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Original Article

A best evidence synthesis in practicing early active movements in ICU patients with mechanical ventilation

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Abstract: Objective: This study summarized the best evidence of early active movements in mechanically ventilated patients in the ICU and applied it in the intensive care unit of our hospital to evaluate the practical effects. Methods: The best evidence for early activity in patients with mechanical ventilation in the ICU was summarized by using an evidence-based nursing method, and the results were clinically applied in the ICU. Patients who were mechanically ventilated in the ICU from January to March 2020 were selected as the control-group, and their counterparts from April to June 2020 were enrolled as the practice-group. The control-group-patients received conventional early active mobilities, and the practice-group-patients performed the best evidence-based early active mobilities. The Barthel index, muscle strength, duration of mechanical ventilation and length of ICU stay between the two groups were compared. Results: The scores of Barthel index and muscle strength of the practice group were remarkably higher than those of the control group, and the duration of mechanical ventilation and length of ICU stay were obviously shorter than those of the control group, and the difference was statistically significant (*P<0.05*). The incidence of deep vein thrombosis in practice group was substantially lower than that in control group (P<0.05), and the incidence of ICU acquired weakness in in practice group was critically lower than that in control group (P<0.05). The anxiety and depression scores of the two groups post-intervention were remarkably less than those before intervention (P<0.05), and the observation group had apparently lower scores than the control group (*P<0.05*). Conclusion: The application of the best evidence of early active movement in ICU patients with mechanical ventilation can improve the daily life ability, promote the recovery of muscle strength, reduce the incidence of deep vein thrombosis and ICU acquired weakness, decrease the duration of mechanical ventilation and length of ICU hospital stay, thereby improving the clinical outcomes.

Keywords: ICU, mechanical ventilation, early active movements, best evidence

Introduction

In recent years, the survival rate of critically ill patients has increased with the continuous advancement of intensive medical technology, and mechanical ventilation is a highly adopted treatment method in the intensive care unit (ICU) [1]. According to surveys, around 40% of hospitalized ICU patients in the United States receive mechanical ventilation, and about 30% of those who have long-term mechanical ventilation [2]. Mechanically ventilated patients usually are required to stay in bed for a long time, and receive sedation and analgesia treatment due to their severe disease as well as care for the prevention of accidents during treatment. As a result, patients are prone to poor nutritional status and physiological functioning, and unbalanced muscle protein synthesis and decomposition, which ultimately leads to the occurrence of ICU acquired weakness (ICU-AW) [3, 4]. ICU-AW is one of the most common serious complications in ICU patients, and it has been reported that 25% to 60% of ICU patients are affected by ICU-AW [5]. ICU-AW not only leads to muscle weakness, but also prolongs the length of the hospital stay and can result in permanent disability in severe cases, which is extremely detrimental to the patients' prognosis. At present, the significance of prevention

and treatment of ICU-AW has been valued by researchers domestically and abroad, and a series of related studies have been carried out [6, 7]. Most studies have shown that early active mobility is the best way to increase the muscle strength of patients. However, due to combined factors such as the lack of knowledge and understanding among medical staff, and the shortage of human resources and therapeutic devices, the clinical application of early active mobility in ICU patients with mechanical ventilation remains low [8]. Research has revealed that the rate of out-of-bed movement in patients with tracheal intubation is as low as 2%, compared with 10% for those on mechanical ventilation [9]. Therefore, in order to better combine the evidence of early active movement in ICU mechanically ventilated patients with clinical practice, this study summarized the best evidence of early active mobility in patients with mechanical ventilation in the ICU and applied it to our ICU department, aiming to provide theoretical and practical basis for clinical nursing work. The detailed reports are as follows.

Materials and methods

General information

A total of 139 ICU patients with mechanical ventilation in our hospital from January to June 2020 were selected as the research subjects. The inclusion criteria were as follows: (1) Patients aged ≥ 18 years old; (2) The length of ICU stay and duration of mechanical ventilation were ≥24 h; (3) Patients or their family members were willing to participate in the study and they signed the informed consents. The exclusion criteria included: (1) Patients with restlessness, delirium, etc.; (2) Patients with diseases that clearly affected the muscle strength; (3) Patients who died at the time of discharge from the ICU or who gave up during treatment. We adopted the pre- and post-control method to classify 65 patients from January to March 2020 in the control group, and another 74 patients from April to June 2020 in the practice group. There were statistically insignificant differences between the two groups in terms of gender, age, acute physiological and chronic health score upon ICU admission, Barthel index and diagnosis category (*P>0.05*), as shown in **Table 1**. The study was approved by the ethics committee of our hospital.

Methods

Establishment of an evidence practicing project team

The evidence practicing project team was composed of 9 members, including 1 ICU physician, 3 nursing managers, 2 therapists and 3 personnel who received systematic evidence-based training. The researchers of this project were responsible for the collection, induction and summary of the best evidence, and the remaining members were in charge of the transformation and clinical practice of the evidence based activities.

Acquisition of evidence

Retrieval of evidence: The Chinese and English keywords and search strategies were obtained and determined: Critical/severe/ICU, mechanical ventilation/artificial ventilation/invasive ventilation, early movement/early rehabilitation/early exercise; Critical/critical/ICU, mechanical ventilation/artificial ventilation/invasive ventilation, early activity/early rehabilitation/early exercise. The full-text literature on early active moments of ICU patients on mechanical ventilation was retrieved from the database below: China National Knowledge Infrastructure (CNKI), Wanfang Database, VIP Database, Evidence-based Healthcare Center Database, China Biomedical Database (CBM), Guideline International Network (GIN), (National Guideline Clearing-house (NGC), Scottish Interhospital Guide Network (SIGN). The time limit of the articles was December 31, 2019.

Evaluation criteria of evidence: Two personnel received systematic evidence-based training, independently conducted the evaluation on the quality of literature, the level of evidence, and the strength of recommendations according to the different types of research quality evaluation tools launched by the Australian JBI Evidence-based Healthcare Centre in 2016 and the Oxford Evidence Rating and Recommendation Strength Scale. Grade-A recommendation referred to a strong recommendation, Grade-B recommendation referred to a weak recommendation, and all of the Grade-A recommended evidence were adopted. When the

Table 1. Comparison of the general information

Item	Control group (n=65)	Practice group (n=74)	X^2/t	*P*
Gender (M/F, number of cases)	37/28	43/31		
Age ($\overline{x}$±s, years old)	64.68±8.27	65.45±7.33	0.5820	0.5615
Acute physiological and chronic health score on ICU admission ($\overline{x}$±s, points)	12.33±2.24	12.87±2.46	1.3461	0.1805
Barthel Index Score ($\overline{x}$±s, points)	16.38±11.52	15.17±12.73	0.5844	0.5599
Diagnosis category of ICU admission (number of cases)			0.3185	0.9565
Severe pneumonia	21	22		
Respiratory failure	18	19		
Acute heart failure	17	21		
Septic shock	9	12		

evidence conclusions were inconsistent, the quality of evidence and authoritative literature were given priority; and in the event of a conflict, we consulted and discussed with a third system reviewer to decide whether to include the research or not.

Inclusion of literature: The inclusion criterion of the literature was the full-text literature related to the topic retrieved in the searched database. The exclusion criterion of literature: The literature quality evaluation standard developed by Australia JBI was used to evaluate the retrieved literature, and those with a score of less than 70% were excluded. According to the inclusion and exclusion criteria, a total of 1064 retrieved articles were re-checked and 983 were screened after reading of the abstract, and 81 articles were obtained. After reading the full text, the articles with poor quality, incomplete research data, unclear outcome indicators, and inconsistent research types were eliminated, and 8 articles were finally included, which contained 1 guideline [10], 1 expert consensus [11], 4 systematic reviewers [12-15], and 2 evidence summaries [16, 17].

Formation of best evidence and clinical review criteria: Based on the executing process of early active moments, we sorted out and summarized the literature obtained above, and generated 18 best evidence practices (see **Table 2**).

Determination of evidence-based clinical review criteria

We synthesized the input from members of the evidence practicing project team and stakeholders to develop 10 review criteria (see **Table 2**).

Status review

The control group received routine ICU intervention measures as follow: We assisted the patients to turn over every 3 h, and raised their heads of the bed over 30°. The patients laid on one side, in a supine, or forced position. They were allowed to move in bed when they were awake and acquired good muscle strength, but moving along or out of bed was prohibited. The early activity of the control group was observed. The reviewers were 55 medical staff in the ICU ward of our hospital, who conducted viewing of nursing records, on-site interviews and inspections, and questionnaires. According to the review criteria, the implementation rate in indicator 1 was 100%, in indicators 2, 3, 4, 5, and 8 it was 0, in indicator 6 it was 60%, and in indicators 7, 9, 10 it was 75%.

Introduction of evidence

According to the results of the baseline review, the members of the evidence practice project team discussed and analyzed the obstacle factors for the review criteria with the implementation rate less than 100%, and formulated the corresponding action countermeasures (see **Table 3**).

Implementation of evidence

We applied the best evidence to the practice group as follows: (1) The rapid assessment of early active movement contraindications was performed by the therapist within 24 h of the patient's admission to the ICU (Absolute contraindications were patients with cardio-brain death or into palliative care; Patients with relative contraindications were able to suspend

Table 2. Summary of the best evidence and clinical review criteria for early active moments in mechanically ventilated ICU patients

Procedures	Content of evidence	Clinical review criteria
Identification of patient needs	1. After the patient entered into ICU, medical staff should fully evaluate whether there were early indications of active movements as soon as possible (Ic evidence, Grade-A recommendation) 2. Patients conducted evaluation on cardiovascular system, nervous system and respiratory system before each active movement (Ib evidence, Grade-A recommendation) 3. Evaluation content included: the myodynamia (MRC), the Barthel index, acute physiological and chronic health, Glasgow Coma Scale, disease diagnosis and comprehensive clinical evaluation (Ib evidence, Grade-A recommendation)	1. Medical staff fully evaluated the patient by myodynamia (MRC), Barthel index, acute physiological and chronic health, Glasgow Coma Scale, disease diagnosis and comprehensive clinical evaluation
Preparation of movement plan	4. Developed personalized and structured early activity plan based on the patient's individual situation (IIb evidence, Grade-A recommendation)	2. Formulate early movement program for each patient in line with his actual situation
Determination of movement timing	5. Carried out early active movements as soon as possible after the patient's hemodynamics was stable (Ib evidence, A level recommendation)	3. The hemodynamics of the patients were monitored daily
Pre-movements preparation	6. Conducted training of early active movement for medical staff (IIb evidence, Grade-A recommendation) 7. The trained medical staff explained the merits of early active movements and the precautions during activities to patients and their families, and signed the informed consent formes for with family members of patients (IIb evidence, Grade-A recommendation) 8. Prepared the portable monitors and ventilators, and confirmed that the devices were in standby state (IIb evidence, Grade-A recommendation)	4. Medical staff received training on the knowledge of early active movements and passed the assessment 5. Medical staff and the patients' families sign the informed consent forms for the conduction of early active movements 6. All the therapeutic devices prepared before the event were in the ready and usable state
While-activity	9. Adopted safety monitoring standards to assess and monitor the patients, and timely terminated the early active movements if unstable vital signs of patients occurred (Ib evidence, Grade-A recommendation) 10. At least one nurse was responsible for fixing the patients' arteriovenous catheter and respiratory machine lines to prevent decontamination incidents (Ib evidence, Grade-A recommendation) 11. One nurse was responsible to communicate non-verbally with patients to understand the needs of them, and ensured the patients were in safety (IIb evidence, Grade-A recommendation) 12. A respiratory therapist should participate in the early movements to focus on the respiratory conditions of patients (IIb evidence, Grade-A recommendation)	7. The activity should be terminated in time if following vital signs of patients occurred: the heart rhythm was irregular, heart rate less than 60 beats/m or over 130 beats/m, and the heart rate decreased by over 20% during the rest; Respiratory rate >40 times/m or <5 times/m; $Sp0_2$ <88%; Mean arterial pressure <60 mmHg or >110 mmHg; The score of Richmond agitation - sedation <-3. 8. Clear division of medical staff
Duration of movements	13. The on-the-bed and out-of-bed movements should be conducted based on the patients' tolerance, and should not exceeded half an hour (IIa evidence, Grade-A recommendation) 14. Gradually extended the movement according to the patient's tolerance, but each time of activity should not exceed 1 hour (IIa evidence, Grade-A recommendation)	9. Assisted the patients with activities according to their formulated plan, and recorded the time of each activity
Manner of movements	15. The patients performed active movement of limbs by supine position on the bed (IIa evidence, Grade-A recommendation) 16. The patient sit on the bed or sit with legs hanging by the bed (IIb evidence, Grade-A recommendation) 17. The patients stranded beside the bed with the assistance of medical staff (IIb evidence, Grade-A recommendation) 18. The patients performed walking exercise with the assistance of medical staff (IIa evidence, Grade-A recommendation)	10. The medical staff carried out passive joint activities on the patient's limbs according to their physical status, assisted the patients to sit and stand on the bedside, or walk along the bedside

Table 3. Obstacles to review criteria and action countermeasures

Obstacle Factors	Action Countermeasures
The lack of knowledge of medical staff on early active movements	Provide training on the knowledge of early active movements for all medical staff, and conducte regular assessments to enhance their understanding.
Lack of reliable program of early active movements	Through sorting out the best evidence included in the literature, the best evidence and clinical review criteria of early active movements of ICU patients with mechanical ventilation are formed.
Lack of interdisciplinary cooperation	The rehabilitation department will be invited for consultation, and the rehabilitation specialist will develop the personalized early activity plans for each patient according to the best evidence of early activity.
Unclear division of labor among medical staff	Set up a working group according to the shift, and the doctor will be responsible for assessing the patient's disease condition; The rehabilitator to guide the patient during functional training; The patients-supporting, fixation of instruments and pipelines will be in charge of designated full-time nurses.
The patient was under unstable condition and worried about adverse events during the process of early active movements	Fully assess if the patient has signs for early active movements; Ensure that the patient's hemodynamics is in stable state before the early active movement are carried out; When the shift is transferred, the full-time nurse records the drainage volume and catheter calibration; Sign an informed consent form for early active movements with family members; The early active movement of patients should be carried out after all medical staff are in place; When the patient has any of the indications in Article 7 of the review form, the active movements should be stopped immediately; Formulate emergency plan for the tumble and artificial airway detachment of patients, and strengthen the executive of standard measures implementation through multiple rehearses.
The patients and their family members were lack of related knowledge on early active movements, and were worried that early movements would bring discomfort or pain to the patients	Make videos and brochures of early active movements and place in the waiting area for family members or upload on WeChat official account for family members to check; The trained medical staff explain the merits of early active movements to patients and their families; Score the postoperative pain of the patient, and give analgesic drugs according to the specific situation by the physician; Develop personalized early activity plan to reduce the tension of patients.

active movements or were currently unable to exercise, including those with uncontrolled or active bleeding; Patients with increased dosage or type of vasoactive drugs within 2 h, or patients with new myocardial infarction, myocardial ischemia or arrhythmia within 2 h; Patients with open wounds in the chest or abdomen). The physician in charge, therapist and the nurse in charge, jointly evaluated the patients without contraindications of early active movements, and formulated the plan of early active movements according to the rehabilitation needs of patients. (2) The therapist assessed whether the patients meet the indications for early active movements. Those who met the indication started the active movements immediately, and the unqualified patients were evaluated again within 24 h (Indications of early active movements: respiratory system SpO_2>88%, breathing 5-40 times/min, inhaled oxygen concentration <0.6 and positive end-expiratory pressure <10 cmH_2O, and the airway of tracheotomy or endotracheal intubation was fully protected; The hemodynamics of cardiovascular system was stable with heart rate of 60-130 beats/min and mean arterial pressure of 60-110 mmHg; In terms of the nervous system, the patient's agitation-sedation scale score was ≤1, the intracranial pressure did not increase, and delirium was negative). (3) We closely monitored the patient's indications for termination of activity during the active movements. Patient's movement was immediately terminated when any of the signs for termination occurred, and they were evaluated again within 24 h for whether they had the indications to start with early active movements (Indications for termination of movements were shown in clinical review criteria 7 in **Table 2**). (4) We evaluated the patients in real time, and updated and implemented the activity plan in time according to the specific conditions of the patients, until they recovered to a functional state or transferred out of the ICU.

Quality control

We composed a quality-control team with members of the evidence practice project team, conducted irregular inspections at least once a week to supervise the implementation of early activities, gave timely feedback on the problems that existed during the implementation, and carried out intensive training for the problems that occurred.

Criteria assessment

Barthel index, muscle strength, duration of mechanical ventilation and length of ICU stay of the ICU patients with mechanical ventilation before and after the practice of evidence were compared. Barthel Index Evaluation Table [18] included dressing, grooming, bathing, eating, control of urine and feces, transfer between bed and chair, walking on flat ground and stepping up and down stairs, etc. The full score was 100 points, and higher scores referred to a better ability of daily living. Muscle strength was graded by MRC-score method developed by the British Medical Research Council (MRC) [19]. The incidences of deep vein thrombosis and ICU-AW in patients with mechanical ventilation before and after the adoption of evidence based movement execution were compared, and those with muscle strength <48 points were judged to have acquired weakness in ICU.

The anxiety and depression scale (HADS) [20] was applied for the comparison of the psychological status of the two groups of patients before intervention (within 24 h of admission to ICU) and after intervention (out of ICU). The scale was divided into two subscales for anxiety and depression, with a total of 14 items. The scale adopted Likert 4-level scoring method, and the score of each subscale with ≤ 7 points referred to non-anxiety/depression, and a higher score indicated a more sever level of anxiety/depression. The Cronbach's α coefficients of the two subscales were 0.797 and 0.822, respectively.

Statistical methods

We used SPSS 19.0 software for statistical analysis and processing of data. The measurement data are expressed by ($\bar{x}\pm s$), the comparison between groups was compared by t-test of independent samples. The enumeration data are expressed as percentages, and the results are assessed by X^2 test. $P<0.05$ referred to a statistically significant difference.

Results

Comparison of Barthel index, muscle strength, duration of mechanical ventilation and length of ICU stay between two groups with mechanical ventilation

The scores of Barthel index and muscle strength of the practice group were remarkably

Table 4. Comparison of Barthel index, muscle strength, duration of mechanical ventilation and length of ICU stay between two groups of ICU patients with mechanical ventilation ($\bar{x}\pm s$)

Group	Barthel index score (points)	Muscle strength score (points)	Duration of mechanical ventilation (h)	Length of ICU stay (d)
Control group (n=65)	33.12±15.38	47.66±7.24	128.75±34.37	9.84±4.37
Practice group (n=74)	58.49±12.61	51.17±5.85	71.22±15.58	6.31±1.28
t	10.6810	3.1590	12.9666	6.6352
P	<0.001	<0.001	<0.001	<0.001

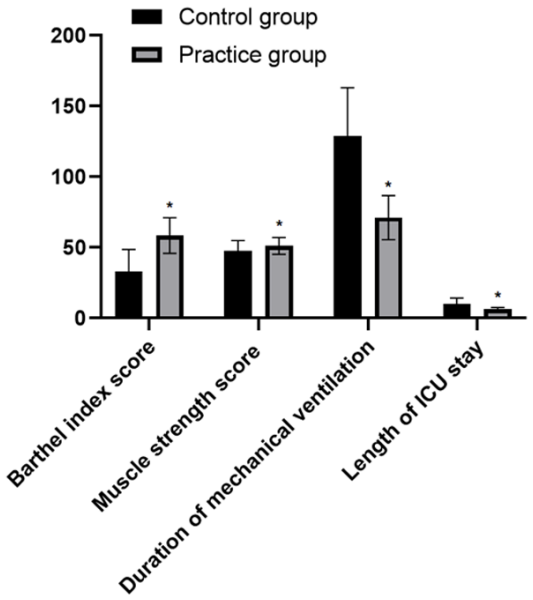

Figure 1. Comparison of Barthel index, muscle strength, duration of mechanical ventilation and patients with mechanical ventilation. Note length of ICU stay between two groups of ICU: Compare with control group, *P<0.05.

higher than which of the control group, and the duration of mechanical ventilation and length of ICU stay were obviously shorter than those of the control group, and the difference was statistically significant (*P<0.05*), as shown in **Table 4** and **Figure 1**.

Comparison of the incidence of deep vein thrombosis and ICU-AW between two groups of mechanically ventilated patients

The incidence of deep vein thrombosis in the practice group was substantially lower than that in control group (0%, 10.77%, X^2=6.2910, *P*=0.0121), and the incidence of ICU acquired weakness in the practice group was critically lower than that in control group (18.92%, 44.62%, X^2=10.6947, *P*=0.0011) (**Table 5**).

Comparison of psychological states between the two groups before and after intervention

The comparison of the anxiety and depression scores of the two groups of patients in pre-intervention was not statistically significant (*P>0.05*), the scores in post-intervention were remarkably less than those before intervention (*P<0.05*), and the scores of the practice-group-patients were dramatically less than the control-group-patients (*P<0.05*) (**Table 6**).

Discussion

The practice of the best evidence exercises for early active movements in ICU patients with mechanical ventilation can improve their clinical outcomes

ICU mechanically ventilated patients usually have varying degrees of muscle deterioration due to their severe disease and the necessity of lying-in bed. Studies have shown that ICU patients are often accompanied by decreased myosin and increased muscle fiber atrophy due to prolonged hospital stay [21]. Long-term mechanical ventilation leads to the gradual loss of respiratory muscle function, and further muscle weakness, aggravating the patient's dependence on the ventilator. The decline of skeletal muscle and respiratory muscle strength will lead to prolonged mechanical ventilation and longer hospital stay, thus forming a vicious circle of treatment. The results of this study showed that the scores of Barthel index and muscle strength of the practice group were remarkably higher than those of the control group, and the duration of mechanical ventilation and ICU stay were critically shorter than those in the control group, which is consistent with most of the study results [22, 23]. Therefore, early active movements can improve the daily self-care ability of patients, promote the recovery of muscle strength, shorten the duration of mechanical

Table 5. Comparison of incidence of deep vein thrombosis and ICU-AW between two groups of mechanically ventilated patients

Group	Deep venous thrombosis			ICU-AW		
	Occurrence (cases)	None (case)	Incidence rate (%)	Occurrence (cases)	None (case)	Incidence rate (%)
Control group (n=65)	7	58	10.77	29	36	44.62
Practice group (n=74)	0	74	0	14	60	18.92
X^2			6.2910			10.6947
P			0.0121			0.0011

Table 6. Comparison of the psychological state of the two groups before and after intervention (points, $\overline{x}\pm s$)

Group	Number of cases	Anxiety	Depression
Control group (n=65)	Before intervention	12.85±1.79	13.47±2.73
	After intervention	8.33±1.26	9.03±1.56
	T	16.648	11.385
	P	<0.001	<0.001
Practice group (n=74)	Before intervention	13.17±2.10	13.75±2.31
	After intervention	6.59±1.57	6.52±0.97
	T	21.588	24.824
	P	<0.001	<0.001

ventilation and ICU stay, and improve the clinical outcomes. The core of the best evidence for early active movements is exercise. Based on the best evidence and clinical review criteria, the nursing staff formulated personalized activity plans through a comprehensive evaluation of patients, so that patients gradually transitioned from bed movements to bedside activities, and then walking activities. The movements in a progressive manner are particularly important for patients to gradually adapt to the intensity of activity. Bed rest can promote the decline of the patients' diaphragm, increase the volume of the chest cavity, and promote pulmonary ventilation. Sitting by the bed with legs suspended is an excessive method to get out of bed. Bedside standing and walking exercise can not only promote the synthesis of myoglobin of patients, but also restore their strength of skeletal muscle and respiratory muscle. At the same time, the activity of macrophages and lymphocytes in patients was increased, and the ability to remove respiratory tract cilia was enhanced, which reduced the rate of respiratory infection and shortened the duration of mechanical ventilation and ICU stay.

The practice of the best evidence for early active movements in ICU patients with mechanical ventilation can reduce the incidence of deep vein thrombosis and ICU-AW

It has been confirmed by previous studies that prolonged bed rest in ICU mechanically ventilated patients, leads to a high incidence of deep vein thrombosis. Most of the thrombosis will spread to the deep vein trunk of the limbs and develop into sequelae of thrombosis if not treated in time, affecting the quality of life of patients for a long time [24]. A total of 33% of patients with mechanical ventilation longer than 4 d experienced ICU-AW, while the incidence rose to 82% in patients with mechanical ventilation longer than 7 d [25]. The results of this study revealed that the incidence of deep vein thrombosis and ICU-AW in the practice group was substantially lower than that in the control group, indicating that the practice of the best evidence of early active movements can reduce the incidence of deep vein thrombosis and ICU-AW. The reasons are as follows: during the process of active movements, patients can contract their own limb muscles, squeeze the intermuscular veins, accelerate blood circulation, thus reducing the incidence of deep vein thrombosis; and promoting the gradual recovery of skeletal muscle strength during active movements can prevent muscle atrophy and thus reduce the incidence of ICU-AW.

The results of this study are consistent with those proposed by other scholars [26], that is, through the application of the best evidence and the conditions of our hospital, a more scientific and consistent intervention plan can be

formulated that is beneficial to the rehabilitation of patients and the improvement of clinical outcomes.

This study obtained evidence through scientific methods, and summarized the obstacles and action countermeasures of review criteria by combining them with clinical practical problems. The clinical practice of the best evidence improves the daily living ability of patients, promotes the strength recovery of muscles, reduces the incidence of deep vein thrombosis and ICU-AW and shortens the duration of ICU mechanical ventilation and length of ICU stay. This clinical practice improves the clinical outcome of patients and provides a reference basis for promoting the clinical application of the best evidence for early active movements in ICU patients with mechanical ventilation.

Disclosure of conflict of interest

None.

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