Research Paper

Application of Three-dimensional Tool Synthesis Model based on Quality Control Circle in Nursing Care of Patients with Indwelling Nasogastric Tube

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In order to avoid the problems of incomplete analysis process, non-assessment of risks in some processes and failure of countermeasures to achieve the expected results in the application of a single quality control circle, in this study, quality control circle, medical failure mode, effect analysis method and root cause analysis method were compared in order to find the similarities, differences, advantages and disadvantages between them. A three-dimensional tool synthesis model based on quality control circle was formed by combining these three factors, and the model was applied to the nursing of patients with indwelling nasogastric tube. The results showed that this three-dimensional tool synthesis model could effectively reduce the probability of extubation of nasogastric tube ($p<0.05$), alleviate the pain suffered by patients in the course of treatment, reduce the cost of indwelling nasogastric tube consumables and nursing time ($p<0.05$), thus greatly improve the work efficiency of medical staff and effectively enhance the comprehensive ability of nurses ($p<0.05$). Hospital operation and management systems were also optimized. This study improved the nursing process of patients with indwelling nasogastric tube and provides a theoretical basis for the humanization and advancement of medical management.

Key words: Quality control circle, medical failure mode and effect analysis, root cause analysis, nasogastric tube, nursing

Quality control circle (QCC) refers to the formation of an activity group by the supervisors of the staff working under similar or identical working environment[1]. In accordance with certain application procedures and rules, the team members use modern scientific statistical methods or statistical tools to discuss some problems or challenges in the research work, so as to optimize the work flow, improve work efficiency and improve the working environment[2]. At present, QCC has been applied in the field of medical management by some developed countries, aiming at improving medical efficiency and quality, reducing medical costs and improving medical services. The process of QCC includes ten steps, selecting a theme, drawing up a plan, grasping current situation, setting goals, analyzing objectives, formulating and implementing countermeasures, reviewing, validating effect, standardizing, reviewing and improving.

Health care failure mode and effect analysis (HFMEA) is an improved method of failure mode and effect analysis (FMEA) applied in the medical field[3]. HFMEA is a management mode put forward by the American research institutes. Its management idea is to do things well once, so as to achieve optimization of target events. The core of HFMEA is to find and analyze the potential causes of the problem by using quantitative methods. In view of the root causes, it is a very effective tool for process management to formulate and implement improvement measures, adjust systems and establish norms so as to achieve the goal of quality improvement[4]. The application process of HFMEA includes confirming the theme, forming project team, creating flow chart, process step analysis table (listing failure modes), hazard analysis (listing failure causes), completing project report, formulating improvement measures, comparing effects, and finally returning to the determination of the theme to form a cycle.

Root cause analysis (RCA) is a retrospective error analysis model[5]. It is a thorough investigation method of risk events. It is usually applied to the optimization of medical care quality and medical care system, the management of patients' suicide, the management of

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drug logistics, the optimization of surgical procedures and the management of hospital environment. RCA model can be divided into four processes. The first stage is to form teams, investigate incidents and confirm problems, confirm adverse events, organize RCA teams, define problems to be solved and collect data. The second stage is to find out the direct causes, find all possible causes of incidents, measure and collect evidence of the most likely influencing factors. The third stage is to confirm the root causes and find out the system involved. The root causes are listed, and questions are asked. The fourth stage is to formulate and implement improvement plans and propose improvement actions/measures. Finally, a cycle is formed from the fourth stage to the first stage.

These three methods of problem analysis improvement applied in the field of medical analysis have their own limitations. Sometimes in the process of QCC activities, there will be specific objectives of the implementation of countermeasures and the desired results are not as expected. HFMEA focuses on prevention in advance. RCA needs a lot of manpower and material resources, and its application cost is high. Therefore, in this study, by comparing the similarities and differences between these, the three would be organically combined to form a synthetic model and its application in the nursing of patients with indwelling nasogastric tube were studied[6].

MATERIALS AND METHODS

Research subjects:

A total of 100 patients were selected in the Fourth Hospital of Harbin Medical University from September 1, 2015 to November 11, 2018. Fifty patients were assigned to the experimental group and 50 patients to the control group. The experimental group uses a three-dimensional tool synthesis model based on the QCC to carry out nursing management for patients with indwelling nasogastric tube. The control group had an adhesive tape to fix nasogastric tube on the cheek side. If the patient has restlessness symptoms, the necessary restraints were imposed. In the course of the experiment, the patients and their families were informed of the relevant matters needing attention. Attention should be paid to setting up the control group in accordance with the actual situation of the patients in the experimental group, following the principle of matching age, gender, type of disease and its severity, family situation, education level and so on.

In addition, during the course of this project, all the medical and research personnel involved in this project should kept the information of the subjects and groups confidential so as to prevent the patients and their families from communicating among the experimental group and the control group, and the experimental group and the control group, so as to ensure the randomness and accuracy of the experimental data. All subjects were signed the informed consent, and the significance of the study and the subject was approved by the Medical Ethics Committee.

Construction of 3-D tool synthesis model:

On comparing RCA with HFMEA it was found that there were many similarities in the basic steps of analysis. In the process of practical application, both of these need to accurately describe the objective status quo, analyze the causality of events and improve the plan. Both of them need to integrate all kinds of useful information through brainstorming, time clues, flow charts and other means to further analyze the events. In addition, RCA and HFMEA have similar ideas in analyzing the causes of events. However, there were also obvious differences between the two. The main manifestation was that HFMEA focuses on prevention in advance, and emphasizes the analysis of the whole process, while RCA focuses on the correction of events that occurred. Therefore, when RCA is carried out, a great deal of manpower and material resources are often wasted because the key to the occurrence of the incident cannot be found. Therefore, the combination of HFMEA initial analysis process and RCA was considered to remedy the shortcoming of RCA, so as to improve the efficiency of RCA of events.

Comparing the basic processes of QCC and HFMEA, it was found that there were many similarities between these. Drawing flow charts and accurately describing the current situation of events are the first steps in their application. At the end of the basic process, action plan needs to be improved. In addition, the QCC and HFMEA have very similar ideas in accurately grasping the status quo, mainly reflected in the similarity of ideas and methods used in the analysis of errors in the process system. However, the difference between the two is that the focus of HFMEA is prevention in advance, and it emphasizes the analysis of the whole process, while the focus of QCC is to correct the exposure time. In addition, in the application process of QCC, there are often problems that the analysis process is not perfect and the risks in the process are not assessed. Therefore,

if the current situation of QCC can be grasped and the complementary HFMA can be added, the shortcoming of QCC can be greatly improved.

Comparing the basic processes of QCC and RCA, it was found that there were many similarities between them. In the process of practical application, both of them need to accurately describe the current situation of the target and make a concrete analysis of the causal relationship between the events. Drawing fish bones and searching checklists are common analytical tools for both of these. In addition, the QCC and RAC have a lot in common in solving the problem, mainly because they are basically similar in analyzing the causes of the incident. There are also obvious differences between them. QCC is an activity organized by medical managers to improve quality. It has low maintenance cost, produces results in a short period of time, amenable for sustainable development and is conducive to creating a pleasant and relaxed working environment for medical staff[7,8]. RCA model is a process analysis methodology, which requires a lot of manpower and material resources, and its application cost is high, so it cannot be used frequently. It is mainly for the purpose of formulating feasible plans for specific objectives, optimizing the operation process and system of events, and constructing a recurrence protection mechanism for risk events. In addition, in the process of QCC activities, sometimes there will be specific objectives of the implementation of countermeasures and the desired results will not be produced. This may be due to problems in one or more links in the process of goal setting and analysis, formulation and implementation of countermeasures, or review. If QCC and RCA are combined organically and the true cause test method in RCA is integrated into the target analysis process of QCC, the situation of similar problems in QCC can be greatly improved and the applicability of QCC can be improved.

Setting up QCC and selected themes:

The head nurse is the circle leader, and the counselor is the deputy head nurse. The team consisted of 8 nurses. A total of 10 medical staff forms the QCC activity group. First of all, the circle leader should organize all circle members to carry out training sessions to introduce and summarize relevant work. Then, the circle members were asked to brainstorm, that is, to collectively think and discuss the current problems in nursing work, to summarize and evaluate the problems, and to select the most serious and urgent problems in the current nursing work. All circle members need to grade the questions put forward before, according to the urgency, execution, rules and regulations, feasibility. Eventually, the theme is finalized.

Drawing up a plan of activities:

The Gantt chart of the activity plan based on the three-dimensional tool synthesis model of QCC is drawn up, which requires each circle member to register the progress of the process timely and practically.

Grasping the present situation:

The flow chart of nasogastric tube indwelling was drawn, as shown in fig. 1. All circle members analyzed and discussed each process step, and summarized the possible situation of nasogastric tube detachment in the process. If there is a failure mode in the event process, it would have a different degree of impact on the related aspects such as the process of events and objectives. The degree of impact was expressed by severity (S), which can be divided into 4 grades, mild, moderate, severe and extremely serious, with a score of 1 to 4. According to the failure modes of the synthetic model, the corresponding severity evaluation method tables are formulated (Table 1). The probability of a certain failure mode occurring in the process is called failure probability, which can be divided into 4 categories, rare, unusual, occasional and frequent, with a score of 1-4. According to the failure modes of the synthetic model, the failure probability evaluation method table is established (Table 1). Step crisis value of HFMEA = severity×failure probability, with a score of 1-16, as shown in NCPS hazard assessment matrix table (Table 2).

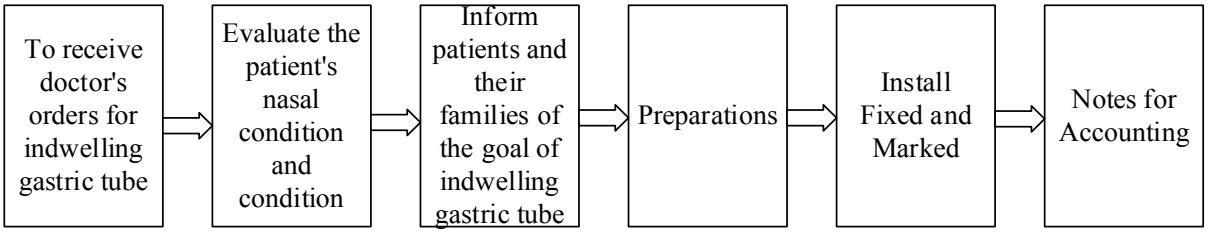

Fig. 1: Flow chart of nasogastric tube indwelling

TABLE 1: SEVERITY EVALUATION METHOD AND FAILURE PROBABILITY EVALUATION METHOD

Grade of consequences	Evaluation criteria	Score
Extremely serious	Gastric tube is completely detached from the body and to be replaced.	4
Serious	The end of the gastric tube is detached from the esophagus and cannot be transfused with nutrients and drugs.	3
Moderate	Gastric tube prolapse is larger than LCM and the end is located in the stomach.	2
Light	Gastric tube prolapse is less than LCM and the end is located in the stomach.	1
Failure probability level	**Evaluation criteria**	**Score**
Often	The probability of gastric tube prolapse is 1/10.	4
occasionally	The probability of gastric tube prolapse is 1/20.	3
Seldom	The probability of gastric tube prolapse is 1/50.	2
rare	The probability of gastric tube prolapse is 1/200.	1

TABLE 2: NCPS RISK ASSESSMENT MATRIX TABLE

	Extremely serious	Serious	Moderate	Light
Often	16	12	8	4
occasionally	12	9	6	3
Seldom	8	6	4	2
Rare	4	3	2	1

Target setting and analysis:

The circle leader organizes a group of circle members to further discuss and analyze the unplanned pull-out of nasogastric tube, summarize the causes of the incident and draw a fish bone diagram. The fishbone diagram was used to analyze the main factors of the event and to summarize all the factors that can lead to the result. The questionnaire was then issued for verification.

Formulation and implementation of countermeasures:

The circle leader organizes all circle members to discuss and study, and puts forward suggestions for optimizing the operation process of indwelling nasogastric tube. After summarizing all the suggestions, the circle leader scores the circle members according to the feasibility, economy and membership ability of the suggestions. Among them, excellent is 5 points, good 3 points, and pass 1 point. According to the 80/20 principle, if the score is greater than or equal to 108 points (135×0.8), it can be judged as an admissible countermeasure. After formulating the countermeasures, it is necessary to formulate strict execution operation methods and carry out the implementation of the countermeasures.

RESULTS AND DISCUSSION

Through the above analysis of the logical relationship among QCC, HFMEA and RCA, the three tools were organically combined to form a three-dimensional tool synthesis model based on QCC, as shown in fig. 2. This

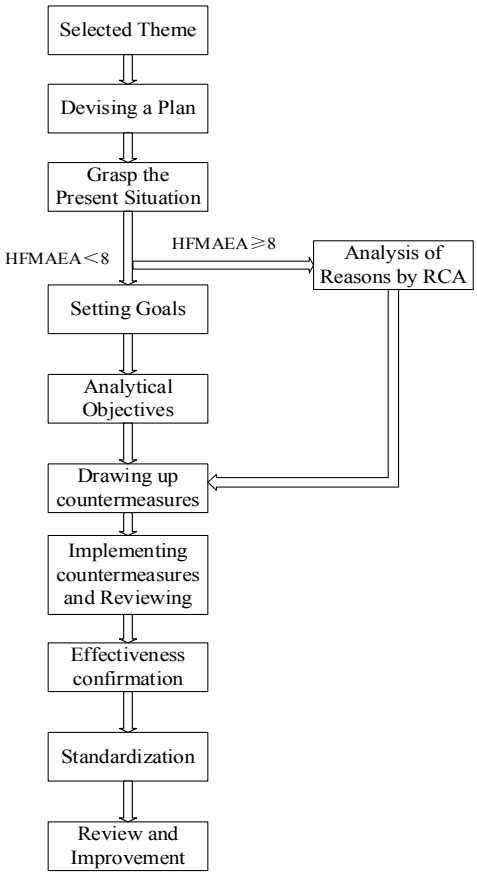

Fig. 2: Three-dimensional tool synthesis model based on QCC

synthetic model can be divided into three processes. The first process is to set up QCC activity groups, select themes and draw up plans. The second process is to use HFMEA model to analyze the current situation, grasp the high analysis link in the process, and calculate the corresponding crisis value. The third process is the next analysis based on the crisis value. If HFAEA ≥8, it shows that the risk seriously endangers the quality and safety of medical treatment. RCA mode should be used to analyze the root causes of the problem in the time flow. Solutions are found in the process of operation and system design. If HFAEA <8, it indicates that this kind of incident cannot cause serious medical quality

and safety problems and has little damage to patients and other aspects. It can continue to follow the process steps of QCC activities, so as to achieve the goal of optimizing medical process and medical system.

The problems urgently needed to be solved in current nursing work raised by circle members were summarized and graded according to urgency, execution, rules and regulations, feasibility and other aspects, and the average value was obtained (as shown in the Table 3). Finally, the theme was identified as the optimization of nursing care for patients with nasogastric tube indwelling.

The circle leader organizes the circle members to discuss and analyze each failure mode using S, 0 evaluation method. According to the Table 1, and 2, the severity (S) and failure probability of failure mode were evaluated and scored. The average of severity (S) score and failure probability score given by circle members were selected, and the crisis value was calculated, as shown in Table 4. By analyzing the failure modes of synthetic model in the nursing of patients with nasogastric tube, from Table 4, it can be seen that the main failure mode leading to unplanned extraction of nasogastric tube in neurological patients was that the nasogastric tube was not fixed properly, and its crisis value was 8.67. This indicates that the proper fixation of nasogastric tube was closely related to the quality of nursing and patient safety. Therefore, in the later process of the three-dimensional tool synthesis model based on QCC, the steps of RCA model should be used to analyze and identify the root causes of the event. Then, the solution to the problem was found out, and the probability of unplanned extraction of nasogastric tube was reduced, so as to optimize the operation and system of medical care. In Table 3, the critical value scores of other steps of HFMA were less than 8 points, so it has no significant impact on the quality of care and patient safety. The next step of verification can be carried out according to the QCC process, that is, goal setting and analysis.

All circle members discuss and analyze, and a fish bone diagram was prepared as shown in fig. 3. According to the fish bone diagram, the main causes of the incident include the following 5 types, lack of constraints on the limbs of patients, lack of effective fixation of gastric tube, improper constraints on limbs, inadequate supervision of family members, and restlessness of patients. Then,

TABLE 3: SUMMARY OF PROBLEMS TO BE SOLVED

Problem	Score
Submersible vein catheterization	9.6
Nursing care of patients with nasogastric tube indwelling	9.7
Accuracy of pathological writing	8.5

TABLE 4: PROJECT FAILURE MODE, FAILURE RESULT AND CRISIS VALUE SCORING

Failure mode			Assessment		
Process Steps	Potential failure modes	Potential failure results	Severity	Failure probability	Crisis value
Doctor's advice	Acceptance error of doctor's advice	Time error	1.22	1	1.22
Patient's condition	Incorrect evaluation of nasal condition	Nasal pain leads to detachment	1.67	1.33	2.22
	Incorrect assessment of illness	Unrestrained patient leads to detachment	2.22	1.89	4.20
Inform the purpose of indwelling gastric tube	The patient was not informed of his purpose	The patient pulled out the tube by himself	1.67	1.44	2.40
	Family members were not informed of their purpose	Family members are not well supervised	1.67	1.22	2.04
Preparatory process	Inadequate preparation	Not fixed properly or the patient pulled out the tube by himself because of uncomfortable	2.89	2.44	7.05
Installation of gastric tube/fixed/ Identification	Non-standard catheterization	patient pulled out the tube by himself because of uncomfortable	1.67	1.78	2.97
	Poor fixation	Gastric tube falling off spontaneously	3	2.89	8.67
	Lack of marking	Gastric tube confusion	1.44	1.22	1.76
Matters needing attention	Failure to give attention to patients	patient pulled out the tube by himself	2.22	1.67	3.70
	Notice not given to family members	Family members are not well supervised	2.22	1.78	3.95
Record	Imperfect records	Other medical staff are unaware of the treatment process	1.67	1.22	2.04

the dispatch table was used to investigate and verify the true causes of the above key links. The results, as shown in Table 5, showed that inappropriate fixation of nasogastric tube, inappropriate patient restraint, and the safety awareness of medical staff need to be strengthened were the real reasons.

Through collective discussion and scoring, 4 strategies were selected, including improving nasogastric tube fixation method, improving limb restraint method, popularizing knowledge of gastric tube safety management and training the nurses in gastric tube operation. The methods of improving nasogastric tube fixation were as follows. After successful indwelling of nasogastric tube, plastic thread was used to fix it in the occipital back and under the eulogy. During the operation, attention should be paid to the fixed strength and the tightness of the plastic wire. The methods to improve limb restraint were as follows. The range of restraint was extended from upper limb to palm and palm, and the patient's restraint position should be observed every day to ensure blood circulation. To popularize the knowledge of safety management of gastric tube, it is necessary to set up a propaganda group to explain the purpose, significance and precautions of indwelling nasogastric tube to patients and their families at regular intervals every week. The training of indwelling gastric tube for nurses requires professional training of indwelling gastric tube for nurses every 2 w, and the skills in the process of indwelling gastric tube were discussed. Based on the 4 strategies mentioned above, improving nasogastric tube fixation method, improving limb restraint method, popularizing knowledge of gastric tube safety management and training of nurses in gastric tube operation, the unexpected extubation incidents of patients with indwelling nasogastric tube in the Neurology Department from September 2018 to October 2018 were investigated and counted. The unplanned extubation rate of nasogastric tube in the experimental group of Neurology Department (16 %) was significantly lower than that in the control group (66 %), $p<0.05$. It shows that the strategy can effectively reduce the unplanned extubation probability of nasogastric tube, improve the treatment efficiency in a sense, and reduce unnecessary injury to patients.

The cost of indwelling nasogastric tube consumables in the experimental group of Neurology Department (6.59±2.61 Yuan/person) is significantly lower than that in the control group (12.03±8.76 Yuan/person), $p<0.05$, which shows that the strategy can effectively reduce the cost of indwelling nasogastric tube consumables.

The working time of nasogastric tube insertion in the experimental group of Neurology Department

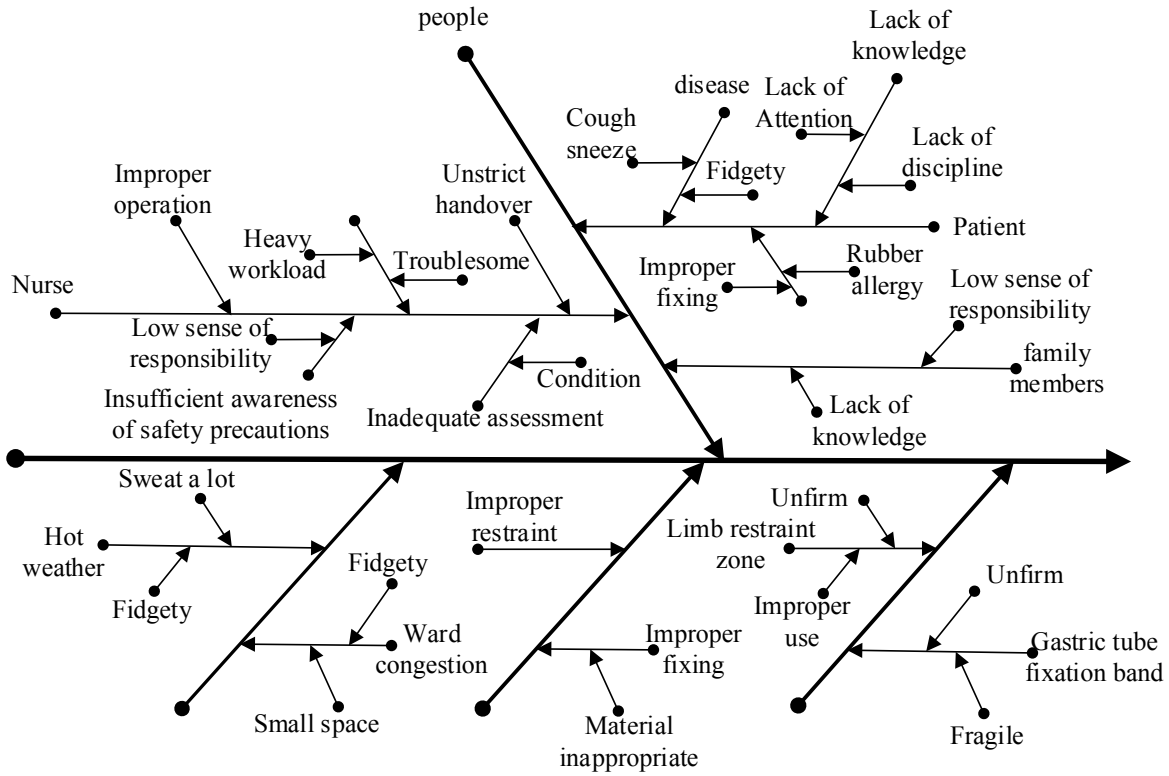

Fig. 3: Cause analysis of unplanned extubation of nasogastric tube with indwelling nasogastric tube

TABLE 5: REAL CAUSE ADJUSTMENT

Project	Number of occurrences	Proportion %	Accumulated %
Lack of effective gastric tube fixation	8	38.09	38.09
Lack of effective restraint in patients	4	19.05	57.14
Nurses lack awareness of safety precautions	4	19.05	76.19
Family members lack awareness of prevention	3	14.28	90.47
Patient irritability	2	9.53	100
Total	21	100	—

TABLE 6: NURSE COMPREHENSIVE ABILITY COMPARISON TABLE

Evaluation projects	Pre-management	After management	τ value	P value
Problem solving ability	2.88±1.88	4.67±0.59	3.033	0.013
Conscientiousness	2.99±1.80	4.34±1.53	1.879	0.090
Communication and coordination	2.87±1.79	3.90±1.80	1.311	0.205
Self-confidence	2.44±1.58	4.73±0.52	3.678	0.005
Team spirit	2.81±1.78	4.55±1.21	2.341	0.028
Enthusiasm	2.30±1.69	4.28±1.39	2.598	0.018
Technique	1.36±0.90	4.23±1.54	4.083	0.002
Innovation ability	1.67±0.97	3.52±1.90	2,501	0.029
Total	19.32±12.39	34.22±10.48	—	—

(6.54±2.33 min/person) was significantly lower than that in the control group (12.98±9.74 min/person) $p<0.05$. It shows that the nursing time of nasogastric tube insertion can be effectively reduced and the nursing efficiency can be improved.

The total score of comprehensive ability of nurses in the experimental group of the Neurology Department after three-dimensional tool synthesis model management (34.22±10.48) was significantly higher than that before management (19.32±12.39) $p<0.05$. The scores of each item are improved, as shown in Table 6.

In this study, 3 common event analysis methods in the medical field, QCC, HFMEA method and RCA method were first analyzed and compared, and a three-dimensional tool synthesis model based on QCC in the nursing of patients with indwelling nasogastric tube was proposed. Drawing fish bone maps and searching checklists were the common analytical means of both. Both of these start with the optimization of medical system and medical process. In addition, the ideas and methods used in these 3 steps were similar. Therefore, QCC can be organically combined with HFMEA and RCA to form a line model, that is, a three-dimensional tool synthesis model based on QCC.

Through discussion and analysis of circle members, the goal is determined to be unplanned extubation of nasogastric tube. After analysis, it was found that inappropriate fixation of nasogastric tube, inappropriate patient restraint, and safety awareness of medical staff need to be strengthened are the real reasons for unplanned extubation of nasogastric tube. After implementing four strategies (improving the fixing method of nasogastric tube, improving limb restraint method, popularizing knowledge of safety management of gastric tube and training of nurses in operation of gastric tube), the patients were investigated by checklist. It was found that the 4 strategies can effectively reduce the unplanned extubation probability of nasogastric tube ($p<0.05$), effectively reduce the cost of materials for indwelling nasogastric tube ($p<0.05$), effectively reduce the nursing time of indwelling nasogastric tube ($p<0.05$), and effectively improve the comprehensive ability of nurses ($p<0.05$).

To sum up, in this study, the theoretical analysis of the proposed three-dimensional tool synthesis model based on QCC and its application in indwelling nasogastric tube nursing were carried out. The experimental results showed that the synthetic model can effectively avoid the shortcomings of QCC, HFMEA or RCA methods in medical and nursing management and provide a theoretical basis for promoting high efficiency, humanization and advancement of medical management.

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