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Impact of Early Mobilization on Clinical Outcomes of Mechanically Ventilated Patients During Critical Care Rehabilitation and Related Nursing Practices

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Abstract

Objective To systematically review the effects of early mobilization in critical care rehabilitation on the key clinical outcomes of mechanically ventilated patients, and deeply explore the key points, challenges and countermeasures of nursing practice under the current evidence-based background. **Methods** A systematic literature search was conducted in PubMed, CINAHL, the Cochrane Library, CNKI, and Wanfang Database. Covering clinical practice guidelines, systematic evaluation, randomized controlled trials and high-quality reviews. According to predefined inclusion and exclusion criteria, the retrieved literature is screened, and thematic analysis method is used for induction, integration and critical analysis. **Results** The existing current evidence shows that early mobilization can significantly improve the prognosis of mechanically ventilated patients, which is mainly reflected in shortening mechanical ventilation time and ICU length of stay, reducing the incidence of ICU acquired weakness (ICU-AW) and delirium, and promoting long-term functional recovery. The core links of relevant nursing practice include: patient assessment and risk stratification based on standardized processes, the construction and coordination of multidisciplinary teams, individualized progressive mobilization plans coordinated with sedation and analgesic strategies, safety monitoring and risk prevention throughout the whole process, and identification and response to implementation obstacles. **Conclusion** Early mobilization is a key evidence-based measure to improve the prognosis of patients with mechanical ventilation. Nurses play an indispensable core role in the implementation of early mobilization. Through a systematic discussion of nursing practice, it helps to transform scientific evidence into clinical practice more safely and effectively, and provides a theoretical basis and practical direction for the construction of a localized early mobilization nursing program, so as to maximize the benefits of patient rehabilitation.

Keywords

mechanical ventilation, early mobilization, critical care rehabilitation, clinical outcomes, nursing practice

1. Introduction

1.1 Research Background

Mechanical ventilation (MV) is one of the core life support technologies for intensive care unit (ICU) to maintain the respiratory function of patients [1]. At present, 30 to 40 million critically ill patients around the world are treated in ICU every year, and about 50% to 70% of ICU patients need ventilator-assisted ventilation treatment. MV often causes respiratory complications such as lung infection and atelectasis due to many factors such as patient's disease status, treatment measures, long-term bed rest, etc., and ventilator-related pneumonia (VAP) may occur in severe patients [1,2]. Patients usually have ICU-acquired weakness (ICU-AW) within a few days of receiving MV treatment in the early stage of entering the ICU, which is the most common and serious complications of neuromuscular involvement in critically ill patients, with an incidence of up to 25% to 80% [3], increasing the duration and weaning duration of MV [4]. The duration of MV is prolonged, and delirium may occur when the patient is still in the ICU, resulting in confusion and loss of consciousness [5, 6]. The incidence of ICU delirium is 16% to 92%, with the highest incidence in elderly patients and mechanically ventilated patients [7]. The difference in incidence reflects the heterogeneity of group evaluation tools and diagnostic criteria in different studies. Affected by factors such as long MV time and reduced patient mobility, the patient's muscle protein synthesis and decomposition increased, resulting in insufficient nutritional support to muscles and nerves, thus causing disuse atrophy of the respiratory muscles. This problem will make it difficult for patients to wean from mechanical ventilation as soon as possible, further prolonging the MV time [8].

Therefore, reducing the occurrence of MV complications in ICU patients and optimizing MV time are the core strategies to meet the above challenges and promote critical care rehabilitation, and are also the focus of research in the field of critical rehabilitation. With the rapid development of rehabilitation medicine theory and rehabilitation technology, the concept of "early rehabilitation" has also been gradually applied to the ICU environment. Early rehabilitation mobilizations help to improve the prognosis of critically ill patients and improve their quality of life [8]. An effective multidisciplinary team (MDT) or interdisciplinary team is a necessary condition for the success of ICU early rehabilitation. As the medical group that has the most contact with patients, nurses play an important role in the construction of multidisciplinary teams and early rehabilitation activities. By forming a multidisciplinary team and carrying out early mobilizations for patients, the clinical outcome of patients can be improved [9, 10, 11].

1.2 Core Concepts

1.2.1 Mechanically Ventilated Patients

Mechanically ventilated patients refer to patients who receive ventilatory support through a mechanical ventilator to maintain airway patency, improve ventilation and oxygenation, and prevent hypoxia and carbon dioxide accumulation in the body. Mechanical ventilation is used to improve respiratory failure by partially or completely replacing, controlling, or modifying spontaneous breathing.

1.2.2 Early Mobilization

Early mobilization (EM) refers to any active and passive activities with a certain intensity that can produce positive physiological benefits carried out by a multidisciplinary collaborative team within 24 to 72 hours after critically ill patients enter the ICU for MV treatment. Supplemented by physical therapy such as muscle electrostimulator, including bed and out-of-bed activities, to enhance circulation, ventilation, muscle metabolism, etc. Finally, improve the lung function of ICU patients, shorten the mechanical ventilation time, improve limb muscle strength, reduce the occurrence of delirium, and improve the long-term quality of life.

1.3 Purpose and Significance

This paper conducts systematic research on the early mobilizations of mechanically ventilated patients. The research purpose includes systematic combing and integrating the high-quality evidence-based basis of the impact of early mobilizations on the clinical prognosis of mechanically ventilated patients, and clarifying its application value and mechanism of action; Analyze and summarize the implementation points, key links and

optimization strategies of early mobilizations of mechanically ventilated patients in clinical nursing practice, and provide reference for optimizing clinical nursing practice.

The theoretical significance of this article is to systematically integrate, summarize and comment on the research results related to the early mobilizations of mechanically ventilated patients. It can make up for the shortcomings of scattered content and lack of systematic combing in existing research, improve the knowledge system in the field of early rehabilitation nursing of critical illness, provide a systematic reference framework for follow-up theoretical research and academic exploration in this direction, and enrich the connotation of evidence-based theory of critical care.

The practical significance of this article is to distill the practical points of scientific and feasible early mobilization nursing by combining the actual needs of clinical nursing. It can provide comprehensive and well-founded clinical practice guidelines for front-line ICU specialist nurses, and assist medical staff to carry out early mobilization intervention in a standardized manner; Improve the scientificity and normative nature of early rehabilitation nursing, and provide practical support for finally improving the prognosis of patients and optimizing the quality of critical care.

2. Evidence-based Foundation for the Effects of Early Mobilization on the Prognosis of Mechanically Ventilated Patients

2.1 Effects on Respiratory Outcomes

Early mobilization is one of the key interventions to improve the outcome of the respiratory system of MV patients. The existing evidence-based basis clearly points out that early mobilizations for patients receiving MV treatment in ICU can significantly shorten the patient’s MV time, improve patient's lung function, prevent disuse atrophy of the respiratory muscles, and reduce the risk of VAP [12, 13, 14].

Othman et al. [15] included an RCT of 124 patients, and randomly grouped patients to carry out range of motion (ROM) exercises, neuromuscular electrical stimulation (NMES) and ROM+NMES combined treatment. The study found that the MV duration (12.80±3.800) of patients receiving ROM+NMES combined treatment was shorter than that of patients receiving ROM or NMES alone and patients in the control group (21.80±4.460, 18.73±4.748 and 20.70±3.932 days respectively). On the 7th day of MV treatment, the difference between SpO2, FiO2, ventilation per minute and positive end-expiratory pressure (PEEP) between the four groups was statistically significant ($P<0.05$). By implementing the early comprehensive rehabilitation program [16], the patient's MV time, analgesia and sedation time, ICU length of stay (ICU LOS) can be reduced ($P<0.05$). The ICU-LOS (17.43±3.17d) of the ROM+NMES group was shorter than that of the ROM group (22.53±4.51d), the NMES group (21.10±5.0d) and the control group (21.50±4.42d), and the difference between the four groups was statistically significant ($p<0.001$) [15]. An RCT by Dos Santos et al. [16] reported that receiving NMES and ROM exercise can reduce patients' MV time by 9 days compared to routine care. The longer the MV time, the higher the risk of VAP. The incidence of VAP in patients who receive 1-day MV is 5%, while the incidence of VAP in patients who receive 30 days MV rises to 65% [18]. Early mobilization reduces the risk of VAP by shortening the MV time.

2.2 Effects on Physical Function Outcomes

ICU-AW is a major complication that affects the physical function and long-term prognosis of MV patients. A large number of current evidence shows that early mobilization is an important measure for the prevention and treatment of ICU-AW. It can improve the strength of the patient's limbs and trunk muscles, improve the overall functional status and activity level at discharge, and improve the long-term quality of life [19, 20].

The American Society of Critical Care Medicine (SCCM) updated the PADIS Guidelines [6] based on the latest evidence covering 58 RCTs and including 8,038 patients, recommending intensive activities or rehabilitation training for adult ICU patients, rather than routine activities or rehabilitation measures, with medium-quality evidence. Intensive activities or rehabilitation training can reduce the incidence of ICU-AW. The evidence is highly certain, and it is likely to improve the functional state and quality of life of patients after discharge from the hospital. The evidence is moderate. The 2023 version of the Japanese Clinical Practice Guidelines for the Rehabilitation of Critically Ill Patients (J-ReCIP 2023) [21] lists the recommendation of

NMES for the treatment of critically ill patients as a 2B-level recommendation, with moderate evidence certainty. In the RCT study of Othman et al. [15], the incidence of ICU-AW in the ROM+NMES group was 0%, 60% in the ROM group, 13% in the NMES group, and 100% in the control group ($p<0.001$). On the 7th day, the MRC scores of the ROM+NMES group and the NMES group were higher than those of the ROM group and the control group (50.37±2.34, 49.77±2.19, 44.97±3.61 and 41.10±3.84, respectively). The analysis results of variance show that there is a significant difference between the four groups ($p<0.001$). Compared with traditional care, daily continuous NMES and/or ROM treatment can maintain the muscle strength measured by MRC and reduce the incidence of ICU-AW. Although there is no significant difference in the incidence of ICU-AW between the NMES group and the ROM+NMES group, both interventions are promising in maintaining muscle strength and reducing the overall incidence of ICU-AW compared with traditional nursing. Schweickert et al. [22] found that 104 patients were included in the analysis in the classic RCT published in The Lancet, and 29 patients (59%) in the intervention group recovered their independent functional state when they were discharged from the hospital. 19 patients in the control group (35%) recovered their independent functional state when they were discharged from the hospital ($p=0.02$; OR 2.7 [95% CI 1.2-6.1]). Compared with the conventional nursing group at 1 year, the incidence of ICU-AW in the intervention group was lower ($p=0.0001$) and the body composition score in the quality of life test was higher (median 52.4 [IQR 45.3–56.8] vs median 41.1 [31.8–49.4]; $p<0.0001$). A retrospective study by Ichikawa et al. [23] pointed out that patients who received the early mobilization and rehabilitation program (EMRP) reduced the incidence of ICU-AW by increasing peripheral muscle tension. The Barthel index score at discharge was significantly higher, the ICU LOS was shorter, the number of days from ICU admission to activity and rehabilitation was shorter, and more patients got out of bed earlier.

2.3 Effects on Neurocognitive Outcomes

ABCDEF bundle care combined with early mobilization intervention for patients receiving MV treatment in ICU can reduce the incidence and duration of delirium, reduce the risk of cognitive impairment, and improve cognitive function at discharge [24].

The PADIS Guidelines [6] points out that rehabilitation training can slightly shorten the duration of delirium, and the evidence is less certain. A large-scale meta-analysis involving 13 RCTs involving 2,164 patients [25] provides strong aggregate evidence that early mobilizations almost halve the risk of delirium in ICU patients (13 studies, 2,164 patients, low to moderate risk of bias: $p=0.01$; OR 0.53 [95% CI 0.34-0.83]), and the certainty of significant heterogeneity ($I^2=78\%$, $p<0.001$) is medium. An RCT study including 198 patients by Bhakti et al. [26] found that the incidence of cognitive impairment in the early mobilization group was 24.2% in the first year, while that in the conventional nursing group was 43.4% (95% CI 32.1%-6.3%, $p=0.004$). When discharged from the hospital, the incidence of cognitive disorders in the early mobilization group was lower (95% CI 28.6%-1.7%, $p=0.03$). The median score of the Montreal Cognitive Assessment (MoCA) scale was higher than that of the conventional treatment group (26 [IQR 24-28] vs 23 [IQR 21-26], $p=0.0001$). The number of people with cognitive dysfunction at the time of discharge from the early mobilization group was small (53 out of 99 [54%] vs 68 out of 99 patients [69%]; -15.2%, -28.6 to -1.7; $p=0.029$). Using Poisson regression model analysis, early mobilization intervention reduces the risk of cognitive impairment by 19% (RR 0.81, 95% CI 0.68-0.96, $P=0.014$). One year later, the risk of cognitive impairment in both groups of patients improved by an average of 2% per month (RR 0.98, 0.97-0.99, $P=0.0010$), but the early mobilization group improved more (intergroup time interaction 0.97, 95% CI 0.95-0.99, $P=0.037$). Cartotto et al. [27] found that the incidence of delirium in the intervention group was significantly lower than that in the conventional nursing group (9.9 vs 15.0%, $P=0.02$), and the intervention reduced the possibility of delirium (OR 0.6; 95% CI 0.39~0.92), The total number of days of delirium in the intervention group was significantly reduced (105 days vs 161 days, $P=0.02$), and the total number of delirium attacks was lower than that in the conventional nursing group (62 times vs 90 times, $P=0.03$). The number of days of ICU delirium in patients in the intervention group ($N=49$) was shorter (2 days vs 4 days, $P=0.03$), and the hospitalization time of delirium patients in ICU was shorter (33% vs 57%, $P=0.02$).

3. Key Nursing Practices and Challenges in Early Mobilization for Mechanically Ventilated Patients

3.1 Prerequisites for Practice: Scientific Assessment and Multidisciplinary Collaboration

3.1.1 Safety Assessment and Decision-making on Initiation Timing

In clinical practice, whether early mobilization can be started is based on a set of safety standards covering multiple physiological systems [28]. Nurses must check all clinical indicators one by one before daily activities. After all indicators are passed, early mobilization can be started or continued, otherwise early mobilization will be delayed or stopped.

The stability of the respiratory system is the most basic guarantee for the patient to accept early mobilization [29], and it is necessary to ensure the relative stability of the patient's oxygenation state. Under the premise of no need for a high level of respiratory support, vital signs such as $PaO_2 \geq 90\%$, $Fi0_2 \leq 0.6$, $PaO_2/Fi0_2 > 200mmHg$, $RR \leq 30$ times/min prove that early mobilization is started when the respiratory function is relatively complete [30].

The stability of the circulatory system is the core of the patient's early mobilization tolerance, and it is necessary to ensure the relative stability of the patient's blood circulation. Under the premise that there is no need for large doses or rapidly increasing doses of vasoactive drugs, and excluding uncontrolled malignant arrhythmia or acute myocardial ischemia, $MAP > 65mmHg$, $HR \leq 120$ times/min and other vital signs prove that early mobilization is relatively complete when circulatory function is relatively complete [31].

The stability of the nervous system is the key to the patient's cooperation in early mobilization, which needs to ensure the patient's state of consciousness and cognitive function. Without the need for a large dose of sedative, the $ICP < 20mmHg$ and Richmond Agitation-Sedation Scale (RASS) score is in the ideal restless-sedative state, -2~+1, starting early mobilization between shallow sedation and restlessness in a quiet state [32].

In addition to the above-mentioned guarantee of physiological system stability, other absolute contraindications should be excluded at the same time, such as uncontrolled active hemorrhage, unfixed unstable fractures, etc. [33] before starting early mobilization.

It should be emphasized that the assessment of early mobilization safety is a continuous and dynamic closed-loop process. The evaluation process occurs not only at the moment of decision-making before the mobilization, but also runs through the continuous monitoring of the mobilization and the re-evaluation after the mobilization. As the team members who have the closest contact with the patient in the MDT, nurses should always ensure that the patient's early mobilizations are always on a safe track throughout the process.

Although there have been many studies, there is still controversy about when the best time to start early physical mobilization in the critical care stage, which hinders the widespread use of early mobilization in the ICU environment [34, 35]. Therefore, it is still crucial to determine the most effective timing of mobilization.

3.1.2 Establishment and Operation of a Multidisciplinary Team

An efficient early mobilization MDT requires an organic whole with its own duties and clear powers and responsibilities. The core members are usually not limited to critical care physicians, ICU specialist nurses, physiotherapists (PT), respiratory therapists (RT) and other members [1].

Critical care physicians are responsible for evaluating the stability of the patient's condition from a medical perspective. As the final decision-maker to start or terminate mobilizations, they need to weigh the potential risks brought about by early mobilizations and benefits and the patient's primary disease, hemodynamics, respiratory support level, etc. [36].

ICU specialist nurses are the core hub of MDT's early mobilizations [37]. As the initiator of the mobilization, it needs to conduct a systematic screening of patients every morning. As the executor of the mobilization, it is responsible for most of the patient's bed activities, including position management, passive joint activity, auxiliary active activity in bed, etc. At the same time, assist the therapist to complete higher-level activities. As a mobilization monitor, carry out real-time monitoring of vital signs throughout the mobilization, find adverse reactions in time, and ensure the safety and effectiveness of early mobilization [38]. As a

communicator of patients and their families, I am responsible for explaining the planning and implementation of early mobilizations, and encouraging and supporting patients' mobilizations [39].

PT is an expert in charge of functional evaluation and rehabilitation program formulation [40]. PT uses MRC scoring, FSS-ICU and other professional evaluation tools to accurately evaluate the patient's muscle strength, joint mobility and functional status. Based on the evaluation results, PT designs individualized and progressive rehabilitation activities for patients, is responsible for guiding and implementing higher-level complex and high-risk activities, while training and guiding nurses in relevant skills.

RT is responsible for ensuring respiratory safety during the mobilizations. By evaluating the patient's respiratory mechanics and offline potential, it is judged whether the patient can tolerate the increased respiratory load caused by the mobilization [41]. During the implementation of the mobilization, adjust the ventilator parameters in real time according to the patient's reaction, and manage the patient–ventilator synchrony. At the same time, it is responsible for the fixation and safety of the patient's tracheal intubation or incision sleeve, and to prevent unplanned extubation. In higher-level activities, be responsible for the management of portable ventilators.

The collaboration of MDT requires the establishment of a standardized collaboration process [42]. MDT needs to work together every day to conduct multidisciplinary ward rounds. Based on the examination results and professional evaluation, jointly decide on the patient's mobilization plan and give bedside collaborative implementation. After the completion of the mobilization on that day, MDT collected information and adjusted the activity plan in combination with feedback, recorded the patient's response and tolerance, and provided a basis for the adjustment of the mobilization plan after the MDT inspection the next day [43], forming an improved PDCA cycle [44].

3.2 Core Components of Practice: Design and Implementation of Individualized Programs

3.2.1 Sedation and Analgesia Management

Good sedation and analgesic management are the prerequisite for MDT to better carry out early mobilizations for patients. Excessive use of sedative analgesics will inhibit the decline in the level of consciousness of the patient's central nervous system, and will also affect the stability of hemodynamics, which in turn affects the patient’s muscle strength, resulting in the patient's early mobilization to be limited or unable to reach the target activity dose [45]. The use of analgesic and sedatives will also inhibit the respiratory system to limit oxygenation, resulting in a decrease in the patient's mobilization endurance, which in turn forced early mobilization to be interrupted [46]. On the one hand, deep sedation and strong analgesia reduce the possibility of patients taking the initiative to accept early mobilizations. On the other hand, they affect the patient's tolerance for mobilizations and reduce the subjective willingness to continue to accept early mobilizations. Modern critical care rehabilitation promotes the strategy of "light sedation + optimal analgesia " to create conditions for patients' early activities. The PADIS Guidelines [6] shows that compared with deep sedation, it is recommended that critically ill adult patients with MV use shallow sedation to improve the prognosis of patients. Daily sedation interruption (DSI) or nursing program sedation is conducive to achieving and maintaining the patient's shallow sedation. The guidelines also show that compared with conventional nursing, it is recommended to treat pain assessment on the premise, program-based, step-by-step treatment of pain and sedation for critically ill patients, and the evidence is conditionally recommended, moderate-quality evidence. China’s guidelines [47] and expert consensus [48] suggest setting different sedation depth targets according to the diagnosis and treatment needs of patients' primary diseases, and shallow sedation is preferred. It is recommended that after the implementation of sedation, it is appropriate to continuously evaluate the sedation depth, adjust the treatment, and approach the target. The target value of sedation depth in shallow sedation is RASS score -2 to +1 points and SAS score 3 to 4 points. A good level of sedation and analgesia provides a guarantee for the early activities.

The implementation of the strategy of "light sedation + optimal analgesia " cannot be separated from the role of nurses in MDT and its ABCDEF bundle care practice. As the main implementer and evaluator of the sedation and analgesia program, nurses need to evaluate the patient's continuous and dynamic sedation level and analgesia level according to standardized evaluation tools such as RASS score, SAS score, CPOT score and BPS score. As a bridge of collaboration and communication in MDT, nurses should actively cooperate with MDT members. Finally, it is up to the doctor to decide to adjust the dose of sedatives and analgesics, and

advocate and implement the implementation of "analgesic priority" [49]. As the main promoter and monitor of the patient's daily spontaneous awakening test (SAT) and spontaneous respiration test (SBT), nurses avoid drug accumulation and excessive sedation through daily sedation interruption, and show the patient's neurological function, creating a window period for patients to assess whether the patient's consciousness and physiological state can meet the standards of early activities, making it possible to carry out patients' early activities continuously and safely [50].

3.2.2 Progressive Mobilization Programs

The early mobilization plan of the patient should be formulated individually by MDT according to the actual situation of the patient, with the core principle of "gradual" early activities. The mobilization plan of the day is based on the bedside evaluation results of MDT on the day, and the content and intensity of daily activities should be gradually improved [43,51].

According to the Johns Hopkins Highest Level of Mobility (JH-HLM), the highest level of activity of patients is quantified, and the graded early mobilization program is often adopted clinically [52,53], The content of the patient's activity ranges from easy to difficult, the mode of activity is from active to passive, and the scope of activity is from bed to under the bed. The first-level mobilization plan, early activities are carried out during the patient's consciousness disorder period, mainly including NMES, passive joint activity, ROM exercise, body position management, etc., to maintain the patient's joint function, prevent stress injury and muscle atrophy, and reduce the incidence of related complications. The second-level mobilization plan, early activities are carried out during the patient's sober cooperative period, mainly including active or PT-assisted active joint activity, bridge exercise, bed limb resistance training, core muscle group training, bed sitting up, bedside sitting position, etc., to activate the patient's core muscle group, improve core strength, and adapt to body position changes. The third-level mobilization plan is to carry out early activities during the patient's functional recovery period, mainly including bed and chair transfer, bedside standing, bedside stepping, walking with walking aids, etc., so as to promote the recovery of the patient's weight-bearing capacity, improve balance, and gradually move towards functional independence [54, 55]. It is worth noting that the above scheme is a general model. When applied to other special patients treated with CRRT, ECMO, prone ventilation, etc., more prudent risk-benefit assessment must be carried out by experienced MDT and individualized adjustment of the way and intensity of early mobilization.

3.3 Practice Support: Comprehensive Risk Management and Quality Control

3.3.1 Identification and Prevention of Key Risks

Ensuring the safety of patients is the first principle of early mobilization treatment plans. MDT should anticipate the risk points that may occur in the patient's activities and carry out systematic sorting and classification.

Safely carrying out early patient activities requires nurses to have a high level of risk prediction and teamwork ability in MDT. Before implementing early activities, MDT should strictly implement safety assessment and set clear termination standards in advance [33, 52, 53, 56]. During the implementation activities, nurses should timely identify patients' common risks, such as circulatory fluctuations, respiratory instability, etc. At the same time, they need to closely monitor the patient's heart rate, blood pressure, blood oxygen and other relevant vital sign indicators and be familiar with the criteria for termination of activities. For the management of key pipelines, the cooperation of MDT is required to prevent the occurrence of serious adverse events such as unplanned pipe removal [57]. Before the start of the activity, it should be checked whether all the pipelines are firmly fixed. In the activity, the RT is responsible for managing the ventilator management, and the nurse is responsible for the monitoring and management of various infusion and drainage pipelines to ensure that there is enough pipe length and space to carry out activities [58, 59, 60]. The safe implementation of the early mobilization plan should ensure sufficient human support, and the daily activity process of patients requires at least 2 members of MDT to participate in the whole process. At the same time, safety equipment such as transfer aids should be actively used [61], and patients should be given full communication before the start of the mobilization to reduce patient anxiety.

3.3.2 Monitoring of Adverse Events and Emergency Response Plans

In order to avoid the occurrence of adverse events in the early mobilization of patients and ensure the safety of patients, MDT should not only formulate clear activity termination standards in advance, but also establish emergency plans and handling processes for common adverse events, such as sudden hypoxia, violent fluctuations in blood pressure, catheter slippage and other events [62]. Nurses should be clearly aware of their position and responsibilities in the plan, carry out closed-loop adverse event monitoring, dynamically monitor the patient's vital signs and subjective feelings before, during and after the activity, and identify the potential risk of adverse events in patients in a timely and fast manner. Once the patient has an early warning signal, the executing nurse should immediately terminate the patient's activities and put the patient in a safe position, start the emergency process, call the doctor and carry out the doctor's instructions [63].

All adverse events should be recorded, reported and analyzed [64] as an important basis for continuous quality improvement of MDT's early activities for patients in ICU in the future, so as to form a complete safety management closed loop from risk identification to prevention to emergency response processes and optimization.

3.4 Barriers to Implementation and Corresponding Strategies

At the level of medical staff, the deep-rooted culture of "protective medical care" is the primary obstacle to the practice and promotion of early mobilizations. Most medical staff are overly concerned about the critical condition of the patient. Due to the lack of understanding of the safety and necessity of early mobilization, in the face of possible adverse events, medical staff still tend to be conservative in medical care decision-making. This preconceived notion directly hinders the development of early mobilization. Secondly, the lack of relevant theoretical knowledge and practical skills of medical staff largely limits the effective development of early mobilization. At present, there is a lack of a standardized process for early mobilizations for critically ill patients. Some nurses lack confidence in a series of nursing practice operations because they have not received systematic training on early mobilization assessment, execution and risk identification, and have not obtained the theoretical basis for early mobilization implementation.

Focus on the patient level, and practice and promote early mobilizations that are subject to the physiological and psychological disorders of patients. The condition of MV patients is critical and changeable. There are a series of absolute or relative contraindications, and the conditions for patients to carry out early mobilizations are constrained. In addition, patients' common ICU symptoms such as pain, restlessness and delirium can further affect their ability to carry out early mobilizations and their willingness to actively cooperate with mobilizations, and it is difficult to actively participate in early mobilizations. Long-term bed rest and repeated torture of pain in ICU may cause patients to have negative emotions such as fear, anxiety and depression, which leads to resistance to participation in early mobilization. The excessive concern of the patient's family about the patient's life safety is also an inevitable resistance to the practice and promotion of early mobilization.

In terms of organization and resources, there is still an imbalance in the human resources of physician–nurse ratio and nurse–patient ratio in the ICU of hospitals in China and other developing countries. Compared with the number of critically ill patients, the number of ICU specialist nurses is still insufficient, and the workload is heavy, and there is not enough time and energy to devote to the non-emergency rehabilitation activities of patients. Hospitals at all levels have not yet set up standardized procedures for early activities and related quality control systems. The hospital management lacks support and promotion for early mobilization. There are insufficient human resources for professional therapists such as PT and RT. The relevant rehabilitation auxiliary equipment has not been fully popularized and the number of holdings is insufficient, which limits the safety of early mobilization, so that early mobilization cannot be carried out continuously for patients as a routine treatment or nursing measure.

In response to the above-mentioned obstacles at the level of medical staff, a series of systematic coping strategies can be adopted from multiple dimensions such as cultural construction, skill training, teamwork, institutional innovation, etc. The hospital can vigorously carry out cultural construction and concept dissemination activities related to early mobilization [65]. Through special lectures on early mobilization, sharing successful rehabilitation cases, theoretical training on early mobilization for all medical staff and other channels, the modern rehabilitation concept can be rooted in the clinical thinking of each MDT team member [66]. At the same time, it is very important to establish a training system for knowledge and skills related to

graded early activities [67]. Nurses' ability to evaluate, execute and risk management of patients' early mobilization can be strengthened through graded and batched theoretical lectures and technical simulation drills. Promote the backbone of early mobilization from the nurse group, and act as the trainer and promoter of the follow-up early mobilization of the team.

For the aforementioned physiological and psychological problems existing in individual patients, interventions should focus on creating conditions enabling patients to initiate early mobilization. MDT can lay the foundation for the safe development of patients' early mobilization. through cluster strategies to optimize patient sedation and analgesia, systematic screening for delirium, and early respiratory function training. At the same time, nurses should strengthen communication with patients and their families, patiently explain the significance of early mobilization to the recovery of patients and the specific precautions for the implementation of early mobilization plans, and constantly strengthen humanistic care [68, 69].

In response to the above organizational and resource barriers, MDT should actively seek organizational and resource support from hospital management. MDT can obtain more early mobilization funds and resource input from the management by presenting real cases of early activities to shorten ICU LOS and early activities to reduce ICU complications to the management and patients and their families, and to obtain more early mobilization funds and resource input from the management.

4. Limitations and Controversies in Current Research

Combined with most of the existing studies and the confirmation of clinical evidence-based practice, the great value of early mobilization for the rapid recovery and long-term improvement of the quality of life of critically ill patients with MV is undeniable. At present, there are still some studies on the early mobilizations of critically ill patients, indicating that there are certain limitations and controversies, and therefore warrant more cautious interpretation and implementation. Intervention protocols for early mobilizations vary across different studies and clinical practices. The lack of definition and quantification of the optimal dose for early mobilization in critically ill MV patients with varying illness severity is the core limitation of existing research. The significant differences in the duration, intensity, and frequency of early intervention mobilizations make it difficult to conduct direct comparisons across studies and pooled analyses of clinical outcomes.

There is still controversy regarding the optimal timing of early mobilization. The 24-72 hour time window for initiating early mobilization is quite broad. When to initiate early mobilization for critically ill MV patients with different levels of illness severity is debatable in the academic community and cannot be generalized. Some post-treatment analyses of TEAM trial [70] have shown that premature mobilization of critically ill patients in the ICU who are not yet fully stable in order to achieve significant clinical outcome benefits carries certain risks. The incidence of adverse events during early mobilization was still higher in the ultra-early mobilization intervention group than in the control group. Most of the adverse events were abnormal fluctuations in blood pressure, arrhythmia, decreased blood oxygen saturation, and tubing dislodgement, and were all transient and self-limiting, without negatively impacting the long-term survival and outcome of the patients. To reduce or avoid adverse events caused by early activities, the timing of initiating early mobilization needs to be standardized.

Furthermore, the study design for early mobilization studies of MV patients in the ICU has methodological limitations, and the unavoidable difficulties in blinding can lead to a high risk of implementation bias. Inconsistent control group settings across different studies lead to excessive clinical heterogeneity, making it impossible to accurately measure the rehabilitation effects of early mobilization, which in turn affects evidence synthesis, conclusion generalization, and inter-study comparisons. Similarly, different studies use different outcome measures, which can lead to difficulties in clinical decision-making. Different outcomes reflect different dimensions of benefit and have different priorities. Patients and their families are more concerned about whether they can be weaned off the ventilator, leave the ICU, and go home to live independently as soon as possible, as well as outcome indicators such as quality of life. Clinicians and researchers more often use outcome indicators such as MV duration, ICU LOS, complication rate, and MRC score. Therefore, the different choices of outcome measures in different studies make it impossible to determine the key outcome measure with the greatest patient value after systematic review.

For specific patient groups, such as other patients receiving CRRT, ECMO, prone ventilation, etc., the applicability of early mobilization remains a research gap, and the evidence regarding its safety and feasibility is still insufficient.

5. Conclusion

Early mobilization for critically ill patients receiving MV treatment in ICU have been proven to be an intervention measure that can effectively prevent ICU-AW, shorten the MV time, reduce the risk of related complications, and improve the overall prognosis of patients. This article systematically sorts out the positive impact of early mobilization on the prognosis of patients, and discusses the core roles and specific practice paths of nurses in the process of evaluation, planning, implementation, evaluation and coordination in the whole process of nursing practice. To transform the evidence-based benefits of early mobilization into clinical results, MDT collaboration led by nurses and systematic nursing practices are indispensable. As mentioned above, the promotion of early mobilization faces many challenges, including the heterogeneity of intervention programs, differences in the timing of launch, insufficient evidence for specific groups, and the challenges of imperfect standardized processes in China's clinical practice. In the face of these challenges. These challenges should not hinder the systematic implementation of early mobilization in clinical practice, but highlights the urgency of building a scientific, standardized and individualized nurse-led MDT and its nursing practice.

As an important focus of critical care rehabilitation in recent years, early mobilization have gradually turned into a part of routine nursing, which still requires the joint efforts of workers in the field of critical care, including continuous professional training in critical care and the construction of an interdisciplinary cooperation model. Future research should focus more on the "dose-effect" relationship model of early mobilization and high-quality clinical experiments for specific patient groups, and pay more attention to the long-term quality of life of patients discharged from the hospital. Through the unremitting efforts and practice of nursing workers, the value of critical care rehabilitation nursing is to make every critically ill patient return to life with high quality.

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Conflicts of Interest

The authors declare no conflict of interest.

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