CASE REPORT

Breathing and Light- to Vigorous-Intensity Aerobic Exercises Improved Respiratory Functions and Functional Capacity of COVID-19 Survivor with Morbid Obesity

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ABSTRACT

Introduction: A decrease in respiratory functions (RF) and functional capacity (FC) may present as complications of intensive care unit (ICU) admission. Morbid obesity worsens these complications.
Case: A 31-year-old male patient with morbid obesity came for pulmonary rehabilitation (PR) one week after hospitalization. He suffered from COVID-19 and received 15 days of mechanical ventilation. The goal of PR was to improve RF and FC. A comprehensive PR, including hospital- and home-based programs, consisting of breathing, aerobic, resistance, and flexibility exercises, diet and psychological counseling was given. Breathing exercises were deep breathing, sustained-maximal breathing, and chest expansion. Hospital-based PR was given with moderate-intensity interval aerobic exercise (AE), while home-based PR was with low-intensity continuous, both with oxygen supplementation. The FC was needed to do his daily activities, and vocational was 1.0 to 6.3 metabolic equivalents (METs). The target of FC 6 METs in 12-18 weeks was set. After six weeks, the RF improved with decreased dyspnea and increased maximum inspiratory volume and chest expansion. The FC increased to 4.2 METs, and monitored-home-based AE was given with vigorous-intensity interval mode. He joined the residency program 10 weeks later and achieved 5.7 METs at the end of PR. We gave unsupervised home-based exercises for his long-term exercise.
Conclusion: Breathing and AE improved RF and FC in a COVID-19 patient with morbid obesity admitted to the intensive care unit (ICU) to previous vocational activities.

INTRODUCTION

Patients with COVID-19 admitted to the intensive care unit (ICU) may have a functional impairment such as decreased respiratory functions (RF) presented as pulmonary function test results, decreased functional capacity (FC) presented as decreased 6-minute walking distance, and quality of life both physically and emotionally.[1] The association of obesity with COVID-19 has been identified with the high frequency of obesity in COVID-19 patients admitted to the ICU and an increase in the severity of COVID-19 with body mass index (BMI). Morbid obesity (BMI >40 in COVID-19 patients is associated with increased mortality, respiratory failure, mechanical ventilation, and serious complications such as heart and renal failure.[2–4] In COVID-19 infection, a decrease in protective cardiorespiratory reserve and immune dysregulation appears to progress the development of COVID-19 to critical illness with organ failure.[5]

Obesity is associated with significant changes in respiratory muscle performance and pulmonary mechanics.[6] Patients with acute respiratory distress (ARDS) showed a greater reduction in RF

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and exercise capacity secondary to severe SARS-COV-2 pneumonia, leading to mechanical ventilation (MV) needed during the acute phase. This is associated with activity-induced oxygen desaturation and decreased FC over time.[7] Patients with obesity also experience increased psychosocial stress from the COVID-19 pandemic. This can lead to depression, anxiety, and eating disorders, leading to weight gain. Therefore, this circle must be intervened early in managing post-COVID-19 patients with obesity.[8]

Exercise recommendations to increase FC in obese patients are those with large volume and long duration.[9] Increasing FC becomes challenging when patients experience a severe decline in FC with signs of exercise intolerance and psychological disorders due to COVID-19 and ICU care. In this study, we report the case of a COVID-19 survivor who experienced a decrease in RF and FC due to COVID-19 and ICU care. He also had barriers to participating in the rehabilitation program due to several comorbidities.

CASE

A 31-year-old male patient came for pulmonary rehabilitation (PR) one week after hospitalization due to a critical case of COVID-19. He was given 15-day invasive mechanical ventilation (IMV) and had an ischemic stroke during hospitalization. He also had morbid obesity, hypertension, and knee osteoarthritis.

He complained about being easily fatigued, accompanied by shortness of breath, especially when walking upstairs and doing daily activities. He could only walk no more than 50 meters before fatigue and shortness of breath appeared. He used oxygen supplementation of 3 liters per minute when he felt shortness of breath. His complaints decreased with rest in sitting or lying positions.

He also complained about weakness in his left limbs but no numbness or tingling sensation. He walked slowly without an assistive device but could only manage 5 minutes without resting, achieving 50 meters distance. Despite improvements in his condition after being discharged from the hospital, he sometimes felt disappointed with his walking ability and physical activity limitations.

After being discharged from the hospital, he was given a home rehabilitation program consisting of ground walking exercises with an assistive device under the supervision of a caregiver and breathing exercises with an incentive spirometer, and light endurance exercises for limb muscles. One week later, he came for a PR program.

He is a member of the residency program and needs to work six days a week, 10-15 hours per day. As a 4th semester resident, the patient works in the operating room and ICU. He must stand for 1-2 hours while working in the operating room. In addition, he is also responsible for and monitors the surgeries in which his juniors are involved. Sometimes, his work hours were extended when it was a protracted surgery. His FC required to do daily activities before hospitalization was between 1.0 to 6.3 metabolic equivalents (METs). Currently, his daily activities range from activities with METs 1.0 to 3.5.

The physical examination found that blood pressure was 140/90 mmHg, pulse rate was 90 bpm, respiratory rate was 20 times/minute, and the temperature was 36.5°C. Oxygen saturation was 95-99% with oxygen support 3 liters/minute via nasal cannula and decreased to 90-94% room air. His BMI was 43.13. The internal status was normal, except for the thorax examination. There were crackles in his lungs at the anterosuperior aspect of both lungs. Chest expansion was 3cm/3cm/2cm (limited). Neuromusculoskeletal examinations were normal, except that muscle strength in the left lower limb decreased (4 with manual muscle testing). The posture and body habitus of the patient are shown in Figure 1.

Figure 1. Posture and body habitus of the patient

A long and comprehensive program was required to improve his FC. Barriers found in giving PR program were social distancing regulation due to the COVID-19 pandemic that prohibited him from undergoing a regular hospital-based PR, morbid obesity, muscle weakness, low cardiorespiratory endurance, exercise-induced hypoxemia, and musculoskeletal pain in both knees which interfered with his exercise programs. However, he had good motivation and adherence to PR programs.

Hospital- and home-based PR of aerobic, breathing, resistance, and flexibility exercises, as well as diet and psychological counseling, were programmed. Supervised moderate-intensity intervals and home-based low-intensity continuous aerobic exercises (AE) were initially given with oxygen supplementation. Supervised AE was given to improve FC to a minimum of 6 METs.

Table 1. Aerobic, resistance, and flexibility exercise programs

Component of Exercise	Aerobic	Resistance	Flexibility
Frequency	• Supervised-hospital-based: 3 times a week • Home-based: 2 times a week	• Supervised-hospital-based: 2 times a week • Home-based: once a week	• Supervised-hospital-based: 2 times a week • Home-based: 5 times a week
Intensity	• Supervised-hospital-based: moderate intensity (40-59% of HRR, or RPE 12-13 on a scale of 6-20) • Home-based: low-intensity with Borg dyspnea scale 2, or RPE 9-11 on a scale of 6-20)	• Supervised-hospital-based: 60% of 1-RM • Home-based: with his body weight resistance	Supervised-hospital- and home-based: hold muscle contraction for 1 minute at the point of slight discomfort
Time	• Supervised-hospital-based: 30 minutes in the form of interval exercise in 2-minute bouts of moderate intensity followed by a 1-minute rest interval of low intensity (30%–39% of HRR, or RPE 9-11 on a scale of 6-20), with warm-up and cool-down activities of 5 minutes • Home-based: 20 minutes of continuous exercise with warm-up and cool-down activities of 5 minutes	• Supervised-hospital-based: 10 repetitions/set, 3 sets, with resting of 3 minutes between sets • Home-based: 10 repetitions/set, 3 sets, with a resting of 3 minutes between sets	• Supervised-hospital-based: 10 repetitions/set, 3 sets, with resting of 3 minutes between sets • Home-based: 10 repetitions/set, 3 sets, with a resting of 3 minutes between sets
Type	• Supervised-hospital-based cardiorespiratory endurance exercise using a treadmill • Home-based: over-ground walking exercise	• Supervised-hospital-based: isotonic knee extension using NK-table • Home-based: wall sit to stand	Supervised-hospital- and home-based: static stretching of the head and neck, shoulder girdle, and chest wall muscles
Progression	• Supervised-hospital-based: increased exercise bouts gradually every 1-2 weeks as tolerated • Home-based: increase exercise time to 5 minutes a week as tolerated	• Supervised-hospital-based: not applicable • Home-based: not applicable	Supervised-hospital- and home-based: not applicable

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Precaution	• Oxygen supplementation 2-3 liters/minute via nasal cannula • Knee pain	• Knee pain • Valsalva maneuver	Not applicable
Education	• Exercise preparations • Symptoms and signs of intolerance • Adverse events	• Exercise preparations • Adverse events	• Exercise preparations • Adverse events

HRR: heart rate reserved; RPE: the rating of perceived exertion; 1-RM: 1-repetition maximum

Table 2. Breathing exercise program

Component of Exercise	Diaphragmatic Breathing	Sustained-Maximal Breathing	Chest Expansion
Frequency	As dyspnea appear	3 times a day	2 times a day
Intensity	Not applicable	50% of maximal inspiratory volume as measured by incentive spirometer	Not applicable
Time	5-10 minutes until dyspnea disappears	3 sets of 10 repetitions, 3-minutes rest between sets	1 set with 10 repetitions
Type	Deep breathing	• Sustained maximal breathing with the incentive spirometer • Deep breathing followed by holding breath for 2 seconds	Deep inspiration, along with chest wall expansion
Progression	Not applicable	Increased volume gradually as the maximal inspiratory volume increased as tolerated	Not applicable
Precaution	Monitoring of dyspnea, vital signs, and oxygen saturation during the exercise		
Education	• Modified prone positioning • Controlled breathing exercises and pacing technique rest, positioning, and during functional activities • Intake of water and positioning to promote mucus clearance • Symptoms and signs of intolerance		

Although there were some physical barriers, the patient was motivated and willing to do the PR program. However, psychological counseling was still needed to reduce the feelings of disappointment with his performance. A diet management program was also given to the patient with education about calorie balance and consultation with the nutritionist for consideration of pharmacotherapy.

After six weeks, an increase in FC from 3.3 to 4.2 METs was achieved. The program was continued with a home-based vigorous-intensity interval exercise, five times a week with bouts of three minutes followed by two minutes rest periods for 45 minutes, monitored through WhatsApp calls before and after the exercise sessions. The patient was also given breathing and resistance exercises with an intensity of 50% of 1-RM two times a week in three sets of 15 repetitions. 10 weeks later, his FC increased to 5.7 METs, and he rejoined a residency program. The program continued with unsupervised home-based exercises with the prescription as given before.

DISCUSSION

Obesity results in infection and the development of contagious virus disease and is associated with worse disease outcomes. Pathophysiology of the respiratory system due to obesity results in various degrees of respiratory dysfunctions that could lead to hypoxemia. Hypoxemia causes the oxygen costs of breathing required by obese patients to be higher than those who are not obese, even at rest. Symptoms of shortness of breath are associated with the risk of death among COVID-19 patients. One study found that a BMI of 35kg/m^2 was a predictor of increased oxygenation requirements, and obesity-related hypoxemia was a contributor to COVID-19 severity.[10] This patient had morbid obesity and suffered from ARDS due to COVID-19 and needed to use IMV in the ICU for 15 days. He also experienced an ischemic stroke during ICU admission. These conditions were described as severe hypoxemia experienced by the patient.

Previous studies found that patients experience reduced exercise capacity and RF after COVID-19.[1,7] These reductions were more pronounced in patients who required IMV or developed an ARDS. Respiratory muscle weakness is the major contributor to these abnormalities. Intubated patients with COVID-19 also frequently experienced oxygen desaturation after weaning.[1,7,11]

PR and gradual physical activity are effective in rapidly restoring functional activities. After being discharged, PR for six weeks in COVID-19 patients improves RF, quality of life, and anxiety.[7,12] Critically ill COVID-19 patients with respiratory dysfunction should undergo PR after discharge. They may have post-traumatic stress disorder, muscle atrophy, post-exertion shortness of breath, and poor physical fitness.[13,14] Symptoms in this patient were consistent with the previous explanations. He complained about easily getting fatigued, accompanied by shortness of breath while doing his daily activities. He needed to use oxygen supplementation of 3 liters per minute to decrease these symptoms. Sequelae stroke symptoms worsened his walking and activity performance. Thus, the patient sometimes felt disappointed.

After being discharged from the hospital, his daily activities ranged from METs of 1.0 to 3.5, while his physical activities before getting sick required an FC between 1.0 to 6.3 METs. Physical barriers to the exercise program were hypertension, oxygen desaturation and the need for oxygen support at rest, obesity, limited chest expansion, decreased strength of the left lower limb, and a low FC (3.3 METs). In addition, his musculoskeletal pain due to osteoarthritis interfered with an AE program.

The recommendation of AE for critically ill COVID-19 patients after discharge began at a low intensity with gradual progression of exercise intensity and duration. The exercise frequency was three to five sessions per week, with an exercise time of 20 to 30 minutes. Intermittent exercise is recommended in patients who are deconditioned.[14] Based on this recommendation, the patient was given a supervised moderate-intensity interval and home-based low-intensity continuous AE. The PR program was already begun during hospitalization and continued with 1-week home-based exercise with low intensity after being discharged.

AE plays an important role in suppressing inflammation, enhancing metabolic homeostasis, improving cardiorespiratory fitness, and decreasing adipose tissues. People with obesity should perform more exercise to gain significant weight loss. The volume of exercise needed in healthy individuals initially is at a moderate intensity of at least 150 minutes a week. A combination of resistance and aerobic exercises and moderate-intensity continuous and high-intensity interval training is beneficial for improving health conditions.[9] Exercise could also improve immunologic and metabolic functions. Other interventions proven effective in obtaining health benefits are medical interventions and psychological support.[15]

In this patient, aerobic exercise given initially was a moderate-intensity exercise in the form of interval training. Considering the patient has morbid obesity, more exercise was needed to increase his FC and reduce body weight. However, a decrease in FC due to COVID-19 and ICU admission becomes a challenge for rehabilitation. In addition, a COVID-19 national regulation prohibited a supervised hospital-based exercise program. Exercise, dietary management, and psychological counseling were needed to achieve rehabilitation goals. Reduced high-caloric diet and interventions to control sleep regulation, stress, and emotional eating are important to prevent weight gain.[14] COVID-19 patients who survive the ICU may need more psychological support than other ICU patients because of higher levels of post-traumatic stress disorder (PTSD).[16] In addition to preventing weight gain, nutritional management was considered an important part of the patient's program. Experts recommend optimizing caloric and protein intake to improve the recovery and muscle mass of ICU survivors.[17]

The patient experienced respiratory, cardiorespiratory, and psychological fitness due to COVID-19. For better activity performance, a comprehensive PR program was needed, which included the management of physical and psychological disorders. Management of physical disorders begins with giving breathing and flexibility exercises along with aerobic and resistance exercises. Breathing exercises, including mobilization of respiratory muscle groups, chest expansion exercise, controlled breathing, and posture management, are recommended in patients with COVID-19.[14] At the beginning of the PR program, the patient had severe hypoxemia with oxygen desaturation at rest and increased with activities. The patient had to use oxygen supplementation for this problem. Breathing exercise was given to the patient to improve hypoxemia, decrease symptoms, increase chest expansion, and improve exercise performance.

Obesity could affect the respiratory system due to deposits of fats at the mediastinum and abdomen which causes alterations in chest wall mechanics and physiology of the respiratory system. The results are decreased expiratory reserve volume and lung compliance due to the limitation of diaphragmatic excursion, low respiratory muscle strength, limited chest expansion, and reduced chest wall elasticity. The impaired ventilation at the base of the lungs results in reduced oxygen saturation in obese patients. Exacerbation of oxygenation problems could be induced by hypoxia and increased oxygen requirement. Weight gain and obesity could also be induced by psychological problems such as sleep disruption, stress, anxiety, fear, and changes in eating habits. Psychological problems are associated with sleep disruption and lower physical activity or inactivity, which increases weight gain.[15,18,19]

The resistance exercise given to this patient was consistent with the recommendation. Progressive resistance exercise to improve strength was recommended. In this program, each muscle group was trained for 1-3 sets of 8-12 repetitions/session, with rest intervals of 2 minutes, 2-3 sessions/week for 6 weeks. Exercise progression was given by increasing exercise load by 5-10% per week.[14,20]

Overall, the PR program for this patient improved his FC. A combination of moderate-intensity exercise, breathing, resistance, and flexibility in the form of supervised-hospital-based along with home-based low-intensity exercise was effective in improving his FC and decreasing his symptoms. Monitored-home-based exercise with vigorous-intensity interval exercise given in the second episode of PR improved his FC close to the METs requirement before being sick. A long-term program is needed to improve FC, control the risk of chronic diseases, and reduce his body weight. However, the patient is believed to be able to maintain his level of physical activity at home because of good compliance during PR and the willingness of the patient to perform an active lifestyle.

CONCLUSION

Breathing and light- to vigorous-intensity aerobic exercises as a combination of interval and continuous exercises improved RF and FC and returned the patient to the previous vocational activities.

Consent
Written informed consent was obtained from the patient.

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Conflict of Interest
The authors declared there is no conflict of interest.

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Authors' Contributions
Preparing data, gathering, analyzing, drafting: AN and ABS. All authors contributed and approved the final version of the manuscript.

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