Ultrasound Guided Vascular Access in The Neonatal Intensive Care Unit: A Nationwide Survey

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Abstract

Ultrasound guided percutaneous vascular access (USG-PVA) is recommended by international practice guidelines but information regarding its use in the neonatal intensive care unit (NICU) is lacking. Our objective was to assess neonatologist's perceptions and current implementation of USG-PVA in Spain. This was a nationwide online survey. The survey was composed of 37 questions divided in 4 domains: 1) neonatologist's background, 2) NICU characteristics, 3) personal perspectives about USG-PVA and clinical experience in USG-PVA. One hundred and eighty survey responses from 59 NICUs (62% of Spanish NICUs) were analyzed. Most neonatologist (81%) perceive that competence in USG-PVA is indispensable or very useful in clinical practice. However, 64 (35.5%) have never used USG-PVA in real patients. Among neonatologists with some experience in USG-PVA most perform less than 5 procedures per year (59% in venous access and 80% in arterial access) and a 38% and 60% have never used USG for venous and arterial access respectively in very low birth weight infants (VLBW). Spanish neonatologists report that residents/fellows training in USG-PVA is absent (52.2%) or unstructured (32%) in their units. The lack of adequate training is identified by a 60% of neonatologists as the most important barrier for implementation of USG-PVA and 87% would recommend that future neonatologists receive formal training. In conclusion, Spanish neonatologists perceive that USG-PVA is important in clinical practice but, currently these techniques are largely underused. Our results indicate that specific training in USG-PVA should be implemented in the NICU.

What'S Known

-Ultrasound guided vascular access is recommended as the preferred method for central venous access and arterial line placement in children and adults

-The degree of current implementation of ultrasound for vascular access in the NICU and the perceptions of neonatologist about its use are largely unknown.

WHAT'S NEW

-Most neonatologists consider that competence in ultrasound guided vascular access is an indispensable aid for clinical practice.

-However, most neonatologists are not adequately trained in ultrasound guided vascular access and the technique is largely underused.

Introduction

Percutaneous vascular access (PVA) in children is more challenging than in the adult patient due to several factors such as vessel size, anatomical variations, lack of collaboration or need for sedation. [1, 2] The neonatal population represents a very particular subset where vascular access is highly problematic, especially in the preterm infant and there is a lack of high level evidence to guide vascular access practices [3–5]. Most preterm and sick neonates require a central venous access. Umbilical vessels are the first choice for central access during the first days of life.[6] Thereafter, most patients receive a peripherally inserted central catheter (PICC) like the epicutaneous-cava catheter (ECC).[7] While such devices suffice for routine care in most instances, the sickest patients who need high intensity care benefit from large-bore central venous catheters (CVC) and arterial lines. Placement of a CVC in neonates has been traditionally considered a high-risk procedure. However, there are several studies that confirm that USG-CVC is feasible and safe in neonates and even preterm infants.[8–11] Recent clinical practice guidelines on point of care ultrasound (POCUS) have been released by the European Society of Pediatric and Neonatal Intensive Care (ESPNIC)[12]. In these guidelines the use of USG is recommended for placement of internal jugular vein (IJV) catheters (strong agreement, quality of evidence A) and it is considered helpful for insertion of other CVCs, peripherally inserted central catheters (PICC), arterial lines as well as for the assessment of central venous catheter (CVC) tip location (strong agreement, quality of evidence B). Despite of the paramount clinical relevance of vascular access in neonates, there is a complete lack of data regarding the current implementation of USG-PVA in the NICU.

With the hypothesis that USG-PVA is underused, the objective of the present study was to assess current practice regarding USG-PVA in the Neonatal Unit as well as to analyze the perceptions of Spanish neonatologist regarding the clinical utility, risks and barriers for implementation of these techniques in their current practice.

Materials And Methods

This was an online-survey based study promoted by the Working Group on Ultrasound (WG-US) of the Spanish Society of Neonatology (SENeo). The WG designed the study according to the CHERRIES and CROSS guidelines for survey studies. [13, 14] The target population

were active Spanish neonatologists who were identified from the affiliate registry of the SENEo. One expert in USG-PVA from the WG and one additional expert not involved in the WG-US activities developed the first draft of the survey. The initial proposal included 46 questions divided in 4 domains: 1) neonatologist's data and background, 2) NICU characteristics, 3) clinical experience in USG-PVA and 4) perceptions about USG-PVA). This initial proposal was reviewed by a panel of 6 neonatologist from the WG-US with interest and expertise in USG-PVA. The WG members discussed the appropriateness of every question. Additionally, each member of the panel was allowed to add and remove up to three questions. Each question was assigned a priority (high, medium, low) based on rating of the content validity and reliability using a predefined color-coded Likert scale.[15] Four rounds of corrections were needed until a consensus was reached. The final survey consisted in 37 questions (Appendix 1 in supplementary content) including an adaptative question to reduce complexity (only those responders who reported some experience in USG-PVA were allowed to answer questions in the domain 3). No personal information from participants apart from the email address was recorded. Only one response per participant was allowed by requesting and checking email address with each response. Incomplete surveys were discarded from the analysis.

The survey was uploaded to Google Forms®. The survey was headed by a brief text with a description of the research group and the study objectives. The questionnaire was arranged in four screen pages and estimated time for completion was 15 minutes. Responders were allowed to review and change responses ("back-button") before final submission.

The survey link was mailed to the 756 affiliates of the SENEo on the 15th of September 2021. The survey was advertised on the SENEo website and during the virtual National Congress of the SENEo that took place on the 27-28th October of 2021. Up to 5 reminder e-mails were sent during a three-month period before closing recruitment.

Statistical analysis

Numerical data are summarized as mean (standard deviation). Qualitative data are summarized as number (percentage). An analysis of factors associated with current use of USG-PVA in real practice was performed using multivariate logistic regression. Covariates were chosen based on author's previous knowledge and a literature review and included operator's age, operator's year working in Neonatology, NICU complexity, working on a teaching NICU, working on a mixed (pediatric and neonatal) unit, previous training in USG-PVA and years performing USG-PVA in clinical practice. Only variables with a $p < 0.1$ in univariate analysis were introduced in the multivariate models. We investigated factors associated with the use of USG-PVA (all responses; $n=180$) and then factors predicting the number of USG-CVC procedures ($n=116$) per year. SPSS v25 software was used for the analysis.

Results

One hundred and ninety-three survey responses were received (response rate 25%). Thirteen surveys were discarded because incomplete data ($n=8$) or duplicates ($n=5$). Finally, a total of 180 surveys coming from 59 NICUs (62% of Spanish NICUs) were included in the analysis. Data related to neonatologist's background and NICU characteristics are summarized in Table 1. The neonatologist's mean (SD) age and years of clinical practice were 41 (7.6) and 12.6 (7.4) years respectively. Most neonatologist worked in teaching units (66.7%) but reported that training of residents/fellows in USG-PVA was absent (52.2%) or occasional (32.2%) in their units. Sixty-four (35.6%) of the responders had no experience placing USG-PVA in real patients. These practitioners were significantly older ($p < 0.001$), have received previous training in POCUS ($p < 0.001$) or USG-PVA ($p < 0.001$) less frequently and worked in lower-complexity ($p < 0.001$) and smaller NICUs ($p < 0.001$) compared to those who have performed USG-PVA in clinical practice. Nearly a half of responders (51.1%) reported that less than 25% of the attending neonatologists perform USG-PVA in their units and only a 13.3% reported that more than >75% of the staff perform these techniques regularly.

Table 1
Neonatologist's basic data and background and NICU characteristics according to experience in USG-PVA

	All (n=180)	No experience in USG-PVA (n=64)	Some experience in USG-PVA (n=116)	p
Neonatologist's basic data and background				
Age	41 (7.6)	45.7 (7.6)	39.4 (6.7)	<0.001
Years of clinical practice in Neonatology	12.6 (7.4)	16.6 (7.6)	10.3 (6.4)	<0.001
Full time dedication as neonatologist	116 (64.4%)	32 (50.8%)	84 (72.4%)	0.004
POCUS training during residency	128 (71.1%)	58 (90.6%)	70 (60.3%)	<0.001
-No training		6 (9.4%)	46 (39.7%)	
-Some training	52 (28.9%)			
Training in USG-PVA	46 (25.5%)	44 (68.7%)	2 (1.7%)	<0.001
-No training		10 (15.6%)	56 (48.3)	
-Unstructured training	66 (36.7%)	10 (15.6%)	58 (50%)	
-Structured training	68 (37.8%)			
NICU characteristics				
Mixed NICU/PICU	36 (20%)	10 (15.6%)	26 (22.4%)	0.276
NICU level according to official denomination in Spain	50 (27.8%)	4 (6.2%)	46 (39.6%)	<0.001
-IIIc		34 (53.1%)	54 (46.5%)	
-IIIb	88 (48.9%)	26 (40.6%)	16 (13.8%)	
-Other (IIIa, IIb, IIc, I)	42 (23.3%)			
High complexity NICU *	44 (24.4%)	4 (6.2%)	40 (34.5%)	<0.001
Number of NICU beds	109 (60.5%)	51 (79.6%)	58 (50%)	<0.001
-≤10		10 (15.6%)	36 (31%)	
-11 to 20	46 (25.5%)	2 (3.1%)	22 (19%)	
->20	24 (13.3%)			
Number of attending neonatologist in your hospital	9.4 (5)	6.7 (3.5)	10.9 (5)	<0.001
Teaching NICU	120 (66.7%)	34 (53.1%)	86 (74.1%)	0.004
Training of residents in USG-PVA	94 (52.2%)	44 (68.7%)	50 (43.1%)	0.003
-No training		14 (21.9%)	42 (36.2%)	
-Occasional training (not structured/incomplete adherence)	58 (32.2%)	6 (9.4%)	24 (20.7%)	
-Formal training program with full or near full adherence	30 (16.7%)			

*High complexity NICU is arbitrary defined as that unit providing ECMO and cardiac surgery. High complexity NICU is defined as that providing cardiac surgery and ECMO. CVC: central venous catheter; NICU: neonatal intensive care unit; PICU: pediatric intensive care unit; POCUS: point of care ultrasound; PVA: percutaneous vascular access; USG: ultrasound guided; VLBWI: very low birth weight infants.

	All (n=180)	No experience in USG-PVA (n=64)	Some experience in USG-PVA (n=116)	p
Professional performing USG-PVA In your unit	90 (50%)	16 (25%)	74 (63.7%)	<0.001
-Always or mostly the neonatologist		10 (15.6%)	26 (22.4%)	
-Neonatologist as well as other professionals (anesthesiologists, pediatric intensivists, radiologists)	36 (20%)	38 (59.3%)	16 (13.7%)	
	54 (30%)			
-Always or mostly other professionals (anesthesiologists, pediatric intensivists, radiologists)				
Attending neonatologists performing USG-PVA regularly in the NICU	92 (51.1%)	54 (84.4%)	38 (32.7%)	<0.001
-<25%		8 (12.5%)	56 (48.2%)	
-25-75%	64 (35.5%)	2 (3.1%)	22 (18.9%)	
->75%	24 (13.3%)			
Percentage of PVA (USG or landmark) procedures in VLBWI	30 (16.6%)	16 (25%)	14 (12.1%)	0.047
-0%		30 (46.9%)	54 (46.5%)	
-<25%	84 (46.6%)	18 (28.1%)	48 (41.4%)	
->25%	66 (36.6%)			
*High complexity NICU is arbitrary defined as that unit providing ECMO and cardiac surgery. High complexity NICU is defined as that providing cardiac surgery and ECMO. CVC: central venous catheter; NICU: neonatal intensive care unit; PICU: pediatric intensive care unit; POCUS: point of care ultrasound; PVA: percutaneous vascular access; USG: ultrasound guided; VLBWI: very low birth weight infants.				

Among those neonatologists (n=116) with some clinical experience in USG-PVA (Table 2) a 62% perform less than 5 USG-CVC insertions per year and a 38% have never used this technique in VLBWI (Figure 1A). Most neonatologist report that the main indication for USG-CVC insertion is as a rescue procedure after exhausted peripheral vein access (53.4%) followed by acute hemodynamic instability (27.5%). Only a minority perform this technique electively (18.9%) for administration of multiple drugs, blood draws or in high-risk surgical patients. The femoral vein (FV) is the preferred insertion site for most neonatologist (62%) followed by the internal jugular vein (IJV) in 32.7%. The use of supraclavicular brachiocephalic (BCV)/subclavian vein cannulation was infrequent (5.1%). Regarding arterial lines most neonatologists (79%) report that they perform less than 5 procedures per year and a 60% have not inserted any USG arterial line in VLBWI (Figure 1B). The main indication for USG arterial line placement is invasive blood pressure monitoring (70.7%). The preferred insertion site for most neonatologist is the femoral artery (62%) followed by the radial artery (31%).

Table 2
Neonatologist's personal experience using ultrasound guider percutaneous vascular access according to NICU complexity

	ALL (n=116)	HC-NICU (n=40)	LC-NICU (n=76)	p
Years performing USG-PVA procedures in clinical practice	40 (34.5%)	10 (25%)	30 (39.5)	0.265
-<2 years	36 (31%)	14 (35%)	22 (28.9%)	
	40 (34.5%)			
-2 to 5 years		16 (40%)	24 (31.6%)	
->5 years				
When you place a PVA, do you use US?	90 (77.6%)	32 (80%)	58 (76.3%)	0.339
-Always	14 (12.1%)	6 (15%)	8 (10.5%)	
-Sometimes	12 (10.3%)	2 (5%)	10 (13.1%)	
-Never				
Number of USG central lines per year	72 (62.1%)	16 (40%)	56 (7.4%)	<0.001
-<5 CVC per year	44 (37.9%)	24 (60%)	20 (26.3%)	
->5 CVC per year				
Percentage of CVC placements in VLBW infants	82 (70.7%)	26 (65%)	56 (73.7%)	0.329
-<25%	34 (29.3%)	14 (35%)	20 (26.3%)	
->25%				
Main Indication for USG-PVA of CVC	62 (53.4%)	24 (60%)	38 (50%)	0.201
-Rescue procedure after exhausted peripheral access	32 (27.6%)	12 (30%)	20 (26.3%)	
-Hemodynamic instability	22 (18.9%)	4 (10%)	18 (23.7%)	
-Elective insertion (multiple drugs, need for blood draws, high risk surgical patients)				
Preferred USG-CVC insertion site	38 (32.8%)	10 (25%)	28 (36.7%)	0.418
-Internal jugular vein	6 (5.1%)	2 (5%)	4 (5.3%)	
-Brachiocephalic/subclavian vein (supraclavicular approach)	72 (62.1%)	28 (70%)	44 (57.9%)	
-Femoral vein	0 (0%)	0 (0%)	0 (0%)	
-Other				
Number of arterial line placements per year	92 (79.3%)	26 (65%)	66 (86.8%)	0.006
-<5 arterial lines per year	24 (20.7%)	14 (35%)	10 (13.2%)	
->5 arterial lines per year				

Only responses from neonatologists with some experience using USG-PVA are included in this description. *These data are referred to the whole sample (n=180). High complexity NICU is defined as that providing cardiac surgery and ECMO. CVC: central venous catheter; ECHO: echocardiography; NICU: neonatal intensive care unit; PVA: percutaneous vascular access; USG: ultrasound guided; US: ultrasound, UVC: umbilical vein catheter; VLBWI: very low birth weight infants.

	ALL (n=116)	HC-NICU (n=40)	LC-NICU (n=76)	p
Percentage of arterial line placements in VLBWI	108 (93.1%)	34 (85%)	74 (97.4%)	0.012
-<25%		6 (15%)	2 (2.6%)	
->25%	8 (6.9%)			
Main indication for arterial line placement	82 (70.6%)	28 (70%)	54 (71%)	0.234
-Invasive blood pressure in hemodynamically instability	16 (13.4%)	8 (20%)	8 (10.5%)	
-Frequent blood gas sampling	18 (15.5%)	4 (10%)	14 (18.4%)	
-Elective in high-risk infants/other indications				
Preferred site for arterial line insertion	72 (62.1%)	26 (65%)	46 (60.5%)	0.809
-Femoral artery	36 (31%)	12 (30%)	24 (31.6%)	
-Radial artery	8 (6.9%)	2 (5%)	6 (7.9%)	
-Other (axillary, humeral, etc.)				
Do you use US/ECHO to check central line tip position?*	80 (44.4%)	20 (45.4%)	60 (44.1%)	0.527
-No	72 (40%)	18 (40.1%)	54 (39.7%)	
-Yes, for any CVC	24 (13.3%)	4 (9%)	20 (14.7%)	
-Yes, just for UVC	4 (2.2%)	2 (4.5)	2 (1.5%)	
-Yes, just for those CVC inserted though extremities/neck				
Exclusive use of US/ECHO to check central line tip position (without confirmation with chest radiography)*	84 (46.6%)	20 (45.4%)	64 (47.8%)	0.181
-0% of central lines	66 (36.7%)	20 (45.4%)	46 (33.8%)	
-<25% of central lines	24 (13.3%)	2 (4.6%)	22 (16.2%)	
-25-75% of central lines		2 (4.6%)	4 (2.9%)	
->75% of central lines	6 (3.3%)			
Only responses from neonatologists with some experience using USG-PVA are included in this description. *These data are referred to the whole sample (n=180). High complexity NICU is defined as that providing cardiac surgery and ECMO. CVC: central venous catheter; ECHO: echocardiography; NICU: neonatal intensive care unit; PVA: percutaneous vascular access; USG: ultrasound guided; US: ultrasound, UVC: umbilical vein catheter; VLBWI: very low birth weight infants.				

Regarding personal perceptions about USG-PVA (Table 3), most neonatologists believe that attaining competence in these techniques is indispensable (30%) or very useful (56.7%) for their practice and would recommend that current Neonatology trainees be taught USG-PVA as an indispensable (40.6%) or very useful skill (46.1%). A 47.8% of the neonatologist believe that reduced vessel size is the main factor that makes PVA difficult. A 60% of the responders identify the lack of training as the main factor limiting the implantation of USG-PVA over other factors such as technical difficulty (18.9%) or lack of adapted equipment for neonates (16.7%). When asked about different locations for insertion of USG central lines, only a 33% identified the BCV as the largest central vein amenable for percutaneous puncture and only a 15.6% would consider supraclavicular cannulation of the BCV as the optimal USG technique for central venous access in neonates. A significant proportion (32.2%) believe that FV is larger than IJV or BCV. Most neonatologists consider that the risk/benefit balance is favorable to conventional ECCs compared to PVA of central veins, especially in preterm infants.

Table 3

Neonatologist's perceptions about ultrasound guided percutaneous vascular access in the neonatal intensive care unit

Perceptions about USG-PVA in the neonatal intensive care unit	
How do you rate the importance of being competent in USG-PVA in your daily practice?	54 (30%)
-Indispensable	102 (56.7%)
-Very useful and necessary	22 (12.2%)
-Useful but not a priority	2 (1.1%)
-Secondary or residual	0 (0%)
-Useless or even counterproductive	0 (0%)
Would you recommend that current Neonatology residents/fellows be trained in ultrasound guided percutaneous vascular access skills?	73 (40.6%)
-Indispensable skill	83 (46.1%)
-Very useful skill	22 (12.2%)
-Useful but not mandatory skill	2 (1.1%)
-Secondary skill during training	0 (0%)
-Not useful or even counterproductive if it rests time for other more important aspects of training.	0 (0%)
Main factor limiting PVA in neonates	86 (47.8%)
-The size of the vessels	25 (13.9%)
-Easy collapse of the vessel	30 (16.7%)
-Lack of adequate transducers	9 (5%)
-Lack of physical space (eg: incubator) during cannulation	30 (16.7%)
-I don't know	0 (0%)
Main factor limiting the use of USG-PVA in Neonatology	108 (60%)
-Lack of adequate training of the neonatologist	34 (18.9%)
-High technical difficulty of the procedure	30 (16.7%)
-Lack of adequate equipment for neonates (ultrasound, probes etc.)	8 (4.4%)
-The high risks of the procedure	0 (0%)
How many USG-PVA procedures are needed to attain competence	20 (11.1%)
-5-10	78 (43.3%)
-10-20	72 (40%)
-20-50	10 (5.6%)
->50	0 (0%)
Which of the following is, in your opinion, the largest central vein amenable for PVA?	60 (33.3%)
-Brachiocephalic vein	58 (32.2%)
-Femoral vein	50 (27.8%)
-Internal jugular vein	12 (6.7%)
-Subclavian vein	0 (0%)
CVC: central venous catheter; ECC: epicutaneous-cava catheter; PVA: percutaneous vascular access; USG: ultrasound guided; VLBWI: very low birth weight infants.	

Perceptions about USG-PVA in the neonatal intensive care unit	
Optimal USG-PVA site location for central line placement in neonates	62 (34.4%)
-Internal jugular vein	
-Femoral vein	
-Brachiocephalic vein (supraclavicular in plane insertion)	
-I don't know	48 (26.7%)
	28 (15.6%)
	42 (23.3%)
Risk/benefit balance of USG-CVC insertion vs ECC in a term neonate	90 (50%)
-Always or nearly always favorable to ECC	76 (42.2%)
-It depends on the patient's characteristics and operator's experience	14 (7.8%)
-Always or nearly always favorable to USG central line	
Risk/benefit balance of USG central line vs ECC in a VLBWI	122 (67.8%)
-Always or nearly always favorable to ECC	36 (20%)
-It depends on the patient's characteristics and operator's experience	22 (12.2%)
-Always or nearly always favorable to USG central line	
CVC: central venous catheter; ECC: epicutaneous-cava catheter; PVA: percutaneous vascular access; USG: ultrasound guided; VLBWI: very low birth weight infants.	

In multivariate logistic regression lower operator age and previous training in the technique were associated with current use of USG-PVA in clinical practice (supplementary table 1). However, when factors associated with a higher number of USG central venous access performed per year were assessed, we found that the main predictors were longer clinical experience using USG-PVA and higher operator's age (supplementary table 2). The relationship between operator's age and use of USG-PVA is shown in figure 2.

Discussion

Effective and safe vascular access is a critical component of care of sick neonates. USG-PVA is recommended for insertion of central venous catheters and arterial lines.[12, 16, 17] There have been several studies assessing the implementation of different POCUS applications, including USG-PVA, in the pediatric intensive care unit[18–21] but a similar information in the NICUs is lacking. In particular, the degree of uptake USG-PVA in the NICU is largely unknown. Our nationwide survey is the first study assessing neonatologist's personal perspectives about USG-PVA and current implementation in the NICU. Our results indicate that neonatologists perceive USG-PVA as an indispensable or very useful aid in daily clinical practice and recognize the need for training during Pediatrics residency and Neonatology fellowship. However, our results indicate that USG-PVA is used infrequently in Spanish NICUs. As many as one third of the neonatologists in our survey have never used USG-PVA in their practice. Among those who use USG-PVA in their practice the number of procedures per year is quite low specially regarding placement of arterial lines and the use is even lower in the case of preterm infants.

Our results provide some insight into possible explanations behind the underuse of USG-PVA in the NICU. The first relates to training in vascular access. Most of the neonatologist who responded to our survey had not received formal training in POCUS or USG-PVA. In addition, an important proportion of neonatologists reported that residents and fellows are not trained in USG-PVA in their units. In this line, most neonatologists identify the lack of training as the most important limitation for implementation of USG-PVA above others such as lack of equipment, difficulty of the procedure or inherent risks. Those neonatologists working in high-complexity and large NICU used more frequently USG-PVA. However, in multivariate analysis only operator's previous training and age were independent predictors of the use of USG-PVA. This finding suggests that structured training is essential to acquire USG-PVA competence in neonates as these procedures are performed infrequently in clinical practice. For most neonatologists 10 to 50 procedures would be necessary to attain competence in USG-PVA. This number is similar to that recommended by some expert authorities. [22] According to our results, this may

take years of clinical practice. Therefore, there is a need to implement training strategies to acquiring competence in USG-PVA more rapidly without compromising patient's safety. There are several recommendations on how USG-PVA training should be accomplished[22, 22–24]. Simulation is a powerful aid for training US guided procedures including vascular access.[25–27] Several vascular access models can be customized to recreate tiny vascular structures that are easy and cheap to build[18, 28]. In these models, the trainee gets familiarized with US vascular exploration and can repeatedly train dynamic needle tip guidance which is the essential skill for effective vascular access.

A second possible explanation for the scarce uptake of USG-PVA relates to the perception of risk and benefits of inserting CVCs and arterial lines in neonates. Most neonatologists considered that CVCs have a less favorable risk/benefit ratio compared to standard ECCs, specially in preterm infants.[29] In fact, the main indication for USG-CVC placement in our study was rescue from exhausted peripheral vein access. It seems that, USG-PVA is used mainly as a last resource for vascular access and perhaps performed late during evolution of NICU stay. In our opinion, this “high-risk” perception regarding CVC insertion in neonates may be an inertia from the past when CVCs were inserted by surgical cut-down in often extreme situations but current data in the US era do not support this conception. Recent research indicates that USG-PVA is safe in neonates. In particular, a growing number of reports have found that supraclavicular access to the BCV is feasible even in preterm infants with high insertion success rate and few mechanical complications and has been proposed as the optimal technique for CVC insertion in small infants and neonates[9, 10, 30, 31]. Furthermore, some data suggest that this technique may reduce catheter related blood stream infection compared to PICCs and other CVCs[32, 33]. However, the reported use of the BCV access in our survey was anecdotal. The most common location for central venous access was the FV. This is surprising as the FV is much smaller compared for instance to the IJV or BCV.[4, 31, 34] In addition, the FV may increase the risk of CRBSI or thrombosis. When asked to identify the largest vein amenable for PVA in neonates only one third of neonatologists mentioned the BCV and a similar number believed that the FV is the largest central vein for PVA. This indicate that most basic anatomical features of central veins might be ignored.

Beyond perceived risks, it is also possible that practitioners do not appreciate much benefit from the use of CVCs in neonates and this may hold true in most instances. ECCs are the most common devices for mid-term central venous access in neonates and they are excellent for routine care such as administration of parenteral nutrition or antibiotics. However, there are important limitations in the performance of these catheters such as low infusion rates, inability to infuse simultaneous medications, impossibility to draw blood or obtain hemodynamic monitoring as well as frequent catheter block and tip malposition. The sickest neonates and preterm infants who need high intensity care benefit from a large-bore safe and stable central catheter and competence in USG-CVC insertion is essential in these cases.

In our survey US was frequently used to check CVC tip position but still a majority of neonatologist perform a radiography for confirmation and expose the infant to ionized radiation. There have been several studies demonstrating accuracy of US in detecting central line tip and some have suggested that US should be the first-line modality to check central line tip location.[35, 36]

Regarding USG for arterial line placement, current use is even less frequent with most responders performing less than 5 procedures per year. In addition, most of the responders have never placed an USG arterial line in VLBWI. As expected, the most common reported indication for arterial cannulation was invasive arterial pressure monitoring. However, it seems that arterial lines are being placed infrequently and that most neonatologist rely on non-invasive blood pressure. This may not be surprising as technical difficulty for placing arterial lines in neonates is high and the risks derived from catheter related arterial ischemia are substantial. However, it has been demonstrated that non-invasive blood pressure is not reliable, especially in hypotensive preterm infants.[37] Hypotension is a strong predictor of mortality and adverse neurological outcome[38] and therefore, accurate and continuous measurement of arterial blood pressure is essential in the sickest infants with hemodynamically instability. USG facilitates not only cannulation, but also catheter selection based on actual arterial size a should be considered in hemodynamic compromised neonates when umbilical artery catheterization is not available. The reported preferred site for arterial line placement in our survey was the femoral artery. However, the use of USG radial artery catheterization may offer some advantages such a less risk of infection and occlusion-related ischemia given the presence of collateral circulation though the cubital artery. [39]

One interesting result in our study was the effect of operator's age in the reported use of USG-PVA. Age was an independent predictor of USG-PVA use. As expected, those practitioners with some experience in USG-PVA were younger and had less years of clinical practice compared to those who had never used this technique. Several studies have shown that senior practitioners may perform worse when switching to US and therefore may be reluctant to use USG-PVA in their practice (“old dog and new tricks” phenomenon)[20]. However, when considering only responses from neonatologist who currently use USG-PVA, we observed that older practitioners place more USG-

CVCs per year compared to the younger ones. This may suggest that acquiring confidence in these techniques in neonates is a slower process compared to children and adults. Taken together our results indicate that training in USG-PVA in Neonatology should begin early.

The main limitation of our study is the inherent risk of bias due to self-reporting of data and the relatively high non-response rate[40]. The willingness to respond the survey may be dependent on the personal interest on the topic of USG-PVA. It is possible that many neonatologists who are not interested about USG-PVA have not responded to the survey and that the actual use of USG-PVA may be even lower than recorded. However, we have received responses from 62% of Spanish NICUs, including community-based hospitals as well as large referral centers so we think that our results are representative of current practice in our country. We think that our findings are an important first step to identify the needs and expectations regarding USG-PVA in the NICU. This is critical to elaborate coordinated strategies to implement training in USG-PVA and increase the uptake of this essential procedure in the next years.

In conclusion, despite most neonatologist perceive USG-PVA as very useful in daily practice, currently these techniques are underused. The lack of adequate training is perceived as the most important barrier for implementation of USG-PVA in the NICU. Our study highlights the need to develop and implement specific training programs in USG-PVA during residency and Neonatology fellowship.

List Of Abbreviations

BCV: brachiocephalic vein

CRBSI: catheter related blood stream infection

CVC: central venous catheter

ECC: epicutaneous-cava catheter

FV: femoral vein

IJV: internal jugular vein

NICU: neonatal intensive care unit

PVA: percutaneous vascular access

PICC: peripherally inserted central catheter

POCUS: point of care ultrasound

SENeo: Spanish Society of Neonatology

USG: ultrasound guided/guidance

US: ultrasound

VLBWI: very low birth weight infant (<1500 grams)

WG-US: working group on ultrasound

Declarations

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COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose

AVAILABILITY OF DATA AND MATERIAL

Data are available from the authors upon request.

ATUHORS CONTRIBUTIONS

Ignacio Oulego-Eroz conceived and designed the study, acquired data, analyzed data and drafted the manuscript.

Antonio Rodríguez-Núñez: designed the study and critically reviewed the manuscript for relevant intellectual content

Almudena Alonso-Ojembarrena, Victoria Aldecoa-Bilbao, Maria Carmen Bravo, Jon Montero-Gato, Rocío Mosqueda-Peña contributed to the study conception and design and critically reviewed the manuscript for relevant intellectual content

All authors gave their approval to the final version of the manuscript

ETHICS APPROVAL

The IRB reviewed and approved the study protocol (CEIC-León; ID: 20103).

CONSENT TO PARTICIPATE

The participants were informed of the study objectives and purposes. Participation was voluntary. The IRB waived the need for specific written informed consent for this survey study

CONSENT FOR PUBLICATION

Not applicable.

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Figures

Figure 1

Number of ultrasound-guided percutaneous vascular access procedure per year

Foot:

Panel A, Number of ultrasound-guided central venous catheter (USG-CVC) insertions per year and percentage performed in very low birth weight infants

Panel B, Number of ultrasound-guided central arterial catheter (USG-AC) insertions per year and percentage performed in very low birth weight infants

Figure 2

Relationship between operator's age and experience in ultrasound guided percutaneous vascular access procedures

Foot:

Panel A: Clinical experience in ultrasound guided percutaneous vascular access (USG-PVA) procedures according to operator's age tertiles. P for lineal trend in χ -square test

Panel B: Number of ultrasound-guided central venous catheter procedures (USG-CVC) according to operator's age tertiles (n=116). P for lineal trend in χ -square test

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