BMC Anesthesiology

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The effect of three different nonpharmacological methods on cannulation success during peripheral intravenous catheter placement in the emergency unit: a randomized controlled trial

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Abstract

Background Peripheral intravenous catheterization is frequently performed in emergency units, but it is a procedure which is difficult for healthcare professionals and painful for patients. The primary objective of the present study was to examine the effect on venous dilation, procedure duration and pain severity of local heat, cold and vibration applications performed on the intervention area before peripheral intravenous catheterization in adults. The second objective of the study was to examine the effects of age and gender variables on the participants' pain intensity levels.

Methods A single-blinded randomized controlled trial. The study included 120 adults who were randomly selected between March and August 2023. One application group ($n=30$) received local heat application, one group ($n=30$) received local cold application, and one ($n=30$) received local vibration using the Buzzy® device. The applications, to the site of the peripheral intravenous catheterization, lasted one minute. The control group ($n=30$) received standard peripheral intravenous catheterization application. The groups' vein dilation was assessed with the vein assessment scale, pain felt during catheterization with the visual analog scale, and the duration of the procedure with a chronometer.

Results It was found that the venous dilation of the cold application group was significantly higher ($p=0.010$, $p=0.015$ respectively) and procedure duration was shorter ($p=0.013$, $p<0.001$ respectively) than that of the heat and vibration application groups, and its pain severity was significantly lower ($p=0.002$, $p=0.001$ and $p=0.001$ respectively) than that of the control group and the heat and vibration application groups.

Conclusions It was determined that local cold application for one minute to the area of peripheral intravenous catheterization increased venous dilation, shortened application time, and reduced pain.

Trial registration ClinicalTrials.gov ID NCT06378424, retrospectively registered 20/04/2024.

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Keywords Cold application, Heat application, Pain management, Pain, Peripheral intravenous catheterization, Vibration

Background

Every year throughout the world, approximately two billion people undergo peripheral intravenous catheterization (PIC) [1]. In a study on the subject, it was found that the prevalence of PIC was 47% [2]. PIC is commonly performed by health services to give a patient fluid replacement or to administer drugs intravenously, for transfusion of blood or blood products, for total parenteral nutrition, for emergency interventions, or to carry out hemodynamic monitoring [3].

PIC is an invasive procedure which is commonly performed in clinics and emergency units for the purpose of treatment [4, 5]. It is among the primary procedures which are performed with most patients in the emergency units [6]. It was stated in one study that more than half of patients in the emergency units undergo PIC [7].

In the literature, PIC is reported to be a painful and uncomfortable procedure for patients [8]. It is reported that the difficulties experienced during PIC can cause a delay in diagnosis and treatment, stress for patients and their relatives, exposure to repeated invasive procedures, and related pain [8, 9]. In addition, unsuccessful PIC can increase the time and cost for securing intravenous access, and can extend the time spent by the patient in the emergency units [6]. In this regard, it is stressed that PIC and the pain and discomfort associated with it can be avoided by careful assessment, taking various measures and applying an effective method [10].

Non-pharmacological methods of bringing pain under control are one of the complementary elements in the approach to the comprehensive reduction of pain. Non-pharmacological methods used in treatment have a greater effect on the emotional, cognitive, behavioral and sociocultural aspects of pain [11]. Also, non-pharmacological methods are low-risk, cost less, and are practicable and easy to apply, and so they constitute a complementary element in the approach to pain reduction [12].

Examining previous studies, it is seen that examinations have been made of the effects on the control of pain and discomfort experienced during PIC of such non-pharmacological methods as the Valsalva maneuver [8, 13] virtual reality [14], the ShotBlocker® apparatus [15], aromatherapy [9] and diverting the attention elsewhere [16]. Apart from these methods, it is seen that other methods to reduce the pain experienced during PIC have been widely used recently, namely local heat application to the intervention site [17–22] local cold application [19, 23, 24] and the Buzzy® device, which is a combination of local cold application and vibration [25].

It is reported in the literature that local vibration [26] and local cold and heat applications [19] reduce pain, activate large-diameter fibers, prevent small-diameter fibers from transmitting pain messages, and close the gate to the passage of stimuli as pain. That is, these kinds of peripheral stimuli raise a person's pain threshold and thus help to control pain [19, 24].

On the other hand, it is seen that the Buzzy® device, designed to use a combination of cold application and local vibration to reduce the pain of invasive procedures, is frequently preferred by all age groups. Buzzy® is a device in the shape of a bee with ice bags in the shape of wings which can be attached to its back. It can be used repeatedly and has a CE certification (Fig. 1). It comes in different sizes, for use with adults and children, but is approximately 8×5×2.5 cm in size [26]. Its mechanism depends on attracting the attention elsewhere and suppressing the feeling of pain using vibration provided by its body, according to the gate control theory [27]. Also, ice bags in the form of wings are attached to the back of the body of Buzzy®, and these fit to the part of the body to be treated [26]. Apart from its use with cold application and vibration together, it can also be used for cold application only, using the wings.

Healthcare professionals play an important role in pain management, and it is emphasized that they should use effective methods in the control of the pain arising from invasive procedures which are easy to use, low cost, and without side effects [27]. Examining studies on the topic, it is seen that there are very few studies which examine the effect of local heat, cold and vibration applications to the intervention area in PIC on parameters such as pain severity, venous dilation and procedure duration. Also, no studies were found evaluating the effect of these techniques together on pain severity, venous dilation or procedure duration.

In emergency units, it is important to use non-pharmacological methods which are easy to use, practical, accessible and cheap. In this regard, it is felt that, in emergency units, where fast and effective interventions are needed, non-pharmacological methods will be effective in bringing under control the pain developing in connection with PIC, in reducing procedure time and in increasing the visibility of veins, and that patient satisfaction and trust can be increased in this way, and thus a need was felt for this research.

The aim of this research, then, was to examine the effect on venous dilation, procedure duration and pain severity of local heat, cold and vibration applications to the intervention area before PIC in adults.

Fig. 1 Buzzy® [Reference; 26]

Methods

Study design

The research was conducted as a randomized controlled single-blind experimental study. It was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines. The flow diagram of the stages in the study procedure can be seen in Fig. 2.

Study setting

The research was conducted between March and August 2023 in the yellow and green area of the emergency unit of a university hospital in the Marmara region of Turkey. The areas of the unit where the research was conducted has 20 beds, and performs a daily average of 150 PICs.

This study was approved by Bursa Uludağ University, Faculty of Medicine Clinical Research Ethics Committee (IRB approval number 2023-6/6) and registered (20/04/2024) in the ClinicalTrials.gov Protocol Registration and Results System (https://clinicaltrials.gov/) with trial registration number NCT06378424. Prior to enrollment, written informed consent was obtained from all study participants.

Participants and sampling

The research sample consisted of 120 adults, 30 in each study group, who fitted the criteria of the research. Their complaints were mostly of vomiting, diarrhea or respiratory system problems.

The size of the sample was determined statistically by power analysis with the use of the program G*Power 3.1.9.6. Using information in the study by Korkut et al. (2020), in which measurements of pain level of groups were measured, to determine sample size in the study (s=1.9), the effect size was determined to be 0.29. For 80% power and a 5% significance level, it was decided that 120 individuals should be included in the study, with 30 in each group. The criteria for inclusion in the research sample were being aged between 18 and 65 years, being able to evaluate the visual analog scale correctly, and participating voluntarily in the research. Exclusion criteria were as follows: being in shock, having delirium or dementia, the appearance of the vein not being good (patients with a high risk of unsuccessful cannulation at the first attempt because of poor vein condition), having a vision or hearing problem, having a mastectomy, having any illness which could affect pain perception, such as sensory-motor disorder, diabetes, peripheral vascular diseases or peripheral neuropathy, having an allergy to heat and cold application, having phlebitis, scar tissue, dermatitis, an incision or findings of infection at the place where the intervention was to be performed, having any trauma or pathological finding in the veins on the hand, having had any catheterization or having had blood samples taken from the hand in the previous week, having taken an analgesic (within the previous six hours) or an anesthetic agent before the PIC procedure, and not wanting to participate in the research or wishing to withdraw during the course of the research.

A simple and stratified randomization method was used in the study. The reason for stratified randomization is that some studies state that age [28] and gender [29] affect pain. Therefore, in order to check the effect of age and gender on the results of the study interventions and thereby to increase the reliability of the results, individuals were classified according to age (into an 18–45 age group and a 46–65 age group) and gender (male-female) when randomization was performed. Those who agreed to participate in the research were assigned to a group by means of a list of electronically generated random numbers from one to four. Those with the number 1, 2 or 3 were assigned to the application groups, and those with the number 4 were assigned to the control group. After the individuals were divided into four groups, the study groups were assigned applications by drawing lots, with closed envelopes containing the numbers. In order to reduce bias in the randomization process, it was performed by a nurse who worked in the unit where the study was conducted, but who was not involved in the study.

Outcomes of the study

The primary outcome of this study was to examine the effects of local heat, cold and vibration applications applied to the intervention area before PIC on venous dilatation, procedure duration and pain intensity in adult individuals admitted to the emergency unit.

The secondary outcome was to determine the effects of age and gender variables that might affect the severity of pain developing due to PIC application in these individuals.

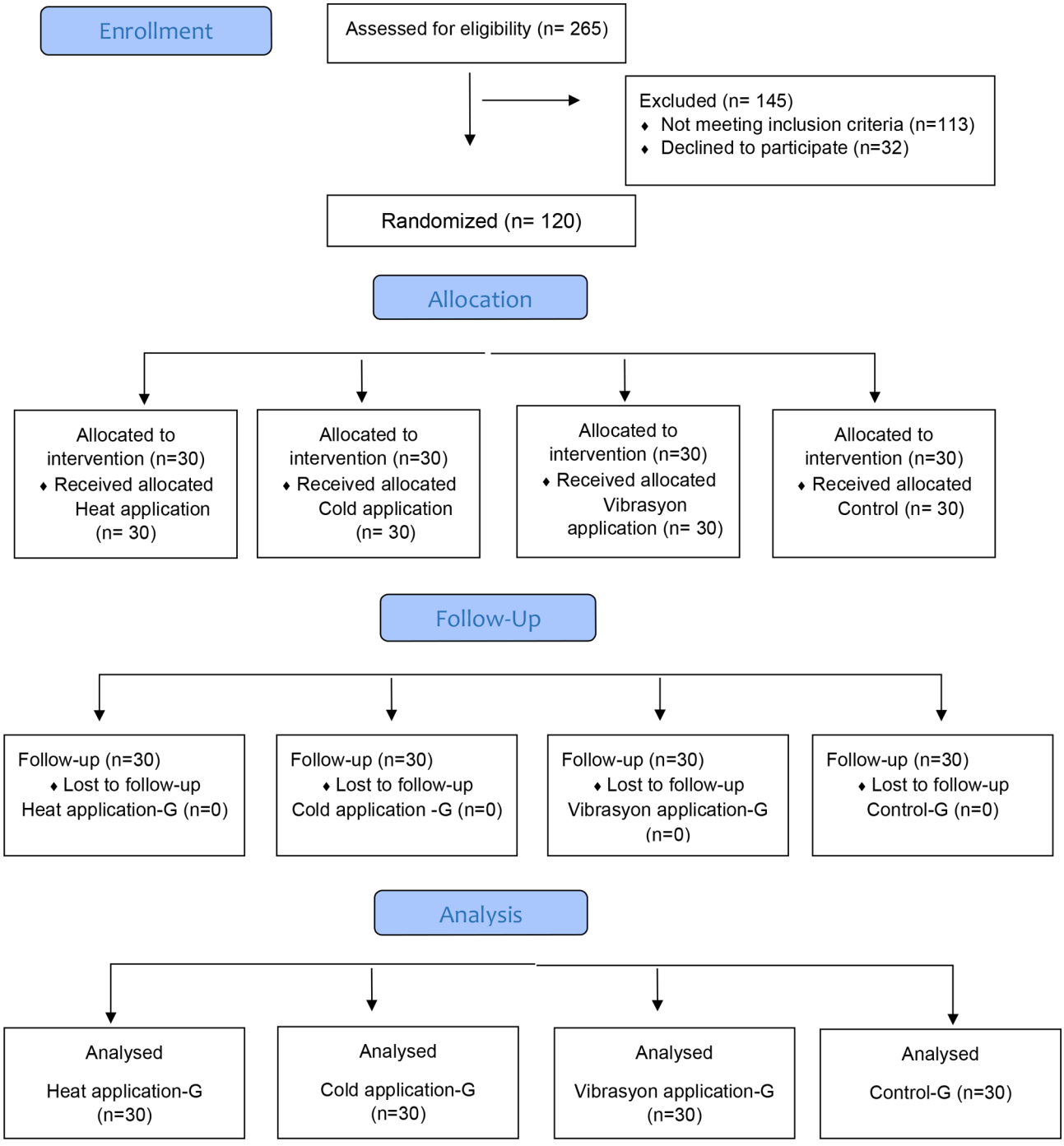

Fig. 2 Flow diagram of the participant selection process for the trial

Data collection

Data collection tools were the demographic questionnaire, Vein Assessment Scale and Visual Analog Scale (VAS).

Demographic questionnaire

This questionnaire collected information on the patient's study group, their age, gender, height, weight, body mass index (BMI), and in relation to the PIC procedure, the degree of venous dilation, the procedure duration and the pain severity.

Vein assessment scale

This scale was used in the study to evaluate individuals' veins. There are five assessment steps: (1) veins are neither visible nor palpable, (2) veins are visible but not

palpable, (3) veins are barely visible and palpable, (4) veins are visible and palpable, and (5) veins are clearly visible and easily palpable [19].

Visual analog scale (VAS)

A 100-mm vertical VAS was used to evaluate the severity of pain felt by the individuals during the procedure. One end indicated lack of pain and the other the most severe pain possible [30].

Procedure

After obtaining the approval of the individuals included in the study, their descriptive information was recorded on this form by face to face interview. After that, they were instructed on the use of the VAS. All PIC procedures were carried out by a single researcher. A 20 gauge catheter was used for all catheterization procedures, and all PIC interventions were performed on the dorsal metacarpal vein of the right or left hand.

In the application groups, before and after the application of local heat, cold or vibration, and immediately before performing PIC, the Vein Assessment Scale was used to assess the vein on which the intervention was to be conducted. In the control group, vein assessment was performed only once, before the catheterization procedure.

The automatic tourniquet was applied to the application groups immediately after heat, cold and vibration applications. In the stages of the PIC intervention of individuals in the application and control groups, a chronometer was started immediately after an automatic tourniquet was attached to the patient's arm. After catheterization was completed successfully and before the evaluation material was applied, the chronometer was stopped, and the procedure duration was recorded in the form of seconds on the data collection form.

The standard PIC procedure was conducted on all individuals in all groups. Immediately after the procedure, the individuals in all groups were asked to assess their pain severity on the VAS, and the scores which they indicated were recorded on the data collection form. Grading of the individuals' vein visibility and palpation, duration of procedure and assessment of pain severity levels were performed by a nurse who was unaware of the method used and not connected to the research.

Cold application group

Before PIC, dry cold was applied to the application area using a cold gel pack. For this purpose, an 11×10 cm pack of non-toxic gel was frozen solid in the refrigerator. The cold gel pack had the feature of preventing pain and sticking that may occur on the skin thanks to its cottony surface. Because this pack is reusable, it was disinfected before and after each use, and left in the service refrigerator to freeze solid. Care was taken that it was used in solid form with all individuals.

Heat application group

Before PIC, heat of approximately 40-42ºC was applied for 1 min to the area of the procedure using a hot pack, which is one of the dry heat application methods. The heat application pack has a feature that it can maintain its temperature when taken out of hot water and does not disturb the person when it comes into direct contact with the skin. In order to apply heat to the individuals in this group, a pack of 11×19 cm is used. This pack is covered with cloth and contains a non-toxic gel, and is placed in hot water to prepare it for use. This pack had the feature of preventing pain and sticking that may occur on the skin thanks to its cottony surface. Because this pack is reusable, it was disinfected before and after each use.

Vibration application group

With individuals in this group, the Buzzy® device was used to provide vibration. The Buzzy® device, at room temperature, was placed by the researcher on the PIC application area before the application was performed. For one minute before the application, a slight, non-discomforting vibration was applied to the intervention area. As the Buzzy® device can be used more than once, it was disinfected after each use and before being used with another individual. In this study, the body of the device was used, and only vibration was applied to the individuals in this group.

Control Group

No intervention was performed on the control group before the PIC procedure, and the standard PIC procedure was performed.

Data analysis

Statistical analyses were performed with IBM SPSS version 28.0 (released 2021, IBM Corp., Armonk, NY, USA). The data were examined by the Shapiro-Wilk test to determine whether or not they presented normal distribution. The descriptive statistics were presented as mean ± SD, frequency and percentage. The Kruskal-Wallis test was used in the evaluations of variables that did not show normal distribution between more than two groups. The Bonferroni test was used as a multiple comparison test. The Mann-Whitney U test was used in the comparison of variables which did not show normal distribution, and the Spearman correlation test was used to show the correlation between variables. Categorical variables were compared using Pearson's χ^2 test and Fisher's exact test between groups. The significance level was taken as $p<0.05$.

Table 1 Demographic characteristics of participants

Variable	Categories	*n* (%) or mean ± SD						
		Heat application	Cold application	Vibration application	Control	Total	Test Value	*p*
		(*n* = 30)	(*n* = 30)	(*n* = 30)	(*n* = 30)	(*n* = 120)		
Gender	Female	15 (50)	15 (50)	15 (50)	15 (50)	60 (50)	-	-
	Male	15 (50)	15 (50)	15 (50)	15 (50)	60 (50)		
Age (years)		53.73 ± 12.98	53.20 ± 11.15	52.96 ± 14.04	53.10 ± 13.51	53.25 ± 12.80	0.592	0.744
BMI		26.33 ± 6.96	26.72 ± 7.43	28.50 ± 5.92	25.53 ± 4.19	26.77 ± 6.27	3.466	0.177

Descriptive statistics are given as mean ± standard deviation or n (%)

BMI, body mass index

Kruskal-Wallis test was used

Table 2 Comparison of groups' vein assessment mean differences before and after heat, cold and vibration applications

Variables	Comparison between groups		Difference	*p*	95% confidence interval	
			Mean±SD		Lower bound	Upper bound
Before						
Vein Assessment Scale	Cold application	Heat application	-0.26 ± 0.22	0.590	-0.87	0.34
		Vibration application	-0.40 ± 0.22	0.494	-1.01	0.21
		Control	0.46 ± 0.22	0.259	-1.07	0.14
After						
Vein Assessment Scale	Cold application	Heat application	0.76 ± 0.25*	0.015	0.14	1.38
		Vibration application	0.73 ± 0.25*	0.010	0.11	1.35

SD, standard deviation

*By post hoc Bonferroni test, $p < 0.05$

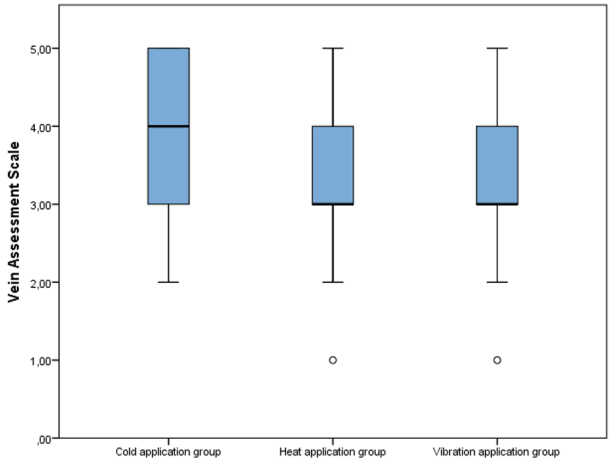

Fig. 3 Comparison of application groups' vein assessments (n=120)

Results

Participants' characteristics

It was found that 50% of those who participated in the research were female, their mean age was 53.25 years (SD=12.80), and their mean BMI was 26.77 kg/m^2 (SD=6.27). Homogeneity was identified within all groups of the 120 participants in the study (Table 1).

The groups' vein assessment scale scores

In the individuals in the application and control groups before the procedure, the Vein Assessment Scale mean scores were 3.23 (SD=1.0) in the heat application group, 2.96 (SD=0.6) in the cold application group, 3.36 (SD=0.9) in the vibration group and 3.43 (SD=0.8) in the control group. No significant difference was found between the groups' pre-application Vein Assessment Scale score means in the result of the statistical analysis ($\chi^2=5.27$, $p=0.153$). From these results, it was seen that before the application, the groups were homogeneous with regard to vein assessment (Table 2).

Immediately after the heat, cold and vibration applications and before the PIC procedure, the application groups' Vein Assessment Scale score means were found to be 3.33 (SD=1.0) in the heat application group, 4.10 (SD=0.9) in the cold application group, and 3.36 (SD=0.9) in the vibration group (Fig. 3). A significant difference was found as a result of the statistical analysis between the Vein Assessment Scale score means of the application groups ($\chi^2=10.403$, $p=0.006$). In the result of the analysis performed to determine the Vein Assessment Scale score differences between the application groups, it was found that the Vein Assessment Scale score of the cold application group was significantly higher than that of the heat application group ($p=0.010$) or the vibration group ($p=0.015$), but that there was no significant effect between the heat application and the vibration groups ($p=0.505$, Table 2). It is seen from the result of the study that venous dilation in the cold application group was significantly higher than in the heat and vibration application groups.

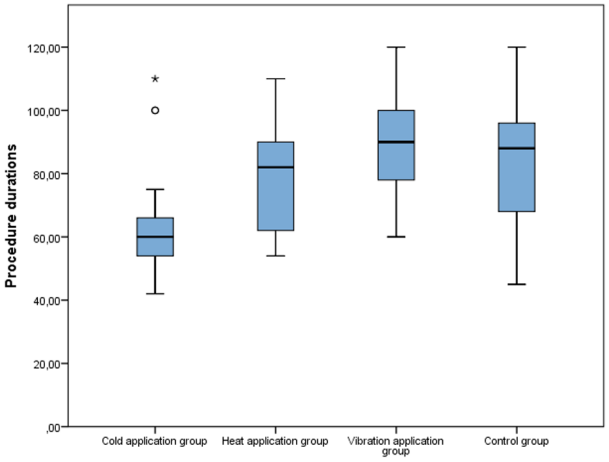

Fig. 4 Comparison of application groups' procedure durations (n=120)

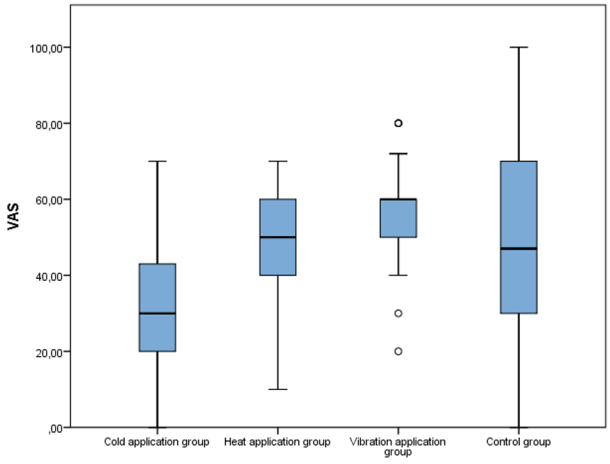

Fig. 5 Comparison of groups' perceived pain severity (n=120)

Duration of the groups' PIC procedure durations

The groups' mean durations of the PIC procedures were recorded as 77.46 (SD=16.97) seconds for the heat application group, 63.63 (SD=15.95) seconds for the cold application group, 88.40 (SD=16.40) seconds for the vibration group, and 81.46 (SD=18.97) seconds for the control group (Fig. 4). A significant difference was found in the statistical analysis results between the PIC duration means of the application and control groups ($\chi^2=26.64$, $p<0.001$). As a result of two-way comparisons made to determine this difference, it was seen that the PIC duration of the cold application group was significantly shorter than that of the control group ($p=0.001$), the heat application group ($p=0.013$), and the vibration group ($p<0.001$), but there was no significant effect between the control group and the heat application group ($p=0.995$) and the vibration group ($p=0.716$) or between the vibration group and the heat application group ($p=0.089$, Table 3). It was seen from the result of the study that the duration of the PIC procedure of the cold application group was significantly less than that of control, heat and vibration groups.

Groups' VAS scores

The pain severity scores of individuals in the application and control group after PIC were found to be 48.66 (SD=17.16) for the heat application group, 30.50 (SD=16.78) for the cold application group, 56.66 (SD=14.03) for the vibration group and 48.36 (SD=24.02) for the control group (Fig. 5). The results of statistical analysis showed a significant difference between the VAS score means of the application and control groups after PIC ($\chi^2=25.78$, $p<0.001$). It was seen as a result of the analysis conducted to determine this difference that the VAS score of the cold application group was significantly lower than that of the control group ($p=0.002$), the heat application group ($p=0.001$) and the vibration group ($p=0.001$), but there was no significant effect between the control group and the heat application group ($p=0.980$) and the vibration group ($p=0.497$) or between the vibration group and the heat application group ($p=0.567$, Table 3). It was seen from the study results that the pain severity in connection with the PIC procedure of the cold application group was significantly less than that of the control, heat and vibration application groups.

Table 3 Comparison between experimental and control groups of mean PIC procedure duration and pain severity score differences

Variables	Comparison between groups		Difference	*p*	95% confidence interval	
			Mean±SD		Lower bound	Upper bound
PIC application duration (sec)	Control	Heat application	4.00 ± 4.41	0.995	-7.86	15.86
		Cold application	17.83 ± 4.41*	0.001	5.97	29.69
		Vibration application	-6.93 ± 4.41	0.716	-18.79	4.92
VAS (mm)	Control	Heat application	-0.30 ± 4.74	0.980	-13.03	12.43
		Cold application	17.86±4.74*	0.002	5.13	30.60
		Vibration application	8.30±4.74*	0.497	-21.03	4.43

Abbreviations SD, standard deviation; PIC, peripheral intravenous catheterization; VAS, visual analog scale

*By post hoc Bonferroni test, $p<0.05$

Participants' age and gender variables and their VAS scores

A weakly significant positive correlation was found between the participants' age variable and their VAS score ($r=0.201$, $p=0.028$). It is seen from these findings that as the individuals' age increased, the pain perception levels also increased.

The VAS score of females participating in the study was found to be 45.71 (SD=22.37), and that of male participants was found to be 46.38 (SD=18.69). It was shown as a result of statistical analysis that there was no significant difference between the variable of the participants' gender and their mean VAS scores (Z= -0.225, $p=0.822$).

Discussion

It was found as a result of this study that local cold application applied to the area before PIC increased venous dilation, shortened procedure duration and reduced the severity of pain following the procedure compared with heat or vibration application. From these results, it can be said that local cold application for one minute at the PIC site increased the success of the cannulation procedure.

There are few studies on the effect of local cold application on the pain of PIC. It was found by Meha as a result of a study conducted to determine the effect on pain perception of local cold application in adult patients when PIC was performed that local cold application was effective in reducing the pain of PIC [24]. Çelik and Düzkaya found that local cold application applied to the area before PIC in child patients in the 7-15-year age group significantly lowered pain and fear scores in comparison with children given the standard PIC procedure [23]. It is reported that cold application slows the ability of pain fibers to transmit pain [19]. This is explained by the gate control theory. This theory suggests that pain is transmitted from the peripheral nervous system to the central nervous system, where it is modulated by a gating system in the dorsal horn of the spinal cord. It has been suggested that the afferent pain-receptive nerves are blocked by faster non-noxious motion nerves [27]. Prolonged cold stimulates the C fibers and may block the A-delta pain signals. Cold may also result in enhanced activation of supraspinal mechanisms, increasing the body's overall pain threshold [25]. The results of the present study support the above-mentioned study results, and show that local cold application applied for one minute to the area is effective in reducing the pain developing in connection with PIC.

Heat application increases the venous blood flow and dilates the veins to increase their fullness [19, 20]. In terms of safety and venous dilation effects, it is recommended that the surface temperature of heated items applied to the skin should be 40±2 °C [31]. There are studies in the literature evaluating the effect of local heat application alone on pain and veins in PIC. In a study by Bayram and Caliskan with patients receiving chemotherapy, it was reported that local heat application applied for 10 min to the area before PIC was effective in chemotherapy patients whose vein visibility was poor [17]. Homayouni et al. conducted a study with the aim of determining the effect of local heat application on vein diameter in the antecubital region. The individuals' forearms were heated for 10 min using a heating device kept at 42 °C. As a result of the study, it was found that local heat application increased the diameter of the cephalic vein by 0.43±0.4 mm, and effectively increased vein visibility [18]. Yasuda et al. reported that seven minutes of dry and moist heat application applied to the forearm region increased vein visibility before PIC [31]. In a study by Mamdouh Abu Zead et al. with patients receiving chemotherapy, it was found that local heat application applied to the region for 10 min increased vein visibility, and decreased procedure duration and the duration of the pain connected with the procedure [20]. Similarly, Sharma et al. found that 10 min of local heat application increased vein visibility and decreased procedure duration and the duration of the pain connected with the application [22]. It is seen that the results of the studies mentioned above and the findings of the present study are not similar. It is thought that this difference may derive from the duration of the heat application to the PIC area. In the present study, heat was applied to the PIC area for one minute, but in the other studies, this was done for seven or 10 min. Yamagami et al. stated that five minutes of local heat application was enough to stimulate vasodilation for PIC [32]. The fact that this study was conducted in the emergency units, where fast and practical interventions are necessary, was the greatest factor in the duration of the local heat application being kept to one minute. In the studies above, extending the duration of the local heat application may have increased venous dilation, widening the veins where the PIC was to be carried out, and may have reduced the perception of pain. The one-minute local heat application in our study may have been inadequate in increasing venous dilation and reducing pain severity. Seen from this angle, it is thought that the duration of the heat application applied to the individuals participating in our study was not sufficient to reduce pain severity and increase vein visibility and dilation, and thus did not affect the duration of the procedure.

It was seen that there were very few studies evaluating local heat and cold applications together in the PIC procedure. Korkut et al. [19] conducted a study with the aim of examining the effect on pain, anxiety level, PIC placement duration and venous dilation of one-minute local heat and cold applications to the area before PIC intervention. A 20-gauge catheter was used with all of the participants included in the study. It was found that local

heat and cold applications applied before PIC placement reduced both the pain and anxiety levels of patients. It was reported that local heat application increased venous dilation and shortened the duration of the procedure, while cold application reduced vein visibility and lengthened the duration of the procedure [19]. When venous dilation increased in connection with the method applied in the PIC intervention, it was expected that the procedure duration would be shortened in parallel. Our study findings were seen to be similar to this study with respect to cold application reducing the severity of pain associated with PIC. However, despite the similarity in duration with heat application, in that study, a significant effect of heat application was found in individuals' pain severity, venous dilation and procedure duration, whereas in our study, it was found not to have an effect. In our study, in contrast to these findings, it was seen that cold application increased venous dilation and thus shortened procedure duration. The local cold application applied for the short time of one minute to the individuals participating in our study may have affected vein palpation according to their vein structure, but may not have affected vein visibility. In comparison with local heat application, this may not have created a significant difference in entry to the vein. From another aspect, it was thought that the differences between the two studies might arise from the demographic characteristics of the individuals participating in the two studies such as age, gender or the presence of chronic illness, and from the area where the PIC intervention was performed.

No studies were found in the literature investigating the effect of the application of vibration on the pain related to PIC intervention, but it has been reported that it reduces the pain associated with various invasive interventions [33–35]. It has been stated that the control of the vibration technique on pain is explained by gate control theory [27]. It was seen in our study that vibration applied to the area of PIC application had no effect on venous dilation, procedure duration, or the pain associated with the procedure. The results of our study are different from the findings of the studies mentioned [33–35]. It is thought that this derives from the difference in the invasive intervention. In the studies mentioned, the effect of the application of vibration on the pain arising from intramuscular injection was examined, while in our study, the effect on pain arising from the PIC procedure was investigated. Thus, it may be thought from the results of our study that short duration vibration application applied to the region of PIC application may not have been effective. On the other hand, several studies have found that the combination of vibration and cold applied with the Buzzy device reduced the pain connected with PIC [25, 36, 37]. From these results, it may be thought that in the reduction of pain relating to the PIC procedure, the use not of vibration alone but together with cold application is more effective.

With age, sensory mechanisms and behavioral, hormonal and social factors may affect the perception of pain. In connection with this, it is emphasized that in older adults, it is important to set out the relation of the experience of pain to changes in biological, psychological and social factors which occur in aging [38]. It was reported in a study that compared with young people, the mean pain threshold significantly increased in old people [39]. In some studies in the literature, it is reported that the variable of age affects the perception of pain connected with invasive procedures [28, 34]. It was seen that as the age variable of the participants in our study increased, their sensitivity to pain also increased. Our study findings are similar to the results of the above studies, but it must not be forgotten that more than one factor may affect the interaction between pain perception and the variable of age.

It was found in the results of this study that the variable of gender did not affect pain severity in the participants. In some studies, it has been found that the variable of gender significantly affects pain severity [29, 34], while in others, it has been concluded that gender has no effect on pain [35, 40]. Our study results are similar to some of the above results, but different from others. It is thought that the differences may arise from the types of invasive procedures and from the individual variables of the sample.

It has been stated that in emergency service units, more than one catheterization attempt is necessary in patients whose vein dilation is bad, and that this increases costs for health institutions [6]. In a study conducted with 1512 patients at three hospitals in Australia, the cost of catheterization for patients which was successful at the first attempt was approximately 9.32 euros, but when five attempts were necessary, the cost rose to 65.34 euros [41]. From these results, it can be said that a successful catheterization has a positive effect on health institution costs. In our study, we did not determine the rates of first PIC success, and therefore we could not calculate total catheter costs. However, in evaluating the intervention costs in our study, the total cost of the cold gel packets and the hot gel packets which we used with the application groups were calculated to be 140.0 Turkish liras (Approximately $4), while the cost of the Buzzy® device was $44.95. Particularly today, when health costs are rising, the cost of an intervention may affect its clinical application. In this regard, when it is considered that local cold application performed with a cold gel packet can be effective in a successful PIC, it is foreseen that this cheap non-pharmacological intervention may be preferred by health institutions.

This study has a number of limitations. The first of these is that the study was conducted at a single center

with a small sample consisting of those coming to the emergency unit of one hospital, and for this reason the findings cannot be generalized. To provide reliability regarding the reduction in pain and the increase in venous dilation occurring in connection with the application of PIC, there is a need for studies with a greater sample size. A second limitation is that the duration of the local hot, cold and vibration applications carried out on the patients was limited to one minute, the number of first catheter placement attempts in the catheterization procedure was not given, and only the veins on the hand were used for the procedure. A need is felt for studies in which different application durations and regions (for example the veins of the forearm) are considered, non-pharmacological methods are compared, and the number of first catheter placement attempts is taken into account. A third limitation is that participants' vein dilation was assessed with the Vein Assessment Scale and that in the catheterization procedure, a 20-gauge catheter was used. These variables may have affected the visibility of the participants' vein diameters and their sensitivity to pain. A need is felt for studies which objectively assess vein dilation with a ruler placed on the vein or with ultrasound, and which compare different catheter sizes. A further limitation of the study is that the variables of needle phobia, anxiety levels and hemodynamic changes, which could have affected participants' pain sensitivity, were not evaluated. Needle phobia and the anxiety experienced in the emergency units especially may have affected the participants' sensitivity to pain.

Conclusion

As a conclusion of the study, it was found that when local cold application was compared with the vibration and control groups, one minute of local cold application to the PIC area increased vein dilation, shortened the duration of the procedure, and reduced the severity of pain associated with PIC. Also, it was seen that local heat application applied for one minute was not sufficient in increasing venous dilation. These results show that one minute of local cold application to the PIC area had a positive effect on the success of cannulation. In emergency unit environments, where PIC procedures are often performed and speedy interventions are important, the method of cold application provided by a cold gel pack is a method which is accessible, without side effects, easy to use, and cheap. For this reason, it may be preferred by healthcare professionals for use before PIC.

Abbreviations

BMI	Body Mass Index
IV	Intravenous
PIC	Peripheral Intravenous Catheterization
SPSS	Statistical Package for the Social Sciences
VAS	Visual Analog Scale

Acknowledgements
We would like to thank patients who participated in the study.

Author contributions
EY: Conceptualization, Methodology, Writing – original draft and editing. DY: Conceptualization, Formal analysis, Writing – original draft and editing.

Funding
This research received no external funding.

Data availability
The datasets used and/or analysed during the current study is available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The whole research was conducted in accordance with the Declaration of Helsinki. This study was approved by Bursa Uludağ University Faculty of Medicine Clinical Research Ethics Committee (IRB approval number 2023-6/6) and registered (20/04/2024) in the ClinicalTrials.gov Protocol Registration and Results System (https://clinicaltrials.gov/) with trial registration number NCT06378424. Written informed consent was obtained from the patients to publish this article in accordance with the journal's patient consent policy. Data confidentiality was ensured, and the results were provided to the participants at their request.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 23 June 2024 / Accepted: 9 September 2024
Published online: 09 October 2024

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