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NURSING

Development of a training program in ultrasound-guided peripheral venous catheter placement: experience in a tertiary pediatric hospital

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INTRODUCTION

Placement of a peripheral venous catheter (PVC) in pediatric patients always poses a challenge. In emergency situations, in 15% of children difficulties in securing a PVC are encountered[(1)].

The DIVA2 (Difficult Intravenous Access) prediction score identifies patients with difficulties in detecting suitable veins for the intravenous administration of medication or sampling due to poorly visible, collapsed, or damaged veins (Table 1).

When a patient is classified as DIVA, it is advisable to use technologies such as infrared imaging and/or ultrasound to optimize the chances of successful venous access.

Ultrasound (US) guidance for PVC placement has proven to be effective, reducing the use of central venous catheters, increasing staff autonomy, and improving patient satisfaction[(3)]. However, the success of the procedure will depend on the proficiency of the operator, highlighting the importance of prioritizing training in these skills[(4)].

In 2008, at the Hospital de Pediatría Prof. Dr. "Juan P. Garrahan" in Argentina, the "catheter patrol" was established—a team of specialized nurses dedicated to infusion therapy. Since 2019, this team has incorporated the use of US for the placement of PVCs in DIVA patients.

Currently, at the emergency department, there is a need to integrate this resource as an effective strategy to address the challenge. For this purpose, a theoretical-practical training program for the healthcare team was developed with the aim of taking a significant step towards a better quality of care.

The aim of this article was to describe our experience with the design and implementation of a training program in the use of ultrasound-guided PVC placement in the emergency department of a tertiary hospital. The analysis of the impact and results of the implementation of this technology for the placement of venous access will be the subject of a future study.

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DEVELOPMENT

Setting

The "Prof. Dr. Juan P. Garrahan" Pediatric Hospital in Argentina is a tertiary care center that receives more than 600,000 outpatient visits per year. It has 587 beds, 132 of which are for intensive care. Each year, the Center for the Comprehensive Care of Hematology-Oncology Patients (CAIPHO) receives around 520 new patients. In addition, approximately 120 transplants (bone marrow, heart, kidney, liver, and cochlea) are performed annually. The Emergency Department receives 120,000 visits per year.

Teaching team

The catheter patrol team consists of five nurses specialized in infusion therapy with graduate training and experience ranging from 3 to 13 years. The nurses have been formally trained by participating in various theoretical, practical, and simulation courses at recognized national and international institutions.

Initially, they incorporated infrared light for percutaneous catheter placement into their routine practice, and in 2019,

TABLE 1. DIVA prediction score.

Variable	Point value		Score
Vision	Visible	0	
	Not visible	2	
Palpability	Palpable	0	
	Not palpable	2	
Age	> 3 years	0	
	1-2 years	1	
	< 1 year	3	
History of prematurity	Full-term	0	
	Premature	3	
		Total	

Modified from: Whitney R, Langhan M. Vascular Access in Pediatric Patients in the Emergency Department[6].

they added US guidance for catheter placement. The implementation of this tool required the mentoring of a pediatric surgeon until the team became proficient and autonomous. Over the years, the number of US-guided catheter placements increased (Figure 1).

The catheter patrol operates from monday to friday from 07:00 am to 9:00 pm and any area of the hospital can request a consultation with this team. Initially, the patrol will evaluate the patient's therapeutic needs and perform a clinical and US assessment to define the type of catheter, approach route, and technology to be used. Secondly, the placement of the catheter will be scheduled with the treating team.

With the aim to improve and expand continuing education the patrol has created its own practice and simulation

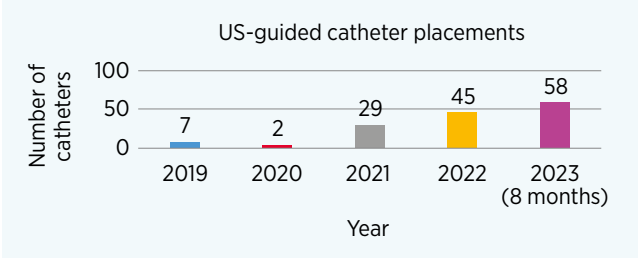


FIGURE 1. Ultrasound-guided procedures in DIVA patients performed by the catheter patrol.

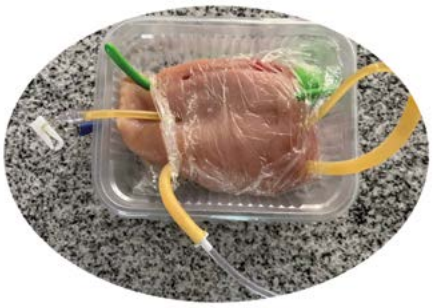
materials for vascular access placement using gel-based devices and biological models (Figure 2).

For over a decade, the patrol has been systematically providing theoretical and practical training to practitioners working in different areas of the hospital. The team conducts educational activities for medical and nursing residents with curricula that include training in these skills.

Intervention

Between March and August 2023, within the framework of the continuing education program of the Emergency Department of the Garrahan Hospital, training in the use of US for PVC placement was implemented for physicians and nurses of the permanent staff. The training was conducted by catheter patrol nurses and emergency department staff and consisted of two 60-minute theoretical-practical modules. Aspects related to basic US handling, recognition of vascular structures, evaluation of the venous system using the RaPeVA (Rapid Peripheral Venous Assessment)5 protocol, and finally, placement of a PVC in gel-based and biological models (Figure 2).

GEL-BASED SIMULATOR
Materials:
- Unflavored gelatin powder
- Water
- Glycerin
- Food coloring (optional, to color the gelatin)
- Containers or molds with holes for inlet and outlet
- Latex tubes 5 x 8 (Inner diameter: 5 mm/Outer diameter: 8 mm).
- Use of Macro Drip (attach a macro dripper with serum to one end of the latex tube. Prime the latex tubing to ensure that no air bubbles are present)



BIOLOGICAL MODEL SIMULATOR
Materials:
- Biological model with inlet and outlet holes
- Latex tubes 5 x 8 (inner diameter: 5 mm/Outer diameter: 8 mm)
- Use of Macro Drip. (Attach a macro dripper with serum to one end of the latex tube. Prime the latex tubing to ensure that no air bubbles are present)

FIGURE 2. Material for the simulation.

FIGURE 3. The emergency team is practicing with US guidance using self-made and low-cost resources.

Trained staff

Thus, a total of 11 physicians and 15 nurses from the emergency department were trained in the basic use of US, evaluation of the venous system, and ultrasound-guided catheter placement (Figure 3).

After completing the theoretical and practical training, emergency department practitioners conducted a series of intravenous line placements under the supervision of the catheter patrol nurses.

Incorporation of US into an algorithm for intravenous line placement

Finally, an algorithm was developed for PVC placement in the emergency department, incorporating the novel use of US.

Adequate management of a patient's venous access should be considered at every stage of care. Upon admission to the emergency department, priority will be given to intravenous line placement, based on the urgency of the clinical situation. Certain circumstances may necessitate evaluation of other variables contributing to the rational management of vascular access, especially in patients undergoing prolonged treatment and frequent hospitalization.

The DIVA prediction score is used to evaluate possible peripheral venous access in patients in need of infusions and/or blood sampling. It evaluates the visibility and palpability of the vessel, along with the patient's age and history of prematurity (Table 1). The cumulative score obtained for each variable represents the DIVA score, ranging from 0 to 10 points[6]. If > 4, the utilization of infrared light technology or US should be contemplated before inserting a PVC.

When admitting a patient, we will first evaluate whether it is an emergency or an urgency and, therefore, how fast we should start specific therapy. Other factors to consider in the choice of vascular access are the estimated treatment time and difficulty according to the DIVA scale (Table 1) as well as the availability of suitable vessels. At this stage, it is also relevant to define the number of suitable vessels in order to select the most experienced operator and consider the use of US (Table 2).

We propose the following algorithm for decision-making regarding venous access in the emergency department (Figure 4). The algorithm introduces the use of US in different clinical scenarios. If the patient presents with respiratory arrest or decompensated shock, intraosseous access is recommended. If the patient requires emergency intervention but does not need intraosseous access, the choice of placement modality is determined based on the DIVA prediction score and the availability of adequate vessels. Venous access via direct puncture (using direct vision, palpation, or anatomical references) is preferred for patients with visible and palpable vessels. However, if direct puncture is unsuccessful after four attempts or if the DIVA score exceeds 4 points, US guidance should be used.

If the patient is not in an emergency situation, we can include an additional consideration related to estimating the duration of required infusion therapy, particularly for patients who are frequently hospitalized or undergo prolonged treatments. For treatments anticipated to last less than 5 days, a short peripheral venous access may be selected, considering the DIVA score and the availability of suitable veins. For treatments lasting between 6-30 days, US-guided midline catheters are recommended.

TABLE 2. Assessment of the degree of difficulty according to the number of suitable veins according to operator skills[7].

Grade	Number of suitable veins	Insertion management
1	3-5 veins	Insertion by trained competent healthcare practitioner
2	2-3 veins	Insertion by trained competent healthcare practitioner
3	1-2 veins	Insertion by trained competent healthcare practitioner
4	No palpable visible veins	Ultrasound-guided insertion by trained competent healthcare practitioner
5	No suitable veins with ultrasound	Refer to specialist

Source: Fuente: Hallam C, Denton A, Weston V, et al. Marco de Salud y Preservación de venas (VHP) del Reino Unido[7].

DISCUSSION

In the pediatric emergency care setting, the search for approaches that reduce the need for repeated punctures represents a challenge. In daily practice, there are several situations that complicate the placement of PVCs in children,

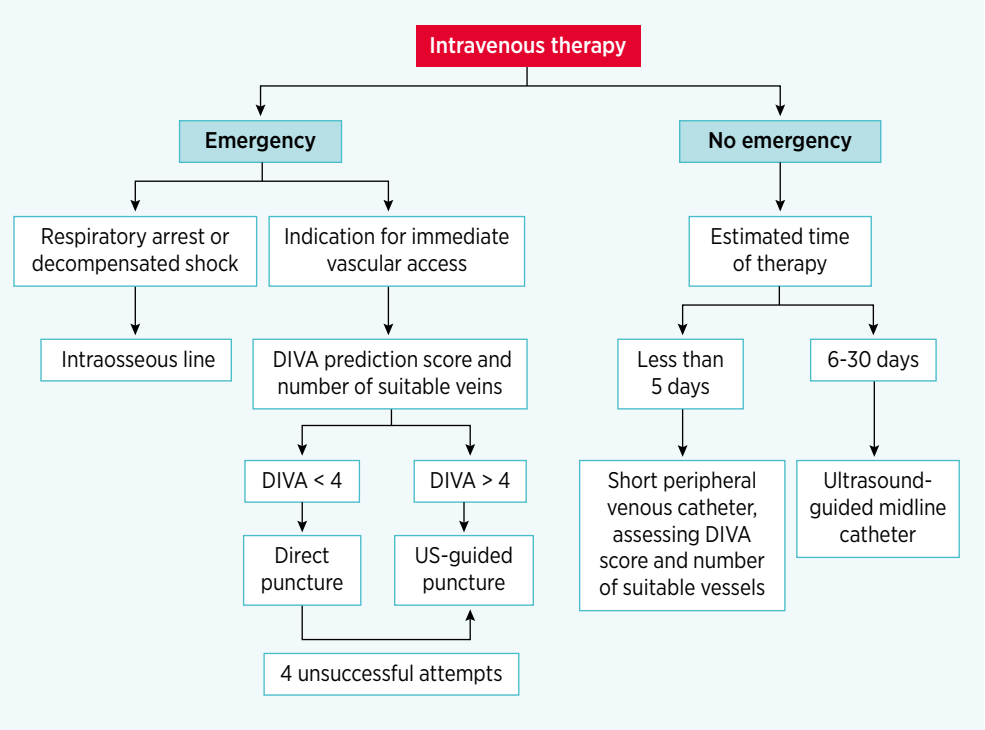


FIGURE 4. Algorithm for the placement of a peripheral venous catheter.

some related to pre-existing conditions (prematurity, young age, obesity, chronic diseases, etc.) and others related to the acute condition (fever, dehydration, acidosis, etc.). According to current recommendations, it is suggested that up to four attempts be made to place a PVC[8].

Currently, there is clear evidence supporting the advantages of incorporating US in the placement of a PVC for both adults and children. Utilizing US facilitates success on the first attempt and overall success[9], thereby avoiding unnecessary punctures and reducing patient pain and anxiety. Moreover, it allows a more precise placement of the catheter minimizing the risk of complications such as arterial punctures, hematomas, infiltration, and extravasation. In addition, by reducing unsuccessful puncture attempts, US guidance saves time and resources, while also preventing the need for more invasive techniques, thus offering significant benefits to the safety and experience of the patient and their families.

Finally, there are numerous studies on the implementation of this type of educational training programs in emergency and critical care departments, which suggest beneficial results in terms of placement time, efficacy, and the need for central access[10,11]. On the other hand, regarding the number of ultrasound-guided PVC placements required to achieve proficiency, literature primarily focused on emergency department nurses and physicians suggests that four attempts are necessary to achieve a success rate of 70%, and between 15 and 26 attempts to achieve a success rate of 88%[4].

In view of the above, the implementation of a theoretical-practical training program in US-guided PVC placement is considered a promising strategy for the acquisition of these skills by emergency practitioners. Such training will serve as an additional resource for managing difficult intravenous access (DIVA) patients.

CONCLUSIONS

The successful implementation of this training program provided benefits in several aspects.

From the perspective of the healthcare team, it has promoted shared training opportunities for both physicians and nurses, reinforcing the concept of teamwork and facilitating the acquisition of skills essential for the daily operation within the emergency department. Similarly, the collaboration with the catheter patrol has proven to be a mutually enriching and exemplary experience of interdepartmental cooperation within the hospital, all aimed at achieving a common goal.

From the standpoint of patient care, the dissemination and training of personnel in this technique significantly contributed to enhancing the quality of care provided to children in the emergency department.

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