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Physiotherapy on a Patient Supported by Extracorporeal Membrane Oxygenation for Acute Respiratory Distress Syndrome: Short- and Long-Term Follow-up

Akut Respiratuar Distres Sendromu Sebebiyle Ekstrakorporeal Membran Oksijenasyon Tedavisi Alan Bir Hastada Fizyoterapi: Kısa ve Uzun Dönem Takip

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Abstract

In recent years extracorporeal membrane oxygenation (ECMO) has been used to maintain adequate gas exchange in patients with Acute Respiratory Distress Syndrome (ARDS). The aim of this case report is to share our center's experience with physiotherapy in patients with ARDS on ECMO, to support the use of physiotherapy and to relate the long-term functional outcomes of the patient at six months after discharge. We present here the case of a 28-year-old female who was referred to our intensive care unit with a diagnosis of ARDS being supported by ECMO. While on ECMO, she received physiotherapy interventions including passive techniques, and participated in an active mobility program following ECMO. Her long-term outcomes, including functional level, exercise capacity, dyspnea, muscle strength, anxiety, depression and quality of life, assessed six months after discharge, were at a very good level. We consider that participation in the early physiotherapy and mobility program may contribute to short- and long-term functional improvements in an ECMO patient.

Key words: *ARDS, ECMO, physiotherapy.*

Özet

Son yıllarda Akut Respiratuar Distres Sendromu (ARDS) olan hastalarda yeterli gaz değişimini sürdürmek için ekstrakorporeal membran oksijenasyonu (ECMO) kullanılmaktadır. Bu olgu sunumunun amacı, merkezimizin ECMO tedavisindeki ARDS'li bir hastada fizyoterapi ile ilgili deneyimini tanımlamak, fizyoterapiyi desteklemek ve taburcu olduktan altı ay sonra hastanın uzun dönem fonksiyonel sonuçlarını aktarmaktır. Burada, yoğun bakım ünitemize ARDS tanısı ile sevk edilen ve ECMO tedavisi alan 28 yaşındaki bir kadın sunulmuştur. Hasta ECMO'da iken pasif teknikleri içeren fizyoterapi uygulamaları almış ve ECMO'nun ardından aktif bir mobilite programına katılmıştır. Taburculuk sonrası 6. ayda hastanın, fonksiyonel seviye, egzersiz kapasitesi, dispne, kas kuvveti, anksiyete, depresyon ve yaşam kalitesi gibi uzun dönem sonuçlarının oldukça iyi seviyede olduğu görülmüştür. Erken fizyoterapi ve mobilite programına katılımın bir ECMO hastasında kısa ve uzun vadeli fonksiyonel iyileşmelere katkıda bulunabileceğini düşünmekteyiz.

Anahtar Sözcükler: *ARDS, ECMO, fizyoterapi.*

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With advances in intensive care medicine, patient survival has improved, but this has brought with it such morbidity problems as general decondition and functional independence (1). Skeletal muscle weakness has been shown to be associated with an increase in mortality, and to continue for years after discharge in Acute Respiratory Distress Syndrome (ARDS) patients (2). For this reason, there is a need for rehabilitation after intensive care unit (ICU), as well as certain evaluations and applications to prevent or reduce the loss of physical functionality during ICU admission.

In recent years, extracorporeal membrane oxygenation (ECMO) has been used to maintain adequate gas exchange in patients with severe respiratory failure that is refractory to even maximal ventilatory support (3). Although patients on ECMO often have many contraindications for physiotherapy, such as bleeding from the cannulation area and dislocation of the cannula, hemodynamic instability, hypoxemia and dependency on veno-venous ECMO support (4), it would seem reasonable that the benefits of early rehabilitation seen in the general ICU population apply also to patients receiving ECMO.

Evidence and awareness of the emphasis of physiotherapy in ECMO patients is increasing. Literature contains case studies investigating the feasibility of physiotherapy in patients on ECMO, although there is only limited data on the assessment of long-term effects and post-intensive care syndrome (3,5,6). The present case report supports early physiotherapy interventions for patients on ECMO, and describes the long-term functional outcomes of the patient six months after discharge.

CASE

A previously healthy 28-year old woman was referred to the ICU with a diagnosis of respiratory failure and suspected Influenza A virus (H1N1). Her arterial blood gas was pH: 7.49, $PaCO_2$: 31.5 mmHg, PaO_2: 40.4 mmHg, HCO_3: 25.3 mmol/l, BE: 1 mmol/L and SaO_2: 75.5%, and her Acute Physiologic and Chronic Health Evaluation (APACHE) II score was 14 at the time of ICU admission.

Over the following 24 hours, the patient's oxygen demand continued, despite receiving non-invasive mechanical ventilation with 100% oxygen support in the ICU, and so intubation ensued. The Intelligent Adaptive Support Ventilation (ASV) mode, which automatically sets the controls for oxygenation (positive end-expiratory pressure [PEEP], Oxygen) was used for invasive ventilatory support. The patient was paralyzed and sedated. At the first hour following intubation, values of PaO_2/FiO_2 82.4 with 20 cmH_2O PEEP and 100% FiO_2 were recorded. The patient was diagnosed with severe ARDS based on the Berlin Criteria (7). Although many ventilation strategies for the management of ARDS were attempted, such as low tidal volumes, high PEEP and recruitment maneuvers, the hypoxemia worsened and the critical care team decided to instigate veno-venous ECMO on the second day of ICU admission (8). On the first day of ECMO treatment, H1N1 was confirmed.

On the 11th day, the ECMO was discontinued and a tracheostomy was performed to ensure airway patency, and the paralysis and sedation subsequently ceased. The patient remained on mechanical ventilation support for five more days, and support was gradually reduced and terminated. During the neurological examination, although her sedation had been ceased on the 11th day she remained unconscious until the 16th day in the ICU. Her consciousness improved progressively between days 16 and 27. Chest X-rays of the patient before admission to the ICU and at the time of discharge, as well as a thorax CT before ECMO, are presented in Figure 1.

The patient was discharged to the respiratory ward on the 27th day of hospitalization with an arterial blood gas of pH: 7.46, $PaCO_2$: 37 mmHg, PaO_2: 91.1 mmHg, HCO_3: 26.8 mmol/l, BE: 2.5 mmol/L and SaO_2: 98.2%. A total of 650 mg rocuronium and 1760 mg steroid, which can have negative effects on skeletal muscle function, had been administered, and a total 24μg of fentanyl had been administered for analgesia. Her total ventilator time in 28 days was 330 hours (13.75 days). The patient was discharged from the ICU in a stable condition in terms of cardiac status, and she was cooperative, eating and mobile with assistance.

Physiotherapy Interventions: The characteristics of the physiotherapy program, which was implemented twice a day throughout the ICU stay of the patient, are presented in Table 1. Before the application, the patient was evaluated in terms of the safety criteria determined based on the proposed algorithm for ECMO patients (9).

The patient was particularly sensitive to bleeding while receiving ECMO therapy. Her cardiopulmonary clinical stability [blood pressure, heart rate, peripheral oxygen saturation, respiratory rate, BORG score (if available)] was monitored during all treatments.

All treatment modalities were performed by the same physiotherapist in all sessions. Positioning, passive range of motion exercises and neuromuscular electrical stimula-

tion (NMES) were applied twice daily throughout the period of unconsciousness (6).

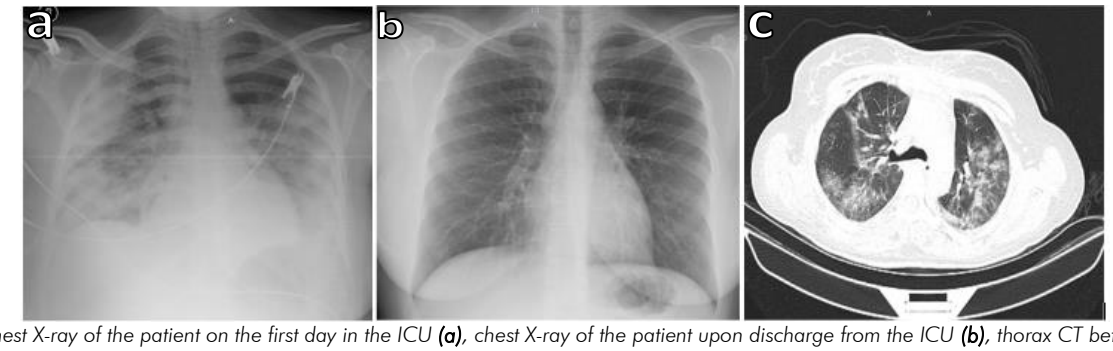

Figure 1: *Chest X-ray of the patient on the first day in the ICU* **(a)**, *chest X-ray of the patient upon discharge from the ICU* **(b)**, *thorax CT before ECMO* **(c)**

Table 1: *Physiotherapy Interventions*

	Interventions
1-11 (Sedated)	Bed position to maintain the feet in neutral dorsiflexion, hip in neutral rotation and keep her heels elevated off the bed Passive range of motion to all major upper and lower extremity joints –except hip flexion (Repetitions: 5 times / joint) Stretching of plantar flexors (20 minutes) NMES (Duration: 60 minutes, Frequency: 45 Hz.) Aspiration for airway clearance
11-16 (ECMO discontinued, sedation stopped, awake but not following commands)	Passive range of motion to all major upper and lower extremity joints (5 times / joint) Stretching of plantar flexors (20 minutes) Sitting with the bed in the chair position (Duration: Changed according to the patient tolerance) NMES (Duration: 60 minutes, Frequency: 45 Hz.) Aspiration for airway clearance
16-27 (Alert, following commands)	Active / Active asistive range of motion of all major upper and lower extremity muscle groups (Repetitions: 8-10, Intensity: BORG:11-13) Active range of motion of all major upper and lower extremity muscle groups against gravity or resistance by physiotherapist or small free weights (Repetitions: 8-10, Intensity: BORG:11-13) Sitting edge of the bed. / Sitting in weelchair / Standing and walking with assistance (Duration: Changed according to the patient tolerance) Breathing control, Diaphragmatic breathing, thoracic expansion exercises (Repetitions: 8-10, Intensity: BORG:11-13) Insentive spirometer training (Repetitions: 8-10/ 2 hour) Huffing and cough for airway clearance

The patient's active participation in the physiotherapy started on day 16, after she regained consciousness. The range of motion exercises were performed, first in an active assistive way, and then actively by the patient (10). For the mobility program, the order followed was: first in the bed, then sitting on the side of the beds, transfer to a wheelchair, standing up and walking (4,11). The patient was unable to walk without support at the time of her discharge from the ICU.

Suctioning of the invasive artificial airway, as a bronchial hygiene technique, was applied by nurses until the 17th day for the clearance of secretions (12). Cough-

ing/huffing and active breathing technique cycles were added to the program after the tracheostomy closure (1).

Table 2: *Physiotherapy Examinations and Findings at Each Phase of Care*

Examination	Days 1-11 (Sedated)	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 27 (Discharge)
Consciousness (RASS)	(-5)	(-4)	(-3)	(-3)	(-2)	(-1)	(0)	(0)	(0)
Cooperation (S5Q)	0	0	1	1	2	3	4	5	5
Muscle Strength (MRC) Hand grip (kg)	-	-	-	-	-	-	-	21/60 R:12 L:18	33/60 R:18 L:22
PFIT Score	-	-	-	-	-	-	-	1/12	5/12
Walking distance with assistance (meter)	-	-	-	-	-	-	-	-	120
Modified BORG Scores at the end of walking	-	-	-	-	-	-	-	-	Dyspnea: 2(before) 6(after) Fatique: 2(before) 8(after) *Vital signs stable

RASS:Richmond Agitation Scale, S5Q:Standardized Five Questions, MRC: Medical Research Council, PFIT: Physical Function in ICU Test (Higher score means higher physical function), R :Right extremity, L:Left extremity

Table 3: Assessment of patients at six mouths after discharge

Assessment	Results
6 Minute walk distance (meter)	560 meter (77% of predicted)
Dyspnea (MMRC)	0/4
Muscle Strength (MRC) Hand Grip (kg)	59/60 R:40 L:42
PFIT	11/12
HAD	Anxiety: 8/21 Depression: 0/21
SF-36	Physical Functioning: 95 Social Functioning: 62.5 Role Physical: 100 Role Emotional: 100 General Health: 77 Mental Health: 76 Bodily Pain: 62 Vitality: 90

PFIT: Physical Function in Intensive Care Test (Higher score means higher physical function), MRC: Medical Research Council, MMRC: Modified Medical Research Council, HAD: Hospital Anxiety and Depression Qustionnaire (Higher score means higher anxiety and depression), SF-36: Short-Form Health Survey (Higher score means higher quality of life)

Outcomes: The patient's consciousness (Richmond Agitation Sedation Scale [RASS]) (13), cooperation, neuromuscular impairments and physiotherapy activities were evaluated at each phase of care given by the same physiotherapist (Table 2). To assess the patient's ability to cooperate, five standardized actions were requested: (1- Open and close your eyes, 2-Look at me, 3- Open your mouth and put out your tongue, 4- Nod your head, 5- Raise your eyebrows on the count of five). According to the scale, a patient that is fully awake and cooperative is one that achieves a score of 5 out of 5, with each correct answer being worth 1 point (14). The Medical Research Council Scale (15) and hand grip measurement were used to assess muscle strength; and functional status was evaluated using the Physical Function in ICU Test (16). In addition to these assessments, the distance that she could walk, and the feelings of dyspnea and exhaustion at the end of the walk were noted at the time of ICU discharge.

Six months after discharge, the patient underwent a six-minute walk test (6MWT), and a Modified Medical Research Council Dyspnea Scale (MMRC) and 14-item Hospital Anxiety and Depression Scale (13,17) assessment, and completed the 36-item Short-Form General Health Survey. The results of these evaluations at six months post-discharge are presented in Table 3.

DISCUSSION

This report details the in-patient and out-patient follow-up care applied to an ARDS patient supported by the newly-implemented ECMO treatment in our ICU. Consensus reports and case series of ECMO use have witnessed a steady increase, however there has as yet been no report in literature on the clinical presentation before, and after six months in a patient based on the assessment parameters used herein. One of the leading motivations behind this study was the desire to provide data relevant to Turkey in terms of functionality to address the long-term process in ECMO patients.

The consensus report recommends that ECMO patients should be included in the physiotherapy program (5). The biggest problem with mobility among ECMO patients is the potential for femoral cannula dislocation, although Abraham et al. suggests that femoral cannula is not an absolute contraindication for mobility, and reporting that their patient had walked around 1.2 meters (18). We did not encounter any side effects in the patient during physiotherapy interventions.

Post-intensive care syndrome is defined as the physical, cognitive and mental effects on patients after being discharged from the ICU (3). Studies have shown that preventive strategies shown to have a positive impact in the prevention of the long-term functional impairments associated with this syndrome include encouraging early mobility in ICU patients (3). Within the first year following ECMO, the physical outcomes experienced by patients are greater than those that are mental in nature, with the risk of mental problems having been reported to be 2–3 times greater than the expected rate, leading to frequent hospital admissions (19). In another study, after undergoing ECMO treatment, 75% of patients were able to return to their daily life and 25% returned to work, while mobility impairment was experienced by 50% (20). There was no evidence of post-intensive care syndrome in our patient at the 6-month evaluation, which may be due to the participation of the patient in a physiotherapy rehabilitation program from the earliest stages and the consequent rapid return of physical independence, the training of the patient and their family, family support and personal motivation.

One of the limitations of the study center is that we are unable to offer our patient rehabilitation after discharge, being a hospital with a specialization in chest diseases. The patient had to be directed to an external center after discharge, as our hospital contains no rehabilitation cen-

ter for ICU survivors. Most of the patients in our country are unable to access adequate rehabilitation after an ICU stay, and so clinical researches and funding are needed for the development of rehabilitation programs for ICU survivors.

CONCLUSION

This case study report suggests that physiotherapy and early mobilization in ECMO patients are effective and have been concluded to be safe, and can reduce the effects of post-intensive care syndrome. Future studies are needed for the formal evaluation of the long-term outcomes of ECMO patients and to explore the risks factors for post-intensive care syndrome.

CONFLICTS OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

Concept - İ.N., Ö.E., C.K.; Planning and Design - İ.N., Ö.E., C.K.; Supervision - İ.N., Ö.E., C.K.; Funding - İ.N., Ö.E., C.K.; Materials - İ.N., Ö.E., C.K.; Data Collection and/or Processing - İ.N., Ö.E., C.K.; Analysis and/or Interpretation - İ.N.; Literature Review - İ.N.; Writing - İ.N.; Critical Review - İ.N., Ö.E., C.K.

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