Ultrasound-guided vascular access in the neonatal intensive care unit: a nationwide survey

Ignacio Oulego-Erroz1,2,3,4 · Almudena Alonso-Ojembarrena2,5,6 · Victoria Aldecoa-Bilbao2,7,8 · María del Carmen Bravo2,9 · Jon Montero-Gato2,10 · Rocío Mosqueda-Peña2,11,12 · Antonio Rodríguez Nuñez2,13,14,15

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Abstract
Ultrasound-guided vascular access (USG-VA) 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-VA 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-VA, and (4) clinical experience in USG-VA. One-hundred and eighty survey responses from 59 NICUs (62% of Spanish NICUs) were analyzed. Most neonatologists (81%) perceive that competence in USG-VA is indispensable or very useful in clinical practice. However, 64 (35.5%) have never used USG-VA in real patients. Among neonatologists with some experience in USG-VA 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 (VLBWI). More than a half of neonatologists (55.5%) use US to check catheter tip location but a 46.6% always perform a radiography for confirmation. Spanish neonatologists report that resident/fellow training in USG-VA 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-VA and 87% would recommend that future neonatologists receive formal training.

Conclusion: Spanish neonatologists perceive that USG-VA is important in clinical practice but currently, these techniques are largely underused. Our results indicate that specific training in USG-VA should be implemented in the NICU.

What is 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 is 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.

Keywords Neonatal intensive care unit · Ultrasound-guided vascular access · Point of care ultrasound · Training · Implementation · Central venous catheter

Abbreviations
BCV Brachiocephalic vein
CICC Centrally inserted central catheter
CRBSI Catheter-related blood stream infection
CVC Central venous catheter
ECC Epicutaneous-cava catheter
FV Femoral vein
FICC Femorally inserted central catheter
Introduction

Percutaneous vascular access (VA) 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 catheter (CVC). 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 centrally or femorally inserted central catheter (CICC/FICC) and arterial lines. Placement of a CICC/FICC in neonates has been traditionally considered a high-risk procedure. However, there are several studies that confirm that USG-CICC/FICC is feasible and safe in neonates and even preterm infants [8–14]. Recent clinical practice guidelines on point of care ultrasound (POCUS) have been released by the European Society of Pediatric and Neonatal Intensive Care (ESPNIC) [15]. 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 CICC/FICCss, peripherally inserted central catheters (PICC), arterial lines, and the assessment of central line 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-VA in the NICU.

With the hypothesis that USG-VA is underused, the objective of the present study was to assess current practice regarding USG-VA in the neonatal unit as well as to analyze the perceptions of Spanish neonotologist 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 [16, 17]. The target population were active Spanish neonatologists who were identified from the affiliate registry of the SEneo. One expert in USG-VA 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) neonotologist’s data and background, (2) NICU characteristics, (3) clinical experience in USG-VA, and (4) perceptions about USG-VA. This initial proposal was reviewed by a panel of 6 neonatologists from the WG-US with interest and expertise in USG-VA. 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 [18]. 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 adaptive question to reduce complexity (only those responders who reported some experience in USG-VA 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 min. 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 15 September 2021. The survey was advertised on the SEneo website and during the virtual National Congress of the SEneo that took place on 27–28 October 2021. Up to 5 reminder e-mails were sent during a 3-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-VA in real practice was performed using multivariate logistic regression. Covariates were chosen based on

| Acronym | Description |
|---------|-------------|
| IJV     | Internal jugular vein |
| NICU    | Neonatal intensive care unit |
| VA      | 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 g) |
| WG-US   | Working Group on Ultrasound |
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-VA, and years performing USG-VA 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-VA (all responses; n = 180) and then factors predicting the number of USG-CICC/FICC 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 of 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-VA was absent (52.2%) or occasional (32.2%) in their units. Sixty four (35.6%) of the responders had no experience placing USG-VA in real patients. These practitioners were significantly older (p < 0.001), have received previous training in POCUS (p < 0.001) or USG-VA (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-VA in clinical practice. Nearly a half of respondents (51.1%) reported that less than 25% of the attending neonatologists perform USG-VA in their units and only a 13.3% reported that more than >75% of the staff perform these techniques regularly.

Among those neonatologists (n = 116) with some clinical experience in USG-VA (Table 2), a 62% perform less than 5 USG-CVC insertions per year and a 38% have never used this technique in VLBWI (Fig. 1A). Most neonatologists 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 neonatologists (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 (Fig. 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%).

Regarding personal perceptions about USG-VA (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-VA as an indispensable (40.6%) or very useful skill (46.1%). A 47.8% of the neonatologists believe that reduced vessel size is the main factor that makes VA difficult. A 60% of the responders identify the lack of training as the main factor limiting the implantation of USG-VA 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%) believes that FV is larger than IJV or BCV. Most neonatologists consider that the risk/benefit balance is favorable to conventional ECCs compared to VA of central veins, especially in preterm infants.

In multivariate logistic regression lower operator age and previous training in the technique were associated with current use of USG-VA 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-VA and higher operator’s age (Supplementary Table 2). The relationship between operator’s age and use of USG-VA is shown in Fig. 2.

Discussion

Effective and safe VA is a critical component of care of sick neonates. USG-VA is recommended for insertion of CVCs and arterial lines [15, 19, 20]. There have been several studies assessing the implementation of different POCUS applications, including USG-VA, in the pediatric intensive care unit [21–24] but a similar information in the NICUs is lacking. In particular, the degree of uptake USG-VA in the NICU is largely unknown. Our nationwide survey is the first study assessing neonatologist’s personal perspectives about USG-VA and current implementation in the NICU. Our results indicate that neonatologists perceive USG-VA 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-VA is used infrequently in Spanish NICUs. As
First, it is important to note that as one third of the neonatologists in our survey have never used USG-VA in their practice. Among those who use USG-VA 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-VA in the NICU. The first relates to training in VA. Most of the neonatologist who responded to our survey had not received formal training in POCUS or USG-VA. In addition, an important proportion of neonatologists reported that residents and fellows are not trained in USG-VA in their units. In this line, most neonatologists identify the lack of training as the most important limitation for implementation of

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

| Neonatologist’s basic data and background | All (n = 180) | No experience in USG-VA (n = 64) | Some experience in USG-VA (n = 116) | p  
|--------------------------------------------|--------------|---------------------------------|------------------------------------|------
| Age (years)                                | 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                                | 52 (28.9%)   | 6 (9.4%)                        | 46 (39.7%)                         |      
| Some training                              | 46 (25.5%)   | 44 (68.7%)                      | 2 (1.7%)                           | <0.001
| Training in USG-VA                         | 66 (36.7%)   | 10 (15.6%)                      | 56 (48.3)                          |      
| Unstructured training                      | 68 (37.8%)   | 10 (15.6%)                      | 58 (50%)                           |      
| Structured training                        |              |                                 |                                    |      
| 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                                       | 88 (48.9%)   | 34 (53.1%)                      | 54 (46.5%)                         | <0.001
| IIb                                        | 42 (23.3%)   | 26 (40.6%)                      | 16 (13.8%)                         | <0.001
| Other (IIa, IIb, IIIc, I)                  | 44 (24.4%)   | 4 (6.2%)                        | 40 (34.5%)                         |      
| High-complexity NICU*                      |              |                                 |                                    |      
| Number of NICU beds                        | 109 (60.5%)  | 51 (79.6%)                      | 58 (50%)                           | <0.001
| ≤ 10                                       | 46 (25.5%)   | 10 (15.6%)                      | 36 (31%)                           | <0.001
| > 20                                       | 24 (13.3%)   | 2 (3.1%)                        | 22 (19%)                           | <0.001
| 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-VA            | 94 (52.2%)   | 44 (68.7%)                      | 50 (43.1%)                         | 0.003
| No training                                | 58 (32.2%)   | 14 (21.9%)                      | 42 (36.2%)                         |      
| Occasional training (not structured/incomplete adherence) | 30 (16.7%) | 6 (9.4%)                        | 24 (20.7%)                         |      
| Formal training program with full or near full adherence | 54 (30%)     | 38 (59.3%)                      | 16 (13.7%)                         |      
| Professional performing USG-VA In your unit | 90 (50%)     | 16 (25%)                        | 74 (63.7%)                         | <0.001
| Always or mostly the neonatologist         | 36 (20%)     | 10 (15.6%)                      | 26 (22.4%)                         |      
| Neonatologist as well as other professionals (anesthesiologists, pediatric intensivists, radiologists) | 54 (30%)     | 38 (59.3%)                      | 16 (13.7%)                         |      
| Always or mostly other professionals (anesthesiologists, pediatric intensivists, radiologists) |              |                                 |                                    |      
| Attending neonatologists performing USG-VA regularly in the NICU | 92 (51.1%)  | 54 (84.4%)                      | 38 (32.7%)                         | <0.001
| < 25%                                      | 64 (35.5%)   | 8 (12.5%)                       | 56 (48.2%)                         |      
| 25–75%                                     | 24 (13.3%)   | 2 (3.1%)                        | 22 (18.9%)                         |      
| > 75%                                      |              |                                 |                                    |      
| Percentage of VA (USG or landmark) procedures in VLBWI | 30 (16.6%)  | 16 (25%)                        | 14 (12.1%)                         | 0.047
| 0%                                         | 84 (46.6%)   | 30 (46.9%)                      | 54 (46.5%)                         |      
| < 25%                                      | 66 (36.6%)   | 18 (28.1%)                      | 48 (41.4%)                         |      

NICU neonatal intensive care unit; PICU pediatric intensive care unit; POCUS point of care ultrasound; VA percutaneous vascular access; USG ultrasound guided; VLBWI very low birth weight infants

*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
USG-VA 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-VA. However, in multivariate analysis only operator’s previous training and age were independent predictors of the use of USG-VA. This finding suggests

| Table 2 | Neonatologist’s personal experience using ultrasound-guided percutaneous vascular access according to NICU complexity |
|---------|------------------------------------------------------------------------------------------------------------------|
| Years performing USG-VA procedures in clinical practice | ALL (n = 116) | HC-NICU (n = 40) | LC-NICU (n = 76) | p    |
| < 2 years | 40 (34.5%) | 10 (25%) | 30 (39.5%) | 0.265 |
| 2 to 5 years | 36 (31%) | 14 (35%) | 22 (28.9%) | |
| > 5 years | 40 (34.5%) | 16 (40%) | 24 (31.6%) | |
| When you place a VA, do you use US? | | | | |
| Always | 90 (77.6%) | 32 (80%) | 58 (76.3%) | 0.339 |
| Sometimes | 14 (12.1%) | 6 (15%) | 8 (10.5%) | |
| Never | 12 (10.3%) | 2 (5%) | 10 (13.1%) | |
| Number of USG central lines per year | | | | |
| < 5 CICC/FICC per year | 72 (62.1%) | 16 (40%) | 56 (7.4%) | < 0.001 |
| > 5 CICC/FICC per year | 44 (37.9%) | 24 (60%) | 20 (26.3%) | |
| Percentage of CICC/FICC placements in VLBW infants | | | | |
| < 25% | 82 (70.7%) | 26 (65%) | 56 (73.7%) | 0.329 |
| > 25% | 34 (29.3%) | 14 (35%) | 20 (26.3%) | |
| Main indication for USG-VA of CICC/FICC | | | | |
| Rescue procedure after exhausted peripheral access | 62 (53.4%) | 24 (60%) | 38 (50%) | 0.201 |
| Elective insertion (multiple drugs, need for blood draws, high risk surgical patients) | 32 (27.6%) | 12 (30%) | 20 (26.3%) | |
| Preferred USG-CICC/FICC insertion site | | | | |
| Internal jugular vein | 38 (32.8%) | 10 (25%) | 28 (36.7%) | 0.418 |
| Brachiocephalic/subclavian vein (supraclavicular approach) | 6 (5.1%) | 2 (5%) | 4 (5.3%) | |
| Femoral vein | 72 (62.1%) | 28 (70%) | 44 (57.9%) | |
| Other | 0 (0%) | 0 (0%) | 0 (0%) | |
| Percentage of arterial line placements in VLBWI | | | | |
| < 25% | 108 (93.1%) | 34 (85%) | 74 (97.4%) | 0.012 |
| > 25% | 8 (6.9%) | 6 (15%) | 2 (2.6%) | |
| Main indication for arterial line placement | | | | |
| Invasive blood pressure in hemodynamically instability | 82 (70.6%) | 28 (70%) | 54 (71%) | 0.234 |
| Frequent blood gas sampling | 16 (13.4%) | 8 (20%) | 8 (10.5%) | |
| Elective in high-risk infants/other indications | 18 (15.5%) | 4 (10%) | 14 (18.4%) | |
| Preferred site for arterial line insertion | | | | |
| Femoral artery | 72 (62.1%) | 26 (65%) | 46 (60.5%) | 0.809 |
| Radial artery | 36 (31%) | 12 (30%) | 24 (31.6%) | |
| Other (axillary, humeral, etc.) | 8 (6.9%) | 2 (5%) | 6 (7.9%) | |
| Do you use US/ECHO to check central line tip position? | | | | |
| No | 80 (44.4%) | 20 (45.4%) | 60 (44.1%) | 0.527 |
| Yes, for any CVC | 72 (40%) | 18 (40.1%) | 54 (39.7%) | |
| Yes, just for UVC | 24 (13.3%) | 4 (9%) | 20 (14.7%) | |
| Yes, just for those CVC inserted though extremities/neck | 4 (2.2%) | 2 (4.5) | 2 (1.5%) | |
| Exclusive use of US/ECHO to check central line tip position (without confirmation with chest radiography) | | | | |
| No | 84 (46.6%) | 20 (45.4%) | 64 (47.8%) | 0.181 |
| Yes | 66 (36.7%) | 20 (45.4%) | 46 (33.8%) | |
| 0% of central lines | 24 (13.3%) | 2 (4.6%) | 22 (16.2%) | |
| < 25% of central lines | 6 (3.3%) | 2 (4.6%) | 4 (2.9%) | |
that structured training is essential to acquire USG-VA 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-VA. This number is similar to that recommended by some expert authorities [25]. 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-VA more rapidly without compromising patient’s safety. There are several recommendations on how USG-VA training should be accomplished [25, 25–27]. Simulation is a powerful aid for training US-guided procedures including vascular access [28–30]. Several vascular access models can be customized to recreate tiny vascular structures that are easy and cheap to build [21, 31]. 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-VA relates to the perception of risks related to the insertion of CICCs/FICCs and arterial lines in neonates. Most neonatologists considered that CICCs/FICCs have a less favorable risk/benefit ratio compared to standard ECCs, especially in preterm infants [32]. In fact, the main indication for USG-CICC/FICC placement in our study was rescue from exhausted peripheral vein access. It seems that USG-VA is used mainly as a last resource for VA and perhaps performed late during evolution of NICU stay. In our opinion, this “high-risk” perception regarding CICC/FICC insertion in neonates may be an inertia from the past when central catheters 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-VA 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 CICC insertion in small infants and neonates [9, 10, 33, 34]. Furthermore, some data suggest that this technique may reduce catheter-related blood stream infection compared to PICCs and other central locations [35, 36]. 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, 34, 37]. In addition, the FV may increase the risk of CRBSI or thrombosis. When asked to identify the largest vein amenable for VA in neonates only one third of neonatologists mentioned the BCV and a similar number believed that the FV is the largest central vein for VA. This indicates that most basic anatomical features of central veins might be ignored. In our survey we focused on USG-CICC/FICC insertion but USG puncture can also be used for peripheral vein catheterization and insertion of PICCs [38]. Beyond perceived risks, it is also possible that practitioners do not appreciate much benefit from the use of CICCs/FICCs 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, and frequent catheter block and tip malposition. Although evidence favoring safety and efficacy of USG-CICC/FICC insertion in neonates is growing, there are no clear recommendations on when to choose a CICC/FICC over a standard ECC. This may justify the clinician for an inappropriate use of ECCs in infants who would benefit from USG-CICC/FICC. This makes that the average neonatologist is exposed to a very low number of USG-CICC/FICC insertions and hinders the attainment of competence. According to our results we are afraid that many infants are being managed sub-optimally with ECCs. We strongly believe that 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-CICC/FICC insertion is essential in these cases.

In our survey US was frequently used to check central line tip position but still a majority of neonatologists perform a radiography for confirmation and expose the infant

Fig. 1 Number of ultrasound-guided percutaneous vascular access procedure per year. A Number of ultrasound-guided central venous catheter (USG-CICC/FICC) insertions per year and percentage performed in very low birth weight infants. B Number of ultrasound-guided central arterial catheter (USG-AC) insertions per year and percentage performed in very low birth weight infants.
to ionized radiation. There have been several studies demonstrating accuracy of US in detecting central line tip. Recently, a specific protocol for the use of US in navigation and location of catheter tip in neonates (Neo-ECHOTIP) has been released. This protocol may help the clinician to apply US systematically and avoid unnecessary and time-consuming routine radiographies after central line insertion [39–41].

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 neonatologists 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 [42]. Hypotension is a strong predictor of mortality and adverse neurological outcome [43], 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 through the cubital artery [44].

One interesting result in our study was the effect of operator’s age in the reported use of USG-VA. Age was an independent predictor of USG-VA use. As expected, those practitioners with some experience in USG-VA 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-VA in their practice (“old dog and new tricks” phenomenon) [23]. However, when considering only responses from neonatologists who currently use USG-VA, 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-VA in Neonatology should begin early.

The main limitation of our study is that we focused on USG puncture for CICC/FICC insertion compared to directly inserted ECC in terms of device performance. However, there is an immense potential for USG in catheter navigation and tip location in neonates that is not adequately explored in this survey. Also, USG can be used for USG puncture of peripheral veins which may improve success rate and reduce complication in the insertion of ECCs. Future studies should focus on the overall impact of universal USG for puncture and tip navigation of any CVC. Another important limitation of our study is the inherent risk of bias due to self-reporting of data and the relatively high non-response rate [45]. The willingness to respond the survey may be dependent on the personal interest on the topic of USG-VA. It is possible that many neonatologists who are not interested about USG-VA have not responded to the survey and that the actual use of UGS-VA 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-VA in the NICU. This is critical to elaborate coordinated strategies to implement training in USG-VA and increase the uptake of this essential procedure in the next years.

In conclusion, despite most neonatologist perceive USG-VA 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-VA in the NICU. Our study highlights the need to develop and implement specific training programs in USG-VA during residency and Neonatology fellowship.

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Authors’ contributions Ignacio Oulego-Erroz 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. Almudeña Alonso-Ojembarrena, Victoria Aldecoa-Bilbao, Maria Carmen Bravo, Jon Montero-Gato, and 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.

Availability of data and material Data are available from the authors upon request.

Declarations

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.

Competing interests The authors declare no competing interests.

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Authors and Affiliations

Ignacio Oulego-Errroz\textsuperscript{1,2,3,4} - Almudena Alonso-Ojembarrena\textsuperscript{2,5,6} - Victoria Aldecoa-Bilbao\textsuperscript{2,7,8} - María del Carmen Bravo\textsuperscript{2,9} - Jon Montero-Gato\textsuperscript{2,10} - Rocío Mosqueda-Peña\textsuperscript{2,11,12} - Antonio Rodríguez Nuñez\textsuperscript{2,13,14,15}.

1 Pediatric Intensive Care Unit, Complejo Asistencial Universitario de León, Altos de Nava s/n, 24002 Leon, Spain
2 Working Group On Ultrasound, Spanish Society of Neonatology (SENeo), Valencia, Spain
3 Working Group On Bedside Ultrasound, Spanish Society of Pediatric Intensive Care (SECIP), Madrid, Spain
4 Biomedicine Institute of León, University of León, Leon, Spain
5 Neonatal Intensive Care Unit, Hospital Universitario Puerta del Mar de Cádiz, Cádiz, Spain
6 Research Unit, Biomedical Research and Innovation Institute of Cádiz (INiBICA), Puerta del Mar University Hospital, Cádiz, Spain
7 Neonatal Intensive Care Unit, Hospital Clinic Barcelona, Barcelona, Spain
8 Center for Maternal-Fetal and Neonatal Medicine (BCNatal), Barcelona, Spain
9 Neonatal Intensive Care Unit, Hospital Universitario La Paz, Madrid, Spain
10 Neonatal Intensive Care Unit, Hospital Universitario Basurto, Bilbao, Spain
11 Neonatal Intensive Care Unit, Hospital Universitario, 12 de Octubre, Madrid, Spain
12 Research Institute Hospital, 12 de Octubre (imas12), Madrid, Spain
13 Pediatric Emergency, Intermediate and Critical Care Unit, Complejo Hospitalario de Santiago de Compostela, Santiago de Compostela, Spain
14 Health Research Institute of Santiago de Compostela (IDIS), Santiago de Compostela, Spain
15 CLINURSID Research Group, University of Santiago de Compostela, Santiago de Compostela, Spain