

Puncture Success after training nurses in the use of transillumination

Sucesso da punção intravenosa periférica após capacitação dos profissionais de enfermagem para o uso da transiluminação

Éxito de la punción venosa periférica después de la formación de profesionales de enfermería en el uso de la transiluminación

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ABSTRACT

Objective: to evaluate the puncture success in the first attempt in children after training nursing professionals in the use of transillumination. **Method:** observational, prospective, comparative before-and-after study, carried out with nurses and nursing technicians were trained for transillumination-guided catheterization and observed performing 35 procedures before and 35 after training, from November 2018 to May 2019, after approval of the ethical merit of the research. Data were analyzed descriptively and analytically. **Results:** success in the first attempt was 62.9% before and 65.7% after ($p=0.803$). Nursing technicians performed more punctures before training and nurses after ($p<0.01$). **Conclusion:** the training professionals to perform transillumination-guided puncture increased success in the first attempt at peripheral intravenous puncture, without significant statistical difference. **Descriptors:** Pediatric Nursing; Patient Safety; Inservice Training; Catheterization, Peripheral; Transillumination.

RESUMO

Objetivo: avaliar o índice de sucesso na primeira tentativa de cateterização intravenosa periférica em crianças após capacitação de profissionais de enfermagem para o uso de transiluminação. **Método:** estudo observacional, prospectivo, comparativo do tipo antes e depois, realizado com enfermeiros e técnicos de enfermagem que foram capacitados para a cateterização guiada pela transiluminação e observados executando 35 procedimentos antes e 35 após a capacitação, no período de novembro de 2018 a maio de 2019, após aprovação do mérito ético do protocolo de pesquisa. Os dados foram analisados de forma descritiva e analítica. **Resultados:** o índice de sucesso na primeira tentativa foi de 62,9% antes e 65,7% depois ($p=0,803$). Os técnicos de enfermagem executaram mais a punção antes da capacitação e os enfermeiros depois ($p<0,01$). **Conclusão:** a capacitação de profissionais para realizar a punção guiada pela transiluminação aumentou o índice de sucesso na primeira tentativa de punção intravenosa periférica, sem diferença estatisticamente significativa.

Descritores: Enfermagem Pediátrica; Segurança do Paciente; Capacitação em Serviço; Cateterismo Periférico; Transiluminação.

RESUMEN

Objetivo: evaluar la tasa de éxito en el primer intento de cateterización venosa periférica en niños después de capacitar a los profesionales de enfermería en el uso de la transiluminación. **Método:** estudio observacional, prospectivo, comparativo de antes y después, realizado junto a enfermeros y técnicos de enfermería capacitados para cateterización guiada por transiluminación y observados realizando 35 procedimientos antes y 35 después del entrenamiento, de noviembre de 2018 a mayo de 2019, previa aprobación del mérito ético del protocolo de la investigación. Los datos se analizaron de forma descriptiva y analítica. **Resultados:** la tasa de éxito en el primer intento fue del 62,9% antes y del 65,7% después ($p=0,803$). Los técnicos de enfermería realizaron más punciones antes del entrenamiento y los enfermeros después ($p<0,01$). **Conclusión:** la formación de profesionales para realizar la punción guiada por transiluminación aumentó la tasa de éxito en el primer intento de punción venosa periférica, sin diferencia estadística significativa.

Descriptores: Enfermería Pediátrica; Seguridad del Paciente; Capacitación en Servicio; Cateterismo Periférico; Transiluminación.

INTRODUCTION

The insertion of short peripheral intravenous catheters in children is not an easy procedure to be performed, mainly in those with risk factors for failures in the procedure¹⁻³.

According to a number of studies, the first-attempt success rate can vary from 8.0% to 44.0% in patients under the age of 3, dehydrated, premature, with vein difficult to see and/or not palpable, previous history of unsuccessful punctures, history of multiple hospitalizations for intravenous therapy, vascular changes and chronic diseases, among other factors³⁻⁶.

For procedures to be successful on the first attempt, mainly in situations where a child's vein is classified as hard to access, the indication is to use devices that will ease seeing the veins and enhance success of the procedure, such as using ultrasound and devices with light sources^{1,4-6}.

Transillumination is the process of watching a structure in its physical state through the reflection of its image by conducting the light over a surface, and the devices used to generate this phenomenon should have a light source capable of illuminating or capturing the radiation emitted, so that images can be formed by means of light refraction, absorption, and reflection. The light sources used can be Light-Emitting Diodes (LEDs) or infrared light^{1,4,7-9}.

Using such devices to assist in seeing children's veins is justified because they are easy to handle and offer more affordable costs, with the ones that capture infrared light and those with LEDs standing out⁷⁻⁹.

Thus, whenever new technologies are introduced in the clinical practice, it is indispensable to train the team so that they are properly used and effective in improving the success rate of punctures. A training program becomes necessary to this end, aiming at proper learning, adequate assimilation of their use and, with that, effective implementation of new technologies¹⁰.

Therefore, the following research question was formulated: "Can the training of Nursing professionals on how to use transillumination increase the first-attempt success rate of puncture in children, when the devices are used to guide the procedure?"

Thus, the current study was conducted with the objective of assessing the first-attempt success of puncture in children after training Nursing professionals on how to use transillumination.

METHOD

This is an observational, prospective, and comparative study of the before-and-after type, with a quantitative approach in which all the research participants were exposed to the intervention to verify if training Nursing professionals on how to use transillumination improves the first-attempt success rate of punctures in children. This study is part of the research entitled "Success rate of puncture in children with puncture difficulties, according to two technologies for seeing veins: A randomized, controlled and crossover study".

This study was carried out from November 2018 to May 2019 in the Pediatric Emergency Service and Pediatric Surgical Ward units of a university hospital from São Paulo, which cares for children aged from zero to 17 years 11 months and 29 days of age, patients with acute and chronic clinical and surgical pathologies.

The sample consisted of punctures performed by day-shift Nursing professionals from both units. The inclusion criterion for the professionals who performed the procedures was participating in the training program. The inclusion criterion for the children was the need to be punctured by the Nursing team.

All Nursing professionals from both units were invited and agreed to participate in the research; they were observed while performing 70 procedures: 35 before the training and 35 after the training, thus constituting a convenience sample. All 35 punctures performed in each group had a 99% confidence level with a 5% error margin.

Data collection took place in three stages. The first one was developed in November 2018, when the Nursing team professionals (nurses and nursing technicians) were observed while performing 35 punctures without using any transillumination device, comprising the Before Group. The second stage consisted in training the professionals for puncture guided by transillumination devices and was carried out in January and February 2019, without observing any procedures. The third one was in May 2019, three months after applying the educational intervention: the professionals were again observed while performing 35 punctures but using transillumination devices this time, comprising the After Group.

For the first and third stages of the research, children who had an indication for puncture were invited to participate in the study. In case of agreement, interviews were carried out with the guardians to verify the variables related to the participants' demographic data and possible risk factors for puncture failure. Subsequently, each child's vein was evaluated and the procedure performed by a professional from the team was observed.

The data obtained were recorded in a data collection instrument created in REDCap® Base. While observing the punctures, their first-attempt success rate was verified following these criteria: insertion of the short catheter in the vein, with blood flow and reflux and infusion of one milliliter of physiological solution, stabilization of the device and absence of intravenous therapy complication signs^{4,5}; in case of failure, the number of attempts until success of the procedure and the caliber of the device used were verified.

The second stage, which consisted of the study intervention, was training the Nursing team professionals on how to use transillumination, based on In-Service Training, which is the development of critical sense based on demands arising from the daily practice, enabling the professionals to prepare for various real-life situations⁹.

The training consisted of two meetings between the researcher and the Nursing team professionals. The meetings took place in the very units where the study participants develop their professional activities. For this phase, Educational Cards and the Protocol for Punctures Guided by Transillumination Devices were prepared.

The Educational Cards were in the form of infographics and were used in the first theoretical meeting, which lasted approximately 40 minutes. They included the main steps to evaluate each child before the puncture; planning of the transillumination-guided procedure; the risk factors that hindered the procedure; the guidelines on the appropriate choice of short intravenous catheters; the puncture guided by the devices; the puncture technique used; and stabilization and fixation of the device.

The second meeting was theoretical and practical, also lasting approximately 40 minutes. In the first 10 minutes, the theoretical part was developed with presentation of the Protocol for Punctures Guided by Transillumination Devices, which, through photographs, illustrated the sequence of how the procedure should be performed. In the following 30 minutes, the professionals participating in the study used the devices cooperatively to understand their handling, positioning in the limb to be punctured, evaluation of the veins, and demonstration of how the short intravenous catheter would be inserted with their help. The technologies used were Venoscópio® and the VeinSeekPro® app installed on a mobile phone.

Venoscópio® has green, red, and white LEDs that, when combined, fall on the structures to be seen with a depth of up to five millimeters. Such colors ease light absorption in the tissues and mainly in non-oxygenated blood cells, thus highlighting the veins, with direct images^{6,7}.

The VeinSeekPro® app generates images by capturing the infrared radiation emitted by the tissues, up to seven millimeters in depth, and the mobile device camera is responsible for this process. It uses the hyperspectral imaging principles to generate the image, where sharpness depends on the quality of the mobile device lens^{7,8}.

The participants who comprised the Before Group also took part in the After Group. At different moments, all the professionals used both devices to assist in visualization of the children's veins.

The outcome studied was the first-attempt success rate (yes and no). The number of attempts until success (1, 2, 3, 4 or more) and the short intravenous catheter caliber (22 and 24 Gauge) were also verified.

The professionals were characterized according to the "professional category" variable (nurses and nursing technicians). The following variables were evaluated to characterize the children subjected to peripheral intravenous punctures: age; skin pigmentation (more and less); Body Mass Index (underweight, eutrophic, obesity); and conditions predisposing to puncture failures, namely: history of premature birth (yes and no); under 3 years of age (yes and no); obesity (yes and no); chronic disease (yes and no); difficult-to-see veins (yes and no); veins not palpable (yes and no); history of multiple punctures (yes and no); and previous intravenous therapy complications (yes and no).

The data were extracted from REDCap® Base to a Microsoft Excel spreadsheet and analyzed in the R 3.5.4 software. The categorical variables were presented according to absolute and relative frequencies and the numerical variables, according to descriptive statistics, with mean and standard deviation. A 5% confidence level was considered for the association analysis, and the Chi-square, Fisher's Exact and t tests were applied, as the punctures were observed in different children both in the Before Group and in the After Group, with no consequent data dependence.

The research protocol was submitted to evaluation by the Research Ethics Committees of the hospital where it was carried out and of the institution to which it was linked, being approved. Prior to data collection, the professionals signed the Free Informed Consent Form, and it is worth noting that all professionals accepted to participate in the study. For the study to be developed, the children who agreed to being observed signed the Free and Informed Assent Form, in addition to their parents or guardian's authorization through the Free and Informed Consent Form.

RESULTS

Table 1 presents the results referring to the 70 procedures performed by the professionals.

Table 1: Professionals that performed the punctures, according to the groups Before and After the training. São Paulo, SP, Brazil, 2021.

Variable	Before n (%)	After n (%)	p-value
Professional category			<0.001 ^c
Nurses	9 (25.7)	23 (65.7)	
Nursing Technicians	26 (74.3)	12 (34.3)	
Total	35 (100.0)	35 (100.0)	

Key: ^c – Chi-square test

The nurses performed more punctures ($p < 0.001$) after introducing the technology.

To verify if training the Nursing professionals on how to use transillumination might increase the first-attempt success rate of punctures in children, the characteristics of those that were punctured by the Nursing professionals before and after the training were compared, as presented in Table 2.

TABLE 2: Characteristics of the children according to the groups Before and After the training. São Paulo, SP, Brazil, 2021.

Variables	Before n (%)	After n (%)	p-value
Age (years old)			0.345 ^t
Mean±SD	5.9±4.8	7.1±5.7	
Skin pigmentation			0.334 ^c
Less	17 (48.6)	13 (37.1)	
More	18 (51.4)	22 (62.9)	
Body Mass Index			0.610 ^F
Underweight	4 (11.4)	4 (11.4)	
Eutrophic	25 (71.4)	28 (80.0)	
Obesity	6 (17.2)	3 (8.6)	
Predisposing factors for puncture failures			
History of premature birth			0.357 ^c
Yes	8 (22.9)	5 (14.3)	
No	27 (77.1)	30 (85.7)	
<3 years old			0.806 ^c
Yes	13 (37.1)	14 (40.0)	
No	22 (62.9)	21 (60.0)	
Obesity			1.00 ^F
Yes	3 (8.6)	2 (5.7)	
No	32 (91.4)	33 (94.3)	
Chronic disease			0.290 ^c
Yes	23 (65.7)	27 (77.1)	
No	12 (34.3)	8 (22.9)	
Difficult-to-see veins			0.015 ^c
Yes	16 (45.7)	26 (74.3)	
No	19 (54.3)	9 (25.7)	
Veins not palpable			0.039 ^c
Yes	7 (20.0)	15 (42.9)	
No	28 (80.0)	20 (57.1)	
History of multiple punctures			0.584 ^c
Yes	25 (71.4)	27 (77.1)	
No	10 (28.6)	8 (22.9)	
Previous IVT complications			0.584 ^c
Yes	25 (71.4)	27 (77.1)	
No	10 (28.6)	8 (22.9)	

Key: SD – Standard Deviation; ^t – t test; ^c – Chi-square test; ^F – Fisher's Exact test; IVT – Intravenous Therapy.

No statistical difference was verified between the groups for age, skin pigmentation, Body Mass Index and almost all the factors predisposing to puncture failures. There was a statistical difference in the “difficult-to-see veins” ($p=0.015$) and “veins not palpable” ($p=0.039$) categories. Thus, it is observed that the participants punctured before the training had similar characteristics to those punctured after the training, enabling a comparison.

Table 3 presents the data related to the first-attempt puncture success rate, number of attempts and caliber of the intravenous catheter used.

TABLE 3: First-attempt success rate, number of attempts and intravenous catheter caliber, according to the groups Before and After the training. São Paulo, SP, Brazil, 2021.

Variables	Before n (%)	After n (%)	p-value
First-attempt success rate			0.803 ^C
Yes	22 (62.9)	23 (65.7)	
No	13 (37.1)	12 (34.3)	
Number of attempts			0.677 ^F
1	22 (62.9)	23 (65.7)	
2	4 (11.4)	6 (17.1)	
3	5 (14.3)	2 (5.7)	
4+	4 (11.4)	4 (11.4)	
Short intravenous catheter caliber (Gauge)			0.143 ^C
22	17 (48.6)	11 (31.4)	
24	18 (51.4)	24 (68.6)	

Key: ^C – Chi-square test; ^F – Fisher's Exact test.

It was observed that the first-attempt success rate of punctures was similar before and after training the professionals, recording values over 60.0% in both groups. However, the second-attempt success rate was higher in the After Group than in the Before Group. 22 Gauge devices were the most used in the Before Group, although the result was not statistically significant.

DISCUSSION

In the current study, there was first-attempt success of punctures in both groups, in approximately 65% of the procedures. This result corroborates with a study conducted in a pediatric clinic that had as its objective testing a screening tool to identify children that would need additional resources to reach the first-attempt success rate, where 60% assertiveness was verified. However, 85.3% of the children had less pigmented skin and 57.3% had visible veins, factors that differ from this research, where 42.8% of the children had less pigmented skin and 40.0% had visible veins⁵.

When analyzing these two risk factors in the group After the training, it is observed that 62.9% of all 35 children in this group had more pigmented skin and that the veins were hard to see in 74.3%. Although these patients had these risk factors, the first-attempt success rate was 65.7% (Table 3), which shows that training the professionals and using the technology improved the care and safety of children subjected to peripheral intravenous therapy, with fewer puncture attempts and less suffering for the child with pain.

A study carried out at a Children's hospital in Australia with the objective of developing and validating risk assessment scores for difficulties in punctures also verified first-attempt success in slightly more than 60% of the children. However, 29.5% of them were at low risk for failure and another 29.5% presented medium risk for failure⁶.

Additionally, although there is no statistical difference between the first-attempt success rate of punctures between the groups Before and After the training, there was an increase in assertiveness: from 62.9% to 65.7%.

This non-significant result in the assertiveness rates can be related not only to the introduction of technologies but also to the change of a highly consolidated practice, where punctures are only based on vein visualization and palpation. In addition, it is possible that a longer period was necessary for this new course of action to actually improve the first-attempt success rate, even for patients with risk factors for failure in the procedures.

However, when verifying the second-attempt success rate there was an increase in the After Group, with the possibility of attributing the adaptation to the way of associating puncture visualization in the device and not only to the short catheter insertion site¹¹.

A study that used transillumination equipment to assess veins and guide punctures verified that most of the professionals that used the technology recommended its use, mentioning the following reasons: handling ease in addition to favoring visualization of the veins and procedure¹².

The incorporation of technologies in this practice also promotes changes in the work process, requiring professional qualification and motivation for the practice to change. Thus, new knowledge will be consolidated when there is adequate support for experienced professionals in the places where the new technology is being implemented¹¹.

No studies showing the necessary number of transillumination-guided punctures were identified in the literature, so that the professionals are in due conditions to perform the procedures. However, there are research studies evidencing that professionals who perform ultrasound-guided punctures need at least 20 procedures to be in due conditions, as well as constant monitoring by accredited professionals for a minimum of four months¹³.

Transillumination devices are also easier to handle and, as they generate the image in the puncture site, they favor use by nurses and nursing technicians to evaluate each child's veins and assist in the procedure, unlike ultrasound, which is only used by qualified physicians and nurses. They can also ease punctures in children treated at urgency and emergency units, which have a large number of patients with conditions predisposing to failure of the procedure and who require immediate installation of an intravenous device^{4,14}.

In relation to the short peripheral intravenous catheter caliber, there was an important change in the professionals' choice of the materials, related to the caliber of the device after evaluating the visualization and palpation of the vessels. Before the training, short catheters of a larger caliber (22 Gauge) were selected, whereas the choice was for short devices of a smaller caliber (24 Gauge) after the training. Larger caliber short catheters are indicated for rapid fluid replacement in emergency situations. For most clinical patients, the indication is to use smaller caliber short devices to avoid insertion traumas and mechanical phlebitis, preserving children's venous network^{1,15}. The change during action is attributed to the possibility of seeing the veins to be punctured and to confidence in the insertion and stabilization of devices that are more appropriate to the vein to be used¹⁶.

The nurses performed more punctures after the training. It is possible that this change was due to the approaches used in the training, as they paid attention to complexity of this procedure, mainly in children with risk factors for failure, for verifying that nurses are the best trained professionals to perform punctures, and because using technologies to perform the procedure is directly related to the care provided by nurses.

The implementation of intravenous therapy in children is considered a complex intervention, and nurses are the professionals with the necessary scientific knowledge, competence, and skill to perform such a complex practice, mainly when related to children. A multicenter study conducted in Latin America verified that 52% of the punctures are performed by nurses. This result corroborates with the current research, as 65.7% of the procedures were performed by the nurses after the training^{1,17}.

American and European hospital institutions choose to hire nurses specialized in Pediatrics and with experience in intravenous therapy because their knowledge, as well as the care they provide to the patients, increases the success rate of punctures, reduces the rate of bloodstream infections related to short peripheral intravenous catheters, phlebitis, occlusion and accidental catheter removal, reducing hospital costs and increasing patient satisfaction in relation to the care provided^{1,12}.

However, in Brazilian hospital institutions there is a reduced number of nurses in hospitalization and emergency care units, oftentimes precluding the exclusive performance of punctures in children by these professionals¹⁷. Thus, based on training sessions, nursing technicians can also resort to easy-to-handle transillumination devices and interpretation of the images generated, favoring success of the procedures and children's safety.

Thus, it is recommended that new randomized and controlled research studies be conducted to compare the first-attempt success rate of punctures in children with the use of transillumination devices, to have more observations and use time of the devices.

Study limitations

The current study presents the following limitations: the brief three-month period to consolidate the change in the practice. In addition, as this is the first stage of the research entitled "Success rate of puncture in children with puncture difficulties, according to two technologies for seeing veins: A randomized, controlled and crossover study", there was no possibility of conducting this phase of the main research for a longer period. Associated with this, the fact

that the professionals had to participate in all three study stages sometimes hindered observation of the punctures. Future observations should be performed to verify if there is an increase in the first-attempt success rate of the procedure.

CONCLUSION

The results of this study showed that training Nursing professionals on how to use transillumination increased the first-attempt success rate of punctures in the After Group, although with no statistical difference; and this result can be associated with the difficulties faced by Nursing professionals to appropriate new technologies in the care practice.

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All authors declare participation in Conceptualization; methodology; formal analysis; investigation; manuscript writing and writing—review editing; and have read and agreed to the published version of the manuscript.