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Original Article

Early rehabilitation nursing in ICU promotes rehabilitation of patients with respiratory failure treated with invasive mechanical ventilation

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Abstract: Objective: This paper aimed at exploring the application value of early rehabilitation nursing (ERN) in intensive care unit (ICU) for nursing patients with respiratory failure (RF) treated with invasive mechanical ventilation (IMV). Methods: Admitted to the ICU of our hospital from January 2019 to June 2020, 172 RF patients that was treated with IMV were selected as the research objects. Those in the general group (n=80) received routine nursing in ICU, whereas those in the recovery group (n=92) received ERN on the basis of the general group. The recovery of their vital signs, blood gas functions and pulmonary functions was monitored. Their treatment time in ICU, mechanical ventilation time (MVT), total hospitalization time (THT) and incidence of complications were recorded. Their negative emotions, quality of life (QOL) and nursing satisfaction were assessed. Results: After intervention, the body temperature, the respiratory rate and the heart rate in the recovery group were lower than those in the general group ($P<0.05$). The arterial partial pressure of oxygen (PaO_2) and blood oxygen saturation (SpO_2) were remarkably higher in the recovery group, while the arterial partial pressure of carbon dioxide ($PaCO_2$) was remarkably lower ($P<0.05$). One-second forced expiratory volume (FEV_1), FEV_1/forced vital capacity (FVC) and FEV_1% were remarkably higher in the recovery group ($P<0.05$). The treatment time in ICU, the MVT and the THT were remarkably shorter in the recovery group ($P<0.05$). During intervention, the total incidence of complications was lower in the recovery group ($P<0.05$). While after intervention, the scores of the Self-rating Anxiety Scale (SAS), the Self-rating Depression Scale (SDS) and the St. George's Respiratory Questionnaire (SGRQ; symptom, activity, impact) were lower in the recovery group, but the nursing satisfaction was remarkably higher ($P<0.05$). Conclusion: During the treatment of RF patients with IMV, ERN can promote their recovery, reduce the incidence of complications, relieve their negative emotions, and improve their QOL and nursing satisfaction. So, this nursing model is worthy of clinical application.

Keywords: Early rehabilitation nursing, respiratory failure, invasive mechanical ventilation, pulmonary function

Introduction

Respiratory failure (RF) is a common acute and critical disease in diseases of the respiratory system, and patients suffer from the unbalanced exchange of oxygen or carbon dioxide [1]. In clinical treatment, invasive mechanical ventilation (IMV) usually helps to improve patients' gas exchange and respiratory functions [2]. It's reported that 39% of intensive care patients have received this treatment [3]. During mechanical ventilation, patients are usually in a clear state of consciousness, unable to express their needs in language, and prone to anxiety, depression and other emotions due to limited activities, which has certain conflicts with their treatment and nursing and is not conducive to rescuing them [4-6]. In addition, long-term mechanical ventilation leads to many complications such as tracheal injury, ventilator-associated pneumonia (VAP), ventilator dependence and muscle weakness, which are not conducive to the prognosis of patients [7-9]. Therefore, it is necessary to cooperate with high-quality nursing interventions for improve treatment cooperation and rehabilitation.

As reported by previous studies, it is very necessary to implement early rehabilitation plans

on patients in intensive care unit (ICU), because the plans help to recover their physical functions and mental health, improve their quality of life (QOL) and reduce medical costs [10, 11]. Although early rehabilitation nursing (ERN) is of great significance to the treatment and recovery of patients in ICU, its implementation all over the world is unsatisfactory [12]. According to statistics, 84% of ICU patients in Australia and New Zealand have not received ERN [13], and 71% of those in Canada have carried out this nursing model, but only 38% of them have activity programs [14]. The research on ERN in ICU has been deepening in recent years, but this model in RF patients treated with IMV has been rarely studied, and nursing staff have not fully played their advantages.

In this study, the application value of ERN in ICU for patients was explored. As shown by the results, compared with routine nursing, ERN can provide better nursing quality for patients. It promotes the recovery of vital signs, blood gas functions and pulmonary functions, shortens the treatment time in ICU, the mechanical ventilation time (MVT) and the total hospitalization time (THT), reduces the incidence of complications, relieves adverse emotions, and improves QOL and nursing satisfaction.

Materials and methods

General data

Admitted to the ICU of the Changzhou No.2 People's Hospital, the Affiliated Hospital of Nanjing Medical University from January 2019 to June 2020, 172 RF patients that was treated with IMV were selected as the research objects. Those in the general group (n=80) received routine nursing in ICU, whereas those in the recovery group (n=92) received ERN on the basis of the general group. Inclusion criteria were as follows: patients who were diagnosed to meet the symptoms of RF treated with IMV; patients who were ≥18 years old; patients who entered ICU with MVT ≥24 h; patients who had not received treatment measures affecting early activities before. Exclusion criteria were as follows: those with clouding of consciousness and unable to communicate normally; those with unstable hemodynamics; those with high intracranial pressure; those with fractures; those with contraindications to injuries caused by activities; those with unstable pulmonary ventilation function. This study has been approved by the Ethics Committee of the Changzhou No.2 People's Hospital, the Affiliated Hospital of Nanjing Medical University. The research objects and their families have been informed and signed an informed consent form.

Methods

The patients in the general group received routine nursing in ICU, including disease monitoring, position nursing, health education and psychological guidance.

Those in the recovery group received ERN on the basis of the general group, mainlyas follows: (1) an exercise plan was worked out. The range of motion, the muscles and the joint mobility of patients were evaluated once every 24 h. According to the evaluation results, the plan of ERN was made, and the amount and intensity of exercise was adjusted in real time, in order to improve the stability and tolerance of exercise capacity. During the activities, oxygen support was given via a ventilator; (2) rehabilitation nursing in a bed was conducted. After patients were stable in vital signs and conscious, the bedside was raised to 30° and passive massage was given to them. The active and passive activities of upper limbs, muscles and joints were guided, and the activity intensity depended on their tolerance; (3) respiratory tract nursing was performed. Atomization inhalation, sputum suction and other methods were used to remove respiratory secretions, which further improved respiratory muscle endurance and local blood circulation. At the same time, patients strengthened respiratory muscle training and were guided to complete the exercises of inspiration and forced exhalation, so as to exercise their intercostal muscles and diaphragms; (4) respiratory muscle training was provided. The nursing staff helped patients keep the respiratory tract unobstructed, assisted them in turning over and patting backs and in vibratory sputum ejection, and guided them to take simple pulmonary function exercises (such as deep breathing and abdominal breathing) for training respiratory muscles.

Outcome measures

At one week after intervention, patients' vital signs (body temperature, respiratory rates and heart rates) were recorded. The Bayer Rapidlab

Table 1. Comparison of general information ($\bar{x} \pm sd$), n [%]

Groups	General group (n=80)	Recovery group (n=92)	χ^2/t	P
Gender			0.665	0.415
Male	56 (70.00)	59 (64.13)		
Female	24 (30.00)	33 (35.87)		
Age (Years)	63.69±8.86	62.38±9.23	0.946	0.346
BMI (kg/m^2)	23.01±2.44	22.85±2.86	0.392	0.696
Causes			2.795	0.424
Severe pneumonia	38 (10.53)	54 (17.78)		
Pulmonary emphysema	19 (18.42)	15 (8.89)		
Esophageal neoplasms	15 (13.16)	13 (20.00)		
Others	8 (15.79)	10 (22.22)		
Types of RF			0.044	0.835
Type I	22 (27.50)	24 (26.09)		
Type II	58 (72.50)	68 (73.91)		
History of smoking			0.151	0.698
Yes	29 (36.25)	36 (39.13)		
No	51 (63.75)	56 (60.87)		
History of drinking			0.480	0.489
Yes	21 (26.25)	20 (21.74)		
No	59 (73.75)	72 (78.26)		

840 blood gas analyzer was used to detect blood gas indices such as the arterial partial pressure of oxygen (PaO_2), the arterial partial pressure of carbon dioxide ($PaCO_2$) and blood oxygen saturation (SpO_2). Before and at one week after intervention, the FGC-A+type pulmonary function analyzer was used to detect the indices of pulmonary functions. The indices included one-second forced expiratory volume (FEV_1), the percentage of FEV_1 in the predicted value (FEV_1%) and FEV_1/forced vital capacity (FVC).

The recovery of patients in both groups was recorded, including the treatment time in ICU, the MVT and the THT. The occurrence of common complications (pneumonia, pulmonary atelectasis, hypoxemia, infection, tracheal mucosal injury) during intervention was recorded.

Before and at one week after intervention, the anxiety and depression of patients were evaluated by the Self-rating Anxiety Scale (SAS) and the Self-rating Depression Scale (SDS) [15], with a total score of 100 points in both scales. Higher SAS and SDS scores indicate more serious anxiety and depression, respectively.

The QOL of patients was assessed by the St. George's Respiratory Questionnaire (SGRQ) [16] from three aspects: symptom, activity and impact. The total score of each aspect was 100 points. The SGRQ scores were negatively correlated with the QOL.

Through questionnaires, the nursing satisfaction of patients was evaluated from four aspects: methods, attitudes, skills and effects. The total score was 100 points. A score above 90 points indicated very satisfied; a score between 60 and 90 points indicated basically satisfied; a score below 60 points indicated dissatisfied. Overall nursing satisfaction = very satisfied + basically satisfied.

Statistical processing

SPSS 21.0 was used for statistical analysis, andfigures were plotted by GraphPad Prism 7. The counting data were compared by Chi-square test. The measurement data between two groups were compared by independent-samples t-test; those within groups before and after intervention was assessed via paired t-test, andthose between multiple groups were analyzed via one-way analysis of variance; the correctness of statistical values was verified by post hoc test. $P<0.05$ was considered to be statistically marked.

Results

Comparison of general data

There were no remarkable differences between the general and recovery groups in their general data such as gender, age, body mass index (BMI), causes, types of RF, and history of smoking and drinking ($P>0.05$) (**Table 1**).

Comparison of vital signs

After intervention, as for the vital signs, the body temperature, the respiratory rate and the heart rate in the recovery group tended to be

Table 2. Comparison of vital signs ($\bar{x}$ ± sd)

Groups	Body temperature (°C)	Respiratory rate (times/min)	Heart rate (times/min)
General group (n=80)	38.05±0.61	28.05±2.23	103.12±8.15
Recovery group (n=92)	37.38±0.63	24.12±2.86	90.75±8.61
t	7.060	9.940	9.634
P	<0.001	<0.001	<0.001

Table 3. Comparison of blood gas indices ($\bar{x}$ ± sd)

Groups	PaO_2 (mmHg)	$PaCO_2$ (mmHg)	SpO_2 (%)
General group (n=80)	88.62±3.45	43.75±3.18	85.63±2.72
Recovery group (n=92)	94.15±3.78	39.15±4.05	97.56±4.85
t	9.964	9.978	19.492
P	<0.001	<0.001	<0.001

normal more obviously; the three vital signs were lower than those in the general group (*P*<0.05) (**Table 2**).

Comparison of blood gas indices

After intervention, as for the blood gas indices, PaO_2 and SpO_2 in the recovery group were remarkably higher than those in the general group, while $PaCO_2$ was remarkably lower (*P*<0.05) (**Table 3**).

Comparison of indices of pulmonary functions

As for the indices of pulmonary functions, before intervention, there were no statistically marked differences in FEV_1, FEV_1/FVC and FEV_1% between the two groups (P>0.05). After intervention, the three indices in both groups remarkably rose, and they were remarkably higher in the recovery group (*P*<0.05) (**Figure 1**).

Comparison of recovery indicators

The treatment time in ICU, the MVT and the THT in both groups were recorded. It in the recovery group was remarkably shorter compared with the general group (*P*<0.05) (**Table 4**).

Comparison of incidence of complications

During intervention, the occurrence of complications in both groups was recorded. The incidence of pneumonia, pulmonary atelectasis, hypoxemia, infection and tracheal mucosal injury was similar in both groups (*P*>0.05), but the total incidence of these complications was lower in the recovery group (*P*<0.05) (**Table 5**).

Comparison of SAS and SDS scores

As for the negative emotions, before intervention, there were no remarkable differences in the SDS and SAS scores between the general and recovery groups (*P*>0.05). After intervention, the two scores in both groups reduced remarkably, and they were lower in the recovery group (*P*<0.05) (**Figure 2**).

Comparison of SGRQ scores

The QOL of patients in both groups was evaluated by the SGRQ. The scores of symptom, activity and impact in the recovery group were all lower than those in the general group (*P*< 0.05) (**Table 6**).

Comparison of nursing satisfaction

The nursing satisfaction of patients on both groups was assessed. Many patients in the routine group said that nursing was not in place, hoping to improve the quality of nursing service in the hospital, while the number of those dissatisfied with the quality of nursing in the rehabilitation group was much less. The satisfaction in the recovery group was remarkably higher than that in the general group (89.13% *V.S.* 73.75%), with statistically marked (*P*>0.050) (**Table 7**).

Discussion

The respiratory system plays a decisive role in maintaining the important life processes of human beings, and the management of the system is the most important part of nursing in ICU [17]. IMV is an effective means to treat RF, but the long-term use easily results in various complications, which cause great damage to patients' physical and mental health [18]. Therefore, it is essential to implement necessary

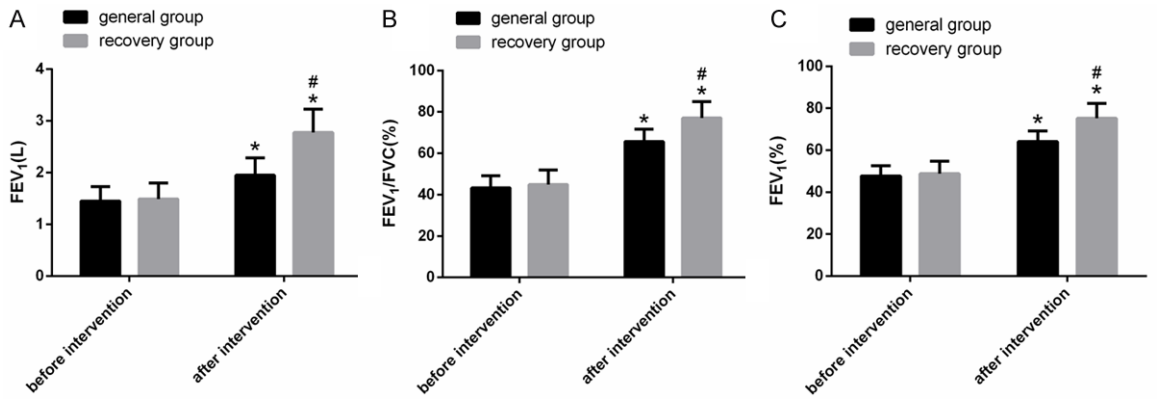

Figure 1. Comparison of indices of pulmonary functions. A: Comparison of FEV_1 changes before and after intervention between the two groups; B: Comparison of FEV_1/FVC changes before and after intervention between the two groups; C: Comparison of FEV_1% changes before and after intervention between the two groups. Note: * indicates $P<0.05$ compared with that before treatment in the same group; # indicates $P<0.05$ compared with that in the general group.

Table 4. Comparison of recovery indicators ($\bar{x} \pm sd$)

Groups	Treatment time in ICU (d)	MVT (d)	THT (d)
General group (n=80)	8.76±1.45	5.88±2.17	14.96±3.53
Recovery group (n=92)	6.52±1.66	4.35±1.85	11.78±2.89
t	9.357	4.992	6.494
P	<0.001	<0.001	<0.001

Table 5. Comparison of incidence of complications

Groups	General group (n=80)	Recovery group (n=92)	χ^2	P
Pneumonia	7 (8.75)	4 (4.35)	1.385	0.239
Pulmonary atelectasis	4 (5.00)	3 (3.26)	0.332	0.565
Hypoxemia	5 (6.25)	4 (4.35)	0.312	0.576
Pressure sores	3 (3.75)	0 (0.00)	3.511	0.061
Oral and nasal mucosal injuries	4 (5.00)	2 (2.17)	1.015	0.314
Total number of those affected	23 (28.75)	13 (14.13)	5.526	0.019

rehabilitation nursing for further improving prognosis. According to some current studies, ERN helps to relieve systemic dysfunction and maintain the functions of various systems, such as reducing the treatment time in ICU, the THT and the MVT of intensive care patients, lowering the occurrence of complications and improving activity levels [19, 20]. However, there is no standardized process for ERN in ICU patients treated with mechanical ventilation. So, this model cannot be routinely implemented in clinical practice for the time being. Clinical practice is still needed in order to formulate corresponding standards and norms.

Due to long-term braking, the sarcolysis in patients treated with mechanical ventilation increases, the levels of muscle protein synthesis reduces, and muscles and nerves are in a state of insufficient nutrition supply for a long time; this leads to ventilator-induced disuse muscular atrophy, which causes difficulties in withdrawing the ventilator and is related to the mortality rates of ICU and hospitalization [21, 22]. Previous clinical experience has shown that for patients treated with mechanical ventilation, physical exercise is helpful to recover their physical function and improve their quality of life [23, 24]. In this study, we implemented the early activity intervention plan to patients in the recovery group. By means of respiratory muscle training, the clearing of respiratory secretions, and proper exercise training and posture interventions, the functions of their limb activity were improved, and the stability of their organic functions was promoted, and their blood circulation was accelerated. The body temperature, the respiratory rate and the heart rate were all lower in the recovery group. PaO_2 and SpO_2 were

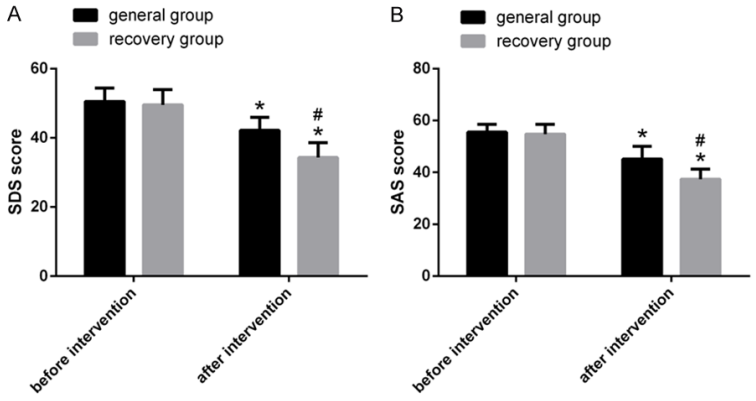

Figure 2. Comparison of SAS and SDS scores. A: Comparison of changes in SDS scores before and after intervention between the two groups; B: Comparison of changes in SAS scores before and after intervention between the two groups. Note: * indicates $P<0.05$ compared with that before treatment in the same group; # indicates $P<0.05$ compared with that in the general group.

Table 6. SGRQ scores ($\bar{x}$ ± sd)

Groups	Symptom	Activity	Impact
General group (n=80)	73.45±4.48	59.11±5.96	80.18±4.85
Recovery group (n=92)	64.48±5.15	46.86±5.45	69.39±7.15
t	12.098	14.076	11.406
P	<0.001	<0.001	<0.001

remarkably higher in the recovery group, while $PaCO_2$, FEV_1, FEV_1/FVC and FEV_1% were remarkably lower, and the MVT and the THT were remarkably shorter. This suggests that during the treatment of RF patients with IMV, ERN can help to promote the recovery of vital signs, blood gas functions and pulmonary functions. Besides, the total incidence of complications in the recovery group was lower than that in the general group. This is possibly due to the fact that this nursing model can promote the recovery of the above indicators.

As an expensive and high-risk intervention measure, mechanical ventilation requires intubation into patients' artificial airway, which leads to many negative psychological symptoms such as anxiety, insanity, restlessness and sleep disturbances [25]. Additionally, patients are more awake and alert when they are on the ventilator, but they may still suffer from painful symptoms, which further damages their mental health [26]. Research has shown that proper exercise can effectively relieve negative emotions [27]. In this study, after intervention, the SDS and SAS scores in both groups reduced remarkably, and they were lower in the recovery group. The survivors of critical illness have serious and lasting physical and psychological dysfunction, which results in a serious decline in their health-related QOL [28]. In addition, the scores of symptom, activity and impact in the recovery group were all lower than those in the general group, which is directly related to the fact that ERN promotes the recovery of the patients. Nursing satisfaction is an important index to measure the quality of nursing, and negative emotions of patients during mechanical ventilation will compromise their nursing satisfaction [29]. Finally, the nursing satisfaction of patients was evaluated, and it was found that the satisfaction was remarkably higher in the recovery group, and 26.25% of patients thought that they could not receive routine nursing. This indicates that the conventional nursing model can no longer meet the needs of patients, which is more conducive to ERN promotion .

This study has confirmed the feasibility and effectiveness of ERN in ICU patients treated with mechanical ventilation, but there are still some shortcomings. First of all, this study is only aimed at adult patients, so it is unknown whether ERN can bring the same benefits to minor patients. Secondly, the research objects are few and all from the same hospital, which may affect the generality of our results. Moreover, due to the short duration of the research, it is impossible to analyze the long-term effect of this nursing model. Thus, these shortcomings will be further analyzed and made up for in follow-up studies.

In summary, during the treatment of RF patients with IMV, ERN can promote their recovery, reduce the incidence of complications, relieve their negative emotions, and improve their QOL and nursing satisfaction.

Table 7. Comparison of nursing satisfaction [n (%)]

Groups	Very satisfied	Generally satisfied	Dissatisfied	Overall nursing satisfaction
General group (n=80)	21 (26.25)	38 (47.50)	21 (26.25)	59 (73.75)
Recovery group (n=92)	46 (50.00)	36 (39.13)	12 (10.87)	82 (89.13)
χ^2	-	-	-	6.851
P	-	-	-	0.009

Disclosure of conflict of interest

None.

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