

Review Article

Implementation of Early Mobilization Protocols for ECMO Patients in the ICU: Clinical Review and Institutional Experience from a Tertiary Care Center in Saudi Arabia

Mohammed Takroni^{1,*} , Uthman Hakami² , Nargis Mirza¹ ,
Mohammed Ibhaish³ 

¹Physical Rehabilitation Department, King Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia

²Physical Therapy Department, Al-Habib Medical Group, Riyadh, Saudi Arabia

³King Faisal Heart Institute, King Faisal Specialist Hospital & Research Center, Riyadh, Saudi Arabia

Abstract

Background: Extracorporeal Membrane Oxygenation (ECMO) represents an advanced life support technique employed in instances of severe cardiac or respiratory failure. Although ECMO significantly improves patient survival rates, extended stays in the intensive care unit (ICU) can result in complications such as ICU-acquired weakness and long-term functional disabilities. Early mobilization (EM) has emerged as a crucial intervention to mitigate these risks; however, its implementation among ECMO patients is often inconsistent, particularly within Saudi Arabia. **Aim of the Study:** This study aims to investigate the implementation of early mobilization (EM) guidelines for ECMO patients in a tertiary healthcare facility in Saudi Arabia. It seeks to identify key indications and contraindications for EM, assess barriers to its application, and develop as well as validate a standardized EM protocol for ECMO patients that can be utilized by healthcare providers across Saudi Arabia. **Methods:** Multidisciplinary approach was employed, involving clinical review assessments of patients' readiness, indication, contraindications, safety protocols, guidelines, and monitoring parameters. The study analyzed existing EM practices, guidelines and the challenges faced by healthcare providers, particularly in the context of limited staffing, awareness and resources. **Conclusion:** The findings underscore the urgent need for standardized, evidence-based guidelines to facilitate the systematic implementation of EM in ECMO settings. By addressing safety considerations and promoting interdisciplinary teamwork, knowing the indications and contraindications, the study advocates for the integration of EM as a routine practice in the management of critically ill patients receiving ECMO. This approach aims to improve recovery trajectories and reduce the adverse effects associated with prolonged immobility in ICU environments, by using a standardize EM guidelines.

Keywords

ECMO, Early Mobilization, ICU, Guidelines, Veno-Venous, Veno-Arterial

*Corresponding author: mtakroni@kfshrc.edu.sa (Mohammed Takroni)

Received: 11 August 2025; **Accepted:** 26 August 2025; **Published:** 10 October 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

1. Background

Extracorporeal membrane oxygenation (ECMO) is an advanced form of life support used in cases of severe cardiac or respiratory failure where conventional therapies are insufficient. ECMO provides prolonged cardiopulmonary support by oxygenating blood outside the body, allowing the heart and lungs to rest and recover [1]. It is increasingly employed in intensive care units (ICUs) worldwide, including in Saudi Arabia, especially during periods of high demand, such as during the COVID-19 pandemic [2]. There are two main types of ECMO: Venous-venous (VV) ECMO that is used for isolated respiratory failure. Blood is drained from a central vein, oxygenated through an artificial membrane, and returned to the venous system. It provides respiratory support without direct circulatory assistance [3]. The second type is the Venous-arterial (VA) ECMO, this mode supports both cardiac and respiratory function. In this type the blood is drawn from a vein, oxygenated, and returned to an artery, effectively bypassing both the heart and lungs [4]. VA ECMO is indicated in cases of cardiogenic shock, cardiac arrest, or severe heart failure. In Saudi Arabia, the implementation of ECMO services has grown rapidly over the past decade, supported by national health initiatives and international training programs. The Saudi ECMO program was formally integrated into various tertiary centers under the Saudi Ministry of Health, including King Faisal Specialist Hospital and Research Center (KFSH&RC) and King Abdul-Aziz Medical City [5]. Notably, Saudi Arabia played a regional leadership role in ECMO deployment during the MERS-CoV and COVID-19 outbreaks, emphasizing the importance of building ECMO capacity and training [2]. While ECMO provides life-saving support, prolonged ICU stays place patients at risk for complications such as ICU-acquired weakness, delirium, and long-term functional disability. Early mobilization (EM) defined as initiating physical activity within the first 48-72 hours of ICU admission, which has been emerged as a critical component of care to prevent these complications [6]. Mobilization efforts may include passive range of motion, active exercises, sitting, standing, and even ambulation, depending on the patient's condition and stability. Mobilizing patients on ECMO was traditionally avoided due to perceived risks, particularly the fear of cannula dislodgement or hemodynamic deterioration. However, international studies have demonstrated that with proper planning and interdisciplinary collaboration, early mobilization is feasible and safe even for ECMO patients [7, 8]. This has led to increasing global support for structured mobilization programs in ECMO centers. In Saudi Arabia, the concept of early ICU mobilization is still developing but is gaining traction. Hospitals such as King Faisal Specialist Hospital, King Saud Medical City and King Abdulaziz Medical City have begun piloting early mobilization protocols as part of quality improvement initiatives [9]. Nevertheless, the practice remains inconsistent, and challenges persist, including limited staffing (especially physiotherapists trained

in critical care), concerns about patient safety, and lack of standardized national guidelines. In addition, a recent review by Al-Shehri et al. [10], examining ICU practices in Saudi Arabia highlighted the need for increased awareness, training, and resource allocation to support early rehabilitation, especially in ECMO units. While the physical therapy (PT) profession has expanded significantly in Saudi Arabia, there is a pressing need for policies that integrate EM into routine ICU care pathways. National initiatives such as Vision-2030 which emphasize health system modernization and evidence-based care present a timely opportunity to institutionalize EM practices [11]. Since, EM is an evidence-based intervention that can significantly improve outcomes, but remains underdeveloped in the Kingdom, there is a clear need for national protocols, interdisciplinary collaboration, and training programs to promote safe and effective mobilization of critically ill patients receiving ECMO. The aim of this study was to highlight the important aspects of EM for ECMO patients in the ICU, clarify key indications and contraindications, identify common barriers and strategies to overcome them, and evaluate barriers to its application, develop and validate a standardized EM protocol for ECMO Patients that can be used by healthcare providers in Saudi Arabia.

2. Rationale and Clinical Significance of the Study

The growing use of extracorporeal membrane oxygenation (ECMO) in Saudi Arabia highlights the urgent need for standardized, evidence-based guidelines on early mobilization for critically ill patients. While ECMO is a life-saving treatment for severe cardiac and respiratory failure, traditional care practices often involve deep sedation and immobility, leading to complications like ICU-acquired weakness, delirium, and prolonged disability. With recent advancements in safer cannulation and circuit stability, international studies have shown early mobilization to be both feasible and beneficial, improving patient recovery and reducing hospital stays. Despite these positive findings, mobilization practices in ECMO remain inconsistent, especially in Saudi Arabia where ECMO services expanded rapidly during health crises like MERS-CoV and COVID-19. At present, there is limited data on the role of physiotherapy in managing ECMO patients in Saudi Arabia. Therefore, developing national guidelines would help ensure the safe and systematic implementation of early mobilization by clearly outlining patient selection criteria, safety protocols, and the responsibilities of the multidisciplinary team.

3. Safety Considerations for ECMO Patients EM in the ICU

Early mobilization of patients supported with ECMO is

increasingly recognized as a feasible and safe intervention when implemented through a multidisciplinary approach. While historically ECMO patients were heavily sedated and immobilized due to concerns over hemodynamic instability, cannula dislodgement, and oxygenation compromise, recent evidence supports the safety of EM when appropriate patient selection and safety protocols are applied [7, 8]. Safety considerations primarily revolve around maintaining ECMO circuit integrity, ensuring cardiovascular stability, and preventing adverse events such as accidental decannulation, bleeding, or oxygen desaturation [12]. Studies have demonstrated that EM including passive range of motion (PROM) exercises, sitting, standing, and even ambulation can be safely performed, particularly in patients with upper-body cannulation (e.g., jugular vein), which offers greater mobility with a lower risk of cannula displacement [13]. A recent systematic review study by Ko et al. [14] the study concluded that EM for ECMO was not associated with augmented adverse events

when conducted by trained multidisciplinary teams, including physiotherapists, ECMO specialists, and critical care staff. In addition, the guidelines from the Extracorporeal Life Support Organization (ELSO) [15] recommend individualized risk-benefit assessments, emphasizing that EM is feasible and beneficial in selected patients, improving physical function without increasing risk. In KFSH&RC, the EM implementation for all ECMO patients will be decided and confirmed by the cardiac multidisciplinary team including surgeons, intensivists, primary nurses, cardiac rehabilitation (CR) physiotherapists, respiratory team and perfusionists. Despite that EM in any ICU should follow the international agreement recommendations for exercising mechanically ventilated (MV) and ECMO patients in the ICU that has been developed by a group of ICU experts [16]. The recommendations comprise four considerations: respiratory, cardiovascular, neurological and other as supported by Boyd et al [17]. See Table 1.

Table 1. International Recommendations for Exercising ECMO Patients [17, 8].

Traffic light	Respiratory	Cardiovascular	Neurological	Other
Green	Endotracheal tube or tracheostomy	Mean arterial pressure (MAP) Within target range with low level support Cardiac devices: Ventricular assist device (VAD) Arrhythmias Stable rhythm	Level of consciousness RASS 1 to +1	Other (ICU-acquired weakness CRRT Venous and arterial femoral catheters Other drains and attachments
Low risk of an adverse event. Proceed as usual according to each ICU's protocols and protocols.	FiO ₂ < 0.6 SpO ₂ > 90% RR < 30/min Positive end-expiratory pressure (PEEP) < 10 cmH ₂ O Ventilator dysynchrony	Pulmonary hypertension Arrhythmias Unstable rhythm Shock with lactate >4 mmol/L Acute DVT/PE Severe aortic stenosis Cardiac devices	Delirium Able to follow commands	
Yellow	High-frequency oscillating ventilation (HFOV) mode	ECMO Blood pressure-on iv anti-hypertensive	Craniotomy Acute spinal cord injury SAB Vasospasm	
Potential risk and consequences of an adverse event are higher than green, but may be outweighed by the potential benefits of mobilizations. Precautions should be clarified before mobilizations. Mobilization should be gradual and cautious				
Red	Rescue therapies (NO, prostacyclin and prone positioning)	Blood pressure-on iv anti-hypertensive	Raised Intracranial Pressure	Surgical (fracture/wound

Traffic light	Respiratory	Cardiovascular	Neurological	Other
The significant potential risk of an adverse event. Active mobilization should not occur unless specifically requested by the Intensivist		Cardiac ischemia	Open lumbar drain	Medical (bleeding/ febrile/active cooling)
		Cardiac devices: Intra-aortic balloon pump (IABP)	Uncontrolled seizure	Femoral sheaths

4. Recommendations Before EM of ECMO Patients

The placement of a cannula can significantly influence patient mobilization. It is recommended that a double-lumen cannula be inserted into the internal jugular vein, as this configuration offers greater mobility compared to the use of two separate cannulas or insertion into the femoral veins. Ensuring that the cannulae are securely fastened with sutures is crucial to prevent issues such as tugging, twisting, kinking, or accidental decannulation. Adherence to pre-mobilization checklists, vigilant monitoring of vital signs, and effective team communication are imperative for maintaining patient safety [8]. The level of patient activity is assessed using the ICU Mobility Scale, a comprehensive scoring system that ranges from “0” (indicating the patient is lying in bed, with only passive rolling or exercises performed by staff) to “11” (indicating the patient is walking independently without the aid of walking devices or assistance). These measurements should be conducted daily for each ECMO patient [16] as it’s adopted by the expert cardiac rehabilitation team at KFSH&RC, see Table 2.

Table 2. Scale of Activity for ECMO patients [18].

Phases	Score	Expected Activities
Phase	0	No mobilization or passive range of motion - 4 h re-assessment Turning in bed (including passive and active range of motion)
Phase	1	Sitting in bed - elevated head of the bed Sitting on the edge of the bed, feet on the floor Sitting in a chair Standing
Phase	2	Marching in place Ambulation with assistance
Phase	3	Ambulation independently (ECMO patients will not achieve phase 3)

5. Common Medication and IVs Attached to ECMO Patients

Patients on ECMO require a complex regimen of intravenous (IV) medications and therapies to manage underlying conditions, prevent complications, and support physiological stability. One of the most essential components is *anticoagulation therapy*, typically with *unfractionated heparin*, to prevent thrombus formation in the ECMO circuit. The dosage is adjusted based on activated clotting time (ACT) or anti-Xa levels [19, 7]. In addition to anticoagulants, *vasoactive medications* are often required to maintain adequate perfusion pressure. Common agents include *norepinephrine*, *epinephrine*, *dopamine*, and *vasopressin*, depending on the patient’s hemodynamic status. These are titrated carefully, especially in veno-arterial (VA) ECMO, where both cardiac and circulatory support are required [15]. *Sedatives and analgesics*, such as *propofol*, *midazolam*, *dexmedetomidine*, and *fentanyl*, are commonly administered to ensure patient comfort, reduce oxygen consumption, and prevent accidental dislodgement of ECMO cannulas. In some cases, *neuromuscular blocking agents* (e.g., *cisatracurium*) may be used, especially in the early phase of ECMO initiation or in severe ARDS to promote ventilator synchrony [3]. Furthermore, *antibiotics and antifungal agents* are frequently administered prophylactically or therapeutically, as ECMO patients are at high risk of nosocomial infections due to prolonged invasive monitoring and mechanical support [20]. Additionally, *volume resuscitation* using *crystalloids*, *colloids*, and *blood products* is tailored to maintain optimal intravascular volume and circuit flow.

6. Contraindications Before EM of ECMO Patients

Initiating early mobilization for patients undergoing ECMO offers significant clinical advantages, such as mitigating ICU-acquired weakness and promoting physical recovery. Nonetheless, it is essential to recognize and adhere to specific contraindications and precautions before starting mobilization in this vulnerable group. Absolute contraindications encompass severe hemodynamic instability, active major bleeding, uncontrolled arrhythmias, and reliance on

high-dose vasopressors [12, 8]. Other contraindications include unsecured or unstable cannulation sites, especially with femoral access, and recent surgical procedures that increase mobilization risks [13]. At KFSHRC a precautionary measures that involve a comprehensive multidisciplinary evaluation, involving intensivists, physiotherapists, perfusionists, and nursing staff to ensure a coordinated strategy were used as recommended by Abrams et al. [7]. Important precautions include vigilant monitoring of anticoagulation to manage bleeding and thrombotic risks, regular neurological assessments to determine mobilization readiness, and ensuring sufficient respiratory support and oxygenation during physical activity were also applied as instructed by ELSO [15]. Additionally, the choice of cannulation site is crucial; patients with upper-body (jugular) cannulation are more appropriate for mobilization compared to those with femoral cannulation [13]. Consequently, establishing clear institutional guidelines that outline contraindications and precautions can facilitate safe and effective mobilization while minimizing potential risks.

7. Important Monitoring Before and During EM of ECMO Patients

Prior to initiating early mobilization in patients undergoing ECMO, a comprehensive evaluation of clinical stability is imperative to ensure patient safety and mitigate the risk of complications. Key parameters to assess include hemodynamic stability, encompassing heart rate, blood pressure, and vasopressor requirements, as well as oxygenation status and ECMO circuit integrity [12]. It is crucial to evaluate the security of the cannulation site, particularly in cases of femoral cannulations, as movement may result in dislodgement or vascular injury [13]. Furthermore, the patient's neurological status, level of sedation, and ability to follow commands should be reviewed to ascertain their capacity to safely engage in mobilization activities [6]. Optimizing ventilator and ECMO settings, including sweep gas flow, FiO₂, and flow rates, is essential to maintain adequate gas exchange during physical activity [1]. Continuous monitoring throughout mobilization is vital for the prompt detection of clinical deterioration. Vital signs, such as SpO₂, respiratory rate, heart rate, and mean arterial pressure (MAP), should be observed in real time [16]. Alterations in ECMO parameters, such as changes in flow, circuit pressures, or oxygenator performance, may indicate hemodynamic stress or cannula displacement, necessitating the immediate cessation of mobilization [7]. Physical signs of distress, including dyspnea, agitation, dizziness, and fatigue, should also inform the decision to pause or modify therapy. Close collaboration among the ICU team, physiotherapists, and perfusionists ensures prompt adjustment of interventions in response to instability. This structured and vigilant approach enhances the safety and efficacy of early mobilization efforts in ECMO-supported patients.

8. Nursing Role Prior to EM of ECMO Patients

Nurses are instrumental in preparing ECMO patients for early mobilization, commencing with a comprehensive patient assessment and evaluation of readiness. This process involves monitoring hemodynamic stability, reviewing anticoagulation status, assessing sedation levels, and evaluating neurological responsiveness. Prior to mobilization, nurses collaborate with the multidisciplinary team to ensure the securement of cannulae, appropriate management of lines, and consideration of patient-specific risk factors [16]. Nurses also engage in pre-mobilization safety huddles to confirm the availability of necessary equipment and personnel, coordinate with physiotherapists and perfusionists, and ensure the implementation of continuous monitoring tools. Ongoing surveillance facilitates the timely identification of any physiological deterioration or complications prior to mobilization [21]. At King Faisal Specialist Hospital and Research Center, nurses play a crucial role in the safe execution of activities before and during EM. They are responsible for maintaining the stability of the ECMO circuitry, particularly ensuring that the cannulae and tubing remain undisturbed during movement as suggested by Munshi et al. [3]. Nurses continuously monitor patients' vital signs, oxygen saturation, and ECMO flow parameters throughout the mobilization process. Additionally, they assist in patient positioning, administer medications as needed (e.g., for pain or sedation), and provide critical support in the event of acute physiological changes. Their hands-on involvement and situational awareness enhance the overall safety and coordination of mobilization efforts, mitigating complications and promoting positive rehabilitation outcomes [22]. This collaborative and proactive nursing role is essential for advancing early mobilization practices in ECMO-supported ICU patients.

9. Respiratory Management Before EM for ECMO Patients

A thorough respiratory assessment is imperative prior to mobilization to ensure patient safety and readiness. This assessment encompasses the review of imaging studies, such as chest X-rays or CT scans, evaluation of ventilator settings, analysis of flow-volume loops and compliance, and interpretation of arterial blood gas (ABG) results and oxygen saturation levels [23]. Clinicians should evaluate chest wall movement, auscultation findings, and secretion load to determine the necessity for airway clearance in patients with tracheostomy. The level of sedation must also be assessed, as deep sedation and limited spontaneous ventilation may lead to secretion retention and impaired respiratory mechanics [6]. This comprehensive assessment ensures that the patient's respiratory system is optimized for the demands of mobilization. Effective secretion management and positioning strate-

gies further enhance respiratory stability prior to mobilization. In cases where mucus stasis is suspected, ventilator hyperinflation to 30 cmH₂O, combined with expiratory chest wall compression in a supine, head-down position, can facilitate mucus clearance through expiratory flow bias, a process that propels mucus toward the central airways via two-phase gas-liquid flow [24]. These respiratory interventions are executed at KFSH&RC by a trained multidisciplinary team, including respiratory therapists and physiotherapists, to prevent complications during early mobilization. Ensuring that pulmonary function is stable and secretion clearance is optimized supports safe mobilization and contributes to improved outcomes in patients undergoing ECMO.

10. Key Elements of PT Assessment Prior to EM of ECMO Patients

10.1. Comprehensive Patient Evaluation

Prior to initiating early mobilization in patients undergoing ECMO, a comprehensive physical therapy assessment is imperative to ascertain the patient's readiness and ensure safety. This evaluation commences with an examination of the patient's medical history, current diagnosis, and the indication for ECMO support, either veno-venous (VV) for respiratory failure or veno-arterial (VA) for cardiac failure. These factors significantly influence the hemodynamic and respiratory stability of patients. The physical therapist should also evaluate the mode of ECMO cannulation, as femoral cannulation presents higher risks for mobilization compared to upper-body access [13]. Understanding ventilator settings, sedation levels, and vasoactive drug support is crucial, as these factors impact the patient's capacity to engage safely in movement.

10.2. Neurological and Functional Status

Assessing the patient's neurological function and level of consciousness is crucial for determining their ability to participate in physical activity and follow instructions. The Richmond Agitation-Sedation Scale (RASS), Glasgow Coma Scale (GCS), and other tools can assist in measuring the alertness and cognitive responsiveness of patients. Additionally, evaluating muscle strength, joint range of motion, and pre-ICU functional status enables therapists to devise an appropriate individualized mobilization approach. The presence of ICU-acquired weakness, which is common in prolonged immobilization, may necessitate a graded progression from passive to active mobilization [6]. Pain levels, delirium, and the ability to communicate discomfort or fatigue should also be considered to ensure a safe and patient-centered intervention.

10.3. Cardiopulmonary and Circuit Safety Considerations

Cardiopulmonary stability is a fundamental aspect of pre-mobilization assessment. Physical therapists must collaborate with the ICU team to review vital signs, ECMO circuit parameters, arterial blood gases, and trends in oxygenation and perfusion. Patients with high ECMO flow requirements or unstable blood pressure may not be immediate candidates for mobilization. Furthermore, meticulous inspection of the cannulation sites is essential to prevent dislodgement or bleeding during movement. Securement of cannulas, tubing management, and coordination with perfusionists are critical to ensuring circuit integrity in ECMO. Finally, standardized checklists and mobilization criteria, often guided by institutional protocols or ELSO recommendations, assist in determining when it is safe and appropriate to proceed with the therapy [7, 15].

11. Teamwork During EM Implementation for ECMO Patients

In KFSH&RC, the teamwork is one of the important elements of patient care, as the organization is one of the unique and well-known patients' centered hospital in the region. Thus, effective EM of patients receiving ECMO necessitates a proactive and collaborative approach by a multidisciplinary team. This team typically comprises intensivists, physiotherapists, nurses, perfusionists, and respiratory therapists. Prior to initiating any mobilization, a comprehensive patient assessment is imperative to ascertain readiness, encompassing hemodynamic stability, cannulation configuration, neurological status, and sedation levels [16]. This collective decision-making process significantly augments patient safety by ensuring all pertinent clinical variables are considered. At KFSH&RC, each discipline contributes a specialized perspective: physicians evaluate medical stability, nurses manage sedation and secure vascular access, and physiotherapists assess functional capacity. In addition, the important role of the ECMO coordinators play a pivotal role in facilitating EM plans within the ICU by ensuring adherence to protocols, coordinating the multidisciplinary team meetings and pre-mobilization huddles which is critical for promoting communication, aligning therapeutic goals, and delineating clear roles, particularly in high-risk procedures such as ECMO patient mobilization [12]. During the mobilization process, seamless coordination among team members is paramount to safely execute patient movement while preserving ECMO circuit integrity and physiological stability. Nurses and perfusionists monitor ECMO flows and cannula security, concurrently with physiotherapists and respiratory therapists guiding physical activity based on patient tolerance and ventilatory requirements [7]. This synchro-

nized, hands-on endeavor mitigates the risk of adverse events, including cannula displacement or hemodynamic compromise. Consequently, the success of EM in ECMO-supported patients is heavily contingent upon the

unity, coordination, and shared decision-making inherent within the multidisciplinary team. For suggested roles and responsibilities of the team, see [Table 3](#).

Table 3. Recommended Roles and Responsibilities of ECMO Team [7].

Inter-professional Team Member	Roles and Responsibilities
Physical Therapist (Cardiopulmonary Rehabilitation Expert)	1. Review medical notes, laboratory/imaging, pharmacological support, and ECMO cannulation strategy and circuit settings 2. Consent patient to rehabilitation or mobilization session explaining goals and intended outcomes 3. Plan and lead the rehabilitation or mobilization process, including obtaining necessary assist devices/ equipment and organizing support personnel to be present during the session 4. Follow up with interprofessional team and patient post rehabilitation or mobilization to discuss tolerance to activity and modifications to plan of care to improve tolerance for the next session
Medical Provider	1. Ensure the patient is appropriate for the planned session 2. Ensure availability of emergency medications, equipment, and personnel 3. Review ECMO settings and circuit with ECMO specialist 4. Optimize cardiorespiratory support
ECMO Specialist/ Perfusionists	1. Inspect ECMO circuit 2. Document cannula insertion depth 3. Ensure cannula securement 4. Document circuit settings and pressures 5. Obtain portable oxygen in sufficient quantity (if moving out-of-the ICU) 6. Ensure the battery capacity of the device (if moving out of the ICU) 7. Ensure 4 clamps are immediately available
Registered Nurse	1. Ensure comfortable and cooperative patient 2. Review and monitor vital signs 3. Check infusions and lines/tubing
Respiratory Therapist	1. Check portable ventilator settings/circuit 2. Prepare suction (oral, subglottic, endotracheal) 3. Ensure tracheostomy or, endotracheal tube securement 4. Ensure adequate oxygen supply and connections

ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit.

12. Physical Therapy Management and Rehabilitation Program for ECMO Patients

A comprehensive physical therapy exercise program for patients receiving ECMO in the ICU must be individualized, progressive, and safety-focused. The program typically be-

gins with passive and active range-of-motion exercises to prevent joint stiffness and muscle atrophy, especially in deeply sedated or immobilized patients. As the patient condition stabilized, bedside sitting, in-bed cycling, and neuromuscular electrical stimulation (NMES) may be introduced to maintain muscle tone and prevent ICU-acquired weakness [8, 25]. Positioning strategies, such as head-up or lateral turning, can assist with secretion clearance and respiratory function, especially for patients on veno-venous ECMO. Close moni-

toring of hemodynamics, ECMO cannula integrity, and respiratory status is essential during all phases of therapy [26]. Once patient condition improved, become more alert, cooperative and physically stable, progression to active mobilization may include sitting at the edge of bed, standing and ambulation with full multidisciplinary support. These activities aim to improve cardiovascular endurance, pulmonary function, and functional independence, and must be coordinated with the medical team, nursing, respiratory therapy, and perfusion teams [27, 7]. Use of assistive devices, such as

mobile ECMO units, walking aids if needed in addition to safety harnesses, allows safe ambulation even while on circuit support. Implementation of standardized EM protocols tailored to ECMO patients has been associated with reduced ICU length of stay and improved long-term physical function [13]. Regular reassessment ensures patient safety and effective progression through the program. At the Heart Center of KFSH&RC, staged rehabilitation protocol is applied as supported by ELSO guidelines [15], as displayed in Table 4.

Table 4. Staged PT Management Protocol of EM for ECMO Patients [7].

Stages	Patient Descriptions	Activity	Equipment	Progress	Regress
0 Passive bed activity level	a) Patient not fully awake not following commands. b) Patient unable to left UL/LE against gravity and unable to assist in movement on bed	a) Bed level AAROM/PROM b) Rolling c) Limb positioning d) Extremity edema control e) Long sitting f) Dependent transfer to seated surface (overhead lift/lateral slide) g) Passive Standing on tilt bed/table	a) Cardiac Chain b) Airway clearing device c) Positioning slings d) Mechanical lifts e) Standing Bed/Tilt	PROGRESS TO STAGE 1 IF: a) Patient Tolerates Stage 0 Activity (Bed mobility and Passive Sitting/Standing) b) Demonstrates initiation of motor tasks c) Follows safety commands	REASSESS STAGE 0 IN 24 HOURS IF: Patient does not tolerate Stage 0 Patient intolerant of any stimulation
		a) Sitting edge of bed/Dangling b) Supine or Sitting UE/LE exercise c) Sitting balance activities d) Mechanics of breathing e) Postural Re-education f) Dependent transfer to seated stationary bike surface or (overhead lift lateral slide)	a) Cardiac Chair b) Thera-band/Free-weights c) Incentive spirometer d) Airway clearing devices e) Leg Press Table f) Positioning slings g) Mechanical lifts	PROGRESS TO STAGE 2 IF: a) Patient Tolerates Stage 1 Activity (Active Sitting) b) Able to sit unsupported >10 second	REASSESS STAGE 1 IN 24 HOURS/REGRESS TO STAGE 0 IF: Patient does NOT tolerate Stage 1 Activity
2 Active static standing	a) Patient responds to voice or physical stimulation b) Follows basic motor and safety commands	a) Tilt Table/Standing bed b) Bedside Chair c) Thera-band/Free Weights d) Incentive spirometer e) Able to stand f) Airway clearing devices g) Standing Assist Devices	a) Tilt Table/Standing bed b) Bedside Chair c) Thera-band/Free-weights d) Incentive spirometer. e) Airway clearing device f) Standing Assist Devices	PROGRESS TO STAGE 3 IF: a) Patient Tolerates Stage 2 Activity (Static Standing) b) Able to stand with/without assist vice >10 sec	REASSESS STAGE 2 IN 24 HOURS/REGRESS TO STAGE 1 IF: Patient does NOT tolerate Stage 2 Activity
3 Active Dynamic	a) Patient awake and alert.	a) Transfer training	a) Tilt Table/Standing bed	PROGRESS TO	REASSESS STAGE 3 IN 24

Stages	Patient Descriptions	Activity	Equipment	Progress	Regress
Standing	b) Follows all commands consistently	b) Pre-gait activities c) Standing (dynamic) balance activities d) Weight shift and marching e) Standing UE/LE exercise at EOB or using tilt table/Standing bed f) Transfer from bed to chair g) Mechanics of breathing h) Postural Re-education i) Standing Assist Devices.	b) Bedside Chair c) Thera-band/Free-weights d) Incentive spirometer. e) Airway clearing device f) Standing Assist Devices	STAGE 4 IF: a) Patient Tolerates Stage 3 Activity (Dynamic Standing) b) Able to complete pre-gait activities with/without assist vice >30 seconds	HOURS/REGRESS TO STAGE 2 IF: Patient does NOT tolerate Stage 3 Activity
4 Active Ambulation	Same as above	a) Gait Training b) Stand Dynamic balance Activity. c) Standing UE/LE exercises d) Standing on Tilt-table or on bed with progression to gait training.	a) Tilt Table/Standing bed b) Bedside Chair c) Thera-band/Free-weights d) Standing Assist Devices	INCREASE JIME/DISTANCE OF AMBULATION AND DECREASE ASSIST IF: Patient Tolerates Stage 4 Activity (Gait)	REASSESS STAGE 4 IN 24 HOURS/REGRESS TO STAGE 3 IF: Patient does NOT tolerate Stage 4 Activity

13. Institutional Constraints and Significant Barriers to Successful EM

Physiotherapists and respiratory therapists often face limited staffing resources, particularly in intensive care units, where the high acuity of patients necessitates intensive monitoring and intervention [6]. The safe mobilization of a patient on ECMO requires a coordinated multidisciplinary team, including nursing staff, perfusionists, and ICU physicians, making it a time- and labor-intensive process [25]. In numerous healthcare settings, especially in regions where ECMO utilization is still evolving, such as certain areas of Saudi Arabia, there may be a scarcity of therapists with specialized training in critical care or ECMO-specific mobilization practices [16]. Inadequate equipment, a lack of mobility aids tailored for ECMO patients, and insufficient institutional support further exacerbate these challenges [7]. Addressing these barriers necessitates comprehensive staff training, the establishment of dedicated protocols, and robust interdisciplinary collaboration to integrate safe mobilization practices into routine ECMO care [22].

14. Conclusion

The implementation of EM guidelines for patients on ECMO in the intensive care unit is crucial for improving patient outcomes and reducing the risks associated with extended immobility. This study illustrates that structured EM practices, facilitated by interdisciplinary collaboration, can be safely incorporated into the care regimen of critically ill patients on ECMO. Despite existing challenges such as staffing constraints and inconsistent protocols, the findings highlight the necessity of developing standardized guidelines to ensure safe mobilization. By prioritizing training and resource allocation, healthcare facilities can better equip their teams to implement EM effectively. Ultimately, fostering a culture of EM will not only enhance recovery routes but also significantly decrease the incidence of complications such as ICU-acquired weakness and long-term functional disabilities. Ongoing research and quality improvement initiatives are essential to refine these practices and ensure their widespread adoption across ECMO centers in Saudi Arabia and beyond.

15. Limitation of the Study

- 1) This study primarily examines EM practices in the context of ECMO programs at specific tertiary care centers in Saudi Arabia. Consequently, the results may not be applicable to other regions or institutions that have different levels of resources, staffing capabilities, ECMO experience, or organizational culture.
- 2) Although, the study offers a solid framework for implementing EM and emphasizes institutional practices, if the primary empirical data regarding patient outcomes, such as post-discharge functional status, ICU stay duration, or complication rates would validate outcomes.

16. Future Suggested Studies

- 1) A Multicenter Prospective Study on the Impact of Early Mobilization on ECMO Patient Outcomes in Saudi Arabia. This study would involve multiple tertiary care centers across the Kingdom to evaluate the clinical outcomes of ECMO patients who undergo early mobilization versus those who receive standard care.
- 2) A prospective, longitudinal study could be designed to monitor the outcomes of ECMO patients including the length of stay in the ICU, the duration of ECMO support, the occurrence of ICU-acquired weakness, hospital mortality rates, and functional status after discharge. incidence of ICU-acquired weakness, hospital mortality, and post-discharge functional status. This would provide strong empirical evidence to support national guideline development.

Abbreviations

ABG	Arterial Blood Gas
ACT	Activated Clotting Time
CRRT	Continuous Renal Replacement Therapy.
CR	Cardiac Rehabilitation
DVT	Deep Vein Thrombosis
ECMO	Extracorporeal Membrane Oxygenation
EM	Early Mobilization
ELSO	Extracorporeal Life Support Organization
GCS	Glasgow Coma Scale
HFOV	High-Frequency Oscillating Ventilation
ICU	Intensive Care Unit
IABP	Intra-Aortic Balloon Pump
IV	Intravenous
KFSH&RC	King Faisal Specialist Hospital & Research Center
LE	Lower Extremity
MAP	Mean Arterial Pressure
MV	Mechanically Ventilated
NMES	Neuromuscular Electrical Stimulation

PEEP	Positive End-Expiratory Pressure
PE	Pulmonary Embolism
PT	Physical Therapy
RASS	Richmond Agitation-Sedation Scale
UE	Upper Extremity
VV	Veno-Venous
VA	Veno-Arterial
VAD	Ventricular Assist Device

Author Contributions

Mohammed Takroni: Formal Analysis, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing

Uthman Hakami: Formal Analysis, Investigation,, Resources, Writing – review & editing

Nargis Mirza: Conceptualization, Investigation, Resources, Writing – review & editing

Mohammed Ibhai: Resources, Supervision, Validation, Visualization, Writing – review & editing

Conflicts of Interest

The authors have no potential conflicts of interest to disclose for this study.

References

- [1] Combes, A., Hajage, D., Capellier, G., Demoule, A., Lavoué S., Guervilly, C.,... & Luyt, C. E. (2018). Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. *New England Journal of Medicine*, 378(21), 1965-1975. <https://doi.org/10.1056/NEJMoa1800385>
- [2] Alshahrani, M. S., Faqihi, F., Balhamar, A., et al. (2021). Extracorporeal membrane oxygenation (ECMO) support for COVID-19 patients: A multi-center, prospective, observational study from Saudi Arabia. *Frontiers in Medicine*, 8, 727861. <https://doi.org/10.3389/fmed.2021.727861>
- [3] Munshi, L., Walkey, A., Goligher, E., et al. (2019). Veno-venous extracorporeal membrane oxygenation for acute respiratory distress syndrome: A systematic review and meta-analysis. *The Lancet Respiratory Medicine*, 7(2), 163-172. [https://doi.org/10.1016/S2213-2600\(18\)30452-1](https://doi.org/10.1016/S2213-2600(18)30452-1)
- [4] Bartlett, R. H., Ogino, M. T., Brodie, D., et al. (2020). Initial ELSO guidance document: ECMO for COVID-19 patients with severe cardiopulmonary failure. *ASAIO Journal*, 66(5), 472-474. <https://doi.org/10.1097/MAT.0000000000001173>
- [5] Alshahrani, M. S., Alghamdi, M. H., Alshehri, A. A., et al. (2016). ECMO support for Middle East respiratory syndrome coronavirus (MERS-CoV) patients in Saudi Arabia. *Intensive Care Medicine*, 42(4), 617-626. <https://doi.org/10.1007/s00134-015-4169-9>

- [6] Needham, D. M., Korupolu, R., Zanni, J. M., et al. (2010). Early physical medicine and rehabilitation for patients with acute respiratory failure: A quality improvement project. *Archives of Physical Medicine and Rehabilitation*, 91(4), 536-542. <https://doi.org/10.1016/j.apmr.2010.01.002>
- [7] Abrams, D., Javidfar, J., Farrand, E., Mongero, L., Agerstrand, C., Ryan, P.,... & Bacchetta, M. (2014). Early mobilization of patients receiving extracorporeal membrane oxygenation: A retrospective cohort study. *Critical Care*, 18(1), R38. <https://doi.org/10.1186/cc13746>
- [8] Hodgson, C. L., Burrell, A. J., Engeler, D. M., et al. (2017). Early mobilization during extracorporeal membrane oxygenation was safe and feasible: A pilot randomized controlled trial. *Critical Care*, 21(1), 66. <https://doi.org/10.1186/s13054-017-1659-0>
- [9] Al-Dorzi, H. M., Tamim, H. M., Al-Harbi, S. A., et al. (2016). Implementation of an intensive care unit clinical pharmacy service in a tertiary care center in Saudi Arabia. *Annals of Saudi Medicine*, 36(5), 379-385. <https://doi.org/10.5144/0256-4947.2016.379>
- [10] Al-Shehri, A., Al Harbi, M. M., Almutairi, M., et al. (2022). Early mobilization practices in intensive care units in Saudi Arabia: A national cross-sectional survey. *Saudi Journal of Physical Therapy*, 2(1), 23-30.
- [11] Saudi Vision 2030. (2016). *Kingdom of Saudi Arabia*. <https://www.vision2030.gov.sa>
- [12] Patel, B. K., et al. (2022). Mobilization of ECMO patients: Current evidence and safety considerations. *Intensive Care Medicine*, 48(1), 22-35. <https://doi.org/10.1007/s00134-021-06514-8>
- [13] Hou, X., et al. (2020). Safety and benefits of early mobilization in patients on venovenous ECMO. *Journal of Critical Care*, 55, 128-134. <https://doi.org/10.1016/j.jcrc.2019.11.016>
- [14] Ko, D., et al. (2022). Safety and feasibility of early mobilization during ECMO: A systematic review. *Critical Care Medicine*, 50(7), e620-e629. <https://doi.org/10.1097/CCM.0000000000005478>
- [15] Extracorporeal Life Support Organization (ELSO). (2021). *ELSO guidelines for adult respiratory failure*. <https://www.elseo.org>
- [16] Hodgson, C., Needham, D., Haines, K., Bailey, M., Ward, A., Harrold, M., & Berney, S. (2014). Feasibility and inter-rater reliability of the ICU Mobility Scale. *Heart & Lung*, 43(1), 19-24. <https://doi.org/10.1016/j.hrtlng.2013.11.003>
- [17] Boyd, J., Paratz, J., Tronstad, O., Caruana, L., McCormack, P., & Walsh, J. (2018). When is it safe to exercise mechanically ventilated patients in the intensive care unit? An evaluation of consensus recommendations in a cardiothoracic setting. *Heart & Lung*, 47(1), 22-28. <https://doi.org/10.1016/j.hrtlng.2017.11.003>
- [18] Rickelmann, C., & Knoblauch, D. J. (2018). Incorporating safe patient-handling techniques to mobilize our most complex patients on extracorporeal membrane oxygenation. *Critical Care Nurse Quarterly*, 41(3), 285-295. <https://doi.org/10.1097/CNQ.0000000000000214>
- [19] Peek, G. J., Mugford, M., Tiruvoipati, R., Wilson, A., Allen, E., Thalanany, M. M., & CESAR Trial Collaboration. (2009). Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): A multicentre RCT. *The Lancet*, 374(9698), 1351-1363. [https://doi.org/10.1016/S0140-6736\(09\)61069-2](https://doi.org/10.1016/S0140-6736(09)61069-2)
- [20] Pappalardo, F., Pieri, M., & Greco, T. (2011). Predicting mortality risk in patients receiving extracorporeal membrane oxygenation: A scoring system from a multicenter cohort. *Critical Care Medicine*, 39(5), 1021-1027. <https://doi.org/10.1097/CCM.0b013e31820a61c3>
- [21] Streiner, D. L., Hance, A., & Bakhru, R. N. (2021). The role of nurses in early mobilization in the ICU: A practical guide. *Critical Care Nursing Clinics of North America*, 33(3), 367-378. <https://doi.org/10.1016/j.cnc.2021.04.003>
- [22] Schweickert, W. D., & Hall, J. (2007). ICU-acquired weakness. *Chest*, 131(5), 1541-1549. <https://doi.org/10.1378/chest.06-2065>
- [23] Eden, A., Iwashyna, T. J., & Wunsch, H. (2017). Recovery and outcomes after the acute respiratory distress syndrome (ARDS) in patients and their families. *Intensive Care Medicine*, 43(9), 1236-1247. <https://doi.org/10.1007/s00134-017-4820-8>
- [24] Cork, G., Greensmith, A. L., & Hazell, W. (2013). Physiotherapy techniques to enhance airway clearance in critically ill mechanically ventilated patients: A narrative review. *Physiotherapy Theory and Practice*, 29(1), 15-25. <https://doi.org/10.3109/09593985.2012.700390>
- [25] Tipping, C. J., et al. (2017). The effects of active mobilization and rehabilitation in ICU on mortality and function: A systematic review. *Intensive Care Medicine*, 43(2), 171-183. <https://doi.org/10.1007/s00134-016-4612-0>
- [26] Bartolo, M., et al. (2021). Physical therapy and rehabilitation in ECMO patients: A practical approach. *Journal of Intensive Care Medicine*, 36(4), 415-424. <https://doi.org/10.1177/0885066619897586>
- [27] Wells, C. L., et al. (2021). Early physical therapy in patients requiring ECMO support: A clinical perspective. *Physical Therapy*, 101(5), pzab009. <https://doi.org/10.1093/ptj/pzab009>