RESEARCH ARTICLES

Training with a peripheral intravenous catheter care algorithm to affect phlebitis and infiltration incidence: An interventional before-and-after study

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ABSTRACT

Objective: This study attempted to determine the effect of training with a peripheral intravenous catheter care algorithm on nurses' knowledge level and the incidence of phlebitis and infiltration.

Background: Peripheral intravenous catheter insertion is a common nursing intervention for hospitalised patients. However, it causes many complications, of which phlebitis and infiltration are the most prevalent. Many factors affect the development of phlebitis and infiltration.

Study design and methods: This study was an interventional and cross-sectional -before and after study. This study was conducted with 19 nurses and 190 patients (who had 297 peripheral intravenous catheters). After the Peripheral Intravenous Catheter Care Algorithm was developed, the study was conducted in three stages: the prevalence of phlebitis and infiltration and the knowledge level of nurses before intervention was evaluated during the first stage; training and consultancy services were provided during the second; and the incidence of phlebitis and infiltration and the knowledge level of nurses after intervention was evaluated in the last stage.

Results: The nurses median scores regarding the knowledge test on phlebitis and infiltration improved significantly after their training. Despite the incidence of phlebitis decreasing after the training, it was not statistically significant. However, the grade of phlebitis proved significantly lower after the nurses' training. Furthermore, the incidence and grade of infiltrations decreased after training, but it was not statistically significant either.

Conclusion: It can be concluded that training with the Peripheral Intravenous Catheter Care Algorithm is effective in increasing the nurses' knowledge and reducing the grade of phlebitis. Accordingly, training nurses with the Peripheral Intravenous Catheter Care Algorithm, based on clinical guidelines, is recommended.

Implications for research, policy, and practice: An algorithm has been developed in this study to guide hospitals in clinics where peripheral intravenous catheter is applied. This is noteworthy that by preventing these complications, patients can be prevented from receiving treatment (medical treatment, surgical repair etc.) for complications, prolonged hospital stay, stress in patients and

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their relatives, increased workload of healthcare personnel, and increased health expenditures can be avoided by preventing these complications.

Keywords: Nursing care, Catheterisation, Peripheral, Algorithm, Phlebitis, Infiltration

What is already known about the topic?

- The prevalence of phlebitis varies in recent studies between 10% and 54.5%.
- The prevalence of infiltration varies in recent studies between 7% and 35%.
- Care protocols are available for peripheral intravenous catheter care.

What this paper adds?

- Although phlebitis developed in 16.1% of the peripheral intravenous catheter before the peripheral intravenous catheter care training, this rate decreased to 8.1% after the training. While infiltration developed in 10.2% of the peripheral intravenous catheters before the peripheral intravenous catheter care training, it only developed in 3% of the peripheral intravenous catheters after the training.
- An algorithm has been developed in this study to guide hospitals in clinics where peripheral intravenous catheter is applied.
- The nurses median scores regarding the knowledge test on phlebitis and infiltration improved significantly after their training.
- This is noteworthy since the unnecessary diagnosis and treatment of patients, prolonged hospital stay, stress in patients and their relatives, increased workload of healthcare personnel, and increased health expenditures can be avoided by preventing these complications.

BACKGROUND

Intravenous infusions are commonly used infusions for the diagnosis of the disease, and alleviation or elimination of symptoms in hospitalised patients.[1] A peripheral intravenous catheter (PIVC) is commonly used for these procedures. Although peripheral intravenous catheterization is a common practice, it can still cause several complications. These complications could subject patients to unnecessary diagnostic procedures and treatments, prolonged hospitalisations, increased stress (including for their relatives), health expenditures, and increase the workload of healthcare personnel. However, many of these complications can be prevented through evidence based PIVC insertion.[1]

The most common complications associated with PIVCs are phlebitis and infiltration. Phlebitis refers to an inflammation of the vein's tunica intima and is a largely preventable complication.[2] The prevalence of phlebitis varies between 10% and 54.5%.[1–9] Infiltration is also a common complication of PIVC insertions. It occurs when the PIVC lesions or perforates the vein layers, which causes non-vesicular solutions or drugs to seep into the tissues surrounding the catheter's insertion site and accumulate under the skin.[6] The infiltration rates range between 7% and 35%.[2,4–6,10]

To minimise PIVC complications, nurses must identify the relevant risk factors and provide care based on scientific evidence; this can be facilitated by increasing nurses' knowledge on the care of patients with PIVCs.[1] Furthermore, utilising the standards, algorithms, care packages, and guides regarding the care of PIVCs is crucial to prevent any complications.[11] The algorithms can both summarise clinical practice guidelines enabling nurses to make healthy, evidence-based clinical decisions and be used as modern educational tools. Since algorithms clearly illustrate the thought process in a logical, step-by-step approach, they allow nurses to engage in critical thinking, clinical decision making, and develop practical clinical skills.[12] Moureau and Carr (2018) report that the use of an evidence-based Vessel Health and Preservation model in clinics improves the quality of acute care and patient outcomes by reducing infection, thrombosis and phlebitis through the selection of the most appropriate catheter and the insertion and management of the catheter by trained staff.[13] Keleekai et al. (2016) found significant improvements in nurses' knowledge, confidence, and skills when using a simulation-based mixed learning program for the placement of Peripheral Intravenous Catheters (PIVC).[14] In another study, a PIVC care algorithm specifically for newborns was developed.[15] Watterson et al. (2018) reported that using an IV Infiltration Prevention Bundle in children helped reduce the occurrence of infiltration.[16] Additionally, Ray-Barruel et al. (2020) developed the I-DECIDED clinical decision-making tool for PIVC assessment and safe removal,[17] which has been shown to be evidence-based, valid, and reliable.[18] Carr et al. (2017)[19] emphasized the need for further research to develop and test appropriate tools, clinical guidelines, and algorithms to improve PIVC insertion outcomes in clinical settings. Furthermore, Ray-Barruel et al. (2019) noted that while the effectiveness of implementing PIVC insertion and care bundles remains unclear, further research is necessary to identify which bundle components are most effective in reducing PIVC-related complications and infections.[20]

To address this dearth in research, a PIVC care algorithm was developed in this study for adult patients that addresses the general care of PIVCs as well as the most common PIVC

complications, namely phlebitis and infiltration. The training provided by this algorithm can increase nurses' knowledge regarding the care of PIVCs as well as how to provide an appropriate standard of care to patients. Furthermore, since nursing interventions are included step by step in the algorithm, it functions as a guide for providing better nursing care for PIVCs, preventing complications, and providing the appropriate nursing care when complications arise in order to improve patient outcomes.

This study attempted to determine the effect of training with a peripheral intravenous catheter care algorithm on nurses' knowledge level and the incidence of phlebitis and infiltration.

Questions of the study:

- Is there a correlation between training with the PIVC Care Algorithm and level of nurses' knowledge regarding care of PIVCs?
- Is there an effect of training with the PIVC Care Algorithm on the development of phlebitis?
- Is there an effect of training with the PIVC Care Algorithm on the grade of phlebitis?
- Is there an effect of training with the PIVC Care Algorithm on the development of infiltration?
- Is there an effect of training with the PIVC Care Algorithm on the grade of infiltration?

METHODS

DESIGN, SETTING, AND PARTICIPANTS

This is an interventional and cross-sectional – before and after study conducted in the neurosurgery clinic and intermediate intensive care unit of a training and research hospital. The study was conducted with two different groups: two patient samples and a nurse sample. The first group consisted of two patient samples that were treated with PIVCs from relevant clinics. The first sample consisted of 118 patients who underwent 186 PIVC insertions and met the inclusion criteria during the prevalence study stage between November 1, 2019, and January 1, 2020. The second sample consisted of 72 patients who endured 111 PIVC insertions and met the inclusion criteria during the incidence study stage between February 1, 2020, and April 1, 2020.

For the prevalence study stage, the inclusion criteria for patients were as follows: suffered from cranial diseases and were hospitalised for at least 72 hours in the relevant clinics, agreed to participate in the study, over 18 years of age, and treated with any PIVCs, regardless of the clinics where PIVCs are inserted. While the exclusion criteria included patients without cranial diseases, that were hospitalised for less than 72 hours in the relevant clinics, under 18 years of age, refused to participate, or were not treated with PIVCs.

In the incidence study phase, the inclusion criteria for patients were as follows: suffered from cranial diseases and were hospitalised for at least 72 hours in the relevant clinics, agreed to participate in the study, over 18 years of age, and their PIVCs were applied solely by nurses in the relevant clinics. While the exclusion criteria included patients without cranial diseases, that were hospitalised for less than 72 hours, under 18 years of age, refused to participate, and those who were treated with PIVCs in different clinics.

The second group consisted of 19 nurses that worked in the relevant clinics between November 1, 2019, and April 1, 2020. All nurses who worked in the relevant clinics during the study, and who agreed to participate in the study, were included without any sample selection.

DATA COLLECTION

The data for this study were collected through several forms.

Data collection form for patients: This form was created by the researchers of this study to collect data on patients in accordance with previous literature.[15] The data collection form consists of 10 question items: age, gender, weight, height, diagnosis, chronic disease, the hand used actively every day, any extremities that cannot be used with PIVCs, languages, and the presence of a situation that prevents communication.

Data collection form for peripheral intravenous catheters: This form was prepared by the researchers of this study in accordance with previous literature and containing factors affecting phlebitis and infiltration complications.[21] This form consists of 13 question items: the PIVC insertion date, PIVC termination date, PIVC type, PIVC number, dressing material, type of antiseptic solution, DosiFlow usage, extension set, liquid set, body part where PIVC was applied, body area where PIVC was applied, the frequency of intervention in the area where the PIVC was applied, the manner of drug administration, the intravenous drugs that were administered, the IV fluids which were administered, and the fluids' flow rate.

Phlebitis scale: This scale was developed by Gorski et al., to determine the status and severity of phlebitis.[22] This scale is graded from 0 to 4. Grade '0': No symptoms, Grade '1': Erythema at access site with or without pain, Grade '2': Pain at access site with erythema and/or edema, Grade '3': Pain at access site with erythema and/or edema, streak formation, palpable venous cord, Grade '4': Pain at access site with erythema and/or edema, streak formation, Palpable venous cord 1 inch in length and purulent drainage.

Infiltration scale: This scale was developed by the Infusion Nurses Society to determine the status and severity of infiltration.[23] This scale is graded from 0 to 4. Grade '0': No symptoms, Grade '1': Skin blanched, edema less than 1 inch in any direction, cool to touch, with or without pain, Grade '2': Skin blanched, edema 1 to 6 inches in any direction, cool to touch, with or without pain, Grade '3': Skin blanched,

translucent, gross edema greater than 6 inches in any direction, cool to touch, mild to moderate pain, possible numbness, Grade '4': Skin blanched, translucent, skin tight, leaking, skin discoloured, bruised, swollen, gross edema greater than 6 inches in any direction, deep pitting tissue edema, circulatory impairment, moderate to severe pain, infiltration of any amount of blood product, irritant, or vesicant.

Data collection form for nurses: This form was developed by the current researcher, in accordance with previous literature, to collect data on nurses,[24] It consists of eight question items: gender, age, educational status, total service time, duration of working in a neurosurgery clinic, PIVC training status after graduation, feelings of competency regarding PIVC insertion skills, and the need for PIVC insertion training.

Information form on nurses' peripheral intravenous catheter care: This form was developed by the current researcher, in accordance with previous literature, to evaluate nurses' knowledge of PIVC care. It consists of 22 questions.[6,22,25,26,27–30]

PIVC care algorithm: This algorithm was developed by the researcher. Studies and guidelines published since 2014 were searched between July 2019 and September 2019 using Medline (US National Library of Medicine, Bethesda, MD), CINAHL (Western Adventist Health Services, Glendale, CA), The COCHRANE Library (The Cochrane Collaboration) and Google Scholar databases to create an evidence-based PIC Care Algorithm in line with the literature. Since the PIC Care Algorithm includes only phlebitis and infiltration complications, the literature was searched with appropriate search terms. To search the literature, 1468 publications and 5 guidelines containing the search terms 'phlebitis and prevention, phlebitis and care, phlebitis and guidelines, phlebitis and algorithm, infiltration and prevention, infiltration and care, infiltration and guidelines, infiltration and algorithm' were reached. The titles and abstracts of all publications reached as a result of the search were examined by the researcher. As a result of the review, publications whose full text could not be accessed, repetitive publications in databases, publications whose publication language was not English or Turkish, and publications that were not related to the subject were not included in the review, and the full text of a total of 64 publications was analysed (Figure 1). Based on 59 studies,[31–89] and 5 guidelines,[22,24,90–92] an evidence-based Peripheral Intravenous Catheter Care Algorithm was developed and sent to seven experts for expert opinion. The experts were selected among nursing faculty members with training or experience in PIC care. In order to prove the content validity of the algorithm with numerical values, an evaluation criterion was developed by the researcher and sent to the experts. This evaluation criterion is a scoring form that includes all items of the form. In this form, the content validity index (CVI) developed by Waltz and Baussel was used for each item and a value ranging from 1 to 4 (1 = Not appropriate, 2 = Item needs to be adapted, 3 = Appropriate but minor changes are needed, 4 = Very appropriate) was asked to be given for each item and a space was allocated for each item to receive experts' suggestions.[93] The content validity index for each item was then obtained by dividing the number of experts who gave the item 3 and 4 points by the total number of experts. All experts gave only 3 or 4 points for each item. Therefore, the content validity index of the Peripheral Intravenous Catheter Care Algorithm was found to be 1. Necessary corrections were made in line with the suggestions of the experts and the Peripheral Intravenous Catheter Care Algorithm was finalised (Figure 2).

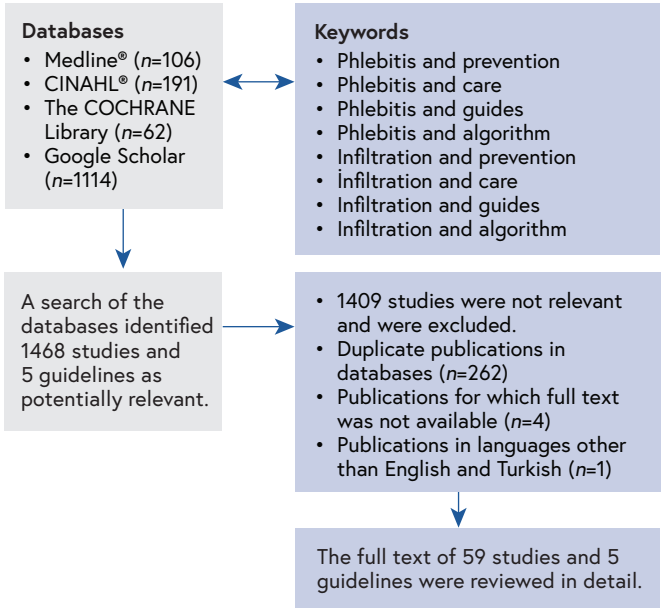

FIGURE 1. FLOWCHART OF THE LITERATURE USED IN THE DEVELOPMENT OF THE PIVC CARE ALGORITHM

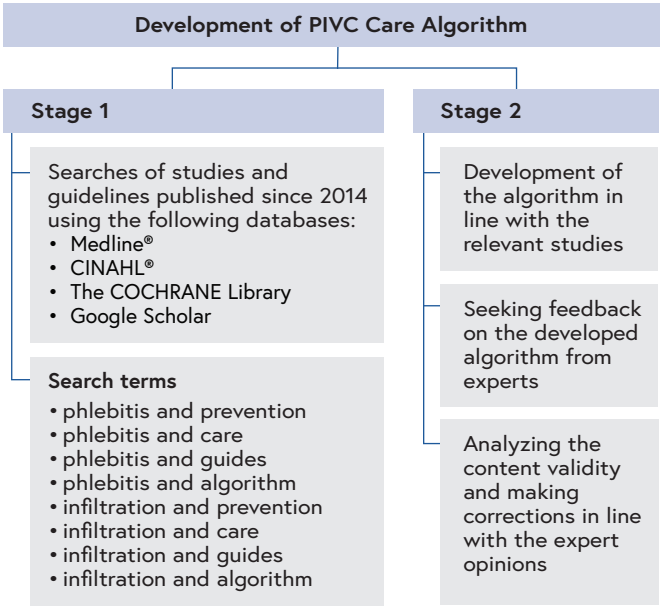

FIGURE 2. SCHEMATIC OF THE DEVELOPMENT OF THE PIVC CARE ALGORITHM

This algorithm includes appropriate site selection for PIVC insertion, vein selection at appropriate areas for PIVC insertion, PIVC selection, dressing selection, PIVC care, assessment of PIVC, diagnosis of PIVC complications, phlebitis severity rating, infiltration severity rating, care suitable for the phlebitis's severity, care suitable for the infiltration's severity (see Supplementary Material).[22,24,31,89–92]

INTERVENTION

The study was conducted in three stages.

Prevalence study stage: The researcher recorded the prevalence of phlebitis and infiltration, which are common PIVC complications, once a day for two months in those patients who were hospitalised at the relevant clinics and met the inclusion criteria.

Training and consultancy stage: The researcher provided one hour of training with the PIVC care algorithm to 19 nurses working in the relevant clinics. The training days and hours were planned according to the nurses' working hours; they were instructed in groups of 3–4 people. The PIVC care algorithm was distributed to the nurses after the training and hung on their clinics' walls for them to see.

After the training, the researcher provided a consultancy service for two weeks regarding the use of the PIVC care algorithm. During this consultancy service, the researcher evaluated the nurses' PIVC practices until the nurses provided care in accordance with the PIVC care algorithm. It was found that the problems experienced with the insertion of PIVC care stemmed from using non-sterile gloves, not washing hands before insertions, and not controlling the arterial flow when a tourniquet was applied. Accordingly, the nurses were informed of the compliance problems identified during the counselling process. After the information, it was determined that the nurses provided PIVC care in accordance with the entire algorithm.

Incidence study stage: Nurses evaluated the incidence of phlebitis and infiltration in patients who were hospitalised at the relevant clinics and met the study's inclusion criteria every eight hours for two months. The researcher monitored these evaluations every day. While evaluating the incidence of phlebitis and infiltration, the previously applied PIVCs at relevant clinics, as well as the PIVCs of patients who were transferred from different clinics, were not taken into consideration. However, those PIVCs applied by nurses at the relevant clinics after training were evaluated. Regardless, all patients with PIVCs received the necessary PIVC care even if they were not considered for the study. A transparent dressing material was used for PIVC fixations to facilitate the observation of PIVCs during the phlebitis and infiltration incidence evaluation.

OUTCOME MEASURES

At prevalence study stage, 186 catheters were evaluated through the Data Collection Form for Patients, Data Collection Form for Peripheral Intravenous Catheters, Phlebitis Scale, and Infiltration Scale in order to collect data on the patients. At training and consultancy stage, The Data Collection Form for Nurses was administered to the nurses working at relevant clinics before the study commenced. The Information Form on Nurses' Peripheral Intravenous Catheter Care was administered to the nurses both before and after their training. During incidence stage, 111 catheters were evaluated using the Data Collection Form for Patients, Data Collection Form for Peripheral Intravenous Catheters, Phlebitis Scale, and Infiltration Scale. The Information Form on Nurses' PIVC Care was utilised to evaluate the long-term effectiveness of the training.

ETHICAL CONSIDERATIONS

Both Gazi University Ethics Committee approval (09/08/2019-E.99239) and institutional permission from Dışkapı Yıldırım Beyazıt Training and Research Hospital (15/08/2019-E.32294) were obtained before conducting the study. Written consent was obtained from the nurses and patients or their relatives who agreed to participate in the study by adequately explaining the study's objective, duration, and process.

DATA ANALYSIS

The data were analysed with the IBM SPSS Statistics 17.0 package program (IBM Corporation, Armonk, NY, USA). The fitness of discrete numerical variables, with regards to normal distribution, was examined by Shapiro-Wilk and Kolmogorov-Smirnov tests. Levene's test investigated whether the assumption of homogeneity of variances was achieved. Descriptive statistics were illustrated as mean ± standard deviations or medians (minimum-maximum) for discrete numeric variables, and as the number of observations and percentages (%) for categorical variables (nominal and ordinal). The Mann-Whitney U Test, Cochran's Q test, Friedman test, and Continuity corrected χ^2 Test were used to evaluate the data.

RESULTS

NURSES' SOCIODEMOGRAPHIC CHARACTERISTICS

In the study, the mean age of the nurses was 27.7 ± 5.5 years. The sociodemographic characteristics of these nurses are as follows: 17 (89.5%) were female, 10 (52.6%) had bachelor's degrees, 9 (47.4%) have been employed for 5 years or more, 13 (68.4%) worked in the brain surgery clinic for 1-5 years, 17 (89.5%) did not receive PIVC care training after graduation, and 16 (84.2%) felt the need for PIVC care training (Table 1).

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TABLE 1. SOCIODEMOGRAPHIC CHARACTERISTICS OF THE NURSES (N = 19)

Sociodemographic characteristics	*n*	%
Age		
Mean = 27.7 years; SD = 5.5		
Gender		
Female	17	89.5
Male	2	10.5
Educational status		
Vocational School of Health	2	10.5
Associate Degree	3	15.8
Bachelor's Degree	10	52.6
Vertical transfer after Associate Degree	3	15.8
Master/PhD	1	5.3

Sociodemographic characteristics	*n*	%
Years in profession		
Median = 5 years; (Min–Max) = (0.08–23 years)		
<1 year	4	21.0
1–5 years	6	31.6
>5 years	9	47.4
Receiving PIVC training after graduation		
No	17	89.5
Yes	2	10.5
Having a need for PIVC training		
No	3	15.8
Yes	16	84.2

TABLE 2. DISTRIBUTION OF THE NURSES CORRECT ANSWERS TO QUESTIONS CONCERNED WITH PIVC CARE BEFORE AND AFTER THE TRAINING (N = 19)

Questions on PIVC care	Before *n* (%)	After *n* (%)	After 2 months *n* (%)	*p*-value*
PIVC application				
1. Area selection	19 (100%)	19 (100%)	19 (100%)	N/A
2. Vein selection	6 (31.6%)	18 (94.7%)	19 (100%)	<0.001
3. Vein selection from lower extremities	8 (42.1%)	16 (84.2%)	19 (100%)	<0.001
4. PIVC selection	9 (47.4%)	19 (100%)	19 (100%)	<0.001
5. Dressing selection	4 (21.1%)	17 (89.5%)	19 (100%)	<0.001
PIVC care and assessment				
6. Asepsis principles in PIVC application	16 (84.2%)	19 (100%)	19 (100%)	0.050
7. Suitable antiseptic solution for PIVC application	10 (52.6%)	15 (78.9%)	19 (100%)	0.004
8. Highlights in PIVC care	10 (52.6%)	19 (100%)	17 (89.5%)	0.002
9. Highlights in PIVC assessment	6 (31.6%)	18 (94.7%)	17 (89.5%)	<0.001
10. Change times of infusion sets	2 (10.5%)	15 (78.9%)	17 (78.9%)	<0.001
11. Change times of PIVCs	9 (47.4%)	19 (100%)	19 (100%)	<0.001
12. Causes of PIVC removal	2 (10.5%)	19 (100%)	18 (94.7%)	<0.001
Complication Management				
13. Diagnosis of phlebitis	11 (57.9%)	19 (100%)	19 (100%)	<0.001
14. Phlebitis grading	8 (42.1%)	18 (94.7%)	17 (89.5%)	<0.001
15. Diagnosis of infiltration	7 (36.8%)	19 (100%)	19 (100%)	<0.001
16. Infiltration grading	7 (36.8%)	16 (84.2%)	16 (84.2%)	0.005
17. Diagnosis of 2ebitis	3 (15.8%)	19 (100%)	19 (100%)	<0.001
18. Phlebitis grading	6 (31.6%)	18 (94.7%)	18 (94.7%)	<0.001
19. Diagnosis of infiltration	6 (31.6%)	19 (100%)	19 (100%)	<0.001
20. Infiltration grading	8 (42.1%)	13 (68.4%)	15 (78.9%)	0.050
21. Appropriate care for phlebitis grade	3 (15.8%)	17 (89.5%)	17 (89.5%)	<0.001
22. Appropriate care for infiltration grade	9 (47.4%)	18 (94.7%)	19 (100%)	<0.001
Total Median (min–max)**	**9 (4–13)**	**21 (17–22)**	**21 (19–22)**	**<0.001**

* Cochran's Q test, N/A: No evaluation was made, ** Friedman test

NURSES' KNOWLEDGE

The median number of correct answers given by the nurses were 9 (min–max: 4–13), 21 (min–max: 17–22), and 21 (min–max: 19– 22) before the training, after the training, and two months after the training, respectively. A statistically significant increase was found in the nurses' total number of correct answers to the questions concerned with PIVC care ($p<0.001$). No statistically significant differences were found between the test scores directly after the PIVC care training and those two months after the training ($p>0.999$) (Table 2).

The nurses' median test score before the PIVC care training was 38.1 (min–max: 14.3–57.1); their median test score after the training was 95.2 (min–max: 76.2–100); and their median test score two months after the training was 95.2 (min–max: 85.7–100). Therefore, statistically significant increases were found between the nurses' test scores before, after, and at two months after their PIVC care training ($p<0.001$) (Table 3).

TABLE 3. DISTRIBUTION OF THE NURSES' MEAN KNOWLEDGE SCORES REGARDING PIVC CARE

Knowledge test	Score					*p*-value**
	Mean	SD*	Median	Min	Max	
Before training	37.6	11.8	38.1	14.3	57.1	<0.001
After training	92.7	7.0	95.2	76.2	100	
2 months after training	95.2	3.5	95.2	85.7	100	

*SD: Standard Deviation, ** Friedman test

PHLEBITIS AND INFILTRATION

Although phlebitis developed in 16.1% of the PIVCs before the PIVC care training, this rate decreased to 8.1% after the training. Furthermore, before the PIVC care training 2nd-grade phlebitis developed in 5.4% of the PIVCs, while 1st-grade phlebitis developed in 5.4% of the PIVCs after the training. Although there was a decrease in the developmental rate of phlebitis after the training, this change was not statistically significant ($p = 0.071$). Conversely, a statistically significant decrease was found in the grade of phlebitis after the training ($p = 0.032$). While infiltration developed in 10.2% of the PIVCs before the PIVC care training, it only developed in 3% of the PIVCs after the training. Furthermore, 4.3% of the PIVCs exhibited a 2nd-grade infiltration before the PIVC care training, while 5.4% of the PIVCs exhibited first-grade infiltration after the training. Although there was a decrease in the rate of infiltration after the training, this decrease was not statistically significant ($p = 0.347$). Moreover, despite the grade of infiltration also decreasing after the training, it did not prove statistically significant either ($p = 0.200$) (Table 4).

Although it is not illustrated in the tables, both groups' data on PIVCs before and after the PIVC care training were similar.

TABLE 4. DISTRIBUTION OF THE PREVALENCE AND INCIDENCE OF PHLEBITIS AND INFILTRATION BEFORE AND AFTER THE PIVC CARE TRAINING (N = 297)

	Prevalence before training ($n = 186$)	Incidence after training ($n = 111$)	*z*-value	*p*-value
	n (%)	*n* (%)		
Phlebitis				**0.071***
No	156 (83.9%)	102 (91.9%)		
Yes	30 (16.1%)	9 (8.1%)		
Phlebitis grade			**2.142**	**0.032****
Grade 0	156 (83.9%)	102 (91.9%)		
Grade 1	8 (4.3%)	6 (5.4%)		
Grade 2	10 (5.4%)	3 (2.7%)		
Grade 3	9 (4.8%)	0 (0.0%)		
Grade 4	3 (1.6%)	0 (0.0%)		
Infiltration				**0.347***
No	167 (89.8%)	104 (93.7%)		
Yes	19 (10.2%)	7 (6.3%)		
Infiltration grade			**1.282**	**0.200****
Grade 0	167 (89.8%)	104 (93.7%)		
Grade 1	4 (2.2%)	6 (5.4%)		
Grade 2	8 (4.3%)	1 (0.9%)		
Grade 3	5 (2.7%)	0 (0.0%)		
Grade 4	2 (1.1%)	0 (0.0%)		
Catheters	**Median (min–max)**	**Median (min–max)**	**z-value**	**p-value**
Number	1 (1-3)	1 (1-4)	0.329	0.742**

* χ^2 test with continuity correction, ** Mann-Whitney U test.

DISCUSSION

In this study, a statistically significant increase was found between nurses' test scores before and after their PIVC care training. The importance of training healthcare personnel to determine the right techniques for PIVC insertion and care is stated in a guide from the Centers for Disease Control and Prevention (CDC).[94] Abraham (2018) stressed the necessity of training and providing healthcare professionals with knowledge and skills concerned with predicting and preventing PIVC complications.[27] A study reported that providing PIVC care training to nurses who care for children undergoing chemotherapy, in accordance with evidence-based practices and PIVC care guidelines, led to improvements in PIVC care for children with cancer.[95] Woody and Davis (2013) conducted an interventional study ($n = 1200$) with the aim of increasing the peripheral intravenous treatment competence of nurses working in internal and surgical clinics.[96] They reported that no significant differences between the nurses' pre- and post-test scores were found. In a study by George and Muninarayanappa (2016), it was reported that there was no significant difference between

the pre-test and post-test scores of nurses who participated in a structured training program on the prevention of intravenous catheter complications.[97] In our study, we posit that the increase in the PIVC care test scores was due to the training the nurses received since, as stated in the literature, the nurses' training greatly increased their knowledge.[27,94] Training the nurses with the PIVC care algorithm can contribute toward an increase in their knowledge regarding PIVC care. Therefore, it is recommended to periodically evaluate both the knowledge of nurses involved in the insertion and care of PIVCs as well as their compliance with current guidelines.[98]

In this study, it was determined that the development rate of phlebitis decreased from 16.1% to 8.1% after training in PIVC care. Previous studies have established that the rates of phlebitis vary between 10.0% and 54.5%.[1–9] The rate of phlebitis was within this range during the prevalence stage of this study; however, it fell below this range during the incidence study. In a study by Hontoria-Alcoceba et al (2023), it was reported that the use of the PIVC care bundle and algorithm reduced phlebitis rates from 14.8% to 4.9%.[99] Similarly, an interventional study conducted by Woody and Davis (2013) determined that phlebitis rates were 50% lower after the training. In this study, despite the seemingly clinical significance of phlebitis rates dropping after PIVC care training, no statistically significant differences were found.[96] A study evaluating the effectiveness of an intervention using protocols and education and performance feedback for healthcare professionals and patients to reduce PIVC failure rates in hospitalised patients reported that the multimodal intervention significantly reduced PIVC failure rates and potential PIVC complications for inpatients.[100] In this study, although grade 1, 2, 3, and 4 phlebitis cases were observed before the PIVC care training, the majority of these phlebitis cases were 2nd-grade cases (5.4%). Furthermore, after the training, 1st-grade phlebitis (5.4%) was observed the most. Accordingly, it can be said that the use of evidence-based practices such as the PIVC care bundle and algorithm improves PIVC care for catheterised patients.[99]

The PIVC care algorithm can motivate nurses to adopt evidence-based preventive care practices concerning phlebitis and inform them on the appropriate care and treatments associated with phlebitis.[6,11] Although the incidence of phlebitis did not exhibit a statistically significant decrease in this study, a significant decrease was found concerning the grade of phlebitis. This is an indicator of the effectiveness of the PIVC care algorithm developed in this study. Therefore, integrating the PIVC care algorithm into nurses' clinical practices can contribute toward the prevention of phlebitis.[11]

With regards to infiltration, this study observed that the infiltration incidence after training (6.3%) was clinically lower than before the training (10.2%). Previous studies have established that the rates of infiltration vary between 7% and 35%.[2,4–6,10] The infiltration incidence was within this range during the prevalence study stage before the PIVC care training; however, it fell below this range during the incidence study after the training. Similarly, Woody and Davis (2013) conducted an interventional study which determined that the infiltration incidence was 50% less after the training was than before.[96] In this study, the rate of infiltration after the PIVC care training was indeed; however, the difference did not prove statistically significant. Furthermore, although grade 1, 2, 3, and 4 infiltration cases were observed before the PIVC care training, most of these cases were 2nd grade infiltrations (4.3%). After the training only 1st and 2nd grade infiltrations were observed, where the majority of these cases were 1st-grade infiltrations (5.4%).

In an internal medicine clinic, Braga et al. (2018) conducted a cohort study ($n = 526$) which found that first-grade infiltrations developed in 84.5% of the catheters, but that no 3rd or 4th-grade infiltrations were observed.[6] Simin et al. (2019) conducted a prospective observational study ($n = 1428$) with adult patients which determined that most infiltration cases were 2nd grade.[2] Despite the grade of infiltration decreasing in this study after the training, the difference was not statistically significant. The algorithm-based training concerned with evidence-based PIVC care enabled nurses to administer safe practices during the diagnosis of infiltration and largely prevent PIVC complications. Therefore, it is thought that the incidence and grade of infiltration decreased after the training due to the nurses' PIVC care in line with the PIVC care algorithm and because the infiltration cases were diagnosed at an early stage. In order to diagnose the infiltration's development during an early period and to initiate the appropriate care and treatments, it is recommended to evaluate the infiltration status effectively and to determine the grading when infiltration first develops.[11]

LIMITATIONS OF THE STUDY

Since this study was conducted with a patient group older than 18 years of age, the findings cannot be generalised to paediatric patients. Furthermore, the study was conducted in a neurosurgery clinic and intermediate intensive care unit, therefore, its results cannot be generalised to all patients. There are many risk factors that affect the development of phlebitis and infiltration. These risk factors may also have affected the study results.

CONCLUSION

In this study, although the decreases in the incidence of phlebitis and infiltration as well as the infiltration grading was not statistically significant, they may demonstrate the effectiveness of the PIVC care algorithm. In this context, training with this PIVC care algorithm developed can help to increase nurses' knowledge of PIVC care, improve the continuity and coordination of care, eliminate the differences in practice, provide care for patients according to the relevant techniques and standards, prevent complications, and improve patient outcomes when complications do develop. Accordingly, it is recommended that patients receive care facilitated by the PIVC care algorithm, and that its use should be generalised by nurses.

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