

## Impact of Local Heat Application on Peripheral Intravenous Cannulation Among Patients

Bhartendra Sharma<sup>1\*</sup>, Sukhbir Kaur<sup>2</sup>, Vikas Sharma<sup>3</sup>, Ram Kumar Garg<sup>4</sup>

<sup>1</sup>Department of Medical Surgical Nursing, Mahatma Gandhi Nursing College, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur, India. <sup>2</sup>Department Psychiatric Nursing, SGRD College of Nursing, SGRD University of Health Sciences, Amritsar, India. <sup>3</sup>Department of Psychiatric Nursing, Mahatma Gandhi College of Nursing, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur, India. <sup>4</sup>Teerthanker Mahaveer College of Nursing, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. \*Corresponding Author's Email: bhartendrasharma@mgumst.org

### Abstract

It is the responsibility of the nurses to safely insert, manipulate, infuse, care and remove the cannula. The aim of this research is to assess the impact of local heat application on peripheral intravenous cannulation among patients admitted in the general wards. A true experimental research design was adopted to select 30 patients in interventional group and 30 patients in standard group by systematic random sampling to assess the visibility and palpability of veins, pain, time required and pricking attempts during IV cannulation. Post-intervention the mean score of vein visibility and palpability was significantly ( $p=.001$ , U value= 445) higher in the interventional group  $4.1\pm.7$  than the standard group  $2.36\pm.6$ . The mean score of patient's pain perception was significantly ( $p=.001$ , t-value 4.41) lower in the interventional group  $1.56\pm1.79$  than the standard group  $5.13\pm2.47$ . The pricking attempts were significantly reduced (Fisher test value= 5.42,  $p=.001$ ) in interventional group than the standard group. The mean score of time needed for IV cannulation was significantly less (t-value 4.76,  $p=.001$ ) in interventional group  $2.2\pm.5$  than the standard group  $5.3\pm.8$ . Thus the application of local heat before IV cannulation is an effective way for veins visibility and palpability, minimizing the patient's pain perception, reducing the time needed and the number of pricking for successful IV cannulation.

**Keywords:** Impact, Local heat application, Peripheral intravenous cannulation, Patients, General wards, Hospital.

### Introduction

In intravenous therapy fluids and electrolytes, medications, blood products etc are administered rapidly in veins for the therapeutic purposes (1). Intravenous cannulation procedure is most frequently performed in the hospitals (2). About 70-80% of hospitals in-patients receive medicines through IV cannula (3). It is a sterile invasive procedure in which a little plastic tube supported by a needle is inserted into the client's vein. Nurses should be well trained and develop skills and expertise in performing intravenous cannulation (4). It is the responsibility of the nurses to safely insert, manipulate, infuse, care and remove the cannula (5, 6). Lack of nurse's competencies can lead to complications in patients like phlebitis, bacteraemia, septicaemia etc. (7-9). In many cases it is reported that unsuccessful cannulation attempt can increase the complications (10-12). The main reason for this is the visibility and palpability of veins is not

accurate (12, 13). Therefore, nurses should adopt various interventions to increase the visibility and palpability of veins. One such intervention is application of moist heat at the selected vein prior to intravenous cannulation. Many studies had reported that by applying the moist heat the vein is visualized and palpable, causes less pain, number of pricks and duration of cannulation is reduced, and patient is satisfied (2, 10, 14-16). A Systematic Review study was conducted to systematically review studies on the effects of local warming before insertion of peripheral venous cannulas on vascular access in adult patients. The following databases were used for searching the relevant studies like Scopus, PubMed, Cochrane, CINAHL, Embase. The keywords used were "heat", "warming", "vein score", "visibility," and "palpability", "catheterization". 244 relevant articles were found and reviewed. It was found that local

This is an Open Access article distributed under the terms of the Creative Commons Attribution CC BY license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

(Received 07<sup>th</sup> November 2023; Accepted 06<sup>th</sup> January 2024; Published 30<sup>th</sup> January 2024)

warming at the IV insertion site before cannulation has increased success rate of insertion in the first attempt, vein score has increased, patient satisfaction and comfort is increased and duration of catheterization time is reduced, reduced pain perception, and the frequency of pricks is also reduced (10).

A quasi-experimental study was conducted to compare the venous dilation effect of using a hot towel (moist and dry heat) to a hot pack before IV cannula insertion. Heat applications like hot pack, moist hot towel, and dry hot towel were provided to 88 patients at  $40 \pm 2$  °C for 7 minutes at the IV cannula insertion site. The study revealed that application of moist hot towel promotes venous dilation at the peripheral intravenous cannulation access site (15).

It was also observed that patient's whose veins are not easily accessed; have to undergo repeated pricks which cause the procedure painful (17). Therefore, the researcher tried to assess the influence of moist heat therapy application prior to IV cannulation. If found effective, it can be included as an evidence-based practice for IV cannulation in patients with poor vein visibility and palpability.

The main aim of the research was to assess the impact of local heat application on peripheral intravenous cannulation among patients admitted in general wards of the hospital. The objectives of the study were as follows:

1. To assess the level of visibility and palpability of vein among patients undergoing peripheral intravenous cannulation before and after the local heat application in the experimental and control group as assessed by Standardized Vein Assessment Scale.
2. To assess the level of pain, number of pricks and time taken to insert the cannula among patients undergoing peripheral intravenous cannulation after the local heat application in the experimental group as assessed by Numerical Pain Rating Scale (NPRS).
3. To assess the level of pain, number of pricks and time taken to insert the cannula among patients undergoing peripheral intravenous cannulation without the local heat application in the control group as assessed by Numerical Pain Rating Scale (NPRS).
4. To compare the scores of levels of pain, number of pricks and time taken to insert the

cannula between experimental and control group.

## Methods

### Research approach and design

Quantitative approach and true experimental research with pretest-posttest design was used.

Setting of the study: General wards of Mahatma Gandhi Hospital, Jaipur, Rajasthan, India.

### Population

Patients in the age group of 18-65 years and admitted in the general wards of Mahatma Gandhi Hospital, Jaipur Rajasthan.

### Sample and sample size

60 Adults patients (aged 18-65 years) undergoing peripheral intravenous cannulation, 30 in interventional group and 30 in standard group.

### Sampling technique

Patients were selected by systematic random sampling technique (alternative method).

### Study variables

**Independent variable:** Application of local heat.

**Dependent variable:** visibility & palpability of veins, level of pain, number of pricks & time taken to insert the cannula.

**Extraneous variables:** Age, gender, marital status, educational status, body built, size of cannula, site of cannula, previous exposure to intravenous cannulation, presence of pain due to any chronic disease.

### Inclusion criteria

- Patients aged between 18-65 years.
- Patients who are admitted in general wards.
- Patients requiring a new intravenous cannulation in forearm or dorsum of the hand selectively.
- Patients who are willing to participate.
- Patients with score of vein assessment  $\leq 3$ .

### Exclusion criteria

- Patients already having pain due to any conditions.
- Patients already have intravenous cannulation in place.
- Patients unable to have pain perception and respond to pain.
- Patients suffering from bleeding & integumentary disorders at the cannula site.
- Requiring urgent IV cannulation
- Patients administered with analgesics medicines two hours before cannulation.

- Patients with critical vital parameters.

## Data collection instruments and techniques

**Tool 1:** The demographic & clinical information of the patients was obtained by a structured questionnaire comprising of information on age, gender, marital status, educational status, body built, previous exposure to intravenous cannulation, size of cannula, site of cannula.

**Tool 2:** Modified vein assessment scale was used to assess the visibility & palpability of veins. In this scale 1-vein is not visible and palpable; 2-vein is visible but it is not palpable; 3-vein hardly visible & palpable; 4- vein is visible & palpable; 5-vein is distinctly visible & palpable.

**Tool 3:** The patient's pain level during intravenous cannulation was evaluated by self-reporting standardized numerical pain rating scale (NPRS). The NPRS has scores from 0-10, where 0 indicates no pain, 1-3 indicates mild pain, 4-6 indicates moderate pain and 7-10 indicates severe pain. The patients were suggested to choose a number from 0 to 10 that indicates their pain experience during intravenous cannulation.

Intervention:

Local Moist heat therapy was administered in interventional group before cannulation. Moist heat therapy was applied for ten minutes at the selected vein of the forearm or dorsum of the hand by soaking the folded towel in warm water with 40° Celsius temperature. This procedure leads to improved vein visibility and palpability, less pain perceived by patients, increased success rate of IV insertion, much comfort of nurses performing PIVC and greater patient satisfaction (18-21).

### Validity and reliability

The validity of the patient's demographic questionnaire and modified vein assessment scale was established by nine experts from the field of nursing, medicines. Their suggestions were incorporated in finalizing these questionnaires.

### Pretesting of the research tools

Pretesting of all the above-mentioned research tools was done on 06 patients to find out their feasibility. The demographic questionnaires language was understandable to the patients. The

reliability of modified vein assessment scale and NPRS was estimated by test-retest method and the reliability value was  $r = 0.94$  and  $r = 0.88$  respectively.

### Ethical consideration

Ethical clearance was obtained from the office of the Institutional Ethics Committee Mahatma Gandhi Medical College & Hospital, Jaipur, Rajasthan with approval number: /MGMC&H/IEC/JPR/2022/824 dated 30/06/2022. Formal permission was obtained from the medical superintendent/ nursing superintendent of the Hospital. Patients were informed about the study and informed consent was obtained from them before participating in the study.

### Data collection procedure

Formal permission was obtained from the hospital authorities. The data was collected from the patients admitted in Mahatma Gandhi Hospital during 01/08/2022 to 30/09/2022. All alternative patients were selected for the study from the general wards. 30 patients were allocated to interventional group and 30 patients were allocated to standard group. Informed consent was obtained from the patients. The veins visibility & palpability score was assessed by modified vein assessment scale and the pain score was measured by numerical pain rating scale.

### Plan for statistical analysis of the study

SPSS software version 20.0 was used to analyse the data as per the objectives of the study using both descriptive statistics and inferential statistics i.e., mean, median, standard deviation, range, "t" test, chi square test, Mann-Whitney test, and Fisher exact test. A statistical significance was considered at  $P < 0.05$ .

## Results

Table 1 demonstrates that there was no significant difference in the demographic and clinical variables of patients in interventional and standard groups such as marital status (0.44), educational status (0.68), body built (0.79) and size of cannula (0.33). Whereas there was significant difference in sex (0.001), previous exposure to intravenous cannulation (0.000) and site of cannula (0.000).

**Table 1:** Comparison of Demographic and clinical variables of patients in Interventional and Standard Groups

Demographic and clinical variables	Interventional Group (n <sub>1</sub> =30)		Standard Group (n <sub>2</sub> =30)		Test applied	Test value	df	p value
	n <sub>1</sub>	%	n <sub>2</sub>	%				
Age in years								
18-28	13	43.33	11	36.66	<i>Fisher exact test</i>	8.85	4	.27
28-38	8	26.66	9	30				
38-48	5	16.66	6	20				
48-58	2	6.66	3	10				
≤ 65	2	6.66	1	3.33				
Sex								
Male	12	40	14	46.66	$\chi^2$	.64	1	.001*
Female	18	60	16	53.33				
Marital status								
Married	19	63.33	21	70	$\chi^2$	.76	1	.44
Unmarried	11	36.33	9	30				
Educational status								
Primary	3	10	6	20	<i>Fisher exact test</i>	6.15	2	.68
Secondary	7	23.33	7	23.33				
Graduate and above	20	66.66	17	56.66				
Body built								
Thin	4	13.33	8	26.66	<i>Fisher exact test</i>	7.83	2	.79
Moderate	20	66.66	15	50				
Obese	6	20	7	23.33				
Previous exposure to IV cannulation								
Yes	11	36.66	14	46.66	$\chi^2$	.53	1	.000*
No	19	63.33	16	53.33				
Size of cannula								
18 gauge	3	10	2	6.66	$\chi^2$	1.23	1	.33
20 gauge	20	66.66	18	60				
22 gauge	7	23.33	10	33.33				
Site of IV cannula								
Forearm right	9	30	8	26.66	<i>Fisher exact test</i>	9.88	3	.000*
Forearm left	7	23.33	10	33.33				
Dorsal metacarpal vein right hand	6	20	7	23.33				
Dorsal metacarpal vein left hand	8	26.66	5	16.66				

\*Significant,  $p < .001$  level. df: Degrees of freedom.  $N = (n_1 + n_2) = 60$

Table 2 shows the visibility and palpability scores of patient's veins after local heat application in interventional and standard group. The mean and SD score was higher in the interventional group ( $4.1 \pm .7$ ) than the standard group ( $2.36 \pm .6$ ). Mann-whitney test was applied to evaluate the significance of local heat application in visibility and palpability scores of veins and the calculated  $U$  value was 445 which was very highly significant

at .05 level. Thus, it is revealed that local heat application before IV cannulation is very much effective for improving the visibility and palpability scores of veins.

Table 3 depicts the patient's mean pain score was  $1.56 \pm 1.79$  in the interventional group and  $5.13 \pm 2.47$  in the standard group and the difference in mean was 3.57. An independent  $t$ -test was analyzed to evaluate the significance of

local heat application in pain scores, the *t*-value was very highly significant at .001 level. Thus, it is revealed that the local heat application was very much effective in minimizing the patient's pain level during IV cannulation.

Table 4 shows that in the interventional group almost all 96.66% of patients had successful IV cannulation in single prick whereas in the standard group half of the patients 50% had IV cannulation in two pricks, 26.66% of them had IV cannulation in one prick, 16.66% had IV cannulation in three pricks and 6.66% of them had to undergo four pricking. Fisher exact test was computed to assess the significance of local heat application before IV cannulation and numbers of pricking. The calculated Fisher exact

test value was 5.42 and was very highly significant at .001. Thus, it is concluded that the local heat application was very much effective in reducing the numbers of pricking in patients during IV cannulation.

Table 5 demonstrates that the mean time (in minutes) needed for IV cannulation was 2.2±.5 in the interventional group and 5.3±.8 in the standard group and the difference in mean was 3.1. An independent *t*-test was analyzed to evaluate the significance of local heat application for time needed for IV cannulation and the *t*-value 4.76 was very highly significant at .001 level. Thus, it is revealed that the local heat application was very much effective in minimizing the time needed for IV cannulation.

**Table 2:** Comparison of visibility and palpability scores of veins in patients undergoing IV cannulation after local heat application

Visibility and palpability scores of veins	Mean	SD	U value	p value
Interventional group	4.1	.7	445	.001***
Standard group	2.36	.6		

\*\*\*Very highly significant, N=60

**Table 3:** 't' test to compare the mean, standard deviation, mean difference and standard error of mean difference of pain scores in patients after local heat application in interventional and standard group

Groups	Mean± SD	Difference in Mean	SE	t value	df	p value
Interventional group	1.56±1.79	3.57	.56	4.41	58	.001***
Standard group	5.13±2.47					

\*\*\*Very highly significant

**Table 4:** Fisher exact test to compare the numbers of pricking during IV cannulation after local heat application in patients of interventional and standard group

Numbers of pricking	Interventional group (n <sub>1</sub> =30)		Standard group (n <sub>2</sub> =30)		Fisher exact test value	df	p value
	n <sub>1</sub>	%	n <sub>2</sub>	%			
1	29	96.66	8	26.66	5.42	2	.001
2	1	3.33	15	50			
3	-	-	5	16.66			
4	-	-	2	6.66			

**Table 5:** 't' test to compare the score of time needed for IV cannulation after local heat application in patients of interventional and standard group

Groups	Mean± SD	Difference in Mean	SE	t value	df	p value
Interventional group	2.2±.5	3.1	.48	4.76	58	.001***
Standard group	5.3±.8					

\*\*\*Very highly significant

## Discussion

The findings of the current study revealed that before local heat application majority (53.33%) of patient's vein were visible but not palpable and 43.33% of patient's veins were barely visible and palpable in the interventional group. Similar findings were reported in a study where 40% of patient's veins were visible but not palpable and 36% of patient's veins were barely visible and palpable (19).

In this study, after application of local heat, 46.66% of patient's veins were visible and palpable and 33.33% of patient's veins were distinctly visible and palpable. The *mean* and *SD* of visibility and palpability score of veins were higher significantly ( $U = 445$ ;  $p = .001$ ) in the interventional group ( $4.1 \pm .7$ ) than the control group ( $2.36 \pm .6$ ). Studies had reported that after the application of moist heat therapy patient's vein become easily visible and palpable with highly significant difference in the vein's visibility and palpability score in experimental and control group at  $p \leq .001$  (10, 20, 21). A survey was conducted to evaluate the heat use during peripheral intravenous insertion and it was reported that applying heat before IV insertion promotes veins visibility and palpability and easier insertion (22). Another study revealed that providing local heat before application of tourniquet is the safe and effective method for venodilation improvement (23). Further it was also evaluated earlier that five minutes of local warming is effective in inducing venodilation for PIVC (18).

The present study also shows that after the application of local heat half of the patients (50%) reported no pain, 36.66% of them reported mild pain and only 13.33% of them experienced moderate pain during IV cannulation. The average pain score of interventional group ( $1.56 \pm 1.79$ ) was found significantly lower than the standard group ( $5.13 \pm 2.47$ ). In a previous study it is found that after administration of moist heat therapy the mean pain score was lower in the experimental group ( $3.63 \pm 2.04$ ) than the ( $6.10 \pm 2.09$ ) control group (20). A study reported less pain perceived by patients after the local heat application (24). Studies by other researchers also stated that local heat application prior to PIVC leads to easier vein visualization by the nurses and minimal pain perception by the patients (25, 26).

In this study, post-intervention most of the patients 96.66% had successful IV cannulation in one pricking only in the interventional group whereas in the standard group only 26.66% of patients had IV cannulation in one pricking, this was very highly significant at .001, revealing that the patients who did not receive local heat application had to undergo multiple pricking during IV cannulation. This finding was supported by a study, who also found that after application of moist heat therapy majority of patients 93.3% in experimental group were IV cannulated in single prick only whereas 56.7% of the patients in the control group were IV cannulated in single prick only and the remaining 43.3% of patients in the control group had to undergo multiple pricks (20). Earlier studies also revealed that application of heat enhances the easy access for IV cannulation and reduces the attempts of repeated pricking (27-29).

In the present study the score of mean time (in minutes) needed for IV cannulation was lower significantly ( $p < .001$ ) in the interventional group  $2.2 \pm .5$  compared to standard group  $5.3 \pm .8$ . This was supported by the studies revealing that the time duration of IV cannulation is reduced after the application of local heat (18, 20, 23, 30).

## Conclusion

Application of local heat before IV cannulation is an effective way for veins visibility and palpability, minimizing the patient's pain perception, reducing the time needed and the number of pricking for successful IV cannulation. Its is recommended that application of local heat at the IV cannula site prior to IV cannulation should become an evidence-based practice and should be taught to the student nurses and it should be incorporated in nursing curriculum also.

## Abbreviation

IV: Intravenous

NPRS: Numerical pain rating scale

## Acknowledgement

The researcher expresses his heartfelt gratitude to the Chancellor, Vice chancellor, Registrar and other administrative personals for providing continuous motivation and support during research. The researcher is also thankful to

nursing officers, general ward-in charges of hospital and other officials of Mahatma Gandhi university of Medical Sciences and Technology, Jaipur, for cooperating during the research. Many thanks to the patients who participated in the study.

### Author contribution

Conceptualization: Bhartendra Sharma, Sukhbir Kaur; Data curation: Bhartendra Sharma, Sukhbir Kaur; Formal Analysis: Sukhbir Kaur, Vikas Sharma; Funding acquisition: Vikas Sharma; Investigation: Bhartendra Sharma, Vikas Sharma; Methodology: Ram kumar Garg, Bhartendra Sharma; Project administration: Bhartendra Sharma, Vikas Sharma; Resources: Bhartendra Sharma, Vikas Sharma; Software: Ram kumar garg, Vikas Sharma; Supervision: Ram kumar garg, Bhartendra Sharma, Vikas Sharma; Validation: Ram kumar garg, Vikas Sharma; Writing – original draft: Bhartendra Sharma; Writing – review & editing: Sukhbir Kaur, Ram kumar garg, Vikas Sharma

### Conflict of interest

All the authors declare that there is no conflict of interest.

### Ethics approval

Ethical clearance for the study was obtained from the office of the Institutional Ethics Committee Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan with approval number:/MGMCa ndH/IEC/JPR/2022/824 dated 30/06/2022 (copy attached with the covering letter).

### Funding

All the expenses during the study was done by the researchers. No external financial support was received for the study.

### References

1. Kaur V, Kaur J, Thakur R.D. Effectiveness of a Training Programme on Intravenous Cannulation Therapy: An Interventional Study. *International Journal of Science and Research (IJSR)*. 2020; 9(2): 336-338. DOI: 10.21275/SR20204170111
2. Lalnunpuii PC, Chetia P and Iawim RA. Study to Assess the Effectiveness of Moist Heat Therapy Before Intravenous Cannulation Among Patients in A Selected Hospital, Guwahati, Assam. *Int J Recent Sci Res*. 2020; 11(02): 37534-7. DOI: <http://dx.doi.org/10.24327/ijrsr.2020.1102.5129>
3. Al-Awaisi H, Al-Harthy S, and Jeyaseelan L. Prevalence and Factors Affecting Difficult Intravenous Access in Children in Oman: A Cross-sectional Study. *Oman medical journal*. 2022; 37(4): e397. <https://doi.org/10.5001/omj.2022.76>
4. Santos-Costa P, Paiva-Santos F, Sousa LB, Bernardes RA, Ventura F, Fearnley WD, Salgueiro-Oliveira A, Parreira P, Vieira M, and Graveto J. Nurses' Practices in the Peripheral Intravenous Catheterization of Adult Oncology Patients: A Mix-Method Study. *Journal of personalized medicine*. 2022; 12(2): 151. <https://doi.org/10.3390/jpm12020151>
5. Morrell E. Reducing Risks and Improving Vascular Access Outcomes. *Journal of infusion nursing: the official publication of the Infusion Nurses Society*. 2020; 43(4): 222-228. <https://doi.org/10.1097/NAN.0000000000000377>
6. Kimori K, Sugama J. Investigation of vasculature characteristics to improve venepuncture techniques in hospitalized elderly patients. *Int J Nurs Pract*. 2016;22:300-6. <https://doi.org/10.1111/ijn.12430>
7. Van Rens MFPT, Hugill K, Mahmah MA, Bayoumi M, Francia ALV, Garcia KLP, and van Loon FHJ. Evaluation of unmodifiable and potentially modifiable factors affecting peripheral intravenous device-related complications in neonates: a retrospective observational study. *BMJ open*. 2021; 11(9): e047788. <https://doi.org/10.1136/bmjopen-2020-047788>
8. Rodriguez-Calero MA, de Pedro-Gomez JE, Molero-Ballester LJ, Fernandez-Fernandez I, Matamalas-Massanet C, Moreno-Mejias L, *et al*. Risk Factors for Difficult Peripheral Intravenous Cannulation. The PIVV2 Multicentre Case-Control Study. *Journal of clinical medicine*. 2020; 9(3): 799. <https://doi.org/10.3390/jcm9030799>
9. Ng M, Mark LKF, and Fatimah L. Management of difficult intravenous access: a qualitative review. *World journal of emergency medicine*. 2022; 13(6): 467-478. <https://doi.org/10.5847/wjem.j.1920-8642.2022.104>
10. Heydari A, Manzari ZS, Khalili H. The effect of local warming before vascular access on vascular access indicators in adult patients receiving chemotherapy: A systematic review. *Nurs Midwifery Stud*. 2021; 10:213-2. DOI: 10.4103/nms.nms\_86\_20
11. Evison H, Carrington M, Keijzers G, Marsh NM, Sweeny AL, Byrnes J, Rickard CM, Carr PJ, and Ranse J. Peripheral intravenous cannulation decision-making in emergency settings: a qualitative descriptive study. *BMJ open*. 2022; 12(3): e054927. <https://doi.org/10.1136/bmjopen-2021-054927>
12. Cooke M, Ullman AJ, Ray-Barruel G, Wallis M, Corley A, and Rickard CM. Not "just" an intravenous line: Consumer perspectives on peripheral intravenous cannulation (PIVC). An international cross-sectional survey of 25 countries. *PloS one*. 2018; 13(2): e0193436. <https://doi.org/10.1371/journal.pone.0193436>

13. Shourav M, Choi J, Kim J. Visualization of superficial vein dynamics in dorsal hand by near-infrared imaging in response to elevated local temperature. *Journal of Biomedical Optics*. 2022; 26(2). DOI: 10.1117/1.JBO.26.2.026003
14. Eren H, Caliskan N, and Durmus Iskender M. Effect of Fist Clenching on Vein Visibility and Palpability: An Observational Descriptive Study. *Journal of infusion nursing: the official publication of the Infusion Nurses Society*. 2022; 45(5): 252–257. <https://doi.org/10.1097/NAN.0000000000000480>
15. Yasuda K, Shishido I, Murayama M. *et al.* Venous dilation effect of hot towel (moist and dry heat) versus hot pack for peripheral intravenous catheterization: a quasi-experimental study. *J Physiol Anthropol*. 2023; 42(23): <https://doi.org/10.1186/s40101-023-00340-5>
16. Zead MMA, Hassan MAA, Mahmoud AS. Effect of Dry Heat Application on Peripheral Intravenous Catheter Insertion Parameters and Discomfort among Patients Undergoing Chemotherapy. *Egyptian Journal of Health Care*. 2023; 14(2): 1187-1198.
17. Sabri A, Szalas J, Holmes KS, Labib L, Mussivand T. Failed attempts and improvement strategies in peripheral intravenous catheterization. *Biomed Mater Eng*. 2013;23:93-108.
18. Yamagami Y, Tsujimoto T, and Inoue T. How long should local warming for venodilation be used for peripheral intravenous cannulation? A prospective observational study. *International journal of nursing studies*. 2018; 79: 52–57. <https://doi.org/10.1016/j.ijnurstu.2017.11.004>
19. Samra AS, Kumar CN. Effectiveness of moist heat therapy on visibility, palpability, pricks and pain experienced while undergoing peripheral intravenous cannulation of patients. *International Journal of Health Science and Research*. 2018; 8(7):192-199.
20. Sarsar AS, Kumari V, Sharma T. An experimental study to assess the effect of moist heat therapy on ease of peripheral venous cannulation among patients admitted in selected hospital of Ambala, Haryana. *International Journal of Health Science and Research*. 2019; 9(1):104-111.
21. Simarpreet K. Effect of moist heat therapy on the visibility and palpability of veins before peripheral intravenous cannulation of patients undergoing chemotherapy. *International Journal of Advance Research*. 2018; 6:230-6. DOI: 10.21474/IJAR01/6432
22. Kiger T, Knudsen ÉA, Curran W, Hunter J, Schaub A, Williams MJ, et al. Survey of heat use during peripheral IV insertion by health care workers. *J Infus Nurs*. 2014; 37:433–40. <https://doi.org/10.1097/NAN.0000000000000074>.
23. Yamagami Y, Tomita K, Tsujimoto T, Inoue T. Tourniquet application after local forearm warming to improve venodilation for peripheral intravenous cannulation in young and middle-aged adults: A single-blind prospective randomized controlled trial. *Int J Nurs Stud*. 2017 Jul;72:1-7. doi: 10.1016/j.ijnurstu.2017.03.009.
24. Radwan H, Kanona A, and Abd-Elghafar S. Effect of Moist Heat on Vein's Integrity and Pain among Patients Receiving Peripheral Intravenous Chemotherapy. *Egyptian Journal of Health Care*. 2022; 13(1): 1156–75. <https://doi.org/10.21608/ejhc.2022.223447>.
25. Korkut S, Karadağ S, & Doğan Z. The Effectiveness of Local Hot and Cold Applications on Peripheral Intravenous Catheterization: A Randomized Controlled Trial. *J Perianesth Nurs*. 2020;35(6):597-602. doi: 10.1016/j.jopan.2020.04.011.
26. Homayouni A, Tabari-Khomeiran R, AsadiLouyeh A. Investigating the effect of local warming on vein diameter in the antecubital area in adults aged 20-40 years. *Br J Nurs*. 2019; 25;28(8):S20-S26. doi: 10.12968/bjon.2019.28.8.S20.
27. Sharaf A, Fatah MMA, Soliman M. The effects of local warm compresses on peripheral intravenous cannulation of patients undergoing chemotherapy. *JNHS*. 2018; 7:1-13.
28. Shishido I, Konya I, Yano R. Effect on autonomic nervous activity of applying hot towels for 10 s to the back during bed baths. *J Physiol Anthropol*. 2020;39:35. <https://doi.org/10.1186/s40101-020-00245-7>.
29. Biyik Bayram S, Caliskan N. Effects of local heat application before intravenous catheter insertion in chemotherapy patients. *J Clin Nurs*. 2016;25:1740–7. <https://doi.org/10.1111/jocn.13193>.
30. Tokizawa Y, Tsujimoto T, and Inoue T. Duration of Venodilation for Peripheral Intravenous Cannulation, as Induced by a Thermal Stimulus on the Forearm. *Biological research for nursing*. 2017; 19(2): 206–212. <https://doi.org/10.1177/1099800416651145>