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Original Article

Construction and clinical practice of an enteral nutrition nursing quality control system for critically ill patients

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Abstract: Critically ill patients are prone to a series of complications during early enteral nutrition (EEN), including gastrointestinal complications, infectious complications, metabolic complications, and mechanical complications, with an incidence of 30.5-65.7%, which attributes to prolonged hospitalization and increased mortality. Therefore, this retrospective study aimed to construct a quality control system of enteral nutrition nursing for critically ill patients as well as apply this system in clinical practice to evaluate its effect. Delphi method was utilized for this purpose, and we compared the incidence of enteral nutrition complications between patients using quality control system and using routine enteral nutrition. The mastery of enteral nutrition related knowledge by nursing staff was also compared before and after the implementation of a quality control system. Our data showed that, after applying the system to patients with critical illness in the nursing clinic, the incidence of enteral nutrition gastrointestinal complications, infectious complications, metabolic complications, and mechanical complications was significantly decreased from 11.51%, 1.96%, 3.41% and 5.88% to 1.86%, 0.52%, 1.71% and 0.97% (P<0.005), respectively. Furthermore, the awareness of enteral nutrition theory by ICU nurses was also significantly improved, and the questionnaire score was increased from 70.22±8.78 to 95.25±4.18 (t=18.792, P<0.001). Hence, the enteral nutrition nursing quality control system we developed could effectively guide nursing staff to implement enteral nutrition, reduce the occurrence of enteral nutrition complications in patients with critical illness and ensure the safety of patients, suggesting the clinical application value of our system.

Keywords: Enteral nutrition, quality of care, tolerance, quality control, intensive care

Introduction

Although early enteral nutrition (EEN) through the gastrointestinal tract is recommended for critically ill patients with no special digestive system abnormalities [1], critically ill patients are prone to a series of complications during EEN, including gastrointestinal complications, infectious complications, metabolic complications, and mechanical complications, with an incidence of 30.5-65.7%, which is a common reason for prolonged hospital stay and increased mortality [2-6].

The quality of nursing care is an integral part of health care, while nursing quality supervision is the core of nursing management. The construction of a nursing quality control system is the central step in nursing quality management. Scientific nursing quality control indicators can promote the continuous improvement of nursing quality [7, 8]. However, in clinic, there is still no unified quality control standard for assessment content, the accuracy of assessment methods, as well as the prevention and management of complications in complete enteral nutrition. Thus, it is critical to establish an enteral nutrition quality control system for the implementation, the continuous evaluation of patients' nutritional status and feeding intolerance, and standardized education for nursing staff [9-11].

Therefore, this study aimed to construct a scientific and feasible enteral nutrition nursing quality control system through the Delphi method and furthermore evaluate it in clinical practice. Our data suggested that our system might

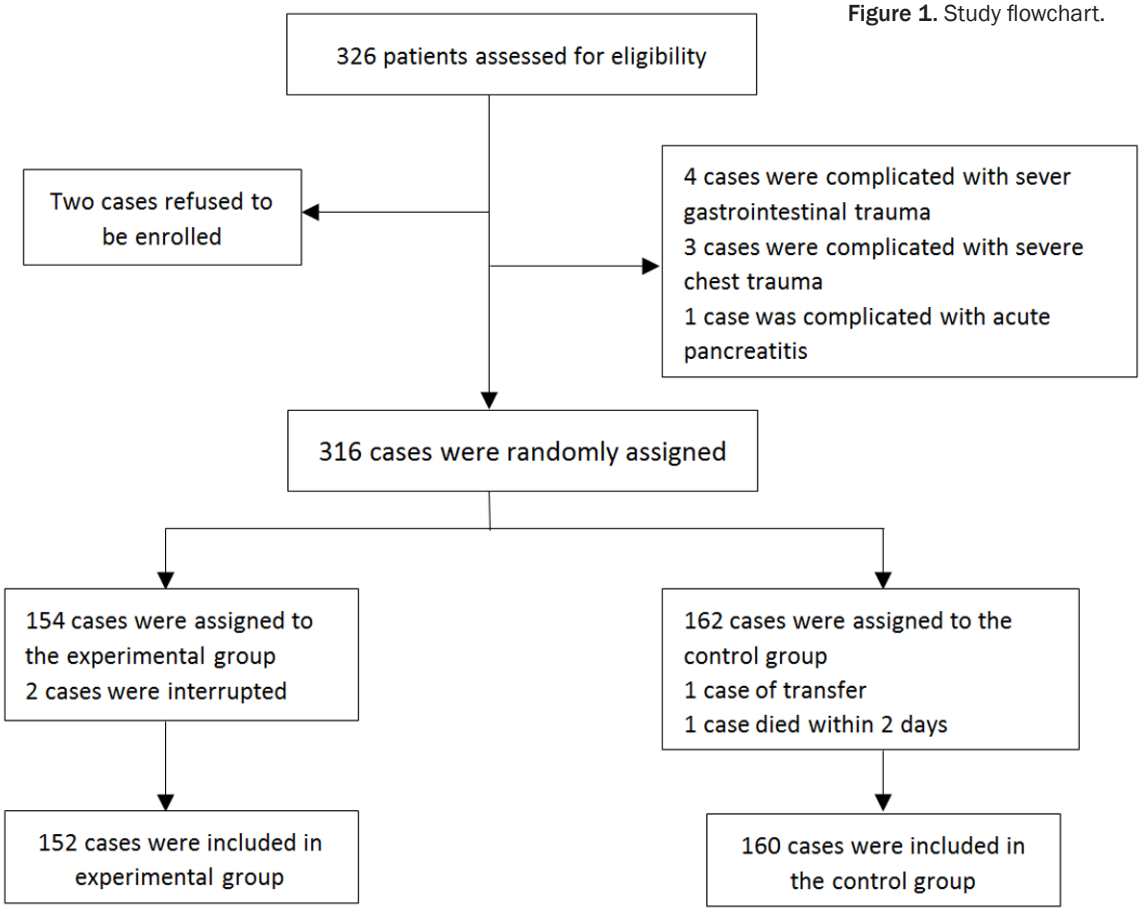

Figure 1. Study flowchart.

provide an effective method for the comprehensive evaluation and continuous quality management of critically ill patients with EEN.

Material and methods

Subjects

A total of 326 patients received enteral nutrition in the comprehensive ICU of Shanghai Changzheng hospital from April 2019 to September 2019 and were included in this retrospective study. Among them, 14 patients dropped out, and 312 patients were eventually enrolled (**Figure 1**). This study was approved by the ethics committee of the Shanghai Changzheng Hospital, and informed consent form was obtained from each participant.

The patient inclusion criteria for this study were: ① Enteral nutrition was started 24-48 hours after ICU administration; ② Gastric tube placement; ③ Informed consent to participate in the clinical study was obtained for more than 7 days.

The patient exclusion criteria were: ① There were contraindications to enteral nutrition, such as mechanical intestinal obstruction, necrotizing enterocolitis, and gastrointestinal bleeding; ② Gastrointestinal neoplasms had not been completely cured; ③ Gastrointestinal obstruction; ④ Bladder function injury; ⑤ Recent history of radiation and chemotherapy.

A total of 65 nurses were included in this study. All nurses were current nursing staff in the comprehensive ICU of the hospital and were registered nurses who volunteered to participate in this study. All of them were female and aged 24 to 51 years.

Intervention methods

Construction of quality control system of enteral nutrition care for critically ill patients was based on the Delphi method, also known as

expert consultation method which was developed in 1946 by the RAND corporation founder. The method is basically an anonymous feedback enquiry method, in which a panel of experts is surveyed in regard to forecasting problems. Through several rounds of survey, a consensus will be reached and used in practice.

Patients were divided into an experimental group (152 cases) and a control group (160 cases) according to the order of inclusion by a random number table. The patients in the experimental group were fed according to the enteral nutrition nursing quality control system, while patients in the control group were fed with routine enteral nutrition.

To construct the enteral nutrition nursing quality control system for critically ill patients, we first set up a research group composed of 3 enteral nutrition nurses, 1 clinician, 1 head nurse, and 1 graduate student. The enteral nutrition nurses were responsible for drafting the evaluation indicators as well as compiling and distributing the consultation questionnaires, while the clinician and the head nurse were responsible for reviewing the first draft of the evaluation indicators. The nursing graduate student was responsible for literature retrieval as well as data collation and analysis. Next, we formulated the standard consultation table of enteral nutrition quality control, including enteral nutrition, nursing quality, evaluation/assessment, criteria/indicators, complications, nursing management and other keywords search for in the literature published within the last 10 years, combined with the problems existing in the examination of enteral nutrition in the hospital nursing department in the last two years. Based on Donabedian's structure-process-outcome evaluation model, the first round of enteral nutrition nursing quality control index system consultation questionnaire was developed. The questionnaire included three parts: 1). The first part mainly introduced the background, purpose, and significance of this study as well as the methods of filling the form; 2). The main body text included quality control indicators, the primary, secondary and tertiary index, and the survey for the experts to judge the importance of the index, according to the level Likert5 scoring method (1 = not important, 5 = very important). 3). General information of experts including personal information, judgment basis for evaluation indicators, and familiarity with the research content was also surveyed. The experts we identified were medical personnel with bachelor's degree or above, intermediate professional title or above, those who have been engaged in enteral nutrition nursing, medical care, teaching, management, and scientific research for critically ill patients for more than 10 years and those who could provide relevant insights. In this study, 12 enteral nutrition medical and nursing experts from 3 grade A hospitals in Shanghai, Nanjing, Wuhan, and Beijing were selected as the consulting subjects. Before the survey, experts were contacted by phone, and questionnaires were sent by E-mail. There were two rounds of consultation, each of which lasted two weeks.

Clinical application of enteral nutrition quality control system in critically ill patients

The experimental group formulated the implementation process of enteral nutrition, cause analysis and treatment process of complications according to the enteral nutrition quality control system and carried out quality control during the implementation of enteral nutrition. General nurses were also trained on the use of nutritional status assessment tools, enteral nutrition start-up time assessment, tolerance assessment methods, complications management, and nursing operation related attention points. The types of training methods included slideshow, on-site teaching, Wechat-push platform, and case rounds.

The observation indicators and criteria [12] were patients showing gastrointestinal complications associated with enteral nutrition: A. Diarrhea: loose or watery stools, hyperactive bowel sounds, defecation more than 3 times a day; B. Abdominal distension: the operator felt the patient's abdomen for firm areas and local distension, or the awake patient complained of abdominal distension; C. Nausea and vomiting: after infusion or oral outflow of gastric contents during infusion, or awake patients complained of nausea; D. Gastric retention: the residual amount of gastric reflux was >200 ml 4 h after infusion every day; E. Constipation: no bowel movement for 3 consecutive days; F. Infectious

complications: inhalation pneumonia could be diagnosed with chest X-ray; G. Metabolic complications: metabolic indicators included pH, sodium, potassium, calcium, electrolytes, and blood glucose levels, among which an abnormal indicator was defined as a metabolic complication; H. mechanical complications: the gastric tube was blocked, and the syringe couldn't be pushed or pulled before and after the infusion of nutrient solution, which was determined if the resistance was too large. Meanwhile, for each patient, medical data were recorded, including length of ICU stay, hospital stay, hospital mortality, and patient satisfaction.

For the nurses' knowledge of enteral nutrition, the "Enteral nutrition Questionnaire for critically ill patients" was prepared by nurses, which contained 50 single-choice questions, including enteral nutrition process management, nutrition assessment, start-up time, gastrointestinal tolerance assessment methods, causes and treatment of complications and other dimensions. The full score was 100 points, the higher the score, the better the knowledge mastery.

Statistical analysis

To construct the enteral nutrition quality control system, we collected the advice from the experts and used Excel 2013 and SPSS 25.0 for data entry and data analysis. Specifically, we calculated the positive coefficient, authority coefficient and coordination coefficient of the experts, conducted the Kendall coordination coefficient significance test, and calculated the mean value of importance score, full mark rate and coefficient of variation of each index. The positive coefficient of experts was expressed by questionnaire recovery rate. The degree of authority of expert opinions was expressed by authority coefficient. The degree of coordination of expert opinions was expressed by coefficient of variation and coefficient of coordination. The degree of expert consensus was expressed by the mean of index importance score and coefficient of variation. Indicators with mean >3.50 and coefficient of variation <0.25 were screened and evaluated based on experts' opinions. The index weight was calculated by the sum of each index, and the enteral nutrition quality control system was finally determined. SPSS 20.0 was used to analyze the data obtained after the enteral nutrition quality control system was applied in clinic. Frequency, percentage, and mean were used for statistical description. Independent sample t test or chi-squared test was used to compare the incidence of enteral nutrition complications in critically ill patients and the mastery of enteral nutrition knowledge of ICU nurses before and after the application of enteral nutrition quality control system. The test level was a =0.05.

Results

General information of the study subjects

Based on the inclusion criteria, 312 patients were enrolled and divided into control and experimental groups, and their general information were analyzed (**Figure 1**). There was no significant difference in age, sex, body mass index (BMI), mean arterial pressure (MAP), nutritional screening scale (NRS2000), acute physiology and chronic health (APACHE II), and sequential organ failure assessment score (SOFA) between patients in the control and experimental groups ($P>0.05$) (**Table 1**). Hence, the baseline of patients between these two groups was comparable.

Determination of the quality control of enteral nutrition in critically ill patients

In this study, two rounds of expert consultation were conducted. A total of 24 questionnaires were sent out, and all 24 were recovered, with the recovery rate of 100%. The authority coefficients of these two rounds were 0.88 and 0.87, respectively, indicating the high reliability of the survey. After the second round of expert consultation, the coordination coefficients of expert opinions were compared (0.312 and 0.352, respectively, $P<0.01$), indicating that the experts had a good degree of coordination and a high degree of consistency. In each round of survey, five experts provided valuable revision opinion and showed high enthusiasm for this project. Meanwhile, we studied the responses from the experts and eventually generated three level indicators, including 10 secondary indicators and 24 tertiary indexes of critically ill patients with enteral nutrition nursing quality control system. As shown in **Table 2**,

Table 1. Patient information

category	Experimental group (n=152)	The control group (n=160)	Statistical quantity	*P*
Age ($\bar{x} \pm s$)	52.32±10.23	61.24±16.72	-0.022[1)]	0.619
Gender			0.089[2)]	0.582
Male	31 (68.9)	28 (63.6)		
Female	14 (31.1)	16 (36.4)		
MAP (mmHg, $\bar{x} \pm s$)	62.18±9.33	61.52±10.71	0.529[1)]	0.491
BMI (kg/m^2, $\bar{x} \pm s$)	19.41±3.17	21.38±2.99	-0.480[1)]	0.529
NRS 2000 (score, $\bar{x} \pm s$)	4.01±0.32	3.98±0.49	0.313[1)]	0.637
APACHE II (score, $\bar{x} \pm s$)	12.78±5.21	11.19±4.73	-0.332[1)]	0.721
SOFA (score, $\bar{x} \pm s$)	6.11±2.72	5.89±3.18	0.299[1)]	0.711

BMI: Body Mass Index; MAP: Mean Arterial Pressure; NRS2000: Nutritional Screening Scale; APACHE II: Acute Physiology and Chronic Health; SOFA: Sequential Organ Failure Assessment; 1) χ^2; 2) t.

for the structure indicators, process indicators and outcome indicators, their importance assignment scores were 4.88±0.22, 4.26±0.33, and 4.77±0.35, respectively. Their coefficients of variation were 0.05, 0.08, and 0.07, respectively.

Comparison of the incidence of enteral nutrition complications between the two groups of critically ill patients

Compared to the control group, the incidence of gastrointestinal complications, infectious complications, metabolic complications, and mechanical complications of enteral nutrition in critically ill patients was significantly decreased in the experimental group (11.25% vs 3.95%, 1.87% vs 0.66%, 5.63% vs 1.32%, and 6.88% vs 1.97%; all P<0.005) (**Table 3**). The patients' clinical outcomes and satisfaction after applying the enteral nutrition quality control system in the experimental group are shown in **Table 4**. For the patients in the experimental group, the length of ICU stay was 17.3±14.8 days, and the satisfaction was 9.2±1.3 days, which was significantly lower than that in the control group (χ^2=4.232, *P*=0.038; χ^2=5.234, *P*=0.029).

Evaluation of the ICU nurses' knowledge of enteral nutrition

After training and practicing in the clinic, the ICU nurses significantly improved their understanding and proficiency on the knowledge related to enteral nutrition, and the score of questionnaire survey was significantly increased from 70.22± 8.78 points before training to 95.25±4.18 points after nursing (t=18.792, *P*<0.001) (**Table 5**).

Discussion

Early enteral nutrition in critically ill patients has been widely applied; however, how to ensure the correct implementation of enteral nutrition and how to control the quality of nursing remain to be determined. The nursing of enteral nutrition is not only for certain complications, but also for the systematic management of the entire process of enteral nutrition [13-15]. The establishment of nursing quality control system can strengthen nursing quality control, continuously improve nursing quality, and ensure patient safety. In recent years, many studies have been constructed and discussed the evaluation system of sensitive indicators of enteral nutrition nursing quality [5, 15, 16], but there have been no reports on the construction and clinical application of nursing quality control system for critically ill patients. Based on literature retrieval and Delphi expert consultation, this study constructed a complete and reliable enteral nutrition quality control and nursing system according to the index of "structure, process and outcome". We found that the recovery rate of the two rounds of expert consultation was 100%, reflecting the high enthusiasm of experts for this study. The expert authority coefficients were 0.88 and 0.87, respectively, suggesting the high reliability of this study. The coordination coefficients of expert opinions were 0.312 and 0.352 (both *P*<0.01), indicating that the consultation experts had a good degree of coordination and a high degree of consistency. Taken together, the control system of enteral nutrition care for critically ill patients developed in this study was scientific, practical, and suitable for clinical use.

Nutrition for critically ill patients is one of the important contents of patient treatment. Standardized enteral nutrition process can

Table 2. Quality control index system of enteral nutrition care for critically ill patients

The index name	Indicators show	Importance assignment ($\bar{X} \pm s$, score)	Coefficient of variation	The weight
1-1 Structure indicators		4.88±0.22	0.05	0.351
2-1 Enteral nutrition care quality control system	Establish enteral nutrition management team to supervise clinical quality control, strengthen nursing staff training and implement continuous quality improvement	4.21±0.33	0.08	0.095
2-2 Enteral nutrition care facility	Enteral nutrition infusion pump and supporting pump pipe, abdominal pressure monitoring instrument	3.98±0.11	0.03	0.090
2-3 Enteral nutrition nursing process management	Department of enteral nutrition implementation standards and procedures	4.21±0.22	0.05	0.095
2-4 Human Resource Management	The bed-care ratio was close to 1:2.5, and key nurses were selected for the training of enteral nutrition specialized nurses	4.11±0.19	0.05	0.093
1-2 Process indicators		4.26±0.33	0.08	0.306
2-1 Nursing assessment		4.78±0.39	0.08	0.108
3-1 Nutritional assessment of critically ill patients	Nrs-2002 was used to assess nutritional status in critically ill patients	4.39±0.26	0.06	0.042
3-2 Timing assessment of enteral nutrition start-up	According to the hemodynamic stability, the starting time was evaluated	4.12±0.33	0.08	0.040
3-3 Gastrointestinal function assessment	Gastrointestinal function was assessed using AGI grading criteria	4.49±0.48	0.11	0.043
3-4 Evaluation of enteral nutritional tolerance	Tolerance scale, gastric residual volume monitoring and peritoneal pressure monitoring were used to comprehensively evaluate enteral nutritional tolerance	4.80±0.41	0.09	0.046
3-5 Evaluation of enteral nutritional feeding approaches	The key to evaluate the method, site, and selection of feeding tube placement; Accurately assess feeding tube position before each feeding	4.12±0.52	0.13	0.040
3-6 Total amount of nutrient solution infusion	Accurately assess the daily total amount of nutrient solution required by critically ill patients	4.27±0.36	0.08	0.041
2-2 Nursing procedures		4.76±0.24	0.05	0.108
3-1 Control patient's position during feeding	If no contraindication, feeding position >30 degrees	4.84±0.88	0.18	0.047
3-2 Nutrient solution configuration, storage management	Manufacturer supply, nutrition department unified distribution, department and vein separately placed	4.15±0.22	0.05	0.040
3-3 Enteral nutrition infusion method	Pump continuously at a constant rate for 24 hours according to the total amount of intestinal nutrients	3.98±0.07	0.02	0.038
3-4 Infusion line and identification management	Special way identification, safety warning board, special infusion pipeline, special pump feeding	4.38±0.49	0.11	0.042
3-5 Fixation and management of nasal and intestinal catheters	Special way identification, safety warning board, special infusion pipeline, special pump feeding	4.44±0.27	0.06	0.043
3-6 Pipeline safety management	Intravenous administration and enteral nutrition were hung separately, and timed pulse flushing tube was used to prevent tube blockage	4.53±0.25	0.06	0.044
3-7 Blood glucose monitoring	The time and method of monitoring blood glucose are correct	3.97±0.52	0.13	0.038
2-3 Analysis and management of complications of enteral nutrition		4.47±0.41	0.09	0.101
3-1 Analysis and management of gastrointestinal complications	Correct prevention and treatment of abdominal distention, diarrhea, nausea, vomiting and cause analysis	4.22±0.33	0.08	0.041
3-2 Analysis and management of infectious complications	Correct prevention and treatment of aspiration and analysis of the cause	4.19±0.52	0.12	0.040
3-3 Analysis and management of metabolic complications	Correct prevention and treatment of hyperglycemia and hypoglycemia and analysis of its causes	3.98±0.47	0.12	0.038
3-4 Analysis and management of mechanical complications	Correct treatment of nasogastric tube blockage, unplanned extubation and nasal injury and analyze the causes	4.76±0.38	0.08	0.046

1-3 Outcome indicators		4.77±0.35	0.07	0.343
2-1 Complication rate		4.13±0.43	0.10	0.093
3-1 Incidence of gastrointestinal complications	Accurately record the incidence of abdominal distention, diarrhea, nausea and vomiting due to nursing reasons	4.11±0.32	0.08	0.040
3-2 Analysis and management of infectious complications	Accurately record the incidence of aspiration due to nursing reasons	3.99±0.23	0.06	0.038
3-3 Analysis and management of metabolic complications	Accurately record the incidence of hyperglycemia and hypoglycemia caused by untimely monitoring and improper handling	3.87±0.47	0.12	0.037
3-4 Analysis and management of mechanical complications	Accurately recorded the incidence of nasogastric tube blockage, unplanned extubation, and nasal injury	4.56±0.26	0.06	0.044
2-2 Health education grasp the situation		4.94±0.33	0.07	0.112
3-1 Nurses' mastery of knowledge and skills related to enteral nutritional feeding in critically ill ICU patients	Through self-designed questionnaire, compare nurses grasp the situation	4.77±0.47	0.10	0.046
2-3 Evaluation of nutritional support effect		4.67±0.55	0.12	0.106
3-1 The nutritional indexes of critically ill patients in ICU were improved	The serum albumin (ALB), total protein (TB) and hemoglobin (HB) of critically ill patients were compared in two weeks	4.88±0.22	0.05	0.047
3-2 Doctors' satisfaction with nurses' work	To understand doctors' satisfaction with nurses' work, a questionnaire was issued to doctors about nurses' level of enteral nutrition nursing	3.85±0.46	0.12	0.037

ICU: Intensive Care Unit; ALB: Albumin; TB: Total Protein; HB: Hemoglobin.

Table 3. Incidence of enteral nutrition related complications in critically ill patients

category	No. of patients	Incidence of gastrointestinal complications	Incidence of infectious complications	Incidence of metabolic complication	Incidence of mechanical complication
The control group	160	18 (11.25)	3 (1.87)	9 (5.63)	11 (6.88)
The experimental group	152	6 (3.95)	1 (0.66)	2 (1.32)	3 (1.97)
χ^2		91.33	10.08	6.35	47.15
P		<0.005	<0.005	<0.005	<0.005

Table 4. Patient outcomes before and after the implementation of enteral nutrition quality control system

Category	patients	Length of ICU stay ($\bar{X}$ ± S, d)	Length of hospital stay, ($\bar{X}$ ± S, d)	Patient satisfaction ($\bar{X}$ ± S, score)
The control group	160	20.3 (12.3)	25.3 (12.3)	6.3 (2.1)
The experimental group	152	17.3 (14.8)	32.8 (14.2)	9.2 (1.3)
t		4.232	2.411	5.234
P		0.038	0.068	0.029

ICU: Intensive Care Unit.

Table 5. ICU nurses' knowledge on enteral nutrition

group		Grade ($\bar{X}$ ± S, score)	*t*	*P*
Before the training	65	70.22±8.78	18.792	P<0.001
After the training	65	95.25±4.18		

ICU: Intensive Care Unit.

reduce related complications, while non-standard feeding may cause many complications such as gastrointestinal tract, metabolic, and infectious diseases [5]. Hence, the quality control system is required. The quality control system developed in this study regarded enteral nutrition in critically ill patients as a whole and carried out quality control from the aspects of "structure, process and outcome". During the 3 months of clinical practice, clinical quality problems were constantly found; quality control was strengthened; improvement plans were put forward, and corrective measures were taken; therefore, the critically ill patients received more professional and high-quality nursing care. Our results showed that after the implementation of the quality control system, the incidence of gastrointestinal complications, infectious complications, metabolic complications, and mechanical complications of enteral nutrition in critically ill patients were significantly lower compared to those who received routine internal nutrition. Meanwhile, the ICU nurses' knowledge on enteral nutrition was significantly improved.

Together, these results indicated that the quality control system provided a scientific and reliable basis for ICU nurses, which may guide them to implement standardized enteral nutrition feeding process to reduce the incidence of complications.

Disclosure of conflict of interest

None.

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