Original Article

Preoperative Pulmonary Function test and Pulse Oximetry among Patients Recovered from COVID-19 Who Were Candidates for Elective Surgery

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Abstract

Background: This descriptive study aimed to assess preoperative pulmonary function test (PFT) results and pulse oximetry readings in patients recovered from COVID-19 who were candidates for elective surgery.

Materials and Methods: This is a descriptive study. A total of 110 patients (men = 51) with a mean age of 52.6 years were enrolled in the study. The study protocol was presented to the ethics committee and received approval. Participants included patients with a positive SARS-CoV-2 PCR test history, with a recovery period of at least 6-8 weeks for symptomatic patients and four weeks for asymptomatic patients. Data collection involved a random selection, obtaining informed consent, and conducting a history and physical examination. Pulmonary function capacity and oxygen saturation were assessed, and frailty was evaluated using the Edmonton Frail Scale. Echocardiography and electrocardiography were performed on all patients.

Results: The study participants mainly underwent trans-ureteral lithotripsy (TUL), laparoscopic cholecystectomy (LC), and percutaneous nephrolithotomy (PCNL). Symptomatic patients exhibited lower pulse oximetry readings than asymptomatic patients (91.18% vs. 96.13%, p-value = 0.005). Although the average ejection fraction was slightly lower in symptomatic patients (44.25%) compared to asymptomatic patients (48.18%), the difference was insignificant. Symptomatic patients also had higher rates of abnormalities in chest X-rays, electrocardiograms, pulmonary function tests, and fasting blood sugar levels, as well as a higher rate of ICU admission.

Conclusion: Comprehensive preoperative evaluations, including pulmonary function and oxygenation assessment, are crucial for COVID-19 survivors undergoing elective surgery. Symptomatic patients showed lower pulse oximetry readings and higher respiratory and cardiovascular abnormalities rates. These findings emphasize the importance of optimizing perioperative management and minimizing complications by thoroughly assessing patients' preoperative health status.

Keywords: COVID-19, Pulmonary function test, Pulse oximetry, Elective surgery, Respiratory function, Oxygenation

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Introduction

The COVID-19 pandemic has posed numerous challenges to the healthcare system worldwide, with millions of individuals affected[1]. As the virus continues to impact communities globally, it has become increasingly important to understand the long-term consequences of COVID-19 infection on patients' health, especially for those who have recovered and are now considered candidates for elective surgery. Among the many concerns related to this population, pulmonary function and oxygenation status are crucial factors to evaluate prior to any surgical intervention[2].

Since the emergence of COVID-19, it has become apparent that the respiratory system is particularly susceptible to its detrimental effects. Many individuals infected with the SARS-CoV-2 virus experience symptoms such as cough, shortness of breath, and lung inflammation[3]. In severe cases, COVID-19 can lead to acute respiratory distress syndrome (ARDS), requiring intensive care and ventilatory support[4]. Respiratory symptoms may persist beyond the acute infection phase, even in individuals with mild or moderate disease. Given the potential impact of COVID-19 on respiratory function, preoperative assessment becomes crucial for patients who have recovered from the virus and are scheduled for elective surgery. This assessment aims to identify any underlying pulmonary complications that may impact these individuals' surgical outcomes and postoperative recovery. Two key components of this assessment include performing preoperative pulmonary function tests (PFTs) and measuring oxygen saturation using pulse oximetry[5].

PFTs are a set of diagnostic tests that evaluate lung capacity, volume, and the overall function of the respiratory system. They provide valuable information about the patient's lung health, including obstructive or restrictive lung diseases, reduced lung capacity, or impaired gas exchange[6]. By conducting PFTs in patients who have recovered from COVID-19, clinicians can assess the extent of lung damage caused by the infection and determine if the patient is suitable for surgery. This evaluation also helps predict potential postoperative respiratory complications and tailors an appropriate anesthetic and surgical plan[7].

Pulse oximetry, on the other hand, is a non-invasive method used to measure the oxygen saturation of arterial blood[8]. It involves the placement of a small device, called a pulse oximeter, on a patient's finger or earlobe, which then measures the amount of oxygen carried by the hemoglobin in the blood. Monitoring oxygen saturation levels is crucial, as low oxygen saturation can indicate impaired lung function or inadequate oxygen supply to the body's tissues[9]. In patients who have recovered from COVID-19, pulse oximetry can identify any persistent respiratory issues or oxygenation abnormalities that may necessitate further evaluation or modification of the surgical plan. This study aims to investigate the role of preoperative PFTs and pulse oximetry in patients who have recovered from COVID-19 and are candidates for elective surgery.

Methods

Study participants: The current study is descriptive and follows a research protocol. The work protocol was presented to the ethics committee of Shahid Beheshti University of Medical Sciences before the study began, and following approval and receipt of the code of ethics, the work process began. The study participants included candidates for elective surgery with a history of a positive SARS-CoV-2 PCR test, considering the recovery period of at least 6-8 weeks for symptomatic patients and four weeks for asymptomatic patients referred to Shahid Modarres Hospital. The inclusion criterion was a positive history of COVID-19 involvement, which recovered. The exclusion criteria were performing emergent surgery and not having consent to participate in the study Figure 1.

Data collection: Patients were chosen fully at random using random table numbers. Initially, the study protocol offered all essential details to all participants, and after the patients' acceptance, an informed consent form was obtained from them. Furthermore, the patients were assured that no additional fees would be paid for this study during their surgery and that all testing would be performed at no cost. For study participants, a history and physical examination were performed, which included signs and symptoms of potential subclinical

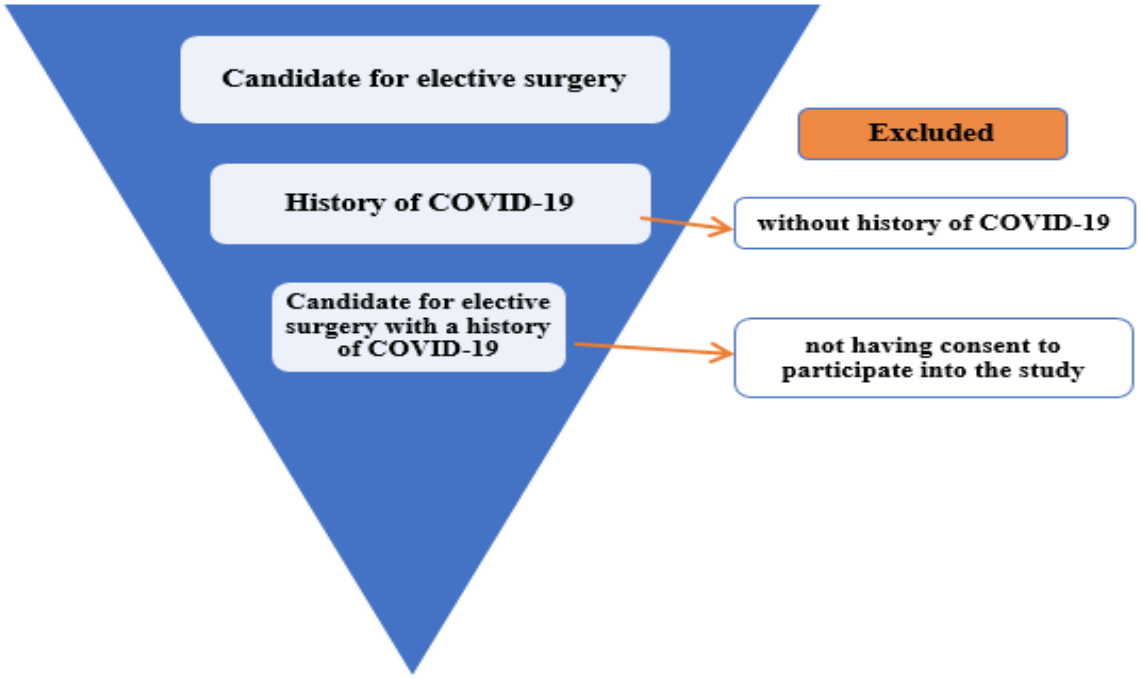

Figure 1. Consort flow chart of participants.

COVID complications, determining whether the patient had returned to their "pre-COVID" baseline health, assessing pulmonary functional capacity, and measuring oxygen saturation from patients. The Edmonton Frail Scale assessed frailty in patients over 65 and those requiring hospitalization for COVID-19 treatment regardless of age.

All of the items we stated are essential components of surgical investigations. In addition to these basic demands, objective testing based on the severity of symptoms during COVID-19 infection, the difficulty of the surgical operation, and the patients' need for general anesthesia were derived from the available data. These tests will assess the patient's cardiopulmonary function, coagulation status, inflammatory markers, and nutritional status. The purpose is to examine several patient systems' good functioning and discover modest COVID problems. One of the main parameters evaluated in this study was pulmonary function (PFT) before surgery. Additionally, all patients underwent echocardiography and electrocardiography.

Measurements: Patients were positioned comfortably supine or semi-recumbent, and standard 12-lead ECG electrode placement was performed. Electrodes were affixed to specific locations on the patient's chest, arms, and legs, including the right and left upper arms, right lower abdomen or thigh, left lower abdomen or thigh, and chest at specified intercostal spaces. An ECG machine recorded the heart's electrical activity, with settings adjusted for appropriate paper speed and calibration. A qualified healthcare professional analyzed the recorded ECG tracings, assessing parameters such as heart rate, rhythm, wave morphology, intervals, and segments. Any abnormalities were documented and considered alongside the patient's medical history and clinical presentation. An expert cardiologist performed echocardiography; only the ejection fraction was included in this study.

Prior to the PFT, patients are given instructions to follow, such as refraining from smoking, avoiding heavy meals, and withholding certain medications as advised by their healthcare provider. They are also briefed on the procedure and its purpose. Patients were seated comfortably during PFTs. They were instructed to maintain an upright posture and follow specific breathing techniques as directed by the technician or healthcare provider administering the

test. The first component of PFTs typically involves assessing lung volumes. This was done by instructing the patient to inhale as deeply as possible and exhale forcefully and entirely into the spirometer. The spirometer recorded the volumes of air exhaled, including vital capacity (maximum amount of air exhaled after maximal inhalation), forced expiratory volume in one second (FEV1), and forced vital capacity (FVC). Following the lung volume assessment, airflow measurements were conducted. The patient was asked to inhale normally and then exhale forcefully and rapidly into the spirometer. This measures parameters such as forced expiratory flow (FEF) and peak expiratory flow rate (PEFR), providing information about the airway resistance and the ability to exhale forcefully. Any abnormality in one of the criteria above was regarded as an abnormality in PFT.

Ethical considerations: This study was approved by the ethical committee of Shahid Beheshti Medical University (IR.SBMU.MSP.REC.1400.154).

Statistical analysis: The intention-to-treat strategy was used to evaluate all outcomes. Depending on the efficiency type, comparing two groups with and without symptoms was done using Student's t-test or Mann-Whitney U tests. Results for primary outcomes were adjusted for confounding variables. All tests were carried out using the SPSS model 21 program.

Results

After considering inclusion and exclusion criteria, 110 patients (men = 51) were enrolled in the study. The mean age (standard deviation [SD]) was 52.6 (16.3) years. General anesthesia was the predicted plan for 89.1% of the study participants. The most common type of surgery was trans-ureteral lithotripsy (TUL), with a prevalence of 18 patients (16.4%), followed by laparoscopic cholecystectomy (LC) and percutaneous nephrolithotomy (PCNL) with a prevalence of 13 patients (15.5%) and 13 patients (11.8%) respectively. Table 1 provides details of the surgery types for which patients were candidates.

Table 1. Surgery types among study participants.

Surgery type	Number	Percent	Surgery type	Number	Percent
BPH	3	2.7	TUL	18	16.4
Gastrectomy	7	6.4	TURP	7	6.4
LC	17	15.5	TURBT	5	4.6
PCNL	13	11.8	Adrenalectomy	1	0.9
Radical Cystectomy	7	6.4	Hernia	1	0.9
Radical Nephrectomy	5	4.6	Hernia Inguinal	3	2.7
Radical Prostatectomy	7	6.4	Hernia Umbilical	2	1.8
Renal Transplantation	3	2.7	Sleeve gastrectomy	11	10.0

BPH: Benign prostatic hyperplasia, LC: laparoscopic cholecystectomy, PCNL: percutaneous nephrolithotomy, TUL: trans ureteral lithotripsy, TURP: transurethral resection of the prostate, TURBT: transurethral resection of bladder tumor.

Sixty patients in the research had asymptomatic COVID-19, whereas the rest experienced symptoms. Importantly, 14 patients (14.7%) had previously been admitted to an ICU. Abnormal chest radiography was found in 26 patients (23.6%). Eighteen (16.4%) patients had abnormal ECG during COVID-19 admission. Regarding PFT, 84 (76.4%) of the patients were in a normal condition, while 14 (13%) were in an abnormal condition. Other past medical history and the mean of laboratory tests are shown in Table 2.

As shown in Table 3, with percentages of 45 and 19%, the ejection fractions of 50 and 45 are the most common. Study participants' mean pulse oximetry (SD) was 94.7 % (2.9).

The patients were divided into two groups—those with symptoms and those without—and their characteristics were compared. Symptomatic and asymptomatic patients had average pulse oximetry readings of 91.18% and 96.13 %, respectively; the difference was statistically significant (P-value = 0.005). The mean

ejection fraction was also 44.25% and 48.18% in symptomatic and asymptomatic patients, although the difference did not touch the significant level (P-value=0.059). Table 4 illustrates the mentioned differences in terms of other variables. Moreover, Symptomatic patients had much higher rates of abnormalities in their chest X-ray, electrocardiogram, pulmonary function tests, and fasting blood sugar than patients without COVID symptoms. The rate of ICU admission was also significantly higher among symptomatic patients.

Table 2: Summary of past medical history and laboratory test of study participants.

	Number	Percent
Past medical history		
Diabetes mellitus	28	25.5
Hypertension	44	40.0
ESRD	3	2.7
Number of past medical history		
0	50	45.5
1	37	33.6
2	20	18.2
3	3	2.7
Plasma hemoglobin (Hb)		
Hb < 10	10	11.8
Hb > 10	97	88.2
Partial thromboplastin time (PTT)		
25 < PTT < 30	110	100%
PTT < 25 or PTT >30	0	0
Fasting blood sugar (FBS)		
FBS < 100 mg/dl	94	85.5
FBS > 100 mg/dl	16	41.5
Normal plasma creatinine level **	106	96.4

** calculated based on age, weight, and height

Table 3: Ejection fraction and pulse oximetry of study participants.

Ejection fraction from echocardiography		
20	6	7.5
25	1	1.3
30	۳	3.7
40	6	7.5
45	15	18.8
50	36	45.0
55	13	16.2
Pulse oximetry	94.7	2.9

* Values are shown as mean (standard deviation) for continuous variables and number (percent) for categorical variables

** calculated based on age, weight, and height

Discussion

In this study, we investigated the preoperative pulmonary function test (PFT) results and pulse oximetry readings among patients recovered from COVID-19 who were candidates for elective surgery. Our findings provide insights into these patients' respiratory status and oxygenation levels, which are crucial considerations in the perioperative management of COVID-19 survivors. SARS-CoV-2 is the virus that causes COVID-19. Although its origin has not yet been established, Wuhan in China is where it was first noticed[10]. Due to transmission from person to person, this virus initially reproduces rapidly. An international outbreak was brought on by the coronavirus[11].

Our study enrolled 110 patients with a mean age of 52.6 years. Most participants were male (51 patients), reflecting a potential gender distribution within our sample. General anesthesia was planned for approximately 89.1% of the study participants, indicating the preference for this anesthesia method in our cohort. Regarding the types of surgeries performed, trans ureteral lithotripsy (TUL) was the most common procedure, accounting for 16.4% of cases, followed by laparoscopic cholecystectomy (LC) and percutaneous nephrolithotomy (PCNL) at 15.5% and 11.8%, respectively. These findings highlight the prevalence of urological procedures in our study population.

Moreover, when considering the patients' COVID-19 status, approximately 54.5% of participants had experienced symptoms, while the remaining 45.5% were asymptomatic. Notably, 14.7% of patients had been previously admitted to an ICU, suggesting a subset of individuals with more severe COVID-19 courses. Abnormal chest radiography was observed in 23.6% of patients, indicating potential pulmonary involvement.

In COVID-19, several arrhythmias and ECG anomalies could appear[12-14]. It is interesting to note that ECG

Table 4. Comparison of COVID-19 symptomatic and asymptomatic patients.

		Symptomatic patients		Asymptomatic patients		p-value
ICU-admission	Yes	14	28	0	0	**0.000**
	No	36	72	60	100	
Chest graph	Abnormal	22	44	4	6.7	**0.000**
	Normal	28	56	56	93.3	
EKG	Abnormal	13	26	5	9.4	**0.013**
	Normal	37	74	55	91.6	
PFT	Abnormal	12	30	2	3.5	**0.000**
	Normal	28	70	56	96.5	
CBC	Abnormal	9	18	4	6.7	**0.068**
	Normal	41	82	56	93.3	
PTT	Abnormal	0	0	0	0	**1.0**
	Normal	50	100	60	100	
NT pro-BNP	Abnormal	4	26.7	2	40	**0.583**
	Normal	11	73.3	3	60	
FBS	Abnormal	12	24	4	6.7	**0.011**
	Normal	38	79	56	93.3	
SCL	Abnormal	3	6	1	1.7	0.229
	Normal	47	94	59	98.3	

PFT: Pulmonary function test, CBC: Cell blood count, PTT: Partial hromboplastin time, FBS: Fasting blood sugar, SCL: Serum creatinine level

interpretation, including the diagnosis of dysrhythmias or the detection of a concerning morphologic issue, is unaffected compared to a patient who does not have COVID-19. On the other hand, there have been considerable changes in the patient presentation environment and, consequently, the clinical relevance of ECG results. In one study, 93% of hospitalized critically sick patients had ECG abnormalities[15]. Approximately 7% of patients may report palpitations, which may indicate dysrhythmias. According to one study, 17% of patients in the general population and 44% in the intensive care unit (ICU) exhibit rhythm disturbance[16,17]. In the current study, regarding the preoperative evaluations, 16.4% of patients had abnormal electrocardiogram (ECG) findings during their COVID-19 admission. PFT results revealed that 13% of patients had abnormal pulmonary function. These findings underscore the importance of assessing cardiac and respiratory function in COVID-19 survivors before elective surgery.

Wajekar et al. mentioned that zero to 2 weeks from the date of negative testing for SARS-CoV-2 is the ideal time frame for all elective surgeries. All patients with hypoxia or cardiac symptoms during a COVID-19 involvement and asymptomatic elderly patients should undergo cardiopulmonary evaluations, including ABG, troponin I level, chest HRCT, PFT, and echocardiography[18]. In the current study, we performed pulse oximetry and PFT on elective surgery candidates with a positive history of COVID-19, and we found that symptomatic patients had abnormalities in chest X-ray, electrocardiogram, PFT, and FBS levels. They had lower oxygen levels compared to asymptomatic patients. Based on our study, it should be noted that physicians should pay more attention to patients who have symptomatic COVID-19 involvement after elective surgery.

Tunescu et al. mentioned that due to cardiovascular and coagulation involvements in patients with a history of COVID-19, for better surgical and post-surgical management, performing clinical and cardiac tests, evaluating previous medications, evaluating the need to prevent deep vein thrombosis, and identifying subclinical inflammatory conditions are evaluations that should be done[19]. Based on our findings, cardiopulmonary evaluations are important in patients with a history of COVID-19 involvement, especially in symptomatic patients.

Additionally, we examined the ejection fraction as an indicator of cardiac function and found a slightly lower average ejection fraction in symptomatic patients than in asymptomatic patients (44.25% vs. 48.18%). Although this difference did not reach statistical significance, it highlights the importance of evaluating cardiac parameters in COVID-19 survivors. Another study found 9.6% (36 cases) of dysrhythmias[20]. Critically ill patients are more likely to experience arrhythmias and ECG abnormalities, which can happen in 33–93% of these cases and have been associated with a higher risk of mechanical ventilation and in-hospital mortality[21,22]. According to a study done on 1258 individuals, atrial fibrillation/flutter, elevated right ventricular pressure, and ST segment abnormalities are all linked to a higher risk of mortality and mechanical ventilation[12].

Regarding pulse oximetry readings, our study participants' mean oxygen saturation level was 94.7%. Further analysis showed a statistically significant difference in pulse oximetry readings between symptomatic and asymptomatic patients, with symptomatic patients exhibiting lower levels (91.18% vs. 96.13%). This finding suggests that symptomatic COVID-19 patients may have lingering respiratory effects that impact their oxygenation levels. Furthermore, symptomatic patients showed higher rates of abnormalities in chest X-rays, ECGs, PFTs, and fasting blood sugar levels than asymptomatic patients. These findings indicate a greater burden of respiratory and cardiovascular abnormalities among symptomatic individuals, emphasizing the potential impact of COVID-19 on these systems.

The most fundamental test is spirometry. A study was performed to determine if any changes in lung function and quality of life connected to breathing up to a year after an acute coronavirus infection[23]. In a single-center prospective observational trial, patients with acute infection were enrolled, tested, and followed up six weeks, three months, six months, and twelve months after the onset of coronavirus symptoms[24]. Respiratory limitations were estimated using a CT scan of the chest, pulmonary function testing, and the St. George Respiratory Questionnaire. Patients were divided into groups based on how severe their acute COVID-19 infection was. Finally, pulmonary limitation was present in 64.6% of patients[25].

Our study provides valuable insights into the preoperative respiratory and oxygenation status of COVID-19 survivors undergoing elective surgery. These findings highlight the importance of comprehensive preoperative evaluations, including PFTs, pulse oximetry, and cardiac assessments, in this patient population to optimize perioperative management and minimize potential complications. It is essential to acknowledge the limitations of our study. Firstly, the study sample was limited to a specific population, potentially affecting the generalizability of our findings. Secondly, the cross-sectional nature of our study restricts our ability to establish causal relationships. Other confounding factors, such as comorbidities, may have influenced our results.

Conclusion

Following the overview, we examined how the symptomatic and asymptomatic groups differed. As demonstrated, symptomatic patients had a higher incidence of aberrant EKG, PFT, CXR, and oximetry values. Moreover, their FBS levels were higher. According to the study, most admitted patients had normal laboratory, oximetry, and spirometry imaging results. Patients who experienced more symptoms during the COVID-19 infection should have their organ involvement looked at more closely during preoperative examinations. More study is needed to evaluate the efficacy of specific preoperative interventions, such as respiratory rehabilitation or targeted respiratory therapies, in improving pulmonary function and optimizing oxygenation levels in COVID-19 survivors undergoing elective surgery. The importance of this study was that we could use fewer and more comprehensive tests for patients in the clinic, saving time and money.

Acknowledgment

None.

Conflict of interest

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

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