



Ultrasound guidance during central venous catheterization: A survey of use by house staff physicians

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Abstract

Purpose: The objective of this study is to explore the attitudes, knowledge, and behavior of house staff physicians regarding the use of ultrasound guidance (UG) during central venous catheter placement (CP).

Materials and Methods: A questionnaire-based study was used to survey house staff in multiple training programs at an academic tertiary care center.

Results: Fifteen percent of the respondents reported using UG on at least 60% of CP attempts. Those house staff physicians who agreed that UG is faster, easier, and more convenient than the landmark method reported more frequent use. Agreement that UG reduces the number of mechanical complications and placement failures was also associated with increased use. Respondents reporting the most CP experience were least likely to use UG. Most agreed that UG is useful in patients without good landmarks or when the landmark method failed, but these attitudes were not associated with the frequency of UG use. Most respondents were not aware of controlled trials demonstrating the benefits of UG.

Conclusions: The use of UG during CP is infrequent despite the demonstrated benefits of this technology. Multiple knowledge and attitudinal barriers to the greater use of UG during CP must be addressed in the design of an effective UG implementation strategy.

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1. Introduction

Central venous catheters are an indispensable component of the care of patients in the intensive care unit (ICU). Their use extends to the operating room (OR) and the general ward as well. Placement of these catheters is common but not risk free, with reported rates of mechanical complications ranging from 0% to 21% [1-3]. Acute mechanical

complications include arterial puncture, hematoma, deep vein thrombosis, pneumothorax or hemothorax, and nerve injury. Attempts to place central venous catheters may result in failure to cannulate the vessel in up to 25% of cases [2,4,5]. Although the mortality and increase in cost attributable to mechanical complications has not been firmly established, catheter-related infections are associated with mortality rates of 10% to 20% as well as up to 24 additional days of hospitalization for survivors [6]. Based upon their association with infection alone, mechanical complications are likely contributing to significant morbidity, mortality, and increase in cost [7].

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The use of ultrasound to assist central venous cannulation was first reported in 1984 by Legler and Nugent [8], who used Doppler ultrasound to reduce the complications of internal jugular vein cannulation. The use of real-time ultrasound guidance (UG) during central venous catheter placement (CP) has subsequently been shown to reduce complications when compared with the traditional landmark method in controlled clinical trials [9,10]. As a result, expanded use of this technology has been recommended by respected individuals and organizations in the United States [11-13] and the United Kingdom [14]. However, at least one report from the United Kingdom suggests that the technique remains underused [15]. We report the results of a survey conducted among house staff physicians at our institution to explore attitudes, knowledge, and behaviors associated with the use of UG.

2. Methods and materials

2.1. Design

This study was conducted at an academic tertiary care center where house staff in multiple training programs perform CP in the ICUs, ORs, emergency department, and, less frequently, general wards. The medical center's average daily census is approximately 450 patients with 28 000 admissions per year. Ultrasounds are available to house staff in the medical ICU, OR, emergency department, and dialysis unit, but no formal educational program exists regarding the use of UG during CP. We distributed a 2-page questionnaire, which could be completed in less than 5 minutes, to all Surgery, Anesthesia, Emergency Medicine, Internal Medicine, and Family Medicine house staff (Appendix 1). Two reminders were sent over a 4-week period, and data collection occurred from March to May in 2003. Data from partially completed forms were included in the analysis.

Table 1 Demographic characteristics of survey respondents

	Respondents, n = 128
<i>PGY (%)</i> , n = 127*	
1	38 (30)
2	37 (29)
3	37 (29)
>3	15 (12)
<i>Sex (%)</i> , n = 124*	
Male	86 (69)
Female	38 (31)
<i>Specialty (%)</i> , n = 128	
Anesthesia	17 (13)
Emergency medicine	14 (11)
Family medicine	15 (12)
Internal medicine	74 (58)
Surgery	8 (6)

PGY, postgraduate year.

* n < 128 because of incomplete surveys.

Table 2 Knowledge and attitudes of survey respondents regarding UG during CP

UG (compared with the landmark method)	Agree (%)	Disagree (%)	Neutral (%)
Is easier to use	40.9	35.7	23.5
Is faster	19.0	55.2	25.9
Reduces mechanical complications	59.5	13.8	26.7
Reduces infectious complications	10.3	37.1	52.6
Results in fewer placement failures	58.6	12.1	29.3
Is useful when a patient lacks good landmarks	91.3	0.90	7.8
Is useful when the landmark method has failed	90.4	0.90	8.7
Is useful when a patient has a coagulopathy	53.5	11.4	35.1
Is less convenient	63.8	18.1	18.1
Is not needed	31.3	32.2	36.5
Will result in loss of skills	14.9	64.0	21.1
Has not been proven in RCTs	10.1	21.1	68.8
Is not cost-effective	10.8	35.1	54.1

RCT indicates randomized controlled trial; UG indicates ultrasound guidance; CP indicates central venous catheter placement.

2.2. Statistical analysis

The dependent variable in the analysis was the reported use of UG during CP. In the survey instrument, this variable had a response frame of 0% to 100%, categorized into 20% increments. For analysis purposes, given the distribution of responses, UG was categorized into 3 levels of use: 0% to 20%, 21% to 60%, and 61% to 100%. The statistical analysis used bivariable χ^2 analyses of associations between the UG and the nominal data for physician attitudes, knowledge, and experience. Analysis of variance was used to examine associations of UG with the integer and Likert-scaled items. A 2-tailed *P* value of .05 was considered statistically significant. SAS 8.02 (SAS Institute, Inc, Cary, NC) was used for all analyses.

To examine the independent association of predictor variables with the dependent variable (UG), a multivariable logistic model was fitted after UG was dichotomized. However, the very high degree of multicollinearity between independent variables and small sample size precluded stable parameter estimates or a useful variable selection procedure for this model. Although a principal component analysis was performed to reduce the number of predictors and their shared variation, a meaningful subset of factors was not obtained. Hence, only the bivariable associations will be reported.

3. Results

Table 1 contains demographic information about the survey respondents, revealing that they were fairly balanced

Table 3 Associations between demographics and experience of respondents and the use of UG during central venous CP

Characteristics	Frequency of use of UG			<i>P</i>
	0%-20% (n = 64)	21%-60% (n = 44)	61%-100% (n = 19)	
PGY				.9123
1	18	12	7	
2	18	14	5	
3	20	12	5	
>3	7	5	2	
Specialty				.0006
Anesthesia	12	5	0	
Emergency medicine	12	2	0	
Family medicine	6	7	2	
Internal Medicine	26	30	17	
Surgery	8	0	0	
Frequency of successful CP				.3506
41% to 60%	5	4	3	
61% to 80%	15	17	6	
81% to 100%	44	23	10	
Frequency of objective confirmation				.0008
0% to 20%	29	10	0	
21% to 80%	7	7	1	
81% to 100%	28	25	18	

UG indicates ultrasound guidance; CP indicates central venous catheter placement.

vis-à-vis postgraduate year and sex. Although the overall response rate was 52%, it was 72% for the subset of Emergency, Family, and Internal Medicine house staff, but only 25% for Surgery and Anesthesia house staff.

The experience of the respondents with CP and the use of UG during CP varied widely. The number of reported CP

attempts varied from 0 to 500 with a mean of 42, and 48% of respondents reported fewer than 20 attempts. The house staff reported a high rate of successful CP with 90% reporting success on greater than 60% of attempts. The success rate was strongly associated with reported experience; those reporting success 60% or less of the time averaged 7 CP attempts, whereas those reporting success more than 80% of the time averaged 57 CP attempts ($P = .005$). Most respondents reported that they confirmed venous cannulation by some objective measure after using the landmark method of CP. Only 15% of house staff reported use of UG during more than 60% of CP attempts, whereas 51% reported its use less than 20% of the time. Of those reporting very limited UG use, 46% stated that it was not available. Almost all house staff reported training in the use of UG, 45% predominantly from other house staff and 39% from faculty physicians.

Knowledge and attitudes regarding UG during CP are summarized in Table 2. Most house staff did not think UG was faster; they found it less convenient than the landmark method. Most (60%) felt that UG reduced mechanical complications of CP, though only 10% believed it reduced infectious complications. Although only 41% felt that UG was easier than the landmark method for CP, 59% believed it resulted in fewer placement failures, and almost all thought that UG was useful when the patient lacked good landmarks or the landmark method failed. Few house staff felt that the use of UG was unproven, too costly, or would diminish their skills at CP. However, most house staff did not report knowledge that UG was supported by clinical trials, remaining neutral when questioned.

Use of UG was not associated with house staff level of training but was associated with specialty (Table 3). Respondents from Anesthesiology, Emergency Medicine, and Surgery were much less likely to use UG than Family Medicine or Internal Medicine house staff ($P = .0006$). Reported CP success rates were not associated with UG use ($P = .35$), but the number of CP attempts was inversely

Table 4 Associations between knowledge and attitudes of respondents and the use of UG during central venous CP

No. of respondents in agreement that UG (compared with the landmark method)	Frequency of use of UG			<i>P</i>
	0%-20%	21%-60%	61%-100%	
Is easier to use (%)	13.2	53.5	89.5	<.0001
Is faster (%)	7.4	16.3	57.9	<.0001
Reduces mechanical complications (%)	37.0	69.8	100.0	<.0001
Reduces infectious complications (%)	0.0	14.0	31.6	<.0001
Results in fewer placement failures (%)	29.6	76.7	100.0	<.0001
Is useful when a patient lacks good landmarks (%)	83.3	97.6	100.0	.0814
Is useful when the landmark method has failed (%)	85.2	93.0	100.0	.3607
Is useful when a patient has a coagulopathy (%)	34.0	67.4	77.8	.0004
Is less convenient (%)	77.8	58.1	36.8	.0015
Is not needed (%)	53.7	14.3	5.3	<.0001
Will result in loss of skills (%)	16.7	16.7	5.6	.1523
Has not been proven in RCTs (%)	13.5	7.3	6.3	.5947
Is not cost-effective (%)	17.7	7.1	0.0	.0018

RCT indicates randomized controlled trial; UG indicates ultrasound guidance; CP indicates central venous catheter placement.

associated with its use ($P = .02$). Those using UG 20% or less of the time reported a mean of 58 CP attempts vs only 17 for those using UG more than 60% of the time. House staff physicians who tended to objectively confirm the success of landmark CP were more likely to use UG than those who did not ($P = .0008$). Respondents taught UG by faculty physicians reported less UG use than those taught by their peers ($P = .004$). Use of UG was also associated with beliefs that it was easier, faster, and safer (Table 4).

Respondents who tended toward agreement with the statement that “physicians often rely too heavily on medical technology” were less likely to use UG than those who disagreed ($P = .04$). House staff physicians responding that “when faced with some uncertainty regarding a diagnosis,” they relied more on judgment than on additional testing, were also less likely to use UG than those who preferred additional tests ($P = .002$).

4. Discussion

The Agency for Healthcare Research and Quality included the “use of real-time UG during central line insertion” among patient safety practices supported by the greatest strength of evidence in their evidence-based assessment published in 2001 [11]. Despite this recommendation, in our survey, less than 15% of house staff reported using UG during most CP attempts. This is consistent with previous reports that this technology has not yet achieved widespread acceptance [15].

A number of attitudes regarding UG were strongly associated with frequent use of the technology. Those respondents who agreed that UG is easier, faster, and no less convenient than the landmark method were frequent users. Though several trials have evaluated the time needed for CP using UG vs the landmark method, the results were inconsistent [9]. Recently under pressure to reduce work hours, house staff physicians are unlikely to use a procedural technique that they believe is slower than the alternative. Respondents who did not agree that UG reduces complications during CP, as well as the number of placement failures during CP, tended to use UG infrequently, implying that lack of knowledge of the proven benefits of this technology may be another barrier to its use. Although there was no difference in the reported CP success rates of those using UG frequently and those using it rarely, the attitude that UG is not needed because of frequent success with the landmark method was strongly and inversely associated with its use. Thus, confidence in their skills with the landmark method may lead practitioners to resist employing UG. In fact, it has been suggested that UG is useful primarily for practitioners inexperienced in CP [16]. We know of no formal research defining the number of CPs needed to attain competence and chose to identify inexperienced respondents by the definition applied in other studies: practitioners who have attempted less than 30 CPs [17]. Our survey found an inverse association between respondent experience and use of UG.

However, even among those respondents reporting little experience, the rate of ultrasound use remained low, with fewer than 20% of this subgroup reporting frequent use of UG.

In our study, concern that the use of UG would result in the loss of skills or that the technology is not cost-effective was uncommon in all groups and showed no association with frequency of ultrasound use. Agreement that UG is useful in patients without good landmarks or when the landmark method has failed was common among all respondents. This did not predict frequent ultrasound use, implying that house staff physicians have accepted UG as suitable for difficult patients but do not frequently encounter such circumstances.

There is often a lag between the availability of a clinical tool or treatment that is known to be an improvement over its predecessor and its adoption by practitioners. In addition, clinical practice guidelines, such as those recommending the use of UG during CP [11,12,14], often have limited effect on physician behavior [18]. The reasons for this may include lack of familiarity or awareness of the new technology, lack of agreement with the guidelines, lack of motivation to change, as well as the many practical and external issues that influence clinician behavior change, including cost, time, availability, and training [18]. Our survey demonstrated that house staff physicians were aware of UG but not knowledgeable of the clinical trials supporting its greater efficacy and safety. Furthermore, most felt that UG was not easier or faster, with almost two-thirds finding it less convenient than the landmark method. Though additional education can increase knowledge regarding this technique, substantial behavior change will likely require that practical barriers to greater use of UG be addressed. Fundamentally, the question of whether UG adds to the safety and success of CP among physicians confident in their landmark-based skills will also need to be answered to convert many to its use.

Several limitations of this study should be noted. First, we sampled house staff at one academic hospital, and our results may not be generalizable to health care providers at other hospitals. Nevertheless, we believe that the associations demonstrated between knowledge, attitudes, and behaviors have applicability elsewhere. It would be helpful to compare behaviors with respect to UG at other hospitals among both house staff and attending physicians. We did not survey attending physicians, and infrequent use of UG by attending physicians may be an unidentified barrier to the adoption of this technology among house staff physicians. In addition, the survey did not distinguish the knowledge and attitudes of the respondents toward the use of UG for internal jugular, subclavian, and femoral CP. As the evidence regarding the use of UG is different for these varying sites of venous access, important attitudes may exist among house staff physicians on this issue. Another limitation is the low response rate from Anesthesia, Emergency Medicine, and Surgery house staff. We do not know whether their responses were representative of their colleagues in these specialties. To eliminate potential

confounding by specialty, all analyses were repeated after restricting the sampling frame to Internal Medicine and Family Medicine respondents. There was no substantive change in the results. The study's reliance upon the estimates and memory of house staff rather than objective medical records or direct observance limits conclusions regarding the behavior of the respondents but gives a good reflection of their knowledge and attitudes concerning UG.

5. Conclusion

Multiple randomized controlled trials demonstrate that the use of UG during CP results in improved patient safety, decreasing the number of procedure-related complications as well as the number of unsuccessful procedures. Despite this fact, our survey indicates that the technology is used infrequently, adding to the growing body of evidence that guidelines often do not change physician behavior. We further demonstrate significant knowledge and attitudinal barriers to the greater use of this technology. It remains to be seen whether the benefits offered by UG in combination with an effective implementation strategy are sufficient to overcome these many barriers.

Appendix A. Ultrasound guided central line placement

Introduction: This survey is intended to gather information on the use of ultrasound guidance in central line placement at the University of Virginia. It should take less than 5 minutes to complete and all responses will remain confidential. Surveys are coded so that reminders can be sent. Your response is greatly appreciated!

PGY:	1	2	3	Fellow	Attending
Gender:	Male	Female			
Specialty:	Anesthesia Surgery	Emergency Medicine Internal Medicine	Family Medicine		
Experience:	Estimate the number of patients in whom you have attempted central line placement. _____				
	Estimate the percentage of those patients in whom you were successful.				
	0%-20%	21%-40%	41%-60%	61%-80%	81%-100%
	When using the landmark technique, how often do you confirm venous cannulation before inserting the dilator (e.g. by ABG or pressure transducer)?				
	0%-20%	21%-40%	41%-60%	61%-80%	81%-100%
Ultrasound Use:	Is a portable ultrasound machine available to assist you in central line placement?				
	Yes	No			
	If so, during what percentage of central line placements have you used ultrasound guidance?				
	0%-20%	21%-40%	41%-60%	61%-80%	81%-100%
	Who served as your primary instructor in the technique of ultrasound guidance in central line placement?				
	Attending	Fellow	Resident	Other	I have had no training

For each of the following statements, please indicate your level of agreement.

When compared to the landmark method, ultrasound guided central line placement:

Is easier to use.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is faster.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Reduces mechanical complications (e.g. pneumothorax, arterial puncture, etc.).	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Reduces infectious complications.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Results in fewer placement failures.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Is useful when a patient lacks good landmarks due to body habitus.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is useful when the landmark method has been unsuccessful.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is useful when a patient has a coagulopathy.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is less convenient.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is not needed. (I am usually successful with the landmark method.)	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Will result in the loss of my skills.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Has not been proven to be beneficial in randomized trials.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Is not cost-effective.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Physicians often rely too heavily on medical technology (e.g. labs, imaging, etc.)

Strongly Agree 1 2 3 4 5 6 7 8 9 Strongly Disagree

When faced with some uncertainty regarding a diagnosis, do you prefer to use your own medical judgment initially or to order more tests or consults?

Judgment 1 2 3 4 5 6 7 8 9 More tests/Consults

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