

# Clinical Nurses' Knowledge, Attitude and Practice of Catheter-Related Thrombosis and Its Influencing Factors: A Cross-Sectional Survey

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**Purpose:** The present study aims to evaluate the current situation of knowledge, attitude and practice of clinical nurses in catheter-related thrombosis, analyze its influencing factors, enhance the attention of nursing managers and clinical nurses about catheter-related thrombosis, and provide a basis for formulating catheter-related thrombosis training plan.

**Patients and Methods:** The research was conducted from January 1 to February 31, 2022, we recruited 549 nurses from two hospitals in Hunan province in this cross-sectional study using a two-stage random sampling method. We used a self-designed questionnaire with good reliability and validity to measure clinical nurses' knowledge, attitudes, and practice toward catheter-related thrombosis. We used  $\chi^2$  test, Welch *t*-test, and multiple linear regression analysis to analyze the data.

**Results:** The knowledge of clinical nurses about catheter-related thrombosis was insufficient (55.00%), while the attitude was positive (88.49%) and the practice was inadequate (68.62%). Knowledge of clinical nurses was significantly associated with job title ( $\beta$ : 1.069,  $P < 0.001$ ), educational level ( $\beta$ : 0.094,  $P < 0.05$ ), and training times ( $\beta$ : 0.085,  $P < 0.05$ ), which were positive factors while whether they are specialized nurses in intravenous therapy ( $\beta$ : -0.126,  $P < 0.05$ ), and hospital level ( $\beta$ : -0.101,  $P < 0.05$ ) were negative factors. Training times ( $\beta$ : 0.166,  $P < 0.001$ ), job title ( $\beta$ : 0.099,  $P < 0.019$ ), and hospital level ( $\beta$ : 0.090,  $P < 0.05$ ) were associated factors of attitude. Moreover, training times ( $\beta$ : 0.255,  $P < 0.001$ ) was the only factor associated with the practice.

**Conclusion:** Although clinical nurses hold a positive attitude towards catheter-related thrombosis, their knowledge level was unsatisfactory and their practice was affected by many factors, suggesting that nursing managers should strengthen the training and skill assessment of catheter-related thrombosis. At the same time, the hospital can formulate relevant rules, regulations, and guidelines to reduce the incidence of catheter-related thrombosis.

**Keywords:** knowledge, attitude, practice, clinical nurses, catheter-related thrombosis

## Introduction

Catheter-related thrombosis (CRT) is venous thromboembolism (VTE) related to venous catheters,<sup>1</sup> it refers to the venous blood clot formation in the vessel and vessel wall where the catheter is located because of a puncture or mechanical injury of the vessel intima or the patient's disease.<sup>2</sup> With the rapid development of intravenous infusion technology, central venous catheterization has become one of the indispensable technologies in modern medicine. Central venous catheter (CVC), peripherally inserted central venous catheter (PICC), and infusion port (PORT) have established effective venous treatment channels for patients in first aid, intensive care, and chemotherapy.<sup>3</sup> It has solved many problems of medium and long-term infusion patients with peripheral venous puncture difficulties. Still, its accompanying catheter-related complications can not be ignored, especially CRT. CRT incidents will prolong the hospitalization time of patients, increase the hospitalization expenses of patients, and delay the treatment cycle of patients.<sup>4,5</sup> Once the thrombus falls off, it will migrate to the pulmonary artery with blood flow, leading to pulmonary embolism and affection.<sup>2</sup> Research

shows that the risk factors of CRT involve multiple dimensions of patients, operators, and catheters. The average time of occurrence is 10 days, and the diagnostic time of most CRT is within 100 days, and the incidence of CRT reported in domestic and foreign literature is 16 ~ 66%,<sup>6</sup> which is related to the different study design, study population, catheter type, and location, retention time, follow-up time, diagnostic methods, etc.<sup>6</sup> Therefore, it is essential to strengthen the prevention and control of CRT and reduce the risk of CRT.

As the principal operator of central venous catheterization, clinical nurses are closely related to the occurrence of CRT. Clinical nurses play a vital role in the prevention and treatment of CRT and in reducing the risk of CRT. Specialized nurses of intravenous therapy carry out Central venous catheterization, and catheter maintenance is the participation of nurses in the ward. If any nurse fails to provide adequate care, CRT may occur. Research shows that nurses' catheter maintenance knowledge and skills are closely related to the occurrence of CRT.<sup>7-9</sup> However, although some experts formulated relevant practice guidelines and pointed out the importance of preventing complications of central venous catheterization at home and abroad,<sup>10</sup> clinical nurses' cognitive level of CRT is still uneven.<sup>11</sup> At the same time, studies have found that central venous catheterization without professional nursing team maintenance is more likely to form venous thrombosis.<sup>12</sup> If clinical medical staff ignore thrombosis or rapid extubation, it can easily cause venous thrombosis falling off and vascular embolism, and even life-threatening in severe cases. Therefore, the vital role of clinical nurses in preventing and treating CRT cannot be ignored.

Research has shown that the application of the knowledge, attitude, and practice (KAP) management model in improving the overall quality of nurses in dealing with venous thromboembolism is practical.<sup>13</sup> Therefore, the key to reducing the incidence of CRT is to improve the mastery rate of clinical nurses' knowledge of the prevention and treatment of CRT, correct the attitude of clinical nurses to prevent and treat CRT, and strengthen the practice of clinical nurses to prevent and treat CRT actively.

Currently, the research mainly focused on the investigation of nurses' KAP of central venous catheterization, the investigation of knowledge and practice of catheter insertion and maintenance, and the improvement of PICC nursing experience and nursing quality, etc.<sup>14-17</sup> In addition, there are also some researches primarily focused on investigating nurses' KAP in preventing deep vein thrombosis, and venous thromboembolism which focused on the single catheter in individual departments, such as oncology nurses, geriatric nurses, etc.<sup>18-21</sup> To sum up, clinical nurses still need to understand CRT knowledge, attitude, and behavior. How clinical nurses view CRT, and what factors will influence clinical nurses' KAP of CRT are important and still unanswered questions. And this question is closely related to patient safety. Research shows that nurses' and doctors' patient safety attitude is closely related to patient safety,<sup>22,23</sup> so knowing the KAP of clinical nurses about CRT and formulating corresponding measures are very important for reducing the occurrence of CRT and improving patient safety.

To bridge this knowledge gap, we conducted a cross-sectional study to evaluate the clinical nurses' CRT knowledge, attitude, and practice and analyze its influencing factors which may strengthen the cognition and attention of clinical nurses about CRT, and provide a scientific basis for the formulation of CRT prevention and treatment training programs.

## Materials and Methods

### Study Design

This cross-sectional research was conducted in Hunan Province, China, from January 1 to February 31, 2022.

### Participants

In the present study, the participants were registered nurses (RNs) working in hospitals in Hunan province, China. The inclusion criteria were: (a) RNs aged more than 18 but less than 60 years old, (b) RNs were given informed consent and participated voluntarily, and (c) RNs with more than one year of clinical working experience. Exclusion criteria: (a) RNs on medication for mental illness, (b) RNs absent from work due to sick leave, personal leave, study abroad, or other reasons, and (c) RNs in the medical technology department and other functional departments. Rejection criteria: (a) Incomplete answers to the questionnaire, (b) The answer options are consistent, and (c) The time for answering the questionnaire is too short.

## Sample Size and Sampling Technique

The sample size of this study was calculated according to the Kendall estimation method: the sample size should be 5–10 times the number of questionnaire items (55 items in total). Thus the sample size was estimated to range between 275–550. We considered non-response and invalid response subjects and increased the sample size by 20%, corresponding to the range between 330 and 660.

We enrolled participants through a two-stage random sampling method. We adopted a two-stage random sampling method to select two hospitals in Hunan province. We selected 549 nurses from 2 hospitals randomly as the survey subjects. The specific sampling method was as follows: In the first stage, we set one Prefecture randomly from 13 prefecture-level cities and one Autonomous Prefecture in Hunan Province using the random number table method. In the second stage, we randomly selected one tertiary hospital and one secondary hospital from the prefecture-level city determined by the first stage sampling using the random number table method. We carried out this study in these two hospitals finally. We recruited RNs according to the study inclusion and exclusion criteria following the principle of informed consent and voluntary.

## Ethical Considerations

The Medical Ethics Committee of Xiangya Hospital, Central South University, Changsha, China, approved this study (Ethics Review and Approval No: 202014123). Informed consent was obtained from all participants before data collection, and all participants' clinical data and basic information were strictly confidential. All procedures complied with the Declaration of Helsinki.

## Instrument

The questionnaire for this study was developed through literature review, focus group discussions, pre-tested and Delphi expert consultation, which consists of two sections. Section one is the General Information Collection Form. Section two is the questionnaire on knowledge, attitude, and practice of CRT. This section has three dimensions (55 items): Knowledge, attitude, and practice questionnaire. The knowledge questionnaire covers seven aspects, with a total of 25 items. All items are single-choice questions, with 1 point for correct answers and 0 points for wrong choices. The higher the score, the better the clinical nurses' mastery of CRT knowledge. The attitude questionnaire includes 13 items in total using the Likert 5-level scoring method, five options of "strongly agree", "agree", "neutral", "disagree", and "strongly disagree" are set, which are calculated as (5, 4, 3, 2, 1) points respectively. The higher the score, the more positive the clinical nurse's attitude in CRT. The practice questionnaire includes 17 items, all of which are frequency problems. Five options are set, including "always", "often", "sometimes", "rarely", and "never", which are calculated as (5, 4, 3, 2, 1) points respectively. The higher the score, the more sufficient the clinical nurses are in preventing and treating CRT.

The questionnaire was confirmed to have good reliability and validity in the preliminary survey, with a Cronbach's alpha coefficient of 0.939 and content validity of 0.813, which can be used in relevant research and practice.

## Data Collection

The data were collected by four postgraduate students in our research group from January 1 to February 31, 2022. The specific steps used were as follows: initially, the investigators contacted the nursing managers in 2 selected hospitals and explained the purpose of the survey to obtain permission and support. At this stage, the investigators determined the total number of RNs in 2 hospitals. Subsequently, the investigators selected the eligible participants according to the study inclusion and exclusion criteria, following the principle of informed consent and voluntary with the help of the head nurses. A total of 587 RNs were selected and recruited. Finally, the investigators sent the questionnaires to 587 recruited RNs through a popular online questionnaire platform in China, Wen Juan Xing, and instructed them to fill them out.

## Quality Control

Before the actual data collection period, we conducted pretesting of the questionnaire on 20 individuals and we made necessary modifications before applying it to the study participants and we excluded those who pretested from the actual

study. To diminish the risk of selection bias, we determined explicit inclusion and exclusion criteria of the research objects and selected the participants strictly following these criteria. Besides, we ensured that the questionnaire was straightforward and did not involve sensitive questions to reduce the non-response rate. We set all questions must be answered before submitting the questionnaire when uploading the questionnaire to the background of Wen Juan Xing. To control information bias (also called observational bias), we provided unified training for the investigators on the study inclusion and exclusion criteria, the questionnaire content, and how to fill out the questionnaire. Also, we took measures to diminish the risk of reporting bias, including guaranteeing the anonymity of the participants and the confidentiality of data. We assured the participants that the questionnaire was answered anonymously, that their information would be kept confidential and only be used for research, and that their scores on the questionnaire would not influence their career and promotion as their employers could not see them.

## Data Analysis

Data were analyzed using SPSS version 25.0 software. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize the participant characteristics and the KAP score of CRT. The KAP scores among nurses with different characteristics were compared using the Wilcoxon rank-sum test for two-group comparisons and the Kruskal–Wallis H-test for multiple comparisons. We used Multiple linear regression analysis to analyze the influencing factors of nurses' KAP towards CRT. The inclusion criteria of variables were 0.05, the exclusion criteria were 0.10, and  $p < 0.05$  was considered statistically significant. We used the Pearson correlation coefficient to analyze the relevance among the three dimensions of KAP, with  $p < 0.05$  considered statistically significant.

## Results

### Demographic Information of Participants

A total of 587 nurses were eligible to answer the questionnaire, and 549 nurses completed it, with a response rate of 93.53%. Among the 549 respondents, 239 nurses (43.5%) were from secondary hospitals, 310 nurses (56.5%) were from tertiary hospitals, and the majority were women. (97.1%). The largest age group was 40 and under (89.6%), followed by the range between 41 and 50 (9.5%). 52.3% of those who had been engaged in nursing work for less than 10 years, and 38.3% for 10–20 years. The majority exhibited an intermediate professional title (51.9%) and an education level of undergraduate (80.5%). Most of them were not specialized nurses in intravenous therapy (91.4%), and most had participated in the training for infusion catheter-related thrombosis. More nurses had participated 1–2 times (54.3%) and 2–4 times (30.6%), and fewer nurses had participated more than 4 times (15.1%). Further socio-demographic information is available in [Table 1](#).

**Table 1** Demographics of the Participants (N=549)

Category		Number	Percentage (%)
Hospital level			
	Tertiary	310	56.47
	Second level	239	43.53
Gender			
	Male	16	2.91
	Female	533	97.09

(Continued)

**Table 1** (Continued).

Category		Number	Percentage (%)
Age			
	≤40	492	89.61
	41–50	52	9.47
	≥51	5	0.92
Working years			
	<10	287	52.28
	10–20	210	38.25
	>20	52	9.47
Educational level			
	Junior college or below	87	15.84
	Bachelor's degree	442	80.51
	Master's degrees or above	20	3.65
Job title			
	Primary	239	43.53
	Intermediate	285	51.91
	Deputy senior and above	25	4.56
Specialized nurses in intravenous therapy			
	Yes	47	8.56
	No	502	91.44
Training times			
	<2	298	54.28
	2–4	168	30.60
	>4	83	15.12

## Knowledge, Attitude, and Practice Towards CRT Among Participants

The questionnaire survey showed that the total CRT knowledge, attitude and practice score of clinical nurses was (138.11 ± 18.11), and the average accounted for 78.92% of the total score. The scores of knowledge, attitude, and practice were (13.75 ± 3.15), (57.52 ± 8.42), (66.83 ± 12.52), respectively, and the average accounted for 55.00%, 88.49%, and 78.62% of the total score. Descriptive statistical analysis was carried out on the scores of secondary items in the three dimensions of knowledge, attitude, and practice. The two secondary items with the highest score rate of knowledge dimension were clinical manifestation (3.28 ± 0.92) and complication prevention and treatment (1.17 ± 0.68). The two secondary items with the highest score rate of attitude dimension were knowledge training (13.62 ± 2.02) and patient education (13.49 ± 2.02); The two secondary items with the highest scoring rate of practice dimension were health education practice (20.30 ± 4.11) and prevention and treatment practice (31.45 ± 5.98). (Table 2).

**Table 2** Score of Secondary Items in Each Dimension of CRT Knowledge, Attitude and Practice

Projects	Category	Score Range	Score (X±S)	Scoring Rate (%)
CRT knowledge	25	0–25	13.75±3.15	55.00
	Concept	0–2	0.95±0.66	48.00
	Clinical manifestation	0–4	3.28±0.92	82.00
	Diagnosis	0–2	0.77±0.67	38.50
	Risk factors	0–3	1.39±0.76	46.33
	Preventive measure	0–3	1.72±0.71	57.33
	Treatment measures	0–9	4.45±1.48	49.44
	Prevention and treatment of complications	0–2	1.17±0.68	58.50
CRT attitude	13	13–65	57.52±8.42	88.49
	Knowledge training	3–15	13.62±2.02	90.80
	Skill improvement	4–20	17.94±2.66	89.70
	Patient Education	3–15	13.49±2.02	89.93
	Disease prognosis	3–15	12.47±2.87	83.13
CRT practice	17	17–85	66.83±12.52	78.62
	Learning practice	4–20	15.08±3.45	75.40
	Prevention practice	8–40	31.45±5.98	78.62
	Health education practice	5–25	20.30±4.11	81.20
Total	55	30–175	138.11±18.11	78.92

## Factors Associated with Knowledge, Attitude, and Practice Towards CRT Among Participants

The results showed that there were significant differences in the scores of clinical nurses' CRT knowledge at the hospital level, the educational level, the job title, and whether they are specialized nurses in intravenous therapy ( $p < 0.05$ ). There were significant differences in CRT attitude scores in the educational level, professional title, and training times about CRT ( $p < 0.05$ ). There were significant differences in CRT practice scores regarding job title, whether they are specialized nurses in intravenous therapy, and training times about CRT ( $p < 0.05$ ). (Table 3).

The results of multiple linear regression analysis showed that knowledge of clinical nurses was significantly associated with job title ( $\beta$ : 1.069,  $P < 0.001$ ), educational level ( $\beta$ : 0.094,  $P < 0.05$ ), and training times ( $\beta$ : 0.085,  $P < 0.05$ ), which were positive factors while whether they are specialized nurses in intravenous therapy ( $\beta$ : -0.126,  $P < 0.05$ ), and hospital level ( $\beta$ : -0.101,  $P < 0.05$ ) were negative factors. Training times ( $\beta$ : 0.166,  $P < 0.001$ ), job title ( $\beta$ : 0.099,  $P < 0.019$ ), and hospital level ( $\beta$ : 0.090,  $P < 0.05$ ) were associated factors of attitude. Moreover, training times ( $\beta$ : 0.255,  $P < 0.001$ ) was the only factor associated with the practice. (Table 4). The Pearson correlation coefficient of clinical nurses' CRT knowledge, attitude and practice showed that the correlation coefficient between attitude and knowledge was  $r = 0.092$ ,  $p < 0.05$ , showing a significant positive correlation. The correlation coefficient between attitude and practice was  $r = 0.418$ ,  $p < 0.05$ , showing a significant positive correlation. (Table 5).

**Table 3** Analysis on the Current Situation of CRT Knowledge, Attitude and Practice of Nurses with Different Characteristics

General Information	n	CRT Knowledge			CRT Attitude			CRT Practice		
		Score	z/H	p	Score	z/H	p	Score	z/H	p
Hospital level										
Tertiary	310	14.14±3.15	12.253	0.002	56.90±9.11	2.277	0.320	66.72±12.41	2.955	0.228
Second level	239	13.06±2.54			59.28±6.28			63.81±11.58		
Male										
Female	16	12.56±4.31	-0.801	0.423	56.00±10.20	-0.170	0.865	70.18±11.58	-0.920	0.357
Male	533	13.79±3.11			57.56±8.36			66.73±12.54		
Age										
≤40	492	13.71±3.11	4.807	0.090	57.43±8.58	0.285	0.867	66.57±12.44	2.930	0.231
41–5	52	14.46±3.32			58.13±6.91			69.48±12.50		
≥51	5	10.80±3.96			59.40±6.80			64.80±19.25		
Working years										
<10	287	13.44±3.06	5.375	0.068	57.17±8.83	0.988	0.610	66.65±12.06	1.227	0.542
10–20	210	14.01±3.19			57.77±8.21			66.74±12.99		
>20	52	14.42±3.34			58.44±6.85			68.23±13.19		
Educational level										
Junior college or below	87	12.80±3.72	9.101	0.011	56.93±7.66	7.317	0.026	67.19±12.77	0.965	0.617
Bachelor's degree	442	13.88±2.96			57.45±8.64			66.69±12.55		
Master's degrees or above	20	15.10±3.68			61.60±5.15			68.45±11.08		
Job title										
Primary	239	13.31±3.03	20.272	<0.001	56.54±9.09	6.236	0.044	66.23±11.99	6.413	0.041
Intermediate	285	13.91±3.11			58.19±7.89			66.85±12.93		
Deputy senior and above	25	16.20±3.55			59.24±6.56			72.36±11.75		
Specialized nurses in intravenous therapy										
Yes	47	15.45±3.75	-3.558	<0.001	58.85±8.18	-1.616	0.106	70.48±14.13	-2.347	0.019
No	502	13.59±3.04			57.39±8.43			66.49±12.31		
Training times										
<2	298	13.52±3.23	5.342	0.069	56.25±8.61	23.246	<0.001	64.25±12.62	36.555	<0.001
2–4	168	13.77±2.93			58.35±7.86			68.32±12.11		
>4	83	14.54±3.21			60.38±8.02			73.08±10.14		

## Discussion

In this survey of 549 nurses in 2 hospitals across Hunan province, we examined clinical nurses' KAP toward CRT and analyzed its influencing factors. To the best of our knowledge, this study is the first questionnaire about CRT knowledge, attitude, and practice of clinical nurses compiled at home and abroad. Only by knowing the KAP level of clinical nurses

**Table 4** Multiple Linear Regression Analysis of Influencing Factors of CRT Knowledge, Attitude and Practice of Clinical Nurses with Different Characteristics

Variable	B	SE	$\beta$	t	p
CRT knowledge					
Constant	14.523	1.333		10.892	<0.001
Job title	0.582	0.236	0.106	2.460	0.014
Whether they are Specialized nurses in intravenous therapy	-1.416	0.475	-0.126	-2.980	0.003
Hospital level	-0.611	0.260	-0.101	-2.354	0.019
Educational level	0.697	0.323	0.094	2.160	0.031
Training times	0.363	0.179	0.085	2.022	0.044
CRT attitude					
Constant	50.028	1.639		30.529	<0.001
Training times	1.896	0.482	0.166	3.934	<0.001
Job title	1.459	0.622	0.099	2.346	0.019
Hospital level	1.448	0.681	0.090	2.127	0.034
CRT practice					
Constant	59.858	1.244		48.118	<0.001
Training times	4.339	0.703	0.255	6.168	<0.001

**Table 5** Pearson Correlation Coefficient of CRT Knowledge, Attitude and Practice Scores

Category	Knowledge	Attitude	Practice
Knowledge	1		
Attitude	0.092*	1	
Practice	-0.035	0.418**	1

Notes: \*The correlation is significant at the 0.05 level (two-tailed)  
 \*\*At the 0.01 level (two-tailed), the correlation is significant.

about CRT and the influencing factors, we can better formulate relevant policies and measures to improve the KAP level of nurses and apply them to clinical work, reduce the incidence of CRT and improve the quality of life of patients. From this study, We found that clinical nurses have a positive attitude towards CRT, but their knowledge and practice were insufficient, consistent with that previous study.<sup>24-27</sup> The present study demonstrated that job title, training times, educational level, whether they are specialized nurses in intravenous therapy, and hospital level are associated factors to knowledge while the job title, training times, and hospital level are associated with the attitude. The training times is the only factor associated with the practice.

The results show that clinical nurses' knowledge of CRT is insufficient, which is similar to the research results of Lu Lina and others.<sup>26,28,29</sup> The reasons may be related to the rapid development of central venous catheter insertion technology. Still, the teaching resources of hospital nursing specialty need to be in line with clinical operations, inadequate training on central venous catheter insertion technology and the prevention and treatment of catheter-



related complications, and the lack of corresponding practice guidelines in local hospitals.<sup>30</sup> Further analysis of the secondary items of CRT cognition shows that clinical nurses' knowledge of CRT mostly stays in concept and clinical manifestation, and their cognition of CRT diagnosis, risk factors, preventive measures, and treatment measures is not comprehensive, which is similar to the research results of Hyunjin.<sup>24</sup> Studies have shown that early identification of CRT risk factors, prevention, and diagnosis can significantly reduce the incidence rate of CRT.<sup>31</sup> At the same time, the study found that clinical nurses play a key role in the prevention and treatment of venous thromboembolism by increasing knowledge and health education for patients.<sup>32</sup>

The results show that clinical nurses' attitude toward CRT is positive, consistent with the previous study.<sup>25</sup> The analysis of the scoring rate of each secondary item of the CRT attitude dimension shows that clinical nurses are willing to strengthen CRT knowledge training, they believe that medical staff should participate in CRT knowledge training and hope that hospital managers can actively and regularly organize CRT knowledge training. On the other hand, clinical nurses expect to improve their catheterization, maintenance, and catheter evaluation ability. Most clinical nurses believe that catheterization and maintenance skills are closely related to the occurrence of CRT, and improving clinical nurses' maintenance skills can reduce the occurrence of CRT. Gibbs found that nurses' CRT risk assessment and prevention can significantly reduce CRT cases and subsequent complications.<sup>27</sup> Most clinical nurses believe that strengthening the health education of patients and caregivers, including knowing the time of catheter maintenance and mastering the correct methods of limb function exercise, may be beneficial to the prevention and treatment of CRT and reduce the incidence of CRT, consistent with previous study.<sup>33</sup>

The results show that clinical nurses' practice of CRT is inadequate, consistent with the previous study.<sup>34</sup> By analyzing the scoring rate of each secondary item of the CRT practice dimension, we know that clinical nurses are unskilled by the corresponding theoretical support when carrying out CRT knowledge publicity and education to patients and their caregivers. Hospital managers have fewer training times for nurses on the advanced technology of central venous catheterization and the prevention of complications. There are fewer guidelines, rules, and regulations on all aspects of CRT knowledge, so clinical nurses have low scores in CRT learning practice, the research shows that strengthened, standardized training may help clinical nurses to improve their comprehension of the relevant guidelines and may finally reduce the occurrence of VTE in ICUs and improve the prognosis of critically ill patients with VTE.<sup>35</sup> A review shows that whether inpatients adhere to CRT treatment depends mainly on the health education of nurses.<sup>36</sup> Stephanie suggests that patients require further information on VTE during their hospitalization to enhance their involvement in VTE prevention and recognition. The provision of written, patient-directed statements could address that lack of participation. This study also highlights the need to strengthen the nurses' role in providing patient education about VTE.<sup>37</sup> It can be seen that the practice of nurses has a significant impact on CRT treatment, so it is essential to standardize further the practical practice of clinical nurses in CRT treatment.

The higher the hospital level is, the higher the knowledge score of clinical nurses about CRT and vice versa. Hospital level and whether they are specialized nurses in intravenous therapy negatively correlate with CRT knowledge. This result may be because the lower the hospital level is, the poorer the medical resources of hospitals are. The higher the level of the hospital, the more advanced the medical equipment and medical technology are. Nurses not specialized in intravenous therapy know less about CRT knowledge, which is negatively related. The prevention and education of advanced central venous catheterization and related knowledge are more in place. In contrast, the equipment and technology of secondary hospitals and below are relatively slow to update. It is suggested that give more material, financial, and policy support to secondary and lower-level hospitals from the government level.<sup>8</sup> On the other hand, due to the large gap in medical resources and technical levels between different cities and regions, it is suggested that tertiary hospitals can play a leading role, and "Internet + care" be used to set up online and offline training mechanisms.<sup>38</sup> We can communicate and exchange experiences with each other, improving clinical nurses' cognitive rate of CRT and narrowing the gap in understanding CRT in regional medical institutions.

The higher the education level, the higher the clinical nurses' knowledge and attitude score in CRT, which may be because nurses with higher education levels receive more relevant practical training and theoretical knowledge about CRT in schools, consistent with the previous study.<sup>28,29</sup> The higher the professional title and more training times, the higher the score of nurses on CRT knowledge, attitude, and practice, which is similar to the previous study.<sup>8,39</sup>

Research shows that nurses with more training times have higher scores on cognition and nursing of thrombus around indwelling venous catheter than nurses with fewer training times.<sup>29</sup> And The better you understand the importance of CRT prevention and treatment through CRT training, your corresponding CRT practice is more active. People with higher professional titles are generally the backbone of the Department's technical business, and their clinical experience and theoretical knowledge are relatively prosperous. Research shows that nursing experience is closely related to nurses' practice,<sup>40</sup> clinical nurses with more clinical experience can better combine theoretical knowledge with practical operation. Nursing managers can encourage experienced, highly educated, professional nurses to teach CRT knowledge to inexperienced clinical nurses. We should focus on improving the CRT cognitive rate of junior nurses and strengthening their subjective initiative. We can carry out various training methods, such as online or offline lectures, knowledge competitions, group case discussions, skill operations, and theoretical knowledge assessments. Nurses' hierarchical and stage training can improve the quality of catheter nursing and reduce the complications of central venous indwelling catheter puncture and indwelling complications to improve the clinical nurses' knowledge level of CRT and reduce the incidence of CRT.<sup>41</sup>

A surprising result was that there was no significant difference in the KAP of clinical nurses of different ages and working years towards CRT, inconsistent with previous studies.<sup>29</sup> The reason for our result may be our sample size is small and unrepresentative, and the age is proportional to the length of service. Some older nurses who work long hours lack the personal initiative to learn and are unwilling to absorb new knowledge, which leads to the decline of their motivation to learn CRT, and cannot profoundly realize the importance of preventing CRT. The results of the Pearson correlation coefficient show that there is a significant positive correlation between clinical nurses' CRT attitudes and knowledge and between attitudes and practice, indicating that the more clinical nurses understand the relevant knowledge of CRT, the stronger their attitudes about CRT, and the stronger their attitudes about CRT, the more active their practice about CRT. This is consistent with Piechowski's research which shows that attitude can affect knowledge and practical practice, and education can change nurses' attitudes.<sup>42</sup>

## Strength and Limitation

The present study has some strengths. To the best of our knowledge, it is the first study to provide data about clinical nurses' knowledge, attitudes, and practice of CRT in Hunan province. Besides, the survey instrument developed in the present study could be used to evaluate nurses' KAP of CRT in hospitals in other regions of China, it also could be used in other countries and territorial dimensions like those in China if it is translated and validated. However, some limitations of the present study are worth reviewing. First, although the quality control procedure was used throughout the data collection and entry, potential information bias may have occurred because the survey was based on self-reported data. Besides, although nurses' attitude toward CRT was extremely positive, it might be affected by social desirability factors and cannot represent their actual attitude. Thus, a qualitative study on the nurse's CRT attitude needs to be conducted in the future to verify the results of this study. Finally, this was a cross-sectional study in Hunan province, China. Even though the sample size was large enough (549) to ensure the statistical power to support the conclusions and the response rate of the survey was excellent (93.53%), the generalization of the results to nurses in hospitals in other areas of China is unclear, and similar studies should be conducted in other regions.

## Conclusion and Future Recommendations

Central venous catheterization has become one of the indispensable technologies of modern medical technology. CRT is one of its serious complications, which may lead to pulmonary embolism and endanger patients' lives. The knowledge awareness rate of clinical nurses about CRT is insufficient, and the attitude toward CRT is relatively positive. Still, the practice of CRT is inadequate. The knowledge, attitude, and practice (KAP) model show that any practice is determined by a person's attitude and knowledge of these practices.<sup>43</sup> Based on the present study's findings, we suggest that hospital managers should improve clinical nurses' cognition of CRT, strengthen nurses' training and assessment of CRT knowledge, optimize the training process and content, improve nurses' comprehension of CRT, and enhance nurses' attention. Nursing managers should urge nurses to combine cognition with practice so that nurses' nursing of CRT presents self-awareness, initiative, and predictability, understands the psychological

characteristics of patients, carries out the evaluation and health education of venous indwelling periductal thrombus before, during, and after catheterization, and achieves targeted publicity and education in place in time, to provide high-quality nursing services in clinical practice and reduce the pain of patients.<sup>15</sup> We can also set up a special central venous catheter quality control team to collect the data of patients with the clinical central venous catheter, monitor the incidence of CRT in the hospital, and provide evidence for clinical CRT control. At the same time, hospitals can further formulate detailed CRT processing processes and systems to standardize CRT processing flow and reduce the rate of CRT.

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## Disclosure

The authors report no conflicts of interest in this work.

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