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World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 23 August 16, 2022

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 23 August 16, 2022

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 10 Number 23 August 16, 2022

Contents

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Retrospective Study

Evaluation of progressive early rehabilitation training mode in intensive care unit patients with mechanical ventilation

Xiao-Jing Qie, Zhi-Hong Liu, Li-Min Guo

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Abstract

BACKGROUND

Mechanical ventilation is a common resuscitation method in the intensive care unit (ICU). Unfortunately, this treatment process prolongs the ICU stay of patients with an increased incidence of delirium, which ultimately affects the prognosis.

AIM

To evaluate the effect of progressive early rehabilitation training on treatment and prognosis of patients with mechanical ventilation in ICU.

METHODS

The convenience sampling method selected 190 patients with mechanical ventilation admitted to the Fourth Hospital of Hebei Medical University from March 2020 to March 2021. According to the random number table method, they were divided into the control and intervention groups. The control group received routine nursing and rehabilitation measures, whereas the intervention group received progressive early rehabilitation training. In addition, the incidence and duration of delirium were compared for the two groups along with mechanical ventilation time, ICU hospitalization time, functional independence measure (FIM) score, Barthel index, and the incidence of complications (deep venous thrombosis, pressure sores, and acquired muscle weakness).

RESULTS

In the intervention group, the incidence of delirium was significantly lower than in the control group (28% *vs* 52%, $P < 0.001$). In the intervention group, the duration of delirium, mechanical ventilation time, and ICU stay were shorter than in the control group ($P < 0.001$). The FIM and Barthel index scores were significantly higher in the intervention group than the control group ($P < 0.001$).

The total incidence of complications in the intervention group was 3.15%, which was lower than 17.89% in the control group ($P < 0.001$).

CONCLUSION
Progressive early rehabilitation training reduced the incidence of delirium and complications in ICU patients with mechanical ventilation, which improved prognosis and quality of life.

Key Words: Mechanical ventilation; Intensive care unit; Early rehabilitation training; Delirium; Barthel index

Core Tip: The patients on mechanical ventilation in the intensive care unit are prone to ventilator dependence, resulting in a series of complications. Through randomized controlled trials, this study showed that progressive early rehabilitation training could effectively reduce the incidence of delirium and improve physical function and quality of life.

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INTRODUCTION

Mechanical ventilation refers to using a mechanical ventilator to replace or assist with active breathing. It produces negative chest pressure by inspiratory action in autonomous ventilation, thereby affecting the pressure of the lungs and airways. Ultimately, this mechanism assists in completing the inspiratory and expiratory breathing process[1]. As a common resuscitation method in the intensive care unit (ICU), mechanical ventilation plays an important role in improving respiratory support to critically ill patients. Additionally, it has become an important treatment method for the resuscitation of critically ill patients [2].

Critically ill patients usually require long-term mechanical ventilation, which further requires prolonged bed time, protective restraint devices, and analgesics. Clinical experience shows that prolonged hospitalization and mechanical ventilation can result in complications such as decreased neuromuscular function, ICU-acquired weakness, venous embolism of lower limbs, and ventilator-associated pneumonia. Furthermore, it affects the patient's activity and self-care ability and shortens the independent activity time, ultimately reducing the therapeutic effect and exaggerating the patient's condition[3-5]. In addition, domestic and foreign studies have pointed out that ICU patients with mechanical ventilation have ventilator dependence due to long-term use of ventilators. This dependence results in difficult or delayed weaning, which not only prolongs the ICU hospitalization time of patients but also increases the incidence of delirium and seriously affects prognosis[6]. The incidence of delirium in ICU ranges between 20% and 50%. In comparison, the incidence of delirium in ICU patients receiving mechanical ventilation is as high as 60%–80%[7]. Delirium mainly manifests as an acute onset and recurrent cognitive or consciousness dysfunction. The occurrence of delirium in ICU patients increases the treatment cost and psychological burden of patients and their families. Furthermore, it directly leads to cognitive function impairment, decreased quality of life, and increased mortality[8].

It is important to provide early rehabilitation training for ICU patients with mechanical ventilation in the clinic. Furthermore, studies in China and abroad have confirmed that the intervention of early rehabilitation training can reduce the use of sedatives, shorten the duration of delirium, improve quality of life, and ultimately improve prognosis in ICU patients with mechanical ventilation[9]. Furthermore, the progressive early rehabilitation training mode based on the quantitative evaluation strategy can significantly improve the pertinence of nursing measures[10]. Therefore, this study explored the effect of progressive early rehabilitation training on ICU patients with mechanical ventilation and evaluated its prognosis to provide a future reference for the clinical nursing intervention of ICU patients.

MATERIALS AND METHODS

Patients general information

A total of 190 patients with mechanical ventilation admitted to the ICU of our hospital from March 2020

to March 2021 were selected by the convenience sampling method. According to the random number table method, the patients were randomized into control and intervention groups (95 in each group). The general data of patients are shown in Table 1. The general data were comparable between the two groups.

Inclusion and exclusion criteria

This study was approved by the Ethics Committee of The Fourth Hospital of Hebei Medical University.

Inclusion criteria: (1) age ≥ 18 years; (2) ICU stay > 24 h, mechanical ventilation time > 72 h; (3) Acute Physiology and Chronic Health Evaluation II (APACHE II) 15–21 points; and (4) consent to participate in the study.

Exclusion criteria: (1) Patients with neurological or craniocerebral diseases, hemodynamic instability, and malignant arrhythmia; (2) patients with severe disturbance of consciousness or mental diseases who cannot cooperate with nursing instructions; and (3) patients with a limb movement disorder, motor dysfunction, neuromuscular disease, unstable fracture, and limb disability.

Control group

ICU routine nursing, diet guidance, traditional rehabilitation training guidance. The specific measures were as follows: close monitoring of vital signs such as respiration, blood pressure, pulse, and blood oxygen; adjusting mechanical ventilation parameters based on the condition; use of an air cushion to prevent bedsores and turning over; patting back and airway humidification; patients were given either passive or active training of limbs and joints, such as internal retraction, internal rotation, abduction, external rotation, flexion, and extension, twice each day for 30 min; psychological counseling for patients and improving treatment compliance; and actively preventing the complications such as bed sores, ventilator-associated pneumonia, and deep vein thrombosis.

Interventional group

Based on a reasonable ICU routine, progressive early rehabilitation training was implemented. The specific content and plan are as follow:

Establishment of rehabilitation training team: one head nurse, one ICU physician, one rehabilitation therapist, and three responsible nurses. All members received unified training of early rehabilitation-related knowledge, and the labor division was made clear for better coordination. The head nurse planned and arranged rehabilitation training plan; ICU physicians and rehabilitation therapists developed the targeted training programs to supervise and evaluate patients during the training period; and responsible nurses were responsible for the rehabilitation training.

Quantitative assessment of the patient's condition: Upon ICU admission, the patient's general and physical condition were evaluated in detail; the patient's gender, age, condition, and APACHE II score were recorded. The clinical manifestations, consciousness, hemodynamic status, and mental muscle strength were closely monitored. The patients were comprehensively evaluated and graded using the functional independence measure (FIM)[11]. FIM includes six dimensions: social cognition, self-care ability, transfer, communication, walking, and sphincter control. Furthermore, these dimensions were divided into four levels: 1, complete dependence, FIM score > 18; 2, severe dependence, 18 points < FIM score ≤ 53 points; 3, moderate dependence, 53 points < FIM score ≤ 71 points; and 4, conditional independence or mild dependence, 71 points < FIM score ≤ 107 points. Individualized and reasonable early rehabilitation training program was developed and modified every other day, based on the patient's grade, assessment of patient's respiratory and acting ability; adjustment of the training program, rehabilitation nursing, and training duration was made until the patient was transferred to the ICU.

Principle of progressive rehabilitation training: patients were graded and given corresponding training based on the above classification method, including active and passive training in the bed, standing, and walking by the bed. After regular training, each patient was scored using the FIM. After reaching the optimum score, the next stage of practice was observed to identify any adverse reactions to modified training. After the real-time monitoring of progress, the training was either continued, regressed, or stopped.

Progressive rehabilitation training method: (1) Level 1 patients: passive training in bed. Rehabilitation therapists instructed patients to perform the passive training of upper limbs, wrists, elbows, and shoulder joints. The training methods included stretching, flexion, external rotation, internal rotation, and abduction. Patients in both groups were trained 10 times each day for about 30 min each time; (2) Level 2 patients: active training in bed. The rehabilitation therapist guided and encouraged the patients to take the initiative to perform lower limb functional exercises. During exercise, the head of the bed was raised by 60°, and patients were instructed to buckle the legs and sit on the bed, while the pillows were placed on both sides to prevent lateral deviation. Then, according to the tolerance, the head of the

Table 1 Comparison of patients' general data in interventional and control groups

Feature	Interventional group (*n* = 95)	Control group (*n* = 95)	*P* value
Age (mean ± SD)	52.52 ± 3.04	53.78 ± 2.85	0.5214
Sex, *n* (%)			
Male	52 (54.74)	58 (61.05)	0.8541
Female	43 (45.26)	37 (38.95)	
Disease type, *n* (%)			0.4574
Chronic obstructive pulmonary disease	27 (28.42)	24 (25.26)	
Pneumonia	15 (15.79%)	17 (17.89)	
Severe bronchial asthma	22 (23.16)	19 (20.00)	
Else	31 (32.63)	35 (36.84)	
APACHE II score (mean ± SD)	17.52 ± 2.54	17.78 ± 2.23	0.078

APACHE II: Acute physiology and chronic health evaluation II.

bed was raised to 65°, and the legs were fully buckled. The active training was carried out with the help of the foot pedal type lower limb exercise device twice a day for 5-10 min each time. In addition, the patient was assisted to sit upright twice a day for 10-15 min each time; (3) Level 3 patients: bedside activities. When the leg can be lifted skillfully, a table with appropriate height was placed at the bedside to assist sitting at the edge of the bed, holding the chest with both hands while holding the elbows on the table. The feet were naturally drooping and standing on the ground. To increase the comfort, soft pillows were placed under the elbows and the feet, respectively. The training time was appropriately controlled according to the degree of tolerance of the body for twice a day/10-60 min each time, where the maximum time was not more than 2 h; and (4) Level 4 patients: standing by the bed or walking indoor. The patient was assisted in leaving the bed and sitting on the bedside chair, guided to use the lower limb strength to complete the standing posture twice a day/10-20 min each time; for patients with rapid recovery and permitted condition, according to the standing condition, they were assisted in short-distance walking training (with the help of walking aids). The number and degree of training were customized to be suitable for patients. Importantly, patient safety was ensured in this process by preventing falls.

Evaluating indicator for studied groups: (1) The incidence and duration of delirium were analyzed using the Confusion Assessment Method for ICU; (2) The related hospitalization indexes such as mechanical ventilation and ICU hospitalization were recorded and compared; (3) FIM scale was used to evaluate and compare the recovery level of neuromuscular function and various functional statuses. The full-scale score was 100, and the higher score represented the higher recovery level; (4) The Barthel index[12] was used to evaluate the daily living ability of the patients, including bathing, dressing, toilet, stool control, stairs, and walking. The total score was 100 points. The higher score represented, the stronger the daily living ability; and (5) The complications of mechanical ventilation, including deep venous thrombosis of the lower extremity, pressure sores, and acquired muscle weakness, were also compared.

Statistical analysis

All statistical analyses were performed using SPSS 24.0 software. Quantitative data were described as mean ± SD and compared between the two groups using the *t*-test or rank-sum test. Qualitative data were described by *n* (%), and the comparison between groups was performed by χ^2 test or exact probability method. All hypothesis testing levels were set to be except specified a = 0.05.

RESULTS

Incidence of delirium, mechanical ventilation time, and ICU hospitalization time

As shown in Table 2, the incidence of delirium in the intervention group (28%) was significantly lower than in the control group (52%) ($P < 0.001$). In addition, the duration of delirium in the intervention group was lower than in the control group (2.62 ± 0.43 *vs* 4.59 ± 0.82), whereas the duration of mechanical ventilation was lower than in the control group (5.74 ± 1.75 *vs* 8.43 ± 2.36). The ICU hospitalization time in the intervention group was also significantly shorter than in the control group (10.52 ±

Table 2 Comparison of delirium occurrence, mechanical ventilation time, and intensive care unit hospitalization time between intervention and control groups

Group	Incidence of delirium, *n* (%)	Delirium duration (d)	Duration of mechanical ventilation (d)	ICU hospitalization time (d)
Interventional group (*n* = 95)	27 (28.00)	2.62 ± 0.43	5.74 ± 1.75	10.52 ± 2.28
Control group (*n* = 95)	50 (52.00)	4.59 ± 0.82	8.43 ± 2.36	15.74 ± 4.24
t/χ^2	15.648	8.542	5.537	9.182
P value	< 0.001	< 0.001	< 0.001	< 0.001

ICU: Intensive care unit.

2.28 *vs* 15.74 ± 4.24; $P < 0.001$).

Functional scores of patients after intervention (FIM)

As shown in Table 3, the FIM scores of the intervention group were significantly higher than in the control group. For example, the social cognitive score of the intervention group (17.48 ± 1.42) was significantly higher than in the control group (16.04 ± 1.36) ($P < 0.001$). The self-care ability score of the intervention group was significantly higher than in the control group (30.36 ± 3.23 *vs* 25.78 ± 3.54, $P < 0.001$). The walking ability score of the intervention group was significantly higher than in the control group (90.14 ± 9.35 *vs* 77.53 ± 8.64).

Daily living ability (Barthel index score): before and after intervention

As shown in Table 4, before the implementation of rehabilitation training measures, the Barthel index of the intervention group was slightly higher than in the control group (66.24 ± 5.12 *vs* 65.74 ± 4.68); however, the difference was not significant. After receiving the different rehabilitation training measures, the Barthel index of the intervention group (85.45 ± 5.86) was significantly higher than in the control group (74.86 ± 6.78, $P < 0.001$). The differences in intragroup Barthel index before and after the intervention were significant. For example, in the intervention group, the Barthel index before intervention was 66.24 ± 5.12, which significantly increased to 85.45 ± 5.86 after intervention ($P < 0.001$).

Incidence of complications

As shown in Table 5, the total incidence of deep venous thrombosis, pressure sores, and acquired myasthenia gravis in the intervention group [3.15% (3/95)] was significantly lower than in the control group [17.89% (17/95)] ($P < 0.05$). The incidence of acquired muscle weakness in the intervention group was 0, which was lower than in the control group (4.20%). In contrast, the incidence of pressure sores was 1.05% in the intervention group, which was lower than 5.26% in the control group.

DISCUSSION

Mechanical ventilation is commonly used during the treatment of ICU patients. When the oxygenation capacity or natural ventilation of patients is impaired, mechanical ventilation significantly improves the respiratory status of patients[13]. For most patients on mechanical ventilation, assisted breathing causes a certain degree of organ dysfunction. Moreover, ICU patients require prolonged bed time and undergo long-term mechanical ventilation. This extended treatment leads to decreased nervous system capacity, bone atrophy, weakened limb blood circulation function, gastrointestinal peristalsis, with additional complications such as pressure sores, deep venous thrombosis of lower limbs, acquired muscle weakness, and ventilator-associated pneumonia[14]. In addition, ICU patients receive long-term sedation and analgesia with mechanical ventilation to implement intensive care. However, long-term sedation and analgesia cause drug accumulation and excessive sedation, resulting in iatrogenic coma and delirium in ICU patients[15]. Mechanical ventilation seriously affects quality of life and prognosis. Therefore, it is necessary to carry out early rehabilitation training by taking the relevant nursing measures for these patients. However, due to the complex condition of ICU patients and the heavy workload of healthcare staff, targeted nursing measures for such patients are still limited and not ideal [16,17].

In recent years, mechanical ventilation has been widely used to correct respiratory failure and prevent disease progression. Therefore, it is essential to strengthen ICU patients' nursing care on mechanical ventilation. However, the traditional rehabilitation nursing mode has certain limitations in improving the patient's activity and self-care ability. However, the progressive rehabilitation nursing

Table 3 Comparison of functional scores of functional independence measure scale between intervention and control groups

Group	Social cognition	Communication	Self-care ability	Transfer	Sphincter control	Deambulation
Interventional group (n = 95)	17.48 ± 1.42	13.23 ± 1.47	30.36 ± 3.23	12.53 ± 1.41	7.54 ± 1.04	90.14 ± 9.35
Control group (n = 95)	16.04 ± 1.36	11.54 ± 1.36	25.78 ± 3.54	9.65 ± 1.14	5.53 ± 0.87	77.53 ± 8.64
t value	5.678	4.785	6.423	8.745	9.742	6.451
P value	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001

Table 4 Comparison of Barthel index before and after intervention

Group	Before intervention	After intervention
Interventional group (n = 95)	66.24 ± 5.12	85.45 ± 5.86[a]
Control group (n = 95)	65.74 ± 4.68	74.86 ± 6.78[a]
t value	0.845	-10.745
P value	0.126	< 0.001

[a]$P < 0.05$.

Table 5 Comparison of incidence of complications between intervention and control groups, *n* (%)

Group	Deep venous thrombosis	Pressure ulcer	Acquired muscle weakness	Total rate[1]
Interventional group (n = 95)	2 (2.10)	1 (1.05)	0 (0.00)	3 (3.15)
Control group (n = 95)	8 (8.42)	5 (5.26)	4 (4.20)	17 (17.89)

[1]Comparison of the total incidence of complications between the studied groups, $Z = 8.754$, $P < 0.001$.

mode helps formulate the appropriate training programs based on the patient's condition and physical function to improve prognosis and rehabilitation[18,19]. The current study applied the progressive early rehabilitation training model to ICU patients with mechanical ventilation based on the quantitative evaluation strategy. The protocol was formulated based on the stability of the patient's condition, using the FIM scale to evaluate the patient's neuromuscular function independence. Progressive functional training was divided into four levels for each disease and body condition level. It can effectively stimulate the muscle neurons, inhibit muscle decomposition, promote the growth of axons in compensatory circulation, and help shorten the unconscious time of muscle to restore neuromuscular function[20]. According to the evaluation results, a progressive early rehabilitation training model developed for appropriate nursing interventions effectively improves the scientific nature of targeted nursing measures[21].

This study showed that the incidence of delirium was significantly lower in the intervention group than in the control group. The duration of delirium, mechanical ventilation, and ICU stay in the intervention group were significantly shorter than in the control group. The results were in concurrence with the previous result. Excessive use of sedation and analgesia in the process of mechanical ventilation is the possible reason for delirium[22]. However, progressive early rehabilitation training mode was vital for patients rehabilitation training, especially when the patients were in disturbance of consciousness or ambiguity. In this process, healthcare staff had sufficient and effective communication opportunities and time. This process improved the patient's cognition, resulting in the direct reduction of delirium and indirect reduction in the use of sedative and analgesic drugs. Most importantly, the increase in the daily activity of patients directly improves the night sleep quality of patients, circadian rhythm, and the excitability of muscle neurons. These events promote the compensatory axonal growth activity, stimulate the brain hemisphere to perform functional compensation rapidly, and reduce the occurrence of delirium[23]. The results of the current study showed that the functional scores (FIM) in the intervention group were significantly higher than in the control group. This observation indicates that the progressive early rehabilitation training model was helpful to improve the physical function and self-care ability as well as the condition and limb activity of the patients. The intervention mode of the progressive nursing model could promote the effective recovery of various functions. Based on this quantitative evaluation strategy, the situation of patients was evaluated on time, which was improved and adjusted based on the related functions. The overall strategy was important for improving the

prognosis and promoting the rehabilitation of these patients. In addition, the incidence of complications was significantly lower in the intervention group than in the control group, which confirmed the safety and feasibility of progressive early rehabilitation training. Moreover, the key to the effective implementation of progressive early rehabilitation training lies in formulating scientific training programs and the healthcare team's degree of coordination and cooperation[24]. In this study, we paid specific attention to establishing the rehabilitation training team. We conducted a unified, centralized training and assessment for the healthcare team involved in the early rehabilitation training. Meanwhile, based on the level of FIM assessment of patients, we formulated a personalized early training program. Head nurses', responsible nurses', and rehabilitation therapists' close interdisciplinary cooperation was ensured to standardize rehabilitation training and effective rehabilitation activities. In addition, medical staff assisted patients in carrying out the targeted rehabilitation training at early stages, which further reduced the long-term complications by promoting peristalsis of the digestive tract, blood circulation, enhancing immunity, and reducing the ischemia and hypoxia and compression of local tissues associated with long-term bed rest, thereby reducing the occurrence of complications[25].

The current study had the following limitations. First, the clinical collection of qualified patients was limited, so the sample size was small, resulting in an insufficient representation of indicators, such as the incidence of complications. Second, this study lacked evaluation of patients' quality of life before and after intervention. However, since the ultimate goal of progressive early rehabilitation training was to improve the prognosis of patients effectively, subsequent studies are required to evaluate and compare the quality of life of these patients.

CONCLUSION

Implementing progressive early rehabilitation training for ICU patients with mechanical ventilation can improve the recovery of body functions, shorten treatment time, and avoid long-term complications. Overall, this nursing strategy is important to improve the prognosis of patients and should be promoted in clinical nursing.

ARTICLE HIGHLIGHTS

Research background

The incidence of delirium in the intensive care unit (ICU) is between 20% and 50%, while the incidence of delirium in ICU patients receiving mechanical ventilation is as high as 60%–80%.

Research motivation

It is urgent and critical to provide early rehabilitation training for ICU patients with mechanical ventilation.

Research objectives

This study aims to investigate the effect of progressive early rehabilitation training on patients with mechanical ventilation in ICU and evaluate its prognosis.

Research methods

The control group received routine nursing and rehabilitation measures, and the intervention group received progressive early rehabilitation training on the basis of routine nursing. Clinical effectiveness and prognosis of the two groups were compared.

Research results

The incidence of delirium, duration of delirium, mechanical ventilation time and ICU hospitalization time in the intervention group were shorter than those in the control group. The daily living ability (Barthel index) score in the intervention group was significantly higher than in the control group.

Research conclusions

Progressive early rehabilitation training can effectively reduce the incidence of delirium in ICU patients with mechanical ventilation, and improve physical function.

Research perspectives

From the perspective of improving prognosis of patients, the clinical effectiveness of progressive rehabilitation training on ICU patients with mechanical ventilation was evaluated.

FOOTNOTES

Author contributions: Guo LM designed the study; Qie XJ collected data and drafted the manuscript; Qie XJ and Liu ZH analyzed and interpreted the data; Liu ZH and Zhang Y were responsible for critical revision of the article for important intellectual content; all authors approved the final manuscript for submission.

Institutional review board statement: This study was approved by the Institutional Review Board of The Fourth Hospital of Hebei Medical University.

Informed consent statement: The data used in this study were not involved in the patients' privacy information, so the informed consent was waived by the Ethics Committee of The Fourth Hospital of Hebei Medical University.

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