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Mobilisation

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Early mobilisation in critically ill patients can improve outcomes during and after critical care. However, it requires a coordinated effort from the multidisciplinary critical care team. Effective early mobilisation strategies in the ICU require a structured and individualised approach, ensuring safety and maximising benefits for critically ill patients.

While beneficial, early mobilisation presents several challenges. Critically ill patients may be prone to hypotensive episodes that may be exacerbated by movement. Patients in shock should not be considered and those with severe cardiovascular compromise do require careful assessment. Patients who are mechanically ventilated may face difficulties during mobilisation. Mobilisation can also cause transient drops in oxygen saturation. Sedation should be avoided if possible. Cognitive impairments can also hinder the patient's ability to understand and engage in mobilisation activities. Also, prolonged immobility can lead to joint contractures and stiffness, making mobilisation painful or difficult. Pain can also be a major barrier to mobilisation.

Addressing these challenges requires careful patient assessment, individualised planning, effective pain and sedation management, and strong teamwork among critical care providers. Critical care teams need to adopt a structured, coordinated approach that prioritises patient safety and optimises outcomes. Effective communication is important to ensure everyone is aligned and that mobilisation is prioritised.

ICU teams should implement standardised protocols that are evidence-based and adaptable to individual patient needs. Personalised mobilisation plans should be developed, and early mobilisation should be initiated as soon as the patient is stable enough to tolerate a physical activity. Patients should be continuously monitored, and teams should adjust or pause mobilisation if the patient exhibits signs of distress. Safety should always be the top priority. Pain should be effectively managed to enable patient participation and sedation protocols should be implemented to allow for lighter sedation levels and facilitate patient engagement.

ICU team leaders should support early mobilisation initiatives, providing the necessary resources, staffing, and equipment. It is essential to foster a culture of continuous improvement by encouraging feedback from staff, patients, and families. By addressing these aspects, critical care teams can implement early mobilisation strategies that improve patient outcomes, reduce complications, and enhance overall recovery from critical illness.

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Mobilisation Matters: Strategies for Efficient Patient Care

Post-Intensive Care Syndrome encompasses long-term physical, cognitive, and mental impairments, impacting patients' quality of life. Early mobilisation is known to improve functionality. However, clinical practice often falls short of guidelines due to barriers like haemodynamic and respiratory instability, staff shortages, and knowledge gaps. Regular multi-professional assessments and educational interventions could enhance safety and implementation.

Introduction

Intensive care unit (ICU) survivors have emerged as a new cohort within the last decade due to decreasing ICU mortality that is founded on the rapid development of modern medicine (Zimmerman et al. 2013). In this cohort, severe long-term sequelae of physical, cognitive and mental nature became evident and have been summarised under the Post Intensive Care Syndrome (Needham et al. 2012). Patients have classified physical impairments as the most relevant outcome for ICU survivors (Nedergaard et al. 2018). Those physical impairments develop rapidly during the acute phase and manifest as muscle weakness (ICU-acquired weakness (ICUAW)) and muscle atrophy with a loss of 17.7% of muscle mass during the first ten ICU days (Wollersheim et al. 2014; Fazzini et al. 2023). ICUAW develops in 40% of all ICU patients and up to ~80% in patients with risk factors such as multiple organ failure (Appleton et al. 2015; Yang et al. 2018). ICUAW has an immediate impact on ICU length of stay, duration of mechanical ventilation and mortality up to five years after discharge (Hermans et al. 2014; Van Aerde et al. 2020). Physical impairments have also been shown up to five years after discharge with reduced walking distance, reduced endurance capacity (VO2 max), symptoms of fatigue and most importantly, health-related quality of life measured mainly via functionality during daily living (Herridge et al. 2011; Van Aerde et al. 2020; Van Aerde et al. 2021; Morel et al. 2022). Interestingly, muscle strength and muscle mass recover after ICU discharge without an impact on quality of life and might, therefore, represent the best surrogate measure during the acute phase rather than a true casual pathophysiologic rationale (Fan et al. 2014; Dos Santos et al. 2016; Wollersheim et al. 2019).

Mobilisation is the current intervention of choice for addressing the physical impairments and has undergone rapid development with the goal of improving quality of life and functionality of ICU survivors.

The Current State of Evidence and Recommendations

Protocol-based mobilisation is generally recommended through international guidelines as it has been sufficiently shown to mediate a treatment benefit, i.e. shorter ICU length of stay and improved physical function (Schweickert et al. 2009; Schaller et al. 2016; Schaller et al. 2023). Furthermore, mobilisation reverses muscle atrophy as a pathophysiological hallmark (Wollersheim et al. 2019). As established before, physical impairments develop early during critical illness, as pathophysiological changes have been shown as early as 48 hours after admission (Tankisi et al. 2021). Hence, the early initiation of mobilisation seems plausible and is backed by multiple trials and a meta-analysis showing a therapeutical benefit (Daum et al. 2024). Nevertheless, until today, no uniform definition of early mobilisation exists, and the latest published guideline out of Germany and Austria has defined it as mobilisation within 72 hours of ICU admission based on the available evidence (Schaller et al. 2023). Mobilisation, in general, is a very safe intervention, with a meta-analysis showing adverse events in only 2.6% of mobilisation sessions, and only 0.6% of those adverse events had any consequences (Nydahl et al. 2014). Immobilisation or minimal handling should consequently always be prescribed since contraindications for mobilisation are scarce (Schaller et al. 2023).

Knowledge Gaps

Even though recommendations for early mobilisation are available, their uptake into daily clinical practice is lacking. Multiple trials over the last decade have shown that out-of-bed mobilisation is especially rare in mechanically ventilated patients. Nydhal and colleagues (2014) found in their point prevalence, including 783 patients, that only 24% of those on mechanical ventilation were mobilised out-of-bed, while Jolley et al. (2017) found that only in 16% of 770 patient-days of mechanically ventilated patients were mobilised out-of-bed. Different reasons (e.g., instability of the patient, lack of knowledge, and staff shortages) have been established as causative for the current mobilisation practice, which is partially incongruent with guideline recommendations. Moreover, there are still open questions regarding the conduction of early mobilisation i.e. dosage and inclusion of devices.

The Early and Unstable Phase

One major barrier and area of uncertainty is the acute, unstable patient, i.e. their haemodynamic instability or different forms of vascular access, airway or drains, as reported by 50% of the studies included in the review by Dubb and colleagues (2016). This was further underlined by the point-prevalence study conducted by Black et al. (2023), who were able to demonstrate that patients who were mobilised less presented a worse haemodynamic or respiratory status. Furthermore, they outlined that active mobilisation, in particular, is most commonly not performed due to instability. However, mobilisation is a safe intervention (Lang et al. 2020). Paton et al. (2024) demonstrated in their systematic review and meta-analysis, including 67 trials with 7004 patients, that the chance for adverse events was under 3% and that there was no effect on mortality. This confirmed the previous investigation by Nydahl and colleagues (2017), who also found mobilisation to be safe.

To prevent adverse and serious adverse events, adherence to certain safety criteria before and during a mobilisation session, e.g. those published in guidelines or consensus statements, is important (Hodgson et al. 2014; Schaller et al. 2023). Secondly, it is very important to perform daily interprofessional evaluations since different professions have different perceptions of the patients' mobilisation capabilities (Hermes et al. 2020). During those interprofessional assessments, potential hazards and barriers can be addressed, improving the safety of the mobilisation session. Additionally, the involvement of an occupation or physical therapist is a strong predictor for achieving a greater mobilisation intensity (Jolley et al. 2017; Hermes et al. 2020). Lastly, a progressive mobilisation protocol starting with passive mobilisation and working towards active mobilisation is recommended. When adhering to this recommendation, it can cautiously be tested which type of mobilisation the patient can tolerate and which adverse events can be prevented. This recommendation is based on the rationale that even passive mobilisation as part of a progressive protocol has shown benefits, and it could be established in the TEAM trial outlined below in more detail that utilising a top-down approach does not convey any benefit (Investigators et al. 2022; Vollenweider et al. 2022).

Dosage and Duration of Mobilisation

A crucial aspect, as with every medical therapy, is the appropriate dosage, which is currently unclear. The dosage for early mobilisation is multifactorial and consists of the duration, intensity (especially the level), and frequency. Various observational studies have examined the optimal dose-response relationship. Scheffenbichler et al. (2021) investigated the question of which dose of mobilisation predicts adverse discharge disposition and found that both the duration of mobilisation and the maximum mobilisation level are predictors of an adverse discharge disposition. The study revealed a wide variability in the dose of mobilisation treatment applied, which could not be explained by patients' comorbidity or disease severity. Importantly, a high dose of mobilisation was identified as an independent predictor of patients' ability to live independently after discharge. Similar results were observed in the study by Mazwi et al. (2023) in neurocritical patients. A high dose of mobilisation was associated with a lower likelihood of adverse discharge disposition.

A study by Lorenz et al. (2023) investigated the effects of daily mobilisation for 40 minutes on the functionality of critical illness survivors at ICU discharge. It was demonstrated that a mobilisation duration of over 40 minutes per day, compared to less than 40 minutes, is an independent predictor of improved functional status at discharge from the ICU. This effect was confirmed in three different models evaluating the baseline characteristics of the patients. However, the study also found that the average treatment effect disappeared when parameters such as the level of mobilisation were included in the analysis. This suggests that the highest level of mobilisation achieved during the ICU stay is the critical factor for proper dosing, as a longer duration showed no additional benefits in patients who had already reached high levels of mobilisation. All those investigations indicate that a higher dosage conveys a beneficial effect.

Despite the many positive examples of aiming for a high level of mobilisation, it has been shown that there can still be too much early mobilisation. This discrepancy was particularly evident in the TEAM trial. In this study, the effect of increased early mobilisation (sedation minimisation and daily active physiotherapy) was compared to usual care (mobilisation according to guidelines) in mechanically ventilated patients, focusing on the outcome of being alive and out of the hospital at 180 days. The results showed that increased early active mobilisation did not result in a significantly greater number of days that patients were alive and out of the hospital compared to the usual level of mobilisation in the ICU. However, the intervention was also associated with increased adverse events (Hodgson et al. 2022). Important points to consider are that (1) the control group received already high-quality mobilisation, (2) the intervention focused on active mobilisation, (3) the goal was to start with the highest possible level each day instead of progressing the level during the day and (4) sedation was still the major barrier for mobilisation in both groups. However, if patients do not receive mobilisation, the negative long-term effects on cognition and physical function are evident (Patel et al. 2023).

In their systematic review, Paton et al. (2024) also addressed the association of active mobilisation variables with adverse events and mortality in patients requiring mechanical ventilation in the ICU. They demonstrated that the implementation of mobilisation in the ICU was not associated with an increase in adverse events or mortality. It remains unclear what the optimal level, frequency, and duration of early mobilisation should be. The task of future research will be to resolve uncertainties and gain a better understanding of early mobilisation dosage, maybe in an individualised approach.

Education

Insufficient knowledge and training have also been shown to be a common barrier to early mobilisation (Dubb et al. 2016). This is underlined by the fact that the knowledge of current mobilisation guidelines led to the selection of higher and more appropriate levels of mobilisation for ICU patients (Hermes et al. 2020). It, therefore, is important to not only focus on the intervention itself but also on its integration into daily clinical practice. Even short training interventions consisting of different teaching formats, such as online lectures, handouts, and bedside teaching, can sufficiently improve the uptake of guideline recommendations into daily clinical practice, as shown by Paul and colleagues (2024). Therefore, the implementation of a new mobilisation protocol or the update of a national or international guideline should always be accompanied by a training intervention.

Assistive Devices and Robotics

Staff shortages are ever present and have been reported as a common structural barrier (Dubb et al. 2016; Hermes et al. 2020). An effective approach to counter this problem is the use of assistive devices and robotics. Rather than serving as an independent therapy, devices and robotics function as a tool to surmount obstacles to early mobilisation. There are various devices and robotics designed for different phases of intensive care stay that are currently being tested in studies.

From sitting to standing

Studies by Raurell-Torredà et al. (2021) and Paton et al. (2021) showed that patients who were mobilised at least to a standing position relatively early had a significantly improved health condition after their ICU stay, and it positively impacted the development of ICUAW. However, for critically ill patients, sitting and standing at the edge of the bed can be significantly hindered by insufficient trunk stability and often requires additional support for the patient. This frequently binds several staff members for a single mobilisation session. An innovative approach tailored to support sitting and standing in critically ill patients in the ICU is a sit-to-stand stabiliser. This type of device has promising potential for facilitating earlier and safer mobilisation. It potentially enables patients to be comfortably stabilised in a seated position without leaving the bed, ensuring the highest level of safety for both patients and caregivers. A possible advantage of such a sit-to-stand stabiliser is that it allows patients to safely sit or stand at the bedside without requiring active assistance from healthcare providers. Healthcare professionals can attend to other tasks in the room without compromising patient safety. By reducing the need for continuous hands-on support, a sit-to-stand stabiliser may enhance the effectiveness of earlier mobilisation and promote a more autonomous and dignified patient experience. The clinical benefits of a sit-to-stand stabiliser, including whether it helps patients stand more quickly and its impact on long-term patient outcomes, are currently being investigated (NCT05716451).

Cycling in the ICU

An excellent example of device-assisted mobilisation, particularly for bedridden patients, is in-bed cycling. This method can be seamlessly and swiftly incorporated into patient care, facilitating early movement and recovery. The primary advantage is that during mobilisation, the patient can perform passive, assisted-active, or active mobilisation independently after setup. This also allows other tasks to be carried out in the patient's room without the nursing or physiotherapy staff needing to be actively involved with the patient. A recently published study by Kho et al. (2024) on the use of early in-bed cycle ergometry in mechanically ventilated patients demonstrated that the use of in-bed cycling was not associated with an increase in adverse events. Thus, they were able to demonstrate that the additional implementation of in-bed cycling is safe. However, the study could not show improvement in physical function three days after discharge from the ICU. Similar findings were observed by Fossat et al. (2018) who investigated whether early in-bed leg cycling combined with electrical stimulation of the quadriceps muscles combined with standardised early rehabilitation would lead to greater muscle strength upon discharge from the ICU. Early in-bed leg cycling exercises did not improve overall muscle strength at the time of discharge from the ICU. Further studies have investigated the long-term effects of in-bed cycling, specifically six months after ICU stay, compared to usual care (Berney et al. 2021; Waldauf et al. 2021). In these studies, no clear clinical benefit for the use of in-bed cycling was demonstrated. This has been investigated on a pathophysiological level, and no effect could be found (Jameson et al. 2023). In conclusion, progressive mobilisation by healthcare providers is the gold standard, and cycling may be considered if mobilisation cannot be provided otherwise (e.g., because of staff shortage).

New approaches in the ICU: Robotic beds

Mobilisation sessions involving walking represent a significant logistical challenge, in particular, if the patient is still ventilated or on ECMO, which could be addressed through modern robotics. An example is a robotic system that combines infinitely adjustable verticalisation with robot-assisted leg movement therapy. A major advantage is that patients can perform ambulating exercises without having to leave their beds. This specific robotic mobilisation system comprises an external robot that attaches to the patient's bed, facilitating both active and passive movements. The patient can engage in in-bed cycling in a horizontal position, transitioning to a stepping motion when the healthcare provider initiates verticalisation of the bed. An initial pilot study by Lorenz et al. (2024) assessed the feasibility of robotic-assisted mobilisation in COVID-19 patients. The implementation appeared to be safe and feasible, demonstrating that integration into clinical practice was possible. Another study also showed that the use of the robot-assisted leg movement system was feasible, but it required process adjustments and consideration of unit staffing levels, as the intervention did not save staff resources or time (Warmbein et al. 2024). The same research group also examined patient-specific outcomes. There were no statistically significant differences in the duration of mechanical ventilation, ICU length of stay, muscle parameters, or quality of life after three months (Huebner et al. 2024). Overall, robot-assisted mobilisation has been demonstrated to be safe in clinical practice without showing any advantage in terms of saving personnel or time for early mobilisation.

Outlook: Artificial Intelligence in the ICU

Artificial Intelligence might be an option to address the barrier of current knowledge gaps. It can be employed to develop personalised therapy concepts, providing tailored treatment options for patients. This potential was highlighted in a study by Fuest et al. (2023), where an AI-based learning approach successfully categorised a diverse critical care cohort with significant differences in clinical characteristics and mobilisation parameters. The use of varied mobilisation strategies improved the likelihood of patients being discharged home, allowing for an individualised and resource-optimised approach to mobilisation. In other areas of medicine, AI-based personalised therapy also improved patient outcomes. Buell et al. (2024) utilised machine learning to define oxygenation targets for critically ill patients and showed that this classification had a relation to mortality. This underscores the importance and potential benefits of individualised treatment adjustments in intensive care medicine. Currently, we are at the very beginning of AI development in the clinical setting with missing evidence of clinical benefits. Nevertheless, it is a rapidly evolving and exciting field.

Conflict of Interest

None.

References

Appleton RT, Kinsella J, Quasim T (2015) The incidence of intensive care unit-acquired weakness syndromes: A systematic review. J Intensive Care Soc. 16(2):126-136.

Berney S, Hopkins RO, Rose JW et al. (2021) Functional electrical stimulation in-bed cycle ergometry in mechanically ventilated patients: a multicentre randomised controlled trial. Thorax. 76(7):656-663.

Black C, Sanger H, Battle C et al. (2023) Feasibility of mobilisation in ICU: a multicentre point prevalence study of mobility practices in the UK. Crit Care. 27(1):217.

Buell KG, Spicer AB, Casey JD et al. (2024) Individualized treatment effects of oxygen targets in mechanically ventilated critically ill adults. JAMA. 331(14):1195-1204.

Daum N, Drewniok N, Bald A et al. (2024) Early mobilisation within 72 hours after admission of critically ill patients in the intensive care unit: A systematic review with network meta-analysis. Intensive Crit Care Nurs. 80:103573.

Dos Santos C, Hussain SN, Mathur S et al. (2016) Mechanisms of chronic muscle wasting and dysfunction after an intensive care unit stay: A pilot study. Am J Respir Crit Care Med. 194(7):821-830.

Dubb R, Nydahl P, Hermes C et al. (2016) Barriers and strategies for early mobilization of patients in intensive care units. Ann Am Thorac Soc. 13(5):724-730.

Fan E, Dowdy DW, Colantuoni E et al. (2014) Physical complications in acute lung injury survivors: A two-year longitudinal prospective study. Crit Care Med. 42(4):849-859.

Fazzini B, Märkl T, Costas C et al. (2023) The rate and assessment of muscle wasting during critical illness: A systematic review and meta-analysis. Crit Care. 27(1):2.

Fossat G, Baudin F, Courtes L et al. (2018) Effect of in-bed leg cycling and electrical stimulation of the quadriceps on global muscle strength in critically ill adults: A randomized clinical trial [with consumer summary]. JAMA. 320(4):368-378.

Fuest KE, Ulm B, Daum N et al. (2023) Clustering of critically ill patients using an individualized learning approach enables dose optimization of mobilization in the ICU. Crit Care. 27(1):1.

Hermans G, Van Mechelen H, Clerckx B et al. (2014) Acute outcomes and 1-year mortality of intensive care unit-acquired weakness: A cohort study and propensity-matched analysis. Am J Respir Crit Care Med. 190(4):410-420.

Hermes C, Nydahl P, Blobner M et al. (2020) Assessment of mobilization capacity in 10 different ICU scenarios by different professions. PLoS One. 15(10):e0239853.

Herridge MS, Tansey CM, Matte A et al. (2011) Tomlinson G, Diaz-Granados N, Cooper A, et al. Functional disability 5 years after acute respiratory distress syndrome. N Engl J Med. 364(14):1293-1304.

Hodgson CL, Bailey M, Bellomo R et al. (2022) Early active mobilization during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Hodgson CL, Stiller K, Needham DM et al. (2014) 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. 18(6):658.

Huebner L, Warmbein A, Scharf C et al. (2024) Effects of robotic-assisted early mobilization versus conventional mobilization in intensive care unit patients: Prospective interventional cohort study with retrospective control group analysis. Crit Care. 28(1):112.

Investigators TS, Hodgson CL, Bailey M et al. (2022) Early active mobilization during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Jameson TSO, Caldow MK, Stephens F et al. (2023) Inflammation and altered metabolism impede efficacy of functional electrical stimulation in critically ill patients. Crit Care. 27(1):428.

Jolley SE, Moss M, Needham DM et al. (2017) Point prevalence study of mobilization practices for acute respiratory failure patients in the United States. Crit Care Med. 45(2):205-215.

Kho ME, Berney S, Pastva AM et al. (2024) Early in-bed cycle ergometry in mechanically ventilated patients. NEJM Evid. 3(7):EVIDoa2400137.

Lang JK, Paykel MS, Haines KJ, Hodgson CL (2020) Clinical practice guidelines for early mobilization in the ICU: A systematic review. Crit Care Med. 48(11):e1121-e1128.

Lorenz M, Baum F, Kloss P et al. (2024) Robotic-assisted in-bed mobilization in ventilated ICU patients with COVID-19: An interventional, randomized, controlled pilot study (ROBEM II Study). Crit Care Med. 52(5):683-693.

Lorenz M, Fuest K, Ulm B et al. (2023) The optimal dose of mobilisation therapy in the ICU: A prospective cohort study. J Intensive Care. 11(1):56.

Mazwi N, Lissak I, Wongtangman K et al. (2023) Effects of mobility dose on discharge disposition in critically ill stroke patients. PM R. 15(12):1547-1556.

Morel J, Infantino P, Gergele L et al. (2022) Prevalence of self-reported fatigue in intensive care unit survivors 6 months-5 years after discharge. Sci Rep. 12(1):5631.

Nedergaard HK, Haberlandt T, Reichmann PD et al. (2018) Patients' opinions on outcomes following critical illness. Acta Anaesthesiol Scand. 62(4):531-539.

Needham DM, Davidson J, Cohen H et al. (2012) Improving long-term outcomes after discharge from intensive care unit: Report from a stakeholders' conference. Crit Care Med. 40(2):502-509.

Nydahl P, Ruhl AP, Bartoszek G et al. (2014) Early mobilization of mechanically ventilated patients: A 1-day point-prevalence study in Germany. Crit Care Med. 42(5):1178-1186.

Nydahl P, Sricharoenchai T, Chandra S et al. (2017) Safety of patient mobilization and rehabilitation in the intensive care unit: Systematic review with meta-analysis. Ann Am Thorac Soc. 14(5):766-777.

Patel BK, Wolfe KS, Patel SB et al. (2023) Effect of early mobilisation on long-term cognitive impairment in critical illness in the USA: A randomised controlled trial. Lancet Respir Med. 11(6):563-572.

Paton M, Chan S, Serpa Neto A et al. (2024) Association of active mobilisation variables with adverse events and mortality in patients requiring mechanical ventilation in the intensive care unit: A systematic review and meta-analysis. Lancet Respir Med. 12(5):386-398.

Paton M, Lane R, Paul E et al. (2021) 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.

Paul N, Grunow JJ, Rosenthal M et al. (2024) Enhancing European management of analgesia, sedation, and delirium: A multinational, prospective, interventional before-after trial. Neurocrit Care. 40(3):898-908.

Raurell-Torredà M, Arias-Rivera S, Martí JD et al. (2021) Care and treatments related to intensive care unit-acquired muscle weakness: A cohort study. Aust Crit Care. 34(5):435-445.

Schaller SJ, Anstey M, Blobner M et al. (2016) Early, goal-directed mobilisation in the surgical intensive care unit: a randomised controlled trial. Lancet. 388(10052):1377-1388.

Schaller SJ, Bein T, Blobner M et al. (2023) Lagerungstherapie und Mobilisation von kritisch Erkrankten auf Intensivstationen. Available at https://register.awmf.org/assets/guidelines/001-015l_S3_Lagerungstherapie-Mobilisation-von-kritisch-Erkrankten-auf-Intensivstationen_2023-07.pdf

Scheffenbichler FT, Teja B, Wongtangman K et al. (2021) Effects of the Level and Duration of Mobilization Therapy in the Surgical ICU on the Loss of the Ability to Live Independently: An International Prospective Cohort Study. Crit Care Med. 49(3):e247-e257.

Schweickert WD, Pohlman MC, Pohlman AS et al. (2009) Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet. 373(9678):1874-1882.

Tankisi A, Pedersen TH, Bostock H et al. (2021) Early detection of evolving critical illness myopathy with muscle velocity recovery cycles. Clin Neurophysiol. 132(6):1347-1357.

Van Aerde N, Meersseman P, Debaveye Y et al. (2021) Aerobic exercise capacity in long-term survivors of critical illness: secondary analysis of the post-EPaNIC follow-up study. Intensive Care Med. 47(12):1462-1471.

Van Aerde N, Meersseman P, Debaveye Y et al. (2020) Five-year impact of ICU-acquired neuromuscular complications: a prospective, observational study. Intensive Care Med.

Vollenweider R, Manettas AI, Hani N et al. (2022) Passive motion of the lower extremities in sedated and ventilated patients in the ICU - a systematic review of early effects and replicability of Interventions. PLoS One. 17(5):e0267255.

Waldauf P, Hrušková N, Blahutova B et al. (2021) Functional electrical stimulation-assisted cycle ergometry-based progressive mobility programme for mechanically ventilated patients: randomised controlled trial with 6 months follow-up. Thorax. 76(7):664-671.

Warmbein A, Hübner L, Rathgeber I et al. (2024) Robot-assisted early mobilization for intensive care unit patients: Feasibility and first-time clinical use. Int J Nurs Stud. 152:104702.

Wollersheim T, Grunow JJ, Carbon NM et al. (2019) Muscle wasting and function after muscle activation and early protocol-based physiotherapy: an explorative trial. J Cachexia Sarcopenia Muscle. 10(4):734-747.

Wollersheim T, Woehlecke J, Krebs M et al. (2014) Dynamics of myosin degradation in intensive care unit-acquired weakness during severe critical illness. Intensive Care Med. 40(4):528-538.

Yang T, Li Z, Jiang L et al. (2018) Risk factors for intensive care unit-acquired weakness: A systematic review and meta-analysis. Acta Neurol Scand. 138(2):104-114.

Zimmerman JE, Kramer AA, Knaus WA (2013) Changes in hospital mortality for United States intensive care unit admissions from 1988 to 2012. Crit Care. 17(2):R81.

Early Mobilisation - When Evidence Comes to Single Patients

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Early mobilisation within 72 hours of ICU admission mitigates risks including reduced functionality and cognitive decline in critically ill patients, improving outcomes such as mobility and quality of life. Overcoming barriers through flexible staffing, protocols, and personalised care strategies is essential to humanising critical care in daily practice. We apply this evidence-based approach to Mr Smith.

Critically ill patients treated in intensive care units (ICU) have an increased risk of developing several sequelae, including reduced functionality and muscle strength, ICU-acquired weakness (ICU-AW), cognitive decline, delirium, and others (Fazzini et al. 2023; Renner et al. 2023). Most of these risks can be mitigated by early physical activity and mobilisation, which is defined as mobilisation starting within 72 hours of ICU admission ICU (Schaller et al. 2024). Early mobilisation has shown to positively influence mobility, functional independence, incidence and days in delirium, days on mechanical ventilation, ICU and hospital length of stay, discharge home, long-term cognitive function, and quality of life (Okada et al. 2019; Wang et al. 2020; Zang et al. 2020). Similarly, complications such as ventilator-associated pneumonia, pressure sores, or deep venous thromboses can be reduced (Daum et al. 2024; Jiroutková et al. 2024; Wang et al. 2020).

Forms of Mobilisation

Early mobilisation includes measures on patients that initiate or support passive or active movement exercises and aim to promote or maintain the ability to move. This includes passive range of motion exercises or cycling, active exercises in bed (active range of motion, sitting up in bed), and out-of-bed activities (sitting on the edge of bed, standing, active/passive transfer to chair, walking). Particularly early on during critical illness, neuromuscular electrical stimulation, assist devices, and robotics can be a useful supplement to facilitate mobilisation therapy (Clarissa et al. 2019; Grunow et al. 2022; Lorenz et al. 2024). Considering inclusion and exclusion criteria and appropriate clinical assessment, these activities are feasible and safe, even with patients on mechanical ventilation, vasopressor therapy, and extracorporeal membrane oxygenation (Schaller et al. 2024).

Protocols

In daily clinical practice, early mobilisation is delivered in an interprofessional team approach and can be guided by protocols such as the ABCDEF bundle, which includes interventions for analgesia and sedation, delirium, spontaneous breathing trials, mobilisation and family integration by the whole interprofessional critical care team (Marra et al. 2017; Pun et al. 2019). For implementing early mobilisation into daily practice, the use of interprofessional protocols is recommended as they facilitate conducting early mobilisation in the ICU (Schaller et al. 2024). Protocols should include a) initiation criteria for mobilisation of patients in- and outside the bed, e.g. by a traffic light system; b) assessment of consciousness and function; c) scales such as the ICU mobility scale for planning, performing, and documenting mobility; d) safety criteria for discontinuing a mobilisation session; e) checklists for devices (Eggmann et al. 2024; Parry et al. 2018; Schaller et al. 2016) (**Table 1**). As such, mobilisation should be an integral component of daily ICU rounds together with sedation, ventilation, haemodynamics, nutrition etc.

Assessment	ICU Mobility Scale		Dose[c]	Safety[d]
Patient is deep sedated/ unarousable (RASS < -3)[a]	0	No active mobilisation (passive mobilisation exercises, NMES, passive cycling)	Lower dosage ↑	Ensure communication with patient and check safety continuously on every level: haemodynamics, respiration, consciousness, neuro, pain, exertion, need for short or complete rests
Patient reacts to touch or voice (RASS ≥-3)	1	Exercises, sitting in bed		
	2	Passive transfer into chair (no standing)		
Can lift arms against gravity, has trunk tension	2	Passive transfer into chair (no standing)		
Can lift legs against gravity	4	Standing[b]		
Can lift legs against gravity and has pelvic stability/tension	5	Active transfer from bed into chair		
	6	Walking on spot		
	7	Walking with ≥ 2 persons > 5m		
	8	Walking with 1 person > 5m		
	9	Walking independently with gait help >5m		
	10	Walking independently	Higher dosage ↓	

Table 1. Example of an assessment for planning mobility

a. *Not applicable to patients with impaired consciousness due to neurological disorders who can be stimulated in their vigilance by mobilisation.*
b. *Avoid longer periods of passive standing to reduce risk of cerebral hypoperfusion and prefer walking on spot instead.*
c. *Lower dose might include lower frequency, lower intensity/level (e.g. and shorter duration (e.g. 2x/day for 40 minutes in total, IMS 1-2), higher dose the opposite (e.g. 3x/day for 120 minutes in total, IMS 5-10), depending on a specific situation.*
d. *Transient changes in physiological parameters are to be expected during exercise, and safety limits might be adapted to the level/intensity of exercises, depending on patient's capability and resources.*

Abbreviations: IMS - ICU Mobility Scale; ICU - Intensive Care Unit; m - metre; RASS - Richmond Agitation–Sedation Scale

Question of the Right Dose

While it is recognised that mobilisation and physical activity improve patient outcomes, there is growing evidence that different variables should be considered when correctly quantifying and applying mobilisation. This includes not only the intensity (most often level) but also the frequency and duration of mobilisation. Accordingly, mobilisation protocols have used a daily frequency of mobilisation (Morris et al. 2016; Schaller et al. 2016) with a proposed number of daily mobilisation sessions. Other mobilisation protocols recommend a duration of physical activity of up to 60-90 minutes per day (Hodgson et al. 2016; Wright et al. 2018). Furthermore, scores to combine the level and duration of activity have been developed (Scheffenbichler et al. 2021; Watanabe et al. 2021). This synergy of characteristics of physical activity positively influences patient-centred outcomes. Yet the optimal dose of mobilisation needs to be adapted to each individual patient based on individual clinical assessment and comorbidities. Receiving the maximum possible activity intensity increased 180-day mortality risk in patients with diabetes mellitus in a secondary analysis of the TEAM trial (Investigators et al. 2022; Serpa Neto et al. 2024). Similarly, very early and longer mobilisation sessions increased mortality in stroke patients treated in stroke units (Bernhardt et al. 2016; Bernhardt et al. 2015). In general, the dose of mobilisation in its level/intensity, frequency, and duration should be adapted to patients' individual capability and tolerance, with higher dose in patients with higher physiological reserves.

Barriers and Implementation

Patient-specific barriers (haemodynamic instability, endotracheal tubes and other lines, delirium and agitation, etc.), structural barriers (time constraints, staff shortage, lack of protocols or equipment, and others) and missing education, knowledge, and culture often prevent early mobilisation from being performed at all or according to the standards proposed in validated mobilisation protocols (Dubb et al. 2016). These barriers can be overcome by several strategies in an interprofessional implementation process, including baseline assessment of mobilisation, identification of local barriers, use of appropriate strategies, implementation, re-assessment of the mobility rates, reflection, and feedback to the team (Barr et al. 2021). The hospital and ICU management should provide the resources to address barriers and implement early mobilisation in the ICU (Schaller et al. 2024).

With regard to the implementation of scientific findings on early mobilisation with better results for patients and cost savings for hospitals, the management levels should also support these practical topics with their own ideas at an early stage (Azuh et al. 2016; Lord et al. 2013; Unoki et al. 2024). The planning of additional mobility teams to ensure early mobilisation is certainly helpful, but in times of staff shortages, it is quite a challenge. Here, flexible working time models and financial incentives could ensure that employees who work part-time, among others, would be willing to increase their working hours for special activities to be additionally available for early mobilisation. In addition to human resources, technical support through mobility aids or robotics may also become increasingly important, but empirical data on the use of robotics to support specialist staff in intensive care units are limited (Lorenz et al. 2024; Mehler-Klamt et al. 2023; Warmbein et al. 2024). Before investments in robotics are made, the minimum requirement for robotics is to demonstrate (1) a benefit for the patients and (2) an actual reduction in the workload of healthcare staff. The authors also argue that such investments must be carefully weighed against additional investment in the recruitment and retention of healthcare professionals until it is also demonstrated that robotic mobilisation adds value to conventional mobilisation.

When Evidence Comes to Mr Smith

Especially in critically ill patients, who often suffer from impaired consciousness, pain, or fatigue, it is essential to adapt the standardised mobilisation to an individual goal setting (Nydahl et al. 2024a). Therapy goals should follow the SMART rule, making them Specific, Measurable, Achievable, Reasonable and Time-bound. A differentiation between long and short-term goals is sensible. To improve patient adherence and clinical outcomes, a shared decision-making (SDM) approach should be used to set goals, which might also prevent wrong expectations (More and Kaplan 2018).

Let us assume that Mr Smith is a patient in our ICU, suffering from sepsis, ICU-AW, delirium, and is still on mechanical ventilation (MV). He is physically weak and mentally fatigued, wondering how fast this all could happen. We approach him with a motivating dialogue and involve his family to get to know his personal interests and short- and long-term goals so that we can motivate him for rehabilitation. His family personalises the room with photos of him with his family, in the garden, with grandchildren, or with his dog. Patient Smith becomes Mr Smith. The family writes notes on his "get-to-know-me" board with personal information, helping us to tailor activities to his interests and daily habits. Meeting the family is important for him, and being outside, so we mobilise him into a wheelchair and arrange a tour for him to the hospital's garden where he can meet his family and dog, even with mechanical ventilation and a few standing exercises in the garden. He comes back with bright eyes and smiles, and the whole team is proud of him and his excellent care. The nurse reports in his ICU diary: "Today, you reached a milestone!" and adds a photo of him being in the sunshine with his family. Only in an ideal world? No, in a lot of ICUs, early mobilisation became routine; studies have shown an overall mobilisation rate ranging from 10% to 73%, the rate for patients with MV being lower with a range of 7% to 33% (Nydahl et al. 2024b). So even though barriers still exist, and the mobilisation rate could still be increased, this could be a real-world case.

Conclusion

In conclusion, early rehabilitation improves patient outcomes when it is appropriately dosed. This individualised approach to early rehabilitation has not yet been sufficiently studied, since early rehabilitation in critical care is a complex intervention comprising multiple interconnected components. As in other areas of medicine, we need to consider the individuality of patients, including their capabilities, needs, experiences, values, and personal contexts, thereby humanising critical care (Heras La Calle et al. 2017). Humanising critical care involves a multi-professional, multi-disciplinary approach that includes elements such as effective communication, patient well-being, flexible visiting hours, the involvement and participation of relatives, the prevention and treatment of Post-Intensive Care Syndrome, humanised architecture and infrastructure, and appropriate end-of-life care (Nin Vaeza et al. 2020). This will be the future of critical care.

Conflict of Interest

None.

References

Azuh O, Gammon H, Burmeister C et al. (2016) Benefits of early active mobility in the medical intensive care unit: A pilot study. Am J Med. 129(8):866-871.e1.

Barr J, Paulson SS, Kamdar B et al. (2021) The coming of age of implementation science and research in critical care medicine. Crit Care Med. 49(8):1254-1275.

Bernhardt J, Churilov L, Ellery F et al. (2016) Prespecified dose-response analysis for A Very Early Rehabilitation Trial (AVERT). Neurology. 86(23):2138-2145.

Bernhardt J, Churilov L, Ellery F et al. (2015) Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial. Lancet. 386(9988):46-55.

Clarissa C, Salisbury L, Rodgers S, Kean S (2019) Early mobilisation in mechanically ventilated patients: a systematic integrative review of definitions and activities. J Intensive Care. 7:3.

Daum N, Drewniok N, Bald A et al. (2024) Early mobilisation within 72 hours after admission of critically ill patients in the intensive care unit: A systematic review with network meta-analysis. Intensive Crit Care Nurs. 80:103573.

Dubb R, Nydahl P, Hermes C et al. (2016) Barriers and strategies for early mobilization of patients in intensive care units. Ann Am Thorac Soc. 13(5):724-730.

Eggmann S, Nydahl P, Gosselink R, Bissett B (2024) We need to talk about adverse events during physical rehabilitation in critical care trials. eClinicalMedicine. 68:102439.

Fazzini B, Märkl T, Costas C et al. (2023) The rate and assessment of muscle wasting during critical illness: a systematic review and meta-analysis. Crit Care. 27(1):2.

Grunow JJ, Nydahl P, Schaller SJ (2022) Mobilisation of intensive care unit patients: How can the ICU rooms and modern medical equipment help? Anasthesiol Intensivmed Notfallmed Schmerzther. 57(1):41-51.

Heras La Calle G, Oviés Á, Tello VG (2017) A plan for improving the humanisation of intensive care units. Intensive Care Med. 43(4):547-549.

Hodgson CL, Bailey M, Bellomo R et al. (2016) A binational multicenter pilot feasibility randomized controlled trial of early goal-directed mobilization in the ICU. Crit Care Med. 44(6):1145-1152.

Investigators TS, Hodgson CL, Bailey M et al. (2022) Early active mobilization during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Jiroutková K, Duška F, Waldauf P (2024) Should new data on rehabilitation interventions in critically ill patients change clinical practice? Updated meta-analysis of randomized controlled trials. Crit Care Med.

Lord RK, Mayhew CR, Korupolu R et al. (2013) ICU early physical rehabilitation programs: financial modeling of cost savings. Crit Care Med. 41(3):717-724.

Lorenz M, Baum F, Kloss P et al. (2024) Robotic-Assisted In-Bed Mobilization in Ventilated ICU Patients With COVID-19: An Interventional, Randomized, Controlled Pilot Study (ROBEM II Study). Crit Care Med. 52(5):683-693.

Marra A, Ely EW, Pandharipande PP, Patel MB (2017) The ABCDEF bundle in critical care. Crit Care Clin. 33(2):225-243.

Mehler-Klamt AC, Huber J, Schmidbauer L et al. (2023) The use of robotic and technical systems for early mobilization of intensive care patients: A scoping review. Pflege. 36(3):156-167.

Morris PE, Berry MJ, Files DC et al. (2016) Standardized rehabilitation and hospital length of stay among patients with acute respiratory failure: A randomized clinical trial. JAMA. 315(24):2694-2702.

Nin Vaeza N, Martin Delgado MC, Heras La Calle G (2020) Humanizing intensive care: Toward a human-centered care ICU model. Crit Care Med. 48(3):385-390.

Nydahl P, Heras-La Calle G, McWilliams D (2024a) Personalized rehabilitation: A step towards humanizing critical care. Intensive Crit Care Nurs. 82:103634.

Nydahl P, Fick LS, Eggmann S (2024b) Break down barriers - Can point prevalence studies change mobilization practice in the intensive care unit? Intensive Crit Care Nurs. 80:103537.

Okada Y, Unoki T, Matsuishi Y et al. (2019) Early versus delayed mobilization for in-hospital mortality and health-related quality of life among critically ill patients: a systematic review and meta-analysis. J Intensive Care. 7:57.

Parry SM, Nydahl P, Needham DM (2018) Implementing early physical rehabilitation and mobilisation in the ICU: institutional, clinician, and patient considerations. Intensive Care Med. 44(4):470-473.

Pun BT, Balas MC, Barnes-Daly MA et al. (2019) Caring for critically ill patients with the ABCDEF bundle: Results of the ICU Liberation Collaborative in over 15,000 adults. Crit Care Med. 47(1):3-14.

Renner C, Jeitziner MM, Albert M et al. (2023) Guideline on multimodal rehabilitation for patients with post-intensive care syndrome. Crit Care. 27(1):301.

Schaller SJ, Anstey M, Blobner M et al. (2016) Early, goal-directed mobilisation in the surgical intensive care unit: a randomised controlled trial. Lancet. 388(10052):1377-1388.

Schaller SJ, Scheffenbichler F, Bein T et al. (2024) Guideline on positioning and early mobilisation in the critically ill by an expert panel. Intensive Care Med. 50(8):1211-1227.

Scheffenbichler FT, Teja B, Wongtangman K et al. (2021) Effects of the level and duration of mobilization therapy in the ICU on neuromuscular function and outcomes: A systematic review and meta-analysis. Crit Care Med. 49(9):1561-1573.

Serpa Neto A, Bailey M, Seller D et al. (2024) Impact of high dose early mobilization on outcomes for patients with diabetes: A secondary analysis of the TEAM trial. Am J Respir Crit Care Med.

Unoki Y, Ono S, Sasabuchi Y et al. (2024) Exploring the influence of a financial incentive scheme on early mobilization and rehabilitation in ICU patients: an interrupted time-series analysis. BMC Health Serv Res. 24(1):242.

Wang J, Ren D, Liu Y et al. (2020) Effects of early mobilization on the prognosis of critically ill patients: A systematic review and meta-analysis. Int J Nurs Stud. 110:103708.

Warmbein A, Hübner L, Rathgeber I et al. (2024) Robot-assisted early mobilization for intensive care unit patients: Feasibility and first-time clinical use. Int J Nurs Stud. 152, 104702.

Watanabe S, Morita Y, Suzuki S et al. (2021) Effects of the intensity and activity time of early rehabilitation on activities of daily living dependence in mechanically ventilated patients. Prog Rehabil Med. 6:20210054.

Wright SE, Thomas K, Watson G et al. (2018) Intensive versus standard physical rehabilitation therapy in the critically ill (EPICC): a multicentre, parallel group, randomised controlled trial. Thorax. 73(3):213-221.

Zang K, Chen B, Wang M et al. (2020) The effect of early mobilization in critically ill patients: A meta-analysis. Nurs Crit Care. 25(6):360-367.

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Abionic: Vision, Key Products and Strategic Direction

Abionic SA has appointed Patrick Pestalozzi as CEO. With three decades of global experience in management consulting and entrepreneurship, Patrick has been instrumental in creating and developing deep-tech ventures. His diverse healthcare background positions him to lead Abionic's next growth phase. ICU Management & Practice interviewed Patrick about his vision for the company.

What is your vision for Abionic?

I took over the leadership of Abionic last April after Nicolas and Iwan, Abionic's co-founders, decided it was time for new blood to steer the company across its next development milestones, including deploying a promising new sepsis biomarker in the U.S.

Building innovative medical technologies has been the DNA of Abionic since its inception in 2010. The winner of multiple industry awards, including "Swiss MedTech of the Year" in 2023, Abionic was founded on the vision that nanofluidics could transform diagnostic testing by delivering lab-quality results in minutes across a range of biomarkers. After a decade of R&D that pushed the boundaries of science and technology, our flagship **abioSCOPE**®, a near-patient rapid diagnostic platform, was released for commercial use.

I was recruited to transform an effective R&D start-up into a nimble commercial organisation capable of delivering our portfolio of rapid tests at the point of need. One particular asset in our portfolio I am focusing on is **PSP** (Pancreatic Stone Protein), an emerging sepsis biomarker that indicates the onset of sepsis 24-48h earlier than current standards. The timely and early detection of sepsis is critical to initiate optimal treatment protocols and increase the odds of patient survival.

Sepsis is an ominous health threat affecting 50 million patients worldwide and the cause of 11 million deaths, or 1 in 5 global deaths (WHO 2024). Our mission is to address the poorly met need for quick & reliable sepsis identification worldwide.

What are key strategic changes to be implemented?

Following a successful multicentric study in Europe which paved the way to our IVDR certification in Q3 '22, we completed a major multi-site study in the U.S. in 2023 and swiftly filed our FDA 510(k) submission in early 2024. These studies and 50+ peer-reviewed publications confirm the high potential PSP holds to address the poorly met need for quick and reliable sepsis recognition in emergency and critical care settings.

My mandate for 2025 is to lay the groundwork to enable Abionic's successful market entry into the United States, where sepsis strikes 1.7M patients, causes at least 350,000 deaths, and costs $38B annually (CDC 2023). That includes building a sustainable commercial capability to ensure we can scale our operations and successfully deploy multiple critical pilots with partner hospitals from coast to coast.

How will Abionic evolve within the ICU segment?

PSP may be of the utmost clinical utility in Burn ICUs where accurate biomarkers are needed to identify septic cases before patient deterioration. Severely burned patients often present an inherent state of hyperinflammation, which frequently conceals septic events, which in turn often delays the initiation of targeted intensive care therapy.

In a monocentric observational study completed in 2021 (Klein et al.), the authors concluded that PSP was able to differentiate between septic and non-septic patients during acute burn care. Its steep rise (up to 72 hours before clear clinical deterioration) provides physicians with valuable clinical insights and actionable information to initiate optimal treatment, resulting in reduced mortality and costs.

However, the clinical utility of PSP is not limited to acute settings but holds tremendous potential in upstream workflows, such as emergency department (ED) triage, or even beyond hospital settings in retirement communities, as a screening tool enabling the early identification of community-acquired sepsis.

Are there any strategic partnerships to be considered?

Indeed, considering the resources and capabilities required to successfully enter a new market, we are currently evaluating alternative GTM options and will consider strategic partnerships to distribute & commercialise the abioSCOPE and the world's fastest sepsis test in the United States.

For other geographies, our strategy is rather simple and follows a proven and tested playbook: we've established a wide network of partners in 50+ geographies and work closely to deliver our solutions across emergency and critical care settings worldwide.

Abionic is known for its rapid diagnostic tools. What new technological advancements are in the pipeline to stay ahead of the competition?

We are continuously innovating and developing our technology. Some key advancements include enhanced sensitivity for detecting concentrations as low as a few picograms per millilitre, optimising functional multiplexing, expanding our test portfolio into other testing areas and developing a comprehensive data analysis capability.

Is AI an option in Abionic's products?

The integration of artificial intelligence and machine learning frameworks (AI/ML) is inevitable and takes us a step closer to a future of "predictive" diagnostics.

Where can Abionic's rapid testing solutions play a role in optimised workflow management?

Optimising hospital workflows is the key to unlocking operational efficiencies and financial savings, beyond improving patient outcomes first and foremost. Emergency departments, intensive care units, ambulance services, remote care and even primary care clinics or retirement communities can benefit from easy-to-use solutions that provide lab-quality results within minutes. The abioSCOPE easily integrates into hospital workflows and can become a major go-to solution to address the need for rapid and accurate results in time-sensitive cases.

What are your strategies for expanding Abionic's market presence? What markets enjoy priority?

Our core portfolio products are currently used across 20 reference sites in Europe, the Middle East, Latin America, and Asia. For 2025, we are planning to work hand-in-hand with our distributors to expand our market reach with our early adopters in Eastern Europe, Greece, and Italy. For larger healthcare markets such as France and Germany, we will deploy a direct-to-market approach to ensure PSP is positioned across key settings in ED & ICUs.

Do you see regulatory challenges as a problem when entering markets?

Regulatory pathways remain a challenge for most small organisations vying to bring innovation at the point of need. We invest a substantial part of our operational budgets, ensuring we fully comply with increasingly complex and demanding requirements

What potential partnerships or collaborations are on the horizon?

Our corporate and business development objectives are still being defined, but I can share that we expect to broaden the field of use of our technology in the coming months. Considering the resources and capabilities required for a successful market entry, we are currently evaluating strategic alternatives to leverage our technology assets and deploy the world's fastest sepsis test in the U.S.

What areas of unmet medical needs are you targeting today?

The timely identification and recognition of sepsis remains a major pain point across emergency and acute care settings. Our PSP assay, which runs exclusively on our abioSCOPE platform, integrates into existing hospital workflows and delivers optimal clinical utility in settings where time-to-recognition is key to improving patient outcomes.

What advantages of cost-effectiveness are met for healthcare providers and patients?

Focusing, for example, on sepsis, our diagnostic tools enable early and accurate detection, reduce the need for extensive testing and prolonged hospital stays, improve patient outcomes, and consequently lower overall healthcare costs.

How do you balance the development of innovative products with cost restraints?

Our product managers and commercial teams scan the market to identify disease areas and viable use cases where time-to-recognition is a must-have, and our rapid Turn-Around-Time Kis a winning feature which confers a clear and distinctive competitive advantage. For example, we recently developed a ferritin test on the basis of a use-case, which confirmed that speed and accuracy were key drivers to rule-in/out donors at the point of collection.

Where do you stand with clinical trials, results and market approvals?

In the sepsis field, we have completed a European multicentre observational study with 14 sites and a U.S. multicentre observational study with six sites, leading to IVDR certification in Europe and a pending 510(k) in the U.S. Besides 50+ publications that evaluated PSP as a sepsis marker, we also have ongoing post-market performance studies which bring continuous insights and strengthen our scientific and clinical evidence backbone.

What are the most significant challenges facing the industry today?

From labour shortages to rising treatment costs, cybersecurity issues, rising regulatory compliance, or even patient safety, our industry is at risk of failing its primary mission - to provide the best care to all. As a scale-up medical technology, besides having to deftly navigate complex international regulatory and reimbursement pathways, competing against established healthcare incumbents on an equal footing makes delivering innovation at the point of need daunting. To ensure the flow of innovative solutions to address current and future unmet needs continues unabated, we should consider new regulatory and buy-side pathways to facilitate market access.

How is Abionic contributing?

Our flagship abioSCOPE delivers lab-quality results from a drop of blood (50 μl) within minutes and integrates seamlessly into existing hospital workflows. In time-sensitive emergencies such as sepsis, ordering a PSP screening assay can accelerate the time-to-recognition and trigger a faster initiation of optimal treatment protocols and increase the odds of patient survival - in terms of improved patient outcomes and streamlined healthcare, I cannot think of a better contribution. Furthermore, as decentralised care becomes more common in the near future, I can imagine that enabling Remote Patient Monitoring (RPM) functions will rely on a consumer version of the abioSCOPE and other such IVD technologies to provide simple and practical testing at home.

Disclaimer

Point-of-view articles are the sole opinion of the author(s) and are part of the ICU Management & Practice Corporate Engagement or Educational Community Programme.

References

CDC (2023) Sepsis Program Activities in Acute Care Hospitals — National Healthcare Safety Network, United States, 2022. Available at https://www.cdc.gov/mmwr/volumes/72/wr/mm7234a2.htm

Klein HJ, Niggemann P, Buehler PK et al. (2021) Pancreatic Stone Protein Predicts Sepsis in Severely Burned Patients Irrespective of Trauma Severity: A Monocentric Observational Study. Ann Surg. 274(6):e1179-e1186.

WHO (2024) Sepsis. Key Facts. Available at https://www.who.int/news-room/fact-sheets/detail/sepsis

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Early Mobilisation, Delirium Prevention and Long-Term Cognitive Function

Early mobilisation showed promising positive effects in preventing and shortening delirium and improving long-term cognitive function. Further research is required to confirm its benefits and to identify the best protocol.

Introduction

In recent years, an increasing demand for critical care services (and Intensive Care Unit (ICU) admissions) has been reported, together with a decrease in short-term mortality (Needham et al. 2012; Dinglaset al. 2018; Hiser et al. 2023). Consequently, the number of ICU survivors is growing. Unfortunately, ICU survivors often present new or worsened long-lasting impairments affecting mental, physical and cognitive health status, ultimately lowering the quality of life. In a seminal paper published in 2012, Needham et al. reported the findings of a conference held two years before by the Society of Critical Care Medicine, which focused on the long-term consequences of critical illness. The international group convened at the conference created Post-Intensive Care Syndrome (PICS) as an umbrella term to raise awareness of those impairments and facilitate screening and research on the issue (Needham et al. 2012).

PICS prevalence in ICU survivors is reported to range between 25% and 40% three months post ICU discharge (Pandharipande et al. 2013), but prevalence higher than 80% has been reported when comprehensive cognitive batteries are used for evaluation instead of subjective assessment or less sensible objective tests like the Mini-Mental State Examination (Honarmand et al. 2020). In PICS, cognitive impairments include deficits in memory, attention, executive function, mental processing speed and visuospatial ability. Of note, almost half of ICU survivors still present cognitive impairment two years after ICU discharge. Cognitive decline has a major negative impact on post-ICU quality of life and carries huge costs on society and a relevant burden on caregivers (Honarmand et al. 2020). Finally, cognitive function is among the most highly rated patient-important outcomes, while survival is among the lowest (Dinglas et al. 2018).

ICU-related cognitive impairment presents non-modifiable risk factors, namely female gender, advanced age, previous mental illness, severity of illness and admission due to acute respiratory distress syndrome (ARDS) (Needham et al. 2012; Honarmand et al. 2020; Hiser et al. 2023). Other risk factors associated with post-ICU long-term cognitive impairment may be modifiable; in particular, negative patient experience in the ICU and delirium are significantly associated with long-term cognitive function and mental outcomes (Hiser et al. 2023).

Delirium in ICU is an acute brain dysfunction manifesting as an impairment or fluctuation in mentation, disorganised thinking, inattention, and altered level of consciousness. It can coexist with other neurological diseases like stroke or traumatic brain injury, but it is not fully explained by these or by other causes (Mart et al. 2020; Palashkappa and Hough 2021). It can present with three main psychomotor manifestations: hyperactive (the easiest to be detected but also the less common), hypoactive, and mixed. Delirium can affect 20-50% of ICU patients, but its prevalence can be as high as 80% in ventilated patients (Palashkappa and Hough 2021). Delirium is independently associated with an increased risk of death, prolonged ventilation, longer ICU and hospital stay, increased costs, and a higher risk of being discharged to a long-term facility. In particular, the hypoactive form showed the worst outcomes (Mart et al. 2020; Palashkappa and Hough 2021).

Delirium is also associated with significant long-term impairments in physical, psychological and cognitive functions. It was associated with cognitive decline at 1-year follow-up or later in 30%-70% of survivors who had experienced it during their ICU stay. Moreover, delirium was associated with an increased risk of developing dementia or of worsening pre-existing dementia (that is by itself a risk factor for delirium) (Mart et al. 2020; Palashkappa and Hough 2021). Unfortunately, so far, no effective pharmacological treatment or prevention for delirium has been found (on the contrary, some drugs like benzodiazepines are known risk factors). The focus remains almost exclusively on non-pharmacological approaches aimed to prevent delirium: preserving non-fragmented sleep, providing visual and hearing aids if needed, preserving space and time orientation (with clocks and calendars, for instance), minimising noise, avoiding physical restraints, providing cognitive stimulating activities, avoiding as far as possible deep sedation and promoting early mobilisation (Mart et al. 2020; Palashkappa and Hough 2021).

Early mobilisation (EM), from passive motion to ambulation, is safe and was associated with reduced risk of delirium and improved long-term cognitive outcomes. (Mart et al. 2020; Palashkappa and Hough 2021). In 2018, the Society of Critical Care Medicine published the international clinical practice guidelines for the prevention and management of delirium and cognitive impairment, among other purposes, in the critically ill (PADIS Guidelines) (Devlin et al. 2018). The authors stated that delirium incidence and cognitive outcomes could be positively influenced by the application of non-pharmacological interventions, such as early mobilisation, with better results when applied in a comprehensive bundle.

In the present review, after briefly defining EM, we report the main findings of trials evaluating the effects of EM in ICU on delirium and long-term cognitive function. We also expose the supposed brain mechanisms mediating this effect and consider the barriers that hinder the application of EM.

Early Mobilisation Effects on Delirium Prevention

In the first review following the Pain Agitation/Sedation Delirium Immobility Sleep Disruption (PADIS) guidelines (Devlin et al. 2018), Kang et al. (2018) aimed to evaluate non-pharmacological interventions that could reduce delirium incidence and duration. Interruption of sedation, exercise, patient education, automatic warning systems, cerebral haemodynamic improvement, family participation and sedation-reducing protocols appeared effective in preventing and shortening delirium (Kang et al. 2018). Single intervention analysis showed similar results, with early physical exercise showing the best efficacy, leading the authors to recommend consistent application of such strategies but also pointing out the lack of strong evidence.

Liang et al. (2021) published a systematic review of nonpharmacologic treatments for delirium, with EM resulting as the most promising strategy. The five considered studies, including randomised and non-randomised trials, showed medium-quality evidence of reduction of delirium incidence (odds ratio (OR) of 0.33) when EM was compared to usual care (Liang et al. 2021).

A similar study with the addition of a network meta-analysis was performed by Chen et al. (2022). The authors only included randomised controlled trials, ranging over a wide variety of nonpharmacological interventions. Overall, the 29 included studies showed for the first time an advantage in the application of these interventions when applied as a multi-component bundle, but with a strong superiority of EM (reduction of incidence and duration of delirium: respectively OR 0.12 and mean reduction of delirium duration -1.34 days) and family participation when compared to other single strategies. The most recent systematic review and meta-analysis investigating the effects of EM alone on delirium analysed 13 recent studies, randomised trials and quality-improvement projects (Nydahl et al. 2023). Higher heterogeneity impaired the analysis; nonetheless, at least three studies with low risk of bias showed a reduction in delirium duration of up to two days when EM was implemented alone.

Other studies which had not been included in the previously described reviews add further data on the role of EM.

A recent randomised trial by Nydahl et al. (2020) evaluated EM as part of a multidisciplinary intervention. The incidence of delirium was a secondary outcome. Lack of adherence to exercise protocols is often pointed out as the main problem in studies in which EM resulted ineffective. This study had a protocol adherence >90% resulting in improved patient mobilisation; nevertheless, it found no difference in delirium incidence.

Delirium, as well as cognitive decline, are common after coronary artery bypass grafting. Physical rehabilitation is widely applied in cardiac surgery patients, and expertise is crucial to improve adherence to mobilisation protocols. A randomised trial by Shirvani et al. (2020) investigated very early mobilisation protocols (first 48h post-surgery) versus usual nursing. Delirium was less common in the interventional group.

Finally, a randomised trial conducted in four ICUs in Germany and UK showed the feasibility of patient mobilisation during the evening, resulting in a tendency towards less delirium (Nydahl et al. 2021).

Early Mobilisation Effects on Long-Term Cognitive Outcome

Few studies have evaluated early mobilisation as a strategy to reduce post-ICU cognitive decline; comprehensive cognitive assessment is neither easy nor quick.

The Australian and New Zealand Intensive Care Society recently published a randomised trial combining early mobilisation with protocolised interruption of sedation (TEAM Study Investigators and the ANZICS Clinical Trials Group 2022). In this study, interventional EM did not improve the days alive and out of hospital, and no improvement in cognition, ADLs and psychological function were found between the groups.

Olotu et al. (2022) applied a delirium prevention bundle, mainly consisting of early mobilisation, in a group of patients who underwent cardiovascular surgery. The cognitive investigation battery was very extensive and performed both preoperatively and after surgery. No effect of the delirium prevention strategies on cognitive function was observed.

Patel et al. (2023) published a subsequent trial investigating EM alone and assessed cognitive impairment. The results at 12-month follow-up were very promising, as there was an overall risk reduction of cognitive deterioration of almost 20%. However, the authors advocated careful care for the increased rate of adverse events with intense and early mobilisation.

Finally, a recent randomised trial performed in the cardiovascular postoperative setting found a reduction in cognitive dysfunction when patients were treated with a three-phase EM protocol compared with a delayed, four-staged protocol and usual care (Allahbakhshian et al. 2023).

Efficacy of Early Mobilisation When Included in a Bundle

The idea of implementing EM as one of the other interventions in a bundle was already present in the earliest Pain Agitation/Sedation Delirium(PAD) guidelines in 2013 (Barr et al. 2013). More recently, Marra et al. (2017) summarised the evidence on which the 2018 PADIS guidelines were built. The different proposed non-pharmacologic strategies forming the bundle were given a name - the ABCDEF bundle (assessing pain, spontaneous awakening and breathing trials, choice of analgesia and sedation, delirium monitoring/management, early exercise/mobility, and family and patient empowerment) (Balas et al. 2013). An early implementation of the 2013 PAD guidelines was performed in a large cohort of more than 6000 patients (Barnes-Daly et al. 2017). Higher bundle compliance was independently associated with better survival and more delirium-free days.

Following the 2018 guidelines, two main reviews summarised the available evidence. A systematic review with meta-analysis by Zhang et al. (2020) evaluated the impact of bundle interventions on ICU delirium prevalence and duration. Including RCTs and cohort studies, the analysis failed to show that bundle interventions were effective in reducing delirium incidence and stay in the ICU. Nevertheless, the authors reported some efficacy in reducing the proportion of hospital length of stay with coma, which might have a beneficial impact on cognitive function. In the most recent systematic review by Sosnowski et al. (2023), the authors searched for barriers and facilitating conditions that influenced complete bundle application. The authors proposed the assessment of a wide range of patient-important and clinically relevant outcomes for future trials, as, unfortunately, no recent studies evaluating PAD/PADIS/ABCDEF bundles reported the impact on cognition.

Biological Mechanisms Mediating Mobilisation Effects on Cognitive Function

Physical activity appears to influence neurologic function with several mediators. Animal studies suggest that angiogenesis and neurogenesis in the hippocampus (the brain area linked to memory and recall) are promoted by physical exercise (Hopkins et al. 2012). These effects are thought to be muscle-induced through a cytokine-based crosstalk between muscle and specific brain areas (Pedersen 2019). These myokines are of growing interest as they appear to influence several other functions, particularly in patients with sarcopenia (Kim et al. 2019).

In humans, exercise is beneficial to patients suffering from neuro-degeneration due to diseases (Mahalakshmi et al. 2020) or from age-related cognitive impairment (Sujkowski et al. 2022). Promoting mobility is helpful also in other pathological conditions such as COPD (Hopkins et al. 2012) and stroke (Middleton et al. 2013).

Since cognitive impairment and delirium are common in the ICU, there is a strong rationale that mobilisation might benefit critically ill patients as well, also considering the high incidence of sarcopenia and muscle wasting.

Conclusion

In addition to its effects on physical outcomes (such as muscular strength and mobility), EM is one of the few and one of the most promising strategies that could prevent and shorten delirium duration and improve long-term cognitive function. Further research is required to confirm these findings and to identify the best EM protocol (as a stand-alone intervention or included in a bundle) aimed at preventing ICU cognitive decline.

Conflict of Interest

None.

References

Allahbakhshian A et al. (2023) Comparison of early mobilization protocols on postoperative cognitive dysfunction, pain, and length of hospital stay in patients undergoing coronary artery bypass graft surgery: A randomized controlled trial. Appl Nurs Res. 73:151731.

Balas MC et al. (2013) Implementing the awakening and breathing coordination, delirium monitoring/management, and early exercise/mobility bundle into everyday care: opportunities, challenges, and lessons learned for implementing the ICU Pain, Agitation, and Delirium Guidelines. Crit Care Med. 41(9 Suppl 1):S116-27.

Barnes-Daly MA et al. (2017) Improving hospital survival and reducing brain dysfunction at seven California community hospitals: Implementing PAD guidelines via the ABCDEF bundle in 6,064 patients. Crit Care Med. 45(2): 171–178.

Barr J et al. (2013) Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit. Crit Care Med. 41(1): 263–306.

Chen TJ et al. (2022) Comparative effectiveness of non-pharmacological interventions for preventing delirium in critically ill adults: A systematic review and network meta-analysis. Int J Nurs Stud. 131:104239.

Devlin JW et al. (2018) Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. Crit Care Med. 46(9):e825–e873.

Dinglas VD et al. (2018) Understanding patient-important outcomes after critical illness: a synthesis of recent qualitative, empirical and consensus-related studies. Curr Opin Crit Care. 24:401-09.

Hiser SL et al. (2023) Postintensive care syndrome (PICS): recent updates. J Intensive Care. 11(1):23.

Honarmand K et al. (2020) Natural history of cognitive impairment in critical illness survivors. A systematic review. Am J Respir Crit Care Med. 202(2):193-201.

Hopkins RO et al. (2012) Improving post-intensive care unit neuropsychiatric outcomes. Am J Resp Crit Care Med. 186(12):1220–1228.

Kang J et al. (2018) Effect of nonpharmacological interventions for the prevention of delirium in the intensive care unit: A systematic review and meta-analysis. J Crit Care. 48(1):372–384.

Kim S et al. (2019) Roles of myokines in exercise-induced improvement of neuropsychiatric function. Pflügers Arch. 471(3):491–505.

Liang S et al. (2021) Effects of nonpharmacological delirium-prevention interventions on critically ill patients' clinical, psychological, and family outcomes: A systematic review and meta-analysis. Aust Crit Care. 34(4):378–387.

Mahalakshmi B et al. (2020) Possible neuroprotective mechanisms of physical exercise in neurodegeneration. Int J Mol Sci. 21(16):5895.

Marra A et al. (2017) The ABCDEF bundle in critical care. Crit Care Clin. 33(2):225–243.

Mart MF et al. (2021) Prevention and management of delirium in the intensive care unit. Semin Respir Crit Care Med. 42(1):112-126.

Middleton LE et al. (2013) Physical activity in the prevention of ischemic stroke and improvement of outcomes: A narrative review. Neurosci Biobehav Rev. 37(2):133–137.

Needham DM et al. (2012) Improving long-term outcomes after discharge from intensive care unit: Report from a stakeholders' conference. Crit Care Med. 40:502-09.

Nydahl P et al. (2020) PROtocol-based MObilizaTION on intensive care units: Stepped-wedge, cluster-randomized pilot study (Pro-Motion). Nurs Crit Care. 25(6):368–375.

Nydahl P et al. (2021) Mobilization in the evening to prevent delirium: A pilot randomized trial. Nurs Crit Care. 27(4):519–527.

Nydahl P et al. (2023) Early mobilisation for prevention and treatment of delirium in critically ill patients: Systematic review and meta-analysis. Intensive Crit Care Nurs. 74:103334.

Olotu C et al. (2022) The effect of delirium preventive measures on the occurrence of postoperative cognitive dysfunction in older adults undergoing cardiovascular surgery. The DelPOCD randomised controlled trial. J Clin Anesth. 78:110686.

Palashkappa JA, Hough CL (2021) How we prevent and treat delirium in the ICU. Chest. 160(4):13265-34.

Pandharipande PP et al. (2013) Long-term cognitive impairment after critical illness. N Engl J Med. 369:1306-16.

Patel BK et al. (2023) Effect of early mobilisation on long-term cognitive impairment in critical illness in the USA: a randomised controlled trial. Lancet Respir Med. 11(6):563–572.

Pedersen BK (2019) Physical activity and muscle–brain crosstalk. Nat Rev Endocrinol. 15(7): 383–392.

Shirvani F et al. (2020) Early mobilization reduces delirium after coronary artery bypass graft surgery. Asian Cardiovasc Thorac Ann. 28(9):566–571.

Sosnowski K et al. (2023) The effect of the ABCDE/ABCDEF bundle on delirium, functional outcomes, and quality of life in critically ill patients: A systematic review and meta-analysis. Int J Nurs Stud. 138:104410.

TEAM Study Investigators and the ANZICS Clinical Trials Group (2022). Early active mobilization during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747–1758.

Zhang S et al. (2020) Effectiveness of bundle interventions on ICU delirium: A meta-analysis. Crit Care Med. 49(2):335–346.

Early Mobilisation: Just a Fad?

A review of recent evidence on early mobilisation and rehabilitation and what remains to be defined.

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Introduction

Critical illnesses encompass a broad spectrum of pathologies that require support for different organs. This often leads to prolonged bed rest and secondary immobilisation, which ultimately fosters the development of Intensive Care Unit-acquired Weakness (ICU-AW). ICU-AW is the onset of muscle weakness detected in critically ill patients without a plausible cause other than critical illness, which can extend beyond hospital discharge (Stevens et al. 2009; Vanhorebeek et al. 2020). It is characterised by generalised muscle weakness with a predominance of proximal and symmetrical muscle involvement (Latronico et al. 2017; Vanhorebeek et al. 2020). ICU-AW harms patient's recovery from critical illness, leads to a deterioration in the quality of life, and recovery may be incomplete. Its prevalence ranges between 25% and 80% of ICU patients (Kho and Connolly 2023).

Different studies have classified ICU-AW into myopathy, polyneuropathy or a combination of both (Stevens et al. 2009). Numerous risk factors associated with ICU-AW have been described (**Table 1**) (Yang et al. 2018; Yang et al. 2022).

Despite the increase in research, studies focused on rehabilitation remain limited due to the absence of a standardised and agreed-upon set of outcomes (Kirkham and Williamson 2022). A systematic review (Lang et al. 2020) evaluated the quality and content of existing clinical guidelines. Despite the heterogeneity of the included publications and significant gaps in the evidence-based literature, it was demonstrated that there is an agreement on the principle of applying early mobilisation. The main areas for improving methodological quality and guideline information were as follows: consistent involvement of patients and families in the guideline development process, detailed evaluation of the quality of existing literature, external review, provision of an updated procedure, and review of existing literature on barriers and facilitators. It is worth highlighting the attempt of the Japanese Society of Intensive Care Medicine to provide standardised rehabilitation guidelines (Unoki et al. 2023) based on ten GRADE (Grading of Recommendations Assessment, Development and Evaluation) recommendations and four comments. The key points are summarised in **Figure 1.**

Defining Early Mobilisation

Mobilisation and rehabilitation activities overlap. The terms are often used interchangeably, although there are notable differences in the therapeutic basis. Mobility is "the process of moving oneself and changing and maintaining positions" (Bussmann and Stam 1998). Any member of the critical care team can perform mobility. In contrast, rehabilitation is "a set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment" (World Health Organization 2023). Rehabilitation interventions reflect individualised goals to address patients' needs. Rehabilitation professionals such as physiotherapists and occupational therapists have specialised skill sets with specific knowledge to assess deficits. That is, rehabilitation requires a high level of teamwork. Its successful application requires continuous interprofessional collaboration and communication, which can be enhanced with interprofessional rounds, standardised protocols, and shared mobilisation goals (Dubb et al. 2016; Lang et al. 2020).

Predisposing factors	Modifiable factors
Pre-admission frailty	Severity upon ICU admission
Female gender	Need for mechanical ventilation or renal replacement therapy
Comorbid conditions	ICU length-of-stay
	Drugs: vasoactives, glucocorticoids, neuromuscular agents

Table 1. ICU-AW risk factors

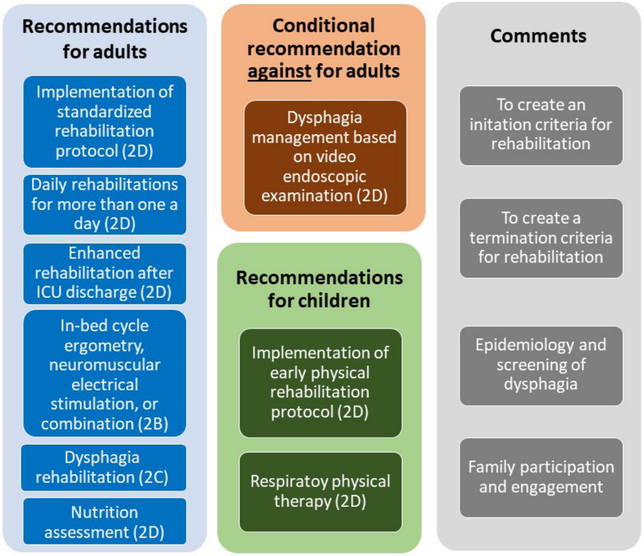

Figure 1. J ReCIP 2023 GRADE recommendations

How Early is Early Mobilisation Recommended?

Studies differ in the timing of the initiation of rehabilitation, which appears to have implications for outcomes. Studies where early mobilisation was started within 24 to 72 hours after ICU admission (Dong et al. 2014; Liu et al. 2022; Schaller et al. 2016) present more favourable outcomes than those where rehabilitation was delayed until the fifth to seventh day of admission, with no differences in hospital stay or functional status (Walsh et al. 2015; Wright et al. 2018).

When considering when to start early mobilisation, we must also acknowledge each patient's characteristics: one size does not fit all (Fuest et al. 2023). In this case, grouping patients according to specific traits allows for optimised treatment. For example, the subset of patients most likely to benefit from physical rehabilitation appears to be those with a prolonged ICU stay (Waldauf et al. 2020). However, patients with greater severity are more likely to suffer ICU-acquired complications (Vanhorebeek et al. 2020). Early evidence indicates that these severe and frail patients can still benefit from achieving higher mobility levels at ICU discharge.

Duration of the Session

Several reasons influence the duration of mobilisation: (1) patient-related, (2) provider-related, and (3) organisational factors. Patient-related factors are probably the most important: the intrinsic possibility and capacity for mobilisation out of bed depend on the pre-admission status and the current impact of the illness. Provider-related factors include workload, individual motivation or attitude towards mobilisation, and training. Organisational factors include the culture towards mobilisation (e.g., the existence of mobilisation teams) and the existence of standard operating procedures or local protocols.

The duration of mobilisation sessions in critically ill patients has not been extensively studied. Two published studies (Lorenz et al. 2023; Schumann et al. 2020) set the limit at more or less than 40 minutes with favourable results regarding the preservation of functionality. The results suggested that longer mobilisation durations could help preserve the functionality of critically ill patients who survive the ICU stay (improvement in functional status and greater independence at ICU discharge: 96% versus 44%; $p < 0.001$). However, the maximum mobilisation achieved was the most important of all mobilisation parameters influencing the outcome. Observing subgroups by the level of mobilisation in patients with the highest level, the duration of mobilisation of more than 40 minutes ceased to be statistically significant.

The interaction between different components of mobilisation remains complex, but what seems clear is that a high dose of mobilisation therapy was associated with better functional outcomes, reduced mortality, and shorter stays—both in ICU and hospital (Scheffenbichler et al. 2021; Watanabe et al. 2021). Paton et al. (2024) demonstrated that higher levels of mobilisation measured by the ICU Mobility Score (IMS) produced better long-term outcomes with a positive impact on both functional status and perceived quality of life. Fuest et al. (2023) confirmed that in severely frail patients, the maximum level of the Surgical ICU Optimal Mobilisation Score (SOMS) achieved was the most influential factor in home discharge. In contrast, in young, traumatised patients, a higher level was not associated with a higher probability of home discharge. Therefore, a uniform mobilisation approach targeting higher therapy levels does not seem helpful in the heterogeneous group of critically ill patients. Finally, the recently published TEAM trial (Hodgson et al. 2022) showed no benefit from more prolonged and intense active mobilisation (120 additional minutes per day) on long-term outcomes, showing a higher incidence of adverse events during the intervention. An individualised approach is needed.

Number of Sessions

A recent systematic review reported how using a basic definition of usual care dose impacted key outcomes (Wang et al. 2022). If usual care was provided less than five days a week, the effect of rehabilitation interventions was amplified with a reduction in mechanical ventilation (MV) duration by 16 days, ICU stay by 18.7 days, and hospital stay by 24 days. In contrast, if usual care was provided five days/week or more, there were no differences in the duration of MV, and the differences in ICU and hospital stay were minor.

Contrary to what we might think, it has also been described (Bernhardt et al. 2015; Greening et al. 2014) that very early, intense, and high-dose mobilisation does not always have the best results in some patient cohorts. ICU-acquired weakness has muscular and nervous system characteristics that may limit the response to treatment.

Rehabilitation Strategies

The exercise performed during rehabilitation can be classified as passive, assisted, or active. Other research groups classify it into functional exercises (sitting, walking, rolling) and non-functional exercises, which include a range of motion, whether active or passive, neuromuscular electrical stimulation, and cycle ergometry (Nadeau et al. 2013; Wang et al. 2022). Studies show that passive mobilisation (Vollenweider et al. 2022) presents only a positive trend in sedated and ventilated patients concerning muscle structure, microcirculation, inflammation, and immune system factors. However, apparent efficacy could not be demonstrated. Different strategies and equipment can help with assisted and active mobilisation, and differences in the type of intervention can influence the demonstration of clinically significant differences (Hodgson et al. 2021).

Higher levels of mobilisation require patient participation. Consequently, physical rehabilitation is more effective when coordinated with proper management of analgosedation. Once again, interprofessional teamwork is key to coordinating the daily management of critically ill patients and rehabilitation strategies; exquisite coordination between doctors, nurses, physiotherapists, and occupational therapists is required. Their combined experience can be helpful in specific rounds for patients with complex needs, discussing recovery challenges, or setting care goals.

Current recommendations are for a gradual progression of functional exercises for at least five days a week (Wang et al. 2022). However, careful monitoring of load and rest is necessary to ensure recovery between sessions.

Beyond Rehabilitation

Other co-interventions should be considered when implementing rehabilitation. It is necessary to tailor the energy needs to the exercise and the stage of critical illness in which the patient is. Adequate nutrition management will provide the required nutrients for optimal muscle performance, minimise the effects of protein catabolism in the late inflammatory phase, and avoid overfeeding (Liu et al. 2024).

A proposed comprehensive strategy (De Man et al. 2024; Yébenes et al. 2024) involves (1) a detailed anamnesis and an adequate initial nutritional assessment to establish a medical and nutritional therapy according to the needs and characteristics of each patient; (2) a safe transition between nutritional therapy routes and between care units, with the primary objective of preserving lean mass in critically ill patients, considering metabolic factors, adequate protein intake, and muscle stimulation; (3) continuous monitoring due to the lack of precise tools to calculate nutritional efficiency in critically ill patients; and (4) a multidisciplinary approach. Such a comprehensive strategy can make a significant difference in the functional recovery of critically ill patients.

Regarding optimising the patient's nutritional aspect, swallowing function should be evaluated appropriately during ICU admission. It should be noted that the exact frequency of dysphagia in critically ill ICU patients remains uncertain due to the lack of a standardised approach. Due to variations in practices and dietary cultures in different countries, various screening methods for dysphagia have been devised, and an international standardisation has not been established. Additionally, although patients may swallow voluntarily, they may experience silent aspiration, making it necessary to combine several screening methods to determine the presence of dysphagia.

In critically ill patients, swallowing function is often impaired due to interventions such as endotracheal tube placement, tracheostomy, and surgical procedures. Older adults may have pre-existing dysphagia due to comorbidities and ageing. Dysphagia can also influence oral intake restrictions, dietary method changes, decisions regarding home discharge, and prognosis. Therefore, screening methods should ideally be easily performed at the bedside without special equipment. These methods must demonstrate high validity, reliability, sensitivity, and specificity and should be compared with reference techniques like video fluoroscopic swallowing studies or fibreoptic endoscopic evaluation of swallowing. Therefore, a combined assessment with a clinical review and endoscopic evaluation, which allows for greater diagnostic accuracy, is probably the correct approach, directing appropriate rehabilitation. Swallowing function rehabilitation should optimise sensory and motor functions, encompassing swallowing, cough efficacy, smell, and communication (Zaga et al. 2024).

How Do We Measure Outcomes?

Measuring outcomes is an essential part of the process, and the way to do it varies between studies. First, gathering information about the patient's functional status is crucial, affecting recovery goals after ICU admission (Muscedere et al. 2017). Additionally, a routine evaluation will help to adjust the rehabilitative treatment to the patient's situation and facilitate the transition at the patient's care level, ensuring continuity in the process and avoiding delays in recovery.

One of the challenges in selecting outcome measures for rehabilitation trials is the lack of reliable and validated measures to evaluate outcomes important to patients. For example, the EQ-5D is considered the most promising tool for measuring health-related quality of life. It is regularly used but has not been rigorously validated in the critically ill population (Lau et al. 2022). There is a lack of consensus on the appropriate timeframe for evaluating outcomes after rehabilitation and mobilisation interventions (Herridge and Azoulay 2023; Kho et al. 2023). It is essential to highlight that in qualitative research, patients describe an evolution of recovery priorities that differ over time (Scheunemann et al. 2020).

Barriers to Implementation

Physical rehabilitation is usually safe (Paton et al. 2024). However, two recent randomised controlled trials (Hodgson et al. 2022; Patel et al. 2023) reported increased adverse events. In particular, the reported events mainly consisted of temporary cardiorespiratory changes that occurred infrequently (<1% of 696 sessions) and rarely caused patient harm (0.1% of all patients). A recent meta-analysis comparing physical rehabilitation with usual care found no effects on the rate of adverse events [3% (693 events in 23,395 sessions); RR 1.09; 95% CI 0.69-1.74] or mortality [RR 0.98; 95% CI: 0.87-1.12] (Paton et al. 2023).

One of the first barriers we encounter when initiating early mobilisation is the haemodynamic instability that patients may present in the first days of admission, the need for deep sedation, or an altered level of consciousness. Regarding haemodynamic instability, the literature includes some studies on the dose of vasopressors considered safe for mobilisation without consensus (Lindholz et al. 2022; Yang et al. 2021). It is suggested that doses below 0.2 mcg/kg/min may be safe for mobilising patients.

Another barrier is patient safety concerns due to multiple catheters, tubes, and drains. Several articles have demonstrated that rehabilitating critically ill patients is generally safe (Adler and Malone 2012). Moreover, one of the leading causes of fear among staff is lack of training. A multiday protocol and ongoing training can significantly eliminate these barriers and provide security to healthcare personnel.

Patients recognise the importance of physical rehabilitation but often express it as a significant obstacle. Good communication and care consistency can foster patient confidence and participation (Van Willigen et al. 2020). Additionally, structured exercise plans that consider personal care, family visits, individual needs, and rest can reduce fatigue. A qualitative systematic review (Goddard et al. 2024) studied survivors' perceptions, opinions, and experiences on physical recovery and rehabilitation after hospital discharge. It was found that survivors struggle to access healthcare professionals and services post-discharge, influencing the drive for physical recovery. Supervised exercise programmes

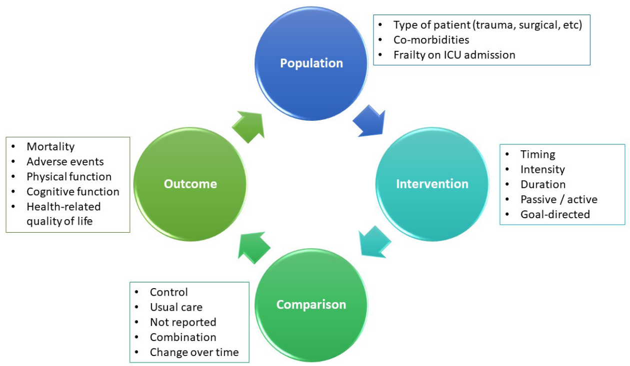

Figure 2. Heterogeneity in ICU rehabilitation studies

positively impact the perception of recovery and motivation. However, the "simple" provision of structured exercise does not address the variety of challenges experienced by ICU survivors (Herridge and Azoulay 2023).

Long-Term Advantages

Early rehabilitation has been associated with fewer hospital visits three years after discharge, shorter hospital stays, and lower healthcare costs after discharge than the late rehabilitation group (Murooka et al. 2023).

The potential of early mobilisation is not limited to counteracting the physiological consequences of critical illness in the physical recovery domain but also affects cognitive and mental function (Jackson et al. 2012). A recent review (Liu et al. 2024) summarises the current scientific evidence supporting early rehabilitation as a strategy against developing post-intensive care syndrome (PICS). The text attempts to elucidate the underlying mechanisms and analyses early rehabilitation from different perspectives: its application during ICU stay, hospital ward admission, and at home, the impact of early mobilisation on physical function, cognitive function, and the patient's psychological dimension (social function, mood, pain, quality of life, etc.).

Three systematic reviews (Brummel et al. 2014; Denehy et al. 2013; Schweickert et al. 2009) examined the effect of early mobilisation in the ICU, focusing on physical and functional outcomes as opposed to the cognitive impacts, for which a Cochrane review (Doiron et al. 2018) could not determine any treatment effect due to the heterogeneity of interventions and small sample size. In 2023, (Patel et al. 2023) published a randomised controlled trial analysing the impact of early rehabilitation on long-term cognitive function in patients who received mechanical ventilation. In this study, early physical and occupational therapy within the first 96 hours of mechanical ventilation was associated with a substantial improvement in cognitive impairment, neuromuscular weakness, and quality of life in physical health domains (although it is not clear whether this improvement is due to the interventions performed or the needed reduction in sedative drugs). In this regard, it should be noted that early mobilisation is one of the strategies included in the recommended bundles to prevent the development of delirium in critically ill patients (Matsuura et al. 2023), with a known impact on the cognitive domain of patients. Therefore, the implementation in practice of complex multidisciplinary interventions such as early mobilisation in the acute phase of critical illness has substantial benefits on long-term disability in survivors after mechanical ventilation.

The Upcoming Future

Incorporating new/emerging technologies such as virtual reality (VR), gaming consoles, apps, and robotics may provide the necessary boost to promote rehabilitation. Examples of already undertaken measures are using apps and telehealth complementary therapies to early mobilisation (Sumner et al. 2023). Apps provide easy system accessibility and customised treatment (Anan et al. 2021; Lo et al. 2018; Thiengwittayaporn et al. 2021). VR immerses the person in a fully simulated environment with 360-degree vision and simulated active movements (Oliveira et al. 2022). The application of VR in the ICU has proven to be safe and feasible while yielding promising results in cognitive/psychological areas such as anxiety reduction, pain levels, and delirium (Jawed et al. 2021; Merliot-Gailhoustet et al. 2022; Vlake et al. 2021). In small studies, VR has proven effective in promoting early mobilisation (through complete bed or chair play) (Hemphill et al. 2021; Lai et al. 2021).

Early mobilisation has also been safely delivered in the ICU through gaming platforms like the Nintendo Wii™ virtual therapy system and Xbox Kinect Jintronix, with studies reporting high patient engagement levels and no adverse events (Abdulsatar et al. 2013; Gomes et al. 2019; Parke et al. 2020). Gaming platforms allow patients to be remotely monitored and objectively assess their progress. From the patient's perspective, game-based exercises are attractive, easy to do, and adjusted to an appropriate difficulty level.

Other novel therapies to improve access to early mobilisation in the ICU may include interventions such as rehabilitation robotics or exoskeleton robots. Robots designed to assist in patient treatments in the ICU are primarily in the development phase or can currently only assist in manual manipulation tasks such as lifting/turning patients in bed. Exoskeletons have been proposed to facilitate out-of-bed mobilisation of ICU patients (Kosa et al. 2022; Luetz et al. 2019; Plaza et al. 2023).

What Remains to be Explored?

It has been demonstrated that early mobilisation is safe and feasible during and after ICU admission. Recent research trends have focused on exploring the optimal dosing and timing of early mobilisation administration (e.g., intensity, duration, frequency), complementary/additional interventions (e.g., clustered care, nutrition, environmental optimisation) (Mion et al. 2023; Renner et al. 2023; Singer et al. 2023), and technology/tools that can deliver early mobilisation (Ferre et al. 2021; Schrempf et al. 2023). The effects of early mobilisation on short-term outcomes (e.g., mortality, delirium, ICU length of stay, and weaning from mechanical ventilation) and long-term outcomes (e.g., PICS-related outcomes, healthcare resource utilisation, and economic and social impacts) are being examined. Research groups investigate the heterogeneous effect of early mobilisation among different ICU patient cohorts, optimising the intervention to fit patients' background comorbidities (Narváez-Martínez and Henao-Castaño 2024). In this regard, an artificial intelligence-based learning approach has recently demonstrated the heterogeneous effect of early mobilisation in different ICU patient cohorts, suggesting the importance of an individualised and optimised resource approach (Fuest et al. 2023).

There is increasing awareness and recognition of the relationship between the physical ICU environment and patient outcomes (Huisman et al. 2012; Wenham and Pittard 2009). Patients and staff report that small, cluttered, and suboptimal physical environments can impede the best care delivery and contribute to staff injuries and poor outcomes (Tronstad et al. 2021). Recent projects have shown that it is possible to optimise ICU environments, but there is no evidence that this impacts patient outcomes (Tronstad et al. 2023). Future ICU designs must consider the recent shift in care models from sedated to awake patients and provide an environment where early rehabilitation is possible (including sufficient space to store rehabilitation equipment).

Our Insight

ICU physicians must go beyond disease resolution and adopt a culture of recovery improvement with optimal physical rehabilitation. Promoting physical rehabilitation includes timely identification of suitable candidates with established safety standards, coordination of evidence-based interventions with selective sedation pauses, mobilisation interventions, and functional outcomes at ICU discharge. Finally, patients' experiences must be followed up and clinically evaluated to improve ICU care continually.

Despite the evolution and knowledge about the effects of early mobilisation on PICS, many gaps remain in current evidence, highlighting the need for continued thorough research, ensuring that individualised assessments and interventions are performed at the right time and continue after hospital discharge, exploring the optimisation of early mobilisation dosing, and evaluating patient outcomes while incorporating multifaceted preventive measures and predictive models. This essential work must be prioritised to ensure that ICU survivors survive and thrive in their post-ICU life.

Conflict of Interest

None.

References

Abdulsatar F, Walker RG, Timmons BW, Choong K (2013) "Wii-Hab" in critically ill children: A pilot trial. J Pediatr Rehabil Med. 6(4):193-202.

Adler J, Malone D (2012) Early mobilisation in the intensive care unit: A systematic review. Cardiopulm Phys Ther J. 23.

Bernhardt J, Langhorne PJ, Lindley RI et al. (2015) Efficacy and safety of early mobilisation within 24 h of stroke onset (AVERT): A randomised controlled trial. Lancet. 386(9988):46-55.

Bourenne J, Hraiech S, Roch A et al. (2017) Sedation and neuromuscular blocking agents in acute respiratory distress syndrome. Ann Transl Med. 5(14).

Brummel NE, Girard TD, Ely EW et al. (2014) 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. 40(3):370-9.

Bussmann JB, Stam HJ (1998) Techniques for measurement and assessment of mobility in rehabilitation: A theoretical approach. Clin Rehabil. 12(6):455-64.

Chillura A, Bramanti A, Tartamella F et al. (2020) Advances in the rehabilitation of intensive care unit acquired weakness: A case report on the promising use of robotics and virtual reality coupled to physiotherapy. Medicine (Baltimore). 99(28):e20939.

Connolly B, Denehy L, Hart N et al. (2018) Physical rehabilitation core outcomes in critical illness (PRACTICE): Protocol for developing a core outcome set. Trials. 19(1):294.

De Man AME, Gunst J, Reintam Blaser A (2024) Nutrition in the intensive care unit: From the acute phase to beyond. Intensive Care Med.

Denehy L, Lanphere J, Needham DM (2017) Ten reasons why ICU patients should be mobilised early. Intensive Care Med. 43(1):86-90.

Denehy L, Skinner EH, Edbrooke L et al. (2013) Exercise rehabilitation for patients with critical illness: A randomised controlled trial with 12 months of follow-up. Crit Care. 17(4):R156.

Doiron KA, Hoffmann TC, Beller EM (2018) Early intervention (mobilisation or active exercise) for critically ill adults in the intensive care unit. Cochrane Database Syst Rev. 3.

Dong Z, Yu B, Sun Y et al. (2014) Effects of early rehabilitation therapy on patients with mechanical ventilation. World J Emerg Med. 5(1):48.

Dubb R, Nydahl P, Hermes C et al. (2016) Barriers and strategies for early mobilisation of patients in intensive care units. Ann Am Thorac Soc. 13(5):724-30.

Ferre M, Batista E, Solanas A, Martínez-Ballesté A (2021) Smart health-enhanced early mobilisation in intensive care units. Sensors (Basel). 21(16):5408.

Flaws DFJ, Laupland K, Lavana J et al. (2024) Time in ICU and post-intensive care syndrome: How long is long enough? Crit Care.

Fuest KE, Ulm B, Daum N et al. (2023) Clustering of critically ill patients using an individualised learning approach enables dose optimisation of mobilisation in the ICU. Crit Care. 27(1):1.

Goddard S, Gunn H, Kent B, Dennett R (2024) The experience of physical recovery and physical rehabilitation following hospital discharge for intensive care survivors—A qualitative systematic review. Nurs Rep. 14(1):148-63.

Gomes TT, Schujmann DS, Fu C (2019) Rehabilitation through virtual reality: Physical activity of patients admitted to the intensive care unit. Rev Bras Ter Intensiva. 31(4).

Greening NJ, Williams JEA, Hussain SF et al. (2014) An early rehabilitation intervention to enhance recovery during hospital admission for an exacerbation of chronic respiratory disease: Randomised controlled trial. BMJ. 349(jul08 5):g4315-g4315.

Harvey MA, Davidson JE (2016) Postintensive care syndrome: Right care, right now...and later. Crit Care Med. 44(2):381-5.

Hemphill S, Nguyen A, Kwong J et al. (2021) Virtual reality facilitates engagement in physical therapy in the pediatric CVICU. Pediatr Phys Ther. 33(1):E7-9.

Herridge MS, Azoulay É (2023) Outcomes after critical illness. N Engl J Med. 388(10):913-24.

Hodgson CL, Berney S, Harrold M et al. (2012) Clinical review: Early patient mobilisation in the ICU. Crit Care. 17(1):207.

Hodgson CL, Schaller SJ, Nydahl P et al. (2021) Ten strategies to optimise early mobilisation and rehabilitation in intensive care. Crit Care. 25(1).

Hodgson CL, Bailey M, Bellomo R et al. (2022) Early active mobilisation during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-58.

Huebner L, Schroeder I, Kraft E et al. (2022) Frühmobilisation auf der Intensivstation – Sind robotergestützte Systeme die Zukunft? Anaesthesiologie. 71(10):795-800.

Huisman ERCM, Morales E, Van Hoof J, Kort HSM (2012) Healing environment: A review of the impact of physical environmental factors on users. Build Environ. 58:70-80.

Jackson JC, Ely EW, Morey MC et al. (2012) Cognitive and physical rehabilitation of intensive care unit survivors: Results of the RETURN randomised controlled pilot investigation. Crit Care Med. 40(4):1088-97.

Jawed YT, Golovyan D, Lopez D et al. (2021) Feasibility of a virtual reality intervention in the intensive care unit. Heart Lung. 50(6):748-53.

Kho ME, Berney S, Connolly B (2023) Physical rehabilitation in the intensive care unit: Past, present, and future. Intensive Care Med. 49(7):864-7.

Kho ME, Connolly B (2023) From strict bedrest to early mobilisation. Crit Care Clin. 39(3):479-502.

Kirkham JJ, Williamson P (2022) Core outcome sets in medical research. BMJ Med. 1(1):e000284.

Kosa G, Morozov O, Lehmann A et al. (2022) Robots and intelligent medical devices in the intensive care unit: Vision, state of the art and economic analysis.

Lai B, Powell M, Clement AG et al. (2021) Examining the feasibility of early mobilisation with virtual reality gaming using head-mounted display and adaptive software with adolescents in the pediatric intensive care unit: Case report. JMIR Rehabil Assist Technol. 8(2):e28210.

Lang JK, Paykel MS, Haines KJ, Hodgson CL (2020) Clinical practice guidelines for early mobilisation in the ICU: A systematic review. Crit Care Med. 48(11):E1121-E1128.

Latronico N, Herridge M, Hopkins RO et al. (2017) The ICM research agenda on intensive care unit-acquired weakness. Intensive Care Med. 43(9):1270-1281.

Lau VI, Johnson JA, Bagshaw SM et al. (2022) Health-related quality-of-life and health-utility reporting in critical care. World J Crit Care Med. 11(4):236-245.

Lindholz M, Schellenberg CM, Grunow JJ et al. (2022) Mobilisation of critically ill patients receiving norepinephrine: A retrospective cohort study. Crit Care. 26(1).

Liu K, Shibata J, Fukuchi K et al. (2022) Optimal timing of introducing mobilisation therapy for ICU patients with sepsis. J Intensive Care. 10(1).

Liu K, Tronstad O, Flaws D et al. (2024) From bedside to recovery: Exercise therapy for prevention of post-intensive care syndrome. J Intensive Care. 12(1).

Lorenz M, Fuest K, Ulm B et al. (2023) The optimal dose of mobilisation therapy in the ICU: A prospective cohort study. J Intensive Care. 11(1).

Luetz A, Grunow JJ, Mörgeli R et al. (2019) Innovative ICU solutions to prevent and reduce delirium and post-intensive care unit syndrome. Semin Respir Crit Care Med. 40(5):673-686.

Matsuura Y, Ohno Y, Toyoshima M, Ueno T (2023) Effects of non-pharmacologic prevention on delirium in critically ill patients: A network meta-analysis. Nurs Crit Care. 28(5):727-737.

Merliot-Gailhoustet L, Raimbert C, Garnier O et al. (2022) Discomfort improvement for critically ill patients using electronic relaxation devices: Results of the cross-over randomised controlled trial E-CHOISIR (Electronic-CHOIce of a System for Intensive care Relaxation). Crit Care. 26(1):263.

Mion LC, Tan A, Brockman A et al. (2023) An exploration of critical care professionals' strategies to enhance daily implementation of the Assess, Prevent, and Manage Pain; Both Spontaneous Awakening and Breathing Trials; Choice of Analgesia and Sedation; Delirium Assess, Prevent, and Manage; Early Mobility and Exercise; and Family Engagement and Empowerment: A group concept mapping study. Crit Care Explor. 5(3):e0872.

Moraes FDS, Marengo LL, Moura MDG et al. (2022) ABCDE and ABCDEF care bundles: A systematic review of the implementation process in intensive care units. Medicine (Baltimore). 101(25):E29499.

Murooka Y, Sasabuchi Y, Takazawa T et al. (2023) Long-term prognosis following early rehabilitation in the ICU: A retrospective cohort study. Crit Care Med. 51(8):1054-1063.

Nadeau SE, Wu SS, Dobkin BH et al. (2013) Effects of task-specific and impairment-based training compared with usual care on functional walking ability after inpatient stroke rehabilitation. Neurorehabil Neural Repair. 27(4):370-380.

Narváez-Martínez MA, Henao-Castaño ÁM (2024) Severity classification and influencing variables of the post-intensive care syndrome. Enferm Intensiva. 35(2):89-96.

Oliveira I, Afonso A, Oliveira E et al. (2022) Design principles for cognitive and physical rehabilitation of ICU patients using Virtual Reality (VR). 2022 IEEE 10th International Conference on Serious Games and Applications for Health (SeGAH). 1-7.

Parke S, Hough CL, Bunnell AE (2020) The feasibility and acceptability of virtual therapy environments for early ICU mobilisation. PM R. 12(12):1214-1221.

Patel BK, Wolfe KS, Patel SB et al. (2023) Effect of early mobilisation on long-term cognitive impairment in critical illness in the USA: A randomised controlled trial. Lancet Respir Med. 11(6):563-572.

Paton M, Chan S, Serpa Neto A et al. (2024) Association of active mobilisation variables with adverse events and mortality in patients requiring mechanical ventilation in the intensive care unit: A systematic review and meta-analysis. Lancet Respir Med. 12(5):386-398.

Paton M, Chan S, Tipping CJ et al. (2023) The effect of mobilisation at 6 months after critical illness—Meta-analysis. NEJM Evid. 2(2).

Paton M, Lane R, Paul E et al. (2021) Mobilisation during critical illness: A higher level of mobilisation improves health status at 6 months, a secondary analysis of a prospective cohort study. Crit Care Med. 49(9):E860-E869.

Peper KK, Aasmann A, Jensen ER, Haddadin S (2023) Real-time-capable muscle force estimation for monitoring robotic rehabilitation therapy in the intensive care unit. 2023 45th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). 1-6.

Plaza A, Hernandez M, Puyuelo G et al. (2023) Wearable rehabilitation exoskeletons of the lower limb: Analysis of versatility and adaptability. Disabil Rehabil Assist Technol. 18(4):392-406.

Renner C, Jeitziner MM, Albert M et al. (2023) Guideline on multimodal rehabilitation for patients with post-intensive care syndrome. Crit Care. 27(1).

Schaller SJ, Anstey M, Blobner M et al. (2016) Early, goal-directed mobilisation in the surgical intensive care unit: A randomised controlled trial. Lancet. 388(10052):1377-1388.

Scheffenbichler FT, Teja B, Wongtangman K et al. (2021) Effects of the level and duration of mobilisation therapy in the surgical ICU on the loss of the ability to live independently: An international prospective cohort study. Crit Care Med. 49(3):e247-e257.

Scheunemann LP, White JS, Prinjha S et al. (2020) Post–intensive care unit care: A qualitative analysis of patient priorities and implications for redesign. Ann Am Thorac Soc. 17(2):221-228.

Schrempf MC, Zanker J, Arndt TT et al. (2023) Immersive virtual reality fitness games to improve recovery after colorectal surgery: A randomised single-blind controlled pilot trial. Games Health J. 12(6):450-458.

Schujmann DS, Teixeira Gomes T, Lunardi AC et al. (2020) Impact of a progressive mobility program on the functional status, respiratory, and muscular systems of ICU patients: A randomised and controlled trial. Crit Care Med. 48(4):491-497.

Schweickert WD, Pohlman MC, Pohlman AS et al. (2009) Early physical and occupational therapy in mechanically ventilated, critically ill patients: A randomised controlled trial. Lancet. 373(9678):1874-1882.

Settembre N, Maurice P, Paysant J et al. (2020) The use of exoskeletons to help with prone positioning in the intensive care unit during COVID-19. Ann Phys Rehabil Med. 63(4):379-382.

Singer P, Blaser AR, Berger MM et al. (2023) ESPEN practical and partially revised guideline: Clinical nutrition in the intensive care unit. Clin Nutr. 42(9):1671-1689.

Stevens RD, Marshall SA, Cornblath DR et al. (2009) A framework for diagnosing and classifying intensive care unit-acquired weakness. Crit Care Med. 37(Suppl 10).

Sumner J, Lim HW, Chong LS et al. (2023) Artificial intelligence in physical rehabilitation: A systematic review. Artif Intell Med. 146:102693.

The TEAM Study Investigators and the ANZICS Clinical Trials Group (2022) Early active mobilisation during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Tronstad O, Flaws D, Lye I et al. (2021) The intensive care unit environment from the perspective of medical, allied health and nursing clinicians: A qualitative study to inform design of the 'ideal' bedspace. Aust Crit Care. 34(1):15-22.

Tronstad O, Flaws D, Patterson S et al. (2023) Creating the ICU of the future: Patient-centred design to optimise recovery. Crit Care. 27(1):402.

Unoki T, Hayashida K, Kawai Y et al. (2023) Japanese Clinical Practice Guidelines for Rehabilitation in Critically Ill Patients 2023 (J-ReCIP 2023). J Intensive Care. 11(1):47.

Van Willigen Z, Ostler C, Thackray D, Cusack R (2020) Patient and family experience of physical rehabilitation on the intensive care unit: A qualitative exploration. Physiotherapy. 109:102-110.

Vanhorebeek I, Latronico N, Van den Berghe G (2020) ICU-acquired weakness. Intensive Care Med. 46(4):637-653.

Vlake JH, Van Bommel J, Wils EJ et al. (2021) Virtual Reality to Improve Sequelae of the Postintensive Care Syndrome: A Multicenter, Randomized Controlled Feasibility Study. Crit Care Explor. 3(9):e0538.

Vollenweider R, Manettas AI, Häni N et al. (2022) Passive motion of the lower extremities in sedated and ventilated patients in the ICU – a systematic review of early effects and replicability of Interventions. PLoS One. 17(5 May):e0267255.

Waldauf P, Jiroutková K, Krajčová A et al. (2020) Effects of Rehabilitation Interventions on Clinical Outcomes in Critically Ill Patients: Systematic Review and Meta-Analysis of Randomized Controlled Trials. Crit Care Med. 48(7):1055-1065.

Walsh TS, Salisbury LG, Merriweather JL et al. (2015) Increased Hospital-Based Physical Rehabilitation and Information Provision After Intensive Care Unit Discharge. JAMA Intern Med. 175(6):901.

Wang YT, Lang JK, Haines KJ et al. (2022) Physical Rehabilitation in the ICU: A Systematic Review and Meta-Analysis. Crit Care Med. 50(3):375-388.

Watanabe S, Morita Y, Suzuki S et al. (2021) Effects of the Intensity and Activity Time of Early Rehabilitation on Activities of Daily Living Dependence in Mechanically Ventilated Patients. Prog Rehabil Med. 6(0):20210054.

Wenham T, Pittard A (2009) Intensive care unit environment. Contin Educ Anaesth Crit Care Pain. 9(6):178-183.

World Health Organization (2023) Rehabilitation. Available at https://www.who.int/news-room/fact-sheets/detail/rehabilitation

Wright SE, Thomas K, Watson G et al. (2018) Intensive versus standard physical rehabilitation therapy in the critically ill (EPICC): A multicentre, parallel group, randomised controlled trial. Thorax. 73(3):213-221.

Yang R, Zheng Q, Zuo D et al. (2021) Safety Assessment Criteria for Early Active Mobilisation in Mechanically Ventilated ICU Subjects. Respir Care. 66(2):307-315.

Yang T, Li Z, Jiang L, Wang Y, Xi X (2018) Risk factors for intensive care unit-acquired weakness: A systematic review and meta-analysis. Acta Neurol Scand. 138(2):104-114.

Yang Z, Wang X, Wang F et al. (2022) A systematic review and meta-analysis of risk factors for intensive care unit acquired weakness. Medicine (Baltimore). 101(43):e31405.

Yébenes JC, Bordeje-Laguna ML, Lopez-Delgado JC et al. (2024) Smartfeeding: A Dynamic Strategy to Increase Nutritional Efficiency in Critically Ill Patients—Positioning Document of the Metabolism and Nutrition Working Group and the Early Mobilization Working Group of the Catalan Society of Intensive and Critical Care Medicine (SOCMiC). Nutrients. 16(8):1157.

Zaga CJ, Wallace S, Freeman-Sanderson A (2024) Letter to the editor in response to the Japanese clinical practice guidelines for rehabilitation in critically ill patients 2023 (J-ReCIP 2023). J Intensive Care. 12(1):25

ESICM Webinar – Cardiovascular Management After Surgery

In a webinar at the ESICM Congress, Dr Aretha and Dr Garcia-Alvarez spoke about cardiovascular management after surgery. More specifically, Dr Aretha spoke about the management of post-operative atrial fibrillation, and Dr Garcia-Alvarez spoke about the importance of early application of vasopressin in septic shock patients.

Management of Postoperative Atrial Fibrillation After Cardiac and Major Non-Cardiac Surgery

Post-operative atrial fibrillation (POAF) can be triggered by acute factors, including inflammation, atrial oxidative stress, high sympathetic tone, electrolyte changes and volume overload, to name a few. Incidences of POAF are as high as 62% in certain types of surgery (combined valve surgery and CABG). These incidences can lead to neurological events, including stroke, renal failure, prolonged ICU stays, increased mortality and consequently also increased costs for the hospital (Hindricks et al. 2021; Maesen et al. 2012; Steinberg et al. 2014; Yadava et al. 2016; Zafrir et al. 2018; Lomivorotov et al. 2017; Farmakis et al. 2014; Chyou et al. 2023).

Rate control vs rhythm control

The European Heart Rhythm Association (EHRA) recommends rate control over rhythm control in the acute management of newly diagnosed AF. Haemodynamically stable patients should be assessed for reversible triggers and further be treated with beta-blockers for rate control (Boriani et al. 2019). The 2020 ESC guidelines recommend using beta-blockers, diltiazem or verapamil as a first-choice treatment in AF patients with LVEF≥40% for rate control. It is also recommended that patients with LVEF<40% should be treated with beta-blockers and/or digoxin for rate control. Amiodarone can be used as a last resort when the heart rate cannot be controlled by first-choice drugs (Hindricks et al. 2020).

According to the EHRA, beta-blockers should be used for rate control in cases of newly onset AF. Specifically, rapid onset and short-acting beta-blockers are preferred if haemodynamic instability is a risk factor (Boriani et al. 2019). Rate control is the preferred approach for ICU and postoperative patients, as the majority will convert to normal sinus rhythm after the resolution of the acute illness. One study showed that 81% of patients with AF reverted to normal sinus rhythm with only rate control treatment (Jones et al. 2020).

Esmolol or Landiolol: Which is the better beta-blocker for treating AF?

While the common beta-blocker used in the post-operative setting is esmolol, esmolol has negative inotropic properties, making its use problematic in patients with haemodynamic instability (Shibata et al. 2012).

Landiolol, which was developed in Japan and has been approved in Europe, is a relatively new beta-blocker with a more favourable pharmacodynamic and pharmacokinetic profile compared to esmolol. While landiolol is also rapid onset and short-acting, it also offers high cardioselectivity – almost eight times higher than esmolol (Krumpl et al. 2017). This is a major advantage as landiolol reduces the heart rate while not interfering with blood pressure. With lower dosing, landiolol is also suitable for patients with impaired left ventricular ejection fraction (Rapibloc SPC, current version).

According to the proposed algorithm for rate and rhythm control in acute, critically ill or postoperative patients by the European Society of Cardiology (ESC) published in the European Heart Journal Supplements, Volume 24, Issue Supplement_D, in June 2022, esmolol or landiolol should be used for rapid heart rate control (Dan et al. 2022). However, if the patient is haemodynamically unstable, landiolol is the preferred drug due to its more appropriate profile (Johnston et al. 2022).

Early Application of Vasopressin in Septic Shock

Septic shock is mainly characterised by vasoplegia because of the release of inflammatory mediators. The identification of hypoperfusion is key for the survival of these patients to select the most appropriate treatment (Kattan et al. 2022; Ramasco et al. 2024).

Control studies show that early administration of norepinephrine was associated with improved outcomes when treating septic shock. The timing of initiation of norepinephrine should be individualised based on the severity of hypotension (Hamzaoui et al. 2023; Evans et al. 2021).

Norepinephrine or vasopressin?

While the SSC guidelines still recommend using norepinephrine as a first-line treatment, as of 2021, these guidelines advocate adding vasopressin early on as second-line therapy rather than increasing the norepinephrine dose (Evans et al. 2021).

This second-line treatment is recommended because various circumstances in septic shock, including acidosis, hypoxia, hypocalcaemia, relative steroid deficiency and adrenergic receptors being less responsive, can decrease vasopressor effects in norepinephrine. In addition, patients with high levels of norepinephrine have an up to 80% risk of mortality due to the harmful effects of catecholamines (Martin et al. 2015). Furthermore, norepinephrine induces immunoparalysis, which is dysregulation of the immune response, compromising the host defence during sepsis (Stolk et al. 2020).

Dr Garcia-Alvarez suggests early multimodal vasopressors in the treatment of septic shock, which comprises a 'broad spectrum of vasopressors' with several therapeutic targets to achieve decatecholaminisation may be a new approach. With this method, the norepinephrine dose does not need to be increased thereby improving safety.

Why use vasopressin in septic shock?

Arginine vasopressin (AVP) is a vasoconstrictor with no inotropic effect, a non-catecholamine and has a short half-life (5-15 mins) (Garcia-Alvarez et al. 2023). In Dr Garcia-Alvarez's opinion, the use of vasopressin in septic shock is rationalised by:

1. The fact that there is an AVP deficiency in septic shock.
2. A multimodal strategy sparing catecholamines.
3. A potential nephroprotective effect.
4. The potential improvement of coagulation.

When is the optimal time to introduce AVP?

The SSC guidelines recommend starting vasopressin when the norepinephrine dose is between 0.25 and 0.5 μg/kg/min instead of escalating the norepinephrine dose (Evans et al. 2021). However, several recent studies showed significant benefits if vasopressin was started within three hours (Brask et al. 2023), at lactate levels <2,3 and/or at norepinephrine doses of <10 μg/kg/min (Sacha et al. 2023).

The response to vasopressin is potentially an indicator of the patient's prognosis. Patients responding to AVP showed lower mortality, more hospital-free days at day 28, and a lower rate of renal replacement therapy (Sacha et al. 2018).

Dr Garcia-Alvarez concludes that it is important to point out that vasopressin is not a rescue treatment but has to be initiated early in the treatment when norepinephrine is at ≥0,25 μg/kg/min to be most effective.

If you want to watch the whole webinar, please visit the webinar library on the ESICM website, or follow this link: https://mediatheque.cyim.com/mediatheque/media.aspx?mediaId=196721&channel=71460

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References

Boriani G, Fauchier L, Aguinaga L et al. (2019) European Heart Rhythm Association (EHRA) consensus document on management of arrhythmias and cardiac electronic devices in the critically ill and post-surgery patient, endorsed by Heart Rhythm Society (HRS), Asia Pacific Heart Rhythm Society (APHRS), Cardiac Arrhythmia Society of Southern Africa (CASSA), and Latin American Heart Rhythm Society (LAHRS). Europace. 21(1):7-8.

Brask AL, Shemanski SM, Barnes TE, Holmes AK (2023) Timing of Vasopressin Addition to Norepinephrine and Efficacy Outcomes in Patients With Septic Shock. Ann Pharmacother. 57(5):521-526.

Chyou JY et al. (2023) Atrial Fibrillation Occurring During Acute Hospitalization: A Scientific Statement From the American Heart Association. Circulation. 147(15): e676-e698.

Dan GA, Dan AR, Ivanescu A, Buzea AC (2022) Acute rate control in atrial fibrillation: an urgent need for the clinician. Eur Heart J Suppl. 24(Suppl D):D3-D10.

Evans L, Rhodes A, Alhazzani W et al. (2021) Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock 2021. Critical Care Medicine. 49(11):e1063-e1143.

Farmakis D, Parissis J, Filippatos G (2014) Insights Into Onco-Cardiology: Atrial Fibrillation in Cancer, Journal of the American College of Cardiology. 63(10):945-953.

García-Álvarez R, Arboleda-Salazar R (2023) Vasopressin in Sepsis and Other Shock States: State of the Art. J Pers Med. 13(11):1548.

Hamzaoui O, Goury A, Teboul JL (2023) The Eight Unanswered and Answered Questions about the Use of Vasopressors in Septic Shock. J Clin Med. 12(14):4589.

Hindricks G et al. (2021) 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. Eur Heart J. 42(5):373-498.

Johnston BW, Chean CS, Duarte R et al. (2022) Management of new onset atrial fibrillation in critically unwell adult patients: a systematic review and narrative synthesis. Br J Anaesth. 128(5):759-771.

Jones TW, Smith SE, Van Tuyl JS, Newsome AS (2021) Sepsis With Preexisting Heart Failure: Management of Confounding Clinical Features. J Intensive Care Med. 36(9):989-1012.

Kattan E, Bakker J, Estenssoro E et al. (2022) Hemodynamic phenotype-based, capillary refill time-targeted resuscitation in early septic shock: The ANDROMEDA-SHOCK-2 Randomized Clinical Trial study protocol. Rev Bras Ter Intensiva. 34(1):96-106.

Krumpl G, Ulc I, Trebs M et al. (2017) Bolus application of landiolol and esmolol: comparison of the pharmacokinetic and pharmacodynamic profiles in a healthy Caucasian group. Eur J Clin Pharmacol. 73(4):417-428.

Lomivorotov VV, Efremov SM, Kirov MY et al. (2017) Low-Cardiac-Output Syndrome After Cardiac Surgery. J Cardiothorac Vasc Anesth. 31(1):291-308.

Maesen B, Nijs J, Maessen J et al. (2012) Post-operative atrial fibrillation: a maze of mechanisms. Europace. 14(2):159-74.

Martin C, Medam S, Antonini F et al. (2015). norepinephrine: Not too much, too long. Shock. 44(4):305-9.

Ramasco F, Aguilar G, Aldecoa C et al. (2024) Towards the personalization of septic shock resuscitation: the fundamentals of ANDROMEDA-SHOCK-2 trial. Rev Esp Anestesiol Reanim (Engl Ed). 71(2):112-124.

Sacha GL, Bauer SR (2023) Optimizing Vasopressin Use and Initiation Timing in Septic Shock: A Narrative Review. Chest. 164(5):1216-1227.

Sacha GL, Lam SW, Duggal A et al. (2018) Predictors of response to fixed-dose vasopressin in adult patients with septic shock. Ann Intensive Care. 8(1):35.

Shibata S, Okamoto Y, Endo S, Ono K (2012) Direct effects of esmolol and landiolol on cardiac function, coronary vasoactivity, and ventricular electrophysiology in guinea-pig hearts. J Pharmacol Sci. 118(2):255-65.

Steinberg BA, Zhao Y, He X et al. (2014) Management of postoperative atrial fibrillation and subsequent outcomes in contemporary patients undergoing cardiac surgery: insights from the Society of Thoracic Surgeons CAPS-Care Atrial Fibrillation Registry. Clin Cardiol. 37(1):7-13.

Stolk RF, van der Pasch E, Naumann F et al. (2020) Norepinephrine Dysregulates the Immune Response and Compromises Host Defense during Sepsis. Am J Respir Crit Care Med. 202(6):830-842.

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Zafrir B, Lund LH, Laroche C et al. (2018) Prognostic implications of atrial fibrillation in heart failure with reduced, mid-range, and preserved ejection fraction: a report from 14 964 patients in the European Society of Cardiology Heart Failure Long-Term Registry. Eur Heart J. 39(48):4277-4284.

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References: **1.** Evans L, Rhodes A, Alhazzani W et al.: Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. Intensive Care Med (2021) 47:11811247 **2.** Russell JA: Benchtobedside review: Vasopressin in the management of septic shock. Crit Care. 2011; 15(226):119 **3.** Dünser M.W.: Arginine vasopressin in advanced vasodilatory shock: a prospective, randomized, controlled study; Circulation.2003 May 13;107(18):23139.17. **4.** Gordon A.C. et al.: The effects of vasopressin on acute kidney injury in septic shock. Intensive Care Med 2010; 36:8391. **5.** Russel JA: Vasopressin versus Norepinephrine Infusion in Patients with Septic Shock. N Engl J Med 2008; 358:87787

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Current Controversies in Early Mobilisation in the ICU


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This article will address current and controversial topics regarding early mobilisation and respiratory therapy in critically ill patients in the Intensive Care Unit (ICU). We will explore the implications, challenges, and potential benefits related to these interventions, highlighting the need for ongoing research and discussion in this evolving field.

Introduction

Holistic management in the ICU integrates physical therapy and rehabilitation to enhance the quality of life and functionality of the patients at discharge. Early mobilisation and respiratory therapy are routinely employed strategies in ICUs; however, recent studies have raised significant controversies that will be examined in this article.

Intensity and Frequency of Early Mobilisation - Is Less More?

Early mobilisation in the ICU has emerged as a strategy to improve outcomes in critically ill patients. However, the dosing and frequency of these interventions are subject to debate. The central question arises: is it more beneficial to perform two or more mobilisation sessions per day compared to just one?

Evidence suggests that, although early mobilisation can reduce complications such as ICU-acquired weakness and prolonged stay, the intensity and frequency of these sessions should be carefully considered. Some studies indicate that a "less is more" approach could be more effective, suggesting that lower doses of mobilisation, guided by functional goals and a rigorous analysis of risks and benefits, could lead to better outcomes without increasing the incidence of adverse events. This approach highlights the need to individualise mobilisation according to patient characteristics and clinical status, which might imply that one or two sessions a day, depending on the situation, could be more appropriate to optimise recovery and minimise risks.

Active mobilisation versus usual mobilisation

Recently, Hodgson et al. (2022) compared two strategies for early mobilisation in patients on mechanical ventilation. The first group, referred to as the active mobilisation group, implemented measures such as assisted standing with an average of 20.8 minutes of activity, compared to the second group, which received an average of 8.8 minutes of activity without the aforementioned measures. The authors demonstrated that there were no significant differences in mortality between the two groups ($p = 0.62$). However, significant differences were found in the incidence of complications in the active mobilisation group compared to usual mobilisation (9.2% vs 4.1%, $p = 0.005$), including arrhythmias $p = 0.03$) and oxygen desaturation ($p = 0.02$).

A systematic review with meta-analysis evaluating short- and medium-term mortality showed that the pooled mean difference was an increase of 4.28 days alive and out of hospital by day 180 in those patients who received early active mobilisation (95% confidence interval, -24.46 to 13.03; $I^2 = 41\%$). Nevertheless, a Bayesian analysis demonstrated a 95.1% probability of improved physical function, measured through a patient-reported outcome at six months (standardised mean difference, 0.2; 95% CI, 0.09 to 0.32; $I^2 = 50\%$) (Paton et al. 2023).

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Systematic mobilisation versus usual mobilisation

A systematic review demonstrated that early systematic mobilisation in patients with invasive mechanical ventilation, combined with occupational therapy aimed at muscle activation and initiated within seven days of ICU admission, defined by a specific protocol, along with neurocognitive intervention and speech therapy, did not show benefits in terms of improvements in functionality, strength, or incidence of ICU-acquired weakness, compared to usual mobilisation (Menges et al. 2021).

Early cycle ergometry in mechanically ventilated patients

A randomised controlled trial aimed at evaluating outcomes by comparing the early use of 30 minutes of cycle ergometry versus usual physiotherapy in mechanically ventilated patients found no improvement in physical functionality after discharge from the ICU (absolute difference, 0.23 points; 95% CI, −0.19 to 0.65; p= 0.29). No serious adverse events occurred in either group.

The discussion on the frequency and intensity of mobilisation sessions becomes a fundamental aspect of clinical practice in the ICU (Martínez et al. 2023). The aspects to consider when deciding on the intensity of mobilisation are:

Patient safety and tolerance

Mobilisation in critically ill patients must be carefully monitored. Recent studies suggest that a single mobilisation session may be sufficient to avoid fatigue and stress in compromised patients (Zhang et al. 2019). Excessive mobilisation can lead to complications such as haemodynamic instability or oxygen desaturation (Ding et al. 2019).

Effectiveness of mobilisation

The quality of mobilisation may be more important than the quantity. A well-structured session, adapted to the patient's capabilities, can provide significant benefits without the risk associated with multiple sessions. This is particularly relevant in patients with severe muscle weakness or those requiring mechanical ventilation (Cuello-García et al. 2021).

Functional outcomes

Recent research indicates that one mobilisation session per day may suffice to improve functional outcomes without needing multiple sessions. This can be particularly true in critically ill patient populations where fatigue and stress can be detrimental (Martínez-Camacho 2020).

Impact on recovery

Daily mobilisation has proven effective in reducing complications associated with ICU stay, such as ICU-acquired weakness and ventilator-associated pneumonia. This suggests that a well-planned session may suffice to achieve positive recovery outcomes (Mejía et al. 2021).

A focus on quality over quantity is essential, as mobilisation should be high-quality and tailored to the patient's individual needs. Instead of performing multiple mobilisation sessions per day, a well-planned and executed session may be more effective in promoting recovery and minimising the risk of complications (Martínez et al. 2023).

Mobilisation should be individualised. Protocols emphasising daily mobilisation, rather than multiple sessions, may be more effective in certain clinical contexts. This allows physiotherapists and medical teams to adjust mobilisation according to patient response, potentially more beneficial than a "one-size-fits-all" approach (Leditschke et al. 2022).

Acute conditions with no benefit from early mobilisation in first 24 hours

Early mobilisation in the ICU is a strategy that, while offering numerous benefits, is not always suitable for all patients within the first 24 hours. Certain pathologies, such as acute stroke, acute myocardial infarction, and severe exacerbations of respiratory diseases, might make immediate mobilisation unadvisable due to haemodynamic instability or the need for intensive medical management. In these cases, it is crucial to carefully assess the patient's condition before implementing any mobilisation programme, prioritising their safety and well-being.

Acute myocardial infarction (AMI)

Recent studies have indicated that although early mobilisation may be beneficial, continuous monitoring and individualised assessment are essential to minimise risks. Early mobilisation in post-myocardial infarction patients has demonstrated that, despite an increase in heart rate, blood pressure, and serum lactate, it does not appear to have significant associated adverse effects (Munir et al. 2020); however, early mobilisation in patients with acute myocardial infarction did not demonstrate a reduction in mortality in a systematic review of randomised controlled trials and quasi-randomised studies (RR 0.85, 95% CI 0.68-1.05) (Cortes et al. 2009).

Early mobilisation can be psychologically stressful for patients who are already dealing with the trauma of a heart attack, potentially compromising reperfusion or contributing to additional myocardial injury (Ferdinandy et al. 2023). Moreover, the associated anxiety and stress can further exacerbate a poor prognosis, as this psychological strain may adversely affect recovery in patients with acute myocardial infarction (Horne et al. 2020). Conversely, a small randomised controlled trial demonstrated a significant reduction in the incidence of depression in post-myocardial infarction patients following early mobilisation (Asgari et al. 2014).

Exacerbated chronic obstructive pulmonary disease (COPD)

Patients with exacerbated COPD may present with significant hypoxaemia and shortness of breath. Mobilisation can increase oxygen demand and respiratory workload, potentially worsening respiratory function and increasing complications such as bronchospasm and atelectasis. The GOLD guidelines suggest the initiation of pulmonary rehabilitation 2-4 weeks after patient

Figure 1. Early mobilisation in a critically ill patient on mechanical ventilation

stabilisation (GOLD 2024). However, a systematic review with meta-analysis aimed at evaluating the effects of early rehabilitation showed a reduction in the incidence of hospitalisation due to COPD exacerbation (RR 0.56, 95% CI 0.36 – 0.86), as well as an increase in submaximal cardiovascular capacity (SMD 0.73, 95% CI 0.48-0.99) (Meneses et al. 2023).

Respiratory instability

Patients with exacerbated COPD often present with hypoxaemia and significant breathing difficulties. Mobilisation can increase oxygen demand and respiratory workload, potentially worsening respiratory function and increasing the risk of complications such as bronchospasm and atelectasis (GOLD et al. 2024).

Muscle fatigue

Muscle weakness is a frequent issue in COPD patients, especially during exacerbations. Early mobilisation may produce excessive muscle fatigue, leading to decreased functional capacity and increased risk of falls and injuries. However, recent studies have shown that, when conducted in a controlled manner, early mobilisation can improve muscle strength and functional capacity without significantly increasing the risk of fatigue or injuries (Moecke et al. 2022).

Haemodynamic instability

Many patients with exacerbated COPD may exhibit haemodynamic instability, and ensuring haemodynamic stability is a criterion for initiating rehabilitation interventions. Failing to assess this can lead to dangerous changes in blood pressure and heart rate (Chou et al. 2019).

Need for intensive monitoring

Mobilisation of COPD patients requires careful and continuous monitoring to detect any signs of deterioration. During the first 24 hours, the medical staff might focus more on patient stabilisation, limiting the ability to implement a mobilisation programme. Nevertheless, recent studies have demonstrated that early mobilisation, even in the early stages of care, can be safe and beneficial, provided there is adequate monitoring (Schweickert et al. 2021).

Ischaemic stroke

Very early mobilisation in patients who have suffered an ischaemic stroke might not be beneficial due to several clinical and physiological factors that need to be considered. During the first 24 hours post-stroke, patients may experience fluctuations in their neurological status, improving neurological instability. In a pragmatic, prospective, multicentre, international randomised controlled trial, very early mobilisation that includes activities such as standing up, sitting out of bed, and walking, compared to usual care, was associated with poorer functional outcomes (46 vs 50%, OR 0.73, 95% CI 0.59-0.90, p=0.004) (Avert et al. 2017).

Very early mobilisation can increase the risk of complications, such as blood pressure drops and oxygen desaturation, which heighten the risk of secondary complications. Early mobilisation without proper evaluation can increase these risks, especially if the patient exhibits significant weakness or consciousness alterations. High-dose and very early mobilisation within 24 hours of stroke onset results in less favourable outcomes at three months (Powers et al. 2019).

Haemorrhagic stroke

Similarly, patients with haemorrhagic brain injuries initiating early mobilisation within the first 24 hours may face numerous risks and potential issues, such as new or increased bleeding, increased intracranial pressure, hypertension, clinical instability, and monitoring challenges. A randomised controlled trial demonstrated higher mortality in patients with haemorrhagic stroke subjected to very early mobilisation within the first 24 hours of the stroke compared to usual care (OR

4.17, 95% CI 1.06-16.43) (Bernhardt et al. 2021). On the other hand, a randomised controlled trial demonstrated that early mobilisation during the first 24 to 72 hours was associated with improvements in motor function (p= 0.004), better functionality at two weeks (p= 0.033) and four weeks (p= 0.011), and a shorter length of stay in a stroke unit (p= 0.004) (Yen et al. 2020). Early mobilisation has also been associated with improved posture, enhanced self-care, and a quicker return to normal activities (Marek et al. 2024).

In summary, it is recommended that the optimal time to initiate early rehabilitation in patients with acute stroke is after 24 hours, based on criteria for haemodynamic stability and safety. The recommended duration of mobilisation is between 15 and 45 minutes per session, divided into one to three times per day; however, these recommendations are not based on strong evidence (Aquino-Miranda et al. 2021).

Conclusion

Early mobilisation is a trending strategy in many ICUs. Based on the best available evidence to date, we cannot recommend very early and intensive mobilisation; instead, it is a better strategy to initiate mobilisation after 24 hours of ICU admission, taking into consideration patient safety and haemodynamic criteria, in order to achieve better functional outcomes and avoid significant complications (**Figure 1**). Further studies are needed on different intensities and frequencies of sessions in specific populations.

Conflict of Interest

None.

References

Bernhardt J, Borschmann K, Collier JM et al. (2021) Fatal and Nonfatal Events Within 14 days After Early, Intensive Mobilization Poststroke. Neurology. 96(8):e1156-e1166.

Chou W, Lai CC, Cheng KC et al. (2019) Effectiveness of early rehabilitation on patients with chronic obstructive lung disease and acute respiratory failure in intensive care units: A case-control study. Chron Respir Dis. 16:1479973118820310.

Cuello-García CA, Pérez-Gaxiola G, Reed K (2021) Early mobilization in critically ill children: a systematic review. J Pediatr. 203:25-33.e6.

Ding N, Zhang Y, Liu Y et al. (2019) What is the optimum time for initiation of early mobilization in mechanically ventilated patients? A network meta-analysis. PLoS One. 14(10):e0223151.

Ferdinandy P, Danser AHJ, Heusch G (2023) Multitargeted approaches to cardioprotection: A review. Pharmacol Rev. 75(1):159-216.

Global Initiative for Chronic Obstructive Lung Disease (GOLD) (2024) Global Strategy for the Diagnosis, Management, and Prevention of COPD. Report.

Horne BD, Thomas D, Rosamond W (2020) Psychological Stress and Early Mobilization in Acute Myocardial Infarction. Am J Cardiol.

Langhorne P, Wu O, Rodgers H, Ashburn A, Bernhardt J (2017) A Very Early Rehabilitation Trial after stroke (AVERT): a Phase III, multicentre, randomised controlled trial. Health Technol Assess. 21(54):1-120.

Leditschke AI, Green M, Irvine J, Bissett B (2022) Barriers to mobilizing intensive care patients: A systematic review. Cardiopulm Phys Ther J. 33(1):26-29.

Manning L, Hirakawa Y, Arima H et al. (2014) Blood pressure variability and outcome after acute intracerebral haemorrhage: a post-hoc analysis of INTERACT2, a randomised controlled trial. Lancet Neurol. 13(4):364-373.

Marek K, Zielińska-Nowak E, Redlicka J et al. (2024) Intracranial Hemorrhage—Is Very Early Rehabilitation Safe? A Narrative Review. Journal of Clinical Medicine. 13(13):3776.

Mariana de Aquino Miranda J, Mendes Borges V, Bazan R et al. (2023) Early mobilization in acute stroke phase: a systematic review. Top Stroke Rehabil. 30(2):157-168.

Martínez CMA, Herrera D, González T et al. (2020) El fisioterapeuta en la Unidad de Cuidados Intensivos: ¿un profesional necesario? Acta Medica. 18(1):104-105.

Martínez CMÁ, Lugo GDS, Gómez GA, Jones BRA (2023) Menos es más en movilización temprana en la Unidad de Cuidados Intensivos? Acta Med GA. 21(4):393-394.

Mejía AAC, Rodríguez MMJ, López GE et al. (2021) Movilización temprana como prevención y tratamiento para la debilidad adquirida en la Unidad de Cuidados Intensivos en pacientes en ventilación mecánica. Eur Sci J. 17(21):19-30.

Meneses-Echavez JF, Chavez Guapo N, Loaiza-Betancur AF et al. (2023) Pulmonary rehabilitation for acute exacerbations of COPD: A systematic review. Respir Med. 219:107425.

Menges D, Seiler B, Tomonaga Y et al. (2021) Systematic early versus late mobilization or standard early mobilization in mechanically ventilated adult ICU patients: systematic review and meta-analysis. Crit Care. 25:16.

Moecke HE, Faber-Langendoen M, Puhan MA et al. (2023) Safety and efficacy of inpatient pulmonary rehabilitation for patients hospitalized with an acute exacerbation of chronic obstructive pulmonary disease: a systematic review and meta-analysis. Ann Am Thorac Soc. 20(2):308-318.

Munir H, Fromowitz J, Goldfarb M (2020) Early mobilization post-myocardial infarction: A scoping review. PLOS ONE. 15(8):e0237866.

Paton M, Chan S, Tipping CJ et al. (2023) The Effect of Mobilization at 6 Months after Critical Illness - Meta-Analysis. NEJM Evid. 2(2):EVIDoa2200234.

Powers WJ, Rabinstein AA, Ackerson T et al. (2019) Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 50(12):e344-e418.

Schweickert WD, Pohlman MC, Pohlman AS et al. (2021) Early mobilization in the intensive care unit: A systematic review. Crit Care Med. 49(1):1-10.

TEAM Study Investigators, ANZICS Clinical Trials Group (2022) Early active mobilisation during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Yen HC, Jeng JS, Chen WS et al. (2019) Early mobilization of mild-moderate intracerebral hemorrhage patients in a stroke center: A randomized controlled trial. Neurorehabil Neural Repair. 33(1):73-81.

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1. Mandelbaum T et al. Outcome of critically ill patients with acute kidney injury using the AKIN criteria. *Crit Care Med* 2011;39(12):2659-2664.
2. Kobayashi M et al. Prognostic Value of Estimated Plasma Volume in Heart Failure in Three Cohort Studies; *Clin Res Cardiol* 2019;108(5): 549-561.
3. Niedermeyer, et al. Calculated Plasma Volume Status Is Associated With Mortality in Acute Respiratory Distress Syndrome. *Critical Care Explorations*: September 2021, V3(9):1-9.
4. Kim HK et al. Prognostic Value of Estimated Plasma Volume Status in Patients with Sepsis. *J Korea Med Sci* 2020;9(37):1-10.
5. Soliman HM. Development of ionized hypomagnesemia is associated with higher mortality rates. *Crit Care Med* 2003;31(4):1082-7.
6. Wilkes NJ et al. Correction of ionized plasma magnesium during cardiopulmonary bypass reduces the risk of postoperative cardiac arrhythmia. *Anesth and Analg* 2002;95(4) 828-834.

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Early Mobilisation in ICU: Current Practice and Areas for Improvement

A literature review to highlight how early mobilisation can improve patient-important outcomes, including length of ICU and hospital stay, duration of mechanical ventilation and overall quality of life in ICU survivors and the risks associated with EM and barriers to safe implementation of current practices, future directions, and the need for more studies to identify effective early mobilisation protocols.

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Introduction

An estimated 13 to 20 million people annually require life support in intensive care units (ICU) worldwide (Adhikari et al. 2010). Among those patients who require mechanical ventilation, 25% will develop prolonged neuromuscular weakness (Ali et al. 2009; De Jonghe et al. 2002). ICU-acquired weakness (ICUAW) is defined as clinically detected diffuse and symmetric muscle weakness without any cause other than the critical illness itself (Kress and Hall 2014). ICUAW has been shown in various studies to increase the risk of death, prolong hospitalisation, and impair recovery (Van Aerde et al. 2020; Hermans et al. 2014). Amongst causative factors, immobilisation and disuse are considered important contributors to the development of ICUAW. The concept of early mobilisation (EM) of critically ill patients has gained substantial favour due to its numerous benefits in patient recovery. Traditionally, critically ill patients were kept immobile to prevent complications, but more recent research has shown that engaging patients in physical activity as soon as it is clinically feasible helps to reduce muscle atrophy, improves cardiovascular function and improves overall functional outcomes in ICU survivors. EM has been linked to shorter hospital length of stay (LOS), reduced incidence of delirium, and better long-term physical and cognitive functioning. This proactive approach represents a paradigm shift towards more dynamic and patient-centred care in critical care settings.

Early mobilisation of ICU patients presents its own unique challenges. These include identifying the patient population that meets the specific criteria for diagnosis of ICUAW, formalisation of clinical tests used to identify ICUAW, screening of patients who will most benefit from early mobilisation, the actual techniques used to carry out early mobilisation, and lastly, the safety of such interventions. Critically ill patients typically have poor cardiopulmonary reserve, often require heavy sedation, and are bound by medical devices and equipment (lines, tubes, mechanical ventilation, and monitors), accidental dislodgement of such which can be fatal. Finally, these interventions should ideally show improvement in patient-centred outcomes, including mortality/morbidity benefits and/or an improvement in overall quality of life.

We reviewed the available literature to assess current knowledge of EM in critically ill patients. The term "early mobilisation" remains ill-defined and encompasses a range of heterogeneous interventions that have been used alone or in combination. Nevertheless, several studies suggest that different forms of EM may be both safe and feasible in ICU patients, including those receiving mechanical ventilation (Kress et al. 2000; Schaller et al. 2016). Unfortunately, studies of EM are primarily single-centre in origin, may have limited external validity and have highly variable control arms. Additionally, emerging technologies such as cycle ergometry, transcutaneous electrical muscle stimulation and video therapy are increasingly being used to achieve EM despite limited evidence of efficacy. Although evidence suggests that EM in the ICU is safe, feasible, and beneficial, it is also labour-intensive and requires appropriate staffing and equipment. Further research is required to identify specific patient populations, techniques, efficacy, and structured algorithms to maximise the benefit and safety of EM while not creating unnecessary demand on already taxed ICU staff and burdensome workflows.

Background

Historically, bedrest was considered a treatment for critical illness. In 1899, it was discovered that bedrest was deleterious in the post-operative period and that LOS could be shortened from days or weeks to hours by instituting earlier mobility (Ries 1899). In the late twentieth century, emerging evidence demonstrated that continuous sedation was associated with prolonged duration of mechanical ventilation as well as longer ICU and hospital LOS. After this, a landmark study by Kress et al. (2000) showed that daily interruption of sedation led to decreased duration of mechanical ventilation and ICU LOS. Researchers then began to examine the effect of mobilising ICU patients. Landmark studies began to show that early mobility decreased ICU and hospital stay, with patients returning earlier to independent functional status with significantly less post-ICU delirium (Bailey et al. 2007).

Early mobilisation is the application and intensification of physical rehabilitation given to patients within the initial two to five days of critical illness. It is delivered more regularly than conventional practice, which typically consists of passive range of motion exercises, reserving active mobilisation for the post-acute phase of illness. By the 1970s, the advantages of early mobilisation in mechanically ventilated patients were studied in adults (Burns and Jones 1975). Burns and Jones described the use of a novel device easily assembled from commercially available parts to incorporate a stable-wheeled walker with an armrest, respirator, oxygen source and IV pole. It demonstrated the utility of early ambulation to facilitate weaning and address the problems associated with prolonged rest. Since the early nineteenth century, studies have shown that EM of critically ill patients reduces the incidence of ICUAW, improves functional capacity, decreases days of mechanical ventilation and length of ICU stay and decreases comorbidities like development of deep venous thrombosis, ventilator-associated pneumonia, and integumentary pressure injuries (Zhang et al. 2019; Zang et al. 2019). However, these studies have been limited by small sample size and lack of standardisation in the population, intervention, and outcome measures. Most importantly, there are significant discrepancies between the diagnostic criteria used for ICUAW.

The Medical Research Council (MRC) sum score for muscle strength evaluation is an assessment of muscle strength and has been used to objectively describe ICUAW. The MRC sum score ranges between 0 and 60, and scores < 48 and < 36 co-relate to ICUAW and severe ICUAW, respectively (Hermans et al. 2012). Muscles tested include wrist flexion, forearm flexion, shoulder abduction, ankle dorsiflexion, knee extension, and hip flexion. Grades for each muscle are from 0 (no visible contraction) to 5 (normal strength). A total score of ≤ 48 with symmetrical weakness is diagnostic of ICU-AW after exclusion of other causes of weakness.

Certain patient populations are at a higher risk of developing ICU-AW. Nonmodifiable risk factors include older age, female sex, obesity, sepsis, and multiorgan failure. Unsurprisingly, in mechanically ventilated patients, the use of vasoactive medications and prolonged sedation has been associated independently with ICU-AW (Wolfe et al. 2018). Modifiable risk factors are extensive but include hyperglycaemia, use of steroids and immobility, especially in patients suffering from refractory hypoxaemia treated with neuromuscular blocking agents. Several observational studies of various EM interventions and their primary outcomes and findings are summarised in **Table 1.**

In the first observational study listed in the table, Bailey et al. (2007) documented 1,449 EM interventions in 103 patients. Of these, 53% involved ambulating patients who relied on positive pressure ventilation through an endotracheal tube or tracheostomy. Adverse events occurred in only 1% of these EM activities. This type of EM treatment utilised existing ICU staff, including nurses, technicians, physical therapists, and respiratory therapists.

Thomsen et al. (2008) conducted another study involving a before-and-after cohort study of 104 patients with respiratory failure necessitating ICU transfer. Patients under the care of an EM-focused ICU significantly increased the likelihood of ambulation during the patients' ICU stay (P <0.0001). 88% of patients survived to hospital discharge, with an average ambulation distance in the ICU of 200 feet.

Schweickert et al. (2009) conducted a prospective, outcome assessor blinded, RCT in two U.S. medical centres. This trial compared EM interventions with standard care in mechanically ventilated patients expected to have prolonged ventilated. The EM protocol included progressive activities during sedation interruption, leading to improved functional outcomes. This trial demonstrated the safety and feasibility of EM, highlighting its potential benefits in clinical practice.

Given the numerous benefits in these landmark studies, EM garnered significant attention. However, despite these initial successes, more recent studies have shown mixed results. In a 2016 RCT by Morris et al. (2016), standardised rehabilitation therapy compared with usual care did not demonstrate improvement in hospital LOS (primary outcome; P = 0.41) or ICU LOS (P = 0.68) or duration of mechanical ventilation (P = 0.59) but did demonstrate improved functional status at six months. Moss et al. (2016) also completed an RCT of EM in 2016 that compared an intensive PT programme with a standard-of-care PT programme in patients receiving mechanical ventilation. The intensive PT programme did not improve long-term (6-month) physical functional performance compared with the standard PT programme (primary outcome; P = .71). Notably, in the recent Treatment of Invasively Ventilated Adults with Early Activity and Mobilisation (TEAM) trial (2022), 9.2% of the patients in the EM intervention arm experienced an AE compared with 4.1% of patients in the usual care mobilisation group.

Discussion

In many ICUs, physical therapy only begins when patients are extubated (Mendez-Tellez et al. 2013). In contrast, early mobilisation starts within 48 hours of mechanical ventilation initiation and continues throughout ICU stay. This requires careful patient assessment and management, as well as interdisciplinary teamwork and training. There are many challenges to implementing early mobilisation interventions, which include identifying the patients that will benefit most from these practices, describing the mobility milestones in ICU, establishing protocols that have been shown to be a safe and consistent demonstration of improvement in long term consequences like overall mortality in ICU patients.

A variety of confounders explain the different outcomes among studies described in **Table 1.** These include variability of study populations, timing of intervention, functional status prior to the development of critical illness, and the use of different EM protocols. While most studies have been able to consistently demonstrate that EM improves physical function outcomes and hospital and ICU LOS, the effect on mortality, duration of mechanical ventilation, and quality of life outcomes remains unclear. Additionally, some of these studies may have been underpowered to demonstrate a difference in the primary outcome. Through our review of the current literature, we believe there is a signal towards improved physical function attributable to EM, a metric often cited by ICU survivors as vital to their sense of recovery after illness.

Study	No. of patients	Inclusion Criteria	EM intervention	Primary outcomes/Key findings
Bailey et al.	103	MV > 4 days	Sit on bed and chair, ambulate	EM events: 1,449 (53% ambulated) AEs: <1% (fall to the knees with no injury, SBP >200 or <90 mmHg, desaturation <80%)
Thomsen et al.	104	MV > 4 days	Early activity protocol including PROM, SOEOB, transfer to chair, walk	Outcomes: Increase in rate of ambulation compared to usual care
Morris et al.	165	MV	Early activity protocol with four levels of activity: PROM, active resisted exercise and sitting, SOEOB, and transfer to a chair	Outcomes: Intervention group received PT versus usual care, 80% vs. 47%, P ≤0.001
Needham et al.	57	MV > 4 days, non-surgical	Decreased sedation and increased PT and OT, particularly with functional mobility	Outcomes: less sedation, less delirium, more frequent EM, decreased ICU LOS and hospital LOS
Kho et al.	22	>18 years old, receiving PT	Video games	Safety and feasibility confirmed
Genc et al.	31	Critically ill Mean BMI 32kg/m^2	SOEOB, standing, transfer to a chair by walking, sitting in the chair	AE: Transient change in SBP or HR in six patients Outcomes: SpO2 significantly increased after mobilisation
Leditschke et al.	106	Mixed medical-surgical ICU	MOS >30 seconds, transfer bed-chair against gravity, passively lifted out of bed (hoist, sling)	AE: hypotension (1.1%) Barriers identified: femoral central lines, sedation, scheduled procedures

Table 1. Observational studies of EM in ICU

Abbreviations: AE, adverse events; HR, heart rate; LOS, length of stay; MOS, marching on the spot, MV mechanical ventilation; OT occupational therapy; PROM, passive range of movement; PT, physical therapy; RR, respiratory rate; SBP, systolic blood pressure; SOEOB, sit over edge of bed.

Patient selection for EM is varied across different studies. Surgical ICU patients, especially those undergoing cardiac surgery, seem to have benefitted the most from EM in terms of hospital length of stay and functional outcomes (Alaparthi et al. 2020). A systematic review by Santos et al. (2017) reported that early mobilisation in patients after cardiac surgery prevented postoperative complications, decreased length of hospital stay, and improved functional capacity when compared with no treatment. This is because EM has demonstrated enhanced oxygen transport and functional return, reducing postoperative complications and length of hospital stay. EM following surgery is beneficial because it improves ventilation, ventilation/perfusion matching, muscle strength and functional capacity.

Moradian et al. (2017) conducted a randomised controlled trial to study the effect of early mobilisation on pulmonary complications after coronary artery bypass graft (CABG) and found a lower incidence of atelectasis, pleural effusion, and improved oxygenation in the intervention group. While these are not patient-centred outcomes, anecdotally, these benefits likely reduce ICU LOS and improve end-organ perfusion.

Of course, confounders in surgical populations may include generally fewer comorbidities, less frailty, and better functional status compared to medical ICU populations. However, while most patients admitted to ICU benefit from physical therapy, there remains a need to identify patient characteristics that enable EM treatment to be prescribed and modified on an individual basis, with standardised pathways for clinical decision-making. To date, we are unaware of studies of the timing and duration of intervention to aid in the development of universal protocols. Furthermore, intensive care delivery relevant to EM is highly variable, including staffing structure, standardised practices, the use of written protocols, and the obvious barrier of over-sedation. Evidence for daily awakening and breathing trials is well documented in the literature and is outside the scope of this review, but similar principles may apply to EM. Lastly, patients need to be screened to determine their eligibility for the highest level of mobility with tailored patient-specific goals.

Proposed by Vasilevskis et al. in 2010, the ABCDE bundle is an effective strategy incorporating Awakening and Breathing coordination, Delirium monitoring/management, and Early exercise/mobility (Pun et al. 2019), aimed at improving the prognosis of mechanically ventilated patients by preventing delirium and ICU-acquired weakness (Vasilevskis et al. 2010). The implementation of the ABCDE bundle shortens the time spent on the ventilator, decreases the incidence of delirium, and increases the rate of early ambulatory mobilisation practice. Standing, walking, and gait exercises can reach higher levels of performance when whole ABCDE bundles are practiced. It is noteworthy that performing the A to D bundle is a prerequisite in order to effectively achieve early mobilisation. Moreover, tools like the ICU mobility scale (IMS) (Tipping et al. 2016) can be used by trained nurses/physical therapists when delivering EM to standardise the goal for patients. In contrast to mobility milestones (i.e. first time to stand or walk), which are commonly used as endpoints in studies of rehabilitation in the ICU, the IMS provides a sensitive 11-point scale, ranging from nothing (lying/passive exercises in bed, score of 0) to independent ambulation (score of 10). In one study, the IMS was predictive of 90-day mortality and discharge destination in an ICU population. The IMS is useful in providing a standardised method for assessing the daily highest level of mobilisation in the ICU for clinical and research purposes (Tipping et al. 2016). Zomorodi et al. (2012) tried to develop an early mobilisation protocol for patients in ICU. While some protocols were successful and decreased the length of ICU stay, we suggest that further studies with a larger sample size should be performed to establish the feasibility and efficacy of EM protocols.

Numerous barriers exist in delivering EM to patients admitted to the ICU. An exhaustive literature review in Chest outlined some of the barriers as well as proposed tactics to address them (Dubb et al. 2016). The study identified several barriers to EM, including concerns about medical stability, availability of appropriate equipment and trained staff, safety issues such as the risk of dislodging medical devices or patient falls, complications from sedation and delirium, and logistical challenges in the ICU environment. To address these obstacles, a multifaceted approach is proposed. This includes adopting a multidisciplinary team strategy involving physical therapists, nurses, and physicians to plan and execute safe mobilisation. Developing standardised protocols and guidelines based on patient condition and readiness is crucial, as is providing ongoing education to healthcare staff about the importance and techniques of EM. Implementing continuous monitoring tools to assess patient stability during mobilisation, engaging family members in the process, and employing a gradual progression approach starting with simple movements are also recommended. These strategies aim to overcome barriers and facilitate the implementation of EM programmes, potentially improving patient outcomes.

Farrand et al. (2014) performed a retrospective analysis of 100 consecutive patients who received ECMO, assessing the outcomes of those who participated in early mobilisation efforts. The study concluded that ambulation can be achieved safely and reliably in patients receiving ECMO with the help of a trained, multidisciplinary team. The study highlighted the potential advantages of early mobilisation for ECMO patients, suggesting that with appropriate protocols, more patients could benefit from active rehabilitation during their critical illness.

Perhaps the most comprehensive publication in this area is a recent systematic review of quantitative and qualitative studies that identified and evaluated factors influencing physical activity in the ICU setting (and post-ICU setting) (Parry et al. 2017). Eighty-nine papers were included with five major themes and 28 sub-themes: first, patient physical and psychological capability to perform physical activity, including delirium, sedation, motivation, weakness and anxiety; second, safety influences, including physiological stability and invasive lines; third, culture and team influences, including leadership, communication, expertise and administrative buy-in; fourth, motivation and beliefs regarding risks versus benefits; and lastly environmental influences including funding, staffing and equipment. Many of the barriers and enablers to physical activity were consistent across both qualitative and quantitative studies and geographical regions, and they supported themes established from previous research in this area. We suggest that most of these barriers can be overcome by raising general awareness about post-intensive care syndrome and the potential risks versus potential benefits of early mobilisation in the ICU. Systematic efforts to change ICU culture to prioritise early mobilisation using an interprofessional approach and multiple targeted strategies are important components of successfully implementing early mobility in clinical practice.

Emerging techniques used in EM include electrical muscle stimulation (EMS), cycle ergometry, hydrotherapy and a specialised tilt table called "the Sara Combilizer". A review by Baron et al. (2019) suggested that neuromuscular stimulation in ICU has positive effects and is safe to use. A cycle ergometer is a stationary cycle with an automatic mechanism that can alter the amount of work performed by the patient. The cycle ergometer can be used passively (no work from the patient) or actively. Cycle ergometry has been tested in healthy subjects as part of the space research programme and has been found to preserve thigh muscle thickness during prolonged immobilisation. The method has been shown to be safe and feasible in studies during haemodialysis and in patients with chronic obstructive pulmonary disease. An RCT studied the effect of cycle ergometry in early mobilisation post-cardiac surgery and concluded that it was safe but did not show significant difference in independent physical activity (Lordello et al. 2020). Fossat et al. (2018) found that early in-bed cycling exercises and EMS for quadriceps did not cause any significant change in global muscle strength at discharge from ICU when compared to usual care. The Sara Combilizer is a combined tilt table and stretcher chair, which allows passive transfer of patients out of bed. It's effectiveness in facilitating safe and early mobilisation found a reduction in time required for mobilisation and may be a beneficial adjunct to EM protocols. Hydrotherapy has also been studied, and it was found to be feasible and safe; however, further studies need to be done to assess its cost-effectiveness and benefits (Alaparthi et al. 2020). In a study of 410 patients receiving physical therapy (PT) in the medical ICU, 22 patients (5% of the total; 64% male; median age 52 years) participated in 42 PT sessions incorporating video games. The median number of video game sessions per patient was 1.0, with an interquartile range of 1.0-2.0. The primary reasons for using video game therapy were to improve balance (52%) and endurance (45%). The most frequently used video game activities were boxing (38%), bowling (24%), and balance board exercises (21%). Notably, 69% of these sessions occurred while patients were standing and 45% while patients were on mechanical ventilation. Throughout the 35 hours of PT treatment involving video games, no safety incidents were reported, with a 95% upper confidence limit for the safety event rate of 8.4%. The study concluded that the novel use of interactive video games as part of routine PT for critically ill patients is both feasible and appears to be safe based on this case series. The researchers suggest that video game therapy could potentially serve as a valuable complement to existing rehabilitation techniques for ICU patients (Kho et al. 2012).

These new interventions provide hope that EM techniques can be delivered safely among ventilated supine patients. However, their cost-effectiveness needs to be considered. Moreover, most of them require cumbersome staff training, and no trials have compared such interventions with a control group receiving standard care.

There remains a need to create standardised protocols and assessments using randomised controlled trials using best practices from the available trials and safety/implantation data to determine the optimal implementation of EM, with patient-centred outcomes including functional capacity and quality of life after ICU and hospital discharge. Despite the publication of safety recommendations and clinical practice guidelines, the implementation of early mobilisation remains a challenge in the ICU, particularly in the nonsurgical population. We recommend better adherence to sedation awakening trials and the development of mobilisation protocols, clinical leadership, and increased staff resources and training to effectively deliver EM techniques in ICU patients. Awareness of the deleterious effects of ICUAW is vital in engaging staff about the importance of EM. Further research is needed to understand the optimal timing, type and dose of interventions and their effect on long-term patient outcomes.

Conclusion

Early mobilisation in the ICU is currently a topic of much discussion and debate, with far-ranging implications for patients and healthcare systems. More than 15 RCTs in the past ten years, including several high-impact publications, have highlighted its importance and areas of future work. There are currently several international practice guidelines available and early mobilisation has been shown to be safe and feasible. There is no doubt that this intervention shows exciting potential. However, medical research has demonstrated that the results of pilot studies and observational studies may not result in improved patient-centred outcomes when tested in a larger trial. Future research should address gaps related to patient selection, dosage, team culture, and expertise. Future clinical practice guidelines in this area should focus on the engagement of patients and families in the development process and the provision of resources to support implementation based on the consideration of known barriers and facilitators. Effective and efficient EM practices require more standardised safety criteria, patient selection, protocolised approach, collaborative teamwork, specifically trained staff and patient and family engagement, as well as well-defined outcome measurements as key components of implementation.

Conflict of Interest

None.

References

Abrams D, Javidfar J, Farrand E et al. (2014) Early mobilisation of patients receiving extracorporeal membrane oxygenation: A retrospective cohort study. Crit Care. 18:R38.

Adhikari NKJ, Fowler RA, Bhagwanjee S, Rubenfeld GD (2010) Critical care and the global burden of critical illness in adults. Lancet.

Alaparthi GK, Gatty A, Samuel SR, Amaravadi SK (2020) Effectiveness, safety, and barriers to early mobilisation in the intensive care unit. Crit Care Res Pract. 7840743.

Ali NA, O'Brien JM Jr, Hoffmann SP et al. (2008) Acquired weakness, handgrip strength, and mortality in critically ill patients. Am J Respir Crit Care Med. 178(3):261-268.

Bailey P, Thomsen GE, Spuhler VJ et al. (2007) Early activity is feasible and safe in respiratory failure patients. Crit Care Med. 35(1):139-45.

Baron MV, de Mello Pinto MV, Koepp J et al. (2019) Neuromuscular electrical stimulation in intensive care unit patients: Integrative review. Mod Res Inflamm. 8(2):11-27.

Burns JR, Jones FL Jr. (1975) Early ambulation of patients requiring ventilatory assistance. Chest. 68(4):608a.

De Jonghe B, Sharshar T, Lefaucheur JP et al. (2002) Paresis acquired in the intensive care unit: A prospective multicenter study. JAMA. 288(22):2859-2867.

Dubb R, Nydahl P, Hermes C et al. (2016) Barriers and strategies for early mobilisation of patients in intensive care units. Ann Am Thorac Soc. 13(5):724-30.

Fossat G, Baudin F, Courtes L et al. (2018) Effect of in-bed leg cycling and electrical stimulation of the quadriceps on global muscle strength in critically ill adults: A randomized clinical trial. JAMA. 320(4):368-78.

Hermans G, Clerckx B, Vanhullebusch T et al. (2012) Interobserver agreement of medical research council sum-score and handgrip strength in the intensive care unit. Muscle Nerve. 45(1):18-25.

Hermans G, Van Mechelen H, Clerckx B et al. (2014) Acute outcomes and 1-year mortality of intensive care unit–acquired weakness: A cohort study and propensity-matched analysis. Am J Respir Crit Care Med. 190(4):410-420.

Kho ME, Damluji A, Zanni JM, Needham DM (2012) Feasibility and observed safety of interactive video games for physical rehabilitation in the intensive care unit: A case series. J Crit Care. 27(2):219.e1-6.

Kress JP, Hall JB (2014) ICU-acquired weakness and recovery from critical illness. N Engl J Med. 370(17):1626-1635.

Kress JP, Pohlman AS, O'Connor MF, Hall JB (2000) Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. N Engl J Med. 342(20):1471-1477.

Lordello GGG, Gama GGG, Ritt LEF (2020) Effects of cycle ergometer use in early mobilisation following cardiac surgery: A randomized controlled trial. Clin Rehabil. 34(4):485-94.

Mendez-Tellez PA, Dinglas VD, Colantuoni E et al. (2013) Factors associated with timing of initiation of physical therapy in acute lung injury patients. J Crit Care. 28(6):1061-6.

Moradian ST, Najafloo M, Mahmoudi H, Ghiasi MS (2017) Early mobilisation reduces the atelectasis and pleural effusion in patients undergoing coronary artery bypass graft surgery: A randomized clinical trial. J Vasc Nurs. 35(2):57-61.

Morris PE, Berry MJ, Files DC et al. (2016) Standardized rehabilitation and hospital length of stay among patients with acute respiratory failure: A randomized clinical trial. JAMA. 315(24):2694-702.

Moss M, Nordon-Craft A, Malone D et al. (2016) A randomized trial of an intensive physical therapy program for patients with acute respiratory failure. Am J Respir Crit Care Med. 193(10):1101-10.

Parry SM, Knight LD, Connolly B et al. (2017) Factors influencing physical activity and rehabilitation in survivors of critical illness: A systematic review of quantitative and qualitative studies. Intensive Care Med. 43(4):531-42.

Pun BT, Balas MC, Barnes-Daly MA et al. (2019) Caring for critically ill patients with the ABCDEF bundle: Results of the ICU Liberation Collaborative in over 15,000 adults. Crit Care Med. 47(1):3-14.

Ries E (1899) Some radical changes in the after-treatment of celiotomy cases. JAMA. 33(8):454-456.

Santos PMR, Ricci NA, Suster ÉAB et al. (2016) Effects of early mobilisation in patients after cardiac surgery: A systematic review. Physiotherapy. 102(1):1-9.

Schaller SJ, Anstey M, Blobner M et al. (2016) Early, goal-directed mobilisation in the surgical intensive care unit: A randomised controlled trial. Lancet. 388(10052):1377-1388.

Schweickert WD, Pohlman MC, Pohlman AS et al. (2009) Early physical and occupational therapy in mechanically ventilated, critically ill patients: A randomised controlled trial. Lancet. 373(9678):1874-82.

The TEAM Study Investigators and the ANZICS Clinical Trials Group (2022) Early active mobilisation during mechanical ventilation in the ICU. N Engl J Med. 387(19):1747-58.

Thomsen GE, Snow GL, Rodriguez L, Hopkins RO (2008) Patients with respiratory failure increase ambulation when transferred to an intensive care unit where early mobility is a priority. Crit Care Med. 36(4):1119-24.

Tipping CJ, Bailey MJ, Bellomo R et al. (2016) The ICU Mobility Scale has construct and predictive validity and is responsive: A multicenter observational study. Ann Am Thorac Soc. 13(6):887-97.

Van Aerde N, Meersseman P, Debaveye Y et al. (2020) Five-year impact of ICU-acquired neuromuscular complications: A prospective, observational study. Intensive Care Med. 46(8):1184-1193.

Vasilevskis EE, Ely EW, Speroff T et al. (2010) Transparency in health care: Reducing iatrogenic risks—ICU-acquired delirium and weakness—Crossing the quality chasm. Chest. 138(5):1224-33.

Wolfe KS, Patel BK, MacKenzie EL et al. (2018) Kress JP. Impact of vasoactive medications on ICU-acquired weakness in mechanically ventilated patients. Chest. 154(4):781-787.

Zang K, Chen B, Wang M et al. (2019) The effect of early mobilisation in critically ill patients: A meta-analysis. Nurs Crit Care.

Zhang L, Hu W, Cai Z et al. (2019) Early mobilisation of critically ill patients in the intensive care unit: A systematic review and meta-analysis. PLoS One. 14(10):e0223185.

Zomorodi M, Topley D, McAnaw M (2012) Developing a mobility protocol for early mobilisation of patients in a surgical/trauma ICU. Crit Care Res Pract. 964547.

Early Mobilisation: Movements, Barriers and Complications

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Early mobilisation includes several progressive kinds of movements. Many barriers and safety concerns must be addressed to allow a smooth and effective introduction of this procedure in the ICU daily practice.

Introduction

Early mobilisation is recommended as part of a multi-component, nonpharmacological strategy to improve physical, mental and cognitive outcomes of critically ill adults. Physical rehabilitation minimises muscle weakness and impaired physical functioning, reduces cognitive impairment and optimises nocturnal sleep (Devlin et al. 2018). Early mobilisation (EM) in the ICU includes passive and active movement and training. This multifaceted intervention involves a wide range of activities, from in-bed to out-of-bed exercises, as shown in **Table 1** (Clarissa et al. 2019; Nydahl et al. 2023; Watanabe et al. 2022). EM also refers to any other type of active exercise modality started while the participant is in the ICU, like activities of daily living (ADLs): self-care tasks such as eating, bathing, dressing and toileting (Doiron et al. 2018). Some studies exclude from this definition interventions such as turning in bed, change of positions, particularly when done to prevent pressure sores, or use of neuromuscular electrical stimulation or robotics (Nydahl et al. 2023), whereas other studies include them (Doiron et al. 2018). At present, EM lacks a specific definition and encompasses a range of heterogeneous interventions that have been used alone or in combination (Hodgson et al. 2013).

The combination of critical illness and prolonged immobility results in substantial muscle wasting during the ICU stay. That's one reason why EM should start as soon as feasible after admission to the ICU. Evidence suggests that starting rehabilitation within 72 hours from admission may lead to improvements in both physical and cognitive function, minimising the sequelae of prolonged physical immobilisation during mechanical ventilation, such as muscle atrophy, weakness, and paresis, thereby enhancing future autonomy and quality of life (Doironet al. 2018; Matsuoka et al. 2023). Furthermore, EM is a holistic activity with physical, cognitive, and psychosocial dimensions, including coordinated movements, increased proprioception, gravity effects, sympathetic activation of neurotransmitters, improved cerebral perfusion, cognitive activation and participation, and interaction with the

IN-BED EXERCISES	OUT-OF-BED EXERCISES
Active-assisted exercises: Exercises performed by the participant with manual assistance of another person	Sitting on the edge of the bed
Active range-of-motion exercises: Exercises moving a joint(s) through its range of motion that are performed independently by the participant	Standing
Cyclo-ergometer: A stationary cycle where work intensity can be adjusted by varying pedal resistance and cycling rate	Active/passive transfer training into a chair or commode
Bed mobility activities: Activities including rolling, bridging and transfer to upright sitting	Pre-gait exercises: Improving postural stability, static and dynamic balance and marching on the spot
	Walking or similar

Table 1: In-bed and out-of-bed exercises

environment and healthcare providers (Lai et al. 2017). These aspects may contribute to improving a patient's orientation and overall well-being, possibly facilitating their return to functional independence (Patel et al. 2023; Zhang et al. 2019).

The most common protocol was created by Morris et al. (2008) and is divided into four levels:

1. Level I: Passive extremities movements for unconscious patients.
2. Level II: Active extremities movements and interaction with the physical therapist for conscious patients who can respond to simple commands in a sitting position on the bed.
3. Level III: Like level II but sitting on the edge of the bed for patient's biceps strength of >3/5 on the Medical Research Council Scale (Medical Research Council 1976).
4. Level IV: Like level II, but with the patient actively moving from the bed to a chair beside the bed for patient's quadriceps strength of >3/5.

The highest level of mobilisation is kept for as long as possible before a step-down to lower levels of activity, should the patient become fatigued, as measured by the ICU Mobility Scale (Hodgson et al. 2014; Lai et al. 2017).

EM should be applied in short and frequent sessions (Eggmann et al. 2022). Morris suggests twice daily, five days a week and, if possible, involving caregivers (Lai et al. 2017; Morris et al. 2008).

The sessions are individually tailored to achieve the highest possible level of mobilisation that is deemed to be safe for the patient at the initiation of daily therapy. EM should be integrated into a patient-centred approach (Zhang et al. 2019).

Implementing an EM programme requires a multidisciplinary team and approach: a critical care nurse, nursing assistant, respiratory therapist, physical therapist, and even family (Lai et al. 2017). EM can be delivered either as a standalone intervention or as part of a broader care approach, such as the ABCDEF bundle, which addresses analgesia, sedation, delirium, mobilisation, and family integration (Frade-Mera et al. 2022; Nydahl et al. 2023).

Barriers to Implementation of Early Mobilisation

Implementation of EM in the ICU can be difficult due to several factors. Barriers correlated with EM could be divided into four groups: patient-related, structural, cultural and process-related barriers (Alaparthi et al. 2020).

Patient-related barriers

These include haemodynamic instability, pain, deep sedation, agitation and delirium, patient denial, lack of motivation, and lack of intensive care unit equipment and devices. Interventions must be tailored to patient conditions such as level of arousal, haemodynamic stability and tolerance. Fontela et al. (2018) reported in their multicentre Brazilian survey that the most common barriers in the application of EM were weakness, haemodynamic instability and sedation. Nurse's opinions about factors limiting EM were analysed in two surveys. In the cross-sectional multicentre survey of Zhang et al. (2022), instability of patients (94.9%), mechanical ventilation (84.6%) and unconsciousness (82.8%) were perceived as the main barriers. In a survey by Babazadeh et al. (2021), deep sedation (88.9%), mobilisation of obese patients (82.2%), mobilisation of agitated patients (65%) and pain induced by mobilisation of mechanically ventilated patients (57.9%) were perceived as significant barriers. Physiotherapists identified haemodynamic instability, raised intracranial pressure, low platelet count and mental instability as barriers (Tadyanemhanduet al. 2022). Barriers to EM were more frequent in the first seven days after admission (Watanabe et al. 2021); haemodynamic instability was the most common barrier on day 1 and day 2, while a reduced level of consciousness was most common on day 3 to 5 (Watanabe et al. 2021). Safety criteria for EM have been proposed in **Table 2.**

	Yang et al. 2021	Alaparthi et al. 2020
RASS	-2/+2	-2/+2
Heart rate	40-130 b/min	40-130 b/min
MAP	65/110 mmHg	60/110 mmHg
SBP	90/200 mmHg	90/180 mmHg
FiO2-PEEP	≤ 0,6 - ≤ 10 cmH2O	<0,6 - <10 cmH2O
SpO2-respiratory rate	≥88% - 5-40 b/min	>88% - >5 b/min
PaO2/FiO2	≥200	-
Temperature	No fever	<38,5

Table 2. Safety criteria for starting an early mobilisation session
RASS=Richmond Agitation Sedation Scale; MAP Mean Arterial Pressure; SBP Systolic Blood Pressure; FiO2: inspiratory oxygen fraction; PEEP: positive end-expiratory pressure; PaO2: arterial oxygen pressure; SpO2: pulse-oximetry

Structural barriers

These include limited staff, lack of guidelines, lack of equipment and lack of protocols. ICU staff reported that there is insufficient equipment and staff (87.9%), lack of appropriate training (83.6%) and lack of time for mobilising patients (Zhang et al. 2019; Babazadeh et al. 2021; Akhtar et al. 2021). Work experience is an important aspect for the perception of the barriers: health professionals with years of experience in hospitalised patients have a better approach to early mobilisation (Tadyanemhandu et al. 2022; Goodson et al. 2020). The lack of guidelines is remedied by the use of their own experience (Goodson et al. 2020). On the other hand, the introduction of guidelines and protocols alone is not sufficient to promote EM (Anekwe et al. 2020; Akhtar et al. 2021).

Cultural barriers

These include lack of knowledge and awareness about benefits and feasibility of EM (Anekweet al. 2020; Akhtar et al. 2021). Nurses and physicians that did not receive education and training on EM have inadequate knowledge about it and a low level of intention to apply EM, considering EM too risky and unnecessary (Zhang et al. 2022; Anekwe et al. 2020;Tadyanemhandu et al. 2022).

Process-related barriers

These include a lack of daily coordination and planning and risks for mobility providers. Patient safety and medical disputes are something nurses are concerned about (Zhang et al. 2022). Poor coordination in the multidisciplinary group can cause problems in planning daily treatments without goal-sharing (Anekwe et al. 2020; Tadyanemhanduet al. 2022; Akhtar et al. 2021).

All these barriers must be addressed and solved to allow the adoption of EM with the right protocol and the right "dose" for all suitable patients.

Adverse Events During Early Mobilisation

Traditionally, EM was avoided for lack of awareness of its beneficial effects and for the possible adverse events which may occur to frail ICU patients. In recent years, some studies have evaluated the incidence and type of adverse events during EM. Doiron et al. (2018) published a review focused on the safety profile of EM. Overall, the analysed studies included 690 adult patients and a wide range of interventions ranging from in-bed mobility to ambulation. Among the four included studies in the review, only two reported adverse events in the intervention group that were deemed to be related to EM: one asymptomatic bradycardia, one episode of severe oxygen desaturation and one episode of catheter dislodgement. Furthermore, only 19 sessions had to be ceased due to patient instability. (Doiron et al. 2018).

In a systematic review and meta-analysis, Takaoka et al. (2020) investigated the impact of in-bed leg cycle ergometry in the ICU. They collected data from 12 RCTs and two nonrandomised studies published between 2014 and 2019. Only five adverse events were reported out of 3117 sessions (0.16%). Six of the evaluated studies reported 18 session terminations during 1829 (0.98%) cycling sessions due to complications. However, the authors underlined the heterogeneity in the definitions of adverse events and in the criteria adopted for suspending a session.

In a meta-analysis on EM in mechanically ventilated patients (Klem et al. 2021), which included 17 studies and 1805 patients, only two life-threatening adverse events were identified: a case of bradycardia and one of hypoxia. A total of 79 adverse events were reported during 5675 sessions (1.4 %) and, among them, 35 of these events caused the interruption of the sessions.

Two studies evaluated EM safety in patients undergoing continuous renal replacement therapy (CRRT) or during extracorporeal life support (ECLS). Wang and colleagues (2014) published a prospective study, collecting data from 33 patients admitted to two Australian ICUs. The primary outcome of this study was to investigate the safety of mobilisation in patients who underwent CRRT via femoral vascular access. The authors included, as adverse events, the following: catheter dislodgement, clotting or disruption of filter and lines, bleeding or haematoma, clinical suspicion of thrombosis and arrhythmias. They tested three levels of mobilisation: in-bed passive mobilisation, sitting on the edge of the bed and walking. Each planned activity lasted 20 minutes. No adverse events occurred during mobilisation or after it. One of the participants also had a Swan-Ganz catheter in place, but neither arrhythmias nor other relevant clinical sequelae were reported. During mobilisation, no CRRT machine alarms rang. The authors also tested the hypothesis that mobilisation might reduce circuit and filter clotting. Data collected from the femoral venous access subgroup indicate that passive hip flexion and position changes might have increased filter life (Wang et al. 2014).

Most of the patients requiring ECLS are still treated with cautious strategies that include deep sedation and invasive mechanical ventilation since immobilisation and reduced range of passive movements may minimise complications. In 2023, Cucchi and co-authors performed a systematic review in order to provide evidence-based recommendations on early mobilisation in awake patients undergoing ECLS (Cucchi et al. 2023). They summarised data from 29 observational studies and one RCT, including 1157 patients who received physiotherapy while undergoing veno-venous or veno-arterial extracorporeal support. They investigated the incidence of adverse events caused by mobilisation while on ECLS, such as circuit kinking or cannula dislocation, bleeding, haemodynamic instability, respiratory failure or need for tracheal intubation, neurological deterioration or infections. Patients supported with non-invasive ventilation (NIV) and with femoral cannulation were more likely to develop mechanical and haemorrhagic complications (respectively 4.2% and 4.4%). Infective and cardiovascular complications were mostly reported in patients undergoing veno-arterial ECLS (11.3 and 9.5%). Neurological sequelae were rare and mostly affected patients supported with NIV who could walk (7.8%). They concluded that EM, and even ambulation, can be safely performed regardless of the cannulation site (Cucchi et al. 2023).

Conclusion

Despite the potential benefits of EM, barriers to its implementation have been reported. Further research is needed to standardise practices and determine optimal initiation timing and extent of mobilisation, including considerations on duration, intensity, and frequency in order to maximise its effectiveness and minimise adverse events.

Conflict of Interest

None.

References

Akhtar PM et al. (2021) Knowledge, attitudes, and perceived barriers of healthcare providers toward early mobilization of adult critically ill patients in intensive care unit. Indian J Crit Care Med. 25(5):512–518.

Alaparthi GK et al. (2020) Effectiveness, safety, and barriers to early mobilization in the intensive care unit. Crit Care Res Prac. 7840743.

Anekwe DE et al. (2020) Intensive care unit clinicians identify many barriers to, and facilitators of, early mobilisation: a qualitative study using the Theoretical Domains Framework. J Physiother. 66(2):120–127.

Babazadeh M et al. (2021) Perceived barriers to early mobilization of intensive care unit patients by nurses in hospitals affiliated to Jundishapur University of Medical Sciences of Ahvaz in 2019. J Med Life. 14(1):100–104.

Clarissa C et al. (2019) Early mobilisation in mechanically ventilated patients: a systematic integrative review of definitions and activities. J Intensive Care. 7(1).

Cucchi M et al. (2023) Awake extracorporeal life support and physiotherapy in adult patients: A systematic review of the literature. Perfusion. 38(5):939-958

Devlin JW et al. (2018) Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. Crit Care Med. 46(9):e825–e873.

Doiron KA et al. (2018) Early intervention (mobilization or active exercise) for critically ill adults in the intensive care unit. Cochrane Database of Syst Rev. 3(3):CD010754.

Eggmann S et al. (2022) Cardiorespiratory response to early rehabilitation in critically ill adults: A secondary analysis of a randomised controlled trial. PloS One. 17(2):e0262779.

Fontela PC et al. (2018) Early mobilization practices of mechanically ventilated patients: A 1-day point-prevalence study in southern Brazil. Clinics. 73:e241.

Goodson CM et al. (2020) Perceived barriers to mobility in a medical ICU: The patient mobilization attitudes & beliefs survey for the ICU. J Intensive Care Med. 35(10):1026–1031.

Hodgson C et al. (2013) Clinical review: early patient mobilization in the ICU. Crit Care. 17(1):207.

Hodgson C et al. (2014) Feasibility and inter-rater reliability of the ICU Mobility Scale. Heart Lung. 43(1):19–24.

Klem HE et al. (2021)Early activity in mechanically ventilated patients - a meta-analysis.Tidsskr Nor Laegeforen. 141(8).

Lai CC et al. (2017) Early mobilization reduces duration of mechanical ventilation and intensive care unit stay in patients with acute respiratory failure. Arch Phys Med Rehabil. 98(5):931–939.

Medical Research Council (1976) Aids to examination of the peripheral nervous system. Memorandum n. 45. London: Her Majesty's Stationary Office.

Morris PE et al. (2008) Early intensive care unit mobility therapy in the treatment of acute respiratory failure. Crit Care Med. 36:2238-2243.

Nydahl P et al. (2023) Early mobilisation for prevention and treatment of delirium in critically ill patients: Systematic review and meta-analysis. Intensive Crit Care Nurs. 74:103334.

Patel BK et al. (2023) Effect of early mobilisation on long-term cognitive impairment in critical illness in the USA: a randomised controlled trial. Lancet Respir Med. 11(6):563–572.

Tadyanemhandu C et al. (2022) Barriers and facilitators to implementation of early mobilisation of critically ill patients in Zimbabwean and South African public sector hospitals: a qualitative study. Disabil Rehabil. 44(22):6699–6709.

Takaoka A et al. (2020) The efficacy and safety of in-intensive care unit leg-cycle ergometry in critically ill adults. A systematic review and meta-analysis. Ann Am Thorac Soc. 17(10):1289-1307.

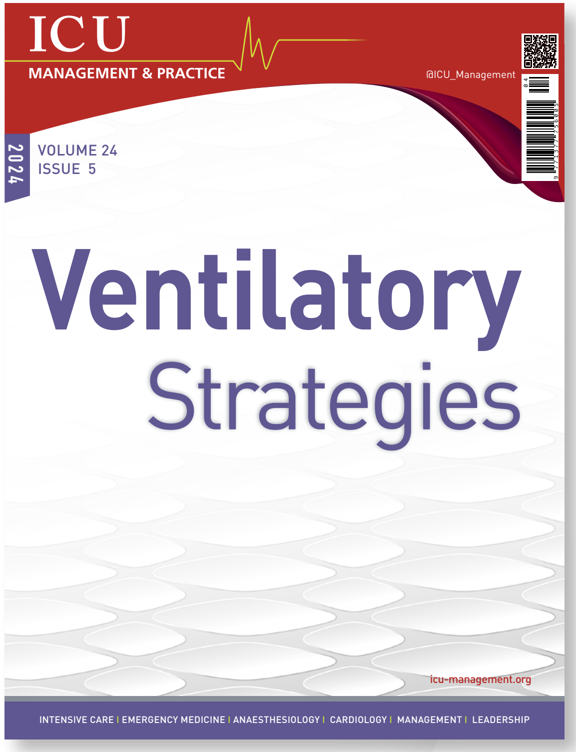
Watanabe S et al. (2022) Association between early mobilization in the ICU and psychiatric symptoms after surviving a critical illness: A multi-center prospective cohort study. JClin Med. 11(9):2587.

Yang R et al. (2021) Safety assessment criteria for early active mobilization in mechanically ventilated ICU subjects. Respir Care. 66(2):307–315.

Zhang L et al. (2019) Early mobilization of critically ill patients in the intensive care unit: A systematic review and meta-analysis. PloSOne. 14(10):e0223185

Zhang H et al. (2022) Early mobilization implementation for critically ill patients: A cross-sectional multi-center survey about knowledge, attitudes, and perceptions of critical care nurses. Int J Nurs Sci. 9(1):49–55.

WHAT'S COMING NEXT?



COVER STORY: Ventilatory Strategies

Ventilatory strategies are critical for managing patients in the ICU. In this issue, our contributors discuss ventilation strategies, lung mechanics, and individual response to treatment while ensuring optimised oxygenation, minimum ventilator-associated lung injury, and effective weaning from mechanical ventilation.

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The ABCs of Physical Therapy for Solid Organ Transplant Patients

Physical therapy is essential for improving outcomes and quality of life in solid organ transplant patients. This paper outlines the fundamental principles ("ABCs") of physical therapy, focusing on evidence-based practices and pre- and post-transplant care to guide healthcare professionals in optimising recovery.

Introduction

Physical therapy is essential in the postoperative care of patients who have undergone solid organ transplant (SOT), including those involving the kidney, liver, heart, or lungs. The primary objectives of physical therapy are to improve the quality of life and enhance clinical outcomes by emphasising physical rehabilitation, preventing post-surgery complications, and promoting cardiovascular-pulmonary readaptation (Sen et al. 2019). Personalised interventions, such as respiratory exercises and muscle strengthening, are used to strike a balance between rest and physical activity. This approach helps prevent muscle atrophy and other negative effects associated with prolonged immobility (Hoogeboom et al. 2014).

Physical therapy works in close coordination with the medical team to adapt the rehabilitation plan according to the patient's evolving condition and their response to immunosuppressive therapy. This collaborative approach not only accelerates recovery but also increases patient autonomy and reduces both the length of hospital stays and readmission rates (Lemanu et al. 2013). As a result, physical therapy is crucial for ensuring the long-term success of organ transplants, facilitating more effective recovery, and extending the viability of the transplanted organ (Reese et al. 2014; Painter et al. 2001).

Prehabilitation for Solid Organ Transplant

Major surgeries, including solid organ transplants (SOTs), can lead to a reduction in functional capacity of up to 40% due to preoperative inactivity. This decreased functional capacity contributes to diminished physiological reserves and muscle atrophy, which impairs the body's ability to manage the stress associated with transplantation and achieve allostasis (Quint et al. 2023). Therefore, it is essential for candidates undergoing SOTs to be in optimal health to improve their resilience and reduce the risk of postoperative complications.

Prehabilitation aims to improve the overall physical condition of patients before surgery through a combination of exercise, dietary modifications, cognitive strategies, and psychosocial support. Most prehabilitation programmes, which typically last between 6 and 12 weeks, focus on aerobic exercise and functional strengthening (Lemanu et al. 2013). Programmes that are shorter in duration may not achieve the desired outcomes, underscoring the need to meticulously adjust factors such as duration, intensity, nutrition, and rest to enhance programme effectiveness (Takahashi et al. 2018).

In general, patients undergoing SOTs should be assessed for the possibility of early extubation (<3-8 hours), except in the case of lung transplants, which require more specific criteria. The decision to withdraw mechanical ventilation (MV) should take into account the transplanted organ, the patient's stability, the

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progress of the surgical procedure, and the likelihood of success (Ragonete-dos-Anjos et al. 2022; Bilbao et al. 2003). Particularly for heart and lung transplants, extubation should not be rushed and must be closely monitored due to the complex interactions between the transplanted organ, the ventilator, and potentially extracorporeal support.

If early extubation is not possible, the critical care rehabilitation team will play a crucial role. Strategies such as early mobilisation, inspiratory muscle training, bronchial hygiene techniques, and respiratory care should be implemented (Hoogeboom et al. 2014). The multidisciplinary team's focus should be on optimising MV and maintaining or improving the patient's physical and respiratory condition to achieve a successful extubation (Ragonete-dos-Anjos et al. 2022).

Post-Transplant Management and Follow-Up

Although transplant patients can be managed similarly to other postoperative patients, understanding the specific complications and mortality risks associated with transplantation allows for a more targeted approach to care (Black et al. 2018). Key complications to monitor in this population include infections, cardiovascular issues, and pulmonary complications (Kinnunen et al. 2018; Piskin et al. 2022; Sen et al. 2019; Zelle et al. 2011). To streamline management, the following mnemonic —ABCs of transplant patient care— has been developed (**Figure 1**).

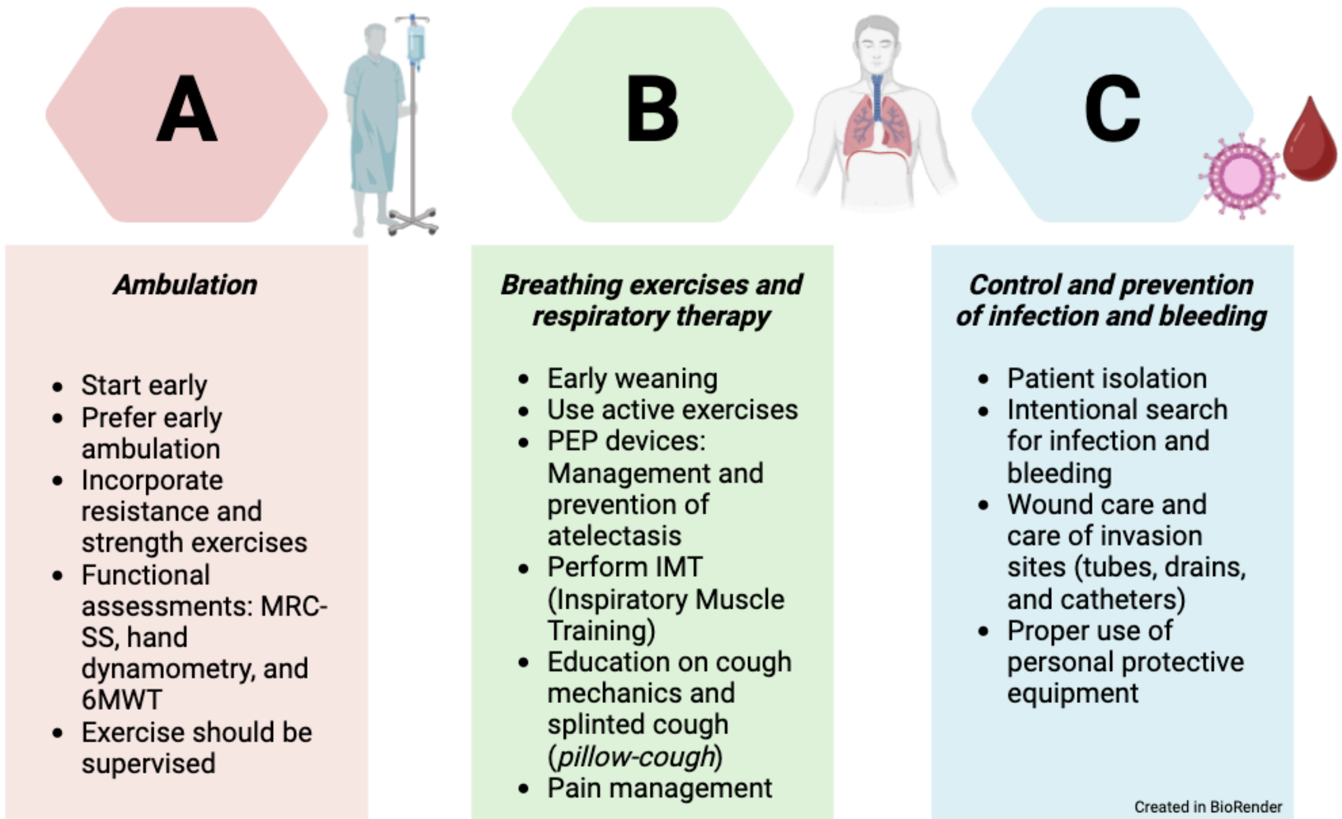

Figure 1. ABCs of Physical Therapy for Patients with SOT
A-Ambulation, B-Breathing exercises and respiratory therapy, C-Control and prevention of infections and bleeding

Ambulation

Physical conditioning plays a crucial role in the pulmonary rehabilitation of patients undergoing SOTs. The benefits include enhanced cardiopulmonary performance, improved survival prediction rates, and reduced hospital stays for liver transplants. Additionally, conditioning leads to increased VO2 max in patients undergoing cardiac, hepatic, and renal transplants (Bartels et al. 2011; Berben et al. 2019). Furthermore, this intervention has led to fewer in-hospital complications and improvements in quality of life and pain levels (Santa-Mina et al. 2015; Dunn et al. 2020).

Post-transplant physical rehabilitation programmes should be initiated early and supervised by physical therapists to maximise clinical benefits. Professional supervision ensures higher exercise intensity, optimised dosing and monitoring, leading to better clinical outcomes compared to self-directed supervision. There are several approaches for dosing exercise and advancing rehabilitation in patients following SOTs. Achieving the ability to walk and ambulate is a crucial functional milestone, as it enables more intensive training and the completion of the six-minute walk test. In addition, muscle strength training is essential for reducing frailty and improving functional capacity (Martins et al. 2020; Lands et al. 1999).

For patients undergoing SOTs, the most critical functional tests are the six-minute walk test and the sit-to-stand test (Quint et al. 2023; Ross et al. 2016; ATS Statement 2002; ATS/ACCP Statement 2002). These assessments are instrumental in estimating, monitoring, and enhancing functional capacity, as well as facilitating the safe dosing of exercise. Additionally, the Medical Research Council (MRC) scale and hand dynamometry are vital for evaluating and tracking muscle strength, and they are key components of the frailty assessment criteria for these patients.

Exercise interventions in clinical practice encompass a variety of approaches and methods aimed at improving the health and well-being of both hospitalised and outpatient patients. Common interventions include cycle-ergometry, functional exercises (such as active transfers to a chair), walking, and resistance training. The SEPAR guidelines underscore the importance of continuing respiratory exercises and promptly initiating seated activities and ambulation following the normalisation of any major surgery (López-Fernández et al. 2023).

Breathing Exercise and Respiratory Therapy

Post-transplant pulmonary care is comparable to that required after any major surgical procedure. Although the incentive spirometer (IS) was once widely utilised, recent evidence does not support its continued use (Larsen et al. 2022). While the device is not harmful and was a useful tool for surgeons before the adoption of mobilisation and respiratory physiotherapy protocols, its role has diminished. Currently, it is the physiotherapist's responsibility to implement protocols and train hospital staff in up-to-date pulmonary care practices for postoperative patients.

Additional respiratory interventions are available for the management of these patients. Positive expiratory pressure (PEP) devices and inspiratory muscle training (IMT) are commonly used. Oscillatory PEP devices facilitate the mobilisation of tracheobronchial secretions, whereas linear resistance PEP devices are employed to prevent and treat atelectasis (López-Fernández et al. 2023). IMT, which is intended to improve inspiratory muscle strength, is adjusted according to the patient's maximum inspiratory pressure (PiMax). The initial resistance of the device is set at 30-40% of the PiMax and can be progressively increased to 50-60% to optimise training outcomes in postoperative patients (Lemanu et al. 2013).

Finally, cough assistance techniques should start with thorough patient education on cough mechanics and secretion mobilisation. Commonly used methods, such as supported coughing or pillow-cough (where a pillow is placed on the surgical site to provide support and manual restriction during coughing) and effective post-coughing clearance, are generally sufficient for achieving proper expectoration. Induced coughing or chest compression techniques for accelerating expectoration are usually not recommended due to the pain at the surgical site; this pain should be managed with analgesia to facilitate effective cough mechanics (Larsen et al. 2022). The use of cough-assist devices is infrequent and is typically reserved for patients who have significant difficulty coughing or those experiencing pulmonary infections that result in excessive tracheobronchial secretions (López-Fernández et al. 2023).

Control and Prevention of Infection and Bleeding

Post-transplant isolation is essential for safeguarding immunosuppressed patients from infections (Black et al. 2018). During this period, the patient's immune system, compromised by the immunosuppressive therapy required to prevent organ rejection, is highly susceptible to infections. Isolation minimises exposure to pathogens, facilitating the adaptation of the transplanted organ and allowing the immune system to recover gradually. The duration and intensity of isolation depend on the type of transplant and the patient's overall health status. Effective isolation is crucial for ensuring the long-term success of the transplant and optimising the patient's recovery.

Healthcare personnel must maintain heightened vigilance and actively identify potential sources of infection, which can manifest as symptoms such as fever, pain, wound discharge, foul odour, and leucocytosis (Kinnunen et al. 2018). Any suspected infection should be reported immediately to the medical team. Adherence to hand hygiene and the use of masks is mandatory during patient care. Likewise, educating patients and their families on preventive measures is crucial to avoid readmissions and ensure effective post-hospitalisation care.

Finally, similar to infection care, early monitoring and identification of postoperative bleeding will be a role that every physiotherapist working with this population should consider. Observing drains and probes, as well as closely monitoring patients' haemoglobin levels, are important data points to review (Faria et al. 2023). The presence of bleeding may be one of the criteria for considering the suspension of rehabilitation until the bleeding is stabilised or resolved.

Conclusion

In summary, physical therapy plays a pivotal role in the recovery of patients following solid organ transplants. It significantly enhances functional outcomes, mitigates complications, and improves overall quality of life. Implementing early exercise programmes and conducting meticulous monitoring are key strategies for optimising long-term results. Effective multidisciplinary collaboration and a patient-centred approach are critical to achieving successful outcomes.

"While we are all mortal, through organ donation, we become eternal".

- Dr Rivera Durón

Conflict of Interest

None.

References

American Thoracic Society Statement (2002) Guidelines for the six-minute walk test. Am J Respir Crit Care Med. 166:111e7.

American Thoracic Society/American College of Chest Physicians (2003) ATS/ACCP statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med. 167(2):211-77.

Argüero-Sánchez R, Sánchez-Ramírez O, Olivares-Durán EM (2020). Donación de órganos y trasplantes en México, ¿todo está resuelto? Gaceta médica de México. 156(3):181-183.

Bartels MN, Armstrong HF, Gerardo RE et al. (2011) Evaluation of pulmonary function and exercise performance by cardiopulmonary exercise testing before and after lung transplantation. Chest. 140(6):1604-1611.

Berben L, Engberg SJ, Rossmeissl A et al. (2019) Correlates and out- comes of low physical activity posttransplant: a systematic review and meta-analysis. Transplantation.103:679-688.

Bilbao I, Armadans L, Lazaro JL et al. (2003) Predictive factors for early mortality following liver transplantation. Clin Transplant. 17:401-411.

Black CK, Termanini KM, Aguirre O et al. (2018) Solid organ transplantation in the 21(st) century. Ann Transl med. 6(20):409.

De Smet S, Van Craenenbroeck AH (2021) Exercise training in patients after kidney transplantation. Clinical kidney journal. 14(Suppl 2):ii15–ii24.

Dunn MA, Rogal SS, Duarte-Rojo A, Lai JC (2020) Physical Function, Physical Activity, and Quality of Life After Liver Transplantation. Liver Transpl. 26(5):702-708.

Faria L, Fraga R, De-Souza D et al. (2022) Hemodynamic impact of early mobilization in critical patients receiving vasoactive drugs: A prospective cohort study. PLoS ONE. 17(12):e0279260.

Garcia AM, Veneroso CE, Soares DD et al. (2014) Effect of a physical exercise program on the functional capacity of liver transplant patients. Transplantation proceedings. 46(6):1807-1808.

Hoogeboom TJ, Dronkers JJ, Hulzebos EH, van Meeteren NL (2014) Merits of exercise therapy before and after major surgery. Current opinion in anaesthesiology. 27(2):161-166.

Kinnunen S, Karhapää P, Juutilainen A et al. (2018) Secular trends in infection-related mortality after kidney transplantation. Clin JAm Soc Nephrol. 13:755-62.

Lai JC, Sonnenday CJ, Tapper EB et al. (2019) Frailty in liver transplantation: an expert opinion statement from the American Society of Transplantation Liver and Intestinal Community of Practice. Am J Transplant. 19:1896–1906.

Lands LC, Smountas AA, Mesiano G et al. (1999) Maximal exercise capacity and peripheral skeletal muscle function following lung transplantation. J Heart Lung Transplant. 18(2):113-120.

Larsen T, Chuang K, Patel S, Betancourt J (2022) Things We Do for No Reason™: Routine use of postoperative incentive spirometry to reduce postoperative pulmonary complications. Journal of hospital medicine, 17(12):1010–1013.

Lemanu DP, Singh PP, MacCormick AD et al. (2013) Effect of preoperative exercise on cardiorespiratory function and recovery after surgery: a systematic review. World J Surg. 37:711-720.

López-Fernández D, Fraile-Olivero CA (2023) Manual de procedimientos de fisioterapia respiratoria en cirugía torácica. Sociedad Española de Neumología y Cirugía de Tórax, Manual 41.

Martins CA, França A, Dias RSC et al. (2020) Prevalence of sarcopenia in kidney transplants and their association with determinant factors of muscle homeostasis. Rev Assoc Med Bras. 66(9):1235-40.

Maury G, Langer D, Verleden G et al. (2008) Skeletal muscle force and functional exercise tolerance before and after lung transplantation: a cohort study. Am J Transplant. 8(6):1275-1281.

Painter P, Krasnoff J, Paul SM et al. (2001) Physical activity and health-related quality of life in liver transplant recipients. Liver Transpl. 7:213e9.

Painter PL, Hector L, Ray K et al. (2002) A randomized trial of exercise training after renal transplantation. Transplantation. 74:42-8.

Piskin T, Simsek A, Murat-Dogan S et al. (2022) Mortality after kidney transplantation: 10-year outcomes. Cirugia y cirujanos. 90(2):172-179.

Prentis JM, Manas DM, Trenell MI et al. (2012) Submaximal cardiopulmonary exercise testing predicts 90-day survival after liver transplantation. Liver Transplantation. 18(2):152-159.

Quint EE, Zogaj D, Banning LBD et al. (2021) Frailty and kidney transplantation: a systematic review and meta-analysis. Transplant Direct. 7(6):e701.

Quint EE, Ferreira M, van Munster BC et al. (2023) Prehabilitation in Adult Solid Organ Transplant Candidates. Curr Transplant Rep. 10(2):70-82.

Ragonete-dos-Anjos AP, Santana IF, Heidemann A et al. (2022) Factores de riesgo de reintubación relacionados con insuficiencia no relacionada con las vias respiratorias despues de un trasplante de hígado en la unidad de cuidados intensivos: estudio observacional. BJT. 25(01):e0222.

Reese PP, Bloom RD, Shults J et al. (2014) Functional status and survival after kidney transplantation. Transplantation. 97:189-195.

Reyes-Acevedo R, Obrador GT, Alberú-Gómez J et al. (2019) Current state and challenges for organ donation and transplantation in Mexico. Transplantation. 103:648-650.

Rongies W, Stepniewska S, Lewandowska M et al. (2011) Physical activity long-term after liver transplantation yields better quality of life. Ann Transplant. 16(3):126e31.

Ross R, Blair SN, Arena R et al. (2016) Importance of assessing cardiorespiratory fitness in clinical practice: a case for fitness as a clinical vital sign: a scientific statement from the American Heart Association. Circulation. 134:e653-e699.

Santa Mina D, Scheede-bergdahl C, Gillis C, Carli F (2015) Optimization of surgical outcomes with prehabilitation. Appl Physiol Nutr Metab. 40(9):966-9.

Sen A, Callisen H, Libricz S et al. (2019) Complications of solid organ transplantation: cardiovascular, neurologic, renal, and gastrointestinal. Crit Care Clin. 35:169-186.

Takahashi A, Hu SL, Bostom A (2018) Physical activity in kidney transplant recipients: a review. Am J Kidney Dis. 72:433-443.

Thuluvath PJ, Yoo HY, Thompson RE (2003) A model to predict survival at one month, one year, and five years after liver transplantation based on pretransplant clinical characteristics. Liver Transpl. 9:527-532.

Zelle DM, Corpeleijn E, Stolk RP et al. (2011) Low physical activity and risk of cardiovascular and all-cause mortality in renal transplant recipients. Clin J Am Soc Nephrol. 6:898-905.

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Early Mobilisation in Critical Care: Beyond Traditional Limits

Early mobilisation in critical care significantly improves outcomes in critically ill patients. Overcoming boundaries requires a proactive approach, training, research and multidisciplinary collaboration.

Introduction

Early mobilisation in the critically ill patient is essential to mitigate the adverse consequences of bed rest and improve outcomes and cost reduction. The absence of muscle contraction results in loss of muscle strength and mass, leading to reduced muscle cross-sectional area, increased production of pro-inflammatory cytokines, proteolysis and muscle catabolism, leading to the development of more complications resulting in more days on mechanical ventilation, more difficult weaning, prolonged ICU stays or hospital days and even increased morbidity and mortality rates. This review provides evidence-based statements about the benefit of early mobilisation in critical care, which is a mainstay in intensive care units.

Importance for the Critically Ill Patient

One of the main problems in intensive care units where there are patients with limited mobility as a result of their underlying pathology, their clinical condition, or as a direct consequence of the necessary treatments, such as the requirement for invasive mechanical ventilation, deep sedation, malnutrition or the use of neuromuscular blockers, involves the risk of developing ICU-acquired weakness; a condition characterised by a decrease in muscle strength, generally associated with atrophy, of acute, diffuse, symmetrical and generalised onset, which develops after the onset of critical illness (Diaz et al. 2017).

Weakness acquired in the ICU does not only affect the muscles of the extremities; on the contrary, atrophy can even affect the diaphragmatic musculature after 18 hours from the start of mechanical ventilation and 96 hours in the skeletal muscles of the extremities, so that the longer the days of ventilation, the greater the muscular and systemic damage (Diaz et al. 2017).

The participation of professionals from various branches of healthcare (medicine, nursing, physiotherapy, respiratory therapy, among others) in the assessment of the patient and consensus decision-making regarding their clinical condition allows a wide range of perspectives to be considered in their management and guarantees that the decisions taken lead to the patient's recovery due to their holistic nature and are backed by an informed consensus based on scientific evidence (Hiser et al. 2023).

Benefits and Barriers in the ICU

The catabolic state during critical illness causes a change in the role of muscle. Per day in the intensive care unit (ICU), there is a 2% loss of muscle mass, and during the first week of hospital stay, there is a 12.5 % loss of muscle cross-sectional area in the presence of mechanical ventilation. The lower limbs, particularly the hip flexors, are susceptible to atrophy (Hiser et al. 2023):

Benefits of early rehabilitation

- Improvement in the level of mobility.
- Preservation of muscle mass.
- Decreased incidence of delirium.
- Reduction of intensive care stay.
- Reduction of days of mechanical ventilation.
- Reduction of morbidity and mortality.

A study in New Zealand found that only 8% of mechanically ventilated patients were mobilised out of bed (Grimm 2019). ICU patients undergo a significant percentage of deep sedation and mechanical ventilation, and haemodynamic support, and therefore, these patients experience reduced mobility and the long-term functional impairment for ICU survivors is mainly

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Figure 1. Early mobilisation and humanisation protocol in an intensive care unit in southeastern Mexico; H-ICU (photos authorised by family members)

characterised by cognitive and motor sequelae (Cuthbertson et al. 2010).

In a survey conducted in intensive care units in Jundishapur of Ahvas, it was found that the main barrier to mobilisation of ICU patients was lack of trained staff, inadequate time for this procedure, as well as deep sedation/coma, obese patients and patients with agitated pain as main patient-related barriers (Babazadeh et al. 2021).

There is a lack of standardised protocol for early mobilisation, including adequate record keeping and a checklist. Inadequate equipment for the mobilisation of mechanically ventilated patients is a limitation present in intensive care units.

A survey of ICU physicians conducted in Brazil aimed to identify attitudes and barriers to the implementation of early mobilisation of critically ill patients; availability of professionals, time to mobilise and excessive stress due to workload were the main findings (Fontela et al. 2018).

In a Canadian study conducted in 46 intensive care units, 60% of physicians stated that they did not have sufficient knowledge or skills to mobilise patients receiving multi-organ support (Koo et al. 2016).

A study in India describes a lack of protocols for patient mobilisation (Akhtar and Deshmukh 2021), similar to that described in developing countries, and sufficient equipment is a limitation (Koo et al. 2016).

Obesity becomes a major challenge in early mobilisation, adding the requirement for extracorporeal supports; they participate in a misconception of seeking lack of mobility to avoid accidental removal of endotracheal tube or vascular access or drains, thereby delaying the window of opportunity to decrease the presence of acquired weakness of the critically ill patient (Bakhru et al. 2015).

'Early rehabilitation in critical areas could improve functional prognosis and hospital costs; persistence of heterogeneous and unsubstantiated behaviours delays progress'.

Implementation Strategies

Mobilisation of the critically ill has become an increasingly important area of interest in recent years. Although most of the literature comes from neurosciences, nursing care, paediatrics, orthopaedics and geriatrics, it is of increasing interest to rehabilitation professionals (Zang et al. 2020).

Efforts to reduce the use of sedatives and to promote early daily patient awakening and spontaneous breathing ventilation methods have become focal points of care in critical areas. This multi-centre approach to interventions that reduce 'treatment-related immobilisation', combined with a focus on patient management immediately after acute illness, may also improve the overall likelihood and safety of patient mobilisation after prolonged or unwarranted sedative use (Alaparthi et al. 2020; Menges et al. 2021).

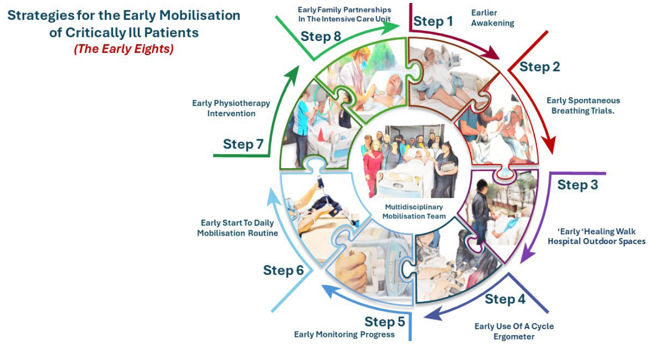

Figure 2. The early eights - strategies for early mobilisation of critically ill patients

Figure 3. Intensive Care Unit (ICU) without walls. This multidisciplinary concept aims to integrate family members into the rehabilitation activity outside the ICU. Videos with QR codes are attached (photos authorised by the family members)

The administration of unwarranted deep sedation in a human being is a practice that should be severely penalised. This intervention, lacking adequate clinical justification, not only carries inherent risks and adverse outcomes, but also entails high human and financial costs. Furthermore, it perpetuates a questionable medical tradition that compromises ethics and patient safety (Hodgson et al. 2022).

A multidisciplinary team is essential to promote early mobilisation of ICU patients. Team members set goals of care for each patient based on the patient's condition, the team's experience, and pending trials and guidelines if the patient is unable to communicate. The ICU environment and specific staff may affect how, when, where and by whom early ambulation/mobility can be initiated in individual patients (Lang et al. 2020; Smith et al. 2022).

Patient and family involvement, and support are critical to the development of a patient-centred critical illness recovery plan and the timely initiation of early mobilisation activities. Patients and their families should be educated about the implications of early mobilisation, expectations based on current condition, appreciation of their role in the early mobility process, provision of reassurance and creating a sense of achievement for the patient (Rawal and Bakhru 2023).

Early mobilisation of critically ill patients, while beneficial, remains underutilised due to concerns about patient safety and tolerance. Conflicting ethical issues may also arise, including respect for patient autonomy, beneficence to the patient, non-maleficence and justice. Dilemmas may arise because of advances in medical management, such as advances in critical care that help sustain life or modes of support that prevent the resolution of illness or disease and rehabilitation that patients may not want (Rawal and Bakhru 2023).

There is limited information on the economic consequences of implementing early mobilisation programmes. However, cost-effectiveness must be considered when allocating resources. From this perspective, it has been argued that early initiation of a progressive exercise and increased mobilisation may place substantial or excessive demands on staff, physical resources and time. Identifying the financial demand of a mobilisation programme and being able to reallocate sufficient resources after its implementation initiative is also vital for these programmes (Morris et al. 2008).

'The prescription of unwarranted deep sedation in a human being should be criminalised, the result is an inhumane act'.

Impact on Clinical Outcomes

The outcomes of early mobilisation in critically ill patients are uncertain, although it has been associated with improved muscle strength by MRC scores and Barthel index (Schweickert et al. 2009), reduced incidence of delirium, return of baseline functional class (OR 2.7 CI 95%, 1.2-6. There is no conclusive information on survival and mortality benefits, as well as no precise definitions of early rehabilitation and no standardised algorithms for early mobilisation and rehabilitation in intensive care units.

A systematic review and meta-analysis comparing the outcomes of adult patients with early mobilisation under mechanical ventilation, defined as within three days of ICU admission, compared to the standard mobilisation group, showed no improvement in mortality at 180 days compared to the intervention group RR 1.09 CI 95% (0.69-1. 76) I2 0%, nor differences in secondary outcomes which were: days ICU stay RR -2.18 CI 95% (-3.27, -0.94) I2 93%, duration of mechanical ventilation RR -1.39 CI 95% (-2.50, -0.56) I2 82%, The analysis had severe limitations such as sample size, high heterogeneity of studies and a lack of consensus on the definition and protocols of early mobilisation (Wang et al. 2023). It is a priority to implement standardised protocols in our critical care units and to assess the risks involved in order to generate lines of research that will strengthen our clinical practice.

A comparative line of research on the effects of mobilisation 72 hours after admission to the intensive care unit followed up six months after hospital discharge, with inconclusive results on the primary outcomes of muscle strength, cognitive function, and adverse effects of early mobilisation RR 1.3 CI 95% (0.49-2.62) I2 47% (Matsukoa et al. 2023). No mortality benefit was observed in the intervention group RR 1.15 CI 95% (0.83-1.60)

I2=0%. The results contrasted in lines of research by (Paton et al. 2022), where the probability of a higher survival rate in the early mobilisation group is observed. The lack of results against continuing strategies of early mobilisation protocols leaves a field of opportunity for new generations and intensive care teams that can add to the results observed in our unit in the southeast Mexican

Conclusion

Active identification of early mobilisation barriers and implementation of a protocol should be part of the mandatory model of care for all intensive care units. Data supporting favourable outcomes of early mobilisation in intensive care unit patients is a growing line of research, and understanding the real short- and long-term impact on critically ill patients requires standardisation of rehabilitation protocols and unification of definitions of early rehabilitation.

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Conflict of Interest

None.

References

Akhtar PM, Deshmukh PK (2021) Knowledge, Attitudes, and Perceived Barriers of Healthcare Providers toward Early Mobilization of Adult Critically Ill Patients in Intensive Care Unit. Indian J Crit Care Med. 25(5):512-518.

Alaparthi GK, Gatty A, Samuel SR, Amaravadi SK (2020) Effectiveness, safety, and barriers to early mobilization in the intensive care unit. Critical Care Research and Practice. (1):7840743.

Babazadeh M, Jahani S, Poursangbor T, Cheraghian B (2021) Perceived barriers to early mobilization of intensive care unit patients by nurses in hospitals affiliated to Jundishapur University of Medical Sciences of Ahvaz in 2019. J Med Life. 14(1):100-104.

Bakhru RN, Wiebe DJ, McWilliams DJ et al. (2015) An environmental scan for early mobilization practices in US ICUs. Critical care medicine. 43(11):2360-9.

Cuthbertson BH, Roughton S, Jenkinson D et al. (2010) Quality of life in the five years after intensive care: a cohort study. Crit Care. 14:R6.

Diaz Ballve LP, Dargains N, Urrutia Inchaustegui JG et al. (2017) Weakness acquired in the intensive care unit. Incidence, risk factors and their association with inspiratory weakness. Observational cohort study. Rev Bras Ter Intensiva. 29(4):466-475.

Fontela PC, Forgiarini LA Jr, Friedman G (2018) Clinical attitudes and perceived barriers to early mobilization of critically ill patients in adult intensive care units. Rev Bras Ter Intensiva. 30(2):187-194.

Grimm J, Silvestri-Elmore A, Grimm E et al. (2019) Perceived barriers to early progressive mobilization in the ICU: Multidisciplinary perspectives in an underserved population. Journal of Nursing Education and Practice. 9(4):5.

Hiser SL, Fatima A, Ali M, Needham DM (2023) Post-intensive care syndrome (PICS): recent updates. J Intensive Care. 11(1):23.

Koo KK, Choong K, Cook DJ et al. (2016) Canadian Critical Care Trials Group. Early mobilization of critically ill adults: a survey of knowledge, perceptions and practices of Canadian physicians and physiotherapists. CMAJ Open. 4(3):E448-E454.

Lang JK, Paykel MS, Haines KJ, Hodgson CL (2020) Clinical Practice Guidelines for Early Mobilization in the ICU: A Systematic Review. Crit Care Med. 48(11):e1121-e1128.

Matsuoka A, Yoshihiro S, Shida H et al. (2023) Effects of Mobilization within 72 h of ICU Admission in Critically Ill Patients: An Updated Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Clin Med. 12(18):5888.

Menges D, Seiler B, Tomonaga Y et al. (2021) Systematic early versus late mobilization or standard early mobilization in mechanically ventilated adult ICU patients: systematic review and meta-analysis. Critical Care. 25:1-24.

Morris PE, Goad A, Thompson C et al. (2008) Early intensive care unit mobility therapy in the treatment of acute respiratory failure. Crit Care Med. 36(8):2238-43.

Patel BK, Wolfe KS, Patel SB et al. (2023) Effect of early mobilisation on long-term cognitive impairment in critical illness in the USA: a randomised controlled trial. Lancet Respir Med. 11(6):563-572.

Paton M, Chan S, Tipping CJ et al. (2023) The Effect of Mobilization at 6 Months after Critical Illness - Meta-Analysis. NEJM Evid. 2(2):EVIDoa2200234.

Rawal H, Bakhru RN (2024) Early mobilization in the ICU. CHEST Critical Care. 2(1): 100038.

Schweickert WD, Pohlman MC, Pohlman AS et al. (2009) Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. Lancet. 373(9678):1874-82.

Smith HAB, Besunder JB, Betters KA et al. (2022) 2022 Society of Critical Care Medicine Clinical Practice Guidelines on Prevention and Management of Pain, Agitation, Neuromuscular Blockade, and Delirium in Critically Ill Pediatric Patients With Consideration of the ICU Environment and Early Mobility. Pediatr Crit Care Med. 23(2):e74-e110.

TEAM Study Investigators and the ANZICS Clinical Trials Group; Hodgson CL, Bailey M et al. (2022) Early Active Mobilization during Mechanical Ventilation in the ICU. N Engl J Med. 387(19):1747-1758.

Wang L, Hua Y, Wang L et al. (2023) The effects of early mobilization in mechanically ventilated adult ICU patients: systematic review and meta-analysis. Front Med (Lausanne). 10:1202754.

Zang K, Chen B, Wang M et al. (2020) The effect of early mobilization in critically ill patients: a meta-analysis. Nursing in critical care. 25(6):360-7.

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