Respir Case Rep 2022;11(1):1-8 DOI: 10.5505/respircase.2022.92195

RESPIRATORY CASE REPORTS

Post Intensive Care Tele Pulmonary Rehabilitation in Post-COVID-19: A Case Series

Post COVID-19 Hastalarında Yoğun Bakım Sonrası Tele Pulmoner Rehabilitasyon: Olgu Serisi

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Abstract

Muscle weakness acquired in intensive care, post-intensive care syndrome, psychological dysfunction and changes in body composition are the main reasons cited in Pulmonary Rehabilitation (PR) applications after discharge in cases followed up in the intensive care unit (ICU) due to COVID-19 pneumonia. Although the limitations of face-to-face PR applications during the pandemic have made tele-PR more common, the appropriate patient profile for PR is still unknown. In this case series, video conferencing-mediated tele-PR was applied as a hybrid approach and compared with PR in a face-to-face format in five cases referred after ICU. After the initial and final evaluations and the first two exercise sessions were performed in the outpatient PR unit, the program was continued via a video-conferencing method. At the end of the total 18 sessions, a decrease was noted in the perception of dyspnea, and an increase in exercise capacity and muscle strength. A decrease in the severity of COVID-19-related fatigue was also noted.

Key words: *Pulmonary rehabilitation, COVID-19, telehealth, intensive care.*

Özet

COVID-19 pnömonisi nedeniyle yoğun bakım ünitesinde takip edilen olgularda taburculuk sonrası Pulmoner Rehabilitasyon (PR) uygulama gerekçelerinin başında yoğun bakımda edinilmiş kas güçsüzlüğü, yoğun bakım sonrası sendrom (PICS), psikolojik disfonksiyon, vücut kompozisyonu değişiklikleri yer almaktadır. Pandemi sürecinde yüz yüze PR uygulamalarındaki kısıtlılıklar tele-PR' yi öne çıkarsa da, PR için uygun hasta profili hala bilinmiyor. Bu olgu serisinde YBÜ sonrası yönlendirilen beş olguda video konferans aracılı tele-PR yüz yüze formatla hibrid olarak uygulanmıştır. Ayaktan PR ünitesinde ilk ve son değerlendirmeler ile ilk iki egzersiz seansı yapıldıktan sonra video konferans yöntemiyle programa devam edildi. Toplam 18 seans sonunda nefes darlığı algısında azalma, egzersiz kapasitesinde ve kas kuvvetinde artış oldu. COVID-19 ilişkili yorgunluk şiddetinde azalma saptandı.

Anahtar Sözcükler: *Pulmoner rehabilitasyon, COVID-19, tele-sağlık, yoğun bakım.*

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Submitted (Başvuru tarihi): 20.07.2021 ***Accepted (Kabul tarihi):*** 10.09.2021

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After SARS Cov-2 (COVID-19) was declared a pandemic by World Health Organization (WHO) in March 2020, the number of COVID-19 cases escalated rapidly in our country (1). COVID-19 is an infectious disease that can affect multiple organ systems, including the heart, neurological system, gastrointestinal system, and, most prominently, the respiratory system (2). The severity of the disease can range from mild to severe respiratory and multiorgan failure (3). Patients with hypoxemia ($sO_2<93$) or more than 50% involvement in imaging methods should be admitted to hospital, and those with multiple organ failure who need mechanical ventilation should be treated in the intensive care unit (ICU) (4). It is known that immobilization and long-term hospitalizations in the ICU can have a detrimental effect on both the respiratory and peripheral muscles (3). Reduced exercise capacity, shortness of breath, low fat-free mass index (FFMI), fatigue, impaired cognitive functions and decreased quality of life (QoL) have been reported in COVID-19 patients (4). As the number of patients with permanent limitations and ongoing symptoms after COVID-19 pneumonia increases, the demand for pulmonary rehabilitation (PR) is also expected to rise (5), but due to the risk of transmission, face-to-face PR approaches have been limited during the pandemic. The PR application model that has come to the forefront at this time is tele-PR, within the scope of telehealth. In terms of its improvement of exercise capacity and respiratory symptoms, tele-PR can be considered as effective as conventional PR, and to be more efficient in terms of program completion (6,7). Tele-PR is also recommended for patients with COVID-19 (10), and has been included in a variety of national and international guidelines (8–10). It is still unclear, however, the optimum PR approach to COVID-19 patients, and the studies of the effectiveness and safety of tele-PR applications in patients with severe COVID-19 are limited. The present study investigates the efficacy of a tele-PR program launched at our center as an alternative or hybrid method in place of face-to-face PR applications in post-COVID-19 cases discharged from intensive care, based on current data.

Written informed consent was obtained from all patients for their participation in face-to-face and tele-PR applications. All patients included in the study had developed pneumonia due to SARS-Cov-2, and were age 49–57 years. Of the five patients, one was female, three had never smoked cigarettes and the others had all quit smoking. While all patients had been admitted to the ICU, none had been intubated. Noninvasive mechanical ventilation (NIMV) was applied in Case 5, while the other cases were treated with high flow oxygen (HFO) support (Table 1). Within 4–6 weeks of discharge, the patients were invited to PR sessions. All patients other than Case 1 were discharged with an oxygen concentrator, and Case 3 remained hypoxemic even at rest. The other three patients were desaturated only with effort. No adverse events were experienced during the videoconferencing-mediated sessions.

Pulmonary Rehabilitation

1. Evaluation:

The patients were referred to our pulmonary rehabilitation center from the clinics from which they were discharged. Appointments were made 4–6 weeks after discharge for an initial evaluation of the patients who were eligible for the tele-PR program using a video conferencing approach, and for the creation of individualized programs. Initial comprehensive evaluations were made face-to-face by a multidisciplinary pulmonary rehabilitation team consisting of pulmonologists, nurses, psychologists, physiotherapists and dieticians. A negative COVID-polymerase chain reaction (PCR) test was required within the last 72 hours prior to the day of assessment. All evaluations were made taking full personal protective precautions related to the pandemic. Respiratory function tests could not be performed due to applied pandemic limitations. The patients were subjected to an incremental shuttle walk test (ISWT) and an endurance shuttle walk test (ESWT) to evaluate exercise capacity (11,12). The peripheral muscle strength of the extremities were measured using manual muscle tests, and maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) measurements were made in appropriate patients. Maximum inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were measured using a Micro-RPM respiratory pressure meter to assess respiratory muscle strength (CareFusion, Hoechberg, Germany). Both measurements were made by the same physiotherapist while the patient was seated, and following the American Thoracic Society and European Respiratory Society (ATS-ERS) recommendations (13). The bioelectrical impedance method was used for the assessment of body composition, and nutritional patterns were recorded. The Hospital Anxiety and Depression Score (HADs), Fatigue Severity Scale (FSS) and Nottingham Health Profile (NHP) were used for the evaluation of psychosocial status (14), COVID-19-related fatigue (15) and quality of life, respectively (16).

2. PR applications:

A personalized tele-PR program was configured in line with the needs of each patient and the suitability of the necessary conditions for exercise in the home environment. The final assessments of the patients after completing a total of 18 sessions spread over 8 weeks were made through simultaneous video conferencing, and also face-to-face in our center, similar to the initial evaluation and the first two sessions.

For the video conference, four patients took part simultaneously with a physiotherapist, who followed the patients on a four-screen display. When necessary, the doctor in charge communicated with the patients. Measuring devices were provided by the patients to control oxygen saturation (SpO_2), pulse and blood pressure, and these parameters were monitored in real time during the PR sessions. When necessary, oxygen support was provided to the patients with the aim being to keep the SpO_2 above 90%. The exercise training program comprised eight weeks of endurance and strengthening training for the upper and lower extremities, and inspiratory and expiratory muscle training when necessary. Cases 3 and 4 were prescribed 30 minutes of endurance exercise at 85% of the VO_2 peak based on the distance they had walked in the ISWT. The workload and time they worked were increased as the sessions proceeded to the level tolerated by the patient. The length of the corridor in the homes of the four patients was learned, and the walking exercises were performed based on the number of tours required over 30 minutes, while a treadmill was used in the home of one patient. The exercises were performed with oxygen (O_2) support in four cases. A program comprising two sets of 12–18 repetitions at 30–50 percent maximum repetition was used with free weights provided for the strengthening exercises. As Cases 2 and 4 had subpleural bullous lesions and Case 5 had pneumothorax during ICU follow-up, respiratory muscle strength could not be evaluated. Approaches to coping with shortness of breath, chest expansion exercises, warm-up and stretching exercises were included in the program. Nutritional counseling was given to patients with Grade 1–2 obesity. It was verified that all of the patients other than Case 5 had lost weight while in hospital, and the amount of weight loss was documented based on the information provided by the patients. The pre-and post-PR evaluation data of the patients are summarized in Table 2; and information about the tele-PR applications of the patients is summarized in Table 3.

CASE

Case 1: Received no further therapy for bilateral ground-glass infiltrates detected on high-resolution lung computed tomography (HRCT) taken for control after discharge. A new control HRCT was scheduled for the third month. His complaint at admission was fatigue and limitations in daily life activities. The patient's MRC muscle strength assessment score was 45, consistent with muscle weakness acquired in intensive care. The upper extremity muscle weakness was considered to be due to the prone position used for the treatment of hypoxemia. After 18 sessions, an increase in anxiety and depression scores was detected. There was an improvement in muscle strength, a decrease in the perception of dyspnea, and a decrease in fatigue intensity.

Case 2: Admitted to the ICU due to severe hypoxemia. The patient was followed in the ICU for 10 days while receiving HFO therapy for a total of 30 days in the hospital. The prominent complaint was dyspnea. Due to the patient's desaturation, the ISWT conducted before and after PR with 2 lt/min oxygen support had to be discontinued. The overall MRC muscle strength score was 45, and the ISWT gain was 60 meters. After 18 sessions, the patient completed the endurance test in 20 minutes. Muscle strength in the lower and upper extremities was shown to be enhanced on both sides. While there was no negativity during the video conference-mediated tele-PR sessions, both his anxiety and depression scores increased to the borderline level.

Case 3: Oxygen therapy was given to the patient whose primary complaint was dyspnea at the time of the initial evaluation. He was undergoing corticosteroid treatment due to the widespread ground-glass infiltration in HRCT. The overall muscle strength assessed by MRC was lower than 48, and was considered to be acquired in the intensive care unit.

Case 4: The exercise capacity of the patient was 120 m. and the total muscle strength score assessed by MRC was below 48. Exercise was discontinued due to increased dyspnea perception and leg fatigue and no desaturation during exercise. As the FSS was less than 4, COVID-19-related tiredness was ruled out. The patient's ISWT increased by 300 meters after the hybrid PR program, while 20 minutes were completed in ESWT.

Table 1: Demographic and clinical features

	Case 1	Case 2	Case 3	Case 4	Case 5
Gender	Female	Male	Male	Male	Male
Age (year)	52	57	56	49	44
Smoking history	Never	50 p/y ex-smoker	30 p/y ex-smoker	Never	Never
Comorbidities	Diabetes mellitus	-	COPD, Obesity, Hypertension, allergic rhinitis	-	Gilbertt's syndrome
Initial symptoms	Fever, weakness	Fever, myalgia, anosmia, diarrhea	Fever, dispnoea, cough	Fever, dispnoea, cough	Fever, weakness
COVID-19 PCR	+	-	+	+	+
Chest CTfindings on ICU admission	Bilateral diffuse ground glass infiltration	Ground glass infiltration in the lower zones	Ground glass infiltration and bronchiectasis areas in the lower zones,	Bilateral diffused ground glass infiltration	Bronchiectasis, mosaic perfusion, peripheral ground glass, pleural shrinkage
Medication and treatment	HFO, Favipiravir, LMWH 30 days	HFO, Remdesevir, Corticosteroid 3 months, LMWH	HFO, Plaquanyl, Favipiravir, Corticosteroid 3 months, LMWH	HFO, Favipiravir, LMWH	NIMV, HFO, Favipiravir, Anakinra, Corticosteroid 3 months, LMWH
Weight loss kg.	10	12	25	15	0
LTOT	-	+	+	+	+
Time until ICU (days)	13	21	5	5	7
Sstay in the ICU/Hospital (days)	12/21	10/30	21/29	7/16	26/44
PR endications at PR assessment	Fatique, Weight loss, Reduced exercise capacity, Muscle weakness	Fatique, Dyspnoea, Weight loss, Reduced exercise capacity, Muscle weakness	Dyspnoea, Weight loss, Reduced exercise capacity, Muscle weakness	Fatique, dyspnoea, Weight loss, Reduced exercise capacity, Muscle weakness	Fatique, dyspnoea, Reduced exercise capacity, Muscle weakness

PR: Pulmonary Rehabilitation, HFO: High Flow Oxygen, LMWH: Low Molecular Weight Heparin, ICU: Intensive Care Unit, LTOT: Long Term Oxygen Therapy

Case 5: The patient developed pneumothorax and diffuse subcutaneous emphysema, followed by type 1 respiratory failure, necessitating NIMV and HFO therapy in the ICU. He was admitted to our PR center with complaints of dyspnea, fatigue and reduced activity in daily life. No MIP and MEP measurements were made, with a multidisciplinary evaluation made face-to-face instead due to a history of pneumothorax. The exercise capacity of the patient was 430 m. After 18 sessions, the patient only needed oxygen support during effort, and there was a decrease in the severity of fatigue and shortness of breath, accompanied by an increase in exercise capacity and QoL.

Table 2: Findings before and after pulmonary rehabilitation

	Case 1 Before/After	Case 2 Before/After	Case 3 Before/After	Case 4 Before/After	Case 5 Before/After
BMI (kg/m^2)	32,10 / 32,90	28,00 / 31,00	27,40 / 29,60	28,70 / 30,10	27,7 / 29,4
FFMI (kg/m^2)	18,10 / 18,10	20,50 / 20,80	19,93 / 21,98	20,80 / 21,30	20,8 / 21,1
mMRC score	2 / 1	3 / 2	3 / 2	3 / 1	3 / 2
BORG at rest	2 / 0	0 / 0	1 / 0	0 / 0	0 / 0
BORG execise	4 / 4	3 / 2	3 / 2	5 / 2	4 / 3
ISWT (meters)	200 / 220	240 / 300	140 / 420	120 / 420	430 / 530
ESWT (minute)	20 / 20	2,00 / 20	2,53 / 20,00	6,14 / 20,00	4 / 13
HADs (Anxiety)	3 / 7	4 / 8	4 / 6	3 / 3	7 / 8
HADs (Depression)	4 / 8	7 / 10	5 / 4	10 / 10	7 / 4
Nottingham health profile	65 / 66	58 / 64	42 / 54	45 / 45	59 / 66
Fatique score	6,11 / 5,66	6,33 / 5,11	3,77 / 3,77	3,66 / 2,77	5,66 / 5,3
SpO_2 (%)	95 / 97	97 / 98 (with O_2 support)	95 / 97 (with O_2 support)	98 / 98 (with O_2 support)	98 / 98 (with O_2 support)
Muscle strength MRC total score	45	45	47	47	52
MIP (cmH_2O)	77 / 81	-	119 / 122		-
MEP(cmH_2O)	89 / 93	-	99 / 114	-	-

BMI: Body Mass Index, FFMI: Fat-Free Mass Index, mMRC: Modified Medical Research Council, ISWT: Incremental Shuttle Walk Test, ESWT: Endurance Shuttle Walking Tests, HAD: Hospital Anxiety and Depression Scale, MIP: Maximal Inspiratory Pressure, MEP: Maximal Expiratory Pressure

DISCUSSION

We describe here the application of a synchronized video conferencing-mediated tele-PR and face-to-face PR hybrid model for case management based on a study of five patients who required ICU hospitalization due to severe COVID-19 pneumonia, and who were referred to our PR center after discharge. There are various suggestions that will guide the patient selection and which patient group the evaluations and program contents of tele-PR applications, which have come to the fore especially during the pandemic period, will be applied (17,18).

The synchronous video conference mediated tele-PR approach was first applied in Turkey at our center during the pandemic. Our PR center makes use of programs with different formats for inpatient, outpatient, hospital-centered home-based, remote-controlled (with phone tracking) and unsupervised applications, which can be conducted with a multidisciplinary approach.

A hybrid tele-PR-face-to-face rehabilitation was applied to allow comprehensive initial and final assessments to be performed with a multidisciplinary approach, and to address the need for close monitoring during sessions. Among the study sample were three patients who had bilateral ground-glass infiltrations and fibrotic lesions in their HRCTs who were undergoing corticosteroid treatment at discharge. Exercise capacity was reduced in our cases in which pulmonary function tests could not be performed due to the pandemic limitations. In four patients, the total score in the manual muscle test was less than 48, indicating acquired muscular weakness in the ICU. No psychological instability was present in any of the patients except for borderline depression in one, and so no post-ICU syndrome, for which comprehensive face-to-face PR should be prioritized, was diagnosed in the sample.

COVID-19-related fatigue, which has been reported to be as high as 72.8% in previous studies, was considered to be one of the determining criteria in exercise limitation in three of our patients whose dyspnea perception was assessed by mMRC score of 2-3 (19). Shortness of breath and fatigue are the most common symptoms after hospitalization due to COVID-19, and extremely high levels of fatigue have been reported. Shortness of breath is seen as an important symptom in two-thirds of the patients admitted to the ICU after discharge (20).

Table 3: Tele-PR programs and follow-up

	Case 1 Before/After	Case 2 Before/After	Case 3 Before/After	Case 4 Before/After	Case 5 Before/After
Educational Status	High school	University	University	University	University
Number of sessions	16	16	16	16	16
Oxygen support	no	yes	yes	yes	yes
Electrical Muscle Stimulation	-	-	-	-	-
Endurance	+	+	+	+	+
Strengthening	+	+	+	+	+
Respiratory Muscle Exercise	+	+	+	+	+
Upper extremity resistance	0,5 / 0,5	0,5 / 0,5	0,5 / 1,5	0,5 / 1	Without weight
Lower extremity resistance	1 / 1,5	1 / 1	0,5 / 2	1 / 2	Without weight
Endurance	800 / 1260	750 / 1440	656 / 1520	750 1446	975 / 1666
BORG after exercise	2 / 1	4 / 1	3 / 2	4 / 1	4 / 3
Heart rate	113 / 106	119 / 107	135 / 114	119 / 107	130 / 120
O_2 Saturations after exercise	92 / 94	83 / 91	85 / 92	83 / 91	88 / 93
Side effect	Leg pain 1 time	Disconnection (1 time), Not using O2 support (It was noticed later-1 time)	Not available	Leg pain in the first session	Not available
Online problem	Not available	Not available	Not available	Not available	Not available

Dyspnea was an expected symptom in parallel with the parenchymal involvement in the lung computerized tomography of the patients. Through the program we applied, the perception of dyspnea decreased at the MCID level, and a decrease was observed in the fatigue scale, aside from in one patient (Case 3) who also had a low baseline fatigue score and exercise BORG level. This patient's primary complaint was dyspnea, although he also had a decreases exercise BORG score after PR, while his fatigue score remained constant. These results are in line with the goals of PR. That said, in a study of patients with Severe Acute Respiratory Syndrome (SARS), which turned into a global pandemic in 2003, it was stated that fatigue can show its effects even one year after the disease (21). We are seeing similarly prolonged and limiting symptoms in the post-COVID-19 period.

A positive change was recorded in the aerobic exercise and endurance tests. The ISWT and ESWT values of all patients except Case 1 showed clinically significant improvement. Case 1 had already completed the ESWT in his initial assessment. ISWT was also slightly increased. An increase was also noted in the peripheral muscle strength of the patients, as expected. Studies of the effectiveness of PR in patients with severe COVID-19 are limited. In the study by Liu et al., an improvement in respiratory function and exercise capacity was noted in COVID-19 patients who underwent PR (22), and there are also case reports revealing that PR increases exercise capacity and muscle strength (23,24).

No desaturation was observed in the exercise tests performed under oxygen support in four patients using LTOT. QoL, as assessed by NHP, improved, aside from in one case (Case 4). After the comprehensive multidisciplinary initial evaluations, warm-up, stretching, endurance, and lower and upper extremity strengthening exercises were applied face-to-face in the first two sessions, simulating the tele-PR via video conference in the individualized hybrid PR model. The hybrid approach not only allowed the cases to be comprehensively evaluated, but also to be monitored simultaneously during their sessions with the video conference method. Through this approach, endurance exercises could be applied in high workloads such as 60–80% of VO_2 peak.

MIP and MEP measurements were possible only in two patients, among which Case 1 had low MIP and MEP values, and Case 3's MIP result was within the normal

range when compared to the reference values, while interestingly the MEP value was found to be lower than MIP (25,26).

Patient compliance with the video conferencing method was very high. The high level of education or the presence of individuals in their families who could support them may have been effective in this regard. During the video conference, two patients experienced leg pain on one occasion. It was noted that one patient did not use oxygen support after starting the exercise. Other than the above, no side effects related to PR practices were encountered.

During the tele-PR applications, the patients' SpO_2, pulse and blood pressure levels were monitored. Being in instant communication with the patients was a significant advantage. In our study, the tele-PR application minimized the risk of coronavirus transmission, and the participation and continuation of the patients to the program was excellent. We concluded that applying PR practices at home contributed greatly to patient compliance. As only the first five cases were reported, and the number of patients was limited, and so the results of this study cannot be generalized. The fact that video conferencing-mediated sessions are performed simultaneously involving more than one patient, and the lack of individual psychological counseling, may explain the failure to achieve the targeted success in anxiety-depression levels. In the face-to-face evaluations made after 18 sessions, different reasons for anxiety and depression such as the continuing pandemic, the anxiety in not regaining their former health and financial losses due to the pandemic were recorded as contributing to the anxiety and depression of the patients.

CONCLUSION

The synchronized video conferencing-mediated tele-PR and face-to-face PR hybrid model can be safely applied to patients with a post-COVID-19 diagnosis who were discharged from intensive care. In cases that require psychosocial support, individual video conferencing mediated counseling can be integrated into programs.

CONFLICTS OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

Concept - M.E.Ş., S.S., P.E.; Planning and Design - M.E.Ş., S.S., P.E.; Supervision - M.E.Ş., S.S., P.E.; Funding - M.E.Ş., S.S., P.E.; Materials - M.E.Ş., S.S., P.E.; Data Collection and/or Processing - M.E.Ş., S.S., P.E.; Analysis and/or Interpretation - M.E.Ş., S.S., P.E.; Literature Review - M.E.Ş., S.S., P.E.; Writing - M.E.Ş., S.S., P.E.; Critical Review - M.E.Ş., S.S., P.E.

YAZAR KATKILARI

Fikir - M.E.Ş., S.S., P.E.; Tasarım ve Dizayn - M.E.Ş., S.S., P.E.; Denetleme - M.E.Ş., S.S., P.E.; Kaynaklar - M.E.Ş., S.S., P.E.; Malzemeler - M.E.Ş., S.S., P.E.; Veri Toplama ve/veya İşleme - M.E.Ş., S.S., P.E.; Analiz ve/veya Yorum - M.E.Ş., S.S., P.E.; Literatür Taraması - M.E.Ş., S.S., P.E.; Yazıyı Yazan - M.E.Ş., S.S., P.E.; Eleştirel İnceleme - M.E.Ş., S.S., P.E.

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