

## ULTRASOUND-GUIDED PERIPHERAL VENIPUNCTURE: PREVALENCE OF SUCCESS AND ASSOCIATED FACTORS\*

Andrey Maciel de Oliveira<sup>1</sup>, Mitzy Tannia Reichembach Danski<sup>2</sup>, Edivane Pedrolo<sup>3</sup>

**ABSTRACT:** The objective of this study was to analyze factors associated with a successful first attempt to ultrasound-guided peripheral venipuncture in adults. An analytical cross-sectional study was carried out in an emergency care unit in the South region of Brazil in April 2015. The participants were submitted to ultrasound-guided peripheral venipuncture. Ninety-seven participants were included. The prevalence ratio of success was 43% higher in visible veins and 128% higher in rectilinear veins. No significant association was found between the variables analyzed and the reduction of the prevalence of success at the first attempt. The presence of rectilinear and visible veins was the main factor associated with success at the first attempt.

**DESCRIPTORS:** Evidence-Based Nursing; Biomedical Technology; Clinical Nursing Research; Peripheral Catheterization; Ultrasonography.

### PUNÇÃO VENOSA PERIFÉRICA GUIADA POR ULTRASSONOGRRAFIA: PREVALÊNCIA DE SUCESSO E FATORES ASSOCIADOS

**RESUMO:** O objetivo deste estudo foi analisar os fatores associados ao sucesso na primeira tentativa de punção venosa periférica guiada por ultrassonografia em adultos. Estudo transversal analítico em uma unidade de pronto atendimento na região sul do Brasil, entre 1º e 30 de abril de 2015. Os participantes foram submetidos à punção venosa periférica guiada por ultrassonografia. Foram incluídos 97 participantes. A razão de prevalência de sucesso foi 43% maior nas veias visíveis e 128% maior nas veias retilíneas. Não foi encontrada relação significativa entre as variáveis analisadas e a diminuição da prevalência de sucesso na primeira tentativa. A presença de veia retilínea e visível foi o principal fator associado ao sucesso na primeira tentativa.

**DESCRIPTORIOS:** Enfermagem baseada em evidências; Tecnologia biomédica; Pesquisa em enfermagem clínica; Cateterismo periférico; Ultrassonografia.

### PUNCIÓN VENOSA PERIFÉRICA GUIADA POR ULTRASONOGRAFÍA: PREVALENCIA DE ÉXITO Y FACTORES ASOCIADOS

**RESUMEN:** El objetivo de este estudio fue el de analizar los factores asociados al éxito en el primer intento de punción venosa periférica guiada por ultrasonografía en adultos. Estudio transversal analítico, realizado en unidad de pronta atención de la región sur de Brasil, entre el 1 y el 30 de abril de 2015. Los participantes fueron sometidos a punción venosa periférica guiada por ultrasonografía. Fueron incluidos 97 participantes. La razón de prevalencia de éxito fue 43% mayor en las venas visibles y 128% mayor en las venas rectilíneas. No se encontró diferencia significativa entre las variables analizadas y la disminución de la prevalencia de éxito en el primer intento. La presencia de vena rectilínea y visible fue el principal factor asociado al éxito en el primero intento.

**DESCRIPTORIOS:** Enfermería Basada en la Evidencia; Tecnología Biomédica; Investigación en Enfermería Clínica; Cateterismo Periférico; Ultrasonografía.

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<sup>1</sup>Nurse. Master's student in Nursing. Federal University of Paraná. Curitiba, Paraná, Brazil.

<sup>2</sup>Nurse. Doctor of History. Professor of Nursing. Graduate Program in Nursing. Federal University of Paraná. Curitiba, Paraná, Brazil.

<sup>3</sup>Nurse. Doctoral student in Nursing. Federal University of Paraná. Curitiba, Paraná, Brazil.

#### Corresponding author:

Edivane Pedrolo

Universidade Federal do Paraná

Av. Prefeito Lothário Meissner, 632 – 80210-170 – Curitiba, PR, Brasil

E-mail: edivanepedrolo@gmail.com

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## ● INTRODUCTION

Peripheral venipuncture (PVP) stands out as the most common procedure in nursing care environments and consists of the introduction of a catheter into a vein. According to statistics, 330 million peripheral intravenous catheters (PICs) were sold in the United States in 2012<sup>(1)</sup>, and records reinforce that 70% of patients undergo this procedure at some time during hospitalization<sup>(2)</sup>. In Brazil, these data are scarce.

Peripheral venipuncture is intended for diagnostic procedures (collection of laboratory examinations) and therapy procedures (infusion of intravenous medications and other solutions)<sup>(3)</sup>. By means of new devices and adjuvant technologies, intravenous therapies have been used for more than 350 years and its potential has increased in numbers and in therapy possibilities<sup>(4)</sup>.

However, success in the insertion of a PIC is often presented as a challenge for professionals, in addition to adding discomfort and anxiety to the experience lived by patients<sup>(5)</sup>. Based on the literature, success rates at the first attempt to insert PICs may range from 10% to 55% when undertaken through the traditional procedure<sup>(6-7)</sup>, and be benefited by technologies that facilitate its execution, such as ultrasonography, with which the same rates might range from 20% to 81.6%<sup>(7-8)</sup>.

Ultrasonography is an innovative technology for intravenous therapies, since it assists professionals in the puncture of difficult veins. Studies point out several benefits, such as an increase in successful punctures, reduction in the procedure's length of time, and reduction in the number of attempts. In addition, there is a reduction in complications, such as hematoma and phlebitis, and improvement to patients' comfort and satisfaction<sup>(9-10)</sup>.

Recommended as level "A" evidence by the American Association of Critical Care Nurses, ultrasonography is a noninvasive procedure that does not make use of ionizing radiation and enables to view deeper vessels, difficult to be accessed by blind palpation or even by some procedures that use rays close to infrared radiation<sup>(11)</sup>. It is worth mentioning that in urgency and emergency situations, the establishment of a fast and effective venous access may be essential to improve the clinical condition of patients.

The use of ultrasonography for venipunctures is regulated in Brazil by regional nursing councils of some states. The use of this technology is exclusively performed by nurses<sup>(12)</sup>. Regarding ultrasound devices, there are several models available in the market; however, for vascular punctures, the device must have a high-resolution linear transducer that operates at a frequency between 5 and 11MHz<sup>(13)</sup>. There are more compact devices programmed for vascular puncture, which facilitates their use.

With regard to difficulties of the venous network, and with the aim at meeting therapy demands of patients under their care, nursing professionals must establish venous accesses with skill and efficiency. Therefore, the evaluation of available technologies is necessary, in order to choose those that add more benefits to their practice.

It is worth mentioning that nursing research regarding ultrasound-guided punctures have as main focus, the puncture of central venous catheters of peripheral insertion, and there is a need for increasing the production of evidence regarding peripheral catheterization. Therefore, the present study aimed at answering the following guiding question: "What are the factors associated with the success of ultrasound-guided peripheral venipuncture in adults?" The objective of this study was to analyze factors associated with success at the first attempt to ultrasound-guided peripheral venipuncture (PVP-US) in adults.

## ● METHOD

This was an analytical cross-sectional study carried out in an emergency care unit of the metropolitan region of Curitiba, in April 2015. The study was approved by the research ethics committee of the institution, under protocol no. 1.015.232, in compliance with the current legislation. Patients aged 18 years or older who were receiving intravenous therapy, with the need of PVP in nonemergency situations were included. The participants were submitted to PVP-US. There were no exclusion criteria.

A group of six nurses with hospital experience, exclusively available for the study, was trained for PVP-US, since they had not received previous training on this skill, whereas the traditional venipuncture procedure was already incorporated into their practice. The training, given by a qualified nurse, approached contents of anatomy and vascular physiology, and ultrasonography principles. It consisted of a 60-minute dialogued expository class, followed by four hours of practice that enabled the puncture in a simulator specific for this purpose. A protocol was established for the procedure, so there was homogeneity among nurses who undertook it.

Short and flexible catheters with 18G, 20G, or 22G and a portable ultrasound device operating in B-mode image with 5-10MHz frequency and images of 1.5-6 cm of depth were used.

All patients had their venous network previously evaluated by a trained nurse, without interference from the researcher. Data collection occurred by means of direct observation of the puncture procedure by researchers, complemented with data from medical records.

The outcome variable was success at the first attempt to venipuncture, defined by the presence of venous reflux and infusion of 2ml of physiological solution, without pain complaint or signs of infiltration to the infusion. The data collection instrument included: sociodemographic variables (gender, age, and skin color); clinical evaluation of nurses on the venous network characteristics; and number of attempts to puncture.

Data tabulation was carried out with the use of the Microsoft Excel® program, and statistical analyses through the Bioestat® program and Comprehensive R Archive Network (CRAN)®. For the sample's characteristics, descriptive analysis was carried out with measures of distribution of absolute and relative frequencies for qualitative variables, measures of central tendency, and measures of dispersion for quantitative variables. QP statistics and calculation of prevalence ratio (PR) were adopted to verify the association of variables with statistical significance for the outcome.

## ● RESULTS

Ninety-seven participants were included in the study, with a prevalence of women (60.82%, n=59), aged 31 to 60 years (40.21%, n=39), with white skin color (52.57%, n=51). Of the total participants analyzed, n=63 (64.95%) presented success at the first attempt to puncture. In this group, no evidence of association of the outcome with sociodemographic variables or the catheter was found (Table 1). Likewise, there was no association among the reason for receiving care in the unit, presence of comorbidities (p=0.9552), and success at the first attempt to puncture.

Table 1 - Distribution of absolute and relative frequencies (f) of sociodemographic variables and the catheter (%). Curitiba, Paraná, Brazil, 2015 (continua)

Variable	Success at the first attempt				P value
	Yes (63)		No (34)		
	f	%	f	%	
Age group					0.2518
18-30	23	36.50	7	20.59	
31-60	24	38.10	15	44.12	
> 60	16	25.40	12	35.29	
Gender					0.05969
Male	29	46.03	9	26.47	
Female	34	53.97	25	73.53	
Skin color					0.4437
White	38	60.32	13	38.24	
Brown	21	33.33	17	50	
Black	4	6.35	3	8.82	
Yellow	-	-	1	2.94	

Insertion region					0.3119
Right upper limb	36	57.14	23	67.65	
Left upper limb	27	42.86	11	32.35	
Catheter gauge					0.1484
> 22G	41	65.08	17	50	
22G	22	34.92	17	50	

According to the distribution of venous network characteristics, considering the 97 participants, there was a prevalence of visible veins (61.86%, n=60), palpable veins (57.73%, n=56), superficial veins (70.10%, n=68), rectilinear veins (86.60%, n=84), nonhardened veins (84.54%, n=82), veins without mobility (90.72%, n=88), non-nodular veins (93.81%, n=91), and nonfragile veins (88.66%, n=86).

Venous network characteristics that presented an association with success at the first attempt to puncture were visibility (p=0.02752) and rectilinear route (p=0.006). Therefore, the prevalence ratio of success was 43% higher in visible veins and 128% higher in rectilinear veins. No association was found between venous network characteristics and failure in PVP-US (Table 2).

Table 2 - Distribution of venous network characteristics associated with the success at the first attempt to ultrasound-guided peripheral venipuncture. Curitiba, Paraná, Brazil, 2015.

Venous network characteristics	Success at the first attempt						
	Yes (63)		No (34)		PR	CI (95%)	P value (QP)
	f	%	f	%			
Visibility							
Visible	44	69.84	16	47.06	1.43	(1.01 : 2.02)	0.02752
Nonvisible	19	30,16	18	52,94			
Palpability					1.19	(0.87 : 1.62)	0.257
Palpable	39	61.90	17	50			
Nonpalpable	24	38.10	17	50			
Depth					1.36	(0.93 : 2)	0.07464
Superficial	48	76.19	20	58.82			
Deep	15	23.81	14	41.18			
Route							
Rectilinear	59	93.65	25	73.53	2.28	(1 : 5.22)	0.006
Tortuous	4	6.35	9	26.47			
Hardening					1.16	(0.82 : 1.64)	0.451
Hardened	11	17.46	4	11.76			
Nonhardened	52	82.54	30	88.24			
Mobility					0.66	(0.31:1.40)	0.1868
Mobile	4	6.35	5	14.71			
Without mobility	59	93.65	29	85.29			
Nodule					1.03	(0.57:1.85)	0.9272
Nodular	4	6.35	2	5.88			
Non-nodular	59	93.65	32	94.12			
Fragility					0.82	(0.47:1.44)	0.4497
Fragile	6	9.52	5	14.71			
Nonfragile	57	90.48	29	85.29			

Note: f-frequency; PR-Prevalence ratio; CI-Confidence interval.

An association between skin characteristics in the region to be punctured and the outcome was evaluated, and no association was found regarding friability ( $p=0.6027$ ), skin tension ( $p=0.6027$ ), brightness ( $p=0.258$ ), transudation ( $p=0.6618$ ), and edema ( $p=0.6618$ ).

## ● DISCUSSION

The results show a prevalence of women and white skin color in the study sample, which corroborates other studies<sup>(6,14)</sup>. A low demand for healthcare services by men is found in several studies, which justifies findings on the prevalence of women<sup>(15-16)</sup>. In addition, the demographic composition of the city where this study was conducted is mostly made up of women, and 72.61% of the population is white due to European colonization in the area<sup>(17)</sup>.

Most participants in this study were aged between 31 and 60 years (40.21%). Studies carried out in Brazilian emergency services show a mean age of  $44 \pm 20$  years<sup>(18)</sup> and  $41.6 \pm 34.6$  years<sup>(19)</sup>, corroborating data found in the present study.

The most used catheter in successful punctures observed during this study was the 20G, grouped in a category entitled ">22G" in this analysis. Similar results with the same gauge were found in previous studies, highlighting that larger-caliber catheters have slightly larger lengths, thus favoring the reach of deeper veins<sup>(7,14,20)</sup>.

It is worth mentioning that the best depths for PVP-US are between 0.5cm and 1.5cm. For a proper cannulation of the catheter and maintenance of the vessel's flow/perfusion, an appropriate catheter must have a length enough to be, at least, half inserted in the vessel (which contributes to a longer length of stay) and must have a maximum diameter of one-third of the vessel's diameter<sup>(7,14,20)</sup>. This shows that lower-caliber catheters are not suitable for this practice.

The choice of place of puncture is another important aspect to be considered in the planning of intravenous therapies. Therefore, evaluation of clinical circumstances becomes necessary, such as conditions of the limb to be punctured, type of intravenous solution, and length of treatment. The antecubital area is the most indicated for emergency care, since it presents as an advantage, the fast infusion of large volumes, and as a disadvantage, the localization in articulation, and consequently, a higher risk of catheter's displacement<sup>(21)</sup>.

The role of nurses is to search for the best evidence available for clinical decision-making that leads to the best therapy outcomes. Therefore, in the venipuncture process, they must be attentive to choices such as veins to be punctured, adjuvant technologies (type and material of catheters, ultrasonography, infrared radiation), and preferences of patients, providing a more assertive and safer care.

The success rate at the first attempt to puncture found in this study was 64.95% ( $n=63$ ). Although it was not the focus of the present study, a study suggests that the use of ultrasound in PVP may lead to better therapy outcomes<sup>(7)</sup>. A systematic review with meta-analysis based on six clinical trials and an observational study evidenced superiority of ultrasound procedures compared to traditional punctures, with increased success rates for patients with difficult venous network [OR=3.96, CI 95%: 1.75-8.94], although without differences in the number of attempts and time spent with the puncture between the two types of approach<sup>(22)</sup>.

A randomized clinical trial carried out with 60 adult patients detected higher success rates in PVP-US (84%) compared to the traditional method (50%,  $p=0.006$ ), considering all attempts observed. For these authors, better results for the number of attempts and success at the first attempt to ultrasound-guided PVP were also not evidenced<sup>(23)</sup>.

Authors point out that success at the first attempt to PVP results from several factors, such as age, skin color, presence of comorbidities, skin and venous network characteristics, and skill of professionals who undertake this procedure<sup>(7,24)</sup>.

Characteristics of the skin in the area to be punctured were not determining factors for the success or failure of a puncture in this study, in spite of authors pointing edema as an important factor that makes PVP difficult. A clinical trial developed with critically ill patients found edema in 80% of them<sup>(25)</sup>.

However, when patients under outpatient treatment were evaluated, only 6.5% of the sample presented edema<sup>(26)</sup>. In the present study, the frequency of edema proved to be low, matching the outpatient profile of patients who received care in the emergency care service.

Therefore, success at the first attempt to venipuncture, even with the use of ultrasound, requires right choices, considering factors that permeate its undertaking and aspects that influence it, in order to achieve the therapy outcome desired. In addition, the use of ultrasound for venipuncture by nurses requires previous training, due to the need for developing manual dexterity to manipulate the probe, that is, the transducer and visual perception of the images generated by the device.

Considering the characteristics found in the venous network of the participants in this study, there was a prevalence of visible, palpable, superficial, and rectilinear veins, without mobility or capillary fragility. It is worth mentioning that visual inspection constitutes a stage of evaluation of the venous network for the choice of the vein to be punctured, only for the traditional puncture procedure, whereas for PVP-US, this clinical decision is taken based on ultrasound scan, carried out with the device's transducer and visualization in the monitor<sup>(6)</sup>.

An exploratory study carried out with 20 adult patients found frequencies of 100% of visibility, 80% of rectilinear veins, and 70% of veins without mobility<sup>(21)</sup>. In the present study, overall frequencies of 85% for rectilinear veins and 91.5% for veins without mobility were found, with a significant statistical association of success at the first attempt with rectilinear route and visible veins. In a study of 20 peripheral venipunctures carried out with 15 outpatient cancer patients, there was 45% of veins with rectilinear route and 10% of simultaneously non-visualized and non-palpable veins, for which the success rate at the first attempt was equal to 90%<sup>(27)</sup>.

For having a tactile or visible segment, veins of rectilinear route are regular and easier to be punctured, whereas tortuous veins are presented as a challenge for the success of punctures, even with adjuvant technologies with ultrasound<sup>(28)</sup>. Although not being characterized as a significant factor for success, fragile veins are associated with chronic conditions, such as diabetes, vascular, or hematological disorders; they are often found in elderly people and more susceptible to the formation of hematomas resulting from attempts to punctures, which may hinder cannulation<sup>(8)</sup>.

Most veins punctured successfully in the present study were superficial, and according to the guidelines of the American Institute of Ultrasound in Medicine (AIUM), veins with depth around 5-15mm are ideal for PVP-US. Due to their depth, these veins may be less accessed during peripheral punctures with the traditional procedure, which often prioritizes superficial veins. This is because ultrasonography can visualize deeper veins, undetectable by palpation<sup>(29)</sup>. It is worth mentioning that the puncture of superficial veins might be associated with characteristics of the population studied, since most patients in acute state of the disease and who are not hospitalized have an intact venous network, which enables the puncture of more superficial veins in detriment of deeper veins.

Regarding visible veins, a clinical trial showed that African-American and Asian ethnicities, as well as obesity and childhood, are associated with reduced venous visibility; white people present a higher percentage of visible veins ( $p < 0.05$ )<sup>(24)</sup>. A study carried out with women with gynecological cancer undergoing chemotherapy presented at the end of treatment: 60% of visible veins, 70% of palpable veins, 20% of mobile veins, 80% of rectilinear veins, and 90% of nonhardened veins<sup>(21)</sup>.

Knowing the elements that contribute to success in PVP helps clinical reasoning and decision-making of nurses, when identifying aspects that are directly and indirectly associated with the results desired to the intravenous therapy. Based on this knowledge regarding soft and hard technologies that facilitate venipunctures, professionals can find the conditions required for the good practice of a more assertive and safe intravenous therapy.

It is worth mentioning that ultrasonography was presented as a technology for the development of skills and competence by the group of nurses during the development of the study, with possible interference in the outcome. An observational study showed that the insertion of four ultrasound-guided catheters is enough for an assertiveness of 70%, and that between 15 and 26 insertions are necessary so the success rate increases to 88%<sup>(30)</sup>. That is, the greater the skill of nurses in using the technology, the higher the success rate of the procedure.

Active participation of nurses in the indication of venous accesses is recommended, based on the planning of the infusion therapy, by means of their insertion in teams of vascular accesses as key elements in interdisciplinary decision-making, in order to identify potential beneficiaries from PVP-US.

It is worth mentioning that there are no studies on the cost-effectiveness or cost-benefit of this technology for peripheral puncture for the Brazilian reality up to this date. However, patients with a difficult peripheral venous network, critically ill patients, patients with cancer, and patients in surgical centers may benefit from the use of this technology.

It is the role of the managers of healthcare institutions to evaluate in what measure this technology can help their population, considering the satisfaction of patients, families, and teams, and the quality of care provided, in addition to training professionals so they have enough skills and competencies to promote quality of care and patient safety with the use of the technology.

## ● CONCLUSION

The success rate at the first attempt to PVP-US was 64.95%. Factors associated with success in PVP were characteristics of the venous network, with emphasis on rectilinear route and visible veins. Therefore, the need for incorporating ultrasonography in the clinical practice of nurses stands out; however, this requires a change in the way of undertaking this procedure, in which visibility is achieved with the help of the technology, thus enabling the puncture of deeper and higher caliber veins.

Knowing the factors of success and failure for punctures at the first attempt may contribute to improve the quality of care provided to patients who need intravenous therapies, since it will help nurses to choose veins that present higher possibilities of being punctured successfully.

Based on the results presented in this study, the development of randomized clinical trials is suggested, with the objective of evaluating the effectiveness of the ultrasound technology and its success rate at the first attempt to punctures, compared to traditional venipuncture undertaken in hospitals.

The limitation of the present study was the short time that the device was made available by the manufacturer, a factor that established the number of days for data collection.

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