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**REVIEW**

# Rationale and recommendations for occupational therapy and physiotherapy in positioning adults with acute respiratory failure connected to extracorporeal membrane oxygenation. A narrative review

# Fundamentos y recomendaciones para la terapia ocupacional y la fisioterapia en el posicionamiento de adultos con insuficiencia respiratoria aguda conectados a oxigenación por membrana extracorpórea. Una revisión narrativa

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## ABSTRACT

Extracorporeal membrane oxygenation (ECMO) is a life support system that facilitates gas exchange in patients experiencing catastrophic respiratory failure. ECMO connection can last from a few days to several weeks, resulting in muscle atrophy, pathological changes in the lengths of both active and passive joint stabilising structures, and alterations in the alignment of body segments. These dysfunctions may be exacerbated if patients do not maintain proper positioning, which can delay rehabilitation. Therapeutic positioning (TP) is a fundamental tool in caring for patients hospitalised in the intensive care unit. Adequate TP application helps prevent immobility complications, promotes body alignment, and enhances the patient's functionality during recovery. From a biomechanical perspective, TP supports preserving essential musculoskeletal functions such as strength, joint mobility, and endurance, facilitating patient participation in meaningful activities. Its implementation should be based on biomechanical principles, personalised adaptations, and continuous monitoring to ensure effectiveness in rehabilitation. This review examines the rationale for TP in adults with acute respiratory failure on ECMO from occupational and physical therapy perspectives. Additionally, recommendations are provided to improve the application of this intervention, particularly in the increasingly common context of prone positioning in patients with ECMO.

**Keywords:** Extracorporeal Membrane Oxygenation; Occupational Therapy; Physical Therapy Specialty; Critical Care; Respiratory Insufficiency; Respiratory Distress Syndrome.

## RESUMEN

La oxigenación por membrana extracorpórea (ECMO) es un sistema de soporte vital que facilita el intercambio gaseoso en pacientes que sufren insuficiencia respiratoria catastrófica. La conexión a ECMO puede durar desde unos pocos días hasta varias semanas, lo que provoca atrofia muscular, cambios patológicos en las longitudes de las estructuras estabilizadoras articulares tanto activas como pasivas, y alteraciones en la alineación de los segmentos corporales. Estas disfunciones pueden agravarse si los pacientes no mantienen un posicionamiento adecuado, lo que puede retrasar la rehabilitación. El posicionamiento terapéutico (PT) es una herramienta fundamental en el cuidado de los pacientes hospitalizados en la unidad de cuidados intensivos. La aplicación adecuada del PT ayuda a prevenir las complicaciones de la inmovilidad, favorece la alineación corporal y mejora la funcionalidad del paciente durante la recuperación. Desde una perspectiva biomecánica, la PT ayuda a preservar funciones musculoesqueléticas esenciales como la fuerza, la movilidad articular y la resistencia, facilitando la participación del paciente en actividades significativas. Su aplicación debe basarse en principios biomecánicos, adaptaciones personalizadas y un seguimiento continuo para garantizar la eficacia de la rehabilitación. Esta revisión examina los fundamentos de la PT en adultos con insuficiencia respiratoria aguda en ECMO desde las perspectivas de la terapia ocupacional y la fisioterapia. Además, se ofrecen recomendaciones para mejorar la aplicación de esta intervención, en particular en el contexto cada vez más frecuente del uso de la posición prona en pacientes con ECMO.

**Palabras clave:** Oxigenación por Membrana Extracorpórea; Terapia Ocupacional; Especialidad de Fisioterapia; Cuidados Críticos; Insuficiencia Respiratoria; Síndrome de Dificultad Respiratoria.

## INTRODUCTION

Individuals experiencing acute respiratory failure (ARF) may need varying levels of support based on the severity of their clinical condition. In mild to moderate acute respiratory distress syndrome (ARDS), employing a high-flow nasal cannula or non-invasive or invasive mechanical ventilation (MV) may suffice.[1,2] Nonetheless, in severe cases of hypoxaemia that do not respond to optimal ventilatory management and prone positioning, more advanced strategies such as extracorporeal membrane oxygenation (ECMO) may be required.[3,4]

The results of ECMO use in adults with catastrophic ARF are inconsistent. Survival rates vary between studies, reaching as high as 63 %.[5] However, critical care frequently encounters substantial sequelae associated with hospitalisation, which can endure for several months following discharge.[6,7,8] Individuals exhibit alterations in various bodily functions that limit their engagement in basic and instrumental activities. Deterioration of mental health and the occurrence of post-traumatic stress disorder are frequently reported among adults who have been critically ill.[6,8,9] However, the alterations in neuromusculoskeletal and movement-related functions are the most extensively studied.[7,8,10] While the certainty regarding the effectiveness of physical rehabilitation interventions tends to be moderate to low, primarily due to the nature of these interventions, it is during the acute phase of hospitalisation for critically ill adults on ECMO that efforts to prevent physical sequelae in these patients should commence.

Depending on the country, context, and legislation, various allied health professionals physically rehabilitate patients hospitalised in critical care units (ICUs). Occupational therapists (OTs) and physiotherapists (PTs) are vital to the physical rehabilitation of these patients and are increasingly essential in ECMO. Based on the stage and stability of the illness and the level of patient cooperation, OTs and PTs implement a range of interventions. Occupational therapists focus on the individual's occupation (occupational performance),[11] while PTs concentrate on human movement and function,[12] aiming to prevent and restore the decline in people's physical capabilities.

In the early stages of ECMO supportive therapy for ARF, it is common to aim for lung rest and to unload the respiratory muscles.[13,14] This involves administering analgesic and sedative medications, as well as neuromuscular blockers,[15,16] to shift the gas exchange function to ECMO while interventions are undertaken to facilitate the recovery process. This stage can last from a few days to several weeks, leading to muscle wasting, pathological changes in the lengths of both active and passive joint stabilising structures, and alterations in the alignment of body segments. These dysfunctions can be exacerbated if patients do not maintain proper positioning, which may delay rehabilitation.

This review examines the fundamentals of therapeutic positioning (TP) in adults with acute respiratory failure on ECMO from occupational therapy and physiotherapy perspectives. Additionally, recommendations are offered to enhance the implementation of this intervention, particularly in the increasingly common context of prone positioning for ECMO patients.

### Extracorporeal Membrane Oxygenation (ECMO)

Extracorporeal membrane oxygenation is a life support system that facilitates blood oxygenation and carbon dioxide elimination in patients experiencing catastrophic cardiac or respiratory failure. This therapy is employed in critical circumstances where other interventions have proven ineffective, such as severe pneumonia, ARDS, or cardiogenic shock. Consequently, it is regarded as a rescue therapeutic strategy.

The fundamental principle of ECMO operation involves the passage of blood through an oxygenator to facilitate adequate gas exchange and total or partial replacement of pulmonary function. To achieve this goal, the ECMO circuit comprises various devices and accessories: 1) Extraction and blood return cannulas, which, depending on the ECMO configuration and patient context, will have different insertion sites; 2) Lines or pipes that connect the cannulas with the rest of the circuit; 3) The oxygenator or oxygenating membrane, where gas exchange occurs; 4) The blender or mixer, where the oxygen blends with medical air; 5) The console, where adjustments to ECMO therapy are made, such as revolutions, and various parameters are monitored, including blood flow; 6) The pump, which serves as the motor for extracting blood from the body and returning it through the return cannula to the patient; and 7) The heat exchanger module, which maintains an appropriate blood temperature (figure 1A).

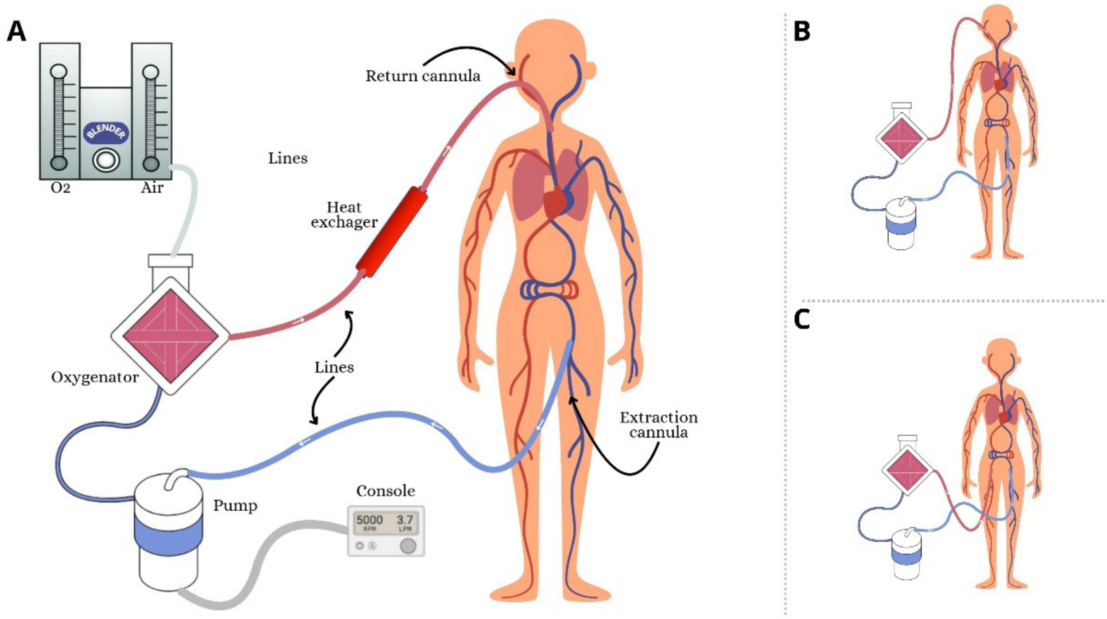


**Figure 1.** ECMO structure and configuration, A: ECMO structure and components; B: Venovenous ECMO with femorojugular cannulation; C: Venovenous ECMO with femorofemoral cannulation

There are two main configurations of ECMO depending on the type of support provided: venovenous (VV) ECMO and venoarterial (VA) ECMO. The latter configuration is used for patients experiencing severe heart failure or cardiogenic shock; therefore, when possible, central cannulation is always preferable. In contrast, VV ECMO is indicated for patients with catastrophic respiratory failure. In this instance, cannulation is achieved through venous access, which can be via the femoral vein, internal jugular vein, or subclavian vein, depending on the patient's anatomy and the urgency of the procedure (figure 1B and 1C). While there is no definitive contraindication to passive or active hip flexion, femoral cannulation typically leads to a higher incidence of neuromusculoskeletal complications.

*Neuromusculoskeletal and movement-related complications*

Patients who survive critical illness requiring ECMO often exhibit considerable muscle weakness and resultant mass loss, known as ICU-acquired weakness (ICU-AW).[17,18] This syndrome typically develops within the first ten days of ICU stay.[19,20]

ECMO patients may experience various motor or sensory impairments. These can be sensorimotor or exclusively motor or sensory. Overall, 23 % of patients who underwent femoral ECMO cannulation experienced neurologic complications in the lower extremity on the same side as the cannulation. Peripheral ischaemia and nerve compression caused by the ECMO cannula are discussed as mechanisms of injury.[21] The femoral nerve is the most reported site of injury. These complications may arise from compression caused by the large ECMO cannulas.[22] Additionally, seroma and haematoma formation related to ECMO cannula access in the groin is frequent, and lumbosacral plexopathies resulting from haematomas following femoral cannulation have been previously documented.[23] Weakness in the foot flexors, particularly in the extensors, has also been reported to a lesser degree.[24]

Implementing preventive measures is essential, as neuromusculoskeletal and movement-related disturbances in ECMO patients may linger for several weeks or months. The selection of the cannulation site and application of an appropriate surgery technique should be complemented by safe mobilisation and therapeutic positioning interventions to support the integrity of movement-related structures.[25,26]

**Therapeutic Positioning in the Individual Connected to ECMO**

Therapeutic positioning refers to the deliberate positioning of an individual to enhance comfort, support recovery, or accomplish specific therapeutic objectives.[27] It is a crucial tool in healthcare, as it guarantees medical procedures' safety, comfort, and efficacy while preventing injuries and optimising clinical outcomes. The objectives of TP are: 1) to maintain body alignment, thus promoting optimal functioning of bodily systems and organs; 2) to protect bodily structures, thereby helping to prevent muscle contractures, postural dysfunctions, or pressure injuries; and 3) to facilitate rest and comfort, which improves the patient's well-being and mood during the recovery process.

*Role of TP in the biomechanical model from the perspective of the International Classification of Functioning, Disability and Health (ICF)*

The biomechanical model is a conceptual approach used in rehabilitating individuals who experience movement limitations due to restricted mobility, decreased strength, or lack of endurance. It is grounded in the principles of kinetics and kinematics, which examine the nature of movement and the forces acting on the human body. It also integrates knowledge of the anatomy and physiology of the musculoskeletal and cardiorespiratory systems, providing an interdisciplinary foundation for its application. Its interventions primarily focus on recovering and compensating lost functions, aiming to optimise mobility and enhance the individual's functionality in daily activities.[28] This model underscores the significance of muscle strength, joint mobility, and endurance for effectively executing movements. The biomechanical model in occupational therapy focuses on the physical aspects of the occupation, addressing the physical capabilities and limitations that affect participation in daily activities.

The ICF categorises patient characteristics into three key areas: Body Functions, Body Structures, and Activities and Participation.[29] These classifications describe a patient's functional status and emphasise how body functions and structures enable the performance of activities and participation in daily life. Among the body functions most affected in ECMO patients are neuromusculoskeletal and movement-related functions. Within these, joint and bone functions and muscle and movement-related functions relate directly to the biomechanical model. During critical illness and while connected to ECMO, there is a decrease in range of motion, a loss of muscle strength and endurance, and alterations in the anatomical integrity of nerve structures, tendons, ligaments, and joints. In this context, therapeutic positioning plays a vital role in preventing complications associated with immobility by promoting proper body alignment. Effective therapeutic positioning ensures these structures maintain integrity, minimising the risk of contractures, pressure injuries, or functional damage. Thus, it is established as a vital strategy to preserve physical functionality and guarantee the patient's return to meaningful occupations and activities.

*Recommendations for proper TP*

Proper patient positioning in the ICU is fundamental to preventing complications, optimising respiratory function, and fostering recovery. Table 1 outlines the most used positions in the ICU, highlighting their benefits and applications by each patient's clinical needs. It is important to note that many patients admitted to the ICU are sedated or have reduced mobility, which increases the likelihood of oedema, contractures, injuries, or pressure injuries. Therefore, for every segment, the correct angle and support ensure the protection of anatomical structures and promote adequate circulation.

**Table 1.** Recommendations for proper TP

| **Positions** | | | |
|---|---|---|---|
| **Position** | **Description** | **Justification** | **Cognitive benefits** |
| Semi-Fowler | 30 to 45° of tilt for the bed's back elevation | It facilitates breathing, diminishes the risk of aspiration, and enhances blood circulation in the upper and lower extremities. It promotes an ergonomic posture that reduces pressure on the spine | Enables the patient to be more alert, more aware of their surroundings, and to interact better with others environment |
| Lateral | The patient lies on their side with their knees slightly bent | It promotes proper spinal alignment, reduces the risk of pressure ulcers at contact points, and facilitates access to medical care. It also enhances peripheral circulation | |
| Seated | The patient is seated in a chair with the backrest at 90° | It encourages active mobility, builds trunk muscles, and enhances posture | It facilitates the performance of daily activities and promotes patient independence while also increasing wakefulness alertness |

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| Body segments | | | |
|---|---|---|---|
| Segment | Description | Justification | Additions or adaptations |
| Head and Neck | It should be maintained in a neutral position (0° of flexion or rotation). It is advisable to use a pillow under the neck to support the cervical region spine | Maintaining proper alignment of the neck prevents contractures and alleviates pressure on the occipital bone, which is susceptible to pressure ulcers in immobilised patients | Use a lateralising wedge to avoid inadequate postures (whether due to invasive ventilation, stroke, or other factors) if necessary. Additionally, adaptations can be made (such as a collar or padding) for the various tubes connected to the patient to promote a correct posture and prevent discomfort |
| Spine | Semi-Fowler position. Elevating the head of the bed by 30 to 45° helps alleviate pressure on the lumbar and sacral spine, distributing the body's weight more evenly body | This position aids in breathing and enhances circulation, thereby diminishing the risk of pressure injuries in the sacral and lumbar region | Lateral decubitus support: Lateral cushions and wedges positioned on either side of the trunk, promoting proper alignment of the structure |
| Upper extremities | Shoulders should be slightly abducted (20 to 30°). The elbows should be slightly flexed (15°), while the wrists should stay neutral. For the hands and fingers, if necessary, use orthoses to prevent finger deformities and contractures | Correctly positioning the upper extremities prevents contractures in the shoulders, elbows, and wrists while also reducing the risk of oedema in the hands | Anti-oedema wedges, upper extremity abductor cushion, shoulder adaptor, and orthoses |
| Lower extremities | The knees should be slightly flexed (5 to 10°). The hips should be abducted somewhat and positioned neutrally regarding internal or external rotation. The feet should be kept in dorsiflexion (90°) | Keeping the lower extremities in these positions aids in preventing the formation of contractures and improves circulation, thereby lowering the risk of oedema and pressure injuries in the heels and ankles | Anti-equinus stops: They maintain the foot in dorsiflexion (90°), which helps prevent clubfoot and Achilles tendon contractures. These can be either soft or rigid, depending on the level of support required. Wedges or pillows should be placed under the knees. An abductor cushion for the lower extremities |

*Recommendations for proper TP in a prone position*

The prone position is a therapeutic strategy predominantly employed in patients with acute respiratory distress syndrome (ARDS), as it provides numerous physiological advantages (figure 2). By positioning the patient this way, the lungs are liberated, which significantly enhances ventilation and oxygenation, aids in secretion clearance, and optimises pulmonary blood flow.[30] Due to these benefits, the prone position has also been utilised in ECMO patients.[31,32] Furthermore, a lengthened duration of prone positioning has been linked to improved clinical outcomes; however, this poses a significant challenge when implementing adequate physiotherapy.[33,34,35]

**Figure 2.** ECMO patient in a prone position
**Note:** ECMO patient in the intensive care unit at the Instituto Nacional del Tórax, Santiago, Chile. The patient's legal guardian granted permission to use the image

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Careful technique is required to achieve a safe and effective PT during prone positioning. It is recommended that the patient's face orient towards the elevated upper extremity at a 30° angle while the lower extremity on the same side is kept in slight hip flexion. The opposite upper extremity should remain aligned alongside the body. Additionally, to enhance tolerance to this position, particularly in individuals with obesity, it is recommended to position the patient in a 30° inverted Trendelenburg tilt. Special attention must be given to the support areas, and preventive measures against pressure injuries should be implemented following established institutional protocols. In cases where the patient cannot tolerate the prone position, the lateral decubitus position may be adopted initially, and rotations can be performed based on individual tolerance and clinical needs.

To ensure patient safety, it is essential to prevent and actively monitor the occurrence of pressure injuries at the support points. Continuous monitoring should also be maintained, adjusting the position of the electrodes if necessary. Furthermore, it is vital to closely monitor the patient's procedure tolerance, detecting any early signs of clinical distress deterioration.

Despite its many benefits, the prone position is not without risk. Due to its unusual nature, it can result in structural complications. For instance, the brachial plexus may suffer damage from prolonged compression. When held in a dorsiflexed position, the foot tends to move into the equinus, potentially leading to the shortening of the associated soft tissues. Similarly, the shoulder of the upper extremity in extension is at risk of dislocation, particularly during the patient's mobilisation. For this reason, careful manoeuvring and constant monitoring are essential to minimise these risks.

### Impact of TP on the Rehabilitation of the ECMO Patient

The proper positioning of a person significantly impacts the alignment of various body segments, which, in turn, influences several components outlined by the ICF.[29] One of the main implications of TP is the body's structures, particularly those of the nervous system responsible for transmitting and processing information and those involved in movement, which support and enable the body's mobility.[29] Proper body alignment helps prevent nerve compressions, awkward positions, and structural injuries. According to the ICF, the most relevant structures in this context include:

- Structures of the head and neck related to movement.
- Structures of the scapular region.
- Structures related to the movement of the upper and lower limbs.
- Structures related to the trunk.
- Muscle and associated movement structures.

On the other hand, proper positioning influences neuromusculoskeletal and movement-related functions, including the control and execution of bodily movements. Correct positioning promotes joint stability, regulates muscle tone, and optimises motor control, all essential for a person's mobility and functionality. However, the impact of PT is not limited to physical aspects; it also affects mental functions as well as sensory and pain-related functions. Proper positioning can enhance the patient's emotional well-being, lowering levels of anxiety and depression associated with prolonged immobility. A comfortable patient in a functional posture feels greater control, encouraging a positive attitude towards recovery and greater participation in therapeutic activities.

## CONCLUSIONS

Therapeutic positioning is a fundamental tool in caring for patients hospitalised in the ICU. Its proper application helps prevent complications associated with immobility, promotes body alignment, and enhances the patient's functionality during recovery. From the biomechanical model, TP supports preserving essential musculoskeletal functions such as strength, joint mobility, and endurance, facilitating patient participation in meaningful activities. Its practice should be grounded in biomechanical principles, personalised adaptations, and continuous monitoring to ensure its effectiveness in rehabilitation. Positioning strategies in various postures, especially prone position, should be employed with specific criteria to optimise circulation, ventilation, and the integrity of body structures. In the case of ECMO patients presenting specific challenges, careful TP planning is key to minimising the risk of injury and promoting functional recovery.

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