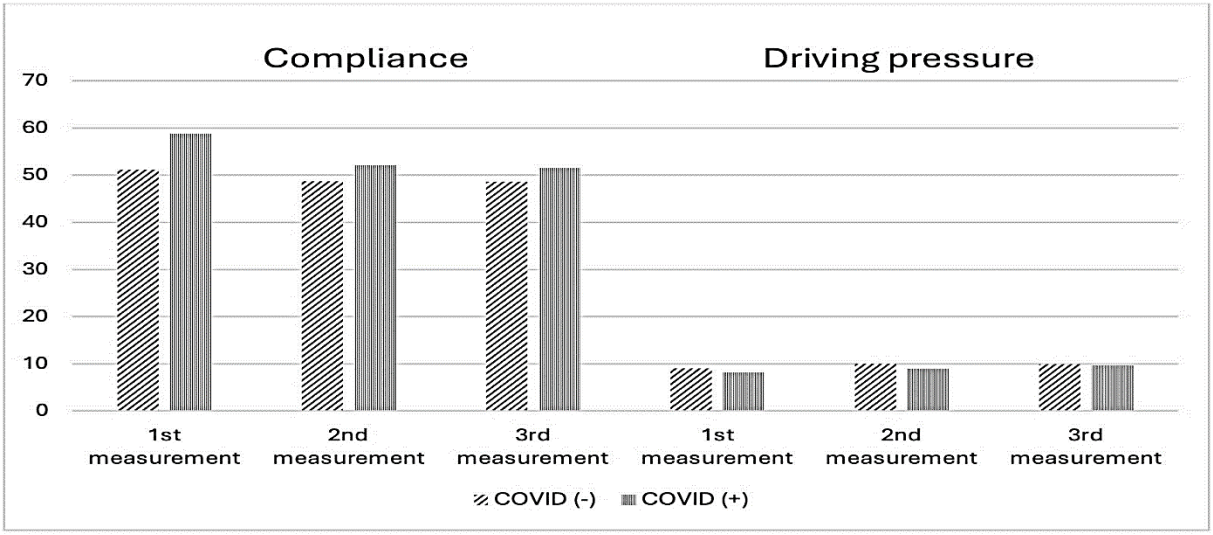

Figure 1: Comparison of compliance and driving pressure changes

Preoperative chest radiographs were available for all patients, and lung imaging data for those with a history of COVID-19 infection were reviewed. No abnormalities were observed in the imaging data. Additionally, no evidence of dyspnoea was recorded in the preoperative assessments of any patient with a history of COVID-19 (**Table 2**).

Peripheral oxygen saturation (SaO2), end-tidal carbon dioxide (ETCO2), IMP, and PP values were consistently recorded at the 1st, 15th, and 30th minutes post-intubation under anaesthesia. These values, along with the calculated compliance and driving pressure, showed no significant differences between the groups. All measurements remained within normal ranges.

4. Discussion

In COVID-19 infection, the observed complications were expected to be in the form of interstitial pulmonary disease and pulmonary-vascular diseases in radiological and clinical terms. Some of the studies involved sequel changes in the form of ground glass opacity changes in 94% of the cases about three weeks later in their second computed tomography (CT) imaging. Yet, several studies found out reduction in the pulmonary carbon monoxide diffusion capacity.[1,4] Another study which investigated cases that went through SARS found out sequel changes in the chest radiography in 36% of the patients at the end of 12th week and ongoing reticular changes in 30% at the end of six months.[4]

In those who contracted the disease as COVID-19 pneumonia, studies are still in progress on the duration of the changes that may affect the respiratory system function of the patients after post-infection, the type of permanent changes it made and it will make is not known for certain yet and studies are still in progress in this field.[4]

The largest study in this area found out that reduced carbon monoxide diffusion capacity was the most frequent respiratory anomaly in the six months' follow-up after the discharge. It was asserted that 22-56% of the patients had this kind of issue depending on the severity of the respiratory failure which emerged during the admission to the hospital.[4] In addition, it was also reported that objective anomalies were observed in high resolution computed tomography following the recovery from acute infection even in the patients who contracted with the disease showing minimal symptoms.[4-7]

However, among the patients included in our study, no follow-up HRCT scans were available for those who had recovered from COVID-19, only preoperative chest radiographs were reviewed.

Huang's study examined limited data with regard to respiratory muscle function. It was found that maximum static inspiratory and expiratory pressure were under the normal values in a significant amount of the patients discharged from the hospital during early follow-up.[8] In order to determine the form of changes in respiratory function

during time whether those anomalies are temporary or permanent, it is emphasized that there is a need for longitudinal studies with longer period of follow-up where respiratory function parameters are evaluated repeatedly.[6]

In his compilation, Boutou et al.[7] reported that the patients who recovered from COVID-19 typically consulted with reduced pulmonary diffusion and abnormal respiratory function in short term follow-up. In addition, authors also emphasized that the results are currently quite limited to reach a reliable conclusion to determine the frequency of the abnormalities and to determine whether they could be temporary or permanent. In our study, we found that there was no difference between IMP, PP, P drive values reflecting pulmonary dynamics, especially pulmonary compliance, between patients known not to had COVID-19 infection under general anaesthesia and all patients known to have COVID-19 infection at home or with short-term hospitalization. This outcome seems to be the most valuable result of our study.

In addition to ours, there are studies conducted with the patients who had mild COVID-19 infection. In his study with healthy young adults who had mild COVID-19 infection, Alper et al.[9] demonstrated that there were no adverse changes in their respiratory function tests hence it was concluded that there were no pulmonary function loss observed after COVID-19 in this patient group. While a couple of studies showed that some of the patients who recovered from SARS-CoV-2 infection could have abnormal respiratory functions and disrupted exercise capacity, it was emphasized that this data could not be generalized for the patients who went through mild COVID-19. Since our study was planned retrospectively, it was not possible to perform pulmonary function tests beforehand. In addition, indeed, the findings emphasized in these studies overlap with the results of our study.[4,10,11] Moreover, another study investigated the respiratory function tests conducted after discharge in 110 patients those had an average of 27 days in hospital stay, and of those, respiratuar function test (RFT) findings of the 24 patients who did not have pneumonia and 67 patients who had pneumonia and 19 patients who had severe pneumonia were compared with each other. While diffusion capacity was found lower in 30% of those who did not have pneumonia, 42% of those with pneumonia and 82% of those with severe pneumonia, the total pulmonary capacity was found to be under normal values in 47% of the patients with severe pneumonia. There was no difference in terms of RFT parameters.[12,13] Several tests have been utilized to monitor the deterioration of physical capacity in patients with coronavirus disease in which Badal et al. showed the impairment in patients with COVID-19 using six-minute walk test.[14] In addition, Lippi et al. emphasized that even in patients with severe or moderate COVID-19, permanent changes affecting many systems, ranging from fatigue and shortness of breath to cognitive disorders may occur in late stages of the disease.[15] We found no evidence of dyspnae in the preoperative records of any of our patients who had COVID-19.

In Behera et al. study, 75 patients with Covid-19 infection were evaluated in the long term and divided into two groups as mild symptomatic group and moderate-severe pneumonia group. The most common complaint was shortness of breath, followed by cough, and 85.7% of patients in the mild symptomatic group had negative lung auscultation findings. In this group, spirometric testing was normal in 46.93% of patients, restrictive in 40.81% and mixed in 12.24%.[16]

The dynamic lung measurements taken in our study were taken at rest and under complete muscle relaxation, and the fact that they were normal does not indicate the absence of implicit respiratory dysfunction, as in studies showing possible respiratory dysfunction after HVPT.[17-19]

In a study investigating long-term sequelae after Covid-19, Boteleux et al. examined patients with mild and moderate Covid-19 and found that 34% of these patients with mild Covid-19 who were treated as outpatients had hyperventilation syndrome (HVS) on exertion. Exertional dyspnea affects the quality of life and rehabilitation programs have been reported to improve the quality of life of these patients.[18]

In another study demonstrating functional impairment in the respiratory system affecting quality of life with silent unrecognized symptoms, mild Covid-19 patients with poorly understood dyspnea underwent hyperventilation provocation testing (HVPT) and the role of dysfunctional breathing was examined. The six patients studied showed delayed “end-tidal” CO2 (PETCO2) recovery consistent with a typical chronic hyperventilation syndrome with provocation testing for respiratory and cardiac undiagnosed symptoms. This study shows that PETCO2 kinetics and respiratory behaviour worsen after hyperventilation challenge in patients with normal cardiac and pulmonary function but without signs of HVS.[19]

Genecand et al. found a condition characterized by hyperventilation, periodic sighing and irregular breathing in patients with normal pulmonary function tests and maximum oxygen consumption (V'O2) in a study of patients who had Covid-19 on an average of 212 days. Patients with dysfunctional respiratory disorders have no or negligible organic damage. In these patients, attention is drawn to the respiratory pattern, which appears to affect quality of life.[20]

The long-term impact of positive CT findings on respiratory symptoms, pulmonary function and quality of life is still unknown.[15,16,20] It is understood that even those with mild disease should be followed up in terms of long-term pulmonary function.[17-21]

Our study had a few limitations that should be considered. Firstly, only a subset of patients with COVID-19

had available lung imaging data, which restricted our ability to evaluate pre-existing lung conditions comprehensively. Additionally, preoperative spirometric measurements were not performed, limiting the baseline assessment of lung function prior to anaesthesia.

As the study was retrospective, it was not feasible to conduct pre-exertional exercise tests to comprehensively evaluate the cardiac and respiratory systems of all patients. Also, a stepwise evaluation of respiratory dynamics—starting with high-volume pressure tolerance (HVPT) tests, followed by pulmonary function tests, and then assessing respiratory dynamics under general anaesthesia could not be performed. Lastly, the respiratory dynamic measurements in our study were conducted under resting conditions, which may not reveal subtle dysfunctional respiratory patterns that, as seen in other studies, might only become apparent under stress.

These limitations highlight the need for prospective studies with more comprehensive methodologies to explore this area further. Future studies should include baseline high-volume pressure tolerance (HVPT) tests and subsequent lung dynamic assessments under general anaesthesia for both COVID-19 and non-COVID-19 groups.

5. Conclusion

No significant differences in respiratory dynamics were observed between patients with and without mild COVID-19. Additionally, there was no evidence of long-term deterioration in lung function in patients recovering from COVID-19 who underwent general anaesthesia. These results indicate that mild COVID-19 does not have a lasting impact on respiratory performance under anaesthesia, highlighting the importance of routine pulmonary function monitoring for comprehensive care. Despite the declining prevalence of the disease, new strains of COVID-19 continue to emerge, making it critical to monitor pulmonary functions and lung tomography in patients, particularly for long-term follow-up.

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Demirci NY. Management of interstitial lung diseases in the COVID-19. TÜSAD. https://solunum.org.tr/TusadData/Book/881/13102020161024-bolum14.pdf
2. Schenck EJ, Hoffman K, Goyal P, Choi J, Torres L, Rajwani K, et al. Respiratory mechanics and gas exchange in COVID-19-associated respiratory failure. *Ann Am Thorac Soc.* 2020;17(9):1158–61.
3. Bektur Aykanat NE. A histopathological overview of Covid-19: lung, kidney, brain, liver. *Osmangazi J Med*. 2020;42(6):714–20.
4. Fakili F, Cetinkaya PD, Baydar O, Baris SA, Kokturk N, Kul S, et al. Post−discharge mortality in the first wave of COVID−19 in Turkey. *Asian Pac J Trop Med*. 2022;15(11):479–84.
5. Hui DS, Joynt GM, Wong KT, Gomersall CD, Li TS, Antonio G, et al. Impact of severe acute respiratory syndrome (SARS) on pulmonary function, functional capacity and quality of life in a cohort of survivors. *Thorax*. 2005 May;60(5):401–9.
6. Boutou AK, Asimakos A, Kortianou E, Vogiatzis I, Tzouvelekis A. Long COVID-19 pulmonary sequelae and management considerations. *J Pers Med.* 2021;11(9):838.
7. Han X, Fan Y, Alwalid O, Li N, Jia X, Yuan M, et al. Six-month follow-up chest CT findings after severe COVID-19 pneumonia. *Radiology.* 2021;299:E177-E186.
8. Cortés-Telles A, López-Romero S, Figueroa-Hurtado E, Pou-Aguilar YN, Wong AW, Milne KM, et al. Pulmonary function and functional capacity in COVID-19 survivors with persistent dyspnoea. *Respir Physiol Neurobiol*. 2021;288:103644.
9. Huang C, Huang L, Wang Y, Li X, Ren L, Gu X, et al. Six-month consequences of COVID-19 in patients discharged from hospital: a cohort study. *Lancet.* 2021;397:220–32.
10. Arslan A. Investigation of the effects of COVID-19 disease on lung functions in the long term. [Master's Thesis]. [Turkey]: [Sakarya University]: 2021.
11. Boutou AK, Georgopoulou A, Pitsiou G, Stanopoulos I, Kontakiotis T, Kioumis I. Changes in the respiratory function of COVID-19 survivors during follow-up: A novel respiratory disorder on the rise? *Int J Clin Pract.* 2021;75(10):e14301.
12. Nascimento WLCD, Moura DM, Almeida KO, Gomes-Neto M, Jezler SFO, Alves IGN. Lung and physical function in post-COVID-19 and clinical and functional associations: a cross-sectional study in Brazil. *Rev Assoc Med Bras*. 2023;69(4):e20221436.
13. Türktaş H, Oğuzülgen İK. Post-COVID-19 pulmonary sequela: long-term follow-up and management. *Tuberk Toraks*. 2020;68(4):419–29.
14. Mo X, Jian W, Su Z, Chen M, Peng H, Peng P, et al. Abnormal pulmonary function in COVID-19 patients at time of hospital discharge. *Eur Respir J*. 2020;55:2001217.
15. Peroy-Badal R, Sevillano-Castaño A, Torres-Castro R, García-Fernández P, Maté-Muñoz JL, Dumitrana C, et al. Comparison of different field tests to assess the physical capacity of post-COVID-19 patients. *Pulmonology.* 2024;30(1):17–23.
16. Lippi G, Sanchis-Gomar F, Henry BM. COVID-19 and its long-term sequelae: what do we know in 2023. *Pol Arch Intern Med*. 2023;133(4):16402.
17. Behera N, Patra JK, Dash BK, Pattnaik M, Sahu D, Rambhoopal Reddy B. Clinico-radiological and pulmonary function assessment of post-COVID-19 patients with respiratory symptoms. *J Family Med Prim Care*. 2024;13(8):2912–20.
18. Pescaru CC, Crisan AF, Marc M, Trusculescu AA, Maritescu A, Pescaru A, et al. A systematic review of telemedicine-driven pulmonary rehabilitation after the acute phase of COVID-19. *J Clin Med*. 2023;12(14):4854.
19. Bouteleux B, Henrot P, Ernst R, Grassion L, Raherison-Semjen C, Beaufils F, et al. Respiratory rehabilitation for COVID-19 related persistent dyspnoea: A one-year experience. *Respir Med*. 2021;189:106648.
20. Ritter O, Noureddine S, Laurent L, Roux P, Westeel V, Barnig C. Unraveling persistent dyspnea after mild COVID: insights from a case series on hyperventilation provocation tests. *Front Physiol*. 2024;15:1394642.
21. Genecand L, Altarelli M, Binkova A, Loew S, Vaudan S, Gex G, et al. Dysfunctional breathing symptoms, functional impact, and quality of life in patients with long COVID-19: a prospective case series. *BMJ Open Respir Res*. 2023;10(1):e001770.

Cite this article: Özmen H, Doğru S, Aydınlı B, Erdem EH, Yalçın Ç, Heybeli H, Titiz L. Pulmonary functions under general anaesthesia in patients recovered from COVID-19. *Indian J Clin Anaesth*. 2025;12(2):229–233.