Submitted: 03 January, 2023 Accepted: 13 February, 2023 Published: 08 July, 2023 DOI:10.22514sv.2023.063

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ORIGINAL RESEARCH

Application effect of nutritional support combined with early motion based on protection motivation theory in ICU-acquired weakness

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Abstract

To explore the effect of nutritional support combined with early motion based on protection motivation theory in acquired weakness in critically ill patients. Patients treated in Intensive care unit (ICU) after operation from January to December in 2021 were selected as the study subjects. Historial control trial (HCT) was used. Patients admitted from January to June were the control group, and those admitted from July to December were the intervention group. Routine ICU management was used in the control group, and early motion combined with nutritional support was used in the intervention group. The incidence of ICU-acquired weakness (ICU-AW), activities of daily living (ADL), nutritional status, ICU stay, total hospital stay along with mechanical ventilation time were compared between the control and intervention groups. Before intervention, there was no significant difference among PatientGenerated Subjective Global Assessment (PG-SGA) score, serum total protein (TP) and albumin (ALB) between the control and intervention groups. After intervention, the incidence of ICU-AW, Barthel (BI) score, PG-SGA score, serum TP and ALB in the intervention group were conspicuously better in comparison with control group. The ICU stay, mechanical ventilation time and total hospital stay were significantly shorter than that in the control group. Nutritional support combined with early motion based on protection motivation theory can abate the incidence of ICU-AW, improve the activities of daily living and the nutritional status of patients, and shorten the hospital stay and mechanical ventilation.

Keywords

ICU-AW; Protection motivation theory; Early motion; Nutritional support

1. Introduction

Intensive care unit acquired weakness (ICU-AW) emerges as a serious neuromuscular complication, with the worldwide incidence up to 25–31% in critically ill patients [1]. ICU-AW can affect respiratory and limb muscles, resulting in prolonged mechanical ventilation (MV) and ICU stay, increased medical expenditure and fatality, and reduced quality of life [2]. ICU-AW patients may take weeks to months to recover function after discharge, and most severe patients are unable to even recover their function. The pathogenesis and etiology of ICU-AW remain elusive, and there are no specific agents or targeted therapies to counteract these alterations. Early motion (EM) remain a possible intervention to overcome ICU-AW. However, it is worth in-depth investigation. EM stimulates muscle protein synthesis and suppresses catabolism *via* increasing muscle load [3]. Besides, early initiation of enteral nutrient (EN) intake can inhibit excessive immune response and inflammation-induced tissue damage, lower secondary infection, and promote intestinal function recovery, thereby protecting from ICU-AW [4]. Adequate nutritional intake combined with exercise can improve muscle protein anabolism, reduce degradation, maintain muscle mass, and improve physical function in critically ill patients [5]. Besides, nutritional support for critically ill patients can mobilize them to engage in activities and exercises. Early motion combined with nutritional intervention can decrease fatality and muscle loss, protect from ICU-AW, reduce impairment of correlative physical function, and accelerate disease recovery [6]. This study attempts to explore the combined effect of early motion with nutritional support and the protection motivation theory on ICU-AW in patients, and the results are as follows.

2. Materials and methods

2.1 Study subjects

Patients admitted to the ICU after surgery from January to December 2021 were considered as study subjects. Historial control trial (HCT) was used. Patients admitted from January to June were the control group, and those admitted from July to

December were the intervention group. Routine ICU management was used in the control group, and early motion combined with nutritional support was used in the intervention group. Inclusion criteria: ① ≥60 years; ② first ICU admission; ③ estimated time of ICU admission ≥72 hours; ④ sufficient awareness to respond to at least three of the following commands in the subsequent 24 hours: "open and/or close your eyes", "look at me", "extend your tongue", "nod", and "raise your eyebrows"; ⑤ BI ≥70 2 weeks before ICU admission. Exclusion criteria: ① limb deformity, paralysis, fracture, or surgery; ② primary systemic neuromuscular disease affecting muscle strength; ③ gastrointestinal surgery completed within 1 month; ④ advanced cancer, expected death, or very poor prognosis.

2.2 Study methods

2.2.1 Study methods of control group

Primary nurse is responsible for closely monitoring vital signs, regularly measuring central venous pressure, arterial blood pressure, and blood gas analysis, and identifying and managing abnormalities in a timely manner. Room temperature and humidity should be maintained at an appropriate level, and the bed should be clean and tidy. All types of pipelines should be carefully managed. Patients receive oral care, perineal care, and pressure ulcer care, turning over every 2 hours. The physiotherapist administered rehabilitation exercise therapy treatment to the patient according to the medical advice of the, but there was no fixed time, method, or frequency. Currently, routine solutions include massage of muscles, passive movements, active-assistive exercise, active movement, and maintenance of the upright posture. The start time and drug delivery route of nutritional support are determined by the physician's experience and there is no nutritional support program. Energy requirement was calculated in 20–25 kcal/kg/day, and the bedhead was raised to 30–45 degrees before feeding to ensure that the nasogastric tube remained in place. Gastrointestinal syndrome was monitored (*e.g.*, diarrhea and abdominal distension). Feeding rate was altered according to the patient's condition and response, feeding was ceased during exercise to avoid aspiration, and blood glucose and electrolyte levels were measured at least every 4 hours. The blood glucose levels were maintained at 6–10 mmol/L and insulin was injected intravenously if necessary. Relatives of the patient may visit once a day for 10 minutes.

2.2.2 Study methods of intervention group

2.2.2.1 Establishment of rehabilitation teams based on protection motivation theory

The rehabilitation team consists of ICU physicians, rehabilitation therapists, dietitians, primary nurses, and head nurses, who are responsible for overall communication and organizational learning. By applying protective motivation theory to analyze the rehabilitation barriers, compliance, causes, approaches and necessity of early enteral nutrition support, and the concrete plan and operation points of early motion in patients. Besides, a complete nutritional exercise intervention program was developed based on the discussion results. Secondly, the head nurse organized a centralized discussion once a week, used the theory of protective motivation to summarize the existing problems in the entire intervention process, and formulates improvement measures for the existing problems.

2.2.2.2 The design of early motion program based on protection motivation combined with Orem theory

According to the theory of nursing system based on the Orem theory framework, the nursing model is classified as three categories: complete compensation system, partial compensation system and supporting education system. The activity pattern that the patient received was determined by its independent functional status, and the Barthel Index score was applied to evaluate the functional status. (1) Complete compensation system: BI >60 points indicates mild dysfunction, and patients can independently complete certain daily activities with some help. Rehabilitation team members instructed patients to perform active exercise and appropriate resistance exercise, mainly including upper limb rotation, lifting movements, hip joint, knee flexion exercise, and bridge exercise, *etc*. The frequency of activity was once a day (20–30 min for each time); patients were given 3 kg elastic belt for upper limb strength training, alternating both hands for exercise, with 10 times of one-hand stretching for each group and 4 groups a day; assist the patient to sit and stand for 20–30 min each time and twice a day, with appropriate adjustment according to the tolerance of patients. (2) Partial compensation system: BI scores ≥40 and <60 indicate moderate dysfunction, which reveals that patients require considerable help to complete daily activities; the members of rehabilitation team formulated exercise mode of passive activity + active activity for patients. The rehabilitation therapists performed passive motion on the joints of the extremities, mainly including wrist, elbow, shoulder, hip, knee and ankle joints, and the activity was performed once a day for 15–20 minutes in each time; members of the rehabilitation team raised the bedhead and assisted the patient to maintain a sitting position for 20–30 minutes each time and twice a day. (3) Supporting education system: BI score <40 reveals severe dysfunction, suggesting that the patients are unable to complete most daily activities. Members of the rehabilitation team developed a scheme of passive movements for the patients by performing passive range of motion exercise such as bending and stretching the upper limbs and fingers; flexion and extension of wrist joints, flexion, extension, abduction, and adduction of the elbow joints; flexion, abduction, internal rotation, and external rotation of the shoulder joints, and the joint movements in each direction were repeated 10 times. During exercise, members pay attention to the respiration, heart rate, oxygen saturation of blood, blood pressure, and other conditions of patients, and immediately cease the exercise if the patients show abnormalities.

2.2.2.3 Design of nutritional support program based on protection motivation theory

Nutritional support runs through early motion, and an early nutritional program should be started within 48 hours of ICU admission, and program of targeted early nutritional intervention should be developed.

(1) Nutritional risk screening and nutritional assessment

was carried out. On the day of ICU admission, nutritional risk was evaluated *via* the Nutritional Risk Screening (NRS 2002), nutritional status was determined by Patient-Generated Subjective Global Assessment (PG-SGA), and the presence or absence of contraindications to enteral nutrition determines the administration route of nutritional support. NRS 2002 $\geq$3 points manifests that the patient needs nutritional support, and a nutritional plan is made with nutritional assessment twice every week. Patients will receive early medical nutrition remedy including early oral nutritional supplements and artificial nutrition (EN, parenteral nutrition). Oral feeding is chosen when the patients can eat food independently. NRS 2002 $<$3 points demonstrated that patients do not require nutritional support and screened weekly for nutritional risk.

(2) Reasonable nutritional support programs were developed. Physicians actively provide nutritional support in the appropriate way according to the patient's status. Patients who can eat orally are given oral dietary intake, and those who cannot eat orally are given early continuous EN within 48 hours. Patients will receive EN within 24 hours of surgery. Patients with severe malnutrition (SGA score C), high nutritional risk (NRS 2002 $\geq$5), and contraindications to EN will receive early progressive low-dose parenteral nutrition (PN) within 3–7 days.

(3) The nutritional support process was monitored. When performing EN during early nutritional intervention, the primary nurse will ensure that the gastric tube or other feeding tube is kept in the correct place and that the gastric residual volume is less than 500 mL (checked every 6 hours). The bedhead should be raised by 30° to 45°. Patients should be fed at a rate of 20 mL/h and monitored for gastrointestinal syndrome (diarrhea, nausea, abdominal distension, abdominal pain, or vomiting, *etc*.). Blood glucose levels will be examined at ICU admission and should be measured at least every 4 hours thereafter for 2 days. The blood glucose levels are kept at 6–10 mmol/L, and insulin are utilized if necessary. Blood electrolytes (potassium, magnesium, phosphorus) were monitored at least once daily in the first week. In patients with hypophosphatemia (serum phosphorus $<$0.65 mmol/L or a decrease of more than 0.16 mmol/L), electrolytes should be inspected twice daily, and phosphorus should be added if necessary.

(4) The experience during the period of nutritional support was summarized. In the early stage (within 3 days) of the acute phase of injury, patients will be provided with hypocaloric nutrition no exceeding 70% of their measured energy expenditure. After 3 days, the amount of calories administered should be increased to 80% of the measured energy expenditure. Feeding rate was altered according to the status and response of patients. Patients need to strictly follow medical recommendations and early nutritional intervention. Feeding need to be ceased during exercise to avoid accidental aspiration.

2.3 Outcome measures

(1) Incidence of ICU-AW: Medical Research Council (MRC) scale was used for the assessments on muscle strength of 6 pairs of muscle groups. The total scores ranged from 0 (quadriplegia) to 60 (normal muscle strength). A total MRC score below 48 is commonly used to diagnose ICU-AW, and the total MRC score is the gold standard for diagnosing frailty in patients.

(2) BI score: The BI assessment contains 10 different activities of daily living, with a total score of 100 points. The higher score is synonymous with better functional independence and self-care ability.

(3) Nutritional parameters: serum total protein (TP), albumin (ALB) and PG-SGA score.

(4) ICU stay, mechanical ventilation time, and total length of stay.

2.4 Statistical methods

SPSS 22.0 (IBM Corporation, Armonk, NY, USA) was employed for statistical analysis. Measurement data were displayed as mean $\pm$ standard deviation ($\bar{x} \pm s$). Two independent samples t test was applied for comparison between groups. Enumeration data were indicated as frequency and percentage. χ^2 test was used for comparison between groups. $p < 0.05$ showed that the differences were statistically significant.

3. Results

3.1 Comparison of general data between the control and intervention groups

No significant differences in the general data including gender, age, Body Mass Index (BMI), Barthel index, PG-SGA, Acute Physiology and Chronic Health Evaluations II (APACHE II) and mechanical ventilation (MV) were found between control and intervention groups ($p > 0.05$), as shown in Table 1.

3.2 Comparison of the incidence of ICU-AW in ICU patients between the control and intervention groups

The incidence of ICU-AW in the control group was significantly higher than that in the intervention group ($p < 0.05$), as shown in Table 2.

3.3 Comparison of daily activities between the control and intervention groups

The BI scores of patients admitted to ICU and transferred out of ICU were compared between the control and intervention groups. The results showed that the BI scores of patients in control group transferred out of ICU was significantly lower than that in intervention group ($p < 0.05$), as shown in Table 3.

3.4 Comparison of nutritional status between the control and intervention groups

The results of TP, ALB and PG-SGA scores before and after intervention were compared between the control and intervention groups. The results showed that the post-scores of TP and ALB in control group were significantly lower than that in intervention group ($p < 0.05$), as shown in Table 4.

TABLE 1. Comparison of general data ($\bar{x} \pm s$, n (%)).

Item	Control group	Intervention group	t/χ^2	p
Gender				
Male	28 (46.7%)	36 (60%)	2.143	0.143
Female	32 (53.3%)	24 (40%)		
Age	61.26 ± 15.85	61.54 ± 17.06	0.190	0.850
BMI	21.88 ± 1.48	21.64 ± 1.34	0.928	0.355
Barthel index	39.00 ± 5.35	40.42 ± 5.84	−1.385	0.169
PG-SGA	3.77 ± 1.16	3.70 ± 1.07	0.336	0.737
APACHE II	15.60 ± 1.73	15.05 ± 1.85	1.685	0.095
Mechanical ventilation (MV)	12 (20.0%)	11 (18.3%)	0.054	0.817

BMI: Body Mass Index; PG-SGA: PatientGenerated Subjective Global Assessment; APACHE II: Acute Physiology and Chronic Health Evaluations II.

TABLE 2. Comparison of the incidence of ICU-AW in ICU patients between the control and intervention groups (n (%)).

Item	Case	No ICU-AW	ICU-AW
Control group	60	42 (70%)	18 (30%)
Intervention group	60	53 (88.3%)	7 (11.7%)
χ^2			6.114
p			0.013

ICU-AW: Intensive care unit acquired weakness.

TABLE 3. Comparison of daily activities between the control and intervention groups ($\bar{x} \pm s$).

Item	Case	Admission to ICU	Transfer out of ICU
Control group	60	39.00 ± 5.35	55.25 ± 6.47
Intervention group	60	40.42 ± 5.84	61.42 ± 3.92
t		−1.385	−6.315
p		0.169	<0.001

ICU: Intensive care unit.

TABLE 4. Comparison of nutritional status between the control and intervention groups ($\bar{x} \pm s$).

Group	Case	TP (g/L)		ALB (g/L)		PG-SGA	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Control group	60	63.08 ± 1.42	65.16 ± 1.46	33.73 ± 1.9	34.95 ± 1.17	3.77 ± 1.16	2.02 ± 1.50
Intervention group	60	63.75 ± 2.77	66.95 ± 1.51	34.19 ± 1.81	35.92 ± 0.91	3.70 ± 1.07	1.82 ± 0.54
t		−1.592	−6.601	−1.394	−5.034	0.336	2.105
p		0.114	<0.001	0.166	<0.001	0.737	0.037

TP: total protein; ALB: albumin; PG-SGA: Patient-Generated Subjective Global Assessment.

3.5 Comparison of hospital stay and mechanical ventilation time between the control and intervention groups

The ICU stay, mechanical ventilation time and total hospital stay in the control group were significantly higher than that in the intervention group ($p < 0.05$), as shown in Table 5.

TABLE 5. Comparison of hospital stay and mechanical ventilation time between the control and intervention groups ($\bar{x} \pm s$).

Group	ICU stay	Mechanical ventilation time	Total hospital stay
Control group	16.45 ± 1.95	6.75 ± 1.27	25.42 ± 1.67
Intervention group	13.48 ± 1.33	5.92 ± 0.94	22.63 ± 1.66
t	9.719	4.078	9.137
p	<0.001	<0.001	<0.001

ICU: Intensive care unit.

4. Discussion

4.1 Nutritional support combined with early motion based on protection motivation theory is conductive to reduce the incidence of ICU-AW

ICU-AW is a common problem in ICU and is correlated with poor prognosis in critically ill patients [7]. It has been shown [8] that EM has a positive impact on preventing ICU-AW and promoting functional independence, and it has been further demonstrated the benefits of early, personalized, progressive exercise strategies in counteracting ICU-AW and restoring self-care ability. As illustrated in the results of this study, the incidence of ICU-AW in intervention group was notably inferior to the control group. It identified that nutritional support combined with early motion based on protection motivation theory can effectively reduce the incidence of ICU-AW. The reason is that by applying the Orem's theoretical framework based on the patient's mobility, not only personalized activities suitable for the patient's activity state was provided, but also that patients were encouraged to active in the ICU to restore their mobility and self-care ability [8, 9]. Moreover, according to the principles of the protective motivation theory, the benefits of early exercise for the recovery of mobility, functional independence, and self-care ability were explained to the participants. Concerns about movement safety was alleviated, and beliefs and confidence to participate in activities and resume movement were improved to inspire patients to overcome ICU-AW and critical illness [2, 10]. An Randomized Controlled Trial (RCT) investigating the impact of an early progressive exercise program also suggests that a 1% increase in activity in the ICU may lead to a 35% increase in the likelihood of functional independence at discharge from the ICU [11], which is in line with this finding.

4.2 Nutritional support combined with early motion based on protection motivation theory is beneficial to improve the nutritional status of patients

Malnutrition accelerates the decomposition and metabolism of muscle protein, and most ICU patients are generally decompensated and at high risk of malnutrition, thus requiring appropriate nutritional support in terms of the condition and nutritional status of patients [12, 13]. Most experts and guidelines deemed that EN should be started within 24–48 hours of ICU admission [14]. Encouraging early EN helps maintain gut integrity, modulate stress and immune response, and reduce disease severity, thereby improving overall outcomes [15, 16]. The American Society of Parenteral Nutrition (ASPEN) provides a reference for nutritional support in critical illness, and guidelines elucidated the benefits of EMN in ICU-AW prevention, functional independence, nutritional status, and muscle strength improvement [17, 18]. The results of this study displayed that the TP, ALB and PG-SGA scores in the intervention group were better than those in the control group, indicating that nutritional support combined with early motion based on the theory of protective motivation is beneficial to improve the nutritional status of patients. The major reason is that early nutrition can promote nutritional status, maintain muscle mass, and provide the energy required for ICU exercise to create nutritional and muscle conditions suitable for exercise, and motivate patients to participate in activities [19]. At the same time, enhanced physical function helps improve patient confidence, stimulates them to respond more aggressively to critical illness and ICU-AW, and increases the food intake to obtain sufficient energy and protein for better performance [20]. Therefore, there is a possibility to establish a positive feedback loop, thereby increasing muscle strength and functional independence. As recommended in the systematic review [21, 22], muscle mass and functional independence could be increased by strengthening nutritional interventions integrated with structured exercise interventions, which is consistent with the results of this study.

4.3 Nutritional support combined with early motion based on protection motivation theory reduces the mechanical ventilation time and hospital stay in patients

According to surveys, 25%–50% of ICU patients develop ICU-AW within 24 hours of mechanical ventilation [13]. The findings in this study exhibited that the ICU stay, mechanical ventilation time, and total hospital stay in the intervention group were inferior to the control group. It is mainly because nutritional support combined with early motion based on the theory of protective motivation can develop a personalized training program according to the actual physical condition of patients and assist patients to perform phased physical exercise step by step, thus restoring the self-care ability of patients [22, 23]. Studies [24] have suggested that early motion integrated with early nutrition program in ICU-AW patients can improve the immune status, enhance respiratory muscle strength, impel the recovery of muscle strength and shorten the hospital stay, which is in line with our findings.

5. Conclusions

In summary, nutritional support combined with early motion based on protection motivation theory improved muscle strength and nutritional status more than routine care. Additionally, in parallel with routine care, nutritional support combined with early motion reduced the incidence of ICU-AW and promoted functional independence. In-depth studies are entailed to compare the impact of early nutritional versus nutritional support combined with early motion, and to explore the long-term effects of nutritional support combined with early motion in critically ill patients. Furthermore, the sample size is single and limited to ICU patients in our hospital, and future studies with larger sample sizes should be considered. Patients should be followed up after ICU discharge, including the measurement of health-related quality of life.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

YZ, YQ, LLS—designed the research study. YZ, YQ, LLS—performed the research. YZ, YQ, LLS—analyzed the data. YZ, YQ, LLS—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Medical Ethics Committee of the First Affiliated Hospital of Suzhou University (Approval no. 2021041). Written informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Yi Zhang, Yue Qiu, Lili Sun. Application effect of nutritional support combined with early motion based on protection motivation theory in ICU-acquired weakness. Signa Vitae. 2023; 19(4): 187-193. doi: 10.22514sv.2023.063.