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Ultrasound approach to patients with difficult venous catheterization by emergency nurses. A Systematic review.

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Abstract

Background: The insertion of peripheral venous access is the invasive procedure that occurs most frequently in hospital facilities and is essential in order to guarantee continuity of care and administration of therapy. The standard technique in a DIVA patient is not efficient causing traumatic experiences, increasing time and waste.

Methods: A systematic review was performed after searching the Scopus, Pubmed and Cinahl databases, with the following keywords: "ultrasound AND intravenous AND nurse". Initially, 1093 articles were identified and after carrying out a selection, 19 articles were taken into consideration.

Results: Among the selected articles, various themes emerged, including: high success rates in DIVA patients; risk factors associated with difficult patients; the consequences related to the lack of a specialized team and the numerous advantages that derive from the routine placement of the appropriate devices with the USGPIVA technique. The high success rate of the ultrasound-guided technique is related to the experience of the nurse who performs it. The use of ultrasound would make it possible to: increase patient compliance and the speed of assistance; reduce traumatic experiences, economic waste, material waste and CVC placement. To find long-lasting access it is essential: identifying the right vein and choosing the right device.

Conclusions: The review of the literature led to the confirmation that the USGPIVA is the best technique to obtain peripheral venous access in DIVA patients. To increase the quality of care provided and reduce waste, it is essential to identify difficult patients early and have qualified staff.

Keywords: ultrasound; intravenous; nurse; systematic review.

Introduction

Peripheral venous access is fundamental and often vital in the acute patient; allows you to infuse life-saving drugs, liquids, perform laboratory tests and administer contrast agents.

In emergency and admission departments, 70% of patients require peripheral venous access; often the patient, due to a series of characteristics linked to the condition or genetics, is difficult (DIVA), causing a series of problems, linked to the various attempts necessary for the positioning of a peripheral venous catheter, including; patient pain, decreased compliance, delays in diagnosis, treatment and discharge (1, 2).

In DIVA patients, the recommended procedure for inserting a peripheral venous access is the USGPIVA and not the traditional technique through a reference point (3). This study aims to identify: the advantages related to the routine use of this technique; the factors that contribute to the variation in success rates and the identification of the right devices.

Materials and methods

For the drafting of this review, the PICO methodology was taken into consideration and on the basis of the PRISMA declaration (4).

Population	Patients with DIVA, in critical care departments.
Intervention	Evaluate the effectiveness of the placement of a USGPIVA in a DIVA patient, in terms of effectiveness, patient satisfaction and costs.
Comparison	with the traditional landmark model for venous access.
Objective	Identify the best procedure.

To select relevant material to carry out this review, it was conducted on the following databases: Scopus, PubMed and Cinhal, with the help of the Boolean operator "AND" and keywords "ultrasound", "intravenous" and "nurse" , in the following order "Ultrasound AND intravenous AND nurse". After the first search for the material, a total of 1093 articles were found, after an initial selection based on the year of publication and then selecting articles published between 2018 and 2023, the remaining articles are 529. Then selecting two from the databases filters, one for the English language and the other for free access to the complete article, 289 remain. We then proceed to read the titles and abstracts, thus selecting the relevant articles and removing the duplicates, 43 articles remain. And finally, following an in-depth reading of the material, we proceed to further eliminate irrelevant articles, thus leaving 21.

Inclusion and exclusion criteria

Inclusion criteria that were used:

1) Articles in English

2) Articles with free access

3) Articles that deal with the positioning of ultrasound-guided venous access

4) Articles regarding nursing practice

5) Articles dealing with the DIVA patient

Exclusion criteria applied:

1) Paid items

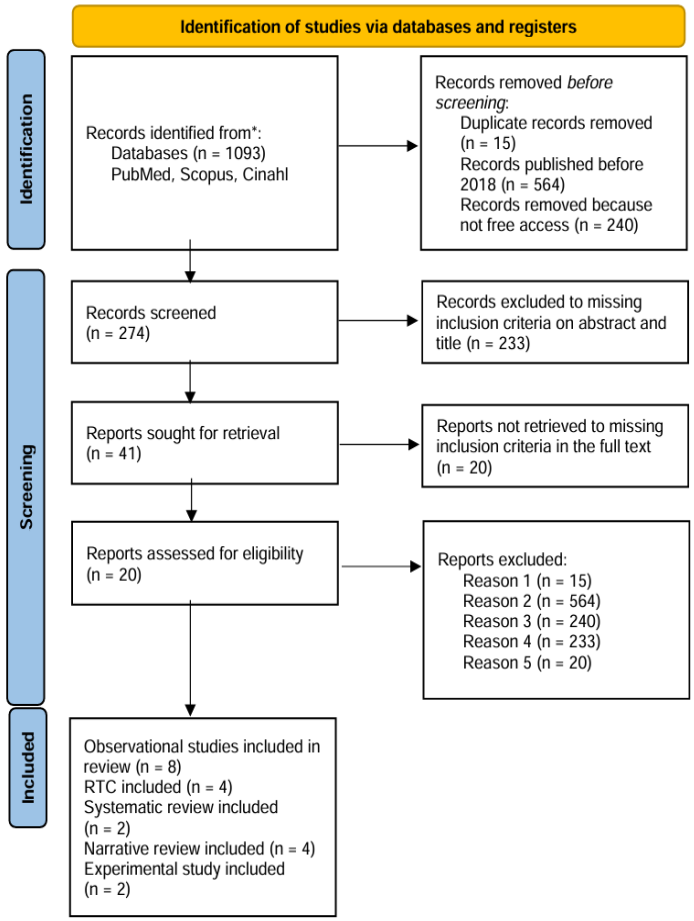
2) Articles that deal with the topic exclusively in the pediatric field

3) Articles not related to the question

4) Articles that concern exclusively medical practice

5) Articles before 2018

Figure 1- Flow diagram for new systematic reviews which included searches of databases



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Results

Author	Source	Year	Nation	Title	Type of study	Results	Evaluation of study
Amy Archer-Jones, Amy Sweenya, Jessica A Schults, Claire M Rickardc, Laura Johnson, Ashleigh Gunter, Stuart Watkins	Australasian Emergency care	2020	Australia	Evaluating an ultrasound-guided peripheral intravenous cannulation training program for emergency clinicians: An Australian perspective	RetrospectiveCohort study	In patients with DIVA, the USG technique should be used at the first attempt for the positioning of a venous access, with a success rate of 63%. Staff training increases their confidence in the short term and increases success rates, nursing staff should participate as teachers.	NOS Scale 7/8
Renee Stone, Rachel M. Walker, Nicole Marsh, Amanda J. Ullman	Australasian Emergency care	2023	Australia	Educational programs for implementing ultrasound guided peripheral intravenous catheter insertion in emergency departments	Systematic review	What is necessary is organizational support in the structures that allows ultrasound machines to be available before the development of implementation and education programs.	AMSTAR2 Moderate
Courtney Edwards, MSN, MPH, RN, CCRN, CEN, TCRN, and Jodi Jones, MD	Journal of emergency nursing	2018	USA	Development and implementation of an ultrasound-guided peripheral intravenous catheter program for emergency nurses	Narrative Review	The establishment of an effective didactic and practical training program has increased skills, nurses recognize its importance and allows them to increase professional autonomy and the quality of care provided.	INSA Scale 3/7
Evan M. Davis, Sarah Feinsmith, Ashley E. Amick , Jordan Sell, Valerie McDona, Paul	American Journal of Emergency Medicine	2020	USA	Difficult intravenous access in the emergency department:	Retrospective Cohort Study	Patients with DIVA experienced significant delays in both access placement, analgesia, therapy	NOS 8/8

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Trinquero, Arthur Moore , Victor Gappmaier, Katharine Colton , Andrew Cunninghamd , William Ford, Joseph Feinglass , Jeffrey H. Barsuk				Performance and impact of ultrasound-guided IV insertion performed by nurses		administration and laboratory tests, compared to patients without DIVA. The insertion of USGIV by trained nurses has made it possible to reduce waiting times and medical intervention, improving the care of patients with DIVA	
Chiho Kanno, Ryōko Murayama, Mari Abe-Doi, Toshiaki Takahashi4, Yui Shintani, Junko Nogami, Chieko Komiyama, Hiromi Sanada	Drug Discoveries & Therapeutics	2020	Giappone	Development of an algorithm using ultrasonography-assisted peripheral intravenous catheter placement for reducing catheter failure	Systematic Review	The positioning of an ultrasound-guided access allows for a drastic reduction in catheter failure with an incidence rate that decreases from 35.2% to 8.7% in cases where the following are taken into consideration: the appropriate vein to be punctured, the type of access to be inserted and the position of the catheter tip which must be inside the vessel. Furthermore, by reducing catheter failure, the risk of developing a thrombus with subcutaneous edema is reduced.	AMSTAR 2 Moderate
Fredericus H.J. van Loon, Harm J. Scholten, Hendrikus H.M. Korsten, Angelique T.M. Dierick - van Daele, Arthur R.A. Bouwman	Med Ultrason	2022	Olanda	The learning curve for ultrasound-guided peripheral intravenous cannulation in adults: a multicenter study	Observational prospective cohort multicentric study	Ultrasound-guided cannulation is recommended by the guidelines for DIVA patients, success at the first attempt is experience dependent, with success rates of 90-94%.	NOS Scale 7/8
Kimberly Alsbrooks, BSN, RN, RT (R), VA-BC and Klaus Hoerauf, MD, DBA	SAGE Open Nursing	2022	USA	Comparative Effectiveness, Efficiency, and ED Nurse Preference Between Two Methods of Visualization for Midline Catheter	Observational prospective cohort study	When inserting an ultrasound-guided venous access, the use of a needle tracking software system has shown (in comparison to the control group without tracking): reduce the number of attempts (by 20%), insertion time (by 37%), redirections (by 51%) and reduction (by 91%) of posterior wall	NOS Scale 7/8

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				Insertion: A Pilot Study		punctures, increase operator safety (by 15%), needle clarity (by 88%) %) and success on the first attempt (94%). Therefore, with the tracking system, a faster and more accurate insertion of vascular access is demonstrated.	
Jon A Bell1 and Timothy R Spencer	The Journal of Vascular Access	2019	USA	Implementing an emergency department vascular access team: A quality review of training, competency, and outcomes	Narrative review	With the increase in the rate of DIVA patients and the failure of nurses to find venous access with a classic procedure, having professionals specialized in finding quality access in healthcare facilities is essential, favoring patient outcomes, reducing device-related complications and improving patients' trust in healthcare personnel.	INSA Scale 5/7
David Convissar, MD Edward A. Bittner, MD, PhD Marvin G. Chang, MD, PhD	Critical Care Explorations	2021	USA	Biplane Imaging Versus Standard Transverse Single-Plane Imaging for Ultrasound-Guided Peripheral Intravenous Access: A Prospective Controlled Crossover Trial	Cross-sectional study	The single plane imaging technique is less efficient than the biplanar technique as it requires that: the operator moves both the tip of the needle and the ultrasound probe simultaneously and, furthermore, it does not allow visualization of the entire length of the needle, but only the cross section. It follows that the biplanar imaging technique is safer, more efficient and faster compared to the previously mentioned technique, with success rates of 78.3%±22.4% versus 41.7%±26% for the standard technique.	NOS Scale 6/8
Céline Bridey, Nathalie Thilly,Thomas Lefevre, Adeline Maire-Richard, Maxime Morel, Bruno Levy, Nicolas Girerd, Antoine Kimmoun	BMJ open	2018	USA	Ultrasound-guided versus landmark approach for peripheral intravenous access by critical care nurses: a	Randomised Trial Controlled	Comparing, in the emergency room, the guided ultrasound technique (UGM) and the traditional technique with reference point (LM), to identify the reference point for venous access, a success rate of 76% was highlighted in	Jadad Scale 5/5

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				randomised controlled study		the UGM group and 56% in the SCI group. However, an increase in extravasation was found for the UGM technique because the catheters used were not long enough for the cannulated deep veins, the length of which should be between 1.75-1.88 inches.	
Toshiaki Takahashi , Gojiro Nakagami, Ryoko Murayama, Mari Abe-Doi, Masaru Matsumoto, Hiromi Sanada	BMJ open	2022	Giappone	Automatic vein measurement by ultrasonography to prevent peripheral intravenous catheter failure for clinical practice using artificial intelligence: development and evaluation study of an automatic detection method based on deep learning	Clinical Trial	In the study, a new method was developed to automatically measure the diameter of the vein, thus making it possible to recommend the appropriate type of device to insert, in order to avoid catheter failure. If the diameter of the vessel is between 2.3-3mm we recommend a 24G device, if between 3-3.6mm a 22G, if greater than 3.6 a 20G.	Jadad Scale 2/5
Hamid Shokoohi MD, MPH Michael A. Loesche MD, PhD Nicole M. Duggan MD Andrew S. Liteplo MD Calvin Huang MD, MPH Ahad A. Al Saud MD Dustin McEvoy BS Shan W. Liu MD Sayon Dutta MD, MPH	Jacep open Wiley	2020	USA	Difficult intravenous access as an independent predictor of delayed care and prolonged length of stay in the emergency Department	Observational retrospective cohort	Patients with DIVA are associated with increased length of stay and adverse events. Factors associated with DIVA are female sex, African origin, acuity and severity of the disease, previous history of DIVA and age between 30-60 years. The delays caused by DIVA concern: IV pain and pharmacological therapy (50 min), fluid infusion (36 min), laboratory tests (29 min), contrast medium administration (59 min) and discharge orders (87 min).	NOS Scale 8/8

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Adrienne Malik, Olga Dewald, John Gallien , Mark Favot, Adam Kasten , Brian Reed, Robert Wells , Robert R Ehrman	Open Access Emergency Medicine	2023	USA	Outcomes of Ultrasound Guided Peripheral Intravenous Catheters Placed in the Emergency Department and Factors Associated with Survival	Observational retrospective case-control	It has been demonstrated that USIV catheters, regardless of the location or subjective characteristics of the patient, have a survival rate similar to accesses positioned with standard technique, reporting an average residence time of 40.3 hours in this study.	NOS Scale 7/8
Emily Smith and Valentin Irimia	British journal of nursing	2023	UK	Evaluation of extended-length cannula inserted using ultrasound guidance in patients with difficult IV access	Observational cohort study	The insertion of extended length catheters with ultrasound guidance improves the quality of life of patients with DIVA, reducing pain, the number of attempts, delay in therapy, improving therapy administration and insertion rates (90.7% on the first attempt). Furthermore, a great economic saving has been highlighted since fewer CVPs are used and at the same time the use of more expensive and more invasive lines is avoided.	NOS Scale 6/8

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Marcel Kaganovskaya and Lorelle Wuerz	Association for vascular acces	2020	USA	Development of an educational program using ultrasonography in vascular access for nurse practitioner students	Clinical Trial	Academic instruction, with theoretical and practical sessions, of the ultrasound-guided venous access placement technique could be successful, with positive impact for students.	Jadad Scale 3/5
Lauren Morata, Mark Bowers	CriticalCareNurse	2020	USA	Ultrasound-Guided Peripheral Intravenous Catheter Insertion: The Nurse's Manual	Review narrative	When positioning ultrasound-guided peripheral vascular devices in DIVA patients, the professional must know the associated risks, such as contact with nerves and arteries and extravasation in management, risks that can be avoided by choosing vessels no deeper than 1.6 cm. Dwell times vary based on the catheter being inserted, times ranging from 6-14 days for catheters 7.6 cm in length, with less chance of infiltration or movement. Furthermore, using ultrasound reduces the positioning of CVCs, with all the associated risks, and success rates of over 20% are recorded compared to the standard technique..	INSA Scale 5/7

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Ulrich Steinwandel, Linda L. Coventryand Homa Kheirkhah.	BMC Medical Education	2023	Australia	Evaluation of a Point-of-care ultrasound (POCUS) workshop for peripheral intravenous cannulation	Mix Methon longitudina l	The POCUS technique, used in DIVA patients, is linked to increased cannulation successes.	Jadad Scale 3/5
Nye, M, Sweeny, A, Watkins, S, Ingold, J, Sharwood, P	Australian Vascular Access Society	2020	Australia	Difficult vascular access in hospitalised patients: delays to treatment, cannulation attempts, and use of ultrasound	Prospective cohort study	Approximately 26% of patients arriving in the emergency room require multiple attempts to insert a venous access. These patients, DIVA, thus suffer multiple delays in treatments, up to 6 hours for 11% of patients. POCUS-guided cannulation can achieve success in fewer attempts.	NOS Scale 8/10
Jacob Price, MD Jane Xiao, MD Katie Tausch, MD Bophal Hang, MD Amit Bahl, MD	Western Journal of Emergency Medicine	2019	USA	Single Versus Double Tourniquet Technique for Ultrasound-Guided Venous Catheter Placement	Randomise d Trial Controlled	Vein dilation devices play an important role in USGPIV insertion. The use of a double tourniquet, one downstream and one upstream of the puncture area, did not lead to an increase in success.	Jadad Scale 3/5

Analyses

The initial search of the databases led to the identification of a total of 1093 articles. After removing duplicate articles, those that met the exclusion criteria and finally those not relevant to the inclusion criteria, based on title and abstract, the articles taken into consideration for this review were 21.

Observational study review

The observational studies deal with the effectiveness that a training plan for the placement of USGPIVA in difficult patients can have come to the conclusion that the use of ultrasound allows to increase the confidence and frequency in performing this procedure, consequently the increased success rate (5, 7, 8, 10).

From an ultrasound point of view, biplanar and single-plane transverse imaging are compared, the average success rates were 78.3% ± 22.4% for biplanar to 41.7% ± 26% the standard (13), the biplanar is associated with faster and more effective cannulation especially if the operator is inexperienced. The use of POCUS is associated with DIVA increases cannulation rates (14). Based on the success rates of the various techniques it can be deduced that: using the double tourniquet does not affect success (15).

The risk factors associated with DIVA patients and the consequences related to the lack of a specialized team in USGPIVA placement are also covered. Patients with DIVA experience delays compared to patients without (1), delays are seen in obtaining intravenous access, in laboratory tests, in administration of analgesics (1).

Other studies deal with the advantages obtained from the routine placement of USGPIVA from which it is noted that, in addition to the increase in success rates, there are advantages for the patient, such as: reduction of attempts to find venous access therefore reduction of pain , timing, stress, more functional treatment path and increased trust in the team. The advantages for the structure are mainly at an economic level and in terms of personnel management; in fact, the positioning of these devices allows for the reduction of medical involvement for CVC positioning, thus speeding up assistance (1).

To reduce the risk of catheter dislocation and early removal, the type of device you intend to place is important. Dislocation causes pain, erythema, bleeding, inflammation and hardening of the area which increases the patient's discomfort. In this regard, the study conducted by Takahashi et al. 2022, proposed 3 catheter sizes based on the diameter of the vein to be cannulated: vein greater than 2.3 mm but less than 3.0 mm 24 G recommended, greater than 3.0 mm but less than 3.6 mm 22 G recommended and greater than 3.6 mm recommended 20 G, not recommended vein less than 2.3mm (19).

Narrative study review

Also, a narrative studies agrees that a training plan for the placement of USGPIVA in difficult patients can have an increase of confidence and success rate (9). The data agrees that the success rates on the first attempt, using ultrasound, are higher compared to the traditional technique, 33% on the first attempt (3), above 76% (3).

To reduce the probability of catheter failure and to increase success, it is essential to puncture the appropriate vessel, position the tip of the catheter inside the vessel and choose the right device (17). Is also important not to puncture a vein deeper than 1.6 cm to reduce the probability of dislocation and puncturing a noble structure and furthermore long catheters are associated with greater survival (9).

Systematic review outcomes

Even articles (6) deals with the other articles about the effectiveness of a training plan for the placement of USGPIVA. The data agree that the success rates on the first attempt are higher compared to the traditional technique, above ~63% (6).

The risk factors associated with DIVA patients and the consequences related to the lack of a specialized team in USGPIVA placement are also covered. Patients with DIVA experience several delays compared to patients without, in terms of timing: 50 minutes for the administration of painkillers, 36 minutes for the administration of fluids, 29 minutes for laboratory tests, 57 minutes for the administration of intravenous contrast medium and 37 minutes for hospitalization (2).

Clinical Trial

The data agree that the success rates on the first attempt, using re 90%- 94%" (11) much higher than the traditional technique. The use of POCUS is associated with DIVA increases cannulation rates (10).

Patients with DIVA experience several delays compared to patients without, in terms of timing there is an average delay of 2.25 hours (12).

Based on the success rates of the various techniques it can be deduced that a needle tracking system would reduce the number of attempts, insertion time and penetration of the posterior wall of the vessel (16).

Making USGPIVA routine, in DIVA patients, would allow the number of CVCs positioned unnecessarily to be reduced by 80%-85%, reducing both the costs, since they are more expensive lines for insertion and management, and the complications associated with them,

such as infections, as there is a risk from 2 to 64 times greater than with a PIVC (18), leading to an increase in the costs that the structure must bear for the pharmacological treatment and the increase in hospitalization times.

Long cannulas provide reliable and prolonged access in DIVA patients, these devices are associated with low complication rates, as well as a significant economic advantage as, for each mini-midline placed the facility saved £172.2 by reducing the use of longer lines expensive (20).

Discussion

Obtaining peripheral venous access is one of the invasive procedures most frequently performed by nurses, it is a fundamental and often vital part of care. However, cannulate a vein peripheral in a DIVA patient is not simple, the use of ultrasound allows you to go from a 33% success rate on the first attempt with traditional technique (5) to significantly higher success rates, from 63% to 94% (3, 6 ,10,11) numbers that depend on the experience of the operators and on training programs.

The use of biplane ultrasound to position a USGPIVA has an average success of 78.3% ± 22.4%" (13), it is recommended instead of single-plane transversal, especially if the operator is novice as it allows to simultaneously visualize the transverse and longitudinal plane, instead of just the transverse plane, thus having a complete ultrasound image. Instead, a needle tracking system, associated with 94% success on the first attempt (16), has proven to be useful as it allows the needle to be visualized more clearly and therefore reduces perforations of the posterior wall of the vessel, obtaining thus greater precision and speed. The use of POCUS is associated with greater success rates (11, 14).

Identifying a DIVA patient early is essential, it is estimated that 11.8% of patients arriving in the emergency room and 25% of hospitalized patients have this designation (21). By directly using the guided ultrasound technique, fewer attempts will be required to find access and will therefore improve the treatment path and cause less pain and inconvenience to patients, increasing their trust in the team. Characteristics associated with patients with difficult venous access are: obesity, prior chemotherapy, non-palpable or visible veins, vascular disease, chronic disease, acute conditions, failed 2 attempts at intravenous catheter insertion, current or past drug abuse, frequent hospitalizations, women and African ethnicity (9,2). Patients frequently suffer delays in treatment, on average of 2.25 hours (12) and treatment delays of 15-120 minutes which could cause exposure to the risk of developing adverse outcomes, negative evolution of acute conditions and increase in length of stay in the facility and in the emergency room (2).

By making the insertion of ultrasound-guided venous access into DIVA patients routine, the facility could obtain significant advantages in terms of material waste, personnel management and economic advantages. Using the correct devices and the right approach

reduces the possibility of catheter dislocation, guaranteeing long-lasting access, and the number of attempts (17,20,2). Doing so could reduce the number of CVCs positioned which are more costly in management and positioning, which are then correlated with greater infectious complications (18). In terms of economic savings, taking into consideration the study conducted by Smith et al. 2023 which analyzes long cannulae, it is possible to observe that by using the right device, associated with greater survival, the hospital managed to save £172.28 per patient.

Limitations of the study

The limitations of this study are given by the reporting bias due to not consulting all available articles. Another limitation is given by the presence of RCTs or TCs with a quality rating lower than sufficient. On the other hand, there were no studies in the literature with a higher quality rating.

Conclusions

In conclusion, making the placement of USGPIVA routine in DIVA patients would certainly offer countless advantages for the healthcare facility and would therefore allow the provision of higher quality nursing care. It has been shown that the use of ultrasound would increase the success rate on the first attempt and consequently cause less pain and discomfort to the patient and increase trust in the nursing figure. Furthermore, the effectiveness of this procedure allows us to avoid waste of material, saving costs, reducing the insertion of CVCs, making staff more available and considerably reducing delays and waiting times. It is necessary to identify DIVA patients early using validated rating scales such as the "EA-DIVA" and the "A-DICAVE".

As for the equipment, ultrasound systems with biplanar imaging are more for those with little experience. There are also studies that demonstrate the success of using innovative needle tracking systems.

The size and type of devices should be chosen based on the size of the vein that you would like to cannulate. If the diameter of the vessel is between 2.3mm and 3mm, a 24G cannula is recommended. If between 3mm and 3.6mm, a 22G cannula is recommended. greater than 3.6mm of 20G, the vessels that should not be considered are: those with a diameter less than 2.3 mm because they are associated with lower survival and those deeper than 1.6 cm due to the risk of puncturing noble structures. Furthermore, it can be deduced that the use of mini-midlines is more effective because they are associated with fewer complications and greater survival.

It is therefore advantageous for healthcare facilities to have specialized equipment and nurses available to make the USGPIVA routine; however, an important obstacle in Italy is

represented by the collective bargaining in force which does not recognize a specific allowance for specialized nurses.

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