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Pulmonary rehabilitation in patients with obstructive ventilatory dysfunction and COVID-19

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Abstract

Background. COVID-19 (Coronavirus disease 2019) is caused by a new coronavirus known as SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). Patients previously diagnosed with obstructive ventilatory dysfunction: COPD (chronic obstructive pulmonary disease) or asthma that becomes infected with SARS-CoV-2 are more prone to severe forms of the disease.

Aims. The aim of our study was to analyze the effects of the individualized respiratory rehabilitation program - correct bed posture, percussion of the chest wall, breathing exercises and kinetic exercises - on respiratory function, range of motion and quality of life in patients diagnosed with obstructive ventilatory dysfunction (COPD or asthma) and COVID-19. We also looked at the extent to which the diagnosis of obstructive ventilatory dysfunction influenced the severity of COVID-19.

Methods. We performed a retrospective study, between May 2020 - April 2021, with 69 patients diagnosed with COVID-19 who were divided into two groups: the first group G1-30 of known patients with COPD and the second group G2-39 of known patients with asthma.

Results. Clinical and functional parameters had a significant modification (increased oxygen saturation of arterial blood, improvement of dyspnea, maintenance of balance, increased quality of life) after the inclusion of patients in the rehabilitation program.

Conclusions. Patients with obstructive ventilatory dysfunction, especially patients diagnosed with COPD, male, smokers, are more prone to the development of severe forms of COVID-19. The altered body mass index in the sense of underweight or obesity contributes to the appearance of complications, implicitly to moderate and severe forms of COVID-19. The consequences of COVID-19 can be treated by pulmonary rehabilitation.

Keywords: pulmonary rehabilitation, COVID-19, obstructive ventilatory dysfunction.

Introduction

Coronavirus disease 2019 (COVID-19) was first detected in China in December, 2019, and declared as a pandemic by the World Health Organization (WHO) on March 11, 2020. The current management of COVID-19 is generally based on supportive therapy and treatment to prevent respiratory failure (Habas et al., 2020). COVID-19 is caused by a new coronavirus known as SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). In our study, patients with obstructive ventilatory dysfunction are represented by patients diagnosed with asthma and chronic obstructive pulmonary disease (COPD).

Given the devastating impact that COVID-19 can have on the lung, it is natural to fear for patients with underlying COPD. Estimating their excess risk for contracting COVID-19 and, in particular, its more severe respiratory manifestations has been a challenging exercise in this pandemic for various reasons (Leung et al., 2020). Most COPD patients have a long history of smoking or exposure to other harmful particles or gases, capable of impairing pulmonary defenses even years after the cessation of exposure. Moreover, COPD is characterized by an ongoing immune dysfunction, which affects both pulmonary and systemic cellular and molecular inflammatory mediators. Consequently, increased susceptibility to viral respiratory infections has been reported in COPD, often worsened

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by bacterial co-infections and leading to serious clinical outcomes (Olloquequi, 2020).

Theoretically, asthmatic patients should have increased susceptibility to and severity of SARS-CoV-2 infection due to a deficient antiviral immune response and the tendency to exacerbation elicited by common respiratory viruses (Liu et al., 2020). The Center for Disease Control and Prevention advises that patients with moderate to severe asthma belong to a high-risk group that is susceptible to COVID-19 (Chhiba et al., 2020).

COVID-19 patients with diabetes, chronic obstructive pulmonary disease (COPD), asthma, cardiovascular diseases (CVD), hypertension, malignancies, HIV, and other comorbidities could develop a life-threatening situation. Comorbid individuals must adopt vigilant preventive measures and require scrupulous management (Ejaz et al., 2020).

Numerous patients with asthma or COPD are likely to be infected with SARS-CoV-2 virus. Although data are limited, patients with severe and/or uncontrolled asthma and those with COPD appear to be at increased risk of a more severe course of COVID-19 infection (Daccord et al., 2020).

Pulmonary rehabilitation is essential in the management of patients with obstructive ventilatory dysfunction, both in asthma and COPD. Also pulmonary rehabilitation is part of the multidisciplinary treatment of COVID-19. The purpose of pulmonary rehabilitation in COVID-19 patients is to improve symptoms of dyspnea, relieve anxiety, reduce complications, minimize disability, preserve function, and improve quality of life (Wang et al., 2020). Pulmonary rehabilitation should be provided throughout the disease management process, whether the patient is hospitalized or at home. In addition, rehabilitation prescriptions should be individualized based on the patient's specific condition. The effective incorporation of pulmonary rehabilitation into disease management and the patient's daily life, so that it becomes a conscious behavior, can provide long-term benefits to both the patient and his/her family (Yang & Yang, 2021). Physical therapy management for patients hospitalized with COVID-19 comprises elements of respiratory support and active mobilization (Felten-Barentsz et al., 2020). Given the complexity of this new condition, multidisciplinary management seems to be the best approach (Gallucio et al., 2020).

Objectives

The aim of our study was to analyze the effects of the individualized respiratory rehabilitation program - correct bed posture, percussion of the chest wall, breathing exercises and kinetic exercises - on respiratory function, range of motion and quality of life in patients diagnosed with obstructive ventilatory dysfunction (COPD or asthma) and COVID-19.

We also looked at the extent to which the diagnosis of obstructive ventilatory dysfunction influenced the severity of COVID-19.

Hypothesis

In the present study, we aimed to highlight the role of the supervised and complete rehabilitation program in the recovery of the clinical and functional status of patients diagnosed with obstructive ventilatory dysfunction and COVID-19. The kinetic exercises were performed according to the form of the disease, being adapted to patients' tolerance.

Material and methods

We mention that we obtained the approval of the Ethics Committee of the University of Medicine and Pharmacy of Craiova No 137/ 07.12.2020 and a signed informed consent from all the subjects participating in our study. Our research was performed on 69 patients diagnosed with COVID-19, with known obstructive ventilatory dysfunction: asthma or COPD.

Research protocol

a) Period and place of the research

We performed a retrospective study, between May 2020 - April 2021, in the Pneumology Department of the „Victor Babeș" Clinical Hospital of Infectious Diseases and Pneumophthisiology, Craiova.

b) Subjects and groups

The 69 patients diagnosed with COVID-19 were divided into two groups: the first group (G1) - 30 of known patients with COPD and the second group (G2) - 39 of known patients with asthma (Table I).

The inclusion criteria taken into account when designing the groups were:

- patients older than 18 years of age;
- the diagnosis of COPD was made according to the GOLD (Global Initiative for Chronic Obstructive Lung Disease) definition and classification, and the diagnosis of asthma according to GINA (Global Initiative for Asthma);
- patient's smoking status;
- compliance with physical exercise during the healthcare program.

Table I

The demographic data of the patients.

Group		Age (years)	Age / Residence place		Female age	Male age	Smokers
			Urban	Rural			
			20	10	8	22	
G1 = 30 patients with COPD + COVID-19	Average	64.26	64.05	64.7	63.25	64.63	
	St.dev.	11.12	9.97	13.73	8.87	12	25
	Minimum	44	48	44	48	44	
	Median	64.5	63.5	70	62.5	65	
	Maximum	90	90	79	75	90	
			25	14	24	15	
G2 = 39 patients with asthma+ COVID-19	Average	54.35	51.2	60	53.29	56.06	
	St.dev.	13.57	13.56	12.06	13.17	14.47	20
	Minimum	30	30	37	30	30	
	Median	53	51	59.5	51	58	
	Maximum	80	75	80	80	75	

c) Tests applied

For the patients included in the study, we analyzed clinical data (complete clinical examination), and laboratory (laboratory screening - biological data, imaging examination - chest radiography) and functional assessment was performed. All tests applied are mentioned below.

The *clinical assessment* included:

- general physical examination;

- determination of BMI (body mass index);
- respiratory system examination - inspection, palpation, percussion and auscultation;
- musculoskeletal examination – somatoscopic exam, and manual muscle testing of the limb muscles;
- examination of balance and gait.

During the examination, we conducted *standard laboratory tests* and *radiological examination* in postero-anterior view of moderate and severe forms of COVID-19 (Fig. 1a and Fig. 1b).

Fig. 1a – Moderate form of COVID-19.

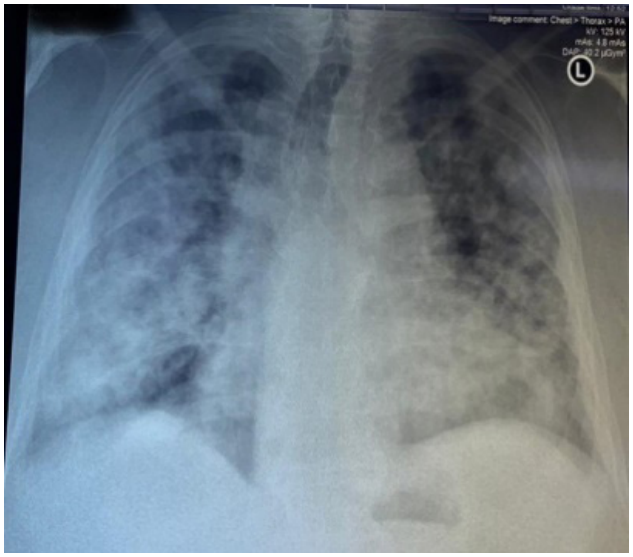

Fig. 1b – Severe form of COVID-19.

For the *functional assessment,* we used:

- Oxygen saturation of arterial blood (SaO2) measured by pulse oximetry, for COVID-19 severity;
- Berg scale for balance - was used to objectively determine the patient's ability to safely balance during a series of predetermined tasks. It is a 14 item list with each item consisting of a five-point ordinal scale ranging from 0 to 4, with 0 indicating the lowest level of function and 4 the highest level of function. Berg scale score: ≤ 20 – wheelchair user; $> 20 \leq 40$ – walking with assistance; $> 40 \leq 56$ – independent;
- Dyspnea by Borg scale - we used Borg scale to measure physical activity intensity (to quantify dyspnea), where 0 means absence of dyspnea, and 10 means maximum dyspnea;
- SF-36 scale for quality of life - it includes questions related to the following aspects: state of health - global, social life, pain parameter, mental (emotional) impact, physical appearance, quality of life. Each scale question has a specific score. The final score of the scale is obtained by summing the scores given by the patient to each question, and ranges between 0 and 114.

Subjects performed daily exercises within the respiratory rehabilitation program. The respiratory rehabilitation program was individualized according to the patient's form of disease. Pulmonary rehabilitation is necessary to restore physical and respiratory function, but also to reduce anxiety and depression.

The *rehabilitation program was complex* and included:

- correct bed position - 2-3 hours in supine position, with the head resting on a pillow placed on the upper 1/2 of the posterior thorax; lower limbs with flexed knees; 2-3 hours in left lateral decubitus, preferably with a pillow placed between the thighs; 2-3 hours in prone position, the head being comfortably placed on a pillow, and a small pillow placed under the abdomen; 2-3 hours in straight lateral decubitus position.
- percussions of the chest wall - manual percussions were performed for 10-15 minutes, every 3-4 hours, on the chest wall, 4-6 percussions, at an interval of 30 seconds.
- breathing exercises - the patient breathed in 4 times (respiratory square): breathe in (inhale), the lung is kept swollen (post-inspiratory pause), exhale, then the lung is empty (post-expiratory pause).
- kinetic exercises - lower limb exercises - The patient grips the legs with the hands in the knee region, under the patella, bringing the knee forward, simultaneously lifting the torso from the plane of the bed. Hold the position for a few seconds (2-3-4 seconds), then slowly return to the starting position. Resume the exercise with the other lower limb.
- complex gait training - weight shifting, tandem walking, lateral stepping over / around objects, obstacle courses, front and lateral step-ups, closed kinetic chain activities.

For both groups of patients (G1, G2), the types of exercises were performed daily, depending on patient's tolerance.

The number of repetitions was progressively increased, every 2-3 days, depending on the patient, and combined exercises were performed three times a day, each session lasting 20 minutes.

d) Statistical processing

All data were collected from the patient observation sheets. For statistical data processing we used the Data Analysis module of the Microsoft Excel program, and for statistical correlations we used the Fisher test, the significance threshold being considered at $p < 0.05$. The results obtained were summarized in tables and figures.

Results

Of the 69 subjects evaluated, 30 were known to have COPD - 43% and 39 were known to have asthma - 57%.

In group G1 male patients predominated - 73%, compared to females - 27%, and in group G2 female patients were predominant - 62%, compared to male patients - 38%. In terms of age, most patients in G1 were aged between 60-69 years - 37%, and in group G2 most patients were aged between 50-59 years - 36% (Fig. 2).

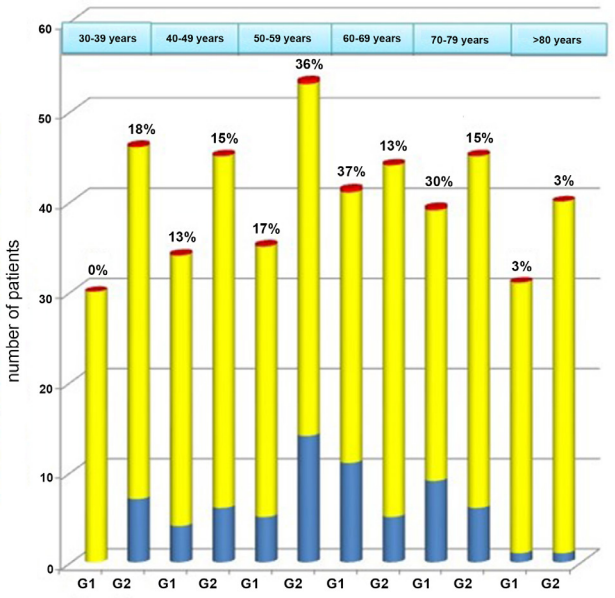

Fig. 2 – Age of patients.

In both groups the urban environment predominated, in G1 - 67% and in G2 - 64%.

Of the 69 patients diagnosed with COVID-19 and obstructive ventilatory dysfunction, 45 were smokers. In G1 - 83% of patients, and in G2 - 51% of patients were smokers.

The forms of COVID-19 among the patients in our study, previously diagnosed with obstructive ventilatory dysfunction, were the following:

- COVID-19 MILD FORM - 24 of the 69 patients (34.78%);
- COVID-19 MODERATE FORM - 26 of the 69 patients (37.68%);
- COVID-19 SEVERE FORM - 19 of the 69 patients (27.54%).

Of the 24 patients with mild COVID-19, 5 patients were in G1 (21%) and 19 in G2 (79%). Patients diagnosed with moderate COVID-19 were distributed as follows - 12 patients in G1 (46%) and 14 patients in G2 (54%), while patients with severe COVID-19 were found in the highest proportion in group G1 - 13 patients (68%), only 6 patients being found in group G2 (32%). The most severe forms of COVID-19 occurred in patients with COPD and changes in the body mass index.

Also, moderate and severe forms were statistically significantly correlated with patients' smoking status ($p = 0.0397$).

The body mass index played a very important role in our study, as only 16 of the 69 patients were normal weight. Most underweight patients were in group G1 (8 of the 9 patients), and most overweight patients were in group G2 (11 of the 14 patients). Obese subjects were approximately equally distributed in the 2 groups.

Regarding weight, moderate and severe forms of COVID-19 were associated with underweight or varying degrees of obesity. Changes in the body mass index were associated with the onset of pneumonia, thus identifying moderate and severe forms of COVID-19 (Fig. 3).

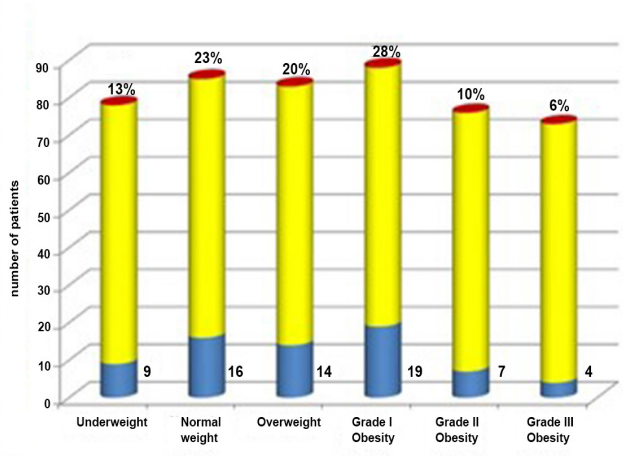

Fig. 3 – Body mass index.

After receiving the drug treatment and performing the exercises included in the pulmonary rehabilitation program, most patients had a favorable clinical course. The pulmonary rehabilitation program was focused on correct positioning in bed (2-3 hours in supine position, 2-3 hours in left lateral decubitus, 2-3 hours in ventral decubitus and 2-3 hours in right lateral decubitus), manual percussion of the chest wall, breathing exercises and kinetic exercises. The exercises were performed daily, depending on the tolerance of each patient.

We found an increase in saturation (Fig. 4), with a reduction of oxygen requirements in patients with severe forms of COVID-19 in both groups, in G1 - 8 of the 13 patients, and in G2 - 4 of the 6 patients. There were no statistically significant differences between the 2 groups ($p = 1.0000$). In the moderate forms of COVID-19, saturation increased in 10 of the 12 patients (G1) and 13 of the 14 patients (G2).

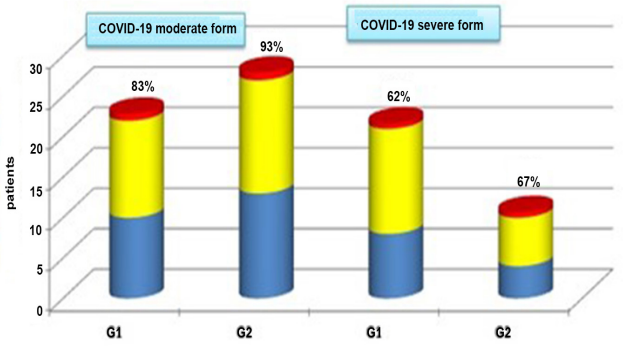

Fig. 4 – Increased oxygen saturation of arterial blood.

To quantify dyspnea, we used the Borg scale and at the end of treatment all patients showed a decrease in the degree of dyspnea, having a higher tolerance to effort. All subjects were satisfied with the overall outcome of the pulmonary rehabilitation program, and the SF-36 scale score was increased for both groups. No statistical differences were recorded between the two groups (p = 0.4646).

We evaluated the maintenance of balance after completion of the medical recovery program in which the patients were included using the Berg scale. Most patients had scores above 40, but there was a statistically significant difference between the 2 groups; in G1 8 of the 30 patients required walking assistance compared to 2 of the 39 patients in G2 (p = 0.0428). None of the patients needed a wheelchair.

Discussion

Pulmonary rehabilitation (PR) has the potential to play a vital role in the recovery of patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Gautam et al., 2020). In a patient-specific manner, PR is planned based on a detailed patient assessment including but not limited to training, exercise, and behavioral changes, since it aims at improving the physical and psychological status of individuals with chronic respiratory disease and focuses on comprehensive interventions for long-term commitment to health improvement attitudes (Aytür et al., 2020).

As we found that male patients with obstructive ventilatory dysfunction (COPD or asthma) and weight changes are more prone to moderate and severe forms of COVID-19, a study conducted in Switzerland in 2020 found that these could contribute to the morbidity and severity of COVID-19. The authors performed RNA sequencing and explored available RNA-Seq databases to study gene expression and co-expression of ACE2, CD147 (*BSG*), and CD26 (*DPP4*), and their direct and indirect molecular partners in primary human bronchial epithelial cells, bronchial and skin biopsies, bronchoalveolar lavage fluid (BAL), whole blood. Asthma, COPD, hypertension, smoking, obesity, and male gender status generally led to a higher expression of ACE2- and CD147-related genes in the bronchial biopsy, BAL, or blood. Additionally, CD147-related genes correlated positively with age and the body mass index (Radzikowska et al., 2020).

In our study, patients included in group G1 diagnosed with COPD showed more severe forms than patients with asthma in group G2. Several studies around the world have shown that the presence of COPD is associated with severe forms of COVID-19. In the larger New York cohort (13,442 patients with COVID-19 attending the emergency department), COPD was associated with an increased risk of hospitalization (RR 1.77, 95% CI 1.67–1.87) (Marcello et al., 2020), and a trend for increased mortality (RR 1.08, 95% CI 0.88–1.33). Similar findings were reported in an Italian cohort involving 1044 hospitalized patients; patients with COPD had a significantly increased risk of severe respiratory failure (RR 1.17, 95% CI 1.09–1.27) (Bartoletti et al., 2020). The ISARIC (International Severe Acute Respiratory and Emerging Infection Consortium) cohort, based on data from over 20,000 patients hospitalized with COVID-19 infection, demonstrated that non-asthma chronic pulmonary diseases are associated with an increased risk of death (HR 1.17, 95% CI 1.09–1.27) (Docherty et al., 2020).

In our study, moderate and severe forms of COVID-19 were statistically significantly correlated with smoking (p = 0.0397). The same was demonstrated by a study based on a meta-analysis that identified 19 reviewed papers, with a total of 11,590 patients with COVID-19, 2,133 (18.4%) with severe disease and 731 (6.3%) with a history of smoking. A total of 218 patients with a history of smoking (29.8%) experienced disease progression compared to 17.6% of non-smoking patients. The meta-analysis showed a significant association between smoking and progression of COVID-19 (OR 1.91, 95% confidence interval [CI] 1.42-2.59, p = 0.001) (Patanavanich & Glantz, 2020).

Pulmonary rehabilitation has an important role in the recovery of patients with COVID-19. The exercises performed by the patients included in our study determined an increase in the oxygen saturation of arterial blood, a decrease in oxygen requirements, an improvement of dyspnea with an increase of tolerance to effort, the maintenance of balance and an improvement of quality of life. A study conducted between March 10, 2020 and April 30, 2020 on 41 patients who were included in a lung rehabilitation program showed a statistically significant improvement in Barthel Index (84.87±15.56 vs 43.37±26.00; p<0.0001), 6-Minute Walk Test (303.37±112.18 vs 240.0±81.31 meters; p=0.028), Borg RPE scale (12.23±2.51 vs 16.03±2.28; p<0.0001) (Curci et al., 2021). These findings suggest that COVID-19 patients might benefit from motor and respiratory rehabilitation treatment.

Another meta-analysis study was conducted in 2021 and looked for publications investigating the benefits of lung rehabilitation on lung function, exertion capacity (6-minute walk test), quality of life (SF-36 scale), and dyspnea. After translating these findings into clinical improvements, the pulmonary rehabilitation intervention increased the predicted FVC by 5.5%, the 6MWD test by 44.55 meters and SF-36 improved by 3.9 points compared to baseline values. While specific evidence for the pulmonary rehabilitation of COVID-19 patients emerges, the resulting data suggest that interstitial lung disease rehabilitation could be considered as an effective therapeutic strategy to improve the functional capacity and quality of life of these patients (Reina-Gutierez et al., 2021). Limitations of the study – given its retrospective nature, we could not follow optimal functional parameters for assessing the real complexity of dysfunction, determined by the association of the 2 entities: chronic respiratory disease and infection with the new coronavirus.

We intend to conduct in the future a randomized study in patients with obstructive ventilatory dysfunction and SARS-CoV-2, to monitor the effectiveness of the kinetic program in restoring and maintaining an optimal quality of life for patients.

Conclusions

1. Patients with obstructive ventilatory dysfunction, especially patients diagnosed with COPD, male, smokers, are more prone to the development of severe forms of COVID-19.

2. The altered body mass index in the sense of underweight or obesity contributes to the appearance of complications, implicitly to moderate and severe forms of COVID-19.

3. The consequences of COVID-19 can be treated by pulmonary rehabilitation.

4. The results obtained indicate that it is very important to include patients in a medical rehabilitation program from the time of hospitalization, in order to maximize respiratory function, prevent disability and increase quality of life.

Conflict of interests

No conflicts of interests.

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