Original Article

Use of ultrasound guidance in central venous catheter placement by emergency physicians in Saudi Arabia

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ABSTRACT

الأهداف: تحديد معدل استخدام الموجات فوق الصوتية في القسطرة المركزية (USG–CVC) لدى أطباء الطوارئ (EPs) في المملكة العربية السعودية.

المنهجية: هذه دراسة استعراضية استقصائية حول الملامح الديموغرافية لأطباء الطوارئ، والتدريب الرسمي وغير الرسمي على وضع القسطرة الوريدية المركزية باستخدام الموجات فوق الصوتية، وخبراتهم وموقفهم تجاه الإجراء. أُرسل الاستبيان عبر البريد الالكتروني لجميع أطباء الطوارئ المرخصين من قبل الهيئة السعودية للتخصصات الصحية، بين الفترة أكتوبر وديسمبر 2018م.

النتائج: في المجمل، 234 طبيب طوارئ مسجل بهيئة التخصصات الصحية أكمل الاستبيان من أصل 350 ممن أُرسِل لهم. كان معدل الاستجابة 66.9%. معظم المجيبين (70.5%) من خريجي برنامج طب الطوارئ. أشار اغلب المجيبين إلى توافر جهاز للموجات فوق الصوتية في قسم الطوارئ. معظم أطباء الطوارئ (78.2%) سبق لهم وضع القسطرة الوريدية المركزية باستخدام الموجات فوق الصوتية. يرتبط استخدام الموجات فوق الصوتية بشكل كبير مع حداثة التخرج من برنامج التدريب. 83.3% من المجيبين تلقوا تدريب رسمي خلال برنامج الإقامة. من أصل 234 إجابة، 53.8% يشعرون بـ«الراحة الشديدة» عند وضع القسطرة الوريدية المركزية باستخدام الموجات فوق الصوتية، بينما يشعر 19.7% بـ«الراحة الشديدة» عند وضع القسطرة الوريدية المركزية بدون استخدام الموجات فوق الصوتية. على الرغم من ذلك، معظم الاطباء يرغبون في مزيد من التدريب على وضع القسطرة الوريدية المركزية باستخدام الموجات فوق الصوتية.

الخلاصة: على الرغم من الأدلة الموجودة، والإجماع على تفوق استخدام الأمواج فوق الصوتية على الطريقة التقليدية. مجموعة صغيرة من أطباء الطوارئ لم تعتمد على جهاز الأمواج فوق الصوتية في ممارساتها الطبية. التدريب الرسمي، والتعليم الممنهج على استخدام جهاز الأمواج فوق الصوتية قد يعالج هذه العوائق.

Objectives: To determine the ultrasound guidance for central venous catheter (USG-CVC) placement rate of emergency physicians (EPs) in Kingdom of Saudi Arabia.

Methods: A cross-sectional survey study regarding the respondents' demographic profiles, formal and informal training in USG-CVC placement, experiences, and attitudes towards the procedure was emailed to all EPs registered with the Saudi Commission for Health Specialties (SCFHS) between October and December 2018.

Results: In total, 234/350 SCFHS-registered EPs completed the survey; the response rate was 66.9%. Most respondents (70.5%) were board-certified in emergency medicine (EM). Ninety percent indicated that US device for CVC placement assistance was available. Most EPs (78.2%) had performed USG-CVC placement; the US usage rate correlated significantly with recent graduation from residency (p=0.048). In total, 83.3% received formal training during residency. Of the 234 respondents, 53.8% felt extremely comfortable with CVC placement with USG and 19.7% without USG (p<0.01). Nevertheless, most respondents desired further USG-CVC training.

Conclusion: Despite existing evidence and a consensus on its superiority over the landmark technique, USG-CVC placement has not been adopted by a small proportion of EPs into clinical practice. Formal training, education, and institutional provision of permanent onsite US machines may address any barriers.

Keywords: central venous catheters, ultrasonography, physicians, emergency medicine

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The placement of a central venous catheter (CVC) has become an integral part of emergency medicine (EM) practice for critically ill patients.[1,2] A previous observational cohort study reported a complication rate of 34% associated with CVC placement, with the majority of complications being related to placement failure.[3] Moreover, a recent systematic review showed that the rate of adverse events such as arterial puncture, hematoma, and hemothorax resulting from CVC placement using the landmark technique was 13.5%.[2] The utilization of ultrasonography during CVC placement is associated with a significant reduction in the relative risk of complications and an increase in the first-attempt success rate.[2,4-7] In addition, real-time sonographic guidance for central venous access is strongly recommended by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) guidelines as a key safety measure.[8]

Despite this evidence, there is limited incorporation of ultrasound guidance for central venous catheter (USG-CVC) placement in clinical practice by some emergency physicians (EPs). Indeed, in a recent study, 44% of respondents stated that they never used USG-CVC placement.[9] Evidence suggests that EPs consider a lack of training to be a barrier to the widespread implementation of USG-CVC placement.[10]

The aim of this study is to survey practicing EPs in Kingdom of Saudi Arabia (KSA) with regard to the frequency of USG-CVC placement and factors that may be associated with its use.

Methods. A cross-sectional survey study targeting all EPs practicing in KSA was conducted. Participants were included if they are EPs practicing in KSA. For the purpose of this study, a physician would be considered an EP if they are in or have completed a residency program in EM or are licensed physicians classified by the Saudi Commission for Health Specialties as emergency physicians. Data was collected over a 2-month period from October to December of 2018. Emergency physicians at various hospitals and at various stages of their careers were invited to participate in the study. An email invitation containing the consent form and the survey material was sent via SurveyMonkey through the Saudi Commission for Health Specialties targeting 350 EPs. The sample size was calculated to be 184 using a 95% confidence level, 5% confidence interval, and power of 80.

The survey's face validity was established through a review of a group of board-certified, university-affiliated EPs with several years of clinical experience. A small-scale feasibility/pilot study was conducted to determine the survey's reliability.

The survey contained direct questions to assess the frequency of ultrasound guidance for CVC placement. We hypothesize that factors associated with or barriers to USG be around demographics, training, clinical experience, attitudes, and resources. This was covered in the survey with questions on the demographic profiles of the respondents (gender, nationality, place of residence, type of hospital, number of years in practice, and number of clinical shifts), formal and informal training on USG-CVC placement, interest in further training, experience with CVCs, attitudes and comfort regarding USG-CVC placement. Likert scales were used to measure the participants' level of agreement regarding USG-CVC placement (1: strongly disagree to 5: strongly agree), their comfort in placing CVCs (0: extremely uncomfortable to 5: extremely comfortable), and their views and judgment toward the use of medical technology and uncertainty in diagnosis (1: strongly agree to 9: strongly disagree). To determine correlations with USG-CVC placement, the respondents were divided into 5 groups based on the percentage of CVCs that they had placed under US guidance: 0-20%, 21-40%, 41-60%, 61-80%, and 81-100%.

The data collected from SurveyMonkey was exported as a worksheet and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0 (IBM Corp., Armonk, NY, USA). The results are expressed as numbers and percentages for categorical variables and as the mean and standard deviation for continuous variables. A Chi-square (χ^2) test was used to compare proportions between 2 groups. The Pearson correlation test was applied to determine the correlation between variables. Finally, univariate and multivariate regression analyses were performed to determine significant factors related to the non-use of USG-CVCs. To determine barriers carrying out USG-CVC placement on the basis, all relevant variables based on p-values ($p<0.05$) were entered into a logistic regression model with USG-CVC placement as the dependent variable.

The study was approved by the Institutional Review Board (IRB), King Fahad Medical City at the Ministry of Health, Riyadh, KSA. It was found that the study compliant with the Principles of Helsinki Declaration. Participation in this study was voluntary

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and participants were informed about the aim, purpose, and procedure of the study. The participants were not offered incentives to participate in the study.

Results. In total, 350 emails were sent via the SCFHS to EPs, 234 of whom responded to the survey (response rate: 66.9%). The majority of respondents (70.5%) were board-certified in EM, and the remaining 29.5% were residents. Of the 234 respondents, the majority were practicing in a government or Ministry of Health hospitals (45.3%) (Table 1).

Availability of US machines and use of USG-CVC placement technique. Most respondents (90.6%) indicated that at least one US device for CVC placement assistance was available. One US machine was available for 54 respondents (23.1%), 2 machines for 83 respondents (35.5%), 3 machines for 49 respondents (20.9%), 4 machines for 20 respondents (8.5%), and 6 or more machines for 7 respondents (2.6%). Table 2 shows the percentage of CVC placements in which US guidance was used. Attending physicians supervised 155 (66.2%) of the placements; other physicians, fellows, or residents supervised the remaining placements.

Formal and informal training. Some form of formal training in USG-CVC placement at various stages of residency training was received by 195 respondents (83.3%). These included didactic or video-only training without hands-on training, experience with US-guided dynamic visualization without needle placement, and USG-CVC placement on a simulation model. Informal training modalities included hands-off observation, maneuvering the US device with or without insertion of a catheter. Thirty-nine (16.7%) respondents did not have any type of formal training on USG-CVC placement (Table 3).

Attitudes and levels of comfort in placing CVCs with or without US guidance. More responders felt extremely comfortable with USG-CVC placement than with CVC placement without USG (53.8% vs. 19.7%, $p<0.01$)

Table 1 - Demographic profiles of the emergency physicians surveyed (N=234).

Demographic profiles	n (%)
Gender	
Male	177 (75.6)
Female	57 (24.4)
Nationality	
Saudi	167 (71.4)
Non-Saudi	67 (28.6)
Place of residence	
Central region	146 (62.4)
Eastern region	18 (7.7)
Western region	55 (23.5)
Northern region	1 (0.4)
Southern region	7 (3.0)
Unspecified	7 (3.0)
Type of hospital	
Government	106 (45.3)
Military	48 (20.5)
University	55 (23.5)
Private	25 (10.7)
Number of years practicing EM	
Currently still a resident	40 (17.1)
<2 years	49 (20.9)
2-5 years	72 (30.8)
6-10 years	45 (19.2)
11-15 years	19 (8.1)
16-20 years	9 (3.8)
Number of clinical shifts (average per month) in EM	
1-2 shifts	3 (1.3)
3-5 shifts	7 (3.0)
6-10 shifts	18 7.7)
11-15 shifts	43 (18.4)
>15 shifts	163 (69.7)

EM: emergency medicine

Table 2 - The percentage of CVC placements conducted with USG.

Percentage of USG-CVC placement	n (%)
0-20%	36 (15.4)
21-40%	12 (5.1)
41-60%	28 (1.0)
61-80%	40 (17.0)
81-100%	115 (49.1)
Ultrasound not available	3 (1.3)

CVC: central venous catheter, USG: ultrasound guidance

Table 3 - Formal and informal training on USG-CVC placement.

Type of training	Formal training (n=195)	Informal training (n=205)
Didactic or video only without hands-on training	33 (16.9)	16 (7.8)
US-guided dynamic visualization without needle placement	32 (16.4)	32 (15.6)
US-guided placement on simulation model	130 (66.7)	157 (76.6)

Values are expressed as number and percentage (%).
USG-CVC: ultrasound guided central venous catheter

(Table 4). The majority of respondents strongly agree/agree that USG-CVC placement is easier to perform, is faster, reduces mechanical complications, results in fewer placement failures, and is useful for patients with difficult landmarks (Table 5).

Correlates of USG-CVC placement. Most EPs (78.2%) had performed USG-CVC placement. Ultrasound guidance for central venous catheter placement correlated significantly with fewer years from graduation of residency (r=0.130, p=0.048), having attended formal courses on their own (r=0.196, p=0.003) and courses provided by the hospital (r=0.161, p=0.014), the availability of a portable US machine to assist EPs in CVC placement (r=0.170, p=0.009), comfort in placing CVCs with US guidance (r=0.253, p<0.001), and perceptions that USG-CVC placement is faster (r=0.272, p<0.001), reduces mechanical complications (r=0.297, p<0.001) and infectious complications (r=0.172, p=0.008), results in fewer placement failures (r=0.355, p<0.001), is useful when the landmark method is unsuccessful (r=0.175, p=0.007), is useful for patients with coagulopathy (r=0.154, p=0.018), is more convenient (r=0.277, p<0.001), and is cost effective (r=0.237, p<0.001).

Table 4 - Levels of comfort in placing central venous catheter with and without USG.

Level of comfort	With USG	Without USG	*P*-value
Extremely comfortable	126 (53.8)	46 (19.7)	<0.001
Moderately comfortable	62 (26.5)	80 (34.2)	0.0703
Mildly comfortable	13 (5.6)	26 (11.1)	0.0300
Mildly uncomfortable	12 (5.1)	31 (13.2)	0.0024
Moderately uncomfortable	7 (3.0)	24 (10.3)	<0.001
Extremely uncomfortable	14 (6.0)	27 (11.5)	0.0332

Values are presented as number and percentage (%).
USG - ultrasound guidance

Discussion. The use of USG-CVCs has been the subject of several research papers and has been found to decrease morbidity and complications caused by the traditional landmark method.[2-6,11-13] Our survey showed that most EPs in KSA agree with the published literature. Despite these findings, 21.8% of the respondents had never/seldom used the US in CVC placement. In a cross-sectional survey of practicing EPs in the United States, 44% had never used US guidance in placing CVCs.[9] However, fewer physicians in our survey had never/seldom used USG in CVC placement than in previous studies. Based on the literature, we believe that every CVC should be inserted under USG and that every effort should target barriers to US use in CVC placement. Several barriers to USG-CVC placement have been identified. Matera et al,[14] reported common

Table 5 - The respondents' levels of agreement on the advantage of using USG over the landmark method for CVC placement.

USG-CVC placement	Levels of agreement					*P*-value
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	(strongly agree/agree versus strongly disagree/disagree)
Is easy to use	125 (53.4)	68 (29.1)	29 (12.4)	8 (3.4)	4 (1.7)	
Is faster	85 (36.3)	56 (23.9)	48 (20.5)	36 (15.4)	9 (3.8)	
Reduces mechanical complications	133 (56.8)	81 (34.6)	19 (8.1)	1 (0.4)	-	
Reduces infectious complications	45 (19.2)	59 (25.2)	88 (37.6)	37 (15.8)	5 (2.1)	
Results in fewer placement failures	114 (48.7)	93 (39.7)	24 (10.3)	3 (1.3)	-	
Is useful for patients lacking good landmarks	157 (67.1)	63 (26.9)	14 (6.0)	-	-	
Is useful when landmark is unsuccessful	144 (61.5)	76 (32.5)	13 (5.6)	-	1 (0.4)	<0.001
Is useful for patients with coagulopathy	119 (50.9)	64 (27.4)	43 (18.4)	7 (3.0)	1 (0.4)	
Is less convenient	23 (9.8)	45 (19.2)	60 (25.6)	67 (28.6)	39 (16.7)	
Is not needed (more comfortable with landmark method)	6 (2.6)	19 (8.1)	49 (20.9)	87 (37.2)	73 (31.2)	
Will result in loss of their skills	11 (4.7)	30 (12.8)	55 (23.5)	97 (41.5)	41 (17.5)	
Is beneficial for randomized trials	15 (6.4)	20 (8.5)	77 (32.9)	70 (29.9)	52 (22.2)	
Is not cost-effective	16 (6.8)	28 (12.0)	54 (23.1)	79 (33.8)	57 (24.4)	

Values are presented as number and percentage (%). USG - ultrasound guided, CVC - central venous catheter

barriers to routine US use in CVC placement, namely, not having completed a US course and perceiving the procedure as time-consuming. In another survey, Scholten et al,[15] found that working in a non-academic hospital and more years of experience were barriers to USG-CVC placement. Two other surveys showed that insufficient training and the limited availability of equipment are barriers to US use.[9,16] In accordance with previous surveys, our respondents identified the lack of formal training and unavailability of a US machine as barriers to USG-CVC placement.

Study limitations. The limitation of this study is that the survey responses were self-reported; indeed, the responses may not reflect the true competence of the respondents. Additionally, the results may have been influenced by bias, and the questions may have been unclear to some of the respondents. Furthermore, our results may not be generalizable because the majority of our respondents were in their early years of practice.

In conclusion, we were able to highlight the use of the USG-CVC placement technique by EPs, the nature and benefits of training on USG-CVC placement, and the respondents' perceptions and attitudes toward CVC placement.

Despite existing evidence and a consensus regarding the superiority of USG-CVC placement over the landmark technique, a small proportion of EPs have been unable to translate evidence into clinical practice. Future studies on the effectiveness of current training and impact of various forms of formal or informal education on adoption and best practices for institutional provisions for placement of US machines on-site may address any barriers.

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