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Impact of Quality Control Circle Activities on Improving the Cleaning Pass Rate of Luminal Instruments

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ABSTRACT: Objective To explore the impact of Quality Control Circle (QCC) activities on improving the pass rate of cleaning for luminal instruments. **Methods** A Quality Control Circle was established, and a non-concurrent controlled experimental study method was adopted. A total of 302 luminal instruments cleaned from April 8, 2024, to April 30, 2024, were selected as the control group, and 359 luminal instruments cleaned from May 21, 2024, to August 8, 2024, were selected as the observation group. The control group was cleaned with a conventional washing machine, while the observation group was managed by the Quality Control Circle and cleaned with a high-temperature, high-pressure steam water gun and a vacuum boiling washing machine. Using the Pareto principle and fishbone diagram, the reasons for the low pass rate of cleaning luminal instruments were analyzed from five aspects: personnel, cleaning facilities, mechanical materials, mechanical equipment, and laws and regulations. Corresponding solutions were developed, and the changes in the pass rate of cleaning luminal instruments before and after the implementation of the Quality Control Circle activities were compared through the implementation and review of the countermeasures. **Results** The pass rate of cleaning luminal instruments increased from 76.82% before improvement to 98.6% after improvement, with a progress rate of 30.17% and a compliance rate of 163.6%. **Conclusion** The implementation of Quality Control Circle activities in the Central Sterile Supply Department (CSSD) has improved the pass rate of cleaning luminal instruments, further improved the work efficiency of cleaning luminal instruments in the Central Sterile Supply Department (CSSD), and reduced the re-washing rate.

KEY WORDS: Central Sterile Supply Department; Quality Control Circle; Luminal Instruments; Cleaning Pass Rate; Decompression Boiling Disinfection Machine; High-Temperature High-Pressure Steam Water Gun

The Central Sterile Supply Department (CSSD) plays an irreplaceable role in infection control in major hospitals. Its responsibilities include the recovery, cleaning and disinfection, inspection and packaging, sterilization, and issuance of diagnostic and treatment instruments and medical tools used by different departments in the hospital. The quality of instrument cleaning directly determines the effectiveness of sterilization and has a direct impact on the prevention and control of hospital infections[1-2]. The "Top Ten Patient Safety Issues of Concern to Medical and Health Institutions in 2018" issued by the national health authorities clearly defined the core position of instrument cleaning, disinfection, and sterilization work[3]. In recent years, with the development of minimally invasive technology, luminal instruments have features such as small lumens and complex structures, which make contaminants such as human tissue, pus, and blood more likely to adhere to the inner wall of the lumen, increasing the difficulty of cleaning. Traditional cleaning methods, such as spray washer-disinfectors, fail to adequately clean luminal instruments and limit their loading time and loading capacity[4]. However, if residues are not completely removed, biofilms will form, which hinder effective contact with sterilizing gases and

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thus affect sterilization efficacy. Additionally, some residual substances may corrode the coating on the instrument surface, leading to rusting, lowering the cleaning pass rate, and increasing the rate of re-cleaning. Meanwhile, incomplete cleaning is a serious problem in the processing of luminal instruments. It may lead to the growth and spread of microorganisms such as bacteria and viruses, thereby causing cross-infection during treatment, that is, triggering infection risks and increasing patients' suffering and treatment costs. A "quality control circle (QCC)"[5-6] is a small group formed by personnel from the same department who voluntarily carry out quality management activities and follow a certain activity procedure to solve problems arising in the workplace, management, culture, and other aspects. This study used the quality control circle method to conduct in-depth analysis and management improvement to increase the cleaning pass rate of luminal instruments, and achieved good results, which are reported as follows.

1 Data and methods

1.1 Data sources

The QCC activities were carried out from April 2024 to September 2024. Events of qualified cleaning of luminal instruments were recorded in real time. Using the problem-solving QCC method, the QCC activity was carried out in an orderly manner according to the ten major steps, and the cleaning pass rate was used as the observational indicator of the study results.

1.2 Methods

A non-synchronous controlled quasi-experimental study design was adopted. The control group used a conventional washing machine for cleaning, while the observation group adopted QCC management and added, in the process, a high-temperature, high-pressure steam water gun + a vacuum boiling washing machine for cleaning. The specific implementation steps were as follows:

1.2.1 QCC formation and circle name

12 experienced nursing staff were selected by the department head nurse from the Central Sterile Supply Department to jointly form a QCC group. The group had a total of 13 members, including 5 nurses-in-charge and 8 nurses. The head nurse served as the circle leader, responsible for planning and organizing the entire QCC activities, organizing QCC knowledge training, and enhancing the QCC activity capabilities of group members. Through brainstorming, "Lianxin Circle" was proposed as the circle name, and the circle emblem was determined.

1.2.2 Selection of the theme

All circle members used brainstorming around the work of the CSSD and proposed 4 themes, which were evaluated from 4 aspects and 3 dimensions, namely: superior policies, including "frequently remind", "occasionally informed", and "never heard of"; urgency, including "solve as soon as possible", "solve next time", and "discuss again half a year later"; feasibility, including "feasible", "relatively feasible", and "not feasible"; and circle capability, including "high" (76%~100%), "medium" (51%~75%), and "low" (0~50%). Scoring used 5 points as the highest score, 3 points as the ordinary score, and 1 point as the lowest score. After calculation, the scores of each evaluation item for all themes were added together, and finally the theme with the highest score, "Improving the Cleaning Pass Rate of Luminal Instruments", was selected as the theme of this activity.

1.2.3 Planning

The circle leader followed the 5W1H principle, namely considering six aspects: object (What), location (Where), time (When), personnel (Who), reason (Why), and method (How), and drew a Gantt chart according to the actual situation. Activity time was allocated in a ratio of 3∶4∶2∶1: ① April 1, 2024 to May 20, 2024 was the planning stage, mainly for data collection, analysis, and formulation of countermeasures for the theme activity; ② May 21, 2024 to August 8, 2024 was the implementation stage, during which improvement measures were implemented; ③ August 9, 2024 to September 6, 2024 was the effect confirmation and standardization stage; ④ September 7, 2024 to September 27, 2024 was the review, improvement, and results reporting stage.

Each stage had a designated person in charge, and the activity was carried out in the CSSD, strictly according to the plan, with activity records properly kept.

1.2.4 Understanding the current situation and cause analysis

The team formulated a pre-implementation checklist, and circle members collected data on the cleaning quality of luminal instruments from April 8, 2024, to April 30, 2024. During this period, a total of 302 luminal instruments were cleaned, of which 232 were qualified and 70 were unqualified. Statistical analysis showed that the current cleaning pass rate of luminal instruments was 76.82%.

With regard to factors contributing to cleaning nonconformity of luminal instruments, the current status of instrument management and the reasons for nonconformity were analyzed, including CSSD staff being unfamiliar with the instruments, nonstandard work processes, insufficient sense of responsibility, incomplete cleaning tools, instrument-related factors, and untimely pre-treatment by clinical departments. A stratified statistical analysis was conducted on the 70 defects, and based on the statistical results, an observation group Pareto chart was drawn (Figure 1). According to the 80/20 rule of the Pareto chart, the five categories of dried contaminants, delayed cleaning, instrument aging and damage, incomplete manual cleaning, and cleaning brushes being too coarse/fine were listed as the key improvement points of this theme.

All circle members used the brainstorming method, identified causes from five aspects—personnel, cleaning facilities, instrument materials, mechanical equipment, and laws and regulations- and drew a fishbone diagram (Figure 2). Twelve circle members then voted to select the key causes. Based on real-time records by circle members of the frequency of occurrence of each cause, it was ultimately determined that six causes—clinical departments performing delayed pre-treatment after instrument use, delayed cleaning, instrument aging and inadequate

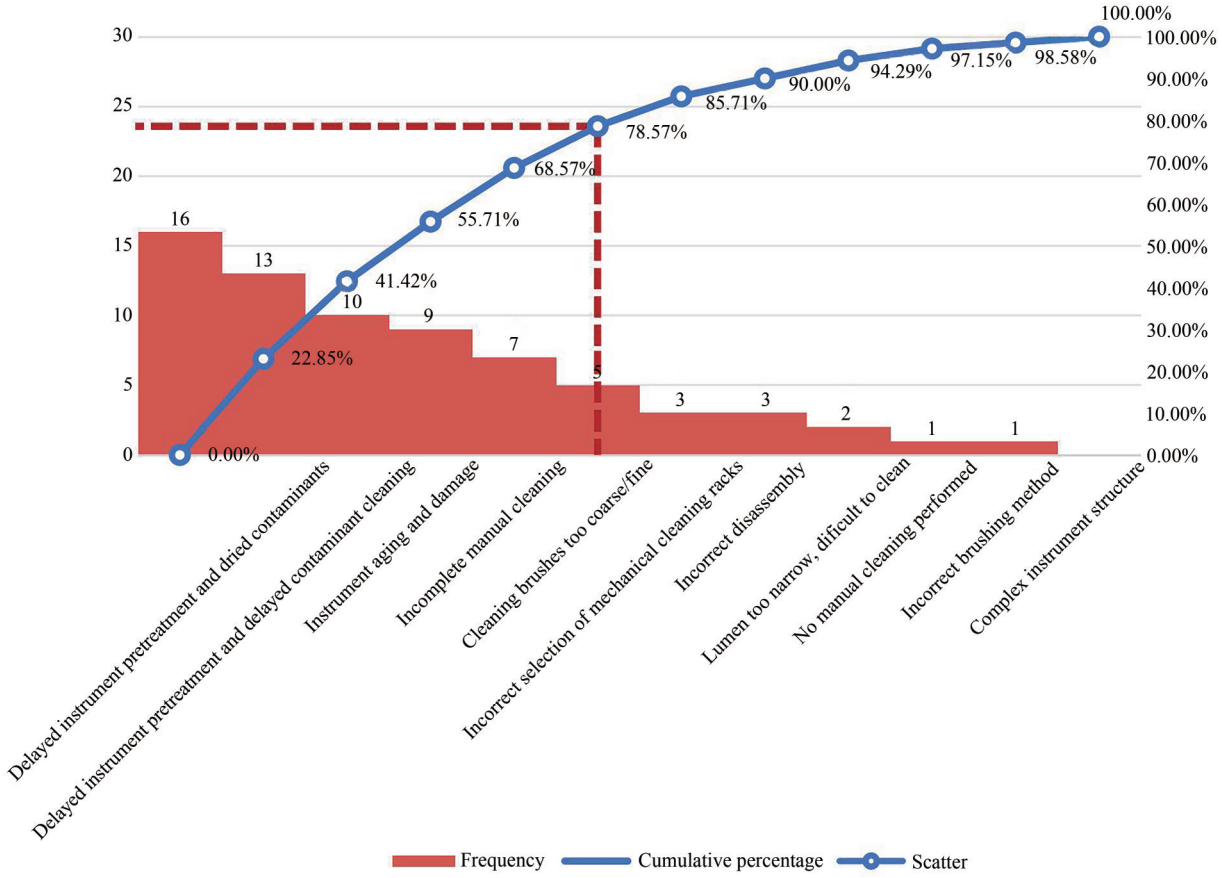

Figure 1 Pareto chart of factors affecting the cleaning pass rate of lumened instruments before QCC implementation

maintenance, incomplete configuration of cleaning tools, failure to strictly implement rules, regulations, and operating procedures/specifications, and failure to perform pre-treatment before cleaning—were the true causes, as shown in Figure 2.

1.2.5 Target value setting

(1) Circle capability calculation method: the 531 rules. Circle capability is calculated based on each member of the QCC rating his/her own capability against the management target on a scale of 1~5. The theoretical full score for this evaluation was 65 points; the actual total score was 40 points, so the circle capability was 61.4%, as shown in Table 1.

(2) Target value

The target value calculation formula commonly used in QCC activities was adopted, substituting the current status value of 76.82%, the standard value of 100%, the key improvement point of 78.57%, and our team's circle capability of 61.4% into the formula (Target value = Current status 76.82% + (Standard value 100% − Current status value 76.82%) × Key improvement point 78.57% × Circle capability 61.4% = 88.0%). Based on the analysis results, the activity target was set; that is, the cleaning pass rate of luminal instruments needed to reach 88.0% or above.

1.2.6 Countermeasure formulation

All circle members conducted brainstorming on each true cause and formulated solutions. The "531" evaluation method was adopted. Scores were assigned according to feasibility, economy, and effectiveness and then integrated. There were 13 circle members in total, so the total score was 195 points. According to the 80/20 rule, a score of 156 points or above indicated an implemented countermeasure, as shown in Table 2. Finally, 6 countermeasures were formed and implemented as follows: (1) QCC group members explained to clinical department staff the importance and impact of instrument pre-treatment. Cleaning personnel in the decontamination area took photos of instruments that had not been pretreated, provided timely feedback and communication with

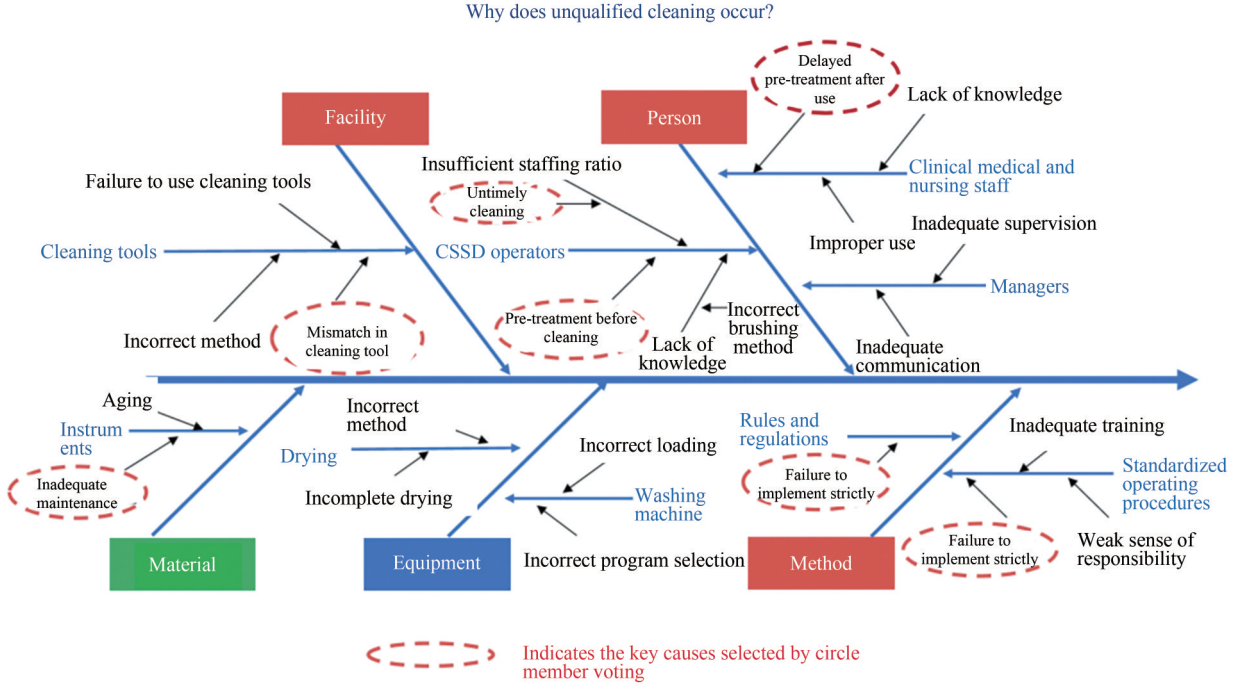

Figure 2 Cause Analysis of the Low Cleaning Pass Rate of Luminal Instruments

Table 1 Circle Capability Evaluation

Circle member	A	B	C	D	E	F	G	H	I	J	K	L	M	Total	*mean±SD*
Circle capability	5	5	5	5	3	3	3	3	2	2	2	1	1	40	3. 75±1. 35
Scoring criteria				Able to complete independently					Requires cooperation from one unit					Requires cooperation from two units	
Reference score				5 points					3 points					1 point	

clinical department personnel, and ensured proper instrument moisturizing. (2) Develop training plans, strengthen staff training, and enhance the sense of responsibility. (3) Reassess cleaning tools and purchase appropriate tools. Luminal instruments must be manually cleaned using special brushes and high-temperature, high-pressure steam water guns. (4) Use a vacuum boiling washing machine to clean luminal instruments[7-8]. (5) Develop detailed cleaning procedures and standardize operations. (6) Packaging staff shall carefully inspect the instruments and communicate promptly with the clinical head nurses, and replace seriously damaged instruments in time. Inform the specialty departments that rusty instruments will affect the quality of other instruments and must be replaced, and request an increase in instrument reserves. For instruments with severe corrosion, the CSSD will notify the department and enforce elimination, provided that surgery is not affected.

1.2.7 Implementation and review of countermeasures

(1) While strengthening the implementation process, for luminal instruments, dedicated high-temperature, high-pressure steam water guns were used for manual cleaning, and a vacuum boiling washing machine was introduced to ensure that all parts of luminal instruments could be effectively cleaned. After confirmation of effectiveness, effective countermeasures were incorporated into standardization to form standard operating procedures. The standardized model was applied to work, and a new workflow was formulated, as shown in Figures 3 and 4, making work standardized and improving the efficiency and quality of cleaning. (2) The head nurse communicated with leaders of relevant functional departments, hoping that they could provide regular supervision and inspection. (3) A circle member meeting was held once a week to analyze the problems existing in the activity, formulate solutions, urge relevant personnel to implement the improvement measures after they were formulated, and regularly track the implementation to ensure the improvement of cleaning quality.

1.3 Statistical methods

SPSS 22.0 statistical software was used for data analysis. Count data were described as case numbers and percentages, and comparisons between groups were performed using the χ^2 test; measurement data were analyzed using the t-test. $P<0.05$ indicated that the difference was statistically significant.

2 Results

2.1 Tangible results after implementation of countermeasures

2.1.1 Comparison of the cleaning pass rate of luminal instruments between the two groups

In the control group, the number of qualified

Table 2 Countermeasure Formulation Scoring

Problem point	Root cause	Countermeasure plan	Evaluation			Total score
			Feasibility	Economy	Effectiveness	
Blood and body fluid residues	Instruments not pre-treated after use and before cleaning	Strengthen pre-treatment	63	61	59	183
	Weak sense of responsibility among staff and non-standard operations	Develop training plans and strengthen staff training	61	59	59	179
	Inadequate suitability of cleaning tools	Replace the relevant cleaning tools in the decontamination area	61	57	57	175
	Cleaning blind spots in traditional cleaning methods	Use a vacuum boiling washing machine to clean luminal instruments	59	57	55	171
	Failure to strictly implement operating procedures and rules and regulations	Develop detailed cleaning procedures	57	55	55	167
	Rusty and damaged instruments are not replaced and eliminated in time	Establish an instrument quality elimination control system	55	53	53	161

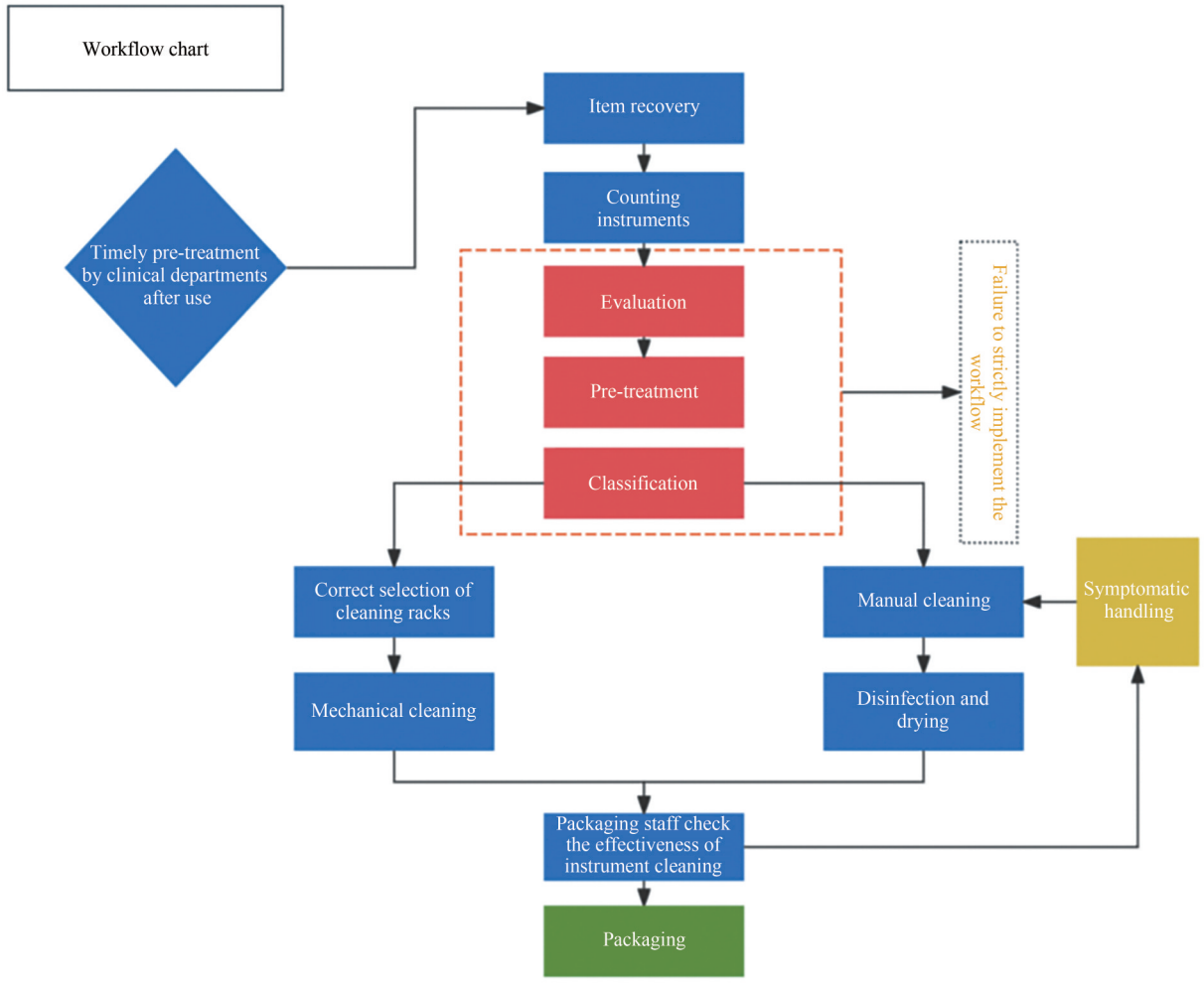

Figure 3 Workflow Chart Before Implementation of Countermeasures

luminal instruments after cleaning was 232, and that of unqualified ones was 70, with a cleaning pass rate of 76.82%. In the observation group, the number of qualified ones was 354, and that of unqualified ones was 5, with a cleaning pass rate of 98.6%.

The pass rate in the observation group was significantly higher than that in the control group (P<0.05), as shown in Table 3.

2.1.2 The cumulative percentage of occurrences of the five key improvement points decreased from 75.87% before implementation to 60% after implementation. The comparison of the incidence of various types of unqualified luminal instrument cleaning before and after the QCC activity is shown in Table 4.

2.1.3 Intangible results after implementation of countermeasures

Based on nine items: enthusiasm, understanding of QCCs, problem-solving ability, ability to tap personal potential, confidence in QCC activities, team cohesion, sense of responsibility and honor, communication and coordination, and use of QCC techniques, 13 circle members performed self-scoring. Each item had a maximum of 5 points and a minimum of 1 point, and the activity growth value was obtained and compared. The results showed that, through this QCC activity, the circle members' abilities in all aspects were improved to a certain extent, and all scores in

Table 3 Comparison of Cleaning Pass Rates of Luminal Instruments Before and After QCC Activities

Grouping	Number of cases	Qualified (cases)	Unqualified (cases)	χ^2	p value
Control group	302	232	70	77. 393	<0. 001
Observation group	359	354	5		

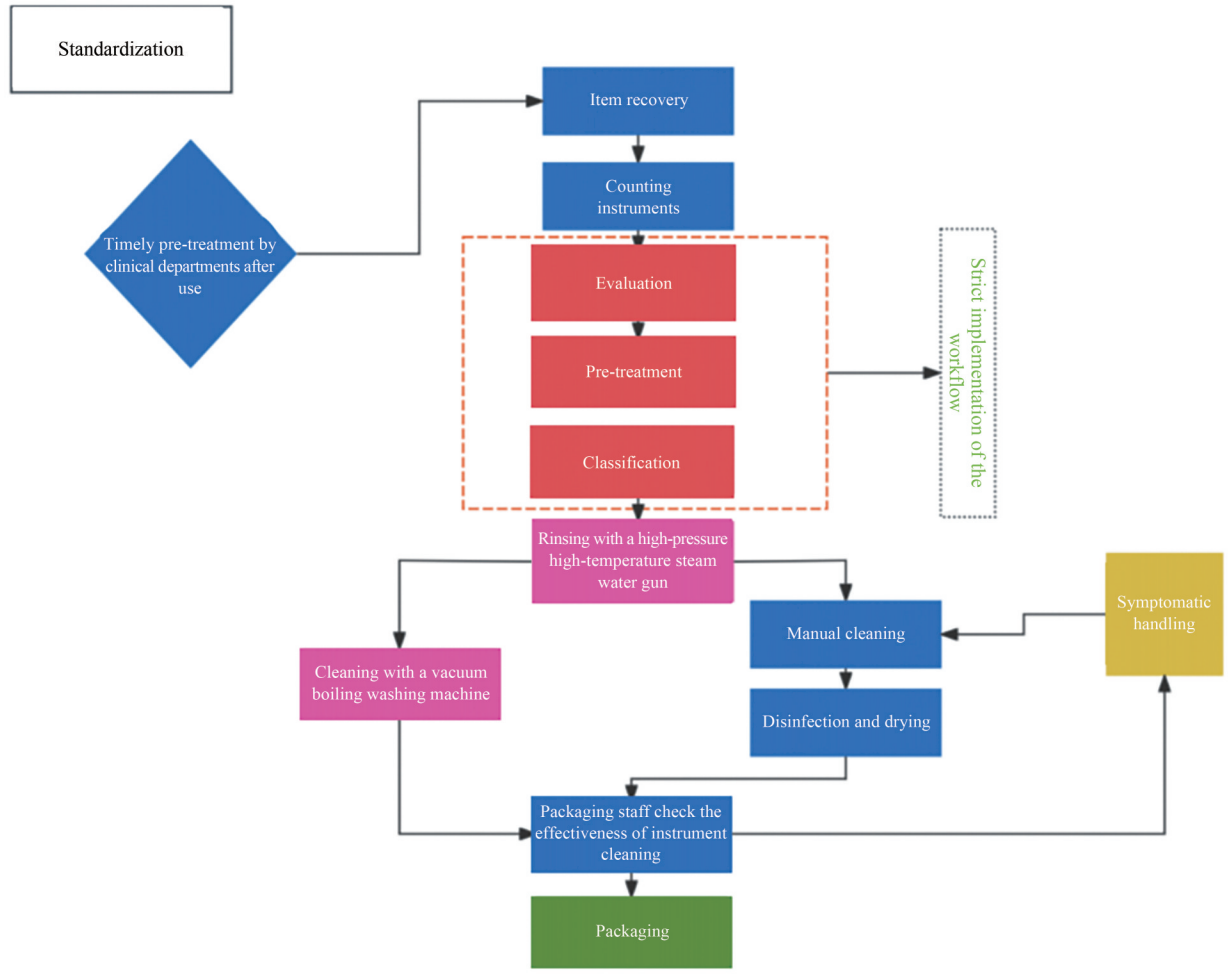

Figure 4 Standardized Workflow Chart After Implementation

Table 4 Comparison of the Incidence of Unqualified Luminal Instrument Cleaning Between the Two Groups Before and After the QCC Activity

Reasons for unqualified cleaning	Number of cases of unqualified cleaning		χ^2 value	*p* value
	Control group *n* (%)	Observation group *n* (%)		
Staff-related factors	28(9. 27)	2(0. 56)	28. 749	<0. 001
Cleaning agents and cleaning tools	12(3. 97)	0(0. 00)	14. 529	<0. 001
Other factors	4(1. 32)	0(0. 00)	4. 784	0. 029
Instrument-related problems	16(5. 29)	3(0. 84)	11. 699	0. 001
Clinical department-related factors	10(3. 31)	0(0. 00)	12. 070	0. 001

the observation group were significantly higher than those in the control group (Table 5, Figure 5) (P<0.05).

3 Discussion

Originated in Japan, the quality control circle was first applied in enterprise management, aiming to improve product quality and work efficiency[9-10], and it has now been widely used in hospital management[11-13]. The CSSD is responsible for handling sterile medical devices for the whole hospital; luminal instruments have complex structures and are used frequently, and the quality of cleaning and disinfection is directly related to patient safety, as well as being a key difficulty in hospital infection control. This study applied the QCC to the cleaning management of luminal instruments, identified problems such as drying of contaminants and delayed cleaning through a survey of the current situation, and formulated countermeasures and implemented them in a standardized manner after root cause analysis.

Table 5 Comparison of Improvement Values of Nursing Staff Before and After the QCC Activity

Item	Control group*mean±SD*	Observation group*mean±SD*	*t* value	*p* value
Enthusiasm	2±0. 58	5±0. 00	18. 735	<0. 001
Understanding of QCCs	1. 5±0. 41	4±0. 54	25. 495	<0. 001
Problem-solving ability	3±0. 76	4. 5±0. 54	8. 832	<0. 001
Ability to tap personal potential	2±0. 46	3. 5±0. 68	8. 379	<0. 001
Confidence in QCC activities	1. 5±0. 61	4. 5±0. 54	20. 564	<0. 001
Team cohesion	2. 5±1. 91	5±0. 00	9. 874	<0. 001
Sense of responsibility and honor	2. 5±0. 71	4. 5±0. 10	10. 198	<0. 001
Communication and coordination	2±1. 22	4. 5±0. 50	9. 208	<0. 001
Application of QCC techniques	1. 5±0. 68	4. 0±0. 76	15. 612	<0. 001

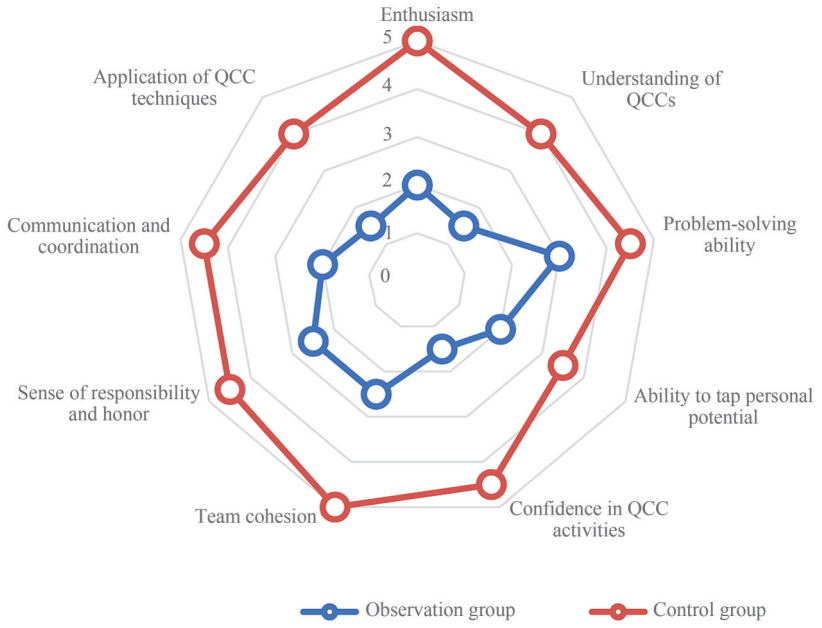

Figure 5 Comparison of Radar Charts Before and After the Activity

3.1 The results of this study showed that the cleaning pass rate in the observation group was 98.6%, which was significantly higher than that in the control group, at 76.82% (P<0.05). The QCC group used brainstorming to sort out the pain points in luminal instrument cleaning and clarify the improvement goals; through measures such as strengthening departmental communication, optimizing cleaning processes, improving cleaning tools, carrying out specialized training, and conducting regular quality supervision, the quality of luminal instrument cleaning and disinfection was effectively improved.

3.2 The results of this study showed that the cumulative percentage of the five key improvement points in the observation group was 60%, which was lower than that in the control group, at 75.87%, indicating a significant improvement effect (P<0.05). Supporting instrument training within the QCC helped nurses become familiar with instrument structures and reduced human cleaning defects. Meanwhile, configuring cleaning tools adapted to different types of instruments can continuously reduce the incidence of unqualified luminal instrument cleaning.

3.3 The results of this study showed that, across nine dimensions—enthusiasm, understanding of QCCs, problem-solving ability, ability to tap personal potential, confidence in QCC activities, team cohesion, sense of responsibility and honor, communication and coordination, and application of QCC techniques—the scores of circle members in the observation group were all significantly better than those in the control group (P<0.001). QCC activities are carried out in the form of small groups and encourage members to offer suggestions, which can enhance

the nurses' sense of job responsibility and professional identity. Supporting training can consolidate nurses' professional competence and strengthen team cohesion, which is consistent with the results of this study.

3.4 Study limitations: This study was a single-center retrospective before-and-after controlled study, belonging to a non-synchronous experimental control, and there was confounding bias caused by time factors; moreover, the representativeness of single-center data is limited, and the extrapolation of the study conclusions has certain limitations. In the future, multi-center studies can be carried out to further verify the application value of this program.

4 Conclusion

This QCC activity achieved the expected effect and resulted in clear and quantifiable improvements in the cleaning quality of luminal instruments. The QCC team successfully identified many problematic steps in the luminal instrument cleaning process, such as delayed pre-treatment, incorrect cleaning methods, and unsuitable cleaning tools. After implementing improvement measures, a more scientific, reasonable, and standardized cleaning process was established, which reduced the instability of cleaning quality caused by human factors. During the QCC activities, communication and collaboration between staff from different departments, including pre-treatment personnel in clinical departments, staff in the CSSD, and hospital infection control personnel, were strengthened. This cross-departmental cooperation model not only helps solve practical problems in cleaning work, but also improves the overall management level of the medical institution in medical device management and enhances team cohesion and problem-solving ability. The results of the QCC activities are sustainable. QCC activities have prompted our hospital to establish a complete set of long-term mechanisms for monitoring and managing the cleaning quality of luminal instruments.

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