

A Quasi-Experimental Study on the Preventive Effect of Risk-Stratified Nursing Interventions for PICC-Related Thrombosis in Cancer Patients

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Objective: To analyze risk factors for PICC-related thrombosis in cancer patients and assess the preventive efficacy of a risk-stratified nursing intervention based on these factors.

Methods: This prospective observational cohort study evaluated the preventive effect of risk-stratified nursing on PICC-related thrombosis in cancer patients. Chemotherapy patients undergoing PICC placement in the oncology department of our hospital from January 2023 to December 2024 were enrolled. Participants were allocated into two cohorts based on the implementation timeline of the nursing protocol: Control group (n=117) received routine PICC care (January 2023–December 2023), while intervention group (n=119) received risk-stratified nursing interventions (January 2024–December 2024) guided by a logistic regression model identifying key thrombosis risk factors (eg, tumor staging, comorbid diabetes, D-dimer levels).

Results: The intervention group (2024) exhibited a significantly lower PICC-related thrombosis incidence compared to the control group (2023) (4.20% vs 29.91%, $\chi^2=28.436$, $P<0.001$). Multivariate analysis identified tumor stage III/IV (OR=2.556, 95% CI 1.798–5.564), history of thrombosis (OR=19.273, 95% CI 10.674–37.561), diabetes (OR=2.572, 95% CI 1.027–5.712), catheter tip malposition (OR=14.339, 95% CI 8.916–29.795), and elevated D-Dimer (OR=9.528, 95% CI 6.703–15.597) as independent risk factors, while anticoagulant use (OR=0.449, 95% CI 0.089–0.874) was protective. In the intervention cohort, protocol-guided anticoagulation showed enhanced protection (OR=0.332, 95% CI 0.121–0.898, $P=0.028$). The intervention group also demonstrated improved quality of life across all SF-36 domains (eg, physical functioning: 58.94 ± 1.97 vs 45.93 ± 3.02 , $P<0.05$) and significantly higher nursing satisfaction (96.64% vs 86.32%, $\chi^2=8.091$, $P=0.004$).

Conclusion: Risk-stratified nursing interventions, guided by logistic regression analysis of thrombosis risk factors, significantly reduce PICC-related thrombosis incidence and improve patient quality of life and nursing satisfaction. This protocol offers a practical framework for oncology nursing to enhance patient outcomes.

Keywords: PICC catheter, thrombosis formation, influencing factors, risk-stratified nursing, oncology, application effect

Background

The occurrence and development of tumors are significant challenges faced by modern medicine. With the continuous advancement of early screening and treatment technologies, the survival period of cancer patients has been significantly extended. To cope with the discomfort and side effects of chemotherapy, an increasing number of cancer patients opt for peripherally inserted central catheter (PICC) placement to ensure safe and effective drug infusion.^{1,2} However, the use of PICC also introduces potential risks, with catheter-related thrombosis being one of the most common and severe complications.^{3,4} Multiple studies^{5,6} have indicated that the occurrence of catheter-related thrombosis not only increases the suffering of patients but may also lead to delays or interruptions in chemotherapy, thus affecting the overall treatment outcome and prognosis. Literature reports⁷ show that the incidence of catheter-related thrombosis in cancer patients can be as high as 30%. This phenomenon is closely related to a variety of factors, including patient-specific variables (eg,

hypercoagulability, immobility), catheter-related characteristics, and procedural protocols.⁸ Despite existing standard operating protocols (SOPs) for PICC care—such as the Infusion Nurses Society (INS) guidelines⁹—there remains a lack of consensus on risk-stratified nursing strategies tailored to cancer patients' unique thrombotic risks. Therefore, systematically identifying and managing these influencing factors is crucial to reducing the occurrence of catheter-related thrombosis, particularly in oncology populations where individualized risk assessment is underemphasized in current SOPs. This gap underscores the clinical significance of our study, which aims to bridge evidence-based SOPs with personalized risk management.

Risk-stratified nursing interventions represent a systematic approach that integrates nurses' expertise with patient-specific risk profiles to optimize care delivery.¹⁰ This method aligns with the principles of dynamic nursing SOPs, which emphasize proactive risk identification and mitigation.¹¹ Existing studies^{12,13} highlight that such interventions not only address patients' current health status but also preemptively target modifiable thrombotic risks through evidence-based practices (eg, early mobilization, anticoagulant protocols). However, the translation of these strategies into oncology-specific PICC care remains limited, necessitating further exploration of risk factor interactions and their clinical implications. To address this, our study employed a logistic multivariate regression analysis model to identify thrombosis-related factors in cancer patients with PICC lines at our institution. Subsequently, we developed and implemented a risk-stratified nursing protocol that operationalizes INS guidelines while incorporating patient-specific risk modulation. The following details our methodology and outcomes, offering actionable insights to enhance clinical nursing practice.

Materials and Methods

Study Design

This prospective observational cohort study aimed to evaluate the effectiveness of a risk-stratified nursing protocol for preventing PICC-related thrombosis in cancer patients. Chemotherapy patients undergoing PICC placement in the oncology department of our hospital from January 2023 to December 2024 were enrolled. To minimize temporal bias, participants were allocated into two cohorts based on the implementation timeline of the nursing protocol: Control group (n=117): Patients admitted from January 2023 to December 2023 received routine PICC care following hospital SOPs. Intervention group (n=119): Patients admitted from January 2024 to December 2024 received risk-stratified nursing interventions based on identified thrombosis risk factors.

This study was approved by the First Affiliated Hospital of Zhengzhou University Medical Ethics Committee (Approval No.: 2024-ZL-003) and conducted in strict accordance with the ethical guidelines of the Declaration of Helsinki. Informed consent was obtained from all study participants.

Participant Recruitment

Participants were consecutively enrolled through a stratified random sampling method. Eligibility criteria were applied to all chemotherapy patients scheduled for PICC placement during the study period. Randomization was performed using computer-generated random numbers, with allocation concealment achieved through sealed opaque envelopes.

Sample Size Calculation

The sample size was determined using the formula for comparative studies:

$$N = \frac{Z(Z_{\alpha/2} + Z_{\beta})^2 [P_1(1 - P_1) + P_2(1 - P_2)]}{(P_1 - P_2)^2}$$

With a 95% confidence interval ($Z_{\alpha/2} = 1.96$), 80% power ($Z_{\beta} = 0.84$), expected thrombosis incidence of 30% in controls (P_1),¹⁴ and a target reduction of 15% in the intervention group (P_2), the calculated sample size was 96 per group. Accounting for a 10% attrition rate, 106 participants per group were required.

Inclusion and Exclusion Criteria

Inclusion criteria: ① Patients undergoing PICC placement for chemotherapy; ② Age ≥ 18 years; ③ No contraindications to PICC placement (eg, active infection at insertion site, venous stenosis); ④ First-time PICC placement; ⑤ Willingness to provide informed consent.

Exclusion criteria: ① Severe organ dysfunction (defined as Child-Pugh Class C liver cirrhosis, eGFR < 30 mL/min/1.73m², or NYHA Class III/IV heart failure); ② Active systemic infections (eg, HIV, tuberculosis, or sepsis); ③ Cognitive impairment (Mini-Mental State Examination score < 24) or psychiatric disorders impairing cooperation.

Research Methods

Establishment of Influencing Factors Logistic Regression Model

Literature Review

A comprehensive review of existing literature and guidelines was conducted to systematically evaluate the influencing factors of PICC-related thrombosis formation in oncology patients, and a draft of the evaluation form was created. By conducting in-depth searches on platforms such as PubMed, the China Biological Medicine Database (CBM), and the China National Knowledge Infrastructure (CNKI), relevant factors related to PICC-related thrombosis formation were collected and summarized. The Chinese search terms included “peripherally inserted central catheter”, “malignant tumor”, “thrombosis”, etc., while the English search terms included “PICC”, “thrombosis”, “risk factors”, etc.

Selection of Relevant Risk Factors

In selecting influencing factors, multiple dimensions were comprehensively considered to fully reflect the clinical status of patients. Specific considerations included: ① Patient factors: Basic information was collected from patients, including gender, age, the presence of chronic diseases such as hypertension, diabetes, and hyperlipidemia, as well as whether there was a history of thrombosis, use of anticoagulants, and the tumor’s location and staging. ② Catheter factors: During the catheterization process, factors such as the number of punctures, the choice of the puncture vein, the position of the catheter tip, and the duration of catheterization could all affect thrombosis formation, and these factors were included in the analysis. ③ Laboratory indicators: These included fibrinogen (Fib), plasma D-dimer (D-D), and platelet count (PLT).

Nursing Methods

Control Group

Received conventional nursing care, including catheter maintenance (eg, patency checks), medication administration, and general condition monitoring.

Intervention Group

The intervention group received risk-stratified nursing interventions led by a specialized oncology team (1 head nurse + 5 staff nurses), incorporating a comprehensive protocol with four core components: risk stratification, standardized procedures, patient education, and fidelity assurance. Patients were categorized using the modified Khorana score, with high-risk individuals (≥ 2 risk factors) undergoing daily catheter site inspections, biweekly Doppler ultrasound surveillance, and individualized anticoagulation plans (eg, enoxaparin 40 mg SC daily). Low-risk patients (< 2 risk factors) received standard monitoring every 72 hours and routine institutional anticoagulant prophylaxis. Standardized care included ultrasound-guided basilic vein selection (≥ 3 mm diameter) and cavoatrial junction positioning via intracavitary ECG during catheter insertion. Maintenance protocols required 10 mL saline flushing pre/post-infusion and heparin lock (10 U/mL) for intermittent use, with dressing changes every 7 days or as needed. Patient education emphasized limb elevation and symptom recognition (eg, swelling, pain) pre-insertion. Anticoagulation management followed D-dimer thresholds (≥ 1.5 $\mu\text{g/mL}$ triggering hematology consultation), with weekly audits ensuring 100% flushing compliance and documentation accuracy. Fidelity was maintained through a 4-hour pre-intervention workshop on risk assessment tools, ultrasound techniques, and adverse event management, alongside biweekly dynamic reassessment of risk status using updated laboratory parameters (platelet count, D-dimer).

Evaluation Indicators

(1) Incidence of catheter-related thrombosis and accompanying diseases: The occurrence of PICC-related thrombosis in both groups was statistically recorded by relevant nursing staff at our hospital.

(2) Quality of life: Before discharge, the patients' quality of life was assessed using the Quality of Life Questionnaire (SF-36).¹⁵ This questionnaire includes eight dimensions: physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. Each dimension is scored between 0 and 100 points, with higher scores indicating better quality of life. In this study, the Cronbach's alpha coefficient for the SF-36 score was 0.843.

(3) Nursing satisfaction: Before discharge, nursing satisfaction was evaluated using the Newcastle Satisfaction with Nursing Scale (NSNS).¹⁶ This scale consists of 19 items scored on a 5-point Likert scale, with higher scores indicating higher satisfaction. Satisfaction levels were categorized as very satisfied (≥ 76 points), satisfied (57–75 points), average (18–56 points), and dissatisfied (< 38 points). Overall satisfaction = (number of very satisfied cases + number of satisfied cases)/total number of cases $\times 100\%$. In this study, the Cronbach's alpha coefficient for the NSNS score was 0.861.

Statistical Methods

All statistical analyses were performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA) and GraphPad Prism 8 (GraphPad Software, San Diego, CA, USA). Categorical variables were presented as frequencies (n, %) and analyzed using the χ^2 -test or Fisher's exact test (for cells with expected counts < 5). Continuous variables were expressed as means \pm standard deviations (SD) or medians (interquartile ranges), depending on their distribution, and compared using independent t-tests or Mann–Whitney *U*-tests for non-normally distributed data.

To identify independent risk factors for PICC-related thrombosis in oncology patients, a multivariate logistic regression analysis was conducted. Candidate variables were selected based on univariate analysis results with $p < 0.20$. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were calculated. For model robustness, sensitivity analyses were performed by varying the inclusion criteria for risk factors (eg, adjusting the univariate screening threshold to $p < 0.10$ or $p < 0.15$). A two-tailed p -value < 0.05 was considered statistically significant.

Results

Study Design Clarification

This observational cohort study compared outcomes between historical controls (2023, routine care) and the intervention cohort (2024, risk-stratified nursing). Baseline characteristics showed no significant differences (Table 1), minimizing temporal confounding.

Table 1 Baseline Characteristics of 2023 Control vs 2024 Intervention Cohorts

Characteristic	Control (2023, n=117)	Intervention (2024, n=119)	t/ χ^2	P
Gender	–	–	0.406	0.523
Male	68 (58.12)	74 (62.18)	–	–
Female	49 (41.88)	45 (37.82)	–	–
Age (years)	63.85 \pm 10.43	64.27 \pm 11.16	0.298	0.765
Tumor Location	–	–	0.849	0.356
Breast Cancer	20 (17.09)	26 (21.85)	–	–
Esophageal Cancer	22 (18.80)	20 (16.81)	–	–
Gastric Cancer	26 (22.22)	23 (19.33)	–	–
Liver Cancer	25 (21.37)	27 (22.69)	–	–
Colorectal Cancer	24 (20.51)	23 (19.33)	–	–

Primary Outcome: Thrombosis Incidence

The intervention cohort (2024) had significantly lower thrombosis rates compared to 2023 controls (4.20% vs 29.91%, $\chi^2=28.436$, $P<0.001$) (Figure 1).

Risk Factor Analysis

Univariate Analysis of Thrombosis Risk in the 2023 Control Cohort

Among the 117 patients in the control group, 35 cases (29.91%) developed PICC-related thrombosis, while 82 cases did not. Significant differences were observed between the two groups in terms of age, tumor stage, history of thrombosis, comorbid diabetes, comorbid hyperlipidemia, use of anticoagulant drugs, number of punctures, catheter tip position, catheterization time, and D-Dimer levels ($P<0.05$), as shown in Table 2.

Multivariate Analysis of Thrombosis Risk in the Total Cohort

In the total cohort ($n=236$), tumor stage III/IV (OR=2.556, $P=0.031$), history of thrombosis (OR=19.273, $P=0.033$), diabetes (OR=2.572, $P=0.035$), catheter tip malposition (OR=14.339, $P=0.004$), and elevated D-Dimer (OR=9.528, $P=0.036$) were independent risk factors, while anticoagulant use was protective (OR=0.449, $P=0.017$) (Table 3).

Intervention Cohort-Specific Analysis

In the 2024 intervention group ($n=119$), despite protocol implementation, tumor stage III/IV (OR=2.251, $P=0.021$) and D-Dimer ≥ 1.5 $\mu\text{g/mL}$ (OR=8.967, $P=0.003$) remained significant risks. However, protocol-guided anticoagulation showed enhanced protection (OR=0.332, $P=0.028$) compared to the 2023 controls (Table 4).

Comparison of Quality of Life Between the Two Groups

The scores for physical functioning (58.94 \pm 1.97), role functioning (53.27 \pm 2.48), bodily pain (54.73 \pm 2.29), general health (59.17 \pm 2.41), vitality (62.79 \pm 2.37), social functioning (62.93 \pm 2.54), emotional functioning (60.57 \pm 2.46), and mental health (61.79 \pm 2.82) in the intervention group were higher than those in the control group (45.93 \pm 3.02, 47.56 \pm 1.85, 48.36 \pm 2.75, 52.43 \pm 2.96, 55.91 \pm 3.12, 55.82 \pm 1.97, 56.03 \pm 2.38, 52.77 \pm 1.85) ($P < 0.05$), as shown in Figure 2.

Comparison of Nursing Satisfaction Between the Two Groups

The nursing satisfaction in the intervention group (96.64%) was higher than that in the control group (86.32%) ($P < 0.05$), as shown in Table 5.

Discussion

The conventional nursing model typically responds to problems that have already occurred, meaning that interventions are carried out only after adverse events have been encountered by the patient.¹⁷ This passive nursing approach not only fails to effectively alleviate patient suffering but may also lead to a waste of medical resources and unnecessary delays.¹⁸ In contrast, risk-stratified nursing intervenes in a proactive manner. Through comprehensive analysis and assessment conducted in the early stages, potential nursing risks are identified in advance, and corresponding preventive measures

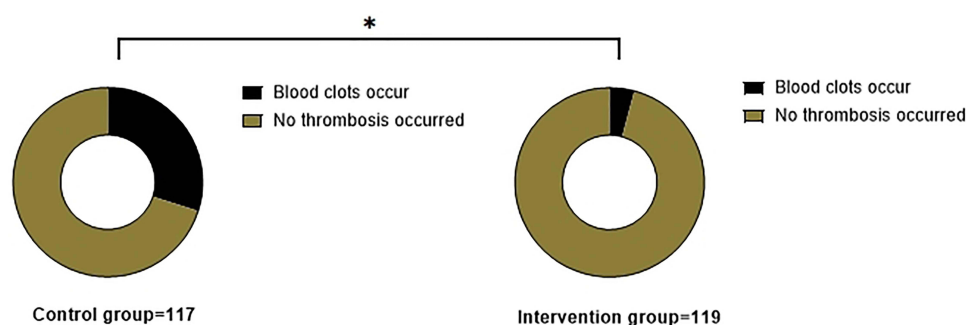


Figure 1 Thrombosis Incidence: 2023 vs 2024 Cohorts Thrombosis Incidence.
Note: Intergroup comparison, * $P < 0.05$.

Table 2 Univariate Analysis of Thrombosis Risk: 2023 Control Cohort

	Thrombosis (n=35)	Non-Thrombosis (n=82)	t/x ²	P
Gender	-	-	0.019	0.888
Male	20 (57.14)	48 (58.54)	-	-
Female	15 (42.86)	34 (41.46)	-	-
Age (years)	67.72±11.85	62.28±9.67	2.600	0.010
Tumor Location	-	-	1.170	0.279
Breast Cancer	7 (20.00)	13 (15.85)	-	-
Esophageal Cancer	6 (17.14)	16 (19.52)	-	-
Gastric Cancer	8 (22.86)	18 (21.95)	-	-
Liver Cancer	7 (20.00)	18 (21.95)	-	-
Colorectal Cancer	7 (20.00)	17 (20.73)	-	-
Tumor Stage	-	-	4.630	0.031
Stage I-II	8 (22.86)	36 (43.90)	-	-
Stage III-IV	27 (77.14)	46 (56.10)	-	-
History of Thrombosis	-	-	28.984	<0.001
Yes	17 (48.57)	5 (6.10)	-	-
No	18 (51.43)	77 (93.90)	-	-
Comorbidities	-	-	-	-
Hypertension	17 (48.57)	32 (39.02)	0.918	0.337
Diabetes	24 (68.57)	6 (7.32)	48.272	<0.001
Hyperlipidemia	26 (74.29)	20 (24.39)	25.596	<0.001
Use of Anticoagulants	-	-	15.536	<0.001
Yes	7 (20.00)	49 (59.76)	-	-
No	28 (80.00)	33 (40.24)	-	-
Number of Punctures	-	-	47.708	<0.001
1	13 (37.14)	78 (95.12)	-	-
>1	22 (62.86)	4 (4.88)	-	-
Puncture Vein	-	-	1.593	0.206
Basilic Vein	7 (20.00)	28 (34.15)	-	-
Median Vein	26 (74.29)	51 (62.20)	-	-
Cephalic Vein	2 (5.71)	3 (3.65)	-	-
Catheter Tip Position	-	-	8.177	0.004
Upper 2/3 of SVC	18 (51.43)	20 (24.39)	-	-
Lower 1/3 of SVC	17 (48.57)	62 (75.61)	-	-
Catheterization Time (days)	-	-	6.814	0.009
≤7	10 (28.57)	45 (54.88)	-	-
>7	25 (71.43)	37 (45.12)	-	-
Fibrinogen (g/L)	2.41±0.64	2.53±0.68	0.889	0.375
D-Dimer (μg/L)	157.46±16.79	141.85±13.16	5.395	<0.001
PLT (×10 ⁹ /L)	303.52±42.46	297.51±38.95	0.743	0.458

are promptly taken to reduce the incidence of adverse events.¹⁹ While our study found no significant differences in baseline characteristics such as age (63.85 vs 64.27 years, $P=0.765$) or gender distribution (58.1% male in controls vs 62.2% in intervention, $P=0.523$) between cohorts, these factors remain critical in thrombosis risk stratification. For instance, older age (>65 years) has been associated with increased thrombosis risk in European cohorts,²⁰ yet our Chinese population showed age-related effects only in univariate analysis ($P=0.010$). This discrepancy may reflect regional differences in comorbidity profiles or genetic predispositions.

During tumor treatment, PICC is a commonly used catheterization method with multiple advantages. Firstly, drugs are directly infused into the large veins, which avoids the damage caused by highly irritating chemotherapy drugs to the peripheral veins, thereby reducing the adverse reactions caused by vein irritation.²¹ Secondly, the drugs entering the large veins through PICC are quickly diluted, effectively reducing the irritation to local blood vessels.²² Additionally, PICC

Table 3 Multivariate Analysis of Thrombosis Risk: Total Cohort

Factor	β	SE	Wald χ^2	P	OR	95% CI
Age	2.713	4.126	0.448	0.722	14.315	0.843~19.572
Tumor stage	0.929	0.402	5.493	0.031	2.556	1.798~5.564
History of thrombosis	2.957	1.269	5.389	0.033	19.273	10.674~37.561
Complicated by diabetes	0.936	0.413	5.107	0.035	2.572	1.027~5.712
Complicated by hyperlipidemia	0.983	0.816	1.453	0.282	2.653	0.092~3.499
Use of anticoagulants	-0.789	0.287	7.342	0.017	0.449	0.089~0.874
Number of punctures	2.986	1.348	4.891	0.040	19.886	8.704~33.492
Catheter tip position	2.659	0.712	14.108	0.004	14.339	8.916~29.795
Catheterization time	2.479	3.987	0.516	0.692	11.539	0.914~22.671
D-D	2.263	0.999	5.069	0.036	9.528	6.703~15.597

Table 4 Multivariate Analysis in the 2024 Intervention Cohort

Factor	OR	95% CI	P
Tumor Stage III/IV	2.215	1.153~4.253	0.021
D-Dimer ≥ 1.5 $\mu\text{g/mL}$	8.967	5.321~14.715	0.003
Protocol Anticoagulation	0.332	0.121~0.898	0.028

can remain in place for a long time, establishing a stable venous access and sparing patients the pain of frequent punctures.²³ Furthermore, since the puncture is performed on superficial peripheral veins, serious complications such as pneumothorax or major vascular perforation are less likely to occur in the event of operational errors. Finally, the insertion of PICC is relatively simple and can be performed in the ward or treatment room, reducing the overall burden on the patient. Despite these advantages, PICC is still an invasive procedure, and the associated risk of complications persists.^{24,25} Therefore, providing risk-stratified nursing for such patients holds significant value and meaning.

Analysis of Influencing Factors of PICC-Related Thrombosis in Cancer Patients

The results of this study indicate that tumor stage, history of thrombosis, coexisting diabetes, repeated punctures, catheter tip position, and D-Dimer (D-D) level are risk factors for PICC catheter-related thrombosis in cancer patients ($\text{OR} > 1$, $P < 0.05$), while the use of anticoagulants is a protective factor ($\text{OR} < 1$, $P < 0.05$). Our identification of tumor stage III–IV ($\text{OR}=2.556$), diabetes ($\text{OR}=2.572$), and catheter tip malposition ($\text{OR}=14.339$) as independent risk factors align with prior studies from South Korea²⁶ and the United States.²⁷ However, the magnitude of diabetes-associated risk in our Chinese cohort ($\text{OR}=2.57$) was lower than reported in Western populations ($\text{OR}=4.1\text{--}5.3$),²⁸ potentially due to stricter glycemic control protocols in our institution. Contrastingly, the protective effect of anticoagulants ($\text{OR}=0.449$) exceeded that observed in a recent Japanese trial ($\text{OR}=0.68$),²⁹ possibly reflecting our protocol's emphasis on early D-dimer-guided escalation. These findings are highly consistent with previous related studies,^{30,31} and the reasons and mechanisms are analyzed as follows.

First, cancer patients are often in a hypercoagulable state due to their pathological characteristics, which is primarily caused by several mechanisms. On the one hand, tumor cells can directly activate the coagulation system, causing the blood to exhibit a hypercoagulable tendency.³² On the other hand, secretions from tumor cells increase the production of mucins and tissue factors,³³ which collectively damage endothelial cells and promote thrombin activity, further enhancing the hypercoagulable state. In addition, during chemotherapy, patients may experience reactive thrombocytosis, which is another important factor contributing to the hypercoagulable state.³⁴

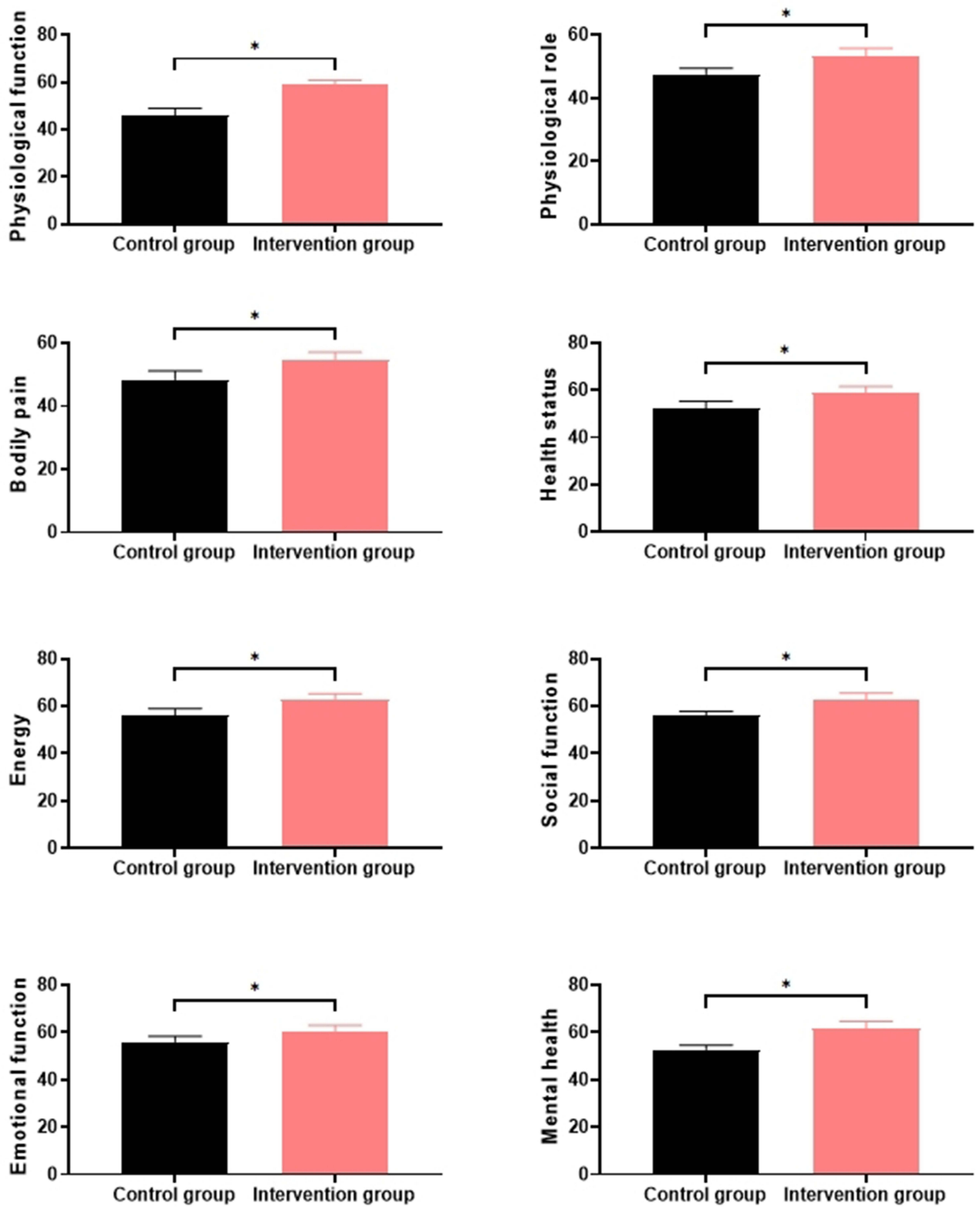


Figure 2 Comparison of Quality of Life Between the Two Groups.
Note: Intergroup comparison, *P < 0.05.

Table 5 Comparison of Nursing Satisfaction Between the Two Groups [n (%)]

Group (n)	Very Satisfied	Satisfied	General	Unsatisfied	Total Satisfaction
Control (n = 117)	43 (36.75)	58 (49.57)	12 (10.26)	4 (3.42)	101 (86.32)
Intervention (n = 119)	55 (46.22)	60 (50.42)	3 (2.52)	1 (0.84)	115 (96.64)
χ^2	—	—	—	—	8.091
P	—	—	—	—	0.004

Mechanistic Insights

The hypercoagulable state in advanced tumors, driven by endothelial damage and thrombin activation [Germany],³⁵ was exacerbated in patients with elevated D-dimer levels—a finding consistent with Brazilian³⁶ and Indian³⁷ cohorts. Notably, our observation that catheter tip position in the upper SVC increased thrombosis risk (OR=14.34) contrasts with a Canadian study³⁸ reporting no positional effect, possibly due to differences in catheter material or insertion techniques. Moreover, the structure of tumor blood vessels differs significantly from that of normal vessels, characterized by poor endothelial integrity, rapid turnover, thin vessel walls, and a lack of regulatory capacity from nerves and muscle tissue.^{39,40} These features make tumor blood vessels more susceptible to damage and lead to increased vascular permeability, thus activating the coagulation system and forming a hypercoagulable state. Consequently, patients with stage III–IV tumors, a history of thrombosis, and elevated D-D levels are at significantly higher risk of thrombosis after PICC insertion.

Diabetes has also been identified as an important risk factor for PICC catheter-related thrombosis in cancer patients. The reason lies in the fact that prolonged hyperglycemia promotes the synthesis of endothelin in plasma,⁴¹ leading to the production and imbalance of free radicals, further activating the polyol pathway, aggravating endothelial damage, and ultimately triggering thrombosis formation. Repeated punctures and the position of the catheter also influence the risk of thrombosis. Due to the poor condition of peripheral blood vessels in cancer patients, repeated punctures may cause endothelial damage, which can activate the body's coagulation mechanism, significantly increasing the likelihood of local thrombus formation.⁴² Additionally, catheter placement in the upper two-thirds of the superior vena cava, compared to the lower third, is more likely to encounter insufficient blood flow, leading to turbulence,⁴³ thereby prolonging the contact time between drugs and the vascular endothelium, increasing the risk of endothelial injury. Conversely, if the catheter is positioned in the lower third of the superior vena cava, the rich blood flow allows for rapid drug dilution, thereby reducing the damage to the vascular endothelium. In summary, when cancer patients undergo PICC placement, the aforementioned risk factors should be carefully monitored, and effective preventive measures should be taken to reduce the risk of thrombosis and improve the safety and efficacy of treatment.

Risk Response Nursing Can Reduce the Incidence of Thrombosis, Improve Patients' Quality of Life, and Increase Satisfaction with Nursing Care

In response to the aforementioned influencing factors, our hospital implemented risk-stratified nursing measures for the intervention group. The study results showed that the incidence of PICC catheter-related thrombosis in the intervention group (4.20%) was lower than that in the control group (29.91%) ($P < 0.05$), confirming the effectiveness of risk-stratified nursing. **Geographic and Clinical Context**

As a single-center study conducted in Zhengzhou, China, our findings reflect local nursing practices and patient demographics. For example, the high prevalence of gastric cancer (22.2% in controls) aligns with regional epidemiology, which may influence thrombosis risk profiles compared to Western populations with higher breast/prostate cancer rates. Future multi-center studies across East Asia are needed to validate generalizability. The reasons for this are as follows: ① **Early Risk Identification and Assessment:** At the early stage of patient admission, nursing staff evaluated the risk factors for thrombosis formation. This early risk identification allowed nursing staff to take preventive interventions at an earlier stage, avoiding the passive waiting typical of conventional nursing. ② **Personalized Nursing Interventions:** Based on the risk assessment, nursing staff implemented personalized nursing interventions tailored to each patient's specific condition. For example, for diabetic patients, timely adjustments to nutrition management and blood glucose control strategies were

made to reduce the damage caused by hyperglycemia to the vascular endothelium. For patients who had undergone multiple punctures, stricter aseptic procedures and vascular protection measures were taken to reduce local endothelial damage caused by puncture. ③ Close Monitoring and Intervention: Throughout the treatment process, patients in the intervention group received more frequent health monitoring. Close intervention allowed nursing staff to detect risks of thrombosis at an early stage, thereby helping patients reduce the risk of thrombosis formation. Additionally, the study also showed that the quality of life scores and nursing satisfaction of the intervention group were higher than those of the control group ($P < 0.05$), consistent with the results of Zhu et al's research.⁴⁴ The reasons for this are as follows: ① Reduction in Pain and Complications: The incidence of thrombosis was significantly reduced in the intervention group through effective risk-stratified nursing, and the accompanying complications such as pain, limb swelling, and local inflammation were also significantly decreased. This not only alleviated the patients' physical discomfort but also improved their mobility and quality of life. ② Alleviation of Psychological Stress: The occurrence of thrombosis can bring significant psychological stress to patients, especially those with malignant tumors, as any complications can intensify their concerns about treatment prognosis.⁴⁵ Risk-stratified nursing reduced the anxiety patients had about potential risks during treatment by lowering the risk of thrombosis formation, enhancing their trust in the treatment and nursing care, and thereby improving their psychological state, indirectly enhancing their quality of life. ③ Improvement of Nursing Experience: risk-stratified nursing not only improved clinical outcomes but also made patients feel cared for and valued through more thoughtful and personalized nursing services. Moreover, with the reduction of complications, patients experienced a smoother treatment process, which further increased their trust and satisfaction with the hospital and nursing team.

Despite the significant results achieved in this study, there are still some limitations. First, the sample size of this study is relatively small and limited to a single medical institution, which may cause the research results to be influenced by regional and institutional differences, making it less representative of other regions or medical institutions. Second, the follow-up period in this study was short, and the long-term effects of nursing interventions on thrombosis formation have not yet been observed. Future research should extend the follow-up period to assess the long-term effects of risk-stratified nursing. In addition, this study did not delve into the impact of individual patient differences (such as different tumor types and chemotherapy regimens) on the incidence of thrombosis. Future studies should further refine patient classification and explore the applicability of personalized nursing plans for different types of patients.

Conclusion

This study demonstrates that risk-stratified nursing significantly reduces the incidence of PICC line-associated thrombosis in cancer patients. By identifying and addressing key risk factors—such as advanced tumor stage, history of thrombosis, comorbid diabetes, catheter tip position, and elevated D-Dimer levels—this approach enables early intervention and improved clinical outcomes. The implementation of this nursing model led to a marked reduction in thrombosis rates (from 29.91% in the control group to 4.20% in the observation group), enhanced quality of life across all measured domains, and increased patient and nurse satisfaction.

These findings underscore the importance of individualized, evidence-based nursing strategies in oncology care, particularly for patients undergoing long-term intravenous therapy via PICC lines. Risk-stratified nursing not only improves safety and efficacy but also supports better coordination between healthcare providers and patients, ultimately enhancing overall care delivery.

Implications and Recommendations

The results of this study provide strong support for the adoption of risk stratification and targeted nursing interventions in the management of cancer patients with PICC lines. Healthcare institutions are encouraged to integrate these practices into standard protocols to reduce thrombotic complications and improve patient outcomes. Furthermore, training programs for nurses should emphasize the identification and management of thrombosis risk factors, including the appropriate use of anticoagulants and optimal catheter placement techniques. Implementation of a standardized risk assessment tool, along with continuous monitoring and feedback mechanisms, can further enhance the effectiveness of

nursing interventions. Future research should aim to validate these findings in larger, multi-center studies and explore the impact of tumor-specific or treatment-specific variables on thrombosis risk.

Abbreviations

PICC, Peripherally inserted central catheter; SF-36, Quality of Life Questionnaire; NSNS, Newcastle Satisfaction with Nursing Scale; D-D, D-dimer; CBM, China Biological Medicine Database; CNKI, China National Knowledge Infrastructure; EKG, Electrocardiogram; Fib, Fibrinogen; PLT, Platelet count.

Disclosure

The authors report no conflicts of interest in this work.

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