

# Effects of Quality Control Circle Activities for Intravenous Cannula Placement Using Deming Cycle Management: A Case-Controlled Study

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**Abstract:** The present study aimed to explore the effectiveness of quality control circle (QCC) activities under the guidance of the Deming cycle Management for improving intravenous (IV) cannula placement. A total of 1,035 patients who underwent IV cannula placement from March 2019 to June 2019 in the Department of Hepatobiliary Surgery and Department of Renal and Thoracic Surgery of our hospital were enrolled as the control group, and 1,437 patients who underwent IV cannula placement in the same places as above but from July 2019 to December 2019 were enrolled as the test group. A between-group comparison was performed on intangible and tangible outcomes (duration of IV cannula placement, complications, patient awareness rate of maintenance knowledge of IV cannula, patient satisfaction rate with nursing staff, nurse skills in IV cannula infusion, and maintenance). After QCC activities were implemented, the scores of 11 QCC members in the five aspects of QCC technique application, communication and coordination, sense of responsibility and honor, motivation, and problem-solving ability all improved compared with those before the activities ( $p < 0.05$ ), and the duration of IV cannula placement in the test group was  $70.22 \pm 48.33$  h, which was longer ( $p < 0.05$ ) than the  $60.59 \pm 41.9$  h of the control group. The test group had a significantly lower ( $p < 0.05$ ) rate of complications (12.9%, 12.6%, and 1.3% for extravasation, phlebitis, and cannula obstruction, respectively) than the control group (30.0%, 11.4%, and 4.1% for blood oozing, phlebitis, and cannula obstruction respectively); the patient awareness rate of maintenance knowledge of IV cannula and patient satisfaction rate with nursing staff in the test group were 90% and 96.3%, respectively, which were significantly higher ( $p < 0.05$ ) than the 82.4% and 81.5% in the control group. The scores of nurse skills in IV cannula infusion and maintenance in the test group were  $90.5 \pm 1.3$  and  $93.6 \pm 2.0$ , respectively, which were significantly higher ( $p < 0.05$ ) than the  $85.5 \pm 2.7$  and  $81 \pm 1.0$  in the control group. The implementation of QCC activities under the guidance of the Deming cycle Management in IV cannula placement improves the ability of the department's nursing team to identify, analyze, and solve problems, which is favorable for continuous improvement of nursing quality, leading to an elongated duration of IV cannula placement, reduced rate of complications, and improved patient satisfaction rate with nursing services.

**Keywords:** Intravenous Cannula Placement, Deming Cycle, Quality Control Circle, Placemat Duration, Complications

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## 1. Introduction

The Plan-Do-Check-Act (PDCA) cycle was proposed by the American quality management expert Deming in the 1950s and is also known as the Deming cycle [1]. It refers to

the cyclic process in all management activities to improve management quality and efficiency. This scientific management method is now widely used in health care management [2]. Peripheral intravenous (IV) catheters (PIVCs) have gained popularity in Europe and the United

States since the 1960s, with approximately 2 billion PIVCs consumed annually across the globe [3]. IV cannulas are one of the most common types of tools used for peripheral intravenous infusion, and studies have shown that more than 70% of hospitalized patients use IV cannulas [4]. IV cannulas can reduce the number of vascular punctures, incidences of extravasation, and the nursing workload [5]. Additionally, IV cannulas are soft and not prone to puncture the blood vessels, thus they have gained wide use in fluid infusion and treatment of the frail elderly, critically ill patients, and patients receiving intravenous nutritional support [6].

However, the failure rate of IV cannula placement is as high as 69% [7]. Reasons for the failure include accidental removal or displacement, pain, phlebitis, occlusion, infiltration, and infection [8, 9, 10]. Removal of IV cannulas before completing venous therapy places a higher cost burden on the patient and makes the patient subject to discomfort and pain due to re-puncture. To reduce the occurrence of medical disputes and to ensure the safety of patients, the two departments of the department of extra renal thoracic surgery and hepatobiliary surgery of our hospital adopted the quality control circle activity guided by the Deming circulation management method in the continuous quality improvement activity for nurses' use of intravenous indwelling needles from March 1, 2019, and December 30, 2019.

## 2. Methods

### 2.1. Study Design

To evaluate the effectiveness of the method for improving the use of intravenous indwelling needles, we used a case-control study. Participants were 2,472 hospital patients who underwent IV cannula placement from March 2019 to June 2019.

### 2.2. Participants

The control group included 1,035 patients in the Department of Hepatobiliary Surgery and the Department of Renal and Thoracic Surgery of our hospital. The test group included 1,437 patients who underwent IV cannula placement in the same places as above but from July 2019 to December 2019.

### 2.3. Inclusion Criteria

Inclusion criteria were: (1) patients who underwent IV cannula infusion; (2) patients who had full communication capability and signed an informed consent form to voluntarily participate in the present study. Exclusion criteria were: (1) patients with edema and hypoproteinemia; (2) patients with psychiatric disorders; (3) patients who underwent infusion of chemotherapy drugs; (4) patients with other wounds, such as scratches and burns on the skin of the puncture site.

### 2.4. Methods

The control group was provided with routine nursing. In addition to routine nursing, the test group was subjected to the PDCA Cycle, which consisted of the following activities:

#### 2.4.1. Organize the Training

Thirty-four nurses of the two departments received centralized training on intravenous indwelling needle puncture technique and maintenance skills to standardize nurse operation. Standardize the process for using a u-shaped fixed catheter, pulse punching tube, sealing tube, etc., and organize assessment after the training

#### 2.4.2. Improve Patient Compliance with Health Education

The management team of venous therapy made an assessment form of IV cannula according to relevant standards and actual situation, recording details of the patient's personal information, information about the IV cannula insertion, and the reason for removing the IV cannula. The questionnaire about maintenance knowledge of intravenous indwelling needle use was established, and the awareness rate of health education knowledge in patients using indwelling needle was regularly investigated. The responsible nurses once again focus on the contents unknown to the patients, and through various forms of education, improve patients' compliance with health education, enhance patients' awareness of safety, and encourage them to participate in protecting patient safety.

#### 2.4.3. Establish a Sound Management Mechanism

- i. The IV therapy management team developed a quality control chart of IV cannula according to relevant standards and actual conditions.
- ii. The items on the chart were randomly picked for inspection by the head nurse for each month, with the IV therapy liaison nurses assessing the quality control every week, the on-duty group leader conducted quality control assessments each day, and the on-duty nurses were in charge of assessing specific items. Next, the on-duty group leader was tasked with summarizing the daily issues encountered in IV cannula placement, as well as discussing and analyzing those issues at a QCC seminar held every two weeks. The QCC team formulated corresponding improvement measures after the QCC discussion and decided to include the issues in the next PDCA cycle for resolution.

## 2.5. Observation Indicators

### 2.5.1. Tangible Outcomes

Between-group comparisons were performed on the duration of IV cannula placement, rate of complications (extravasation, phlebitis, cannula obstruction, and blood oozing), and patient awareness rates regarding maintenance knowledge for the IV cannula. We also compared patient satisfaction with the nursing staff and nurse skills in IV cannula infusion and maintenance between the study groups.

### 2.5.2. Intangible Outcomes

Intangible outcomes consisted of six aspects: QCC technique application, teamwork, communication and coordination, sense of responsibility and honor, motivation, and problem-solving ability. Each QCC member performed a self-assessment before and after the activity, and each item

was scored 5, 3, or 1, with a higher score indicating a stronger working ability.

### 2.6. Statistical Analysis

Data analysis and p-value calculations were performed in IBM SPSS 24.0 software. The survey results were analyzed using descriptive statistical methods. Count data were expressed as percentages (%) and subjected to  $\chi^2$ -test. Measurement data were expressed as mean  $\pm$  standard deviation and subjected to t-test, with  $p < 0.05$  indicating a statistical difference.

## 3. Results

### 3.1. Participants

The control consisted of 484 males and 551 females, with a mean age of  $38.81 \pm 19.21$  years; the test group consisted of 725 males and 712 females, with a mean age of  $37.44 \pm 17.17$  years. There was no statistical significance ( $p > 0.05$ ) between the two groups in the distribution of gender and age.

**Table 2.** Between-group comparison of complication rate. Values before brackets refer to the numbers of cases, and values in brackets refer to the percentage as n (%).

Group	Number of subjects	Extra-vasation	Phlebitis	Cannula obstruction	Blood oozing
Control group	1,035	311 (30.0)	118 (11.4)	42 (4.1)	25 (2.4)
Test group	1,437	185 (12.9)	181 (12.6)	18 (1.3)	19 (1.3)
$\chi^2$ -value		110.645	19.99	44.113	0.808
p-value		0.000	0.008	0.043	0.369

### 3.2.3. Between-Group Comparison of Patient Awareness Rate of Maintenance Knowledge of IV Cannula and Patient Satisfaction Rate with Nursing Staff

Patient awareness rate of maintenance knowledge of IV cannula and patient satisfaction rate with nursing staff were 90% and 96.3%, respectively, in the test group, which were significantly higher ( $p < 0.05$ ) than the counterparts of 82.4% and 81.5% in the control group, as shown in Table 3.

**Table 3.** Between-group comparison of patient awareness rate of maintenance knowledge of IV cannula and patient satisfaction rate with nursing staff.

Duration	Number of patients surveyed	Total number of items	Number of items that the patients are aware of	Awareness rate (%)	Satisfaction rate (%)
Control group	54	540	445	82.4	81.5
Test group	54	540	486	90	96.3
p-value				0.000*	0.014*

### 3.2.4. Between-Group Comparison of Nurse Skills in IV Cannula Infusion and Maintenance

**Table 4.** Between-group comparison of nurse skills in IV cannula infusion and maintenance.

Item	Pre-activity (n = 34)	Post-activity (n =34)	t	p
Skill for IV cannula infusion	85.5 $\pm$ 2.7	90.5 $\pm$ 1.3	-9.934	< 0.01
Skill for IV cannula maintenance	81 $\pm$ 1.0	93.6 $\pm$ 2.0	-33.248	< 0.01

### 3.3. Intangible Outcomes

The average age of the 11 members of the quality control circle was ( $33.9 \pm 5.6$ ) years old, 10 females and 1 male. The self-assessment scores of 11 QCC members were improved

### 3.2. Tangible Outcomes

#### 3.2.1. Between-Group Comparison of Duration of IV Cannula Placement

The test group had a duration of  $70.22 \pm 48.33$  h for IV cannula placement, which was significantly longer ( $p < 0.05$ ) than the duration of  $60.59 \pm 41.9$  h in the control group, as shown in Table 1

**Table 1.** Between-group comparison of duration of IV cannula placement.

Group	Number of subjects	Placement duration (h)
Control group	1,035	60.59 $\pm$ 41.90
Test group	1,437	70.22 $\pm$ 48.33
p-value	/	$p < 0.05$

#### 3.2.2. Between-Group Comparison of Complications Due to IV Cannula Placement

The test group had a significantly lower ( $p < 0.05$ ) rate of complications (12.9%, 12.6%, and 1.3% for extravasation, phlebitis, and cannula obstruction, respectively) than the control group (30.0%, 11.4%, and 4.1% for blood oozing, phlebitis, and cannula Obstruction respectively), as shown in Table 2.

after QCC activities in the five aspects of QCC: technique application, communication and coordination, sense of responsibility and honor, motivation, and problem-solving ability ( $p < 0.05$ ), as shown in Table 5.

*Table 5. Self-assessment scores of QCC members before and after.*

Item	pre-activity (n = 11)	post-activity(n = 11)	t	P
QCC technique	2.6 ±1.2	3.7 ±1.0	-2.301	0.032*
Teamwork	2.8 ±1.1	3.7 ±1.0	-2.041	0.055
Communication and coordination	3.0 ±0.9	3.9 ±1.0	-2.193	0.040*
Responsibility and honor	2.8 ±1.1	4.1 ±1.0	-2.811	0.011*
Motivation	2.5 ±0.9	4.1 ±1.0	-3.873	0.001*
Problem-solving ability	2.6 ±0.8	3.7 ±1.0	-2.798	0.011*

## 4. Discussion

### 4.1. Deming Circulation Can Prolong Intravenous Indwelling Time and Reduce the Incidence of Complications

Intravenous medication is characterized by a strong effect with a fast onset, and it has become an important mode of clinical treatment. Guo *et al.* pointed out that IV cannula placement reduces the pain of repeated punctures, which ensures puncture safety for the patients [11]. During the implementation of quality control circle nursing, strengthening patient education and preparation before puncture can reduce patients' fear and increase their active cooperation with the puncture. These informed patients also understand the occurrence of adverse reactions and complications. Wang Fang *et al.* [12] showed that PDCA circulation was beneficial to prolong the indwelling time of intravenous indwelling needle. Zhong Yuqing *et al.* [13] showed that PDCA circulation could reduce the incidence of adverse events in patients with intravenous indwelling needles. The results in Tables 1 and 2 showed that the duration of intravenous indwelling needles was longer and the incidence of complications was lower than that in the control group. The results showed that Deming circulation could prolong the indwelling duration for intravenous indwelling needles and reduce the incidence of complications.

### 4.2. Deming Circulation Improves the Compliance of Patients with Health Education

The responsible nurse conducted a regular survey on the awareness rate of health education knowledge among the patients who used indwelling needle. The questionnaire was distributed the next morning after the catheterization to gauge the patients' health-education awareness levels; the topics that required more attention or were unknown to the patients were taught again. Pertinently providing ongoing propaganda and education to the patient helps focus on, and highlights, the target. Table 3 results shows that the awareness rate of maintenance of intravenous indwelling needle increased, indicating that the Deming circulation improved the compliance of patients with health education.

### 4.3. Deming Cycle to Improve the Professional Level of Nursing Staff

Based on the Deming cycle management model, the

knowledge and practical operation level of nurses responsible for preventing complications related to indwelling needles was significantly improved [14-15]. The intravenous infusion puncture technique is one of the basic operations performed by nursing staff. After the implementation of Deming cycle, nursing staff's scores for using pulsed punching tubes, pulsed sealing tubes, U-shaped fixed catheters, and puncture techniques for intravenous indwelling needles improved. Table 4 shows that the scores for maintenance and operation techniques of nursing staff using intravenous indwelling needles improved, indicating that use of the Deming cycle correlates with a boost in the nursing staff's business level.

### 4.4. Deming Cycle to Improve Nursing Staff Comprehensive Quality

Deming cycle is the basic theory and method followed in total quality management, including the four stages of P (plan), D (execution), C (inspection), A (treatment) to achieve improvements in quality management, according to the cycle. The quality management circle activities include selecting topics, scheduling activities, evaluating situations, setting targets and goals, analyzing the current situation in relation to the goals, proposing measures and countermeasures to reach targets, implement the measures, evaluating their effectiveness, and confirming the ten steps to continuously standardize, review, and improve performance. This process requires all members to participate in problem solving, contribute to the work atmosphere, and develop the nursing staff's sense of pride responsibility, and importance.

In recent years, the Deming cycle Management and QCC activities have been gradually integrated and applied in clinical nursing practices to improve nursing outcomes. Wang Hongwei's research [16] shows that the activities of quality control circle improve the comprehensive quality of the circle members. Table 5 shows that after the activity, all the team members in this study scored according to 5, 3 and 1 in the aspects of technique application, communication and coordination, sense of responsibility and honor, enthusiasm, and problem-solving ability in the quality control circle; the scoring results were improved compared with those before the activity, indicating that the application of Deming cycle may improve the comprehensive quality of nursing staff.

## 5. Conclusion

The present study shows that QCC activities applied to IV cannula nursing under the guidance of the Deming cycle Management improved the nursing team's ability to identify,

analyze, and solve problems, which was favorable for continuous improvement of nursing quality. In the meantime, the above practices led to a longer duration of IV cannula placement and lower rates of complications (extravasation, phlebitis, and cannula obstruction) in the test group compared with the control group, which improved the patient satisfaction rate with nursing services.

However, the improvement of nursing quality in this study was mainly aimed at patients in two departments, which did not cover the whole hospital. Therefore, the further study was on the department using intravenous indwelling needle in the whole hospital, which was the deficiency of this study.

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