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Radiological and functional pulmonary complications in patients recovered from COVID-19

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Abstract

Background: The COVID-19 disease caused by the new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which appeared at the end of 2019 in Hubei Province, Wuhan Region of the People's Republic of China. **Objective**: To determine radiological and functional pulmonary complications in patients recovered from COVID-19. **Methods**: We included observational studies, studies of radiological and functional pulmonary complications related to COVID-19 in patients discharged from hospital, studies of available text and studies in English and Spanish. A formal narrative synthesis of the collected data was carried out; no formal statistical synthesis was carried out. The synthesis focused on qualitative analysis. The methodological quality of the articles was assessed using the quality assessment tools of the National Heart, Lung, and Blood Institute. **Results**: In this systematic review it was observed that the functional pulmonary complications that the patients manifested were: 45.05 % of impaired diffusion capacity (DLCO), 30.1 % of restrictive pattern (FEV1) and 20.4 % of obstructive pattern (FEV1/FVC). Radiological complications were: 59.7% ground-glass opacity (GGO), 18.75% consolidation, 9.3% bronchiectasis, 6% thickening of the underlying pleura, 3.9% thickening of the interlobular septum, 3.83% crazy-paving and 0.96% pleural effusion. **Conclusion**: This review concludes that post-COVID-19 infection patients showed impaired lung and radiological functions, with DLCO and GGO being the most important.

Key word: COVID-19, SARS-CoV-2, lung effect, respiratory function test (Source: MesH-NCBI)

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Introduction

The COVID-19 disease is caused by the new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which appeared at the end of 2019 in Hubei province, Wuhan region of the People's Republic of China (1). The COVID-19 infection spread rapidly throughout all countries, which is why the world health organization (WHO) declared it a pandemic on March 11, 2020, causing a great problem in public health worldwide. Until June 13, 2021, the WHO reported 175,306,598 confirmed cases and 3,792,777 deaths (2).

The organ mainly affected by COVID-19 is the lung, with different pathophysiological events such as diffuse destruction of the alveolar parenchyma, formation of the hyaline membrane, capillary damage and bleeding, fibrous proliferation of the alveolar septum, and pulmonary consolidation (3). COVID-19, like the severe acute respiratory syndrome coronavirus 1 (SARS-COV-1) of 2003, produces an extensive lesion of the alveolar epithelial cells and endothelial cells with secondary proliferation, indicating a chronic vascular and alveolar remodeling producing fibrosis, diffuse pulmonary and arterial hypertension (4).

In people who recovered from COVID-19, possible long-term lung sequelae and impaired lung functional capacity wes observed. It is also known that between 30% to 60% of people who overcome SARS-CoV-2 manifested prolonged symptoms, such as dyspnea on exertion, fatigue, joint pain, headache and chest pain, colloquially known as post-COVID syndrome or prolonged COVID (5).

The first reports on lung function related to COVID-19 indicated that patients have a restrictive defect and a small dysfunction of the airways that can be persistent and not related to the severity of the disease. In addition, a deterioration in diffusion capacity was reported followed by restrictive ventilatory defects, both associated with the severity of the disease (6). The literature on previous coronavirus infections, such as SARS-CoV-1 and Middle East

respiratory syndrome (MERS), is concurrent with one of these reports and suggests that patients may experience persistent deterioration for months or even years after discharge. (7). The most common pulmonary function tests (PFT) are spirometry, diffusion capacity, and lung volumes. Also other complementary pulmonary tests, such as the evaluation of the respiratory muscles or the resistance of the airways that can help to improve the study of the properties of the lungs and allow us to objectively determine the consequence of acute or chronic respiratory disease (3).

Chest computed tomography (CT) abnormalities, described in some epidemiological reports, can lead to pulmonary fibrosis and, therefore, can be analyzed in conjunction with lung function (8). Recent clinical guidelines suggest the follow-up of patients with severe COVID-19 pneumonia with a complete PFT 12 weeks after discharge (9). For mild to moderate pneumonia, PFTs should be performed after an abnormal chest x-ray. In both cases, if any abnormality in lung function is found, along with an abnormality on CT, the patient should be referred to a specialist in interstitial lung disease (8).

Because the detection of alterations of pulmonary function is essential for the diagnosis and follow-up of patients with COVID-19, it was decided to carry out a systematic review to determine the radiological and functional pulmonary complications in patients who recovered from COVID -19.

Methods

This systematic review report was carried out in accordance with the reference items to publish protocols for systematic review and meta-analysis (PRISMA) (10)

Eligibility criteria

This systematic review included a) observational studies (cross-sectional, longitudinal, case-control, and cohort), case reports, review studies, meta-analysis, and open-control trials (RCTs); b) studies of the radiological and functional pulmonary complications of COVID-19 in patients discharged from hospital; c) studies with available texts and d) studies in the English language were included. A) letters to the editor, books, journals and clinical trials were excluded; b) studies of radiological and functional pulmonary complications in patients with COVID-19, not discharged from hospital; c) studies without reliable data; d) duplicate sources; e) studies that are not available and f) studies in languages other than Spanish and English.

Search or bibliographic strategy

A literature search was conducted in PubMed / MEDLINE and JAMA until May 15, 2021. The authors developed the search strategies according to the recommendations of the Cochrane Handbook of Systematic Reviews. Controlled vocabulary search terms were used for MEDLINE (MeSH), linked in text terms for each of the selected concepts using Boolean operators: "COVID-19", "SARS-CoV-2", "COVID-19 AND LUNG FUNCTION", "COVID-19 AND SPIROMETRY", "COVID-19 AND THORAX TOMOGRAPHY AND HOSPITAL DISCHARGE". No date filters or format restriction of the search document were used. Search strategies were performed, with the advanced search tool in the database, before approving a final consensus of the search strategies. Mendeley's program was used to manage bibliographic references, and elimination of duplicate articles.

Study selection and data extraction

The review was carried out by the author. The full texts of the articles were retrieved to verify eligibility and to verify the inclusion and exclusion list. Disagreements were discussed until a consensus was reached. The Microsoft Excel program was used for data extraction, storage and analysis. The following data were extracted: author, reference, country, study population, quality assessment method, study design, comorbidity, follow-up symptoms, follow-up time after discharge, abnormal PFTs in the follow-up and residual pulmonary CT.

Synthesis of results

A formal narrative synthesis of the collected data was carried out; a formal statistical synthesis was not carried out. The syntheses focused on the qualitative analysis of the clinical manifestations mentioned in each of the countries of the published studies.

Assessment of study quality

The methodological quality of the articles was assessed using the quality assessment tools of the National Heart, Lung, and Blood Institute (NHLBI) (10). Each tool contains criteria that assess internal validity and risk of bias. The criteria were evaluated as "Yes", "No" or "Other" and an overall rating was provided for each study of the items rated with an affirmative answer: 75% = Good, 50-75% = Fair, <50% = bad.

Results

Selection and characteristics of the studies

The initial search identified 850 results. 600 duplicate results were removed. After filtering by titles and abstracts, we evaluated 175 full-text articles. Seventeen articles were initially registered that provide specific information related to the objectives of this study. In addition, a secondary search of the 17 initially included studies was carried out, from which 2 additional studies were incorporated, resulting in 19 studies. Finally, 19 studies were attached for further analysis and 12 studies on comments for this review.

Most of the items come from China (11/19), France (1/19), Netherlands (1/19), UK (1/19), Belgium (1/19), Norway (1/19) , Canada (1/19), Switzerland (1/19) and Japan (1/19). The mean population was 76.1 (18-177) patients and the majority were men. Furthermore, the prevalence of arterial hypertension (HT), followed by diabetes mellitus (DM), obesity and chronic obstructive disease (COPD) and other comorbidities was observed in patients. Important follow-up symptoms were cough, dyspnea, fatigue, headache, and chest pain (Table 1).

Table 1. Clinical and socio-demographic characteristics

Author (#ref)	Country	Design of study	Population size	Features of the population	Comorbidity (N)	Symptoms of follow-up (N)	Quality of study
Tú J et al -11	China	Retrospective	18	M= 10 F= 8 Mean age= 51 años	HT (3) Diabetes mellitus (1) Hypothyroidism (1)	-	Regular
Huang Y y et al (12)	China	Retrospective	57	M= 26 F= 31 Mean age= 47 años	HT (11) Diabetes mellitus (4) Cancer (3) Cardiovascular (3)	Cough (6) Dyspnoea (4) Occasional Whistles (3)	Regular
Zhao Y y et al (13)	China	Retrospective cohort	55	M= 32 F= 23 Mean age= 48 años	HT (6) Diabetes mellitus (2) Cardiovascular (2)	GI (12) Headache (7) Fatigue (6) Dyspnea on exertion (6) cough and sputum (1)	Regular
Liang L et al (14)	China	Prospective	76	M= 21 F= 55 Mean age= 41,3 ± 13,8 años	HT 5) Cardiovascular (1) Diabetes mellitus (3) Thyroid (2) Pulmonary disease (11) Digestive disorder (14)	Fever (15) Cough (45) Sputum (33) Thoracic tightness and palpitations (47) Fatigue (45) Diarrhea (20)	Regular
Wu Q et al -16	China	Retrospective	54	M= 32 F= 22 Mean age= 54.4 ± 13.6 años	HT (10) Diabetes mellitus (7) Coronary heart disease (4)	Dyspnea on exertion (10) Fatigue (13) Cough (3) Sore throat (3) Taste and smell dysfunction (5) Nausea (3) Loss of appetite (4) Abdominal pain and diarrhea (3)	Regular
Morin L et al (17)	France	Retrospective cohort	177	M= 109 F= 68 Mean age= 56.9 años	HT (137) Obesity (95) Diabetes mellitus (85) Respiratory disease (50) IRA (33) Psychiatric disorder (26) Neurodegenerative Disorder (20) Alcoholism (14) Malignant tumor (11) Other immunodeficiencies (12) COPD (11) Chronic Dialysis (11) HIV infection (8) Organ transplant (7) Liver disease (6)	Anosmia (21) Headache (22) Paresthesia (48) Anorexia (30) Fatigue (110) Chest pain and palpitation (31) Cough (20) Memory Difficulty (67) concentration disturbance (41) Dyspnoea (77)	Regular
Van Gassel R et al (18)	Netherlands	Cohort	48	M= 33 F= 15 Mean age= 63 años	Asthma (3)	-	Regular
Wang Et al (29)	China	Prospective	90	M= 33 F= 57 Mean age= 45 ± 14 años	-	Fever (55) Hypodynamia (22) Cough (20) Chest pain (8) Chills (7) Diarrhea (6) Anorexia (6) Headache (4) Muscle pain (4) Abdominal pain (2)	Regular
Arnold D et al (30)	United Kingdom	Prospective	110	M= 68 F= 42 Mean age = 53.3 años	DM1 (3) DM2 (16) Heart disease (20) COPD (28) Severe liver disease (1) IRA (7) HT (27) HIV (1)	Dyspnoea (32) Fatigue (32) Insomnia (19)	Regular

N= population; M= male; F= female; HT= arterial hypertension; ARF = acute renal failure; DM1= diabetes mellitus type 1; DM2= diabetes mellitus type 2; COPD = chronic obstructive disease; HIV = human immunodeficiency virus.

Table 2. Results of the pulmonary function test in post-COVID-19 patients

Author (#ref)	Follow-up time after discharge from hospital	Population size (N)	PFT abnormalities at follow-up,% (N)	Restrictive pattern (N) FVC% predicted <80%	Obstructive pattern (N) FEV1 / FVC <70%	Diffusion impairment% (N) DLCO <80% predicted
Tú J et al (11)	40 ± 11.6 days	18 Patients	7 (38.9 %)	3 (16.7 %)	3 (16.7 %)	-
Huang Y et al (12)	30 days	57 Patients	43 (75.4 %)	6 (10.5 %)	7 (12.3 %)	30 (52.6 %)
Zhao Y y et al (13)	90 days	55 Patients	14 (25.45 %)	6 (10.91 %)	5 (9.1 %)	9 (16.36 %)
Liang L y et al (14)	90 days	32 Patients	32 (42 %)	-	5 (6.6 %)	15 (20 %)
Wu Q y et al (16),	6 months	54 Patients	22 (42 %)	4 (7.5 %)	-	17 (32.1 %)
Morin L y et al (17)	4 months	177 Patients	23 (69.7 %)	157 (92 %)	157 (83 %)	152 (87 %)
Van Gassel R et al (18)	3 months	94 Patients	48 (92 %)	38 (88 %)	34 (79.9 %)	26 (61 %)
Smet J y et al (19)	74 ± 12 days	220 Patients	119 (54.1 %)	84 (38.2 %)	-	48 (21.8 %)
Shah A y et al (20)	12 weeks	60 Patients	35 (58 %)	27 (45 %)	7 (11 %)	31 (52 %)
Lerum T y et al (21)	83 days	1032 Patients	205 (20 %)	7 (6.8 %)	-	24 (23.3 %)
Huang C y et al (22)	186 days	349 Patients	18 (22 %)	56 (16 %)	22 (6 %)	144 -32.70%

N = sample number; PFT = Pulmonary function test; FVC = forced vital capacity; FEV1 / FVC = forced expiratory volume in 1 second; DLCO = diffusing capacity of carbon monoxide

Post COVID-19 pulmonary function test results

In this segment, only the results of the pulmonary function test in post-COVID-19 patients will be discussed (Table 02)

Tú J et al (12) performed a pulmonary function test in 18 patients with COVID-19 after hospital discharge, which included 12 cases of moderate illness, five cases of severe illness, and one case of critical illness. The duration from hospital discharge to the pulmonary function test was 40 ± 11.6 days in cases of non-serious disease and 34.7 ± 16.5 days in cases with severe disease. They observed abnormalities in maximum vital capacity (VCmax) in 3 (16.7%) patients, forced expiratory volume in the first second (FEV1) in 3 (16.7%) patients, forced vital capacity (FVC) in 3 (16.7%) patients, FEV1 / FVC% in 3 (16.7%) patients, maximum mean expiratory flow (MMEF) in 7 (38.9%), forced expiratory flow at 50% of forced vital capacity (FEF 50%) in 2 (11.1%) and FEF 75% in 11 (61.1%) patients. In addition, among the 12 non-serious patients, 3 (25.0%) had obstructive ventilation impairment, 1 (8.3%) had restrictive ventilation impairment, and 5 (41.7%) had small airway dysfunction, and among the 7 patients severe, 2 (33.3%) had restrictive respiratory failure and 1 (16.7%) had small airway dysfunction.

In a study conducted by Huang Y et al (13), they evaluated 57 patients with acute post-COVID-19 convalescence, 40 non-serious patients and 17 serious patients. They observed abnormalities in pulmonary function tests in 43 (75.4%) of the patients. In addition, 6 (10.5%), 5 (8.7%), 25 (43.8%), 7 (12.3%) and 30 (52.6%) patients had values of FVC, FEV1, FEV1 / FVC, total lung capacity (TLC) and DLCO capacity less than 80% of predicted values, respectively. Compared with non-severe cases, severe patients showed a higher incidence of DLCO deterioration (75.6% vs 42.5%).

Zhao Y et al (14), carried out a retrospective study, where they registered 55 post-COVID-19 patients discharged from hospital for 90 days, including 4 (7.27%) mild cases, 47 (85.45%) moderate cases and 4 (7.27%) severe cases. Spirometry was completed in all patients and pulmonary function alterations were observed in 14 (25.45%) patients. In addition, of the TLC abnormalities of 4 (7.27%) patients, FEV1 of 6 (10.91%) patients, FVC of 6 (10.91%) patients, DLCO of 9 (16.36%) patients, and small airway function in 7 (12.73%) patients.

A study carried out in the People's Republic of China by Liang L et al (15), registered 76 patients, 3 months after medical discharge. They observed that 32 (42%) patients had some abnormalities in FEV1, FEV1 / FVC ratio and DLCO. According to the recommendations of the American Thoracic Society (ATS) to evaluate respiratory failure (16), 4 (5%) patients were required to have a slight deterioration of FEV1, 17 (22%) patients suffered a slight deterioration of FEV1 / FVC and 15 (20%) patients showed a mild deterioration of DLCO. Among the 32 patients with impaired lung tests, 15 (47%) had decreased DLCO levels averaging 73.5 ± 4.3% and 5 (6.6%) had obstructive abnormalities with a predicted FEV1 / FVC ratio

<70%.

Wu Q et al (17) conducted a follow-up study of lung function, 6 months after hospital discharge in 54 patients, 31 moderate patients and 22 seriously ill patients. They observed that 22 (42%) patients had pulmonary dysfunction, 4 (7.5%) had abnormal FVC, indicating restrictive ventilatory dysfunction, 10 (18.7%) patients had small airway dysfunction and 17 (32.1%) with abnormality of the respiratory tract. lung function characterized by DLCO <80% of the predicted value.

Morin L et al (18) conducted a prospective cohort study, which included 177 patients after hospital discharge in a period of 4 months. They observed that 157 presented FEV1 (92%), FEV1 / FVC (83%) and TLC at 83%. The mean diffusion capacity of DLCO was 87% of the predicted value in 152 patients. It was 77% in the 49 patients with previous acute respiratory distress syndrome, 23 of 33 patients (69.7%) with diffusing capacity of the lungs for carbon monoxide less than 70% had persistent abnormalities of lung function.

Van Gassel R et al (19) conducted a cohort study, where they enrolled 94 patients for a 3-month follow-up, after hospital discharge. They observed that 52 (55%) of the patients were alive 3 months after hospital discharge and 48 (92%) of them participated in the follow-up clinic. In addition, 43 patients were registered for PFT follow-up and noted 95% in FEV1, 79.9% in FEV1 / FVC, 87% FVC, 88% residual volume (VR), 84% TLC, 61% of DLCO. A decreased TLC and diffusion capacity were found in 23 and 36 patients, respectively, but without airway obstruction in the PFT, while 5 patients had no pulmonary abnormalities.

In a study carried out in Belgium by Smet J et al (20). 220 patients discharged from hospital were registered for a follow-up of 74 ± 12 days. It was observed that 119 (54.1%) of the patients had PFT abnormalities at follow-up. However, 84 patients had 38.2% predicted FVC% <80% and 48 (21.8%) patients had DLCO deterioration.

Shah A et al (21) conducted a prospective cohort study in 60 patients who were discharged from hospital for 12 weeks. The mean age of the patients was 67 years and 68% of them were male. At least some of the PFT variables were abnormal in 35 (58%) of the patients. An abnormal DLCO was present in 31 (52%) patients and 27 (45%) of these patients also had an abnormal TLC indicating a concurrent restrictive ventilatory defect. Airflow obstruction, defined as FEV1 / FVC <70%, was present in 7 (11%) of the patients.

The study carried out in Norway by Lerum T et al (22), included 1032 patients after being discharged from hospital with a follow-up of 83 days. The average age was 49 years and 54% were male. They observed in 205 (20%) patients, pulmonary restrictive patterns present in 7 (6.8%) patients, with a FVC <80% lower than normal and 24 (23.3%) patients had abnormal DLCO.

Huang C et al (23) recruited 1733 patients discharged from hospital for a follow-up of 186 days, with an average age of 57 years and the majority were men (52%). In addition, they observed that 89 patients did not require supplemental oxygen, 172 patients required supplemental oxygen, and 88 required mechanical ventilation. They noted that the proportion of participants with impaired lung function was 18 (22%) patients. Furthermore, the restrictive pattern (FVC <80%) in 56 patients was 16%, the obstructive pattern (FEV1 / FVC) in 22 (6%) patients was lower than normal, and the DLCO in 144 (32.7%) patients it was less than normal limits.

Post COVID-19 Pulmonary CT Results

In this segment, only the results on pulmonary CT alterations in post-COVID-19 patients will be discussed (Table 03)

Table 3. Post-COVID-19 pulmonary CT results

Author (#ref)	Follow-up time after discharge from hospital	Sample size (N)	Residual CT abnormalities% (N)	Parenchymal band or fibrous streak% (N)	GGO% (N)	Consolidation % (N)	Interlobular septum thickening% (N)	Distortion of the bronchovascular bundle or bronchiectasis% (N)	Thickening of underlying pleura% (N)	Pleural effusion % (N)	Crazy paving% (N)
Zhong L et al (23)	29 ± 62 days	52 Patients	39 (75 %)	19 (37 %)	33 (64 %)	9 (17 %)	3 (6 %)	4 (8 %)	5 (10 %)	-	-
Pan F et al (24)	4 ± 1 days	21 Patients	18 (86 %)	-	18 (75 %)	10 (48 %)	-	-	-	-	6 (29 %)
Liu D et al (25)	3 weeks	149 Patients	62 (41.6 %)	14 (9.4 %)	67 (45 %)	-	-	6 (4 %)	1 (0.7 %)	-	-
Han X et al (26)	175 days	114 Patients	40 (35 %)	-	71 (62 %)	27 (24 %)	-	-	-	-	-
Guler S et al (27)	128 days	113 Patients	-	27 (51.9 %)	30 (57.7 %)	15 (28.8 %)	1 (1.9 %)	20 (38.5 %)	1 (1.9 %)	-	-
Zhao Y et al (13)	90 days	55 Patients	39 (70.9 %)	-	7 (12.7 %)	-	15 (27.3 %)	-	23 (41.8 %)	1 (1.8 %)	3 (5.5 %)
Miwa M et al (28)	100 days	17 Patients	90 (90 %)	-	16 (94 %)	6 (35 %)	-	-	-	-	-
Wang Y et al (29)	18 days	90 Patients	66 (94 %)	-	31 (74 %)	6 (9 %)	-	-	-	-	-
Arnold D et al (30)	90 days	110 Patients	15 (14 %)	-	8 (53 %)	1 (7 %)	-	5 (33 %)	-	1 (7 %)	-

N = sample number; CT = computed tomography; GGO = ground glass opacity

Zhong L et al (24) conducted a study where they enrolled 52 patients discharged from hospital after the acute stage of COVID-19. The time to the first follow-up CT was 29 ± 62 days, after the onset of symptoms and 11 days after discharge. Compared with the CT manifestations at the last time of admission, the first follow-up results showed that 30.77% (16/52) of the patients with COVID-19 recovered to a normal presentation of chest CT. The CT findings returned to normal in 42.42% (143/33) of the moderate group and 10.53% (2/19) of the severe group, with the difference between the two groups being statistically significant. Chest CT images, 39/52 COVID-19 patients, revealed residual lung lesions. Of the 52 patients with COVID-19 in the first follow-up after discharge, they presented primary manifestations on chest CT, where 33 patients showed ground-glass opacity (GGO), 19 patients indicated fibrous strip shadow and 5 showed pulmonary consolidation. In addition, they presented concomitant manifestations, where thickening of the interlobular and / or intralobular septum was observed in 3 patients, 5 patients showed a subpleural curvilinear line and 4 patients exhibited traction bronchiectasis.

Pan F et al (25), conducted a study, which included 21 patients, the average age was 40 years. The patients underwent a total of 82 lung CTs with a mean interval of 4 ± 1 days. The distribution of the lesions and the main CT findings were compared in the four stages of recovery. About 18 (86%) patients presented abnormalities on pulmonary CT. In general, subpleural lesions were more frequent than central lung lesions (54% vs 29%, respectively). In addition, they observed that in 18 (75%) GGO patients, 6 (29%) patients showed a crazy-paving pattern (GGO with overlapping interlobular and intralobular septal thickening) and 10 (48%) patients presented lung consolidation.

Liu D et al (26) conducted an observational study, which included 149 patients with a ratio of 67 men to 82 women. The average age was 43 years. They observed that 62 (41.6%) patients presented pulmonary abnormalities at discharge, which included 125 (83.9%) patients with GGO, 81 (54.4%) patients with fibrous band, 33 (22.1%) patients showed thickening of the adjacent pleura, 10 (6.7%) patients presented distortion of the bronchovascular bundle and 3 (2%) patients demonstrated a small pleural effusion. However, in the third week after hospital discharge, CT showed: 67 (45%) patients with GGO, 14 (9.4%) patients with fibrous band, 1 (0.7%) patients presented thickening of the adjacent pleura, 6 (4%) patients showed distortion of the bronchovascular bundle and none of the patients presented pleural effusion.

In the study carried out in China by Han X et al (27), which included 114 patients, 80 men and 34 women. The mean age was 54 ± 12 years. The initial and follow-up examinations were obtained 17 days and 175 days after the onset of the disease, respectively. Evidence of fibrotic-like changes was observed in 40/114 (35%) patients on follow-up CT, of which the proportion of patients with de novo fibrotic abnormalities was 38/114 (95%) patients. The remaining 74/114 (65%) patients presented complete radiological resolution or 31/144 patients showed residual GGO or interstitial thickening. In the 114 patients, 2 patients were observed with unilateral pulmonary involvement and 112 patients with bilateral lung involvement. In addition, 71 (62%) patients had GGO, 27 (24%) patients showed pulmonary condensation and 16 (14%) patients with pulmonary reticular pattern.

Guler S et al (28), included 113 patients (66 critical patients and 47 moderate patients). The median from initial symptoms to follow-up visit was 128 days. In addition, they observed the following on chest CT: 27 (51.9%) patients presented fibrous band, 30 (57.7%) patients presented GGO, 15 (28.8%) patients showed pulmonary consolidation, 1 (1.9%) patient presented interlobular septal thickening, 20 (38.5%) patients presented distortion of the bronchovascular bundle and 1 (1.9%) patients presented adjacent pleural thickening.

Zhao Y et al (14) recruited 55 patients out of 77 COVID-19 survivors who completed the study. The mean age was 47.74%, of which 41.82% were women. The follow-up time from the onset of symptoms was 90 days. They observed that 39 (70.9%) patients had pulmonary abnormalities on residual CT. In addition, that 7 (12.7%) patients presented GGO, 15 (27.3%) patients showed interlobular septal thickening, 23 (41.8%) patients presented adjacent pleural thickening, 1 (1.8%) patient presented pleural effusion and 3 (5.5 %) patients showed crazy-paving (GGO with superimposed interlobular and intralobular septal thickening).

Miwa M et al (29), enrolled 17 critical COVID-19 patients for a follow-up examination approximately 100 days after the onset of symptoms. Where, 14 (82%) patients were men and the mean age of all patients was 63 years. The median duration of hospitalization was 23 days and the median duration of mechanical ventilation was 9 days. They observed that most of the patients had abnormalities on pulmonary CT. In addition, 16 (94%) patients presented GGO and 6 (35%) patients presented pulmonary consolidation.

Wang Y et al (30), included 90 patients (33 men and 57 women). The median follow-up period of 18 days (5-43 days). Where, 70 patients were discharged from hospital (66 presented residual pulmonary anomalies on CT and 4 patients showed complete resolution of the pulmonary anomalies). They observed that the reticular pattern was the predominant pulmonary anomaly in 42 (60%) patients (31 patients presented GGO, 8 patients showed GGO with irregular lines and interfaces, and 3 patients presented GGO with intralobular line). In addition, 17 (24%) showed a mixed pattern and 6 (9%) patients presented lung consolidation on pulmonary CT.

Arnold D et al (31), recruited 110 patients with hospital discharge, where they were followed up with a median of 83 days, after hospital admission and 90 days, after the onset of COVID-19 symptoms. The mean age of the patients was 60 years and 56% were men. They observed that the 15 (14%) patients presented pulmonary abnormalities on chest CT: 1 (7%) patients presented pulmonary consolidation, 8 (53%) patients presented reticular pattern, 5 (33%) patients showed bronchiectasis and 1 (7%) patient presented pleural

effusion.

Discussion

The important findings of this systematic review were the prevalence of patients infected by COVID-19 with some comorbidity, such as hypertension followed by obesity, diabetes mellitus and some lung disease. Morin et al (18) and Arnold et al (31) reported the frequency of patients with hypertension, obesity and diabetes mellitus, followed by another comorbidity. The monitoring of pulmonary anomalies was found mostly in men in relation to women, this gender being the most affected by COVID-19, as reported by some studies (12,13). In this study, it was found that post COVID-19 symptoms were; cough with sputum production, headache, chest pain, fatigue and dyspnea; as in some studies (15,17).

Since the appearance of SARS-CoV-2, concern has increased about the potential risk of the appearance of pulmonary fibrosis and deterioration of lung function, the most important factor being pulmonary diffusion (12). In this study, a significant decrease was observed in DLCO (45.05%), in relation to the other restrictive and obstructive pulmonary alterations (30.1% and 20.4%, respectively). In comparison with some studies, where they reported that the restrictive and obstructive patterns are greater than DLCO alteration, but without major significant differences (18,19). Huang et al (13) reported that 30 days after hospital discharge, the patients presented a decrease in the DLCO (52.6%) and alteration of the restrictive and obstructive pattern (10.5% and 12.3%. respectively). Van Gassel R et al (19) reported that 3 months after hospital discharge, regardless of the degree of severity of COVID-19, no significant differences were observed in FEV1 and FVC or their relationship. However, the DLCO value was significantly lower as the severity of the clinical picture increased (20).

Because COVID-19, Severe Acute Respiratory Syndrome (SARS-CoV), and Middle Eastern Respiratory Syndrome (MERS-CoV) belong to the same family of coronaviruses, lung CT images are similar. Even so, there appear to be unique image characteristics for COVID-19 (4). For this reason, in this study it was observed that in the pulmonary CT there was a frequency of GGO (59.7%) followed by pulmonary consolidation (18.75%). In addition, 0.96% of the patients in this study suffered from pleural effusion as a serious complication. Zhong L et al (24) reported that 29 ± 62 days after hospital discharge, 64% of patients suffered GGO and 17% suffered consolidation on pulmonary CT.

Study limitations

This study has several limitations. First, the follow-up time was variable between studies, making it difficult to accurately compare the proportion of patients with residual abnormalities. Second, some studies reported only clinical severity, leading to selection bias.

Conclusion

In this review, it is concluded that post-COVID-19 patients showed impaired pulmonary and radiological functions, with DLCO and GGO being the most important.

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Conflict of interest : The author declares no conflicts of interest.

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