Ultrasound guidance for central venous catheterisation. A Colombian national survey.

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ABSTRACT

Quality problem or issue

Ultrasound (US) is a widely propagated medical technology. Anaesthesiologists increase procedural safety by using US techniques, but training and availability are essential for its usage. Although its utility for central venous catheterisation (CVC) is well established, only a paucity of evidence is available regarding its use in low- and middle-income countries. This study is a nationwide survey of Colombian anaesthesiologists designed to explore the current use of US guidance for CVC.

Initial assessment and implementation

Web-based survey at National level. Anaesthesiologists registered in the Colombian Society of Anaesthesiology and Resuscitation database.

Choice of solution

Demographic variables (age and gender), anaesthesia expertise, years of anaesthesiology practice, US availability, use of US during CVC, reasons for not using US and training experience were collected.

Evaluation

Of 351 respondents (12.3% response rate), 45% reported using US sometimes and always for CVC (95% CI 39%–50%) (n = 157). Most anaesthesiologists obtained training in US through external courses (50.4%) or from colleagues (22.8%). Of the total respondents, 62.7% (n = 220) have US equipment available at all time and this factor was independently associated with the use of US for CVC (adjusted odds ratio [OR] = 38.6, $P < 0.001$).

Lessons learned

US guidance is not a common technique used for CVC by Colombian anaesthesiologists; an important barrier for its use is lack of equipment.

Keywords

ultrasound, central venous catheterisation, patient safety

QUALITY PROBLEM OR ISSUE

Introduction of ultrasound (US) in the medical practice has shown several benefits in the safety of numerous procedures [1]. US-guided insertion of central venous catheter has become a highly recommended or even mandatory technique, according to several guidelines and protocols of venous catheterisation [1]. In 1984, Legler et al. [2] used the Doppler technique (ultrasonic Doppler, doppler study or evaluation) to guide jugular venous catheterisations. Two years later, Yonei et al. [3], used 2D-US to insert central venous catheters. Since then, this technique has improved in terms of precision, safety and availability for healthcare workers.

CVC is a common procedure performed by anaesthesiologists and many physicians in the emergency department and intensive care units [1]. US has proven to be a good complementary strategy for CVC because of a great number of benefits, like increased success rates [1, 4], reduced number of attempts and shorter time required to perform the procedure compared with a landmark technique [4, 5] and lessened complications (e.g. malposition, lung or vascular injuries, pneumothorax and thrombosis) [5–7].

Because of these advantages, several medical organisations and government agencies advocate the use of this technique and encourage its propagation across all healthcare centres [8–12]. Despite these recommendations, many limitations and barriers still exist for US to become a universal technique for CVC and other anaesthesia-related procedures. Some of the major barriers are the access to a device and the requirement of advanced training and experience [13].

US-guided insertion of central venous catheters is considered a common practice in developed countries; however, there is a lack of information about the patterns of using this technique in low- income countries. We sought to describe and analyse the current use of US guidance for insertion of central venous catheters by Colombian anaesthesiologists.

INITIAL ASSESSMENT AND IMPLEMENTATION

Approach

The Institutional Review Board and the Research Ethics Committee from the Colombian Society of Anaesthesiology and Resuscitation (SCARE, for the term in Spanish) approved this study. Inclusion of participants in this study required electronic acceptance, but the written consent was waived by the committee because of the low risk represented by this study and the strict confidentiality and anonymity strategies for data management.

Sampling and recruitment

This study involved anaesthesiologists and fellows in anaesthesia registered in the SCARE database. Inclusion criteria included being registered in the database and accepting to answer an electronic web-based survey sent via email. There were no exclusion criteria. Two people with prior training from the authors of the protocol at the Universidad del Cauca in Colombia conducted the questionnaire and collected the data without knowledge of the study objectives to avoid observer-expectancy bias.

Choice of solution

The survey contained 15 questions (Supplementary material). The variables were grouped by the following sections: demographic variables (age, gender and current academic degree) and clinical variables (anaesthesia expertise, years of anaesthesiology practice, US availability, use of US, reasons for not using US, training experience and complications). To assess the use of US guidance for the insertion of central venous catheters, we used a passive question to reduce the risk of bias (Do you use US guidance for insertion of central venous catheter?) and the answer options for that question were 'Always', 'Sometimes', 'Rarely' and 'Never'. For purposes of statistical analysis, we categorised this variable in 'Use of ultrasound' that included the options Always/Sometimes and 'Do not use ultrasound' included Rarely/Never. The first option was used as the main outcome under study. Specialised personnel from the SCARE designed the interface of the electronic web-based survey. The format and answer options were carefully revised and all authors discussed the questions before delivering such via email to the study population.

Data analysis

The time interval between delivering the survey and closing the option for input was 2 months. First, an initial exploratory analysis of the respondents was performed by describing the quantitative variables in averages with their respective standard deviations (SD) or median with interquartile ranges (IQR) according to the normal data distribution. Qualitative variables were expressed with absolute values as frequencies or proportions, with their respective 95% confidence interval (95% CI). Thereafter, a univariate analysis was per- formed, comparing the variables in order to use (grouping the options 'Always' and 'Sometimes') or not use (grouping the options 'Rarely' and 'Never') US for CVC. Comparison of qualitative variables was performed by using chi-squared test ($\chi 2$) and Student's t-test. We con- ducted a logistic regression for the multivariate analysis by using a model that includes age, gender and professional degree. We calculated the linear trend for the relation of age versus percentage of US users. We considered a P-value <0.05 as statistically significant. The data was analysed in the R statistical software [14].

EVALUATION

Participants

From July to September 2016, 351 responses were collected, which resulted in a response rate of 12.3% (351/2850). The respondents were predominantly general anaesthesiologists 76% (n=266), followed by other fellowships, such as cardiovascular anaesthesia 9% (n = 30), intensive care 6% (n = 20), neuro-anaesthesia 3% (n = 10), paediatric anaesthesia 2% (n = 7), obstetric anaesthesia 1% (n = 4) and other sub-specialisations 4% (n = 14). The mean age of the respondents was 44 years (SD = 9.9 years) and the male:female ratio was 3.2:1.

Use of US guidance during CVC insertion

The proportion of respondents who reported using US sometimes and always for guidance during CVC was 45% (95% CI 39–50%) (n = 157). Table 1 shows the characteristics of the US-guided CVC by Colombian anaesthesiologists.

Colombian anaesthesiologists (n = 157).

The participants with US equipment available 'all the time' in their workplaces were 62.7% (n = 220). The main reason given for not using or only having limited use of US guidance for CVC was the lack of US equipment in 50% of cases (n = 174) while a minority admitted that the use of US exceeds their clinical abilities 5% (n = 18). The training on this technique was variable, 50.4% (n = 177) of the respondents have had external courses, 22.8% (n = 80) have acquired experience from colleagues, 29.3% (n = 103) from empirical experience and 16% (n = 56) have never received training on this technique.

Determinants of the use of US guidance

Univariate analysis showed that age (<40 years) and availability of US were related with the use of US for CVC. Figure 1 illustrates the linear trend of the use of US depending on age ($P < 0.001$). After adjusting for covariates (gender and professional degree) availability of US was an independent factor associated with use of the technique. Table 2 shows details of the univariate and multivariate analyses.

LESSONS LEARNED

This study describes the current patterns of using US for CVC among Colombian anaesthesiologists. Our results demonstrated that US guidance is not a common practice for CVC and it appears that availability of this technology is an important limitation to its use.

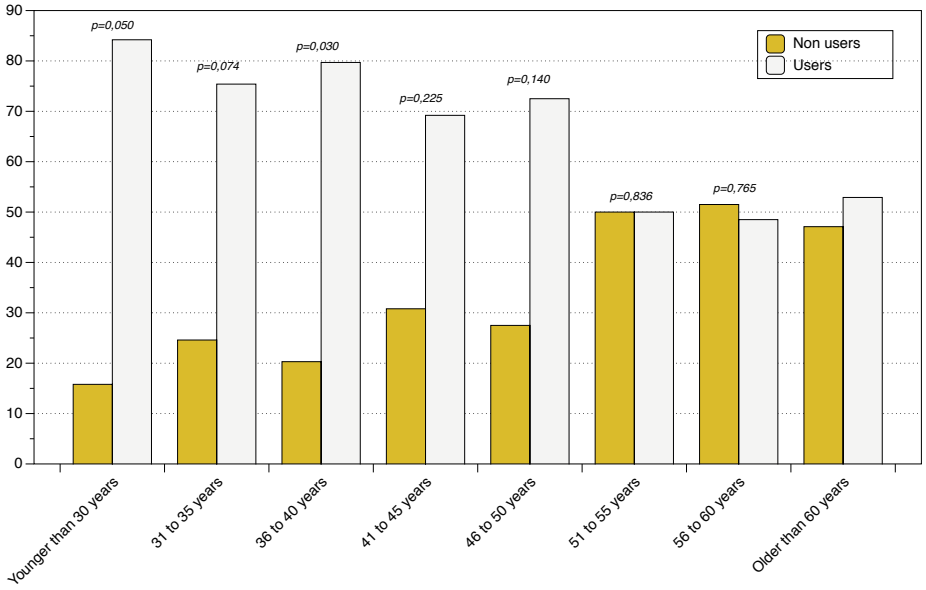

Figure 1. Relationship between age and proportion of US use during CVC (n = 351).

Table 1. Characteristics of the US-guided technique for CVC by Colombian anaesthesiologists (n = 157).

Characteristic	n (%)
Time of US guidance	
Since the beginning of the procedure	153 (97%)
When there are difficulties of insertion	4 (3%)
Technique used	
Real-time US-guided insertion	156 (99%)
Anatomic assessment without guidance	1 (1%)
Needle approach	
In plane	76 (48%)
Out of plane	81 (52%)

Abbreviations, US: ultrasound, CVC: central venous catheterization.

The prevalence of US guidance for CVC by Colombian anaesthesiologists was 45%. The range of proportions reported in the literature varies between 15% and 96% [13, 15–20], depending on the population, year of the survey [16], country and other settings.

Table 3 describes studies that have assessed the use of US for CVC. Note a high qualitative heterogeneity among studies clearly reflected in the different rates of US use. Our results show that Colombian anaesthesiologists, compared with other scenarios from high-income countries, underuse US.

Table 2. Univariate and multivariate analyses for the relation between covariates and the use of US guidance during CVC (n = 351)

Variable	Univariate analysis		Multivariate analysis	
	OR	P value	Adjusted OR [95% CI]	P value
Age [years]				
≥ 61	Ref.		Ref.	
56 – 60	0.83	0.77	0.61 [0.11 – 3.30]	0.57
51 – 55	0.88	0.84	0.33 [0.06 – 1.62]	0.17
46 – 50	2.34	0.14	2.50 [0.51 – 12.1]	0.26
41 – 45	2.00	0.23	1.72 [0.35 – 8.32]	0.50
36 – 40	3.48	0.03	2.78 [0.58 – 13.2]	0.20
31 – 35	2.71	0.07	2.77 [0.58 – 13.1]	0.20
≤ 30	4.74	0.05	3.11 [0.38 – 25.3]	0.29
Gender				
Male	Ref.		Ref.	
Female	2.14	0.01	1.29 [0.55 – 3.05]	0.55
Type of anaesthesia practice				
General	Ref.		Ref.	
Cardiovascular	2.64	0.06	2.78 [0.79 – 9.77]	0.11
Intensive care	1.20	0.68	1.99 [0.56 – 7.02]	0.28
Neuro-anaesthesia	2.10	0.35	1.45 [0.14 – 15.2]	0.75
Other	1.60	0.29	0.76 [0.16 – 3.49]	0.73
Technology availability				
Not available	Ref.		Ref.	
Available	27.4	< 0.001	38.6 [18.5 – 80.3]	< 0.001

$R^2 = 0.57$

To our best knowledge, sufficient evidence is unavailable about US use for CVC in developing countries. Despite the potential of US-based imaging to improve the diagnosis of many medical conditions and to guide individual patient management, we know little about current practices in low- and middle-income countries, such as the extent of use of portable US devices, major indications for the use of US techniques and impact on patient outcome. A recent systematic review did not find any study on the use of US during CVC [22]. Most current applications focus on obstetrical and abdominal complaints, with a lack of high-quality evidence from developing countries [22]. In terms of procedural US in the developing world, most evidence relates to peripheral venous access, ultrasound-guided thoracentesis or paracentesis and regional anaesthesia [23].

A well-documented association exists between availability of US equipment and use of this technique for CVC [11, 20]. Our survey reports conflictive results in terms of using US in operating rooms. Although 62% of the participants report having US equipment

Table 3. Similar survey studies about use of US guidance during CVC insertion in other scenarios around the world

Study	Country	Participants	Percentage of US-guided CVC	Comments
Adhikari et al. 2015.[16]	USA	Emergency medicine residents	53%, 96%	Increasing of ultrasound use from 2007 to 2013.
Bailey et al. 2007.[13]	USA	Members of the Society of Cardiovascular Anaesthesiologists	15% (223/1494)	Availability of US equipment was associated with use of US (OR=18.9, P<0.001).
Bosman et al. 2006.[15]	UK	Paediatric anaesthesiologists	68% (133/196)	-
Girard et al. 2005.[17]	USA	Surgery, anaesthesia, emergency medicine, internal medicine and family medicine house staff	15% (19/137)	A total of 19 anaesthesiologists were surveyed, of which only 5 use US with a frequency of 21%-60%.
Lindgren et al. 2013.[18]	Sweden	Anaesthesiology and intensive care departments	53% (26/49)	-
Schummer et al. 2007.[19]	Germany	Anaesthesia departments	40% (188/468)	12.7% routinely and 60% when faced difficulties
Soni et al. 2016.[20]	USA	Intensivist and Hospitalist	82.5% (647/784)	US guidance varied by site from 80% for internal jugular vein to 31% in subclavian vein.
Tovey et al. 2006.[34]	UK	Paediatric anaesthesiologists	49% (104/212)	-

inside the operating room, they also report the absence of equipment as a reason for not using it. Many hospitals in Colombia only have a single portable US device for use in many services and wards. Therefore, knowing that the equipment is available at the hospital does not guarantee its use all the time; this could explain the difference between availability and actual usage during CVC.

Access to US has increased significantly in resource-limited settings, including the developing world. A survey on perceived barriers in the use of US in low- and middle-income settings identified lack of training as a primary barrier to regular use of US in their practice, followed by lack of equipment. Equipment requirements, including maintenance and cost of machines, are also important factors [24]. Our results show availability of equipment as an independent factor for using the technique among respondents, but this potential association should be taken with caution due to the very high uncertainty with the broad CI of the estimation.

The World Bank currently identifies Colombia as a middle- income country, but it is still in the process of developing a modern healthcare and academic system. Most anaesthesiology residency programs in Colombia have begun to incorporate US into their education, training, and clinical practice to improve the quality and safety of healthcare.

However, even in some of Colombia's most advanced urban university-based hospitals, limited resources are still a reality. In addition, there is a lack of evidence related with the current use of procedural US. Henwood et al. [25] conducted a nationwide survey of Colombian emergency medicine residents designed to explore the state of US use and examine barriers for its expansion. The most frequently indicated barriers to ultrasound use were lack of instructors, equipment and time. We consider this finding could also be valid for anaesthesiologists and other specialisations.

Patient safety is a priority in this revolutionary era of technology [26, 27]; catheterisations have inherent risks of mechanical, infectious and haemodynamic complications [16]. Mechanical complications (e.g. arterial puncture, failure rates of insertion, haemothorax and pneumothorax) are common and independently increased by the number of attempts [28]. A recent Cochrane systematic review compared US guidance versus a landmark technique for CVC and concluded that US guidance is significantly associated with lower number of attempts needed for successful catheterisation, increased chances of success at the first attempt, and reduced possibilities of haematoma formation. However, this technique did not show a significant reduction in mechanical complications, such as arterial punctures or time for successful catheterisation [6].

The infectious risk of US equipment is a controversial concern of this technique. This concern is based on a recent outbreak in which sterile gel acted as a vehicle for the spread of infection to patients. This led to a product safety alert by the United States Food and Drug Administration [29]. However, a recent prospective observational study rejected this hypothetical association [30].

In this study, age seems to be related to not using US guidance during CVC. We found a non-adjusted linear trend depending on the age of the anaesthesiologist, which disappeared after multivariate analysis. Regarding this finding, there is growing evidence on the effect of age on practitioners' performance. Aging is associated with decreased processing speed, limiting ability to complete complex tasks, increased difficulty for information processing, reduced hearing and visual acuity, and decreased manual dexterity and visuo- spatial ability [31–34]. US guidance requires motor and visuospatial skills that aging practitioners may have not acquired or have lost. In addition, young anaesthesiologists could have greater exposure to US training during their residency programmes. On the other hand, older practitioners may feel they have developed enough experience allowing them to perform the insertion without the US technique.

Study limitations

This study had important limitations, including a small sample size. We used the database of all anaesthesiologists registered in SCARE (~2850) although many of them are not active practitioners. The response rate can be considered acceptable, compared with other similar online-based surveys. Additionally, the respondents using US guidance could be

more motivated to complete the questionnaire in which case the frequency of use of US for CVC in this study would be overestimated. Another limitation is the study design in which the accuracy and self-reporting information from participants was assumed correct because direct observations were not conducted. All the questions included in our survey were closed ended, which might have introduced response bias. Finally, the questions used in the questionnaire did not distinguish the use of US for internal jugular, subclavian, or femoral vein catheterisation.

CONCLUSION

Use of US for CVC is not a common practice among Colombian anaesthesiologists. Limited availability of this technology in healthcare centres hinders the use of this technique. Only half of the respondents have taken an external course to learn about US Management, the rest admitted to acquiring experience by themselves or from colleagues. More education and strict compliance of protocols on this technology would be helpful for safer CVC. Further, US guidance can be used in many other procedural applications, like regional anaesthesia, basic echocardiography, vascular assessment, pleural drainage, pulmonary US, and others, ensuring safety and quality of care.

APPENDIX

ULTRASOUND GUIDANCE FOR CENTRAL VENOUS CATHETERISATION. A COLOMBIAN NATIONAL WEB-BASED SURVEY

How old are you?
Answer:

Gender:
Male
Female

Which year did you graduate from residency?
Answer:

Which specialty do you practice?
General:
Cardiovascular:
Paediatric:
Intensive care:
Neuroanaesthesia:
Other:

Is ultrasound equipment available in your workplace?
Yes:
No:

Do you use ultrasound-guidance during insertion of central venous catheter?
Always:
Often:
Rarely:
Never:

What is the reason for not using ultrasound-guidance for insertion of central venous catheter?
It is not needed:
It increases costs:
It is time consuming:
It is not available:

It decreases the ability for insertion of CVC:
I always use ultrasound:

How was your training on ultrasound?
External courses:
Colleagues:
Experience:
None:

Do you think that ultrasound is important for guidance during the insertion of central venous catheter?
Yes:
No:
Sometimes:

In which cases do you use ultrasound-guidance?
Since the beginning of the procedure:
Only when I have difficulties:

What is the utility of ultrasound during insertion of CVC?
For real-time guidance:
For looking at the anatomy before insertion:

What approach do you usually use for ultrasound-guidance?
In plane:
Out of place:

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