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Review of Clinical Practices on Reducing PICC Catheter Infection Rates through Quality Control Circles (QCC) Activities

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Abstract: Peripherally Inserted Central Venous Catheters (PICC) are now widely used in clinical nursing. However, catheter-related infections have become a major concern in clinical practice. This review summarizes the application of Quality Control Circle (QCC) activities in reducing PICC infection rates and finds that QCC activities play a significant role in improving nurses' competencies, standardizing operating procedures, enhancing patient education, optimizing environmental materials and so on, thereby effectively reducing infection rates. Clinical data show that QCC has an outstanding application effects in groups such as cancer patients, neonatal patients, and leukemia patients, with an improvement in infection rates over 50%. Moreover, QCC activities enhance nurses' professional competence and help establish a systematic infection prevention and control framework. The QCC model provides a standardized improvement pathway for clinical catheter management and holds significant guiding value.

1. Introduction

In intravenous infusion therapy, central venous infusion technology is a commonly used method for infusing irritating fluids and medications [1]. Among them, the Peripherally Inserted Central Catheter (PICC) is widely applied. It was first used in pediatric malignant tumor patients in the United States in the 1970s and introduced into China in the 1990s. PICC is often used in treatments such as chemotherapy and long-term infusion due to its long indwelling time, high safety, and ability to reduce repeated punctures [2-3]. However, with the popularization of the technology, complications such as catheter-related infections have occurred frequently. Literature shows that such infections account for about 40% of catheter-related complications, ranking first [4-5]. Infections can lead to unplanned catheter removal, prolonged hospital stay, and even sepsis. Therefore, reducing the incidence of PICC catheter infections is of great significance in clinical nursing.

The traditional management model relies on individual experience, with problems such as non-standardized operations, loose training, and lack of patient education. In high-risk departments such as oncology and neonatology, differences in nurses' skills and low patient compliance have exacerbated the risk of PICC catheter infections. Quality Control Circle (QCC), a management tool founded by Dr. Ishikawa of Japan in 1962, achieves efficient use of resources and quality improvement through full participation and division of labor and cooperation [6-7]. In view of the limitations of the traditional model in PICC catheter infection control, QCC activities have been introduced into clinical nursing owing to their systematic analysis, process standardization, and multi-dimensional intervention strategies, significantly optimizing the infection prevention and control path. This article reviews the application status of QCC activities in reducing the incidence of PICC-related infections, providing a reference for improving nursing quality and reducing infections.

2. Overview and Core Theories of QCC

Quality Control Circle (QCC) is a grassroots quality improvement model centered on employees' autonomous management. Members voluntarily form cross-functional circles based on work relevance, adhering to the concept of "full participation and continuous improvement." Using tools such as the PDCA cycle, they form teams around work pain points, analyze problems, propose solutions, and form a closed-loop of quality improvement through data verification.

Currently, QCC activities are widely applied in the medical field and play an important role in quality management [8]. In clinical nursing, their implementation process includes 8 links: establishing a QCC team, selecting a theme, conducting a current situation survey, setting goals, analyzing causes, formulating countermeasures, implementing countermeasures, and evaluating effects [9]. These activities can not only optimize nursing processes, reduce adverse events, and improve patient satisfaction but also cultivate nurses' ability to solve problems through knowledge sharing and teamwork [10-11]. Meanwhile, they create a cultural atmosphere where employees participate deeply and pursue continuous improvement, achieving multiple goals of enhancing quality, efficiency, and organizational capabilities [12].

3. Application of QCC in PICC Infection Control

3.1. Improvement of Nurses' Competence

In clinical nursing, the risk of PICC infection is associated with bacterial invasion through the skin at the insertion site, and the standardization of nurses' operations, their knowledge level, and differences in experience are key factors affecting the effectiveness of infection prevention and control. The "Evergreen Circle" established by Zhang Xinlei et al. found that infections caused by incomplete maintenance procedures and nurses' lack of theoretical knowledge accounted for 53.33% of cases. Through measures such as improving procedures, strengthening training and assessment, and implementing mentoring by senior nurses, the number of infection cases caused by nurses' incompetence decreased from 36 (51.4%) to 15 (15.3%) [13]. Lu Meizhu's "Hand-in-Hand Circle" also confirmed that infections caused by non-standard operations of nurses accounted for 35.29% of cases, and after special training and qualification certification, the number of infection cases decreased from 17 to 8 [14]. It can be seen that standardized operations and continuous education are the core to improving nursing competence and reducing PICC infection rates, and QCC activities are an effective way to achieve this goal.

3.2. Optimization of Nursing Operation Process Standards

PICC puncture, maintenance, and removal must strictly follow aseptic techniques and standardized operations. Standardized processes can not only reduce operational differences, unify nursing standards, and lower the risk of human operational errors but also help new nurses master skills quickly and facilitate quality monitoring [15]. Meanwhile, standardized processes provide support for data collection and analysis, promoting continuous optimization of operations, and their scientificity is derived from authoritative research and guidelines. Jiao Jin et al. improved PICC nursing systems in accordance with clinical norms through the "Tumor Care Circle" QCC activities, effectively reducing the infection rate [16]; Gao Jinhua et al. established the "Sweet Circle" to improve the disinfection process of neonatal PICC, reducing the detection rate of skin bacteria from 35% to 15% [17]. It is evident that QCC activities, through unifying standards and strengthening refined management, fully practice scientific guidelines, provide a quantifiable and traceable quality improvement path for clinical nursing quality improvement, and effectively ensure nursing quality and patient safety.

3.3. Education for Patients and Their Families

Education for patients and their families is a key link in the prevention and control of PICC infections. Systematic education can not only improve their ability to perform correct self-care, reduce the risk of infection, but also enhance compliance and reduce infections caused by improper operations [18-19]. In addition, after understanding relevant knowledge, patients and their families can alleviate anxiety and better cooperate with treatment [20-21]. He Lijuan et al. established the "Red Ribbon Circle" and through analysis found that 40% of infection cases were caused by patients' poor maintenance compliance and insufficient attention to catheters due to their lack of knowledge about PICC catheters and maintenance. By developing diversified education methods before, after catheterization, and during daily use, combined with regular telephone follow-ups, the PICC infection rate was effectively reduced [19]. Ding Yu et al. formed the "Ribbon Circle" and through analysis found that insufficient health education for patients was one of the key factors leading to a high PICC infection rate after breast cancer surgery. By strengthening health education during catheter indwelling, emphasizing the importance of PICC catheters, maintenance methods, and precautions, the treatment effect was improved and the risks of infection or displacement were avoided [22]. Xu Pian et al. set up the "Butterfly Circle" and found that 45% of infection cases were caused by incomplete patient education and poor compliance. Through measures such as distributing PICC graphic flowcharts, providing discharge guidance and follow-ups, establishing communication platforms and QQ groups, implementing personalized maintenance plans, and regularly holding knowledge lectures, the compliance and satisfaction of patients with catheters were improved, and the infection rate was effectively reduced [23]. It can be seen that the construction of personalized education programs through QCC activities can effectively implement educational effects and improve medical quality and patient prognosis.

3.4. Optimization of Environment and Materials

Poor environment and inferior materials are "hotbeds" for pathogen growth. The optimization of environment and materials is the "physical foundation" for controlling PICC infections. It can directly reduce the risk of infection through multi-dimensional effects such as blocking pathogen contact, inhibiting microbial colonization, and reducing operational pollution. Zhang Minghua et al. established the "Sweet Circle" and through analysis of PICC infections found that there were problems with materials such as heparin caps, infusion extension tubes, and disinfected alcohol

cotton pads, as well as environmental issues such as the absence of dedicated operating rooms and failure to perform air disinfection before operations. The infection cases caused by these factors accounted for 44.8%, and the infection was effectively controlled after optimizing relevant factors [24]. Through analysis, Zhou Enxia et al. found that factors such as too few cotton balls in the maintenance kit, poor patient compliance, low air permeability index of dressings, and undisinfected dressing change locations were the causes of PICC-related infections. By negotiating with the supply room to increase the number of cotton balls, strengthening the concept of sterility and education, increasing maintenance frequency, using suitable dressing materials, fixing dressing change locations and regularly disinfecting them, the quality of patient care was effectively improved and the risk of infection was reduced [25]. Zheng Ailing et al. carried out QCC activities, optimized the materials and environmental factors causing PICC infections by measures such as daily assessment of puncture points and dressing edge curling to ensure a sterile surrounding environment, selecting appropriate fixing materials, and setting up special PICC maintenance locations, which achieved a 75% reduction in the PICC puncture point infection rate among breast cancer chemotherapy patients [14]. Clinical practice shows that QCC activities can scientifically optimize materials and environment, and combine patient education and operational standards to build a coordinated prevention and control system of "people-materials-methods-environment", effectively controlling PICC infections.

4. Effectiveness and Reflection on the Application of QCC

4.1. Tangible Outcomes

Table 1: The Application Effect of QCC in Different Patient Populations.

Patient Type	Total Sample Size	Infection Rate Before QCC (%)	Infection Rate After QCC (%)	Improvement Rate (%)	References
Patients with PICC catheterization	168	35.2	15.3	56.53	[13]
Cancer patients	25	68	32	52.94	[14]
Tumor patients	123	30	10	66.67	[16]
Neonatal patients	/	0.737	0.133	81.95	[17]
Breast cancer patients	773	4.13	1.97	52.30	[19]
Breast cancer patients	170	14.29	4.65	67.46	[22]
Thoracic tumor patients	159	19.5	7	64.10	[23]
Neonatal patients	98	2.11	0.38	81.99	[24]
Patients with PICC catheterization	263	13.2	5.8	56.06	[25]
Tumor patients	90	22	6.7	69.55	[26]
Patients with PICC catheterization	400	12.5	3	76.00	[27]
Patients with acute leukemia	397	31.77	10.73	66.23	[28]
Tumor patients	24111	0.237	0.09	62.03	[29]
Patients with PICC catheterization	260	9.23	1.54	83.32	[30]
Tumor patients undergoing hyperthermia therapy	80	75	25	66.67	[31]
Patients undergoing PICC catheterization in cardiothoracic surgery	108	50	7.4	85.20	[32]
Patients in the myelosuppressive phase after chemotherapy for leukemia	84	19	4.8	74.74	[33]
Neonatal patients	50	66.7	23.1	65.37	[34]
Tumor patients	53	13.2	5.8	56.06	[35]

QCC activities have demonstrated significant clinical application value in reducing the infection rate of PICC catheters, especially showing excellent effects in the prevention and control of PICC infections in groups such as cancer patients, neonatal patients, and leukemia patients. Multiple practical results in clinical nursing (Table 1) indicate that QCC activities can effectively reduce the

infection risk, with an improvement range of more than 50%. For the prevention and control of PICC infections, QCC activities can systematically analyze the causes, standardize operational procedures, and achieve effective control over the incidence of PICC infections by constructing multi-dimensional intervention strategies in aspects such as nurses, patients and their families, materials, environment, and operational processes.

4.2. Intangible Outcomes

QCC activities have not only achieved significant improvements in clinical indicators such as reducing the infection rate of PICC catheters but also yielded profound intangible outcomes by enhancing the professional capabilities of nursing teams and fostering an infection control culture. Through mechanisms of full participation and continuous improvement, QCC activities have significantly strengthened nurses' awareness of proactive infection prevention and control, and improved their standardized operation skills. Meanwhile, diversified educational methods have enhanced patients' mastery of catheter-related self-management knowledge, increased the compliance of family members in participating in inspections, and further reduced the risk of human errors. In addition, QCC activities have promoted the formation of a team collaboration culture, further driving a positive cycle of nursing quality improvement.

5. Conclusions

In summary, as an effective quality management tool, QCC activities have effectively reduced the incidence of PICC catheter-related infections. Through a structured improvement process, QCC activities play an important role in improving nurses' capabilities, optimizing operational process standards, strengthening education for patients and their families, and optimizing the environment and materials. Its core advantages lie in establishing key intervention measures in multiple links such as standardization (reducing differences), specialization (enhancing capabilities), closed-loop management (continuous improvement), and socialization (full participation), thereby achieving the expected goal of reducing the infection rate. Clinical data show that QCC activities have achieved significant improvement effects in cancer patients, neonatal patients, and leukemia patients, with the infection rate reduced by more than 50%. In addition to the tangible outcomes in reducing PICC infection rates, QCC activities have also enhanced nurses' awareness of improving nursing quality and teamwork, cultivated a culture of continuous improvement, and laid a foundation for the long-term optimization of clinical nursing quality. Future research can further explore the broader application of QCC activities in clinical nursing work and their sustainable impact on long-term infection prevention and control, aiming to provide more optimized solutions for clinical nursing practice.

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