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Research Article

The Impact of Coronavirus Disease 2019 (COVID-19) on Lung Function, Exercise Capacity and Quality of Life in a Cohort of Survivors

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Abstract:

Background: The lung function outcome among COVID-19 survivors in Hong Kong remained unknown.

Methods: Patients above the age of 18 years old with the principal diagnosis of COVID-19 who were discharged from a tertiary center in Hong Kong between the period of 1st February 2020 to 31st July 2020 were offered three lung function tests at approximately one, three and six months upon discharge for monitoring of their outcome. Six-minute walk test (6MWT) and health related quality of life assessment by Medical Outcomes Study 36-item Short Form General Health Survey (SF-36) were arranged on the same day of lung function test.

Results: Thirty patients had lung function test performed within 60 days after discharge. Nineteen and twelve patients had lung function test performed at 60-180 days and 180 days after discharge respectively. After corrected for underlying lung diseases, 32% patients have reduced hemoglobin adjusted DLCO and PImax, while 88% patients have reduced PEmax. For patients with serial lung function performed, adjusted DLCO and PImax improved with time. The exercise capacity of COVID-19 survivors was significantly lower than normal subjects in most age groups. COVID-19 survivors have lower quality of life in the context of physical functioning, social functioning and role limitation due to physical problems, compared with normal subjects.

Conclusion: COVID-19 leads to lung function abnormalities including reduced diffusing capacity of carbon monoxide, maximal inspiratory pressure and maximal expiratory pressure in more than 40% of patients, which improved with time. Exercise capacity and health status of COVID-19 survivors are lower than normal subjects.

Key words: COVID-19; lung function; 6-minute walk test; SF-36

1. Introduction

COVID-19 is a novel viral infection that was characterized as a pandemic by the World Health Organization since March 2020. There were multiple waves of outbreak in Hong Kong. Among local survivors, the outcome remained unknown. This study aims to analyze the lung function, exercise capacity and quality of life of the first cohort of survivors.

Similar study was done in Hong Kong for Severe Acute Respiratory Syndrome which led to the outbreak in 2003. Significant impairment in diffusing capacity of lung for carbon monoxide (DLCO) was noted in SARS survivors at 6 months and 12 months after illness onset. Exercise capacity and health status of SARS survivors were remarkably lower than those of a normal population [1,2].

The first case of COVID-19 was reported in Hong Kong in late January 2020. Hospital Authority Infectious Disease Centre (HKIDC) received all local COVID-19 cases at the beginning of the outbreak. Due to the increasing number of cases, COVID-19 patients were later taken care in hospitals at different clusters. In the first 6 months of the outbreak from 1st February 2020 to 31st July 2020, adult patients discharged from the HKIDC were offered three lung function tests at approximately one, three and six months upon discharge for monitoring of their outcome. Six-minute walk test (6MWT) and health related quality of life assessment by Medical Outcomes Study 36-item Short Form General Health Survey (SF-36) were arranged on the same day of lung function test.

This study will provide information for counselling COVID-19 patients on the long-term consequences and insight on follow up plan for COVID-19 survivors.

2. Hypothesis

COVID-19 leads to lung function abnormalities, reduced exercise capacity and impaired quality of life in survivors.

3. Objectives of this study

1) To describe the lung function abnormalities, exercise capacity and health-related quality of life in COVID-19 patients within 60 days after discharge.

2) To describe the trend of abnormal lung function parameters.

4. Methodology

4.1 Subjects

This is a retrospective study involving COVID-19 patients who were discharged from Princess Margaret Hospital in Hong Kong in the first six months of the outbreak. Patients above the age of 18 years old with the principal diagnosis of COVID-19 who were discharged from the Princess Margaret Hospital HKIDC between the period of 1st February 2020 to 31st July 2020 and had follow-up lung function test at 1-2(early), 3-6(mid) and >6(late) months after discharge were included in the study. A list of patients will be generated from the clinical data analysis and reporting system (CDARS) using the searching criteria of COVID-19 and lung function test. Patient records will be reviewed retrospectively for data collection. Patients who refused lung function tests will be excluded.

4.2 Study design

The early, mid and late lung function test parameters including spirometry (Forced Expiratory Volume in one second FEV1, Forced Vital Capacity FVC, FEV1/FVC ratio and peak expiratory flow PEF), lung volumes (Total Lung Capacity TLC), DLCO, maximal inspiratory pressure (PImax) and maximal expiratory pressure (PEmax) were recorded using CareFusion Vmax system. Normal lung function parameters are defined as 80% above the age-predicted reference. Obstructive lung defect was defined as FEV1/FVC ratio of smaller than 70%. The mean of individual parameters in terms of percentage predicted will be presented. The number and percentage of patients with abnormal lung function parameters within 60 days after discharge will be reported. The trend of abnormal lung function parameters will be described.

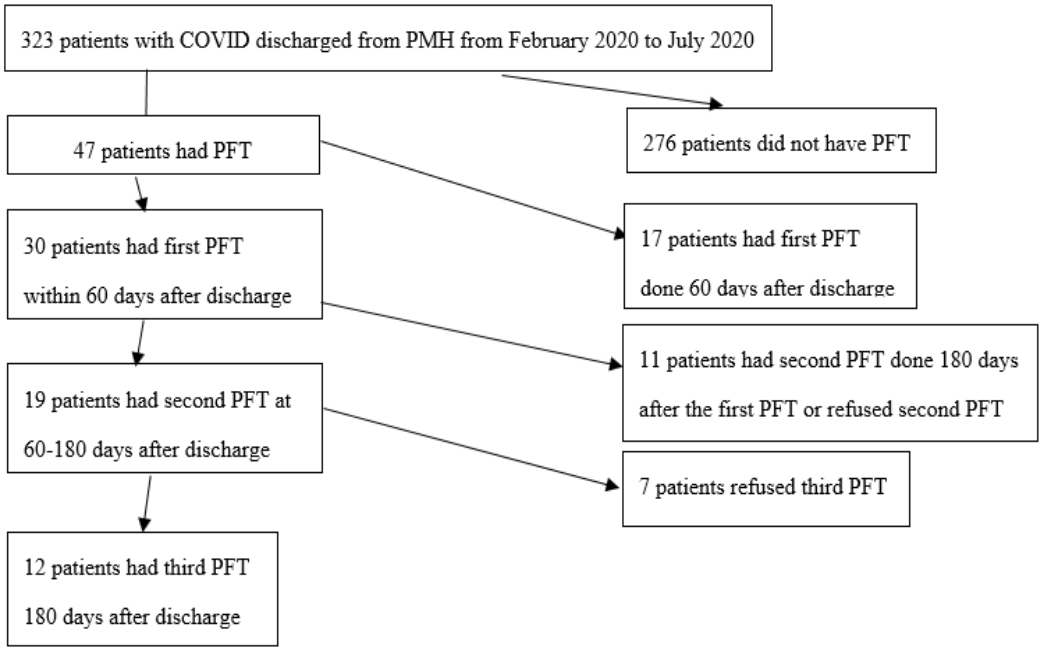
The mean of 6MWT result and SF-36 scale scores of COVID-19 survivors within 60 days after discharge will be presented. The 6MWT results of COVID-19 survivors will be compared to normative reference data collected from a population survey of 538 normal healthy subjects in 2004 by the Coordinating Committee in Physiotherapy, Hospital Authority [3]. The SF-36 results of this study will be compared to the Hong Kong normative data collected from a random telephone survey of 2,410 Chinese adults ≥ 18 years old [4].

4.3 Statistical analysis

Statistical analysis was performed using Statistical Package for Social Science (SPSS) version 26. Statistically significant was taken as p-value<0.05.

5. Results

CDARS search yielded 323 patients discharged in the period of February 2020 to July 2020 for COVID-19. Among them, 47 patients had lung function test performed after discharge. There are 30 patients with first lung function test performed within 60 days after discharge. Among the 30 patients, 19 of them had second lung function test performed at 60-180 days after discharge. Among the 19 patients, 12 of them had third lung function test performed 180 days after discharge.



Among the 30 patients with first lung function test, the age ranged from 21 to 80 years old (mean 53 years old). There are 16 males and 14 females. There are 25 patients with good past health. The remaining 5 patients had scoliosis, bronchiectasis, chronic obstructive lung disease, history of tuberculosis and lung cancer respectively. The first lung function test was performed on day 21 to day 59 after discharge (mean day 37).

The first PFT results of all patients and patients with good past health were summarized in table 1 and table 2. All lung function parameters are abnormal, especially PEmax, hemoglobin adjusted DLCO, PImax and PEF. After corrected for underlying lung diseases, 32% patients have reduced hemoglobin adjusted DLCO and PImax, while 88% patients have reduced PEmax.

parameters	Percentage of predicted (values expressed as mean)	number of patients with abnormal result (%)
Post bronchodilator FEV1	100%	4/30 (13.3%)
Post bronchodilator FVC	97%	4/30 (13.3%)
FEV1/FVC	82%	1/30 (3.3%)
TLC	98%	4/30 (13.3%)
Hemoglobin Adjusted DLCO	80%	12/30 (40%)
PImax	94%	10/30 (33.3%)
PEmax	61%	26/30 (86.7%)
PEF	90%	9/30 (30%)

Table 1: First PFT result (number = 30)

parameters	Percentage of predicted (values expressed as mean)	number of patients with abnormal result (%)
Post bronchodilator FEV1	105%	1/25 (4%)
Post bronchodilator FVC	101%	2/25 (8%)
FEV1/FVC	82%	0/25 (0%)
TLC	101%	1/25 (4%)
Hemoglobin Adjusted DLCO	82%	8/25 (32%)
PImax	94%	8/25 (32%)
PEmax	61%	22/25 (88%)
PEF	95%	5/25 (20%)

Table 2: First PFT result of patients with good past health (number = 25)

The six-minute walk test results of COVID-19 survivors within 60 days after discharge, compared with Hong Kong normative data, were shown in table 3. The exercise capacity of COVID-19 survivors was significantly lower than normal subjects in most age groups. Two patients had SpO2 < 88% after 6MWT.

		Normal subjects		COVID-19 survivors	
Age group	gender	number	mean	Number	mean
21-70	Male	223	635	16	517
21-70	Female	573	573	14	494
21-30	Male	80	651	3	559
21-30	Female	85	600	1	668
31-40	Male	78	645	1	438
31-40	Female	108	606	3	555
41-50	Male	38	623	3	544
41-50	Female	79	541	0	-
51-60	Male	23	588	4	527
51-60	Female	33	534	3	561
61-70	Male	4	484	3	517
61-70	Female	14	432	6	428
71-80	Male	-	-	2	436
71-80	Female	-	-	1	330

The SF-36 scale scores between Hong Kong normal subjects and COVID-19 survivors were summarized in table 4. COVID-19 survivors have lower quality of life in the context of physical functioning, social functioning and role limitation due to physical problems, compared with normal subjects. **Table 4:**

Domains		Scores
Physical functioning	Normal subjects	91
	COVID-19 patients	87
Role Limitation due to physical problems	Normal subjects	82
	COVID-19 patients	67
Bodily pain	Normal subjects	84
	COVID-19 patients	86
General health	Normal subjects	56
	COVID-19 patients	66
vitality	Normal subjects	60
	COVID-19 patients	66
Social functioning	Normal subjects	91
	COVID-19 patients	81
Role limitations due to emotional problems	Normal subjects	72
	COVID-19 patients	81
Mental health	Normal subjects	73
	COVID-19 patients	75

For patients with serial lung function performed, adjusted DLCO and PImax improved with time.
Among 9 patients with abnormal adjusted DLCO in the first lung function, 6 patients improved (figure 1).

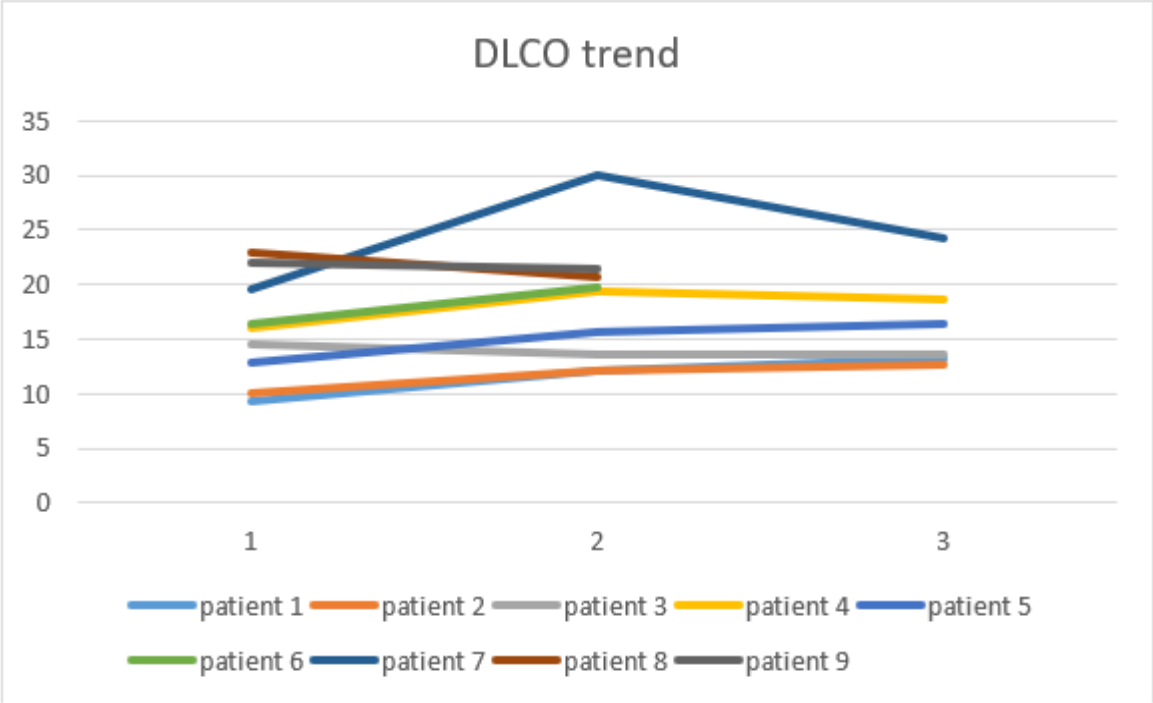


Figure 1: showing adjusted DLCO trend

Among 10 patients with abnormal PImax in the first lung function, 8 patients improved (figure 2).

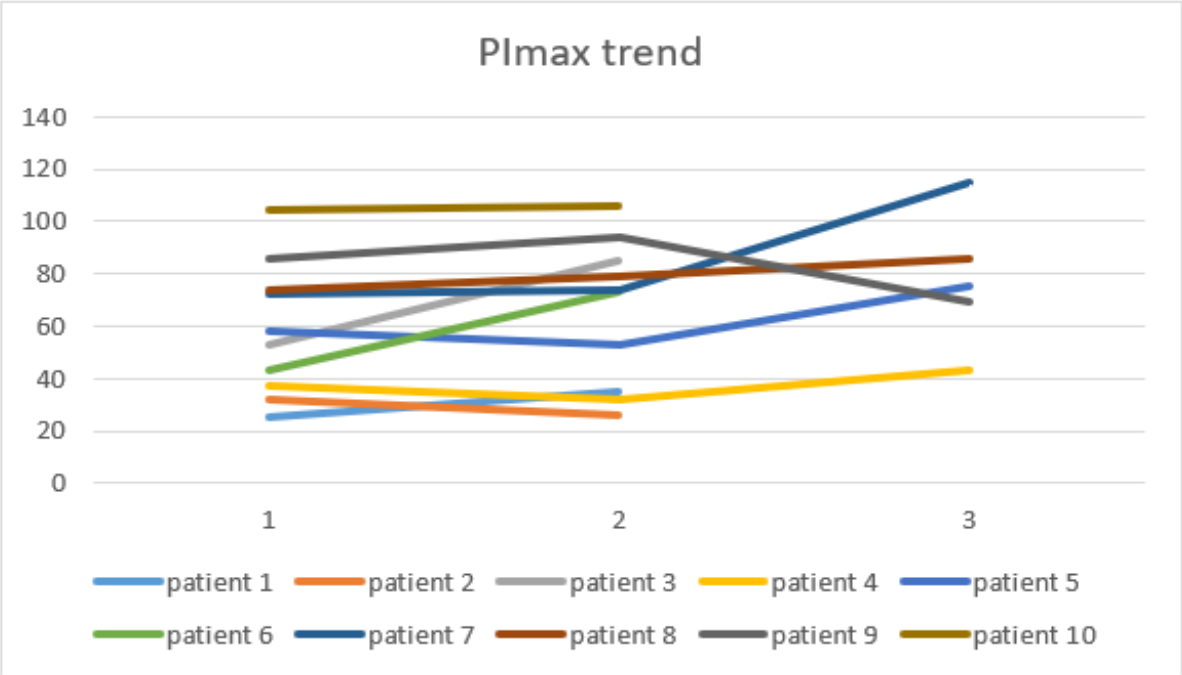


Figure 2: showing PImax trend

Among 21 patients with abnormal PEmax in the first lung function, 8 patients improved (figure 3).

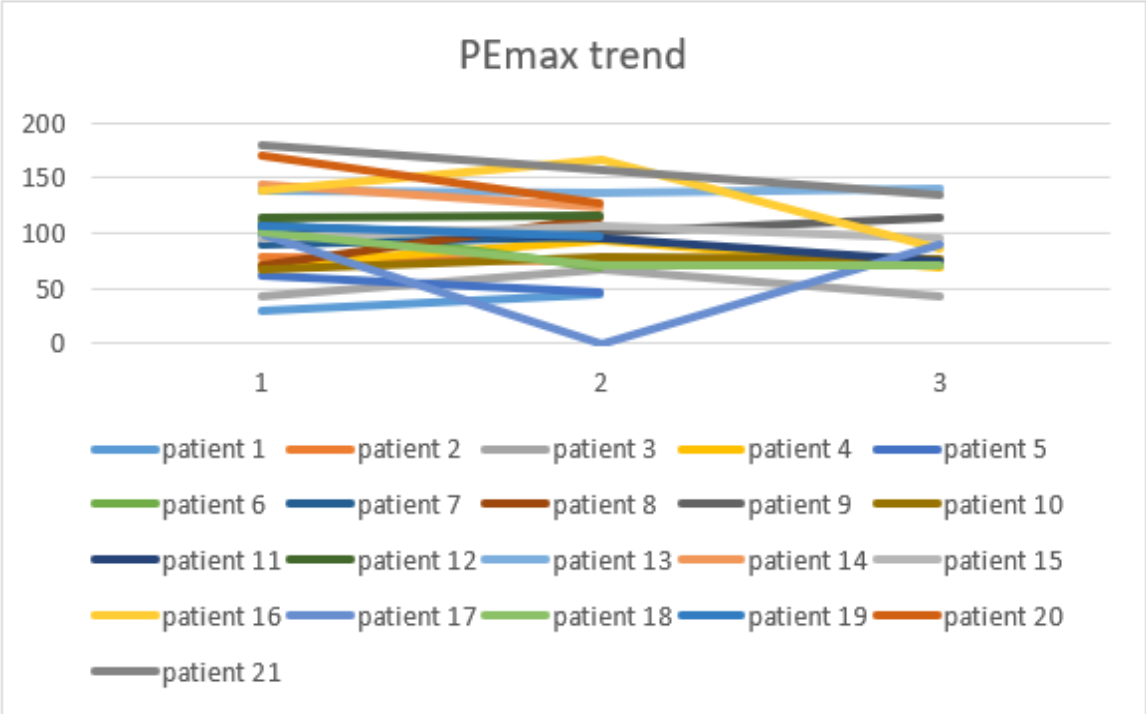


Figure 3: showing PEmax trend

6. Discussion

Our study demonstrated that 40% of the COVID-19 survivors in Hong Kong had abnormal lung function in terms of reduced diffusing capacity of carbon monoxide within 60 days after discharge, which improved with time. COVID-19 survivors also have reduced six-minute walk distance and impaired quality of life in terms of physical functioning, social functioning and role limitation due to physical problems.

For COVID-19, lung function outcome was reported in different countries. In China, impaired diffusing-capacity, lower respiratory muscle strength, and lung imaging abnormalities were detected in more than half of the COVID-19 patients in early convalescence phase [5]. In Swiss, lung function was normal for patients with mild to moderate disease, but patients with severe disease had a DLCO 20.9% lower [6]. In Austria, 22% of COVID-19 survivors had reduced DLCO 100 days after the diagnosis [7]. In Italy, restrictive lung defect was identified 6 weeks after the infection [8]. In the United Kingdom, interstitial lung disease was diagnosed in 4.8% of survivors, predominantly organizing pneumonia [9]. A systematic review involving 380 patients identified a prevalence of 0.39 for reduced DLCO after the infection [10].

Up to 86.7%of our cohort demonstrated abnormal maximal respiratory pressure. The possible reasons include technical problems such as mouth leakage, muscle weakness due to prolonged bed rest during hospital stay, steroid related myopathy if steroid was used for immune-modulation during admission [11] and COVID-19 associated myositis [12].

The limitations of this study include small sample size, high exclusion rate and single center study. First, at the beginning of the COVID-19 outbreak in Hong Kong, many patients were travelers and they left Hong Kong after discharge. Second, strict infection control regulations were observed during the outbreak, so lung function test was less available. Third, many patients refused follow up lung function tests because they were asymptomatic after recovery. The change in lung function parameters over time thus cannot be traced.

However, our study result is consistent with overseas studies on COVID-19 outcome [5,7] and studies on SARS outcome [1,2]. Follow up of discharged COVID-19 patients was warranted, given the impaired

DLCO. The British Thoracic society provided guidance for respiratory follow up of COVID-19 survivors [13]. For patients with severe pneumonia, a clinical review at 4-6 weeks after discharge was suggested and full lung function test at 12 weeks should be considered. For patients with mild pneumonia, a follow up CXR at 12 weeks after discharge is recommended.

7. Conclusion

COVID-19 leads to lung function abnormalities including reduced diffusing capacity of carbon monoxide, maximal inspiratory pressure and maximal expiratory pressure in more than 40% of patients. Exercise capacity and health status of COVID-19 survivors are lower than normal subjects.

8. References

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