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ASSESSING RESPIRATORY FUNCTION IN COVID 19 PATIENTS USING PULMONARY FUNCTION TESTS: IMPLICATIONS FOR LENGTH OF HOSPITAL STAY AND DISEASE SEVERITY

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ABSTRACT

Pulmonary Function Tests (PFTs) can used to analyze and screen respiratory conditions, counting COVID-19. Ponders have appeared that PFT variations from the norm are common in patients with severe COVID-19, and these anomalies are related with longer hospital stays and worse outcomes.

This was a prospective cross-sectional study, used convenient sampling to evaluate the respiratory function of discharged patients from one of three COVID hospitals in the Duhok Governorate specifically the burn and plastic hospital. Spirometer pulmonary function tests (PFT) were used to conduct the evaluation, which took place over six months period from 1/11/2021 to 1/5/2022. The first two weeks were an experimental trial on normal patients.

The results revealed that a quarter of the patients had normal respiratory function, with nearly half of them had a mild degree of disease. Fortunately, less than one third of the patient were classified as having moderate to severe degrees of disease. The presence of pulmonary disease was highly correlated with high blood glucose and the duration of stay in the hospital. The last in turn was shown to affect the patient ability to cough.

***KEYWORDS*:** COVID 19, Pulmonary Function Test, remaining pathology.

1. INTRODUCTION

COVID-19 tests can identify SARS-CoV-2, biomarkers of SARS-CoV-2, or antibodies created by the body in reaction to COVID-19 or inoculation. Lung work testing (LFTs) can detect abnormalities even after non-critical COVID-19 pneumonia, and precautions should be taken to restrain transmission during testing. Nurses can perform LFTs in patients' rooms and provide assistance as required, especially for patients with neuromuscular diseases or pediatric patients. (Marie-Yosie Saint-Cyr, 2010)

The COVID-19 pandemic has had a significant impact on healthcare professionals and national healthcare systems. Wellbeing experts have had to work extra shifts to preserve healthcare administrations, frequently covering for their colleagues who were sick or in isolation (Alava & Guevara, 2021). They have had to adjust rapidly to modern therapeutic procedures and rules for overseeing COVID-19 patients. Moreover, healthcare laborers have been confronted with challenging clinical and moral choices with respect to end-of-life care for their patients. (Philip & Cherian, 2020)

PFT measures different perspectives of lung work, counting how much discuss an individual can breathe in and breathe out, how rapidly they can move discuss in and out of their lungs, and how well their lungs exchange oxygen to the circulatory system. PFT can be utilized to analyze and screen respiratory conditions, including COVID-19. Ponders have appeared that PFT variations from the norm are common in patients with serious COVID-19, and these anomalies are related with longer clinic remains and more awful results. In any case, the choice to perform PFT in a COVID-19 understanding ought to be made on a case-by-case premise by a healthcare provider, taking into consideration components such as the seriousness of the patient's ailment, there by and large wellbeing status, and the accessibility of assets. (Milanese et al., 2021)

Spirometry is a pulmonary function test that assesses the volume and speed of air that a person can inhale and exhale. It can be carried out at a medical professional's office or pulmonary function laboratory and is a non-

invasive, secure test. In order to perform the exam, you must breathe into a mouthpiece that is connected to a spirometer, which measures the airflow and volume. Spirometry is a tool for determining lung function, identifying respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD), and gauging the success of therapy. The subject is required to inhale deeply before forcing fully and completely exhaling into the mouthpiece during the spirometry test. The spirometer records the forced vital capacity (FVC) and the forced expiratory volume in one second (FEV1), which are both the bases to evaluate lung functions. (Hirai, 2021)

2. Methods and Materials

This was a prospective cross-sectional study using convenient sampling to evaluate the respiratory function of discharged patients from one of three COVID hospitals in Duhok Governorate (burn and plastic) using spirometer pulmonary function tests (PFT). The duration of the study was six months from 1/11/2021 to 1/5/2022, with the first two weeks being an experimental trial on the spirometer for normal patients. After approval from the scientific committee of the College of Health Science and the local ethical medical committee, 100 patients were included in this study after providing verbal consent. The respiratory clinic of Dr. Ramazan Salahadeen Essa was used for the examination. The inclusion criteria were patients who had tested negative for PCR and had normal levels of d-dimer (< 0.5 ug/ml or <1.1mg/l), were taking no medication for COVID-19 or its complications, and needed no admission to the hospital. Any patient with post-COVID-19 respiratory complications or ventilator complications, patients taking drugs that affect the respiratory system in addition to refusal were excluded from the study. Patient assessment was based on age, sex, weight, height, and smoking status. This information was admitted in the software of the spirometer in order to calculate predicted values of (FVC, FEV1, PEF, FEV1/FVC, FEf25, FEF 50, FEF 75, FEF 25/75). These patients' specific parameters were then inserted into an Excel form in addition to the date of admission and discharge (duration of hospital admission), presence of chronic diseases, other drugs, drugs that the patient took for treatment of COVID-19, blood sugar, blood pressure and the value of the oximeter. Spirometry is a commonly used method to assess lung function and diagnose pulmonary diseases. To perform spirometry, a nasal clip was placed on the patient's nose and the patient is asked to inhale as much as they can and then exhale forcefully into a disposable mouthpiece connected to a spirometer. The spirometer calculates predicted lung parameter values and the actual values obtained from the patient's test. These values were then recorded in Excel. (McGowan et al., 2022)

In the case of COVID-19, it was important to consider the safety constraints when performing spirometry to minimize the transmission risk to both staff and patients. Factors such as the individual patient being tested, their medical conditions and needs, the risk of transmission through contact, droplet, and aerosol, the duration of the test, and the availability of proper ventilation should be taken into account. (McGowan et al., 2022)

To evaluate the severity of pulmonary disease after COVID-19, the FEV1/FVC ratio was used to determine if the patient has obstructive or restrictive pulmonary disease. An obstructive condition was indicated by an FEV1/FVC ratio of less than 69% of the predicted value, while a restrictive condition was indicated by an FEV1/FVC ratio greater than 85% of the predicted value. Additionally, the severity of pulmonary disease can be determined by the FEV1 value, with a normal value being greater than 85% of the predicted value, mild disease being between 65% and 85% of the predicted value, moderate disease being between 50% and 65% of the predicted value, and severe disease being less than 50% of the predicted value. (McGowan et al., 2022)

3. Results

According to Table 1, the median (IQR) age was 38.0 (22) years, the systolic blood pressure of the patients was (124.9±13.4 mmHg), the diastolic blood pressure was (81.7±7.4 mmHg), the blood glucose concentration was (171.4±50.39 mg/dl) and the mean ±Sd of SpO2 in the patients was (1.0±0.2471).

To determine the severity of pulmonary disease after covid19 and by depending on the fact that FEV1/FVC ratio is used to categorize patients as having obstructive or restrictive pulmonary disease (obstructive <69% of predicted, restrictive >85%). Additionally, the severity of pulmonary disease can be determined

by the FEV1 value. A normal value is greater than 85% of the predicted value, mild disease is between 65% and 85% of the predicted value, moderate disease is between 50% and 65% of the predicted value, and severe disease is less than 50% of the predicted value.

Table (1):-Descriptive statistics of Age, Systolic and Diastolic Blood pressure, blood glucose, SpO2, FVC, FEF, and Hospital Stay of Covid-19 Patients

Character	Mean	95% Confidence Interval for Mean		Median	Std. Deviation	Mini	Maxi	Interquartile Range
		Lower	Upper					
Age (Y)	41.1	38.1	44.0	38	14.76	19	85	22
SBP mmHg	124.9	122.3	127.6	120	13.4	90.0	180.0	10.0
DBP mmHg	81.7	80.2	83.2	80	7.4	50.0	110.0	5.0
Blood glucose mg/dl	171.4	161.3	181.6	150	50.39	127	400	50
SpO2	1.0	0.9	1.0	0.96	.02471	.85	.99	.03
FVC-Pred	0.7	0.7	0.8	0.72	.20780	.23	1.39	.21
FEV1-Pred	0.5	0.5	0.6	0.53	.24752	.09	1.06	.40
PEF-Pred	0.3	0.3	0.3	0.27	.18353	.04	.84	.25
FEV1\FVC	0.6	0.6	0.7	0.69	.23063	.19	.99	.39
FEf25-Pred	0.3	0.3	0.3	0.26	.19464	.04	.84	.29
FEF 50-Pred	0.4	0.3	0.4	0.33	.22412	.04	.96	.34
FEF 75-Pred	0.5	0.5	0.6	0.50	.29030	.12	1.46	.43
FEF 25\75-Pred	0.4	0.3	0.4	0.35	.23571	.05	1.09	.37
Stay (D)	15.3	14.7	16.3	15.00	4.334	1	28	3

Table 2 shows that less than quarter were normal about half of them had mild degree of disease fortunately only less than one third of the patient were between moderate and severe degrees.

Parallel to this only one third of those revealed normal lung parameter along with more than half of them showed obstructive parameter. Restrictive outcomes composed only 16% of the patients which was against what expected.

Table (2):- Frequency and Percent of Pulmonary Diseases' Severity and Type of Pulmonary Diseases of Covid-19

		Frequency	Percent
Pulmonary Diseases Severity	Normal	23	23.2
	Mild	46	46.5
	Moderate	13	13.1
	Severe	17	17.2
Type of Pulmonary Diseases	Normal	4	4.0
	Obstructive	50	50.5
	Restrictive	45	45.5
Total		99	100

Table 3 presents the results of the Chi-square tests were not significant based on an alpha value of .05, $\chi^2(1) = 0.05$, $p = .819$, suggesting that sex and low pulmonary function test could be independent of one another. Also, not significant based on an alpha value of .05, $\chi2(1) = 0.40$, p = .525, suggesting that hypertension and low pulmonary function test could be independent of one another. Meanwhile, the results of the Chi-square test were significant based on an alpha value of .05, $\chi2(1) = 8.56$, p = .003, suggesting that high blood glucose level and low pulmonary function test are related to one another. The results were not significant for history of respiratory diseases and history of chronic diseases with pulmonary diseases. Hereby, the results of the Chi-square test were significant based on an alpha value of .05, $\chi2(1) = 5.21$, p = .022, suggesting that Hospital stay, and pulmonary disease are related to one another.

By examining the relationship between FEV1 outcome and variables such as gender, hypertension, high blood glucose level, history of respiratory diseases, history of chronic

diseases, and hospital stay (>14 days) using Pearson's chi-square test, it was revealed that there is a strong relationship between hospital stay (>14 days) and poor FEV1 outcome. This may be due to the severity of COVID-19 requiring hospital admission for more than 14 days or the admission of the patient leading to a decrease in FEV1 (cough ability). However, there was no significant relationship between FEV1 outcome and gender, hypertension, high blood glucose level, history of respiratory diseases, or history of chronic diseases. Table 4

Table (3):- Relationship of Pulmonary diseases outcome and gender, Hypertension, High blood glucose, History of Chronic Disease, and hospital stay, of Covid-19 Patients

Variables		Pulmonary Diseases		Total n (%)	Pearson Chi-Square	Sig. (P < 0.5)
		Yes n (%)	No n (%)			
Gender	Female	45 (77.6)	13 (22.4)	58 (58.6)	.053	0.819
	Male	31(75.6)	10 (24.4)	41 (41.4)		
Hypertension		18 (81.8)	4 (18.2)	22 (22.2)	.405	0.525
High Blood glucose level		22 (100.0)	0 (0.0)	22 (22.2)	8.560	0.003
History of Respiratory Diseases		13 (81.3)	3 (18.8)	16 (16.2)	.215	0.643
History of Chronic Diseases		16 (88.9)	2 (11.1)	18 (18.2)	1.812	0.178
Hospital Stay (> 14 Days)		50 (84.7)	9 (15.3)	59 (59.6)	5.211	0.022
Total		76 (76.8)	23 (23.2)	99 (100)		

Table (4):- Relationship of FEV1 outcome and gender, Hypertension, High blood glucose, History of Chronic Disease, and hospital stay, of Covid-19 Patients

Variables		FEV1 ability of cough		Total n (%)	Pearson Chi-Square	Sig. (P < 0.5)
		Yes n (%)	No n (%)			
Gender	Female	49 (84.5)	9 (15.5)	58 (58.6)	.218a	0.640
	Male	36 (87.8)	5 (12.2)	41 (41.4)		
Hypertension		18 (81.8)	4 (18.2)	22 (22.2)	0.073	0.787
High Blood glucose level		21 (95.5)	1 (4.5)	22 (22.2)	1.249	0.264
History of Respiratory Diseases		12 (74.0)	4 (25.0)	16 (16.2)	0.940	0.332
History of Chronic Diseases		15 (83.3)	3 (16.7)	18 (18.2)	0.000	1.000
Hospital Stay (> 14 Days)		54 (91.5)	5 (8.5)	59 (59.6)	3.862	0.049
Total		85 (85.9)	14 (14.1)	99 (100.0)		

By examining the relationship between gender, hypertension, high Blood glucose level, history of respiratory diseases, history of chronic diseases, and hospital Stay (>14 Days) with obstructive restrictive outcome using Pearson Chi-Square test, it was found that patients with a history of respiratory diseases were more likely to have an obstructive restrictive outcome. Table 5

Table(5):- Relationship of Obstructive Restrictive Outcome and gender, Hypertension, High blood glucose, History of Chronic Disease, and hospital stay, of Covid-19 Patients

Variables		*Presence of Obstructive or Restrictive Lung Diseases*		*Total n (%)*	*Pearson Chi-Square*	*Sig. (P < 0.5)*
		Yes n (%)	*No n (%)*			
Gender	*Female*	*42 (72.4)*	*16 (27.6)*	*58 (58.6)*	*1.437*	*0.231*
	Male	*25 (61.0)*	*16 (39.0)*	*41 (41.4)*		
Hypertension		*14 (63.6)*	*8 (36.4)*	*22 (22.2)*	*.211*	*0.646*
High Blood glucose level		*13 (59.1)*	*9 (4.9)*	*22 (22.2)*	*.953*	*0.329*
History of Respiratory Diseases		*15 (93.8)*	*1 (6.3)*	*16 (16.2)*	*5.931*	*0.015*
History of Chronic Diseases		*10 (55.6)*	*8 (44.4)*	*18 (18.2)*	*1.478*	*0.224*
Hospital Stay (> 14 Days)		*38 (64.4)*	*21 (35.6)*	*59 (59.6)*	*.714*	*0.398*
Total		*67 (67.7)*	*32 (32.2)*	*99 (100.0)*		

4. DISCUSSION

The use of spirometry has been reported in seven studies. Studies (Mo et al., 2020b), (Frija-Masson et al., 2020b), (You et al., 2020a), (K. Liu et al., 2020a), (Huang, Lv, et al., 2020), (X. Li et al., 2020), and (Zhao et al., 2020). They all found an estimated forced vital capacity (FVC) percentage in the range of 91. The reported FEV1/FVC ratios ranged from 60.5% to 81.2. %. Three studies reported the percentage of maximum mean expiratory flow (MMEF) to assess the severity of COVID-19.

Six studies reported lung volume:

(Mo et al., 2020b), (Frija-Masson et al., 2020b), (You et al., 2020a), (Huang, Lv, et al., 2020), (X.Li et al., 2020) and (Zhao et al., 2020). (Mo et al. , 2020b), (Frija-Masson et al., 2020b), (Huang, Lv, et al., 2020) and (Zhao et al., 2020), RV (Mo et al., 2020b) and (Huang, Lv, et al., 2020), (You et al., 2020a) and (Huang, Lv, et al., 2020) reported vital capacity (VC). Tidal volume, expiratory reserve, inspiratory reserve, and inspiratory capacity were reported in only one study, namely (You et al., 2020a). One study (K. Liu et al., 2020a) reported no pattern of PFT abnormalities. Therefore, in the sensitivity analysis he only six studies were analyzed.

(Mo et al., 2020b), (Frija-Masson et al., 2020b), (You et al., 2020a), (K. Liu et al., 2020a), (Huang, Lv, et al., 2020), (X.Li et al., 2020) and (Zhao et al., 2020) had a predominant restrictive pattern of 0.15 (CI 0.09-0.22, p = 0.03, I2 = 59%) and an obstructive pattern of 0.07 (CI 0.04-0.11, p=0.31, I2=16%). However, the severity of restrictive and disturbing patterns due to inadequate articles was not analyzed.

To eliminate redundancy, studies by (Mo et al., 2020b), (Frija-Masson et al., 2020b), and (Huang, Lv, et al., 2020) found that 39% of COVID, 15 %, and 7% -19% patients have a restrictive or obstructive pattern as a consequence to lung tissue damage. Spirometry, and diffusing capacity were the most commonly used assessments of respiratory function in COVID-19 patients. Additionally, altered diffusive abilities were most common. Zhao et al. (2020) reported a prevalence of 16%, whereas in his three other studies (Mo et al., 2020b; Frija-Masson et al., 2020b; Huang, Lv, et al., 2020) found a prevalence of 44–56%. Although PFT was performed in the first month after infection in a higher prevalence study, Zhao et al. performed the test three months after the COVID-19 patient was discharged from the hospital. The British Thoracic Society (BTS) guide recommends evaluating her PFT 3 months after discharge, especially in patients with suspected interstitial disease. However, in the studies reviewed, most PFTs were performed 1 month after COVID-19 onset or 1 month after hospital discharge.

110 discharged cases were enrolled in a study by Mo et al. (2020a). This included 24 cases of mild illness, 67 cases of pneumonia, and 19 cases of severe pneumonia, with a mean age of 49.1 years and 55 females. Among the patients, 40% had at least one underlying comorbidity, with 23.6% having hypertension and 8.2% having diabetes. Only 3 patients were reported as having chronic respiratory diseases.

The study by Liao et al. (2021) aimed to comprehensively describe the radiological and pulmonary function test features of COVID-19 patients three months after hospital discharge using data from a designated hospital in Shenzhen, China. Their results were showed disparity between radiological and PFTs results.

The study found that a significant proportion of COVID-19 patients continued to exhibit abnormal lung function and imaging findings three months after hospital discharge, even in those with mild or moderate disease. Specifically, the study found that over half of the patients had abnormal CT scans and around a quarter had abnormal pulmonary function tests. The most common abnormalities observed in the pulmonary function tests were reduced FVC and FEV1, indicating a restrictive pattern of lung disease.

5. CONCLUSION

Most patients who tested positive on pulmonary function tests post-COVID-19 showed mild obstructive lung disease. High blood sugar levels and extended hospital stays are highly associated with the persistence of lung pathology post-COVID-19. A patient's ability to cough is significantly related to the duration of their hospital stay. The presence of a respiratory disease prior to a COVID-19 infection is highly related to the persistence of lung pathology after recovery.

6. RECOMMENDATION

Periodic and regular long-term follow-up studies are warranted to evaluate changes in lung function in COVID-19 patients.

Evaluating the lung diffusion capacity and total lung volume is of great value in follow up of patients post cure of COVID 19.

It is of considerable need to give special attention regarding respiratory physiology follow up to the COVID 19 cure patients whose had previously respiratory disease, diabetes, developed thrombotic complications and if admitted for more than 14 days.

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