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Analysis and Countermeasures of Nursing Problems in the Placement of PICC Guided by Endocardial Electrocardiogram Positioning Technology

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Abstract: This study aimed to explore an effective nursing plan for peripherally inserted central catheter (PICC) placement guided by endocardial electrocardiogram (ECG) positioning technology and to analyze related nursing problems and countermeasures. A total of 96 patients who underwent PICC placement using ECG-guided positioning technology in our hospital from January 2024 to December 2024 were selected and randomly divided into an experimental group (n = 48) and a control group (n = 48) using a random number table. The control group received routine basic nursing care, while the experimental group was provided with comprehensive high-quality nursing care. The results showed that the success rate of one-time catheter placement was significantly higher in the experimental group than in the control group ($P < 0.05$), while the incidence of complications was notably lower in the experimental group ($P < 0.05$). These findings suggest that comprehensive high-quality nursing care during PICC placement guided by ECG positioning technology can effectively enhance the success rate of catheter placement and reduce complications, indicating that this nursing approach is valuable for clinical promotion and application.

Keywords: Electrocardiogram-guided positioning technology; PICC catheter placement; Nursing care

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1. Introduction

PICC (Peripherally Inserted Central Catheter) placement has a wide range of clinical applications and the endocardial electrocardiogram-guided positioning technology is a new catheter placement technique. Its main feature is that it does not require X-ray examination and can be operated beside the bed. The end of the PICC is

connected to a heparin cap and a 20ml syringe needle tip is inserted. Two electrode patches are attached to each other and the ECG lead RA of the monitor is connected. After the PICC reaches the patient's superior vena cava, observing the P-wave changes in the electrocardiogram can accurately locate the catheter, thereby achieving the desired catheter placement effect [1]. The clinical operation of inserting a PICC catheter guided by endocardial electrocardiogram positioning technology is complex and can easily induce various adverse events. Therefore, it is necessary to analyze common nursing problems and develop reasonable nursing countermeasures to achieve the desired catheter placement effect [2]. In this study, 96 patients with PICC catheters placed using endocardial electrocardiogram-guided positioning technology were selected to study effective nursing plans, and nursing problems and countermeasures were analyzed.

2. Materials and methods

2.1. General information

A total of 96 patients who underwent PICC catheter placement using endocardial electrocardiogram-guided positioning technology in our hospital from January 2024 to December 2024 were selected for a comparative analysis study. They were randomly divided into an experimental group (n = 48) and a control group (n = 48) using a random number table method. The experimental group consisted of 28 males and 20 females, aged between 38 and 65 years, with an average age of (46.57 ± 3.08) years. The disease types included 20 cases of gastric cancer, 17 cases of bile duct cancer, and 11 cases of pancreatic cancer. The control group consisted of 25 males and 23 females, aged between 43 and 64 years, with an average age of (46.65 ± 3.02) years. The disease types included 21 cases of gastric cancer, 15 cases of bile duct cancer, and 12 cases of pancreatic cancer. There was no significant difference in basic data between the two groups ($P > 0.05$), indicating good comparability. The inclusion criteria were as follows: (1) clear diagnosis of the disease, (2) no contraindications for PICC placement, and (3) signed informed consent for participation in the research plan. The exclusion criteria included: (1) presence of combined mental or psychological disorders and (2) poor nursing compliance.

2.2. Methods

The control group received basic routine nursing care. Nursing staff prepared the necessary items for catheter placement, completed the procedure in a standardized manner, monitored changes in the patient's vital signs, and promptly and appropriately handled any abnormalities. The experimental group received comprehensive high-quality nursing care, with the specific nursing plan as follows:

(1) Preparation for catheter placement

Nursing staff communicated with the patients, explaining the process, cooperation methods, and precautions of PICC catheter placement using endocardial electrocardiogram-guided positioning technology in easy-to-understand language, to alleviate patients' anxiety. The nursing staff prepared the necessary items for catheter placement, including ECG monitors, sterile electrode patches, PICC puncture kits, ethanol, etc. The nursing staff properly connected the ECG monitor, placed the electrode patches on the left anterior axillary line and the mid-clavicular line on both sides, checked the P-wave shape before catheter placement, adjusted the ECG to lead II, and observed the patient's P-wave status.

(2) Nursing operations for endocardial electrocardiogram-guided positioning technology

The nursing staff completed the PICC catheter placement procedure in a standardized manner, closely

observed changes in the ECG, located the tip position of the catheter based on image features, and developed a follow-up nursing operation plan. During the process of catheter placement into the peripheral veins, the ECG showed a normal P-wave. When it reached the sinoatrial node, the P-wave increased significantly. After entering the right atrium, the P-wave appeared high and pointed. At this time, the nursing staff stopped the catheter placement operation and slowly withdrew the catheter. When the catheter entered the deep area of the patient's right atrium, the P-wave decreased or showed a slight inversion. After the catheter exited the atrium and reached the superior vena cava area, the high and pointed P-wave gradually returned to normal, indicating that the catheter had entered the right atrium and superior vena cava areas.

(3) Catheter placement nursing operations

The nursing staff controlled the length of the catheter placement from the puncture site to below the right clavicular joint and then to the third intercostal space. When the length of the PICC catheter was close to the length of the external catheter, the rate of catheter placement was reduced. The nursing staff closely observed changes in the P-wave shape on the ECG. If the P-wave was slightly higher, it indicated that the tip of the catheter had reached the sinoatrial node area of the right atrium. If the P-wave potential was 1/2 of the Q-wave, it indicated that the tip of the catheter had reached the right atrium area. After the P-wave returned to normal, the nursing staff withdrew the metal guide wire in the PICC catheter, properly fixed the catheter, and then performed a chest X-ray examination to confirm that the catheter position was normal before ending the catheter placement operation.

2.3. Evaluation criteria

The success rate of catheter placement was compared between the two groups: the number of people with one-time successful catheter placement and the number of people who needed to adjust the catheter position again after placement were recorded. The one-time success rate of catheter placement was calculated as the number of people with one-time successful catheter placement divided by the total number of people, multiplied by 100%.

The incidence of adverse events was compared between the two groups: the number of people with phlebitis, catheter blockage, and thrombosis was recorded. The incidence of adverse events was calculated as the number of people with the above adverse reactions divided by the total number of people, multiplied by 100%.

2.4. Statistical methods

SPSS 23.0 software was used to analyze the research data. Measurement data ($\bar{x} \pm s$) were tested using t-test, and count data (%) were tested using chi-square test. $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of the one-time success rate of catheter placement between the two groups

In terms of the one-time success rate of catheter placement, the experimental group was higher than the control group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of the one-time success rate of catheter placement between the two groups (n/%)

Groups/*n*	One-time successful catheter placement	Need to adjust the catheter position again after placement	One-time success rate of catheter placement
Experimental group (*n* = 48)	47	1	47(97.9)
Control group (*n* = 48)	42	6	42(87.5)
χ^2-value			3.852
p-value			0.049

3.2. Comparison of the incidence of complications between the two groups

In terms of the incidence of complications, the experimental group was lower than the control group ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of the incidence of complications between the two groups (n/%)

Groups/*n*	Phlebitis	Catheter blockage	Thrombosis	Incidence of adverse events
Experimental group (*n*=48)	1	0	1	2(4.2)
Control group (*n*=48)	3	2	3	8(16.7)
χ^2-value				4.018
p-value				0.045

4. Discussion

PICC catheterization mainly refers to the insertion of a central venous catheter through peripheral venous puncture, establishing a venous access for patients to meet the long-term intravenous drug administration needs. The placement of the PICC catheter using intracavitary electrocardiogram-guided positioning technology involves connecting the monitor's ECG lead RA to the PICC catheter through double electrode patches. Observing changes in the electrocardiogram P-wave can determine the catheter's position, improving the success rate of one-time catheter placement [3]. The operation of inserting a PICC catheter using intracavitary electrocardiogram-guided positioning technology is relatively complex. To ensure the effectiveness of the catheterization, appropriate nursing measures need to be taken.

This study shows that the success rate of one-time catheterization in the experimental group is significantly higher than that in the control group and the incidence of complications is significantly lower than that in the control group, confirming that comprehensive high-quality nursing can improve the success rate of one-time catheterization and reduce the incidence of complications. Analyzing the reasons, basic routine nursing operations are relatively simple and nursing staff have not developed a comprehensive nursing plan, which cannot achieve the ideal nursing effect. In the comprehensive high-quality nursing plan, nursing staff are proficient in catheterization-related operations. Before catheterization, health guidance and psychological intervention are provided to patients, which can improve patient cooperation [4]. During the catheterization operation, nursing staff closely observe the electrocardiogram, accurately determine the position of the catheter tip based on changes in the P-wave, and strictly standardize the catheterization-related procedures. This careful approach can significantly improve the success rate of one-time catheter placement and effectively reduce the incidence of adverse events such as phlebitis [5].

The nursing difficulty of PICC catheterization using intracavitary electrocardiogram-guided positioning

technology is relatively high and various problems can easily arise during nursing operations. Therefore, effective countermeasures need to be taken to ensure the effectiveness of nursing intervention. In this study, there were cases of catheterization failure in both groups. The reason is that some patients have severe conditions and excessively high heart rates. There is no significant P-wave change in the process of converting skin potential into atrial electrocardiographic potential, and there is no typical high P-wave image in the electrocardiogram, leading to intracavitary electrocardiogram guidance failure [6]. Some patients experience atrial fibrillation during catheterization, resulting in no significant change in the P-wave. To improve the success rate of catheterization, nursing staff need to provide health guidance and psychological guidance before the operation, appease patients' anxious emotional state, provide psychological counseling to patients, and avoid arrhythmia or tachycardia caused by emotional issues. A comprehensive electrocardiogram evaluation should be performed before catheterization. If the patient has arrhythmia, atrial flutter, or atrial fibrillation, a specific P-wave image cannot be formed during the catheterization process and other PICC catheterization technical solutions need to be adopted. If the patient has a cardiac pacemaker implanted and the P-wave does not change after the catheter enters the atrium, other PICC catheterization technical solutions need to be adopted [7].

Another issue that may arise during catheterization is the absence of a high P-wave. The main reason some patients do not generate a high P-wave during catheterization is improper positioning during the procedure. The internal jugular vein is not in an acute angle, and the catheter tip fails to enter the atrium during catheterization, resulting in no significant P-wave changes in the electrocardiogram. To solve such problems, nursing staff need to provide health guidance before catheterization, inform patients of the cooperation methods for PICC catheterization, and focus on explaining the positional requirements. When the PICC catheter enters the patient's subclavian vein, guide the patient to turn their head to the catheterization side, with the lower jaw touching the clavicle, forming a head-down and head-turning position to ensure that the internal jugular vein forms an acute angle. If no high P-wave of atrial electrocardiogram is generated during the PICC catheterization process, nursing staff can withdraw the catheter, assist the patient to adjust to a head-down and head-turning position, and then perform puncture catheterization again. During catheterization, they can press on the vein tissue on the body surface, and if necessary, use DSA guidance to complete the catheterization operation, thereby ensuring that the catheter accurately enters the predetermined position [8].

Another common issue encountered during catheterization is improper positioning of the catheter tip. Some patients have a catheter tip position that is too shallow or too deep after catheterization. The main reason is that the nursing staff are not proficient in catheterization operations and do not align the catheter tip with the guidewire. To solve such problems, nursing staff need to be proficient in the operation of PICC catheterization using intracavitary electrocardiogram-guided positioning technology. They should conduct a detailed inspection before the operation to ensure that the catheter tip is aligned with the guidewire. If a high P-wave is found during catheterization, the catheter should be slowly withdrawn, and changes in the P-wave should be closely observed to avoid negative P-waves.

Phlebitis is another common adverse event associated with PICC catheterization. One of the primary causes of phlebitis is venous pressure, which arises from repeated adjustments of the catheter, leading to continuous friction between the catheter and the vascular endothelium. This mechanical irritation can result in inflammation of the vein, causing discomfort and potential complications for the patient. To effectively prevent the occurrence of phlebitis, nursing staff should take proactive measures such as applying warm compresses to the puncture site to promote local blood circulation and reduce vascular irritation. In cases where phlebitis has already developed, external medications should be administered promptly to alleviate inflammation and manage symptoms [9–10].

5. Conclusion

In summary, comprehensive high-quality nursing for patients undergoing PICC catheterization using intracavitary electrocardiogram-guided positioning technology can significantly improve the success rate of catheterization and reduce the incidence of adverse events, which can be promoted and applied.

Disclosure statement

The authors declare no conflict of interest.

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