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Case Report

Physiotherapy Section

Physical Therapy Management of a COVID-19 Patient on Extracorporeal Membrane Oxygenation: A Case Report

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ABSTRACT

Coronavirus Disease-2019 (COVID-19) can be classified as a respiratory disease that ranges from pneumonia to critically ill cases. Extracorporeal Membrane Oxygenation (ECMO) is a therapeutic procedure that can treat severe cases of respiratory failure. Hereby, the authors present, a 28-year-old case of Acute Respiratory Distress Syndrome (ARDS) young patient with COVID-19 on ECMO therapy, presenting with complaints of weakness, decreased mobility and function, and depression. The patient has received physical therapy interventions during the hospitalisation period. Respiratory, mobility, activity level, and psychological assessments were done before and after treatment using blood gases, the Intensive Care Unit (ICU) Mobility Scale, the University of Michigan scale, and the Hamilton Anxiety and Depression Rating Scale, respectively. There was an improvement in respiratory function, mobility (scores increased from 0 to 1), activity level (scores increased from 0 to 3), and psychological well-being (depression scores decreased from 18 to 15, and anxiety scores decreased from 20 to 14) after physical therapy. The treatment resulted in better recovery and prevented the worsening of the COVID-19 disease scenario.

Keywords: Coronavirus disease-2019, Physical therapy modalities, Venovenous extracorporeal membrane oxygenation

CASE REPORT

A 28-year-old male patient was admitted to the critical care department with severe ARDS due to bacterial pneumonia caused by COVID-19. He presented with rapid heartbeat, breathlessness, and confusion. The patient had a past medical history of Graves' disease for 10 years and complained of an enlarged thyroid gland, weight loss, irregular heartbeat, fatigue, and muscle weakness. The patient underwent Polymerase Chain Reaction (PCR) testing for COVID-19 about five times every two weeks. The test was positive three times within a span of 45 days, and then the patient tested negative after one more month. A tracheostomy was done as the patient required prolonged Mechanical Ventilation (MV). Subsequently, the patient developed a left-side thoracic haematoma (pneumothorax and haemothorax), and two chest tubes were inserted. Venovenous ECMO (VV ECMO) was initiated after MV failure [Table/Fig-1]. The patient's vital signs before ECMO were as follows: temperature of 38.2°C, heart rate of 105 bpm, blood pressure of 129/78 mmHg. After ECMO, the temperature was 36.9°C, heart rate was 79 bpm, and blood pressure was 120/70 mmHg. The patient remained fully conscious and well-oriented. The patient received the following medical treatment: antibiotics, antivirals, and anti-inflammatory medication for four weeks, including Tienam 2 g daily, Tavanic 750 g daily, Penfinix 600 mg twice daily, and Carbimazole 10 mg twice daily. Additionally, the patient took Colistin 9 mL, Solupred 5 mg, Cipralex 20 mg, Respiridal 1 mg, and Procoralan 75 mg as part of the antidepressant treatment. Nutritional support was provided through Aminoliban, Addamel 25%, N-acetylcysteine (NAC) 600 mg, Fresubin 50 mL, and Cevarol 2 g.

After the patient achieved haemodynamic stability, physical therapy intervention was initiated in the 4th week of admission to mitigate complications arising from being bedridden and improve lung aeration. Various physical therapy procedures were implemented twice a day for approximately 30 minutes. These procedures included active range of motion exercises for the upper and lower limbs (1 to 3 sets of 8 to 10 repetitions of 5 active range of motion), airway clearance techniques like positioning, chest wall vibration, percussion, segmental breathing exercises, diaphragmatic breathing exercises (2 sets of 10 minutes per set), and Manual Hyperinflation (MH) for 15 minutes per session, two time/day for two weeks. The rehabilitation protocol adhered to legal and international requirements, specifically the Declaration of Helsinki from 1964. The patient received information about the procedure and gave written consent before evaluation. The physical therapy rehabilitation program consisted of two daily training sessions, averaging 30 minutes each. During the first and second weeks, the program focused on modified positioning (sitting, side-lying on both sides) combined with chest wall oscillation and vibration (every 1-2 hours for 5 minutes). Additionally, active range of motion exercises for the upper and lower limbs (1 to 3 sets of 8 to 10 repetitions of 5 active range of motion), diaphragmatic breathing, and segmental breathing (2 sets of 10 minutes per set) were incorporated [1,2]. Furthermore, MH was employed to stimulate coughing, facilitating the mobilisation of airway secretions towards the larger airways [Table/Fig-2] [3].

Setting/unit	1st assessment (1st week)	2nd assessment (2nd week)	3rd assessment (3rd week)
Blood flow (rate/rpm)	3400	3370	2945
Sweep flow (L/min)	8	12	6
Venous oxygen saturation (SvO_2)/%	47.6	60	65

[Table/Fig-1]: ECMO flow rate and sweep flow.

Procedure and techniques	1st week	2nd week	3rd week
Positioning	✓	✓	✓
Upper and lower limbactive exercise training	✓	✓	✓
Chest wall vibration	✓	✓	✓
Percussion	✓	✓	✓
Segmental breathing	✓	✓	✓
Diaphragmatic breathing	✓	✓	✓
Manual Hyperinflation (MH)	✓	✓	✓
Cough assist	-	-	✓
Trunk (abdominal ex)	-	-	✓

[Table/Fig-2]: Physical therapy procedure and techniques.

After two weeks, the patient started cough assist sessions with the previous protocol. This began with inspiratory pressures between +10 and +15 cm H_2O and expiratory pressures between -10 and -15 cm H_2O. The patient continued with several cough cycles, 4 to 6 in a session, with a pause of 2 to 5 seconds between cough cycles. A rest period of 30 seconds was used before repeating the session. During the rest period, the patient returned to their normal oxygen or ventilation settings.

Specific evaluation for ECMO COVID-19 patients:

1. The ECMO flow, ventilation settings, and venous oxygen saturation (SVO_2) were continuously monitored via the ECMO circuit during the patient's mobilisation [Table/Fig-1] [3,4].
2. The activities for ECMO patients were measured using the University of Michigan scale for assessing the safety and efficacy of early mobilisation in the ICU [Table/Fig-3] [4,5].
3. Assessment and meachanical ventilator setting has been presented in [Table/Fig-4].
4. Mobility was measured using the ICU Mobility Scale [Table/Fig-5] [6].
5. Respiratory assessment, including venous blood gases and oxygen saturation, should be done before and after physical therapy treatment [Table/Fig-6] [7].

Phase 0-1	No mobilisation or passive range of motion – 4 hour re-assessment Turning in bed (including passive and active range of motion) Sitting in bed– elevated head of the bed Sitting on the edge of the bed, feet on the floor Sitting in a chair Standing	Patient achievement Achieved in the 1st, 2nd and 3rd week
Phase 2	Marching in place Ambulation with assistance	-
Phase 3	Ambulation independently (ECMO patients will not achieve phase 3)	-

[Table/Fig-3]: Scale of activity for ECMO patients [4,5].

Ventilator setting	1st assessment (1st week)	2nd assessment (2nd week)	3rd assessment (3rd week)
Mode	Pressure control (APRV)	CPAP	CPAP/T tube
FiO_2 (%)	60%	50%	50%
PEEP (cm H_2O)	7	6	5
Pressure support (cm H_2O)	20	25	11
RR	29 spontaneous	26	17
Vt/mL	177	280	385
VE	4.13 L/min	7.31 L/min	6.5 L/min

[Table/Fig-4]: Mechanical ventilator setting.
APRV: Airway pressure release ventilation; CPAP: Continuous positive airway pressure; FiO_2: Fraction of inspired oxygen; PEEP: Positive end-expiratory pressure; RR: Respiratory rate; Vt: Tidal volume; VE: Minute ventilation

Parameters	1st assessment (1st week)	2nd assessment (2nd week)	3rd assessment (3rd week)
Activities for ECMO measured by the University of Michigan scale	0 No mobilisation	1 Turning in bed, Sitting in bed	1 Elevated head of the bed and Sitting on the edge of the bed
Mobility measured by the ICU mobility scale	0 No activity	1 Exercises in bed	3 Sitting on bed
Hamilton depression and anxiety rating scale			
Hamilton depression rating scale, HAM-D	18	16	15
Hamilton anxiety rating scale, HAM-A	20	19	14

[Table/Fig-5]: Physical therapy mobility and psychological evaluation.

Laboratory (value/unit)	1st assessment (1st week)	2nd assessment (2nd week)	3rd assessment (3rd week)
Haemoglobin/(gm/dL)	9.4	10.8	11.1
WBCs/×(10^9L)	18.7	17	14
PTT/(seconds)	68	64	62
Platelets (10^9 L)	134	199	219
INR	1.1	1.1	1.2
CRP (mg/L)	224	70	57
K (mmol/L)	3.1	3.9	3.8
Na (mEq/L)	129	133	138
Venous blood gases			
PH	7.45	7.36	7.31
PCO_2 (mmHg)	70	53	48
PO_2 (mmHg)	22	31	37
HCO_3 (mEq/L)	33.5	30	29
Arterial oxygen saturation			
SpO_2	93%	95%	96%

[Table/Fig-6]: Laboratory profile of the case.

6. Psychological assessment was done using the Hamilton Anxiety and Depression Rating Scale (HAM-D-HAM-A) [Table/Fig-5] [8].

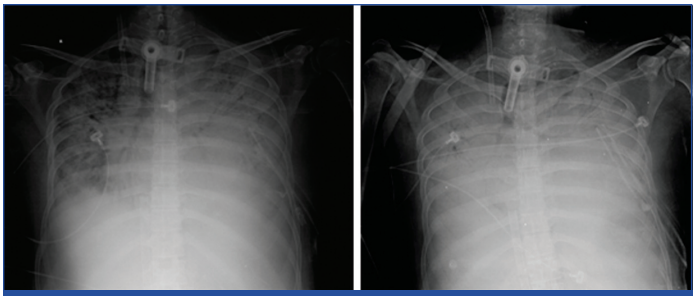
In the third week, the patient followed the same previous program, along with trunk (abdominal ex) and cough assist sessions. The frequency remained at 4 to 6 cough cycles per session, with a pause of 2 to 5 seconds between cough cycles. Throughout the physical therapy sessions, vital parameters and the patient's well-being were evaluated and monitored. If the patient became haemodynamically unstable, the sessions were terminated.

Follow-up and outcomes: The assessments performed using the previous specific COVID-19 evaluation showed improvement in several functions for the patient. Regarding ECMO flow, ventilation settings, and SVO_2, the initial assessment of ECMO blood flow rate, sweep flow, and SVO_2 was 3400 rpm, 8 L/min, and 47.6%, respectively. After the physical therapy program, they were 3370 rpm, 12 L/min, and 60%, respectively. The final assessment showed 2945 rpm, 6 L/min, and 65%, respectively [Table/Fig-1]. Regarding the ventilator settings, the patient was initially dependent on ventilation with Pressure Control (APRV) mode, with a pressure support of 20 cm H_2O, FiO_2 of 60%, PEEP of 7, and minute ventilation of 4.13 L/min. After the physical therapy sessions, the ventilator settings improved to Continous Positive Airway Pressure (CPAP) mode, then T-tube mode, with FiO_2 of 50%, PEEP of 5, and minute ventilation of 6.5 L/min.

Additionally, there were improvements in the patient's activities, measured using the University of Michigan scale [4,9]. The patient's score started at zero, indicating no mobilisation. Then the score progressed to one, indicating the ability to turn in bed and sit in bed while elevating the head of the bed. There were also improvements in mobility, transitioning from no activity (being passively rolled or passively exercised by staff without active movement) to activity in bed with an assistant (assisted by staff and involving active sitting over the side of the bed with some trunk control).

Respiratory assessments, including venous blood gases, blood tests, and oxygenation saturation, were performed before and after physical therapy treatment, showing improvement. Psychological assessment was done using the Hamilton Anxiety and Depression Rating Scale (HAM-D-HAM-A) [Table/Fig-5] [8]. Furthermore, the patient's condition gradually improved over time, and they were weaned from the ventilator and ECMO. Subsequently, they started online outpatient rehabilitation, which lasted for approximately three months.

The pre- and post-intervention radiographic findings are shown in [Table/Fig-7,8].



[Table/Fig-7]: Chest shows airspace opacities (dense consolidation in both lung.
[Table/Fig-8]: Chest X-ray shows apparent improvement of consolidations in both lower lungs after physiotherapy. (Images from left to right)

DISCUSSION

The present case report applied to ARDS COVID-19 patients on ECMO support measured mobility, activity level, and psychological status before and after physical therapy treatment. The results showed an improvement in venous blood gases, arterial oxygenation saturation, mobility scale, activity level, anxiety, and depression scale. There have been few studies published on the effect of physical therapy on ECMO COVID-19 patients [10-12]. The patient is currently being managed according to the proposed modalities of exercise training established by Kourek C et al., [8].

Physical therapy is important for ECMO COVID-19 patients with severe respiratory diseases, which can severely affect peripheral tissues, leading to significant functional impairment. Early mobilisation and exercise in ECMO patients could prevent bedridden complications, enhance early recovery, and improve functional ability, mood, and psychological well-being. Physical therapy management may include therapeutic positioning, ROM exercises, progressive ambulation, and breathing exercises [7].

In ICU physical therapy plays a crucial role for patients who require support such as ventilation and MV [13]. Critically ill patients may develop significant functional deficits and/or ICU-acquired weakness; therefore, mobilisation and exercise are recommended [14]. Physiotherapy is an important strategy in the ICU for patients with COVID-19, as it prevents complications and improves their stability during critical periods, facilitating quicker recovery [15].

Early mobilisation is based on the aetiology of ECMO support. The upper-body cannulation approach is preferred when mobility is of sufficiently high priority for that patient [16]. Additionally, the statement edited by Sommers J et al., on rehabilitation recommendations in ECMO patients suggests that rehabilitation management is primarily determined by the patient's level of consciousness [17].

Similar to the case report by Mao L et al., for severe COVID-19 after bilateral lung transplantation, different techniques were used, including airway clearance, respiratory exercises, muscle strength exercises, transfer activities, and psychological support. Their results revealed that physical function, respiratory function, and activities of daily living improved for this patient after a thorough evaluation and early intervention from a multidisciplinary team [18]. Additionally, the case report by Ibrahim AA et al., reported that COVID-19 patients with respiratory and physical problems benefit from physiotherapy expertise through telerehabilitation programs, which include intercostal muscle stretching, chest wall vibration, walking short distances, and breathing exercises. They assessed physical function, quality of life, depression, and anxiety [19].

In a case report by Lowman JD et al., a young female patient with severe respiratory failure due to cystic fibrosis and on ECMO received physical therapy treatment, including exercise, manual therapy, and airway clearance techniques. After eight days on ECMO, she successfully underwent a bilateral lung transplant [20].

Turner DA et al., (2011) presented two female cases with end-stage respiratory failure on ECMO awaiting lung transplantation. They received active rehabilitation while still on ECMO. After successful transplantation, the patients were weaned from mechanical ventilation and ECMO, transitioned out of the ICU, and became ambulatory in less than one week [21]. In addition to respiratory and physical complaints, COVID-19 patients may feel neglected and depressed. Exercise therapy can help overcome stress and anxiety, allowing patients to return to their normal lives. Exercise therapy is essential for COVID-19 patients' mental and physical health, helping them maintain physical fitness and independence [22].

CONCLUSION(S)

The present case report suggests that early physical therapy and mobilisation in ECMO patients with COVID-19 infection is effective, safe, and helpful in decreasing bedridden complications and improving lung aeration. Future studies are needed to further evaluate the long-term outcomes of ECMO patients and to explore the risk factors for these individuals.

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