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Effectiveness of Using Ultrasonography in Peripheral Intravenous Catheter Application

Tuba Sengul[1], Rengin Acaroğlu[2]

[1]Department of Fundamentals of Nursing, Koç University Faculty of Nursing, İstanbul, Turkey
[2]Department of Fundamentals of Nursing, İstanbul University, Florence Nightingale Faculty of Nursing, İstanbul, Turkey

Abstract

Background: Peripheral intravenous catheter applications, in addition to the traditional method in various clinics, are among the common methods using ultrasound guidance.

Methods: The study was conducted using a quasi-experimental design on 30 patients who were treated in a daily chemotherapy unit and agreed to participate in the study. The data of the study were collected using "Patient Information Form," "State Anxiety Inventory," "Pain Scale," "Satisfaction Scale," "Infiltration Scale," "Visual Infusion Phlebitis Assessment Scale," and "Peripheral Intravenous Catheterization Follow-up Form." Patients were randomly assigned to the application groups, peripheral intravenous catheterization was performed using ultrasonography-guided method and the traditional method, and the application methods were repeated by crossing the groups. The data were analyzed by descriptive analysis, a Chi-square, and paired *t*-test.

Results: The mean age of the participants in the study was 56.16 ± 12.29 and the mean body mass index was 32.71 ± 4.43. Of which, 53.3% of the patients were male and 36.7% of the patients had lung cancer. There was no significant difference between ultrasonography-guided method and the traditional method. Peripheral intravenous catheterization applications in terms of success rate (100.0%-93.3%), number of interventions (1 ± 0.0-1.20 ± 0.40), and state anxiety score means (46.93 ± 6.10-45.10 ± 6.60), respectively. In the USG-guided method, while the time spent was 63.33 ± 34.52 second, pain intensity was 1.53 ± 1.13, and satisfaction level was 9.76 ± 0.81, a significant difference was found in terms of the time spent (84.53 ± 47.13 second), pain intensity (2.96 ± 1.77), and satisfaction score average (7.433 ± 1.40) in the traditional method. A statistically significant difference was found between these results obtained in both application methods ($P < .05$). There were no complications that occurred in the patients of both application methods.

Conclusion: It was found that the application of peripheral intravenous catheter in ultrasonography-guided method reduced the time spent for the intervention, reduced the pain felt, and increased the level of satisfaction, however, had no effect in terms of complication development. The study is recommended to be repeated in different clinical area and patient groups.

Keywords: Peripheral intravenous catheterization, ultrasonography-guided, nursing care

Introduction

Peripheral intravenous catheterization (PIVC) is the procedure of placing a catheter into the peripheral vein by impairing the patient's skin integrity.[1] Peripheral intravenous catheterization application, which is within the scope of the legal authority and responsibilities of nurses, is one of the most frequently applied treatment methods, applied to more than 80% of patients admitted to the hospital.[1] Peripheral intravenous catheterization application is needed for reasons such as eliminating fluid and electrolyte deficiencies; administering irritant drugs such as chemotherapy, transfusion of blood and blood products; and providing total parenteral nutrition support, hemodynamic monitoring, and diagnostic aids.[2,3]

Nurses may encounter various difficulties during catheter placement. These difficulties may arise from factors related to the patient's condition, as well as depending on the clinical experience and skills of nurses. Some of these factors are age (infant, child, and old age), obesity, current health status, thrombophlebitis due to previous interventions, hematoma, ecchymosis, chemotherapy, peripheral edema, dehydration, hypovolemia, burns, deep or small in diameter veins, individual anatomical differences, past

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Corresponding author: Tuba Sengul,
E-mail: tsengul@ku.edu.tr

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experiences (history of unsuccessful PIVC application), fear of injection, and mental and emotional problems.[4,5] Repetitive unsuccessful attempts due to the difficulties experienced by nurses during PIVC application may lead to a decrease in motivation over time and the development of a sense of stress and panic.[6,7] In addition, repetitive unsuccessful PIVC attempts by nurses may lead to delays in patient care and the initiation of treatment.[8] The effort to increase the success of PIVC applications and to eliminate the negative factors caused by the patient led the nurses to search for different techniques. In this context, the use of vein viewer, near infrared devices, and ultrasonography (USG) in addition to the traditional method in emergency, intensive care, and pediatric services are among the methods tried for successful PIVC application.[9] USG-guided PIVC application is among the commonly used methods today in parallel with medical technological developments. The vein and the depth of the vein can be clearly visualized in both transverse and longitudinal axes with the USG-guided PIVC method without the need for inspection or palpation technique. At the same time, it can be understood whether the vein is an artery or a vein or whether it is an occluded vein by using the Doppler effect.[5]

The goals to be achieved in successful PIVC applications with USG are to reduce the number of multiple interventions, decrease the level of pain felt by the patient, not to damage the tissues and vein in the insertion area of the catheter, not to enter the artery, and not to develop complications such as nerve damage and infection. Thus, the trial-and-error method is eliminated; time loss in treatment is prevented; and the relationship of trust between the patient, family, and healthcare team members is preserved. As a result, the patient's satisfaction and comfort level increase by ensuring patient safety.[11] Besides all these, the fact that the USG device that can be used in the procedure is portable, does not contain radiation, does not require additional materials, the procedure is performed with a standard intravenous (IV) catheter, and the PIVC procedure is performed with USG makes the application more secure.[1] Two techniques, which are dynamic and static approaches, are used for USG-guided PIVC placement.[11-13] The dynamic approach has one or two users. In the single-person technique, the person performing the application must be experienced and follow the catheter insertion in coordination with the monitor during the application.[13] In the two-person technique, while one person uses the probe, the other person inserts the catheter into the vein. In this technique, practitioners must work in coordination with each other during the application and monitor the procedure simultaneously from the monitor. In the static approach, the entry point of the vein is marked after determining the localization of the vein with the USG probe. Intravenous catheter placement is performed with the traditional method from the marked point without imaging.[1,11]

When studies on successful PIVC application are examined, it is seen that the procedure has been performed with USG in different patient groups abroad since 1999 and many positive results have been obtained.[5,7,14-16] Although studies on the application of PIVC with USG are increasing,[17] studies on the applicability of PIVC in special patient groups with difficulties in application are limited. It is recommended to strengthen the level of evidence with more studies, especially because of the difficulties in the application of PIVC in certain patient groups treated with cancer and the lack of strong evidence in the systematic analyses.[18]

Aim of the Study

This research was conducted to evaluate the effectiveness of USG use in PIVC application.

Hypotheses of the Study

H_0: There is no difference between USG-guided and traditional PIVC applications in terms of the number of interventions, time spent, pain intensity, satisfaction level, and complication development frequency.

H_1: In USG-guided PIVC application, the success rate is higher, and the number of interventions is less compared to the traditional method.

H_2: In USG-guided PIVC application, the time spent is shorter, the pain intensity is lower, and the level of satisfaction is higher compared to the traditional method.

H_3: In USG-guided PIVC application, patient anxiety level and complication development frequency are lower compared to the traditional method.

Materials and Methods

Type of the Study

The research is a quasi-experimental study.

The Place and Sample of the Study

The population of the study consisted of patients who were treated in the outpatient chemotherapy unit of a private hospital, and the sample consisted of 30 patients among this population who met the inclusion criteria of the study. Individuals aged 18 and over, not being pregnant, undergoing chemotherapy for the first time, having the catheter inserted in the PIVC for at least 48 hours (for monitoring signs and symptoms of infection) body mass index (BMI) of 25 kg/m^2 and above (in patients with difficult vascular access), and voluntarily agreeing to participate in the study were determined as the inclusion criteria of the study. Pregnant women, children, and patients who had previously undergone chemotherapy were not included in the study. The research was performed between May 2014 and February 2015. The sample size of the study was calculated by using power analysis. The study was completed with 30 patients after it was determined that 30 patients were sufficient for sampling at a power of 80%, a margin of error of 5%, and a confidence interval of 0.95.[11]

The crossover method was used in this study to eliminate the differences that may arise from patient characteristics. The groups of the patients were determined by drawing lots. For this procedure, the patients were assigned to the groups by drawing lots from the bag containing 15 traditional methods and 15 USG-guided (dynamic approach, two-person technique) written papers (Figure 1). The first application was performed for the patients with a suitable method for the group they were assigned to. In both methods, veins in the antecubital region were used for PIVC application. When these patients came back to the outpatient clinic for treatment, the second application was performed with the traditional method in the USG-guided application group, and the second application was performed with the USG method in the traditional method group. A total of 60 PIVC applications, both with the traditional method and with USG, were performed on 30 patients within the scope of the study when the applications were completed.

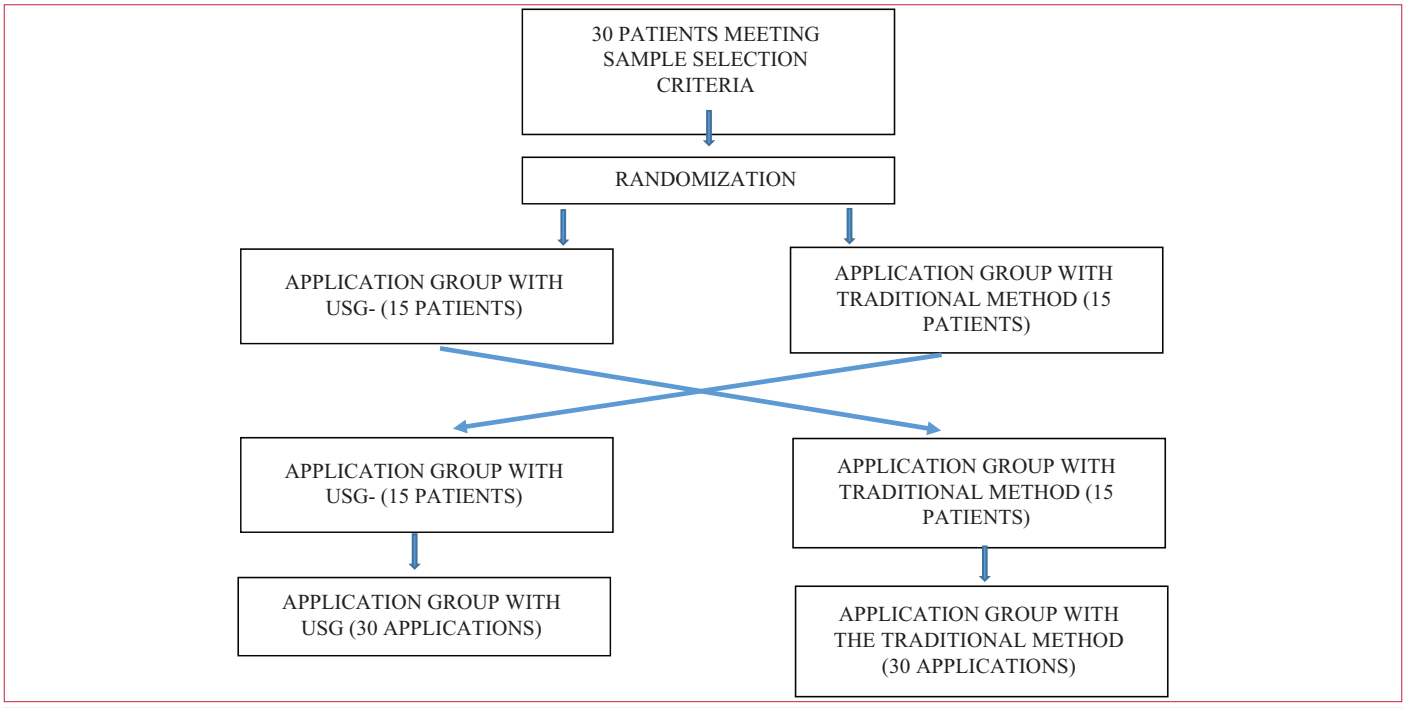

Figure 1. Flowchart of study selection.

Data Collection Tools

In the collection of data, Patient Information Form, State Anxiety Scale, Pain Perception Scale, Satisfaction Scale, Visual Phlebitis Diagnostic Scale, Infiltration Scale, and PIVC Follow-up Form were used.

The State Anxiety Scale is a very responsive tool for evaluating abruptly changing emotional reactions. It was developed by Spielberger et al in 1970, translated into Turkish in 1975 for validity and reliability, and adapted to the Turkish Society in 1985 by Öner and Le Compte.[19] The Cronbach α internal consistency coefficient of the scale ranges from 0.94 to 0.96, and the total score obtained from the scale varies between 20 and 80. A high score indicates a high level of anxiety, and a low score demonstrates a low level of anxiety. The Cronbach α internal consistency coefficient of the scale in this study was found to be between 0.90 and 0.92.

With the Pain Perception Scale (Visual Analog Scale, VAS), the patients were asked to mark the intensity of pain they felt during the PIVC insertion procedure on a 10-cm ruler with the words "No pain" at one end and "Unbearable pain" at the other end. The pain perception of the patients was scored between 0 (I have no pain) and 10 (I have unbearable pain).

In the Satisfaction Scale (with the Visual Analog Scale [VAS]), the patients were asked to mark their satisfaction level during the PIVC placement procedure on a 10-cm ruler with the words "very satisfied" on one end and "very dissatisfied" on the other. The satisfaction level of the patients was scored between 0 (not at all satisfied) and 10 (very satisfied).

The PIVC Follow-Up Form, which was prepared by the researcher in line with the literature, included information about the duration of catheterization, body temperature from the tympanic region, whether a culture was taken as a result of the development of a catheter-related infection, and whether hematoma, phlebitis, and infiltration developed in the catheter region in the patient who had a peripheral intravenous catheter. The Visual Phlebitis Diagnostic Scale, which was developed by Alyce Schultze and Paulette Gallant and adopted to 20 languages by Paşalıoğlu (2012), was used to determine the development of phlebitis. The Infiltration Scale, which is included in the 21 standards of the Infusion Nurses Association (2006), was used to evaluate the development of infiltration.

Implementation Phase

PIVC was placed by the researcher and two different nurses were working in the unit where the study was conducted. Both nurses who voluntarily supported the study had 5 years of professional experience in this unit. The researcher and one nurse only took part in the USG-guided (using dynamic approach–two-person technique), while the other nurse took part in the PIVC application, which was performed only with the traditional method. In the USG-guided PIVC application, the researcher used the USG probe, while the nurse inserted the catheter with simultaneous imaging. The other nurse inserted the catheter using the traditional method. The durations in the application were recorded by another nurse working in the clinic while both methods were applied.

Before the application, 1 hour of theoretical and 3 hours of practical training was given by the radiology specialist to the nurse who would perform the application with the guidance of researcher and USG. In the theoretical training, the technical introduction of the USG device, the selection of appropriate probe, the anatomical appearance of veins, the probe positions that enable the differentiation of

veins, arteries and other tissues during imaging were included. In the practical training, the position of the probe and the angle of holding the catheter in the evaluation of the transverse and longitudinal axes, how the depth of the veins was determined, and how the catheter was placed in the vein were shown in line with the information. At the end of this training, at least 10 successful applications were performed on the IV arm model by the researchers and nurses, and then the application phase was started. SonoSite M-Turbo Portable Doppler USG device (with 13.5 MHz superficial probe) belonging to the institution, from which the research data were collected, was used for all patients both during the training and the implementation phase of the study.

USG-guided PIVC Application

Patient Information Form and State Anxiety Scale were applied to the patients. With the dynamic approach (using the two-person technique), USG-guided PIVC was performed, and the patient's future date for the next treatment was recorded. After the PIVC procedure, the Pain Perception Scale and then the Satisfaction Scale were applied to the patients. It was noted that the next application would be performed with the traditional method.

In the application with the traditional method, all the steps were the same as the USG application phase, and the PIVC procedure was performed with the traditional method in the application. After both applications, the contact information of the researcher was given to the patients, and they were informed that they could call if they had a problem at home. Twenty-four hours later, the patients were called by phone and redness, pain, discoloration, etc., at the catheter site were questioned whether a condition occurred or not, and whether there was a change in body temperature. When the patients came back to the unit for chemotherapy after 48 hours, the body temperature was measured (from the tympanic region) by the researcher, the catheter site was checked in line with phlebitis and infiltration scales, and the evaluation results were recorded in the PIVC Follow-up Form (Figure 1).

Ethical Aspect of Research

Ethical committee approval was received from Koç University (Date: February 27, 2014, Decision No: 2013.129.IRB2.43), written institution permission of the hospital, where the practice was done, and of the nurses who participated in the study, written permission was obtained to ensure that they voluntarily supported the implementation phase and that they would not claim any rights when the research was completed. The purpose, plan, duration, and use of the data obtained were explained through the "Informed Consent Form," and written consent for their participation was obtained from the patients.

Analysis of Data

The data obtained in the study were analyzed using the SPSS (Statistical Package for Social Sciences) for Windows 22.0 program (IBM SPSS Corp.; Armonk, NY, USA). In the analysis of the data, Shapiro-Wilk test was used to determine the conformity of the data constituting the descriptive statistical methods (number, percentage, mean, standard deviation), independent variable (USG use), and dependent variables (time spent, number of attempts, anxiety state, patient satisfaction, pain, body temperature, and infection) to the normal distribution, and paired t-test was used to determine the difference between groups. The findings were evaluated with a confidence interval of 95%, assuming a $P<.05$ value for statistical significance.

Results

The mean age of the patients was 56.16 ± 12.29 (27-80), and the mean BMI was calculated as 32.71 ± 4.43 (25-43). It was determined that 53.3% of the patients were male and 36.7% of them were treated for lung cancer (Table 1).

In this study, when the success rate of PIVC procedure with USG and traditional method was compared, it was determined that the success rate in the practice performed with USG was 100%, while it was 93.3% in the traditional method, but there was no statistically significant difference between the two groups ($P > .05$; Table 2).

In the study, the mean number of interventions in the USG group was 1 ± 0.0, and 1.20 ± 0.40 in the traditional group. There was no statistically significant difference between the two groups in terms of the mean number of attempts ($t=-1.98$, $P > .05$; Table 3).

In the study, while the average time spent was 63.33 ± 34.52 seconds in the USG group, it was found to be 84.53 ± 47.13 seconds in the traditional group, and when the averages of time spent were compared, a statistically significant difference was found between them ($t=-2.55$, $P < .05$; Table 3).

In the pain severity assessment performed immediately after the PIVC application, it was determined that the mean pain score of the patients was 1.53 ± 1.13 in the USG group and 2.96 ± 1.77 in the

Table 1. Descriptive Characteristics of the Patients

Descriptive Characteristics	Mean ± SD	Min-Max
Age	56.16 ± 12.29	(27-80)
BMI	32.71 ± 4.53	(25-43)
	Number	%
Gender		
Women	14	46.7
Man	16	53.3
Type of cancer		
Lung cancer	11	36.7
Breast cancer	9	30.0
Colon cancer	8	26.7
Testicular cancer	2	6.6

SD, standard deviation.

Table 2. Distribution of PIVC Application Success by USG and Traditional Method According to PIVC Application Groups (N=60)

	USG Group (n=30)		Traditional Group (n=30)		
PIVC Application	n	%	n	%	*P*
Successful attempt	30	100	28	93.3	$x^2=2.069$ $P = .246$*
Failed attempt	0	0	2	6.7	

PIVC, Peripheral intravenous catheterization; USG, ultrasonography.
Chi-square test, * $P > .05$.

Table 3. Distribution of Measurement Means by USG-Guided and Traditional Method According to PIVC Application Groups (N=60)

	USG (n=30)		Traditional (n=30)			
Measurements	Mean ± SD	Min-max	Mean ± SD	Min-max	*t*	*P*
Number of interventions	1 ± 0.00	1	1.20 ± 0.40	1-2	–1.98	.303
Time spent (s)	63.33 ± 34.52	13-150	84.53 ± 47.13	35-210	–2.55	.01
Severity of pain	1.53 ± 1.13	0-5	2.96 ± 1.77	1-9	4.24	<.01
State anxiety	46.93 ± 6.10		45.10 ± 6.60		–1.98	.30
Satisfaction	9.76 ± 0.81	6-10	7.43 ± 1.40	4-10	7.86	<.01

PIVC, Peripheral intravenous catheterization; USG, ultrasonography; SD, standard deviation.
Paired *t*-test.

traditional group. The lower mean pain score in the USG group was found to be statistically significant ($P < .05$; Table 3).

In the study, it was observed that the mean of state anxiety (46.93 ± 6.10) in the PIVC application with USG was higher than the average of the state anxiety (45.10 ± 6.60) in the PIVC application with the traditional method. However, this situation did not demonstrate statistically significant difference ($t=1.790$; $P > .05$; Table 3).

In the study, it was determined that the mean satisfaction score of the patients in the USG group (9.76 ± 0.81) was statistically significantly higher than the patients in the traditional group (7.433 ± 1.40) ($P < .05$; Table 3).

It was observed that the mean body temperature after PIVC application with USG was 36.41 ± 0.16, and the average body temperature after PIVC application with the traditional method was 36.36 ± 0.2 when the averages of body temperature measured 48 hours after the practice were examined. No increase in body temperature was observed in both treatment groups, and no statistically significant difference was found between the mean body temperature scores ($t=1.071$, $P > .05$; Table 4). In the study, it was observed that patients who had PIVC placed with both USG and traditional method, when the catheter entry site was evaluated 48 hours after the practice, phlebitis, infiltration (Grade 0), and hematoma did not develop in line with the Visual Phlebitis Diagnostic Scale and Infiltration Scales (Table 5). As a result of these results, it was not necessary to take cultures from the patients.

Discussion

In the literature, it is emphasized that the USG-guided PIVC application has positive results for patients who have difficulty in vascular access and for nurses who want to access IV vascular access.[1,13-15]

Table 4. Distribution of Patients' Body Temperature by USG-Guided Method and Traditional Method According to PIVC Application Measurement Results (n=30)

	With USG (n=30)		Traditional Method (n=30)		*t*	*P*
Measurements after 48 hours	Mean	SD	Mean	SD		
Body temperature	36.41	0.16	36.36	0.24	1.071	.293

PIVC, peripheral intravenous catheterization; USG, ultrasonography; SD, standard deviation.
Paired *t*-test.

Although there was no statistically significant difference in this study, the observation that the success rate of the PIVC procedure performed with USG was slightly higher than the success rate of the traditional method and the average number of interventions was lower, which supported the literature. In similar studies generally performed in emergency departments and intensive care units, it is emphasized that the success rates of PIVC placement with USG and the average number of interventions are higher than the traditional method.[5,7,11,13,17,22-24] In this study, the fact that the success rates and the average number of attempts in two methods were close to each other was attributed to the fact that experienced nurses conducted the practices. It was thought that the slightly higher success rate of the first attempt in the PIVC application placed with USG was due to the clear visualization of the vascular structures by USG and the more anatomical images obtained for the differentiation of arteries, nerves, and other tissues. In the study, the first hypothesis of the research was not accepted as a result of the data obtained in the success rates and the number of attempts.

In the study, a significant difference was found between the averages of time spent for PIVC application with USG and traditional method. It was observed that the time spent in the application with USG was shorter. Similar studies by Keyes et al.[5] Costantino et al.[15] Bauman et al.[14] and Mahler et al[12] supported this finding indicating that the time spent for USG-guided PIVC application was shorter than the time spent in the application with the traditional method.

Although there are studies examining attempts to reduce pain in the PIVC application,[25] which is applied with the traditional method, only one study was found that examined the perception of pain during the PIVC application. In this study by İsmailoğlu,[17] it was determined

Table 5. Distribution of Complication Development Status in Patients with USG-Guided Method and Traditional Method According to PIVC Application Groups (n=30)

After 48 hours	With USG (n=30)	Traditional Method (n=30)	Total (60)
Degree of phlebitis	1	1	60
Degree of infiltration	0	0	60
Hematoma development	-	-	60

PIVC, peripheral intravenous catheterization; USG, ultrasonography.

that the mean pain intensity in the group treated with USG was lower than the group treated with the traditional method. In similar to İsmailoğlu's17 study, the severity of pain felt during PIVC application under USG was found to be lower in the study, which suggested that the less time spent in the USG-guided PIVC application, and the few numbers of interventions indirectly caused less pain in the patients. In the study, the pain intensity felt during PIVC application under USG was found to be lower.

The study indicated that the mean satisfaction score of the patients in the application of PIVC with USG was higher than the application with the traditional method. In the relevant studies,[10,12,14,15,26] the high level of satisfaction of patients who underwent PIVC with USG is in parallel with this finding. In the study, the difference between the two methods was found to be significant in terms of the average satisfaction scores of the patients. While this finding of the study was similar to the results of the studies above, it was also evaluated as a reflection of the shorter duration of the procedure, a smaller number of interventions and lower pain felt during the application in patients who underwent USG guided PIVC. The second hypothesis of the study was accepted in line with the results obtained in terms of the time spent in the study, pain intensity and satisfaction levels.

In this study, it was determined that the use of USG in the PIVC application did not affect the state anxiety levels of the patients. There was no study demonstrating the relationship between PIVC application and state anxiety. This finding was evaluated as a result of patients' perception of USG-guided PIVC application as a new method and their concerns about whether the application would be successful or not. In the study, it was observed that patients who had PIVC placed with both USG and traditional method, when the catheter entry site was evaluated 48 hours after practice, any complications (phlebitis, infiltration [Grade 0], and hematoma) did not develop. This study showed that no complications related to the intervention developed in accordance with the aseptic technique in both methods applied to the patients. Similarly, in the study of Mills et al.[24] when the catheter site was observed at 26 hours, no signs of infection were found, and it was determined that no colonization developed in the culture study performed after the catheters were removed. In the study conducted by Gregg et al.[22] it was determined that 0.7% of the patients developed phlebitis and 3.4% developed infiltration. In the systematic review of Düztepeliler et al.[27] it is emphasized that the use of USG is not superior to the traditional method in terms of complication rates, and the complication rates are close (infection, infiltration). While this finding of the study was similar to the research results of Mills et al.[26] it differed from the research results of Gregg et al[23] and Düztepeliler et al.[27] The third hypothesis of the study was not accepted while considering the anxiety levels and complication development results of the study.

Limitations of the Study

One of the limitations of this study is that it contains a relatively small sample (n=30) and the application was carried out in a private foundation hospital. Since the nurses who supported the research have 5 years of experience, it should be considered that the nurses' experience in practice may affect the success rate of the intervention in the PIVC application. In addition, since it was thought that different years of professional experience and the device used in the practice might affect the research results, it was ensured that the professional experience years of the nurses who supported the practice were similar and the same device was used in all interventions. Another limitation is that the data obtained from the study cannot be generalized to all patients treated in the chemotherapy unit due to the small number of patients. On the other hand, the data obtained from this study indicated that nurses should receive training on USG and that PIVC can be a useful method in interventions.

Conclusion

In this study, it was found that USG-guided PIVC application shortened the time spent for the intervention, reduced the pain felt during the application, and increased the level of satisfaction. On the other hand, it was found that there was no effect in terms of success rate, number of attempts, anxiety level, and complication development in practice. Although there was no difference between the two groups in terms of the number and rates of successful attempts, it is considered that the difference in favor of USG in the time spent, perceived pain, and satisfaction levels provide the necessary data for the more widely use of this method. It is very important to disseminate the USG-guided PIVC application, especially in order to reduce the pain during the procedure, as well as to provide timely care and treatment applications, to shorten the time spent in performing interventions in special clinical areas such as the emergency room, intensive care, and operating room. In addition, it is recommended to include the issue in in-service training programs in order to raise awareness about the application of PIVC with USG in future studies, and to repeat the research with different patients, age groups, and larger samples.

Ethics Committee Approval: Ethics committee approval was received for this study from Koç University (date and number: 2013.129.IRB2.43).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – T.Ş.; Design – T.Ş., R.A.; Supervision – R.A.; Resources – T.Ş., R.A.; Materials – T.Ş., R.A.; Data Collection and/or Processing – T.Ş.; Analysis and/or Interpretation – T.Ş., R.A.; Literature Search – T.Ş.; Writing Manuscript – T.Ş.; Critical Review – R.A.

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Declaration of Interests: The authors have no conflicts of interest to declare.

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