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Original Article

The effect of quantitative assessment on the nursing of children with severe pneumonia

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Abstract: Objective: To explore the effect of quantitative assessment on the nursing of children with severe pneumonia. Methods: A total of 106 children with severe pneumonia were enrolled in the study and assigned to a control group and a study group of 53 cases each. The patients in the control group received routine nursing care, while the patients in the study group received quantitative assessment-based nursing in addition to the routine nursing. The overall response rate, respiratory tract infection and complication rates, rehabilitation efficacy, and pulmonary function before and after the nursing in the two groups were studied prospectively. Results: The study group had a higher overall response rate and a lower respiratory tract infection rate than the control group (94.33% vs. 71.70%, 7.55% vs. 22.64%, both P<0.05). The time to symptom improvement (including defervescence, relief of cough and anhelation, mitigation of heart failure, and disappearance of lung rale), duration of mechanical ventilation, and length of hospital stay in the study group were shorter than they were in the control group (all P<0.001). The study group also had higher maximum voluntary ventilation, vital capacity, and ratio of forced expiratory volume in one second to forced expiratory volume, and a lower complication rate than the control group (complication rate: 5.66% vs. 20.75%, all P<0.05). Conclusion: The application of quantitative assessment in the nursing of children with severe pneumonia can achieve a marked effect, as it can significantly shorten the recovery time of children, improve their pulmonary function, and reduce the incidence of respiratory tract infections.

Keywords: Severe pneumonia, quantitative assessment, pulmonary function, inflammatory response, respiratory tract infection

Introduction

Pneumonia, a respiratory disease, is a challenging health concern in the clinic. It is characterized by high morbidity, high mortality, and high risk, with the morbidity and mortality reaching up to 1.1% and 38.2%, respectively. The disease is usually caused by an infection of the terminal bronchioles by bacteria, viruses, and other microorganisms [1]. The dissemination and aggravation of local inflammation can bring about systemic symptoms and eventually lead to severe pneumonia. The disease, which is a complex syndrome with the common respiratory symptoms of pneumonia and complicated by respiratory failure or other system damage, has a high prevalence in infants and toddlers [2]. This is because infants and toddlers have weak immunity to infection as the physiological structure of their lungs is still to be developed [3]. Clinically, if children present typical symptoms of fever, cough, and anhelation, severe pneumonia should be suspected first [4]. Furthermore, the primary changes in children with severe pneumonia include dysfunction of gas exchange, a rapid decline of pulmonary function, and decreases in the levels of pulmonary function markers, including maximum voluntary ventilation (MVV), vital capacity (VC), and the ratio of forced expiratory volume in one second to forced expiratory volume (FEV1%) [5]. Some research has also indicated

that the progression of the disease can cause pulmonary fibrosis, affect multiple systems in the body, and increase the complications in the digestive and nervous systems (such as heart failure, cerebral edema, hypovolemia, and shock) as well as systemic poisoning, resulting in increased risks of mortality. Therefore, it is of great significance to actively manage the clinical symptoms of severe pneumonia and apply a timely and effective therapy [6].

Normally, adequate sleep, water and oxygen intake, and sputum discharge are provided to children with severe pneumonia to maintain normal vital signs. Etiological treatment is also necessary to achieve some efficacy [7]. However, because severe pneumonia is a complicated condition that is already at a severe and critical stage and because it is very likely to cause a lower respiratory tract infection, especially a bronchiole infection, it is essential to have an effective nursing intervention during the treatment for improving symptoms and promoting recovery and rehabilitation [8]. Moreover, most of the patients are young and the routine nursing care is normally aimed at avoiding cross-infection, with measures such as isolation, anti-infection, and maintaining a suitable room temperature and humidity, thus other emergences apart from the symptoms of the disease itself, such as other systemic diseases and drug resistance, can be overlooked, resulting in poor symptom improvement and a high respiratory tract infection rate in many children. Therefore, a personalized nursing care model of higher quality is needed clinically [9]. Some research has reported that mechanical ventilation can cause trauma to children, causing family members to feel distressed and intolerant and have a psychological burden [10]. Thus, it is necessary to provide psychological care for the families. Quantitative assessment is a targeted and individualized nursing intervention based on a comprehensive risk evaluation of patient's condition and offers the care with the quality and intensity that match the needs and conditions of the patients, which maximally benefits both patients and the hospital. Some studies reported that quantitative assessment applied in the nursing of patients after undergoing chemotherapy for breast cancer could increase the efficacy of postoperative rehabilitation by 0.5 times and significantly save the human resources of the hospital, hence this method has been widely applied in the nursing of patients following breast cancer chemotherapy [11]. However, quantitative assessment has been rarely used in pediatric care, especially in the care of those with severe diseases. Thus, in the present study, we carried out a quantitative assessment innovatively in the nursing of children with severe pneumonia to investigate its effects and provide some guidance for the clinical nursing care.

Materials and methods

General information

This prospective study was approved by the Medical Ethics Committee of Tengzhou Central People's Hospital, and written informed consent was obtained from the patients' family members. A total of 106 children with severe pneumonia who were treated in the Tengzhou Central People's Hospital from July 2016 until September 2018 were enrolled in the study and randomized into a study group and a control group of 53 cases each. The study aimed to evaluate the effects of quantitative assessment in the nursing of children with severe pneumonia.

Inclusion criteria: 1) patients who met the diagnostic criteria for severe pneumonia as defined in *Internal Medicine 9th edition* (People's Medical Publishing House) [12]; 2) patients with no other severe organic disease, such as liver, kidney, heart, or brain disease; 3) patients with no severe congenital malformations; 4) patients with no severe immune system diseases.

Exclusion criteria: 1) patients who were allergic to the medicine used in this study; 2) patients who kept crying excessively and were unwilling to cooperate with the nursing; 3) patients with severe asthma, tuberculosis, atelectasis, or other respiratory diseases.

Methods

The patients in the control group received routine nursing intervention, which included keeping the ward environment clean and tidy, maintaining a suitable room temperature and

humidity, and anti-infective treatment such as using antibiotics.

In addition to the treatment as implemented in the control group, the study group also received a quantitative assessment with the details listed below.

The markers and evaluation criteria of quantitative assessment

Data from all the patients were collected and scoring was conducted based on the patients' ages and conditions. The evaluation criteria are listed in **Table 1**. After the assessment, the total score of each child was calculated for classification purposes. A quantitative assessment score of <9 was considered to be low-risk, 9-12 was considered to be middle-risk, and >12 was considered to be high-risk [13].

Nurse grading and allocation

The nursing staff involved in the study were fully trained and divided into four levels (N0-N3) according to their training test results, academic qualifications, professional titles, professional competence, and personal characteristics [16]. The allocation of the different levels of nurses is shown in **Table 2**.

Rehabilitation care

Targeted rehabilitation care was performed based on the patients' risk levels.

For low-risk children, oral care was performed on time each day to maintain oral hygiene, and the dressing at the tracheal incision was changed to keep the area dry. The patients' families were asked to pay attention to any infection or eczema on the skin around the incision and to assist the children to lie in a lateral prone or lateral position.

In addition to the nursing care as described for low-risk children, sputum discharge was also performed for middle-risk children using a device. Each night, nurses would turn over the patients and pat them on their back gently every 1-2 hours to avoid difficulty in sputum discharge, vomiting, and suffocation.

In addition to the nursing care as described for the middle-risk children, the high-risk children were also administered an ultrasonic aerosol inhalation of amoxicillin powder (Baiyunshan Pharmaceutical, Guangzhou, China) and diluted acetylcysteine (Yihaotian Biotechnology, Jiangsu, China) for anti-bacteria and expectoration. Bronchial blocking based on children's specific conditions were conducted when necessary with a duration of 24-48 hours. Furthermore, if a tracheotomy was performed, sterile sputum suction would be carried out on time daily.

Health education

Prior to nursing, the family members were given different levels of health education based on the patients' risk levels.

Families of low-risk children were educated with a basic knowledge of the disease, treatment methods, and nursing procedures to help them to gain some understanding about the diseases, reduce panic, and facilitate their cooperation.

In addition to receiving the health education described for the low-risk children, the families of the middle-risk children were also given a detailed explanation of the things they needed to cooperate with during the treatment and nursing and potential risks such as infection, thereby enhancing the families' sense of responsibility and compliance to improve the efficiency of nursing.

In addition to receiving the health education described for the middle-risk children, the families of the high-risk children were asked to attend a health lecture about the importance of their roles in the nursing of children with severe pneumonia. The lecture aimed to help them gain some basic nursing skills and to better cooperate with the medical workers.

Psychological education

Targeted psychological education was provided for the families based on the patients' risk levels, stress response, and family members' mental conditions.

If low-risk children had a weak stress response and their families were not quite vigilant and attentive, the psychological education would help the families increase their sense of responsibility and cooperation. If the families were too

Table 1. Markers and evaluation criteria used in the quantitative assessment for children with severe pneumonia

	1 point	2 points	3 points
Age	>2 years old	1-2 years old	<1 year old
Shock index	<0.7	>0.7 and <0.9	>0.9
Concomitant disease	None	Concomitant with one disease or heart failure	Concomitant with no fewer than two diseases
APACHEH II score	≤19 points	20-29 points	≥30 points
Drug resistance	No antibiotic resistance	Resistance to no more than two types of antibiotics	Resistance to no fewer than three antibiotics
Early lactate clearance rate	>25%	0-25%	<20%
Treatment history	Received relevant medical treatment before		Received no treatment before

Note: Early lactate clearance rate = (initial lactic acid value - remeasurement of blood lactic acid value)/initial lactate value * 100% [14]. Shock index = pulse/systolic pressure [15]. APACHEH II: acute physiology and chronic health evaluation.

Table 2. Grading and allocation of the nursing staff

Grading of nurses	Qualification	Patients	Number of nurses of allocated
N0	Junior college or above majoring in nursing; more than one-year experience of nursing; nurse or nurse practitioner	Low-risk children	1
N1	Junior college or above majoring in nursing; 1-3 years' experience of nursing; nurse or nurse practitioner	Low-risk children	1
N2	Junior college or above majoring in nursing; 3-8 years' experience of nursing; nurse practitioner or nurse-in-charge	Middle-risk children	1
N3	Bachelor's degree or above majoring in nursing; more than 8 years' experience of nursing; associate chief nurse	High-risk children	1

Table 3. General information about the two groups (n, $\bar{x} \pm sd$)

Group	Gender (male/female)	Age (year)	BMI (kg/m^2)	Course of disease (d)	Disease type (n)			Pathological type (n)		
					Acute	Chronic	Persistent	Bronchial	Interstitial	Lobar
Control group (n=53)	29/24	2.27±0.64	14.63±2.12	7.55±2.31	19	18	16	20	21	12
Study group (n=53)	30/23	2.41±0.62	14.85±2.02	7.57±2.29	19	16	18	21	20	12
χ^2/t/H	0.038	1.144	0.547	0.045	0.000	0.173	0.173	0.040	0.040	0.000
P	0.845	0.255	0.586	0.964	1.000	0.677	0.677	0.842	0.842	1.000

Note: BMI: body mass index.

Table 4. Overall response rate and infection rate in the two groups (n, %)

Group	Markedly effective	Effective	Ineffective	Overall response rate	Infection rate
Control Group (n=53)	18 (33.96)	20 (37.74)	15 (28.30)	38 (71.70)	12 (22.64)
Study Group (n=53)	33 (62.26)	17 (32.08)	3 (5.66)	50 (94.33)	4 (7.55)
P				0.002	0.030
χ^2/t				9.643	4.712

stressful or worried when seeing children cry during injections or other treatments, psychological counseling was provided to make them understand that the risk was comparatively low and crying was normal, so as to avoid a delay in treatment caused by the families' intolerance.

If families with middle or high risk children were not sufficiently vigilant and attentive, they would be advised of the necessity of paying close attention to their children's conditions, in order to avoid negligence in cooperating with the nursing and treatment. If the families were overly worried, they would be advised of the importance of maintaining an optimal attitude for assisting the nursing and treatment.

Main outcome measures

Overall response rate: The overall response rate was compared between the two groups. The relevant literature was referred to for the standard of the nursing effect [17]. The standards were graded as follows: 1) markedly effective: clinical symptoms including wheezing, cough, asthma, and difficulty breathing basically disappeared after nursing; the results of the chest x-rays and the laboratory tests exhibited significant improvement; 2) effective: the clinical symptoms and results of the chest x-rays and the laboratory tests were partially improved; 3) ineffective: no evident improvement or even some worsening of the symptoms and the results of the auxiliary tests. Overall response rate = (number of cases that achieved marked effect + number of cases that achieved effect)/total number of cases * 100%.

Rehabilitation effect: The time to symptom improvement (including defervescence, relief of cough and anhelation, mitigation of heart failure, and the disappearance of lung rale), the duration of mechanical ventilation, and the length of the hospital stay were compared between the two groups. The armpit temperature below 37.3°C indicated defervescence. Cough relief meant almost no coughing or fewer than 2 periods of coughing occurred within 24 hours. Relief of anhelation meant no tachypnea and the patients had stable breath. The mitigation of heart failure meant the disappearance of the decline in physical strength, general edema, palpitation, chest tightness, cough, and asthma. The improvement in lung rale meant no moist rales were detected by auscultation.

Pulmonary function: The pulmonary function markers of MVV, VC, and FEV1% before and after nursing were compared between the two groups (instrument used for testing: Jaeger, Germany; Pony FX YZB/ITA 1498-2013, Xinghai, China).

Secondary outcome measures

The incidence of respiratory tract infections: The relevant literature was referred to for the infection criteria [18]. Respiratory tract infections were diagnosed based on routine blood

Table 5. Time to symptom improvement, duration of mechanical ventilation, and length of hospital stay in the two groups ($\bar{x}$ ± sd)

Group	Time to defervescence (d)	Time to relief of cough and anhelation (d)	Time to mitigation of heart failure (d)	Time to the disappearance of lung rale (d)	Duration of mechanical ventilation (d)	Length of hospital stay (d)
Control Group (n=53)	6.11±1.56	5.42±1.94	3.45±0.99	11.37±3.86	4.56±1.02	10.81±1.26
Study Group (n=53)	2.09±0.59	1.52±0.48	1.69±0.42	5.62±1.01	2.92±0.87	8.01±1.03
t	17.547	14.207	8.394	10.492	8.906	12.526
P	0.000	0.000	0.000	0.000	0.000	0.000

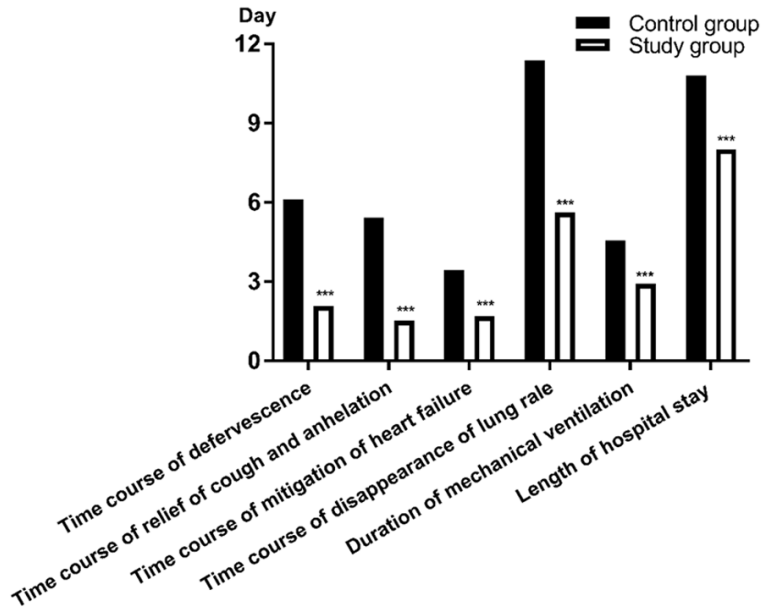

Figure 1. Comparison of the time to symptom improvement, the duration of mechanical ventilation, and the length of hospital stay between the two groups. ***P<0.001 vs. the control group.

tests and imaging results and respiratory symptoms such as nasal congestion, runny nose, swelling, and sore throat, cough, and expectoration concomitant with fever. The respiratory tract infection rate = number of patients with respiratory infection/total number of patients * 100%. Blood samples from the patients with an empty stomach were collected in the morning for a routine blood test.

Complication rate: The incidences of complications such as pulmonary edema, bronchiectasis, and septic shock were compared between the two groups. Pulmonary edema is fluid accumulation in the lungs and the imbalance of reflux. In this disease, a large amount of tissue fluid extravasates from the pulmonary capillaries and accumulates in the alveoli, interstitium, and small bronchi, leading to severe dysfunction in pulmonary ventilation and air exchange [19]. Bronchiectasis is chronic diapyetic inflammation and fibrosis in the bronchus and the surrounding lung tissue, which damages the muscle and elastic tissue in the bronchial wall, leading to deformation and a permanent dilation of bronchus [20]. Septic shock is sepsis syndrome combined with shock caused by microorganisms and their toxins [21].

All outcome measures were studied three months after the intervention.

Statistical methods

SPSS 21.0 was applied for the data analysis. Measurement data are expressed as the mean ± standard deviation, and independent samples *t*-tests were performed. Count data are expressed as n and %, and χ^2 test or Fisher's exact probability tests were conducted. The rank variable was examined using a rank-sum test. P<0.05 was considered to indicate a statistically significant difference.

Results

General information

There were no significant differences in the general data between the two groups (all P>0.05). See **Table 3**.

The overall response and infection rates in the two groups

The study group had a higher overall response rate and a lower respiratory tract infection rate

Table 6. Levels of the markers regarding pulmonary function before and after nursing in the two groups

Group	VC (mL)		MVV (mL)		FEV1%	
	Before nursing	After nursing	Before nursing	After nursing	Before nursing	After nursing
Control group (n=53)	59.87 ±14.97	63.29 ±15.83*	52.15±13.71	62.27±16.71*	57.45±14.36	59.26±15.04*
Study group (n=53)	59.91 ±14.98	76.93 ±19.23*	52.27±13.69	71.31±18.63*	57.53±14.38	68.02±17.10*
t	0.014	3.987	0.045	2.630	0.029	2.800
P	0.989	0.000	0.964	0.010	0.977	0.006

Note: *P<0.05 vs. before nursing. VC: vital capacity; MVV: maximum voluntary ventilation; FEV1%: the ratio of forced expiratory volume in one second to forced expiratory volume.

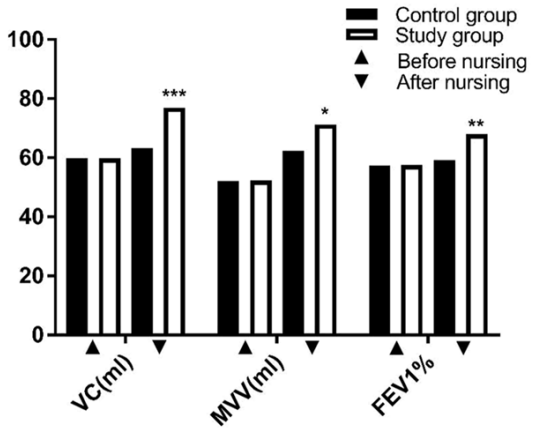

Figure 2. Comparison of the levels of pulmonary function markers between the two groups before and after nursing. *P<0.05, **P<0.01, and ***P<0.001 vs. the control group, VC: vital capacity; MVV: maximum voluntary ventilation; FEV1%: the ratio of forced expiratory volume in one second to forced expiratory volume.

than the control group (94.33% vs. 71.70%, 7.55% vs. 22.64%, both P<0.05). See **Table 4**.

The time to symptom improvement, duration of mechanical ventilation, and length of hospital stay in the two groups

Compared with the control group, the duration of mechanical ventilation, the length of hospital stay, and the time to defervescence, the relief of cough and anhelation, the mitigation of heart failure, and the disappearance of lung rale were shorter in the study group (all P<0.001). See **Table 5** and **Figure 1**.

Levels of pulmonary function markers in the two groups before and after nursing

There were no significant differences in the levels of markers of pulmonary function between the two groups before nursing (all P>0.05). After the nursing, the levels of all the markers were elevated in the two groups, but the levels of VC, MVV, and FEV1% in the study group were higher than those in the control group (all P<0.05). See **Table 6** and **Figure 2**.

The complication rate in the two groups

The total complication rate of pulmonary edema, bronchiectasis, and septic shock in the study group was lower than it was in the control group (5.66% vs. 20.75%, P<0.05). See **Table 7**.

Discussion

Severe pneumonia is a greatly complex disease that usually affects a special population, setting a high requirement for clinical treatment and nursing. Moreover, in routine nursing care, there is a lack of targetability and humanity, and the patients' individualization and their families' mental states are often ignored [22]. In view of this, the present study employed a quantitative assessment in nursing and innovatively included families' assistance in the nursing and their mental state improvement as the main part of this nursing program. Moreover, the allocation of different levels of nursing staff to the corresponding children with different risk levels was carried out to improve the nursing efficiency.

The results of the study showed that the study group had a higher overall response rate than the control group. After nursing, the levels of MVV, VC and FEV1 (%) increased by an average of 18% in the study group versus the control group. Meanwhile, the respiratory tract infection rate was lower in the study group, and the complication rate of pulmonary edema, bronchiectasis, and septic shock in the study group was only about 25% of that in the control group. In the quantitative assessment, children with

Table 7. Complication rates in the two groups (n, %)

Group	Pulmonary edema	Bronchiectasis	Infectious shock	Total complication rate
Control Group (n=53)	5 (9.43)	2 (3.77)	4 (7.55)	11 (20.75)
Study Group (n=53)	1 (1.89)	1 (1.89)	1 (1.89)	3 (5.66)
χ^2				5.267
P				0.022

different risk levels were taken care of by nurses with the corresponding grading; the higher the risk in the children, the more complicated and detailed the nursing work would be. This grading and allocation not only achieves a rational use of medical resources and improves the efficiency of nursing, but it also ensures the children receive proper nursing based on the severity of their conditions, which improves the comprehensiveness and targetability of the nursing care, avoids over-nursing for children with milder conditions and inadequate nursing for children with a more severe conditions, thereby accelerating the improvement of patients' pulmonary function and reducing the inflammatory responses. Du et al. reported that the application of quantitative assessment in the nursing of patients with severe pneumonia can significantly speed up the improvement of symptoms and pulmonary function and achieve marked effects, which is consistent with the results of our study [23]. Li et al. indicated that the use of quantitative assessment in the nursing of children with severe pneumonia can greatly reduce the complication rate, which also aligns with and verifies our findings [24].

In this study, the time taken for symptom improvement, the duration of mechanical ventilation, and the length of hospital stay in the study group were much shorter than they were in the control group, and the time it took for the relief of cough and anhelation was only about 1/4 of that in the control group, indicating that the quantitative assessment gave a correct evaluation of the children's risk levels, and appropriate nursing care was provided to each individual correspondingly, which achieved a targeted improvement. Moreover, health education was offered to the children's families, including information about the disease and nursing care and how to cooperate with the nurses. The education was delivered in the form of lectures, brochures, and one-on-one teaching, and the level increased with the risk level of the children's conditions. This approach not only enhanced the utilization of the educational resources, but it also increased the families' motivation and capability to cooperate with the nursing, so as to achieve a better rehabilitation effect.

Furthermore, our study results indicated that due to the young age and low tolerance of the children, the families were likely to be distressed when seeing the children exposed to strong stressful situations. The risk level of the condition was usually positively correlated with the degree of distress of their families. Therefore, psychological education for the families is quite necessary, as it can avoid the delay of nursing due to the poor mental state of the families. Pyne et al. have documented in a study that the current nursing mode has been upgraded from a disease-centered mode to a patient-centered mode, and including psychological factors throughout the entire nursing process can improve the overall response rate, which proves the necessity of involving psychological factors in our nursing program [25]. However, there were still some limitations to the study. The markers regarding the adverse conditions were few, so we could not demonstrate whether this nursing care can improve nursing safety. As a result, studies with more relevant markers and a wider scope need to be conducted in the future for further verification.

In conclusion, nursing with quantitative assessment can achieve marked effects in treating children with severe pneumonia. It can accelerate the recovery and improve the overall response rate, and it is recommended for clinical application.

Disclosure of conflict of interest

None.

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