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Effect of Near-Infrared Vein Finder Technology on Success Rate of Cannulation in Obese Diabetic Patients

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Abstract

Background: Intravenous cannulation is needed in about 90% of patients admitted to hospitals to administer medications or replace fluids, which is difficult to perform in obese patients with diabetes.
Objectives: The present study aimed to assess the effect of using near-infrared vein finder technology on the success rate of cannulation in obese patients with diabetes.
Methods: This randomized controlled trial was conducted on 92 eligible patients with type 2 diabetes and obesity at Al-Rusafa hospitals in Baghdad, Iraq, in September 2021. The subjects were divided into the intervention (n = 46) and control (n = 46) groups. However, cannulation using near-infrared vein finder technology was only performed for the intervention group. The data were collected using a demographic and clinical data questionnaire and a chronometer.
Results: The success rates of cannulation for the first time were 60.9% and 15.2% in the intervention and control groups, respectively. The mean values of procedural time were 53.2 $\pm$ 28.9 and 94.3 $\pm$ 41.5 seconds in the intervention and control groups, respectively. The independent effects of patients' body mass index (P = 0.002) and skin color (P = 0.040) on procedural time were significant.
Conclusions: The use of near-infrared vein finder technology in obese diabetic patients reduces procedural time and venipuncture attempts.

Keywords: Near-Infrared Light, Vascular Access, Intravenous Cannulation, Obese Diabetic Patients

1. Background

Diabetes mellitus is an increasing international health concern with no probability of termination. The percentage of individuals with type 2 diabetes mellitus (T2DM) is 95% of those with diabetes mellitus in general (1). The Middle East and North Africa have the second-highest rate of diabetes with 9.2%; however, Iraq is one of the 21 countries in the region. The number of deaths due to diabetes accounts for 10.7% of adult mortalities (2). Individuals with T2DM constitute 8.5 - 13.9% of Iraqis (3). A noticeable increase was recorded in the percentage of individuals with diabetes (35%) in 2011, compared to that of 2005 (11.9%), among Iranians within the age range of 25 - 70 years (4).

Obesity or being overweight is the major modifiable risk factor for more than 90% of the patients with T2DM because it exacerbates insulin resistance (1). Obese diabetic patients have more visits to hospitals and medical centers due to complications of obesity and diabetes, and the possibility of venipuncture to send laboratory samples or prescribe fluids and medications in this group of patients is high (5). For nurses or even other healthcare providers, conducting laboratory diagnostic tests and procedures is considered a paramount portion of patient care that should be performed by following the highest quality of standard guidelines to avoid complications that might result from cannulation and inaccurate findings of laboratory tests (6).

The literature confirmed that about 90% of patients in a hospital might need intravenous cannulation peripherally to administer medications or replace fluids (7). In addition, the literature shows the maximum rate of mistakes in the clinical laboratory that involve sample collection by venipuncture, also known as phlebotomy (8). The identification of the vein site is not simple. Some elements affect the visibility of the patients' vasculature, such as the dif-

ference in the skin character of young children (especially neonates), dehydration, and obesity (9). Due to high subcutaneous fat in obese patients, it is difficult to see veins and have access to blood vessels; therefore, nurses face numerous problems in terms of time and technique when caring for these patients (5). Furthermore, overweight and obesity exacerbate insulin resistance, which leads to the development of complications of diabetes linked to a poor vascular network (10-13).

The use of certain devices or techniques, including tourniquet (14), local heat (13-15), ultrasound (16), and transilluminating devices (5), will help have better access to the veins of the limbs. A transilluminating device is one of the technical evolutions which employs near-infrared light-emitting diodes (NIR-LEDs) to show superficial veins with hemoglobin absorbing the light generated and producing a view on the surface of the skin, which has lately been advanced (5). Moreover, NIR-LEDs discover the non-invasiveness of the veins for the venipuncture processes, such as blood sample collection and drug preparation, which can be utilized for intravenous administration. The apparatuses can be utilized in numerous patient care sectors where vascular access operations are carried out and might be utilized for all patients, such as obese or diabetic individuals (17). Due to the challenge of various human factors, an increased number of parameters and participants/humans should also be considered for actual vein visualization testing. It was observed that the literature on the evaluation of the performance of phlebotomy using the findings of the vein was limited (18).

2. Objectives

Furthermore, previous studies related to the assistance of new technology in the process of cannulation reported various factors that affect vein visibility required for vein cannulation; however, none has specifically investigated patient characteristics and obese diabetic patients (19). Therefore, the present study aimed to assess the effect of near-infrared vein finder technology on the success rate of cannulation in obese diabetic patients.

3. Methods

This randomized controlled trial (IRCT 20210705051797N1) in two groups was conducted at Al-Rusafa hospitals in Baghdad, Iraq, in September 2021 after obtaining approval from the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran. Sampling was carried out using the appropriate sampling method and random allocation by simple lottery (coin), and 92 patients were selected. The inclusion criteria were T2DM, body mass index (BMI) of 30 kg/m^2 and above, no history of vein problems (eg, phlebitis and extremities edema), the age range of 18 - 70 years, and a completed informed consent form. The samples could withdraw from the study if they were not willing to cooperate at any stage of the study. During the study period, if the participants experienced failing insertion of the cannula at more than the fourth attempt, the exacerbation of the disease, or the occurrence of unpleasant accidents for the patient, such as severe hemorrhage and hematoma, they were excluded from the study.

Prior to the intervention, the samples were randomly allocated into two intervention (n = 46) and control (n = 46) groups. In the intervention group, vein access was gained using the vein detection device with NIR-LED technology by illuminating the skin with near-infrared light, which penetrates the skin and subcutaneous tissues to a depth of approximately 3 mm, with increased absorption by deoxygenated hemoglobin. AccuVein AV400 (manufactured in the USA) is the only handheld, noncontact vein illumination device with an actual size of 5 $\times$ 6 $\times$ 20 cm (2" $\times$ 2.4" $\times$ 7.9"), weight of 275 g (9.7 oz), and typically 180 minutes of continuous run time on a full charge. The apparatus could be used in different directions and 10 - 45 cm away from the skin surface. A patient will be lying down in a dorsal position, the sleeves will go up, and selecting suitable vein will be selected by near-infrared vein finder (NIVF) technology. As for the interventional group, the time of intravenous cannulation was measured, starting from turning on the device until inserting the needle into the vein. The procedure will be considered a success if the cannula is inserted using near-infrared vein finder technology within the first to fourth attempts. In the control group, cannulation for the patient will be performed routinely by the same nurse in the intervention group. The time of intravenous cannulation will be measured, starting from tying the tourniquet until inserting the needle into the selected vein.

In both groups, the demographic characteristics and medical record questionnaires were completed before the intervention. The information, such as age, gender, BMI, blood sugar, blood pressure, educational level, work experience, work shift, comorbidities, skin color, hair presence at the cannulation site, and site of successful cannulation, were recorded in the demographic questionnaire. This researcher-made questionnaire includes two items on the procedural time of cannulation within a few seconds for inserting the cannula and the number of cannulation attempts. The chronometer of a mobile phone with an Android operating system was used to measure the duration of the venipuncture process.

Necessary explanations about the research according to the informed consent form were given orally to the research unit in person by the researcher, and written consent was obtained to participate in the study (ethics code: IR.MUMS.NURSE.REC.1400.037). The SPSS software (version 25), chi-square test, two-way analysis of variance (ANOVA), Mann-Whitney U test, and independent *t*-test were used for data analysis.

4. Results

This study was performed on 92 patients with no sample attrition. Statistical analysis showed no significant differences between the two groups in age, gender, weight, height, BMI, medical diagnosis, blood sugar, blood pressure, mean arterial pressure, comorbidities, hair presence at the site of cannulation, skin color, and site of successful cannulation; therefore, the aforementioned findings indicated that the two groups were homogeneous in terms of demographic variables and context (Table 1).

The success rates of cannulation for the first time were 60.9% (n = 28) and 15.2% (n = 7) in the intervention and control groups, respectively. In the intervention and control group, 18 (39.1%) and 39 (84.8%) cases had successful cannulation for more than the first time, respectively. The chi-square test showed a significant difference in this regard ($P < 0.001$; Table 2). The mean values of procedural time in the intervention and control groups were 53.2 ± 28.9 and 94.3 ± 41.5 seconds, respectively. The Mann-Whitney U test showed a significant difference in this regard ($P < 0.001$; Table 3).

Two-way ANOVA was used to evaluate the effects of contextual and intervening variables on the procedural time after the intervention in both groups. The independent effects of patients' BMI ($P = 0.002$) and skin color ($P = 0.040$) on procedural time were significant. In other cases, the independent or interaction effects of contextual and intervening variables on procedural time were not significant ($P > 0.05$).

5. Discussion

The current study aimed to assess the effect of near-infrared vein finder technology on the success rate of cannulation in obese diabetic patients. The findings of this study showed that the success rate of cannulation in obese diabetic patients after using the vein detection device with NIR-LED technology was significantly increased in the intervention group, compared to that of the control group. In hospital wards, especially emergency wards, intravenous catheter placement is one of the most important and challenging nursing procedures that can improve the success rate using new technology (20). In this regard, the results of a study by Zyhier also confirmed that using infrared technology to find peripheral veins and insert intravenous catheters increased the level of successful cannulation through a significant improvement in nurses' confidence (21).

Furthermore, Girgis demonstrated that both ultrasound and transillumination facilitate peripheral intravenous cannulation in children with difficult intravenous access and increase the overall success of cannulation; nevertheless, the number of efforts did not change significantly (22), which is to some extent consistent with the results of the present study. The reason is the type of intervention of the two studies. In general, the results of studies show that using some technologies, such as ultrasound, transillumination, and near-infrared, can be attributed to more success and improvement in peripheral intravenous cannulation. In line with the factors associated with the success of intravenous cannulation, the results of this study showed that BMI, dark skin color, and blood pressure have independent growing effects on the cannulation success rate.

Aulagnier et al., in a clinical trial in France, stated that the use of AccuVein infrared light technology for cannulation does not improve the success rate, duration, and patients' pain, which is not in line with the findings of the present study. The cause of this inconsistency can be different kinds of intervention (AccuVein infrared), sample size, sampling method (random selection), data collection, and data collection tools (type of questionnaires) in both studies (20).

One study showed that BMI, dark skin color, history of unsuccessful cannulation, drug use, and concomitant vascular diseases, such as hypertension and diabetes, have made intravenous cannulation more difficult to succeed due to physiological changes, such as intravascular volume depletion or increased contraction of the sympathetic system for deep veins; therefore, it is needed to apply some technologies, including local heat and infrared, to increase the success rate; this finding is to some extent consistent with the conclusion of the present study (23).

Perry et al. conducted their randomized trial in Texas, USA, in a pediatrics department to examine the effect of the near-infrared illumination on the improvement of the success rate of intravenous cannulation for the first time by increasing the visibility and touch of veins. The results of the aforementioned study are in line with the findings of the current study. They proposed that using infrared technology can improve venous detection results (18).

The application of new technologies, such as near-infrared, to reduce procedural time and cannulation at-

Table 1. Demographic Characteristics of Patients by Variable and Group [a]

Variables	Group		Test Result
	Intervention	Control	
Gender			χ^2 = 1.1; df = 1.0; P = 0.297
Male	21 (45.7)	27 (58.7)	
Female	25 (54.3)	19 (41.3)	
Age (y)	50.3 ± 11.5	51.3 ± 10.5	*t* = 0.1; df = 90.0; P = 0.945
Weight (kg)	97.2 ± 11.1	101.2 ± 12.9	Z = -1.5; P = 0.123
Height (cm)	168.1 ± 6.2	168.5 ± 6.9	Z = -0.5; P = 0.639
Time since medical diagnosis (y)	8.1 ± 6.6	8.5 ± 6.8	Z = -0.2; P = 0.860
blood sugar (mg)	194.2 ± 77.8	215.2 ± 97.4	Z = -0.7; P = 0.485
Systolic blood pressure (mmHg)	137.5 ± 22.6	138.5 ± 29.6	Z = -0.4; P = 0.711
Diastolic blood pressure (mmHg)	90.3 ± 13.6	88.2 ± 13.0	Z = -0.5; P = 0.628
Hair presence at the site of cannulation			χ^2 = 4.5; df = 1.0; P = 0.035
Yes	25 (54.3)	14 (30.4)	
No	21 (45.7)	32 (69.6)	
Skin color			χ^2 = 0.1; df = 2.0; P = 1.000
Caucasian	11 (23.9)	10 (21.7)	
Dark	32 (69.6)	33 (71.7)	
Black	3 (6.5)	3 (6.5)	
Site of successful cannulation			P = 1.000
Upper limbs	44 (95.7)	45 (97.8)	
Lower limbs	2 (4.3)	1 (2.2)	

[a] Values are expressed as No. (%) or mean ± SD.

Table 2. Frequency Distribution of Patients according to Number of Required Attempts by Groups [a]

Variables	Group		Test Results
	Intervention	Control	
Number of required attempts			χ^2=23.8; df = 3.0; P < 0.001
1st time	28 (60.9)	7 (15.2)	
2nd time	11 (23.9)	13 (28.3)	
3rd time	5 (10.9)	17 (37.0)	
4th time	2 (4.3)	9 (19.6)	
Total	46 (100.0)	46 (100.0)	

[a] Values are expressed as No. (%).

tempts helps comfort patients, as well as nurses and other healthcare providers (24-26). Therefore, this should be the goal of the healthcare team in caring for hospitalized and supervised patients and should be considered and used to maximize success in cannulation, improve the quality of care, accelerate recovery, and ultimately reduce hospital costs (21).

The main limitation of the present trial is the lack of randomization, which causes a bias. Although the sample size was large to compare, it might have been too small that should be considered by readers and researchers for further studies. The number and workload of the selected nurses as project collaborators were different; therefore, it is required to select a homogeneous sample in future studies. Because coronavirus disease 2019 is widespread in the studied hospitals, most patients had anxiety, which

Table 3. Mean Value of Procedural Time by Group

Variables	Group		Intergroup Test Results
	Intervention	Control	
Procedural time (s)	53.2 ± 28.9	94.3 ± 41.5	Z = -4.9; P < 0.001

[a] Values are expressed as mean ± SD.

led to their exclusion from the study. This study was performed at some hospitals affiliated with the Baghdad Al-Rusafa Health Directorate; therefore, the findings should be generalized with caution.

The present study did not use any assistive techniques to enhance vascular visualization and tactility, such as clenching patients' fists, using a tourniquet, heat application, Esmarch bandages, nitroglycerin ointment, or non-infrared devices, such as ultrasound or transillumination. Therefore, future studies can examine the aforementioned techniques in actual venipuncture experiments.

5.1. Conclusions

The findings of the present study showed that near-infrared vein finder technology has the most favorable impact on the success rate of cannulation by reducing the procedural time and the number of attempts for cannulation in obese diabetic patients. In addition, patients' BMI, skin color, and blood pressure have an independent and significant effect on the success rate of cannulation.

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Footnotes

Authors' Contribution: Study concept and design: S. F. A. and H. K. M.; Acquisition of data: S. F. A. and S. A.; Analysis and interpretation of data: M. B. and S. F. A.; Drafting of the manuscript: M. B. and S. F. A.; Critical revision of the manuscript for important intellectual content: H. K. M. and S. A.; Statistical analysis: M. B.; Administrative, technical, and material support: H. K. M., S. A., and M. B.; Study supervision: H. K. M.

Clinical Trial Registration Code: IRCT 20210705051797N1. Link: https://en.irct.ir/trial/57392

Conflict of Interests: There is no conflict of interest.

Ethical Approval: IR.MUMS.NURSE.REC.1400.037 (ethics.research.ac.ir/EthicsProposalView.php?id=213949)

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Informed Consent: Necessary explanations about the research according to the informed consent form were given orally to the research unit in person by the researcher, and written consent was obtained to participate in the study.

References

1. Centers for Disease Control and Prevention. *Type 2 Diabetes*. Centers for Disease Control and Prevention; 2021, [cited 5/22/2021]. Available from: https://www.cdc.gov/diabetes/basics/type2.html.
2. Cho N, Kirigia J, Ogurstova KR. *IDF Diabetes Atlas*. International Diabetes Federation; [cited 7/23/2021]. Available from: https://idf.org/aboutdiabetes/complications.html.
3. Mansour AA, Al-Maliky AA, Kasem B, Jabar A, Mosbeh KA. Prevalence of diagnosed and undiagnosed diabetes mellitus in adults aged 19 years and older in Basrah, Iraq. *Diabetes Metab Syndr Obes*. 2014;**7**:139–44. doi: 10.2147/DMSO.S59652. [PubMed: 24833912]. [PubMed Central: PMC4014373].
4. Esteghamati A, Larijani B, Aghajani MH, Ghaemi F, Kermanchi J, Shahrami A, et al. Diabetes in Iran: Prospective Analysis from First Nationwide Diabetes Report of National Program for Prevention and Control of Diabetes (NPPCD-2016). *Sci Rep*. 2017;**7**(1):13461. doi: 10.1038/s41598-017-13379-z. [PubMed: 29044139]. [PubMed Central: PMC5647418].
5. Ialongo C, Bernardini S. Phlebotomy, a bridge between laboratory and patient. *Biochem Med (Zagreb)*. 2016;**26**(1):17–33. doi: 10.11613/BM.2016.002. [PubMed: 26981016]. [PubMed Central: PMC4783087].
6. Lippi G, Baird GS, Banfi G, Bolenius K, Cadamuro J, Church S, et al. Improving quality in the preanalytical phase through innovation, on behalf of the European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Preanalytical Phase (WG-PRE). *Clin Chem Lab Med*. 2017;**55**(4):489–500. doi: 10.1515/cclm-2017-0107. [PubMed: 28231060].
7. Lamperti M, Pittiruti M. II. Difficult peripheral veins: turn on the lights. *Br J Anaesth*. 2013;**110**(6):888–91. doi: 10.1093/bja/aet078. [PubMed: 23687310].
8. Giavarina D, Lippi G. Blood venous sample collection: Recommendations overview and a checklist to improve quality. *Clin Biochem*. 2017;**50**(10-11):568–73. doi: 10.1016/j.clinbiochem.2017.02.021. [PubMed: 28242283].
9. Shahzad A, Saad MN, Walter N, Malik AS, Meriaudeau F. Hyperspectral venous image quality assessment for optimum illumination range selection based on skin tone characteristics. *Biomed Eng Online*. 2014;**13**:1–13. doi: 10.1186/1475-925X-13-109. [PubMed: 25087016]. [PubMed Central: PMC4132203].
10. Bramante CT, Lee CJ, Gudzune KA. Treatment of Obesity in Patients With Diabetes. *Diabetes Spectr*. 2017;**30**(4):237–43. doi: 10.2337/ds17-0030. [PubMed: 29151713]. [PubMed Central: PMC5687113].

11. Okonkwo UA, DiPietro LA. Diabetes and Wound Angiogenesis. *Int J Mol Sci*. 2017;**18**(7). doi: 10.3390/ijms18071419. [PubMed: 28671607]. [PubMed Central: PMC5535911].
12. Shakouri M, Rashidi A, Amiri Z. A Study on the Association between Type of Obesity and Level of Changes in Obesity Indices Following Weight-Loss Diet. *Qom Univ Med Sci J*. 2013;**7**(3):43–52.
13. Tasavori M, Mazloum SR, Froutan R. Effect of local heating on the success rate of venipuncture in the patients with overweight: a randomized clinical trial. *Hayat J*. 2017;**23**(2):173–84.
14. Wilde C, Out D, Johnson S, Granger DA. Sample Collection, Including Participant Preparation and Sample Handling. *The Immunoassay Handbook*. Elsevier; 2013. p. 427–40. doi: 10.1016/b978-0-08-097037-0.00029-4.
15. Guillon P, Makhloufi M, Baillie S, Roucoulet C, Dolimier E, Masquelier AM. Prospective evaluation of venous access difficulty and a near-infrared vein visualizer at four French haemophilia treatment centres. *Haemophilia*. 2015;**21**(1):21–6. doi: 10.1111/hae.12513. [PubMed: 25335191].
16. Brusasco C, Corradi F, Zattoni PL, Launo C, Leykin Y, Palermo S. Ultrasound-guided central venous cannulation in bariatric patients. *Obes Surg*. 2009;**19**(10):1365–70. doi: 10.1007/s11695-009-9902-y. [PubMed: 19554381].
17. Malarbi S, Stargatt R, Howard K, Davidson A. Characterizing the behavior of children emerging with delirium from general anesthesia. *Paediatr Anaesth*. 2011;**21**(9):942–50. doi: 10.1111/j.1460-9592.2011.03646.x. [PubMed: 21726352].
18. Perry AM, Caviness AC, Hsu DC. Efficacy of a near-infrared light device in pediatric intravenous cannulation: a randomized controlled trial. *Pediatr Emerg Care*. 2011;**27**(1):5–10. doi: 10.1097/PEC.0b013e3182037caf. [PubMed: 21178814].
19. Chiao FB, Resta-Flarer F, Lesser J, Ng J, Ganz A, Pino-Luey D, et al. Vein visualization: patient characteristic factors and efficacy of a new infrared vein finder technology. *Br J Anaesth*. 2013;**110**(6):966–71. doi: 10.1093/bja/aet003. [PubMed: 23384732].
20. Aulagnier J, Hoc C, Mathieu E, Dreyfus JF, Fischler M, Le Guen M. Efficacy of AccuVein to facilitate peripheral intravenous placement in adults presenting to an emergency department: a randomized clinical trial. *Acad Emerg Med*. 2014;**21**(8):858–63. doi: 10.1111/acem.12437. [PubMed: 25176152].
21. Zyhier S. *The Efficacy of Near Infrared Vein Finder Technology to Decrease Multiple Intravenous Cannulation in Patients by Novice and Advanced Beginner Nurses: A Mixed Methods Study on Improving Intravenous Catheter Insertion*. Robert Morris University; 2018.
22. Girgis K. Ultrasound guidance versus transillumination for peripheral intravenous cannulation in pediatric patients with difficult venous access. *Egypt J Cardiothorac Anaesth*. 2014;**8**(1). doi: 10.4103/1687-9090.137236.
23. Carr PJ, Rippey JC, Cooke ML, Bharat C, Murray K, Higgins NS, et al. Development of a clinical prediction rule to improve peripheral intravenous cannulae first attempt success in the emergency department and reduce post insertion failure rates: the Vascular Access Decisions in the Emergency Room (VADER) study protocol. *BMJ Open*. 2016;**6**(2). e009196. doi: 10.1136/bmjopen-2015-009196. [PubMed: 26868942]. [PubMed Central: PMC4762116].
24. Barreras J, Chang TP. Using a Near Infrared Device to Improve Successful Venous Access in Children with Special Health Care Needs. *J Assoc Vasc Access*. 2017;**22**(2):75–80. doi: 10.1016/j.java.2016.12.005.
25. Pedagogy. *Peripheral IV Catheter Chart*. Pedagogy; 2021, [cited 7/30/2021]. Available from: https://www.pedagogyeducation.com/Infusion-Campus/Resource-Library/Infusion/Peripheral-IV-Catheter-Chart.aspx.
26. Nizamoglu M, Tan A, Gerrish H, Barnes D, Dziewulski P. Infrared technology to improve efficacy of venous access in burns population. *Eur J Plast Surg*. 2015;**39**(1):37–40. doi: 10.1007/s00238-015-1165-3.