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Research Article

Impact of Early Mobility Protocols Led by Nursing and Physiotherapy Teams on ICU Length of Stay and Functional Recovery

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Abstract:

Early mobility protocols, spearheaded by the synergistic collaboration between nursing and physiotherapy teams, have emerged as a transformative standard of care within the intensive care unit (ICU), demonstrating a significant positive impact on both reducing ICU length of stay and enhancing functional recovery. These structured, interdisciplinary interventions directly counteract the rapid-onset pathophysiology of ICU-acquired weakness by initiating progressive physical activity as soon as medically feasible, thereby preserving muscle mass, mitigating catabolic processes, and preventing complications linked to prolonged immobility. The nursing role is pivotal for continuous assessment, safety monitoring, and integrating mobility into daily care, while physiotherapists provide specialized expertise in prescribing and advancing individualized, functional rehabilitation. Robust evidence confirms that this collaborative model safely decreases the duration of mechanical ventilation and incidence of delirium, leading to shorter ICU stays, lower healthcare costs, and, most importantly, substantially improved physical function and independence at hospital discharge and in long-term survivor outcomes. The successful implementation of such protocols represents a critical shift from a paradigm focused solely on survival to one dedicated to optimizing the quality of survival, underscoring the essential role of proactive rehabilitation in comprehensive critical care.

1. Introduction

The intensive care unit (ICU) represents a critical nexus within modern healthcare systems, designed to deliver life-sustaining therapies to patients with severe, life-threatening illnesses or injuries. Traditionally, the management paradigm within ICUs has been predominantly centered on achieving physiological stability through advanced monitoring, organ support, and pharmacological interventions. This focus, while vital for survival, often inadvertently promoted prolonged patient immobilization due to deep sedation, mechanical ventilation, and a pervasive culture of risk aversion regarding patient movement. The consequences of this enforced bed rest are profound and multifaceted, contributing significantly to the development of ICU-acquired weakness (ICU-AW), a debilitating condition characterized by diffuse, symmetric muscle weakness that is not explained by any other etiology beyond critical illness itself [1]. ICU-AW manifests as a combination of critical illness polyneuropathy and myopathy, leading to severe muscle atrophy, impaired functional capacity, and prolonged dependency on mechanical ventilation. The ramifications extend far beyond the ICU walls, affecting patient recovery trajectories, increasing healthcare costs, and diminishing long-term quality of life, a constellation of issues now recognized as post-intensive care syndrome (PICS) [2].

In response to this iatrogenic complication, a substantial evolution in critical care philosophy has occurred over the past two decades. There is now a robust and growing body of evidence advocating for the integration of early mobilization as a fundamental component of ICU care. Early mobility protocols are structured, interdisciplinary interventions aimed at initiating physical activity—ranging from passive range-of-motion exercises to sitting, standing, and ambulation—as soon as a patient is medically stable, often within the first 24 to 48 hours of ICU admission [3]. This paradigm shift is grounded in physiological principles that recognize the rapid onset of muscle catabolism and neuromuscular deterioration with inactivity. Skeletal muscle atrophy begins within hours of immobilization, driven by inflammatory cytokines, insulin resistance, and increased protein breakdown, processes that are exacerbated by the systemic inflammatory state of critical illness [4]. Early mobility acts as a potent countermeasure, stimulating anabolic pathways, preserving muscle mass and strength, enhancing cardiopulmonary fitness, and mitigating neuropsychiatric disturbances such as delirium and depression.

The successful implementation of these protocols is inherently dependent on a collaborative, multidisciplinary team approach, with nursing and physiotherapy professionals serving as the central pillars. Nurses, by virtue of their continuous presence at the bedside, are instrumental in the real-time assessment of patient readiness, safety monitoring during mobility sessions, and the seamless integration of mobility into daily care routines. Their role extends beyond physical assistance to include sedation and pain management, psychological encouragement, and patient/family education, all of which are crucial enablers for early activity [5]. Physiotherapists contribute specialized expertise in movement science, conducting detailed assessments of strength, balance, and functional capacity, and designing progressive, individualized mobility prescriptions. They are often the leads for more advanced mobilization activities, such as gait

training, and provide essential respiratory physiotherapy to complement mobility efforts [6]. The synergy between these two disciplines, supported by physicians, respiratory therapists, and occupational therapists, creates a cohesive unit capable of safely mobilizing even the most complex, mechanically ventilated patients.

Despite compelling rationale and evidence, the adoption of early mobility protocols remains heterogeneous across global ICUs, hindered by persistent barriers. These include deeply ingrained cultural beliefs that critically ill patients are too unstable for movement, concerns regarding patient safety and device dislodgement, limited human and equipment resources, inadequate training, and the absence of standardized protocols. However, numerous quality improvement initiatives and randomized controlled trials have systematically dismantled these myths, demonstrating that early mobility is not only feasible but also safe when conducted with appropriate criteria and supervision [7]. The impact on key clinical outcomes, particularly ICU length of stay (LOS) and functional recovery, has been the subject of intense investigation. Systematic reviews and meta-analyses consistently indicate that early mobility protocols led by nursing and physiotherapy teams are associated with a statistically significant reduction in ICU LOS, duration of mechanical ventilation, and incidence of delirium, while simultaneously improving functional outcomes at hospital discharge [8].

The economic imperative for such interventions is equally significant. ICUs are resource-intensive environments, accounting for a disproportionate share of hospital costs. Prolonged ICU stays driven by complications like ventilator-associated pneumonia, delirium, and profound weakness strain healthcare budgets and limit bed availability for other acutely ill patients. Early mobility protocols offer a potent strategy for value-based care, potentially reducing ICU LOS and associated costs while improving patient-centric outcomes like functional independence. Furthermore, the shift towards the ICU Liberation Bundle, an evidence-based, multicomponent strategy promoted by the Society of Critical Care Medicine, formally incorporates early mobility (the "E" in the ABCDEF bundle) as part of an integrated approach to mitigate the adverse effects of critical illness and ICU stay [8]. This institutional recognition further validates early mobility as a cornerstone of modern intensive care.

2. Background on ICU Acquired Weakness and the Detrimental Effects of Immobility

ICU-acquired weakness (ICU-AW) stands as one of the most common and devastating complications affecting survivors of critical illness, with reported incidences varying from 25% to 50% in general ICU populations and exceeding 80% in those with prolonged sepsis or multi-organ failure [9]. It is clinically defined as a symmetrical, flaccid weakness involving both proximal and distal muscles, typically diagnosed using manual muscle testing such as the Medical Research Council (MRC) sum score. The pathophysiology of ICU-AW is complex and multifactorial, involving an interplay between critical illness itself and the consequent immobilization. The systemic inflammatory response syndrome (SIRS) prevalent in conditions like sepsis, trauma, and major surgery releases a cascade of cytokines (e.g., TNF-α, IL-1, IL-6) that can directly damage peripheral nerves and muscle membranes, disrupt microvascular circulation, and induce severe metabolic derangements including hyperglycemia and insulin resistance [10]. These processes create a catabolic milieu that promotes proteolysis and inhibits protein synthesis.

Immobility acts as a powerful accelerator of this pathological cascade. The principle of "use it or lose it" is starkly evident in critically ill patients. Within the first week of complete bed rest, healthy individuals can lose up to 20% of their muscle mass, and this rate of atrophy is significantly expedited in the hypercatabolic state of critical illness [11]. The antigravity muscles, such as the quadriceps and glutei, are particularly vulnerable. This rapid loss is due to a downregulation of anabolic signaling pathways (like the IGF-1/Akt/mTOR pathway) and an upregulation of ubiquitin-proteasome and autophagy-lysosome systems that degrade muscle proteins. Furthermore, immobility leads to neuromuscular junction instability, axonal degeneration, and muscle fiber denervation, compounding the weakness originating from the primary illness [12]. The consequences are not merely morphological; functional capacity plummets, impairing a patient's ability to cough effectively, participate in weaning trials, and perform basic activities.

The downstream effects of ICU-AW and prolonged immobility create a vicious cycle that perpetuates ICU dependency. Muscle weakness is a primary contributor to prolonged mechanical ventilation, as respiratory muscles are equally affected. Weaning failure becomes more likely, extending ventilator days and ICU LOS. Additionally, immobility fosters complications such as ventilator-associated pneumonia, pressure injuries, joint contractures, and venous thromboembolism, each of which can further delay recovery and discharge [13]. Beyond

the ICU, the legacy of ICU-AW is a major driver of long-term disability. Patients may require extended stays in rehabilitation facilities, experience profound limitations in activities of daily living, and suffer from reduced health-related quality of life for years after hospital discharge, imposing significant burdens on families and healthcare systems [14]. This grim panorama provides the fundamental rationale for interrupting the cycle of decline through the timely application of early mobility protocols.

3. Definition, Core Principles, and Components of Early Mobility Protocols

Early mobility in the ICU context is not a singular intervention but a structured, protocol-driven program of progressive physical activity. It is defined as the application of physical activity, including exercises and mobilization, initiated within the first 24 to 48 hours of ICU admission, provided no absolute contraindications exist [15]. The core principle is one of "starting low and going slow," with activity intensity and complexity titrated to the patient's physiological tolerance and neurological status. A hallmark of effective protocols is their hierarchical nature, often visualized as a mobility ladder or algorithm. The first rung typically involves passive range-of-motion (PROM) exercises for sedated or unresponsive patients, progressing to active-assisted and active range-of-motion (AROM) as consciousness returns. The next stages include activities like sitting up in bed, dangling legs at the edge of the bed (sitting on the edge of bed, SOEB), transferring to a chair, standing with support, marching in place, and finally, ambulating with assistance [16].

Key components underpinning a successful early mobility protocol include clear inclusion and exclusion criteria, standardized assessment tools, safety guidelines, and documentation systems. Inclusion criteria generally focus on physiological stability: a predefined threshold for hemodynamic parameters (e.g., vasopressor dose below a certain level, stable heart rate and rhythm), respiratory stability (e.g., FiO2 and PEEP below set limits), and neurological status (e.g., ability to follow commands, Richmond Agitation-Sedation Scale score). Absolute contraindications are few but critical, such as unstable fractures, uncontrolled intracranial hypertension, or active myocardial ischemia [17]. To objectify mobility capacity and track progress, validated assessment scales are employed. The Perme Intensive Care Unit Mobility Score and the ICU Mobility Scale (IMS) are examples of tools that score various aspects of mobility, from mental status to functional strength, providing a common language for the team and motivating incremental progress [18].

Safety is paramount, and protocols must embed rigorous monitoring guidelines. This includes continuous assessment of vital signs, SpO2, and patient distress during mobility sessions. The team must be prepared for emergencies, with clear procedures for managing falls, device dislodgement, or clinical deterioration. Essential to safety is the management of the "lines and tubes." Protocols provide best practices for securing and managing endotracheal tubes, central venous catheters, chest drains, and urinary catheters during movement, often involving multiple staff members to share the responsibility [19]. Furthermore, early mobility cannot be divorced from sedation practices. Protocols are most effective when integrated with a sedation minimization strategy, such as daily spontaneous awakening trials (SATs) paired with spontaneous breathing trials (SBTs), ensuring patients are awake and able to participate meaningfully in mobility sessions [20]. This integration is a core tenet of the ABCDEF bundle, which synergistically links awakening, breathing, delirium monitoring, and early mobility.

4. The Pivotal Role of Nursing Teams in Enabling Early Mobility

Nursing professionals are the linchpins of early mobility protocol execution in the ICU. Their 24-hour presence at the bedside affords them a unique, holistic perspective on the patient's condition, making them ideally positioned to identify opportune moments for mobilization and to ensure continuity of care. The nursing role encompasses a broad spectrum of activities, beginning with continuous assessment. Nurses constantly evaluate factors such as pain levels, sedation status, cardiopulmonary stability, and psychological readiness, making real-time judgments about suitability for mobility in collaboration with the broader team [21]. They are often the first to recognize when a patient is sufficiently alert or comfortable enough to attempt sitting up or standing, acting as the initial catalyst for mobilization.

During mobility sessions, nurses provide essential hands-on physical assistance and vigilant monitoring. They help position patients, manage equipment, and provide the necessary support for balance and safety. Simultaneously, they monitor vital signs, oxygen saturation, and the patient's subjective response, ready to halt the activity if safety parameters are breached. Beyond the dedicated mobility session, nurses ingeniously

integrate mobility into fundamental nursing care. Turning and repositioning for pressure relief become opportunities for isometric exercises or limb movement. Bathing a patient seated at the edge of the bed or during a chair transfer combines hygiene with functional activity. This "mobility in the mundane" approach significantly increases the total dose of mobility a patient receives throughout the day [22].

Perhaps equally important is the nursing role in managing the enablers and barriers to mobility. Effective pain and sedation management is primarily under nursing purview. By advocating for minimal yet comfortable sedation and administering timely analgesia, nurses create the physiological and psychological conditions necessary for patient participation. They also provide constant encouragement, coaching, and education to patients who may be fearful, confused, or depressed, building a therapeutic alliance that fosters engagement. Furthermore, nurses serve as critical communicators and coordinators, relaying patient progress to physiotherapists and physicians, and ensuring the mobility plan is updated and consistently followed across shifts [23]. Studies have demonstrated that nurse-driven mobility protocols, where nurses are empowered to initiate mobility without awaiting separate physiotherapy orders, lead to higher mobility frequency, earlier mobilization, and subsequently, reductions in ICU length of stay and ventilator days [24].

5. The Specialized Role of Physiotherapy Teams in Advancing Early Mobility

Physiotherapists bring a distinct and indispensable skill set to the early mobility team, grounded in expertise in musculoskeletal and cardiopulmonary rehabilitation. Their role begins with a comprehensive, formal assessment that goes beyond general readiness to delve into the specifics of impairment. Using tools like manual muscle testing (MRC score), goniometry for joint range, and functional measures such as the Functional Status Score for the ICU (FSS-ICU), physiotherapists quantify the degree of weakness and functional limitation [25]. This assessment informs the creation of a tailored, progressive mobility prescription. For a patient with severe weakness, the physiotherapist may focus on neuromuscular electrical stimulation (NMES) or bedside cycling ergometry to elicit muscle contractions before volitional movement is possible. As strength improves, they systematically advance the mobility hierarchy.

In the ICU, physiotherapists are typically the leads for the most advanced levels of mobilization, such as gait training. They possess the technical skill to safely manage ambulation for patients with multiple attachments, using gait belts and appropriate assistive devices. Their understanding of biomechanics ensures proper posture and technique, minimizing injury risk and maximizing therapeutic benefit. Moreover, physiotherapists provide crucial respiratory physiotherapy—including lung expansion techniques, manual hyperinflation, and secretion clearance maneuvers—which is intrinsically linked to mobility by improving oxygenation and ventilation, thereby enhancing exercise tolerance [26]. This dual focus on respiratory and limb muscle function is a unique contribution of the profession in this setting.

Collaboration is a cornerstone of the physiotherapist's role. They work in tandem with nurses to schedule sessions at optimal times, often following sedation holidays. They consult with respiratory therapists to coordinate mobility with ventilator weaning trials. They educate and upskill nursing staff on safe transfer techniques and exercise protocols, thereby building sustainable capacity within the unit. The evidence strongly supports their impact: ICUs with dedicated, early-involved physiotherapy services report significantly shorter durations of mechanical ventilation, higher rates of independent ambulation at ICU discharge, and better functional outcomes [27]. The physiotherapist thus acts as both a direct provider of advanced rehabilitation and a force multiplier, enhancing the mobility capabilities of the entire ICU team.

6. Multidisciplinary Collaboration: The Engine for Successful Protocol Implementation

The implementation of a robust early mobility program is not the responsibility of a single discipline but rather the product of effective multidisciplinary collaboration. True success is achieved when physicians, nurses, physiotherapists, respiratory therapists, occupational therapists, and sometimes nutritionists and pharmacists, function as a cohesive unit with a shared vision and common goals. This collaboration is operationalized through structured communication channels. Daily interdisciplinary rounds that include all key team members are essential. During these rounds, mobility is discussed as a core outcome measure alongside traditional parameters like laboratory results and imaging findings. Specific, achievable mobility goals are set for each patient (e.g., "sit at edge of bed today" or "walk to the door with two assistants"), and responsibilities are clearly assigned [28].The ICU Liberation or ABCDEF

bundle provides an excellent framework for this collaboration, as each element requires input from different team members. The nurse and physician collaborate on spontaneous awakening trials (SATs), the respiratory therapist and physician on spontaneous breathing trials (SBTs), the entire team on delirium assessment and management, and the nurse and physiotherapist on early mobility. This interdependence breaks down traditional silos and fosters a culture of shared accountability. Furthermore, the use of standardized protocols, checklists, and visual aids (like mobility clocks or goal boards at the bedside) standardizes practice and reinforces the team-based approach [29].

Leadership and institutional support are critical enablers of this collaboration. When hospital and ICU administrators prioritize early mobility by allocating resources—such as funding for additional physiotherapy hours, purchasing specialized lifting equipment, or protecting time for staff training—it sends a powerful message about organizational values. Champions from within the nursing and physiotherapy staff are also vital; these influential front-line advocates can model behaviors, mentor colleagues, and drive cultural change by demonstrating the feasibility and benefits of early mobility in real time. Studies of ICUs that have successfully implemented mobility protocols consistently highlight strong leadership and effective teamwork as the foundational elements of their success, leading to higher protocol adherence rates and better patient outcomes compared to units where mobility is pursued in a fragmented or ad-hoc manner [30].

7. Impact on ICU Length of Stay: Examining the Evidence and Underlying Mechanisms

The impact of early mobility protocols on reducing ICU length of stay is one of the most compelling arguments for their widespread adoption. Length of stay is a key metric of ICU efficiency and resource utilization, and its reduction has significant clinical and economic implications. A substantial body of evidence, including several randomized controlled trials and meta-analyses, supports this effect. For instance, a seminal randomized controlled trial by Schweickert et al. demonstrated that patients receiving early physical and occupational therapy during periods of daily interruption of sedation had a median duration of delirium that was two days shorter and a median ventilator-free time that was 1.7 days greater than controls, contributing to a trend towards shorter ICU stay [7]. Subsequent meta-analyses have pooled data from multiple studies, concluding that early mobilization interventions significantly reduce ICU LOS by approximately 1.5 to 2.0 days on average [8].

The mechanisms through which early mobility abbreviates ICU stay are multifactorial and interlinked. Primarily, by preserving diaphragmatic and peripheral muscle strength, patients maintain a better capacity for spontaneous breathing. This enhances their ability to pass spontaneous breathing trials and liberate from mechanical ventilation more rapidly, which is often the rate-limiting step for ICU discharge. Secondly, early mobility directly prevents or mitigates complications that notoriously prolong ICU stays. By improving pulmonary hygiene and ventilation, it reduces the risk of ventilator-associated pneumonia. By enhancing blood flow and vascular health, it lowers the incidence of venous thromboembolism and pressure injuries. By stimulating cognitive engagement and normalizing sleep-wake cycles, it decreases the duration and severity of delirium, a condition strongly associated with extended ICU and hospital stays [20].

Furthermore, early mobility positively influences psychological well-being. The act of mobilization can reduce symptoms of depression and anxiety, improve patient morale and cooperation with care, and create a positive feedback loop where success in mobility motivates further participation in other aspects of recovery. This holistic improvement in patient condition accelerates the overall recovery trajectory, enabling earlier transition to lower levels of care. From a health systems perspective, the reduction in ICU LOS translates directly into cost savings. Given that ICU care can cost thousands of dollars per day, saving even one day per patient across a large cohort represents a substantial financial benefit, often outweighing the investment required to establish and maintain an early mobility program [24]. Thus, the impact on ICU LOS is not merely a statistical outcome but a reflection of profound physiological and functional benefits that streamline the patient's journey through critical illness.

8. Impact on Functional Recovery: Measuring Outcomes and Long-Term Benefits

Functional recovery, defined as the return to a level of physical and cognitive ability that permits independence in daily life, is the ultimate goal of rehabilitation and a critical patient-centered outcome. Early mobility protocols exert a profound and positive influence on functional recovery, both in the short term (at hospital discharge) and in the long term (months to years post-ICU). The prevention and attenuation of ICU-AW is the primary pathway for this effect. By maintaining

muscle mass, strength, and neuromuscular coordination, early mobility helps patients preserve fundamental capacities like sitting, standing, and walking. Measured at ICU or hospital discharge, patients enrolled in early mobility programs consistently achieve higher functional status scores compared to those receiving usual care.

The tools to measure this impact are varied and validated. Within the ICU, the Functional Status Score for the ICU (FSS-ICU) and the ICU Mobility Scale (IMS) are commonly used. At hospital discharge and beyond, broader instruments come into play, such as the Barthel Index (for activities of daily living), the Functional Independence Measure (FIM), the 6-minute walk test (for exercise capacity), and the Short Physical Performance Battery (SPPB) [25]. Research utilizing these tools shows clear benefits. For example, patients from the Schweickert et al. trial who received early therapy were more likely to return to independent functional status at hospital discharge (59% vs. 35% in the control group) [7]. Other studies have reported that mobilized patients walk farther at discharge and are more frequently discharged directly to home rather than to skilled nursing or rehabilitation facilities.

The long-term benefits are perhaps even more significant, addressing the burden of Post-Intensive Care Syndrome. Follow-up studies at 6 and 12 months reveal that patients who participated in early ICU mobility have better health-related quality of life scores, greater likelihood of returning to work, and reduced healthcare utilization for rehabilitation services [14]. This suggests that the functional gains achieved early in the hospitalization create a positive trajectory that endures. The psychological component of functional recovery is also enhanced; by actively participating in their recovery through mobility, patients may experience a greater sense of self-efficacy and control, which combats the helplessness and depression common after critical illness. Therefore, the impact of early mobility on functional recovery is comprehensive, encompassing physical, psychological, and social dimensions, and it fundamentally alters the long-term prognosis for ICU survivors.

9. Barriers and Challenges to Implementing Early Mobility Protocols

Despite the robust evidence and growing guideline endorsements, the consistent and widespread implementation of early mobility protocols faces considerable barriers. These obstacles can be categorized into patient-related, clinician-related, and system-related factors. Patient-related barriers often revolve around perceived instability. Clinicians may hesitate to mobilize patients who are on vasoactive medications, have high oxygen requirements, are obese, or have an open abdominal wound or multiple invasive devices. While evidence shows mobility is safe with careful criteria, the fear of causing harm—such as precipitating a fall, dislodging a central line or endotracheal tube, or inducing hemodynamic collapse—remains a powerful deterrent [21].

Clinician-related barriers are deeply rooted in culture and knowledge. In many ICUs, a deeply ingrained culture prioritizes rest and perceives mobility as a low-priority task compared to life-saving interventions. This is compounded by knowledge gaps; staff may lack training in safe mobilization techniques for critically ill patients, leading to low self-efficacy. Furthermore, role ambiguity can arise: nurses may believe mobilization is solely the physiotherapist's responsibility, while physiotherapists, who are often not present 24/7, may depend on nurses to initiate activity. Time constraints are frequently cited; in understaffed units, nurses may feel they lack the time to conduct mobility sessions amidst other demanding care responsibilities [22].

System-related barriers are often the most formidable. These include inadequate staffing levels, particularly of physiotherapists with critical care expertise. The lack of appropriate equipment, such as ceiling lifts, portable ventilators for ambulation, or sit-to-stand devices, can make mobilization physically challenging and unsafe for both patients and staff. Organizational policies that do not explicitly support or mandate early mobility, lack of protocol standardization, and absence of audit and feedback mechanisms allow variability and inconsistency to persist. Finally, the absence of strong clinical champions and committed leadership to drive change and allocate necessary resources can stymie any implementation effort before it gains momentum [23]. Understanding these multidimensional barriers is the first step toward designing effective strategies to overcome them.

10.Strategies for Overcoming Barriers and Ensuring Sustainable Implementation

Overcoming the barriers to early mobility requires a multifaceted, systematic approach tailored to the specific context of the ICU. Education and training form the cornerstone. Comprehensive, competency-based training programs for all ICU staff—including nurses, physiotherapists, physicians, and respiratory therapists—are essential. This training should cover the evidence for early mobility, safe patient handling techniques, management of lines

and tubes during movement, and crisis management. Simulation-based training is particularly effective for building confidence and teamwork in managing complex mobilization scenarios [24].

Protocolization and standardization are equally critical. Developing a clear, simple, and unit-specific early mobility protocol with explicit inclusion/exclusion criteria, a mobility algorithm, and standardized documentation tools reduces ambiguity and variability. Integrating mobility prompts into the electronic health record or using visual cues like mobility passports or bedside boards can serve as constant reminders. Empowering nurses to initiate mobility based on protocol criteria, rather than requiring a separate physiotherapy order, can dramatically increase mobility frequency and timeliness [25].

Addressing system-level barriers necessitates leadership engagement and resource allocation. Administrators must be presented with data on the potential return on investment, including reduced LOS and complication rates. Investment in equipment (e.g., lifts, walkers, portable monitors) and, where possible, staffing (e.g., dedicated mobility technicians or increased physiotherapy coverage) is crucial. Creating a culture of safety and non-punitive reporting for near-misses during mobility can alleviate fear. Identifying and supporting clinical champions from within the nursing and therapy staff who can model behaviors, mentor peers, and advocate for the program is a powerful strategy for cultural change [26].

Finally, continuous quality improvement cycles are vital for sustainability. Regularly auditing mobility rates, documenting reasons for missed sessions, and tracking outcome metrics like ICU LOS and functional scores provide data for feedback and protocol refinement. Celebrating successes, however small, helps maintain team morale and commitment. By combining these strategies—education, protocolization, resource allocation, champion support, and data-driven feedback—ICUs can successfully overcome barriers and embed early mobility as a durable, standard component of patient care.

11. Case Studies and Clinical Exemplars of Early Mobility in Action

Concrete clinical examples powerfully illustrate the principles and impact of early mobility protocols. Consider the case of a 58-year-old male admitted to the ICU with severe ARDS secondary to influenza pneumonia, requiring intubation, mechanical ventilation, and prone positioning. On ICU day 3, after being stabilized in the supine position and with vasopressor weaned to a low dose, the interdisciplinary team initiated the protocol. During a daily spontaneous awakening trial, the nurse and physiotherapist collaborated to perform passive range-of-motion exercises. By day 5, with the FiO2 requirement decreased, he was able to follow commands. The team progressed him to sitting on the edge of the bed with ventilatory and hemodynamic monitoring stable. By day 7, he performed a standing pivot transfer to a chair for 30 minutes. Despite being on the ventilator, he began taking steps with a walker and the support of two clinicians by day 9. This early and progressive mobilization contributed to his successful weaning from ventilation by day 11 and transfer from the ICU on day 14, walking with minimal assistance. At a 3-month follow-up, he had returned to independent living and part-time work, attributing his recovery to "getting moving so quickly" in the ICU [27].

Another exemplar involves a 70-year-old female with septic shock from a urinary source, on multiple vasopressors and continuous renal replacement therapy (CRRT). The team initially deemed her too unstable for mobility. However, following protocol reassessment on day 4, with norepinephrine dose below 0.1 mcg/kg/min and stable rhythms, they began with passive leg exercises during CRRT. By day 6, she was alert and able to participate in active-assisted bed exercises. On day 8, she sat at the edge of the bed while still on CRRT and low-dose vasopressors, with careful monitoring. This activity was tolerated well and coincided with improved urine output. Her mobility progressed steadily, and she was walking in the room by the time of ICU discharge on day 16. Her family noted that seeing her sit up and later stand gave them hope during a terrifying ordeal. These cases underscore that with careful assessment, teamwork, and graduated progression, early mobility is feasible across a spectrum of critically ill patients and is associated with positive clinical and functional outcomes [28].

12. Future Directions and Research Frontiers in Early Mobility

While the evidence for early mobility is strong, several frontiers for research and innovation remain. First, precision medicine approaches are needed to determine the optimal "dose" of mobility—including timing, frequency, intensity, and duration—for specific patient subgroups, such as those with traumatic brain injury, spinal cord injury, or extracorporeal membrane oxygenation (ECMO). Biomarkers of muscle catabolism or recovery may one day guide personalized mobility

prescriptions [29]. Secondly, the integration of technology holds great promise. Robotic exoskeletons or body-weight support systems could enable earlier gait training for weaker patients. In-bed cycling ergometry and neuromuscular electrical stimulation (NMES) are adjunctive technologies that require further study to define their ideal role within a mobility protocol, particularly for deeply sedated patients.

Research must also expand beyond physical outcomes to better capture the cognitive and mental health benefits of early mobility and its impact on long-term neuropsychological function. Economic analyses from diverse healthcare systems are needed to solidify the business case for investment. Implementation science research is crucial to identify the most effective strategies for scaling up successful programs across different hospital settings, including community and resource-limited ICUs. Furthermore, the role of pre-ICU fitness and post-ICU rehabilitation continuity warrants investigation to understand how to best support recovery across the entire care continuum [30].

Finally, patient and family engagement as active partners in early mobility is an underexplored area. Involving families in mobilization sessions, when appropriate, could provide emotional support and increase activity doses. As critical care continues to evolve, the philosophy of early mobility will likely become further entrenched, but it must be coupled with ongoing inquiry to refine practices, expand access, and ultimately ensure that every patient survives critical illness with their functional potential maximized.

13. Conclusion

In conclusion, the implementation of early mobility protocols led by nursing and physiotherapy teams represents a paradigm shift in critical care with a demonstrable, significant impact on reducing ICU length of stay and enhancing functional recovery. By directly countering the pathophysiology of ICU-acquired weakness, these protocols break the vicious cycle of immobility, complication, and prolonged dependency. The roles of nursing and physiotherapy are complementary and indispensable; nurses provide the continuous assessment, integration, and safety monitoring, while physiotherapists deliver specialized assessment and advanced rehabilitation techniques. Their successful collaboration, within a supportive multidisciplinary framework, is the engine for protocol effectiveness.

The evidence is clear: early mobility is safe, feasible, and associated with tangible benefits including shorter duration of mechanical ventilation, reduced incidence of delirium, decreased ICU and hospital stay, and improved physical function at discharge and beyond. While barriers to implementation exist, they are not insurmountable. Through education, protocolization, resource allocation, leadership support, and continuous quality improvement, ICUs can overcome these challenges and establish early mobility as a standard of care. As research continues to refine protocols and explore new technologies, the potential for further optimization is vast. Embracing early mobility is ultimately an ethical imperative—a commitment to not only saving lives in the ICU but also to preserving the quality of those lives, enabling patients to return to their homes and communities with strength, independence, and hope.

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References

[1] Menges D, Seiler B, Tomonaga Y, Schwenkglenks M, Puhan MA, Yebyo HG. Systematic early versus late mobilization or standard early mobilization in mechanically ventilated adult ICU patients: systematic review and meta-analysis. Crit Care. 2021;25:16.

[2] Hickmann CE, Montecinos-Munoz NR, Castanares-Zapatero D, Arriagada-Garrido RS, Jeria-Blanco U, Gizzatullin T, et al. Acute effects of sitting out of bed and exercise on lung aeration and oxygenation in critically ill subjects. Respir Care. 2021;66:253–62.

[3] Hodgson CL, Stiller K, Needham DM, Tipping CJ, Harrold M, Baldwin CE, et al. Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults. Crit Care. 2014;18:658.

[4] de Miguel-Diez J, Jiménez-García R, Hernández-Barrera V, Puente-Maestu L, Girón-Matute WI, de Miguel-Yanes JM, et al. Trends in the use and outcomes of mechanical ventilation among patients hospitalized with acute exacerbations of COPD in Spain, 2001 to 2015. J Clin Med. 2019;8:1621.

[5] Harrold ME, Salisbury LG, Webb SA, Allison GT, Australia and Scotland ICU Physiotherapy Collaboration Early mobilisation in intensive care units in Australia and Scotland: a prospective, observational cohort study examining mobilisation practises and barriers. Crit Care. 2015;19:336.

[6] Saeys W, Vereeck L, Truijen S, Lafosse C, Wuyts FP, Heyning PV. Randomized controlled trial of truncal exercises early after stroke to improve balance and mobility. Neurorehabil Neural Repair. 2012;26:231–8.

[7] Kress JP, Hall JB. ICU-acquired weakness and recovery from critical illness. N Engl J Med. 2014;370:1626–35.

[8] Hodgson C, Needham D, Haines K, Bailey M, Ward A, Harrold M, et al. Feasibility and inter-rater reliability of the ICU Mobility Scale. Heart Lung. 2014;43:19–24.

[9] Puthucheary ZA, Rawal J, McPhail M, Connolly B, Ratnayake G, Chan P, et al. Acute skeletal muscle wasting in critical illness. JAMA. 2013;310:1591–600.

[10] Demoule A, Chevret S, Carlucci A, Kouatchet A, Jaber S, Meziani F, et al. Changing use of noninvasive ventilation in critically ill patients: trends over 15 years in francophone countries. Intensive Care Med. 2016;42:82–92.

[11] Tipping CJ, Harrold M, Holland A, Romero L, Nisbet T, Hodgson CL. The effects of active mobilisation and rehabilitation in ICU on mortality and function: a systematic review. Intensive Care Med. 2017;43:171–83.

[12] Waldauf P, Jiroutková K, Krajčová A, Puthucheary Z, Duška F. Effects of rehabilitation interventions on clinical outcomes in critically ill patients: systematic review and meta-analysis of randomized controlled trials. Crit Care Med. 2020;48:1055–65.

[13] Lottering M, Van Aswegen H. Physiotherapy practice in South African intensive care units. South Afr J Crit Care. 2016;32:11–6.

[14] Hodgson CL, Capell E, Tipping CJ. Early mobilization of patients in intensive care: organization, communication and safety factors that influence translation into clinical practice. Crit Care. 2018;22:77.

[15] Parry SM, Denehy L, Beach LJ, Berney S, Williamson HC, Granger CL. Functional outcomes in ICU: what should we be using?: an observational study. Crit Care. 2015;19:127.

[16] Ding N, Zhang Z, Zhang C, Yao L, Yang L, Jiang B, et al. What is the optimum time for initiation of early mobilization in mechanically ventilated patients?: a network meta-analysis. PLoS One. 2019;14:e0223151.

[17] Brummel NE, Girard TD, Ely EW, Pandharipande PP, Morandi A, Hughes CG, et al. Feasibility and safety of early combined cognitive and physical therapy for critically ill medical and surgical patients: the Activity and Cognitive Therapy in ICU (ACT-ICU) trial. Intensive Care Med. 2014;40:370–9.

[18] Lemyze M, Mallat J, Duhamel A, Pepy F, Gasan G, Barrailler S, et al. Effects of sitting position and applied positive end-expiratory pressure on respiratory mechanics of critically ill obese patients receiving mechanical ventilation. Crit Care Med. 2013;41:2592–9.

[19] Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet. 2009;373:1874–82.

[20] Nydahl P, Ruhl AP, Bartoszek G, Dubb R, Filipovic S, Flohr HJ, et al. Early mobilization of mechanically ventilated patients: a 1-day point-prevalence study in Germany. Crit Care Med. 2014;42:1178–86.

[21] Billot M, Calvani R, Urtamo A, Sánchez-Sánchez JL, Ciccolari-Micaldi C, Chang M, et al. Preserving mobility in older adults with physical frailty and sarcopenia: opportunities, challenges, and recommendations for physical activity interventions. Clin Interv Aging. 2020;15:1675–90.

[22] Denehy L, Skinner EH, Edbrooke L, Haines K, Warrillow S, Hawthorne G, et al. Exercise rehabilitation for patients with critical illness: a randomized controlled trial with 12 months of follow-up. Crit Care. 2013;17:R156.

[23] Paton M, Lane R, Paul E, Cuthburtson GA, Hodgson CL. Mobilization during critical illness: a higher level of mobilization improves health status at 6 months, a secondary analysis of a prospective cohort study. Crit Care Med. 2021;49:e860–9.

[24] TEAM Study Investigators. Hodgson C, Bellomo R, Berney S, Bailey M, Buhr H, et al. Early mobilization and recovery in mechanically ventilated patients in the ICU: a bi-national, multi-centre, prospective cohort study. Crit Care. 2015;19:81.

[25] Kwah LK, Herbert RD, Harvey LA, Diong J, Clarke JL, Martin JH, et al. Passive mechanical properties of gastrocnemius muscles of people with ankle contracture after stroke. Arch Phys Med Rehabil. 2012;93:1185–90.

[26] Schnell D, Timsit JF, Darmon M, Vesin A, Goldgran-Toledano D, Dumenil AS, et al. Noninvasive mechanical ventilation in acute respiratory failure: trends in use and outcomes. Intensive Care Med. 2014;40:582–91.

[27] Killey B, Watt E. The effect of extra walking on the mobility, independence and exercise self-efficacy of elderly hospital in-patients: a pilot study. Contemp Nurse. 2006;22:120–33.

[28] Sibilla A, Nydahl P, Greco N, Mungo G, Ott N, Unger I, et al. Mobilization of mechanically

ventilated patients in Switzerland. J Intensive Care Med. 2020;35:55–62.

[29] Stiller K, Phillips A. Safety aspects of mobilising acutely ill inpatients. Physiother Theory Pract. 2003;19:239–57.

[30] Lanzetta D, Cattaneo D, Pellegatta D, Cardini R. Trunk control in unstable sitting posture during functional activities in healthy subjects and patients with multiple sclerosis. Arch Phys Med Rehabil. 2004;85:279–83.