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CASE REPORT

Clinical impact and benefits of a simultaneous cardio-pulmonary rehabilitation in a COVID-19-infected patient following cardiac arrest: A case report

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Abstract

Since the advent of the pandemic, cardio-pulmonary rehabilitation (CR) has been shown to be an effective treatment. However, there are no studies showing data to substantiate its simultaneous application. A 62-year-old man was resuscitated for asystole during the work-up after presenting with a 2-day history of difficulty breathing. PCR test was positive for COVID-19. He was intubated and admitted to a negative pressure zone. Symptoms improved in response to acute treatment. Following extubation, respiratory distress persisted, and CR was implemented. Clinical indicators of cardiopulmonary function improved resulting in a successful return to community participation. The decline in cardiopulmonary function has been on the rise among COVID-19 survivors. The simultaneous application of CR treatment in our patient resulted in improved clinical indicators of cardiopulmonary function. The patient regained full function for independent community participation.

KEYWORDS

cardiac arrest, cardio-pulmonary rehabilitation, COVID-19

1 | INTRODUCTION

The application of cardio-pulmonary rehabilitation (CR) has dramatically increased in many areas globally. Studies have reported that CR treatment has significantly decreased mortality rates, reduced re-admissions, and improved quality of life among patients with heart and respiratory diseases.[1,2] On the other end of the spectrum, the current public health crisis stemming from the coronavirus (COVID-19) outbreak has taken many lives primarily owing to severely compromised respiratory status. Since the first human-infected case was reported in late 2019, followed by rapid transmission and its global spread, the state of a pandemic was declared by the World Health Organization in early 2020.

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In response to the pandemic, various acute care and treatment methods for COVID-19 infection have been proposed based on limited research data. The recent and notable preventive measure in response to the crisis has been developing vaccines to achieve herd immunity. However, there is still insufficient research evidence for the treatment of conventional acute cardiopulmonary failure, which is accompanied by deterioration of physical condition, postural instability, muscle shortening, and contracture that may occur after COVID-19 infection.[3,4]

Our patient with cardiac arrest, presumably associated with recent COVID-19 infection, showed improvement in cardiopulmonary function after undergoing a simultaneously combined pulmonary and cardiac rehabilitation. The resultant effect was a rapid return to daily life activities and vital community participation.

2 | CLINICAL CASE

2.1 | History of present illness and hospital course

A 62-year-old man with chronic hypertension and no other significant medical history presented to the emergency department (ED) with complaints of severe dyspnea. He reported the onset of breathing difficulties 2 days prior to presentation. The patient's wife was undergoing mandatory self-isolation at home, where they reside together, due to a recent COVID-19 infection positive test result. He was transported to the emergency room via ambulance. While en route, 15 L of O_2 was applied by reservoir mask, and saturation was measured at SpO2 of 60% upon arrival. The patient was immediately intubated.

During the work-up in the ED, an onset of asystole required cardiopulmonary resuscitation for approximately 2 min. The efforts resulted in the return of spontaneous circulation (ROSC). PCR test result was positive for COVID-19. He was intubated and admitted to the Infectious Disease service for the acute treatment of COVID-19 in a negative pressure isolation room in a separate wing of the hospital. The patient was extubated on hospital day 10 with significantly improved clinical symptoms by hospital day 28. He was released from the quarantine zone following a confirmed resolution of COVID-19, and a gradual improvement of pneumonia was observed via serial radiography (Figure 1).

Medical management was discontinued at this juncture of the hospital course, and discharge planning was initiated. However, as a former COVID-19 patient with a recent cardiac event, residual respiratory distress and symptoms were noted when engaging in any activity with the slightest movement. Upon returning home, he could not perform basic daily life activities independently and was prompted to undergo CR.

2.2 | Evaluation tools

Pre-requisite evaluation (hospital day 38; T1) before CR involved the following areas of assessment: pulmonary function test (PFT), cardiopulmonary exercise (CPX) test, 6-min walk test (6MWT), and Berg balance test (BBS). The patient was reassessed after 7 days of CR (hospital day 48; T2).

Pulmonary function was based on PFT evaluation (Pony FX MIP/MEP, Cosmed Srl) which included measurements of Functional Vital Capacity (FVC%), FEV1(%), FEV1/FVC (%) with Peak Cough Flow (PCF), Vital Capacity (VC), Maximal Insufflation Capacity (MIC), Maximal Inspiratory Pressure (MIP), and Maximal Expiratory Pressure (MEP). CPX test was conducted using American College/American Heart Association guidelines using Peak Oxygen uptake per Kilogram (VO2/Kg), Peak Oxygen uptake per Heart Rate (VO2/HR), and Oxygen Uptake Efficiency Slope (OUES) as clinical indicators.

2.3 | Clinical intervention

The rehabilitation course required a combined program consisting of 1) 60 min of pulmonary rehabilitation, 2) 60 min of cardiac rehabilitation, and 3) 30 min of strengthening exercise with balance training. The regimen was applied once daily for a total of 7 days.

Pulmonary rehabilitation comprised pursed-lip breathing exercises, deep breathing exercises (secretion mobilization and diaphragmatic breathing), rib cage expansion exercises, and controlled coughing exercises. The patient was also educated on self-management practices, emphasizing coping skills, dietary intake, self-medication, and performance in activities of daily living.

Cardiac rehabilitation involved the use of a hand-bike ergometer system based on CPX results of the initial evaluation. Our patient was supervised by a therapist using a pulse oximeter during the exercise period. The intensity of the activity was adjusted based on the patient's heart rate (HR). The criteria for discontinuing or reducing the exercise intensity was determined by using oxygen saturation of SpO2 $< 85\%$, symptom-limited by the subjective rating of perceived exertion (RPE >14).

The regimen also required 30 min of strengthening exercise and balance training, as aforementioned. A strengthening exercise was performed in three sets of 12–15 repetitions with the 30%–40% of one repetition maximum (RM).[5] When oxygen saturation fell below 85%, 2 L

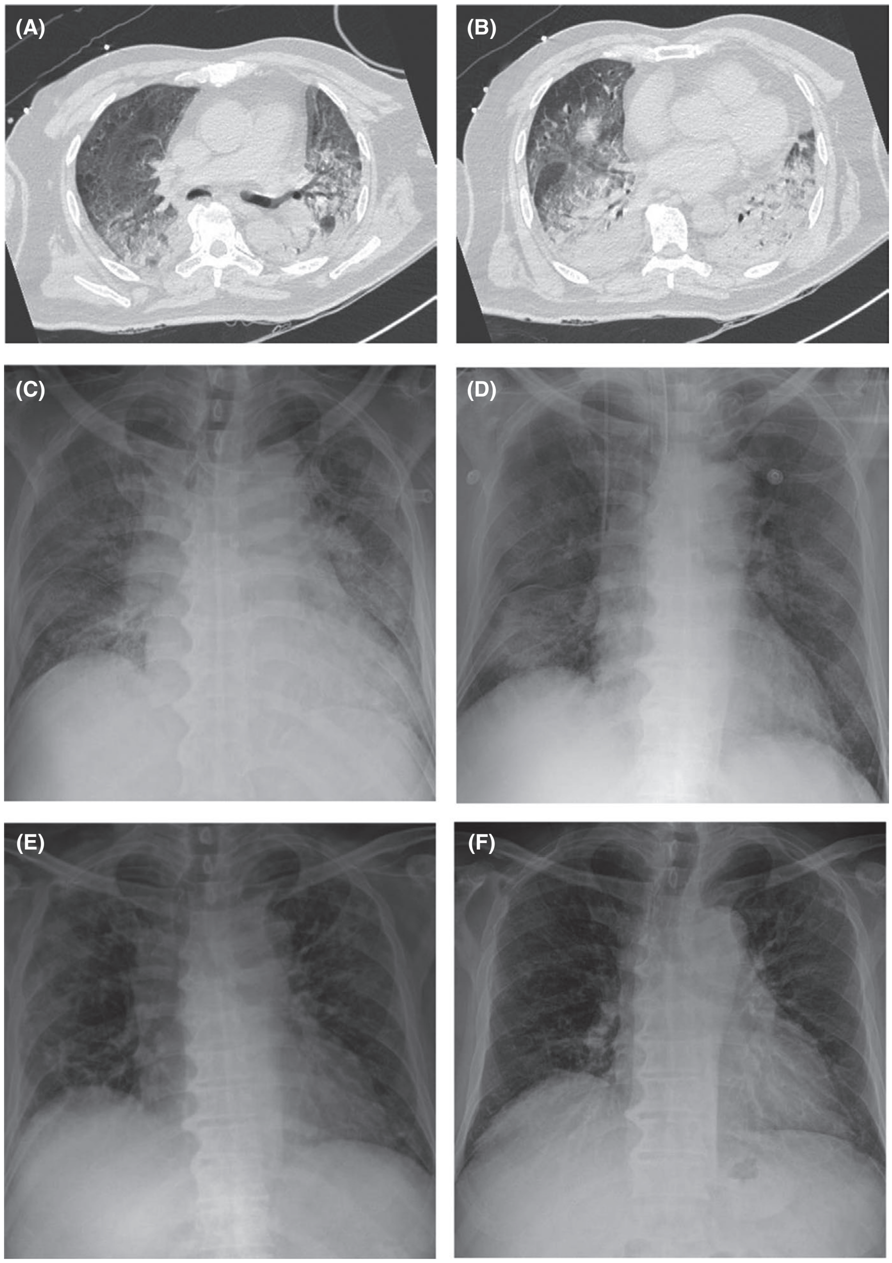

FIGURE 1 Progressive resolution of bilateral patchy opacity findings by radiography during hospital course. (A, B) A large extent geographic appearance opacity distributed in both lungs, predominant in lower fields were observed on computed tomography (CT), performed on HD#2 (December 24); (C) Patchy opacity findings in both lung fields, observed on HD#1 (December 23) by plain radiography; (D) Patchy opacity findings improved on HD#10 (January 1); (E) Patchy opacity findings, further improved on HD#38 (January 29); (F) Patchy opacity in both lungs, vastly improved on HD#48 (February 8); HD, hospital day

of supplemental oxygen was applied via nasal cannula to maintain oxygen saturation greater than 90%.

Despite the patient's confirmed resolution of the infection, precautionary measures were strictly enforced during the rehabilitation treatment phase. Protective equipments, including gowns, face shields, and masks, were required for patients and clinical staff in the rehab center to minimize potential risks of new infection and re-infection.

3 | DISCUSSION

The sequela of COVID-19 infection primarily causes a decrease in diffusion capacity and compromised function via obstructive respiratory patterns and weaknesses of accessory muscles.[6] In addition, impairment of cardiac function due to complex mechanisms, an inflammatory immune response from infection, virus invasion of cardiomyocytes, and hypoxic myocardial injury can all occur as complications.[7] A similar pathophysiologic mechanism presumably manifested in this patient.

Many experts in the field believe that it is indispensable to perform respiratory and cardiac rehabilitation treatment simultaneously. However, cardio-pulmonary rehabilitation's implementation and clinical practice are insufficient and sparse due to the lack of hospital resources and the heightened risks of contagion,[3] especially during the current global public health crisis. Moreover, the decline in cardiopulmonary function is a clinical sequela observed as an increasing trend among COVID-19 survivors.[8]

The effects of respiratory and cardiac rehabilitation therapies have been proven through various studies to date.[8–10] A recent systematic review showed that respiratory rehabilitation treatment after COVID-19 infection improves respiratory function and quality of life.[10] Since the advent of the current pandemic, CR has been combined with respiratory rehabilitation treatment across centers in many geographic areas. However, no studies show data to confirm its generalizability and substantiate its clinical application as a reliable treatment. The observed clinical result shown in our case study is consistent with the improved effects of CR when combined with respiratory rehabilitation in patients with severe COVID-19 infection following cardiac arrest. Symptoms improved, and bilateral patchy opacity was reduced on chest X-ray findings after acute pharmacologic treatment at 38 days of hospital admission. At this juncture, CR was implemented without concomitant antibiotic therapy. Subsequently, symptoms and radiographic findings were further diminished, and although unaffected by antibiotic treatment, the patient's decline in function improved following CR application. Nevertheless, the residual symptoms and radiographic opacity persisted.

Hermann et al. (2020)[8] demonstrated in their study of 28 participants following 2–4 weeks of CR in which the group requiring mechanical breathing ($n = 12$) compared to the group without ($n = 16$) showed a significant increase in the measured outcome on 6MWT evaluation. The improvement was shown in VO2/kg, VO2/HR, OUES, and 6MWT, all of which served as indicators of cardiovascular function. In addition, the BBS index by functional balance test also showed improvement.

Aytur, et al. (2020)[10] proposed a theory and produced guidelines of respiratory rehabilitation for COVID-19-infected patients through a multi-center trial in Turkey. We followed this model in our study and applied the proposed treatment model in pulmonary rehabilitation. Upon completing the week-long CR treatment, the following respiratory function indicators improved: PFT, FVC, FEV1, PCF, VC, MIC, and MIP/MEP, as shown in Table 1. Simultaneously, cardiovascular function improved which enabled the patient to ambulate independently without difficulty in respiratory function.

Cardiopulmonary exercise test results showed improvement in VO2/Kg, VO2/HR, oxygen uptake efficiency slope (OUES), 6MWT, and BBS, as summarized in Table 2. The patient showed functional improvement after a short period of CR by independent ambulation and performance in daily life movements at home without dyspnea and other related respiratory signs and symptoms. Prior to discharge, transthoracic echocardiography findings revealed concentric modeling, left ventricle relaxation abnormality, and left atrial enlargement; however, adequate cardiac function was preserved with an ejection fraction of 67%. As a result, the clinically improved patient regained baseline level of function which enabled him to successfully return to community participation.

TABLE 1 Pulmonary function variance

	Pre-test (T1)	Post-test (T2)
FVC (L, %predicted)	2.42, 52	2.61, 56
FEV1 (L, %predicted)	2.10, 61	2.35, 69
FEV1/FVC (%)	87	90
VC (L, %predicted)	2.18, 53	2.47, 60
MIP (%)	69	92
MEP (%)	48	69
MIC (L)	2.30	3.10
PCF (L/min)	550	600

Abbreviations: FEV1, forced expired volume in the first second; FVC, functional vital capacity; MEP, maximal expiratory pressure; MIC, maximum insufflation capacity; MIP, maximal inspiratory pressure; PCF, peak cough flow; T1, Pre-requisite evaluation, hospital day 38; T2, after 7 days of CR, hospital day 48; VC, vital capacity.

TABLE 2 Cardiopulmonary function, lactate, and functional ability variance

	Pre-test (T1)	Post-test (T2)
VO2/Kg (ml/min/Kg, %predicted)	9.4, 35	11.7, 44
VO2/HR (ml/beat, %predicted)	6.0, 46	6.6, 51
METs	2.7	3.4
OUES	284.18	1004.4
6MWT (m)	221	317
Lactate (mmoL/L)	1.9	1.6
BBS	36/56	42/56

Abbreviations: 6MWT, 6-min walk test; BBS, Berg balance scale; METs, metabolic equivalents; OUES, oxygen uptake efficiency slope; T1, Pre-requisite evaluation (hospital day 38); T2, after 7 days of CR, hospital day 48.

4 | SUMMARY AND CLINICAL APPLICATION

The presented case in this report substantiates the critical need for cardio-pulmonary rehabilitation following the onset of a cardiac event preceded by the resolution of a recent COVID-19 infection. Under the usual protocol, following the resolution of COVID-19, individuals are immediately discharged to home regardless of overt residual symptoms. It is recommended that patients undergo cardio-pulmonary rehabilitation directly following treatment of a COVID-19 infection, given its effectiveness and benefits for improved clinical status following a short treatment period.

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None.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

Mirim Lee, MD (first author) involved in clinical care and work-up, drafting original write-up, administration, proofreading, reviewing final revision of the manuscript. Jeong Jae Lee, MS, PT (second author) involved in investigation, clinical evaluation and work-up, acquisition and interpretation of data, reviewing of the final manuscript. Jun young Ko, MD (co-author) involved in initial investigation with clinical care and work-up, contributed to original draft preparations, data acquisition, and analysis. Yong Kyun Kim, MD, PhD (co-author) involved in project administration and support with the supervision of the clinical aspects, reviewing and editing. Seungbok Lee, MD, MPH (corresponding author) involved in conceptualization and design, supervision with the provision of resources, manuscript drafting, reviewing and final editing with technical language (as a native English speaker), proofreading. All authors participated sufficiently in the presented work; the authors have read and agreed to the final approval of the manuscript to be published as well as the updated authorship taxonomy.

CONSENT

A written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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