EVALUATION OF POST-COVID-19 RESPIRATORY IMPAIRMENT IN HEALTHCARE WORKERS

BY

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Abstract

Introduction: Healthcare workers have an increased risk of COVID- 19 infection either due to their contact with infectious known cases, or due to exposure to subclinical or undiagnosed patients. In cases of mild to moderate pneumonia, the pulmonary function tests (PFTs) should be carried out following abnormal chest x-rays. **Aim of Work:** To evaluate the respiratory impairment in healthcare workers after COVID-19 infection using chest X-ray and pulmonary function tests in relation to their age and disease duration. **Materials and Methods:** The study included 87 healthcare workers at El-Nasr Hospital for Health Insurance, Helwan, Cairo. They all had recovered from a proved COVID-19 infection 3 months at least prior to the assessment. The studied group was subjected to full medical and occupational history taking, plain chest X-ray, pulmonary function testing and Whole Person Impairment (WPI) rating using American Medical Association Guides, 5th Edition, 2000. **Results:** the mean age of the studied group was 41.26 years, most of them were females (87.3%) and 52.9% were nurses, 88.5% had respiratory impairment. X-Ray findings were detected in 94.2%, mainly in the form of reticulonodular opacities (58%), most commonly affecting both lungs (95.1%), mainly the basal parts (51%). The mean FVC of the studied group is 64.12% of predicted indicating moderate restrictive ventilatory impairment. WPI classification showed that about half of the patients have class 3 respiratory impairment. **Conclusion and Recommendations:** Evaluation WPI using pulmonary functions should be done for healthcare workers after recovery from COVID-19 infection and before they return to work in order to determine their ability to practice their jobs.

Keywords: COVID-19, Healthcare workers, Whole Person Impairment (WPI) rating, Pulmonary functions and Chest X-ray.

Introduction

Coronavirus disease 2019 (COVID-19), was first described in the city of Wuhan, China, when numerous cases of pulmonary infection with a new strain of coronavirus were discovered and described as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The disease rapidly spread to other areas in China and, eventually, to the whole world, which encouraged the World Health Organization (WHO) to announce it a pandemic on March 11, 2020 (Zhu et al., 2020).

Occupational hazards to healthcare workers have, formerly, been relatively unexpected or unnoticed during times of disasters, including the current COVID-19 pandemic (Chou et al., 2020), as well as previous influenza and coronavirus epidemics, such as the severe acute respiratory syndrome (SARS) and middle eastern respiratory syndrome (MERS) (Burrer et al., 2020).

Healthcare workers can have an amplified risk of COVID- 19 infection either due to their contact with infectious known cases, or due to exposure to subclinical or undiagnosed infectious patients (Wang et al., 2020).

Lungs are, by far, the organs most commonly affected by COVID-19 (Shi et al., 2020), frequently with widespread damage to the alveolar epithelial and endothelial cells leading to fibroproliferation, with subsequent lung fibrosis (Farija-Masson, 2020).

Most patients with COVID-19 infection do not progress to pneumonia; nevertheless, chest X-ray of critically ill patients with respiratory symptoms can help to recognize those with COVID-19 pneumonia (Wu and McGoogan, 2020). Chest X-ray is very useful in the diagnosis of intermediate to severe cases of COVID-19 as well as throughout their follow-up (Song et al., 2020).

Functional respiratory evaluation can be performed objectively using pulmonary function tests (PFTs), such as spirometry (Torris-Castro et al., 2021). Recent clinical guidelines recommend following up cases with severe COVID-19 pneumonia with PFTs 12 weeks after recovery. In cases of mild to moderate pneumonia, the PFTs should be carried out following abnormal chest radiographs (British Thoracic Society, 2020).

The American Medical Association (AMA) Guides to the evaluation of permanent impairment (5th edition, 2000) defines impairment as “a loss,

loss of use, or derangement of any body part, organ system, or organ function" (p. 2), while disability is "an alteration of an individual's capacity to meet personal, social, or occupational demands because of an impairment" (p. 8). The role of the occupational physician is to estimate the impairment and to deliver medical information to help in disability evaluation, taking into consideration that an impaired person may or may not have a disability. The whole person impairment percentages listed in the Guides estimate the effect of the impairment on the person's general capability to carry out the usual daily living activities, excluding work (AMA Guides, 2000).

Aim of Work

To evaluate the respiratory impairment in healthcare workers after COVID-19 infection using chest X-ray and pulmonary function tests, in relation to their age and disease duration.

Materials and Methods

- **Study design**: This study is a cross-sectional observational descriptive study.

- **Place, and duration of the study:** This study was done in Occupational Medicine Clinic of El-Nasr Hospital for Health Insurance, Helwan, Cairo. It was done along 6 months from September 2020 to March 2021.

- **Study Sample:** Eighty-seven subjects participated in the study, including one physician, 46 nurses, 16 technicians and 24 administrative employees. The study sample consisted of all healthcare workers of El-Nasr Hospital for Health Insurance, Helwan, who applied for occupational diseases committee during the 6 months duration of the study. They all had proved COVID-19 infection by positive Polymerase Chain Reaction (PCR) test of nasopharyngeal swab and recovered with negative PCR at least 3 months prior to the assessment. The study group included 76 females and 11 males. **Inclusion criteria:** They should have had a COVID-19 infection with positive nasopharyngeal swab using PCR at least once. Assessment was carried out at least 3 months after recovery with negative PCR. **Exclusion criteria:** Healthcare workers who had a history of chronic chest diseases unrelated to COVID-19 or autoimmune diseases were excluded.

- **Study methods:** The studied group was subjected to the following:

A- A questionnaire: full medical and occupational history taking.

B-Plain chest X-ray posteroanterior (PA) view, with assessment of the degree of disease severity using the severity score proposed by Warren et al, 2018. Each lung was given a score of 0–4 depending on the extent of lung involvement (score 0 = no involvement; 1 ≤ 25%; 2 = 25–50%; 3 = 50–75%; 4 ≥ 75% lung affection). A total severity score was calculated by summing both lung scores (total severity scores ranged from 0 to 8).

C- Pulmonary function tests: Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC ratio were measured.

D-Whole Person Impairment (WPI) rating for each subject using American Medical Association (AMA) Guides to the Evaluation of Permanent Impairment (5th ed, 2000).

Consent

An informed written consent was taken from healthcare workers who agreed to participate in the study before the start of work with assurance of confidentiality and anonymity of data.

Ethical Approval

Approval of the administrative authority of El-Nasr Hospital for Health Insurance was obtained. The study protocol was approved by the Ethical Committee of the Department of Occupational and Environmental Medicine, Faculty of Medicine, Cairo University.

Data management

Data were analyzed using Statistical Package for Social Science version 21 (SPSS 21). Data were expressed as numbers, percentages, means, and standard deviations. One-Way ANOVA test and post-hoc test (Turkey multi-comparison test) were used to compare between more than two groups with nominal data. Correlations were done to detect the linear relations between quantitative variables. p values less than 0.05 ($p<0.05$) were considered statistically significant, and p values less than 0.001($p<0.001$) were considered highly statistically significant.

Results

Table (1): Demographic characteristics of the studied group.

Items	The studied group (No. =87)		
Age (years)	**Mean ±SD**	**Range**	**Minimum - maximum**
	9.33±41.26	36	22- 58
Gender	No	%	
Males	11	12.6%	
Females	76	87.3%	
Occupation			
Physician	1	1.1%	
Nurse	46	52.9%	
Technician	16	18.1%	
Administrative	24	27.5%	
Outcome			
Impairment without pneumonia	65	74.7%	
Impairment with pneumonia	12	13.8% of the studied group (16% of the impaired group)	
No impairment	10	11.5%	

Table (1) showed that the mean age of the studied group was 41.26 years, 87.3% were females and 52.9% were nurses, 88.5% had respiratory impairment, while only 12 subjects (16%) of the impaired group had pneumonia with hospital admission in the acute stage of the disease.

Table (2): X-Ray findings among the studied group.

X-ray findings	Studied group (No =87)	
	No	%
Positive	82	94.2%
Negative	5	5.7%
Affected lung		
Right	3	3.7%
Left	1	1.2%
Both lungs	78	95.1%
Distribution of lesions		
Basal	42	51.2%
Perihilar	10	12.1%
Diffuse	30	37.5%
Type of opacities		
Reticulonodular opacities	51	58.6%
Ground glass opacities (GGOs)	23	26.4%
Vascular congestion	8	9.1%
Total severity score (TSS)		
0	5	5.7%
1	4	4.6%
2	25	28.7%
3	7	8%
4	23	26.4%
5	1	1.1%
6	11	12.6%
7	3	3.4%
8	8	9.1%

Table (2) showed that 94.2% of the studied group had positive X-Ray findings mainly in the form of reticulonodular opacities (58%), most commonly affecting both lungs (95.1%), mainly in basal part of lungs (51%). The most frequent TTS of the X-Ray findings were 2 (28.7%) and 4 (26%) scores. Mild findings with TSS between 0 and 2 were found in 34 patients (41.5%) and moderate TSS between 3 and 5 were found in 31 patients (37.8%), while severe cases with TSS between 6 and 8 were found in 22 patients (26.8%).

Table (3): Pulmonary functions parameters and Whole Person Impairment (WPI) of the studied group.

Pulmonary functions parameters	Mean± SD	Range	Minimum -Maximum
FVC% pred[a]	64.12 ± 8.85	43	50- 93
FEV1% pred[b]	70.54 ± 6.96	29	66- 95
FEV1/FVC%[c]	92.40 ±7.43	36	66- 102
WPI	**No = 87**	**%**	
Class1 (0%)	10	11.5%	
Class 2 (10-25%)	20	23%	
Class 3 (26-50%)	44	50.6%	
Class 4 (51-100%)	13	14.9%	

[a:] FVC% pred: Forced vital capacity percent of the predicted

[b:] FEV1% pred: Forced expiratory volume in first second percent of the predicted

[c:] FEV1/FVC%: Forced expiratory volume in first second/ Forced vital capacity ratio

Table (3) showed that the mean FVC of the studied group was 64.12% of predicted indicating moderate restrictive ventilatory impairment. Whole Person Impairment (WPI) classification showed that about half of the patients have class 3 respiratory impairment.

Table (4): Comparison between age subgroups and Total Severity Score of X-ray findings in relation to Whole Person Impairment (WPI).

Subgroups	Below 40 yrs (0- Mild TSS[#]) No =13	Below 40 yrs (Moderate -severe TSS[#]) No =25	Above 40 yrs (0- Mild TSS[#]) No =20	Above 40 yrs (Moderate- severe TSS[#]) No =29	One-Way ANOVA test	
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	F	p value
WPI	18.15± 8,37	38.12± 9.23	23.35± 3.12	51.55± 5.23	39.40	**<0.001****

[#]TSS: Total Severity Score **: Highly statistically significant

Table (4) showed that there was a statistically significant difference between subgroups as determined by one-way ANOVA test (p<0.001). A Turkey post-hoc test reveals that the WPI is statistically significantly higher among HCWs above 40 years with moderate to severe TSS subgroup.

Table (5): Correlation between the disease duration and the age of the studied group with some measurable parameters.

Parameters	Disease duration		Age	
	r	p value	r	p value
FVC% pred[a]	-0.63	**<0.05***	-0.39	**<0.001****
FEV1%pred[b]	-0.48	**<0.001****	-0.46	**<0.001****
FEV1/FVC%[c]	-0.35	**<0.001****	-0.17	>0.05
Age	0.22	**<0.05***	-	-
Disease duration	-	**-**	0.22	**<0.05***
TSS[d]	0.32	**<0.05***	0.20	**<0.05***
WPI[e]	0.10	**<0.05***	0.39	**<0.001****

[a:] FVC% pred: Forced vital capacity percent of the predicted

[b:] FEV1% pred: Forced expiratory volume in first second percent of the predicted

[c:] FEV1/FVC%***: Forced expiratory volume in first second/ Forced vital capacity ratio

[d:] TSS: Total Severity Score of X-ray findings [e:] WPI: Whole Person Impairment

*: Statistically significant **: Highly statistically significant

Table (5) showed that there were statistically significant negative correlations between FVC%, FEV1% and the disease duration as well as the age of the studied group. Meanwhile, there were statistically significant positive correlations between TSS and WPI on one side, and the disease duration and age of the studied group on the other side.

Discussion

Healthcare workers (HCWs) in their battle against COVID-19 have been described as heroes, who appreciate all signs of respect. However, the designation as heroes should not be associated with unwanted life-threatening conditions (Carlsten et al., 2020). Chest x-ray may be useful in the diagnosis and follow up of patients with COVID-19 (Rousan et al., 2020). The British Thoracic Society (BTS) guide recommends the evaluation of pulmonary function tests (PFTs) at three months post-discharge (British Thoracic Society, 2020). Previous studies on lung functions after COVID-19 showed that patients had a restrictive defect that may be persistent (You et al., 2020).

Evaluation of Whole Person Impairment (WPI) resulting from respiratory function impairment in healthcare workers exposed to COVID-19 infection has not been highlighted in previous studies. The objective of this study was to evaluate the WPI in healthcare workers after COVID-19 infection using chest X-ray and pulmonary function tests.

Demographic characteristics of the studied group showed that their mean age was 41.26+ 9.33 years, with minimum of 22 and maximum of 58 years. Most of them were females (87.3%), and 52.9% were nurses (Table 1). This was consistent with the findings reported by Yasin and Gouda (2020) from Egypt, who studied chest X-ray findings in COVID-19. They stated that the mean age of their patients was 41.68 ± 14.12 years.

These findings were also in agreement with those reported by Neinhaus and Hod (2020), who studied COVID-19 among healthcare workers in Germany. They found that 73% of the patients were females, mainly nurses (63.9%) and their median age was 41 years.

Respiratory impairment was found in 88.5% of the studied group, with 12 subjects of them (16% of the impaired group) having history of hospital admission due to COVID-19 pneumonia earlier during the disease (Table 1). These findings suggested that post-COVID-19 respiratory impairment occurred in most of the cases irrespective of pneumonia.

This was similar to the results obtained by Frija-Masson et al. (2020), who studied functional characteristics of patients with COVID-19 pneumonia at 30 days post infection. They found

that most of patients with COVID-19 have abnormalities in lung functions one month after infection, without clear association with pneumonia.

It was also in accordance with the results obtained by Zhao et al. (2020), who conducted a follow-up study of the pulmonary function and related physiological characteristics of COVID-19 survivors 3 months after recovery. They concluded that imaging and pulmonary functions showed abnormalities in a significant number of COVID-19 survivors without critical illness 3 months after discharge.

Chest X-ray abnormalities were found in 82 subjects (94.2% of the studied group), with bilateral affection in 78 subjects (95.1% of cases with abnormal X-ray) (Table 2). The distribution of the opacities was mainly basal in 42 subjects (51.2%) and was diffuse in 30 subjects (37.5%). These findings agreed with those reported by Yasin and Gouda (2020), who found that most of the post-COVID-19 cases with abnormal X-rays had bilateral lung affection (67.5%) mainly of the lower lung zone (73.1%).

This was also consistent with the results reported by Wong et al., (2020), who studied frequency and distribution of chest radiographic findings in COVID-19 positive patients. They concluded that radiographic findings were more frequent in the peripheral and in the lower zones, but the entire lung can be affected.

The type of opacities in the current study was mainly reticulonodular (58.6%) followed by ground glass opacities (GGOs) (26.4%) (Table 2) . These results were in accordance with the study done by Yasin and Gouda (2020), in which reticular interstitial thickening was found in 39.9% of cases followed by GGOs in 32.5% of cases.

These results were also in harmony with those reported by Cozzi et al., 2020, who studied chest X-ray in new COVID-19 infection. They reported that chest X-ray showed patchy or diffuse reticulonodular opacities, with basal and bilateral distribution. This can be explained by the pictorial review on portable chest X-ray in COVID-19 done by Jacobi et al. (2020). They stated that GGOs are hard to distinguish by chest X-ray and that reticular opacities are more easily visible. However, in another study done by Rousan et al. (2020) on chest x-ray findings in patients with COVID-19 pneumonia, the authors detected GGOs involving the lower

lung zone as the most frequent findings.

The total severity score (TSS) of the X-ray findings of the current study ranged from 0 to 8, whereas TSS from 0 to 2 was considered mild, from 3 to 5 was considered moderate and from 6 to 8 was considered severe lung affection (Table 2). The most frequently observed score was 2 followed by 4 (28.7% and 26% respectively). Mild TSS was found in 34 patients (41.5%), moderate TSS in 31 patients (37.8%), while severe TSS in 22 patients (26.8%).

This was mostly in agreement with the results declared by Yasin and Gouda (2020), who found that the most frequent TSS was 2 (26%) followed by score 0 (23.4%). They also reported that mild affection was the most common (65.7%), followed by moderate affection(23.4%), while severe affection was the least of all (10.9%).

This was also consistent with the results obtained by Abougazia et al. (2021), who studied chest X-Ray findings in COVID-19 patients during the first wave of the pandemic in Qatar. They found that the most common TSS was mild, including score 1 (45.1%) and score 2 (40.5%). Moderate TSS scores were observed in 13.5% of cases, while severe TSS (score 6) was found in 0.9% of cases.

Pulmonary functions of the studied group revealed that the mean FVC was 64.12 ± 8.85 % of the predicted (Table 3), which represents moderate restrictive ventilatory impairment. Meanwhile, mean FEV1/FVC% was 92.40 ± 7.43%, which means no obstructive impairment was observed. Mean FEV1% of the predicted was mildly reduced (70.54 ± 6.96%).

These findings were in accordance with the results of the systematic review and meta-analysis done by Torres-Castro et al. (2021) on respiratory functions in patients after infection by COVID-19. They reported that in the six studies which they analyzed; a restrictive pattern was observed in 15% of cases. They also found an obstructive pattern in 7% of cases. However, they declared that chronic respiratory comorbidities, resulting from smoking and air pollution, were considered confounding factors in the obstructive pattern.

It was also similar to the results obtained by Salem et al. (2021), who studied the long-term impact of COVID-19 pneumonia on the pulmonary functions of survivors. They

observed a prevalent restrictive pattern in 50% of patients.

Whole Person Impairment was calculated for each subject of the studied group according to the AMA guides, 5th edition, 2000 (Table 3). It was found that more than half of the patients (50.6%) had class 3 (moderate) respiratory impairment, and 23% had class 2 (mild) impairment.

These findings agreed with those reported by Munker et al. (2022), who studied pulmonary function impairment 4 months after COVID-19 according to disease severity. They found that considerable respiratory function impairment was observed in 52.6% of patients.

It was also in accordance with the results declared by Torres-Castro et al. (2021). They concluded that after COVID-19 infection, patients showed impaired lung functions in all the studies analyzed in the meta-analysis.

In order to determine the risk factors for Whole Person Impairment (WPI) percentage, the studied group was divided into 4 subgroups as regards the age and the TSS of the X-ray findings (Table 4). A statistically significant difference was found between subgroups as determined by one-way ANOVA test ($p<0.001$). A Turkey post-hoc test revealed that the WPI was statistically significantly higher among HCWs above 40 years with moderate to severe TSS subgroup. Also, a statistically significant negative correlation was detected between age of the studied group on one side, and FVC%, FEV1%, disease duration, TSS of the X-ray findings and WPI on the other side (Table 5).

This was similar to the results of the study done by Abougazia et al., (2021). They reported that TSS of the X-ray features of pulmonary involvement increased with age. It was also consistent with the results obtained by Munker et al. (2022), who found that the age of the patients with mild and moderate to severe disease was significantly less than patients with critical disease with mean age (± SD) 44.3 ± 14.6, 48.1 ± 19.6 and 63.8 ± 10.3 years, respectively.

A statistically significant negative correlation was identified between disease duration on one side, and FVC%, FEV1%, FEV1/FVC%, TSS of X-ray findings and WPI of the studied group (Table 5). These findings suggest that the degree of restrictive ventilatory impairment increased as the disease

duration increased.

Contrary to these results, You et al. (2020) found that there was no significant difference between the COVID-19 survivors with different disease severity in relation to ventilatory function abnormalities. After classified by age, there was also no significant difference in the two groups.

Limitations of the study: However, the authors declared some limitations for their study including the small sample size because many patients refused to perform lung function test or had returned to their work in areas away from the place of the study.

Conclusion and Recommendations: COVID-19 is considered an occupational disease among healthcare workers, and therefore, evaluation of Whole Person Impairment (WPI) using pulmonary functions should be done after recovery from COVID-19 infection and before they return to work in order to determine their ability to practice their jobs.

Conflict of interest

Authors have declared that no conflict of interest exists.

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