

2015

Central venous catheterization: Are we using ultrasound guidance?

Srikar Adhikari

University of Arizona Medical Center, Tucson

Daniel Theodoro

Washington University School of Medicine in St. Louis

Christopher Raio

North Shore University Hospital, Manhasset

Mathew Nelson

North Shore University Hospital, Manhasset

Matthew Lyon

Georgia Regents University

See next page for additional authors

Follow this and additional works at: https://digitalcommons.wustl.edu/open_access_pubs

Recommended Citation

Adhikari, Srikar; Theodoro, Daniel; Raio, Christopher; Nelson, Mathew; Lyon, Matthew; Leech, Stephen; Akhtar, Saadia; and Stolz, Uwe, "Central venous catheterization: Are we using ultrasound guidance?." *Journal of Ultrasound in Medicine*.34,11. 2065-2070. (2015).

https://digitalcommons.wustl.edu/open_access_pubs/4838

Authors

Srikar Adhikari, Daniel Theodoro, Christopher Raio, Mathew Nelson, Matthew Lyon, Stephen Leech, Saadia Akhtar, and Uwe Stolz

Central Venous Catheterization

Are We Using Ultrasound Guidance?

Srikar Adhikari, MD, MS, Daniel Theodoro, MD, Christopher Raio, MD, Mathew Nelson, MD, Matthew Lyon, MD, Stephen Leech, MD, Saadia Akhtar, MD, Uwe Stolz, PhD

Received January 12, 2015, from the Department of Emergency Medicine, University of Arizona Medical Center, Tucson, Arizona USA (S.Ad., U.S.); Division of Emergency Medicine, Washington University, St Louis, Missouri USA (D.T.); Department of Emergency Medicine, North Shore University Hospital, Manhasset, New York USA (C.R., M.N.); Department of Emergency Medicine, Georgia Regents University, Augusta, Georgia USA (M.L.); Department of Emergency Medicine, Orlando Regional Medical Center, Orlando, Florida USA (S.L.); and Department of Emergency Medicine, Albert Einstein Beth Israel Medical Center, New York, New York USA (S.Ak.). Revision requested February 2, 2015. Revised manuscript accepted for publication February 27, 2015.

We thank Ilir Frrokaj for assistance with data entry. This work was presented in abstract form at the Society of Academic Emergency Medicine Annual Meeting; May 2014; Dallas, Texas.

Address correspondence to Srikar Adhikari, MD, MS, Department of Emergency Medicine, University of Arizona Medical Center, PO Box 245057, Tucson, AZ 85724-5057 USA.

E-mail: sriadhikari@aol.com.

Abbreviations

ED, emergency department; EM, emergency medicine

doi:10.7863/ultra.15.01027

Objectives—To assess the self-reported frequency of use of ultrasound guidance for central venous catheterization by emergency medicine (EM) residents, describe residents' perceptions regarding the use of ultrasound guidance, and identify barriers to the use of ultrasound guidance.

Methods—A longitudinal cross-sectional study was conducted at 5 academic institutions. A questionnaire on the use of ultrasound guidance for central venous catheterization was initially administered to EM residents in 2007. The same questionnaire was distributed again in the 5 EM residency programs in 2013.

Results—In 2007 and 2013, 147 and 131 residents completed questionnaires, respectively. A significant increase in the use of ultrasound guidance for central venous catheterization was reported in 2013 compared to 2007 ($P < .001$). In 2007, 53% (95% confidence interval, 44%–61%) of residents reported that they were initially trained in central venous catheterization using ultrasound guidance compared to 96% (95% confidence interval, 92%–99%) in 2013 ($P < .0001$). In 2007, more residents thought that faculty were insufficiently adopting ultrasound (42% versus 9%), and there was a lack of ultrasound teaching during residency training (14% versus 5%) compared to 2013.

Conclusions—The use of self-reported ultrasound guidance for central venous catheterization significantly increased from 2007 to 2013 at academic institutions. Most residents were aware of the benefits of using ultrasound guidance. Although faculty adoption of ultrasound for central venous catheterization remains a barrier, it has decreased.

Key Words—catheters; central venous catheterization; emergency medicine; residents; ultrasound

The benefits of using ultrasound guidance for central venous catheter placement have been well documented in the literature.^{1–4} Multiple studies have shown that the use of ultrasound guidance for central venous catheter placement increases success rates, reduces the number of attempts, shortens the time required to perform the procedure, and decreases placement failure rates.^{5–7} A recent meta-analysis demonstrated that real-time ultrasound guidance, in which the operator uses ultrasound to visualize the needle and guides it to the vessel, decreased complications when compared to the anatomic landmark-based approach for central venous catheterization.⁸ As a result of the compelling evidence, the use of ultrasound guidance for central venous cannulation has been recommended by numerous professional medical organizations

and government agencies.⁹ The Agency for Healthcare Research and Quality identified the use of real-time ultrasound guidance during central line insertion as an evidence-based patient safety practice.¹⁰ The National Institute for Health and Care Excellence recommended the use of 2-dimensional ultrasound imaging guidance for insertion of central venous catheters.¹¹ The Centers for Disease Control and Prevention also recommended ultrasound guidance to decrease the number of puncture attempts and mechanical complications.¹² Several medical societies have created position statements advocating for the use of ultrasound guidance for central venous catheterization.^{13,14} The National Quality Forum has endorsed ultrasound guidance for internal jugular central venous catheter placement as one of the quality measures.¹⁵

Despite overwhelming evidence and endorsement from multiple societies, ultrasound guidance is not universally used for central venous catheterization. The underuse of ultrasound guidance for central venous access has been reported in a variety of settings.^{16–20} The published evidence to date suggests that ultrasound guidance remains underused by emergency physicians.^{21–24} To our knowledge, no prior studies have investigated the recent trends in the use of ultrasound guidance for central venous catheterization. The objectives of this study were to assess the self-reported frequency of use of ultrasound guidance for central venous catheterization by emergency medicine (EM) residents, describe residents' perceptions regarding the use of ultrasound guidance, and identify barriers to the use of ultrasound guidance.

Materials and Methods

Study Design and Population

This longitudinal cross-sectional study was conducted in 2007 and 2013 at 5 academic medical centers with EM residency programs. Each emergency department (ED) at these institutions had an annual patient census of at least 50,000, with hospital credentialing in emergency ultrasound available for emergency physicians. All 5 EDs had an active emergency ultrasound training program with a dedicated emergency ultrasound director. Four EM residency programs were 3-year training programs, and 1 was a 4-year program. Three EM residency programs were located at centers that already had an emergency ultrasound fellowship in place in 2007, and 1 program started a fellowship in 2011. The emergency ultrasound fellowship training programs were 1 year long, not accredited by the Accreditation Council for Graduate Medical Education, and implemented in accordance with American College

of Emergency Physicians emergency ultrasound fellowship guidelines.²⁵ This study was deemed exempt or approved by the Institutional Review Board at all participating institutions.

Survey Content and Administration

A 16-item questionnaire on the use of ultrasound guidance for central venous catheterization was developed on the basis of existing literature and suggestions from emergency ultrasound experts (Table 1). The questionnaire was reviewed by a biostatistician experienced in survey research and 3 emergency physicians with expertise in ultrasound for the relevance and clarity of each survey item. The questionnaire consisted of multiple-choice questions assessing the use of ultrasound guidance for central venous catheterization. The questionnaire consisted of specific questions regarding demographics, central venous access training methods, number of central line procedures performed, current use of ultrasound guidance for central venous catheterization, barriers to ultrasound use for central venous catheterization, and perceptions of residents. Questions assessing perceptions were answered on a 5-point Likert scale (1, strongly agree; 2, agree; 3, neither agree nor disagree; 4, disagree; and 5, strongly disagree). The questionnaire was pilot tested on a small group of volunteer EM residents, and items were modified according to the responses from the pilot group.

The questionnaire was initially administered to EM residents in 2007, and the same questionnaire was distributed again to residents in the 5 EM residency programs in 2013. The emergency ultrasound faculty was responsible for distributing and collecting the questionnaires. All EM residents in the 5 residency programs were invited to participate in the study. Survey participation was voluntary, and verbal consent was obtained from the residents who agreed to participate in the study. The surveys were administered and collected anonymously to protect the confidentiality of the participants. The percentage of surveys returned was tracked to determine the response rate.

Measures

The primary outcome was the frequency of use of ultrasound guidance for central venous catheterization. The secondary outcomes were barriers to the use of ultrasound guidance, methods of central venous catheterization training, and perceptions of EM residents and awareness of evidence supporting ultrasound guidance. The outcomes were compared between EM residency programs with and without an emergency ultrasound fellowship.

Data Analyses

Data analyses were performed with Stata version 12.1 software (StataCorp, College Station, TX). Imputation of missing data was not attempted. The response rate was calculated by using the number of actual participants as the numerator and the total number of eligible participants as

the denominator. Questionnaire responses were reported in terms of the percentages of total respondents along with 95% confidence intervals. All statistical comparisons were done with the Fisher exact test. No adjustment for multiple comparisons was performed. $P < .05$ was considered statistically significant.

Table 1. Questionnaire on Use of Ultrasound Guidance for Central Venous Catheterization

1.	Approximately how many central venous catheters have you placed?	<5	5–10	11–20	21–30	31–40	41–50	>50
2.	What percentage of central venous catheters have you inserted under ultrasound guidance?	<20%	21%–40%	41%–60%	61%–80%	81%–100%		
3.	What method was adopted during your initial training of central venous access?							
	Traditional landmark technique					Yes	No	
	Ultrasound-guided access					Yes	No	
4.	Were you taught about anatomic variations during central venous access training?	Yes	No					
5.	Please indicate whether you consider the following to be barriers for your use of ultrasound for central venous access in your emergency department:							
	Not enough faculty using ultrasound					Yes	No	
	Not enough teaching during residency training					Yes	No	
	Technically challenging to learn					Yes	No	
	Difficulty performing the procedure					Yes	No	
	Not enough time during a busy shift					Yes	No	
	Other, specify _____							
6.	To what extent do you agree or disagree with this statement: "Ultrasound-guided central venous access is faster than the traditional landmark method."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
7.	To what extent do you agree or disagree with this statement: "Ultrasound-guided central venous access is easier than the traditional landmark method."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
8.	To what extent do you agree or disagree with this statement: "Ultrasound-guided central venous access is more convenient than the traditional landmark method."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
9.	To what extent do you agree or disagree with this statement: "Ultrasound-guided central venous access is safer than the traditional landmark method."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
10.	To what extent do you agree or disagree with this statement: "Ultrasound guidance reduces complications associated with central venous access."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
11.	To what extent do you agree or disagree with this statement: "Ultrasound guidance reduces placement failure rates associated with central venous access."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
12.	To what extent do you agree or disagree with this statement: "Ultrasound guidance is especially useful in patients with difficult line placement."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
13.	To what extent do you agree or disagree with this statement: "Ultrasound guidance is especially useful in patients without good landmarks."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
14.	To what extent do you agree or disagree with this statement: "Ultrasound guidance is especially useful in patients with a failed traditional landmark method."?							
	a. Strongly agree	b. Agree	c. Neither agree nor disagree	d. Disagree	e. Strongly disagree			
15.	Are you aware of any controlled trials demonstrating benefits of using ultrasound guidance for central venous access?	Yes	No					
16.	Are you aware of any major organizations recommending ultrasound-guided central venous access?	Yes	No					

Results

In 2007 and 2013, 147 and 131 residents completed questionnaires, respectively. Residents from regionally diverse EM residency programs located in 4 different states participated in this study. The response rates were 86% in 2007 and 80% in 2013. No differences were noted in the number of residents that had performed more than 20 central venous catheterizations between 2007 and 2013 ($P = .015$). Significant differences were reported in the use of ultrasound guidance for central venous catheterization between 2007 and 2013, and the differences were more pronounced between residency programs with and without a fellowship (Tables 2–4). A significant increase in the use of ultrasound guidance was reported in 2013 compared to 2007 ($P < .001$). In 2007, 53% (95% confidence interval, 44%–61%) of residents reported that they were initially trained in central venous catheterization using ultrasound guidance compared to 96% (95% confidence interval, 92%–99%) in 2013 ($P < .0001$).

Most residents (92% in 2007 and 94% in 2013) thought that the use of ultrasound guidance for central venous catheterization is safer than the traditional landmark method. Similarly 84% (2007) and 90% (2013) agreed that ultrasound guidance reduces complications and placement failure rates associated with central venous catheterizations. No significant differences were found in the number of respondents (42% in 2007 versus 45% in 2013) who acknowledged that they were aware of recommendations by major societies regarding the use of ultrasound guidance for central venous catheterization ($P = .6$). Table 5 shows the barriers identified by EM residents for ultrasound use for central venous catheterization. In 2007, more residents thought that faculty were insufficiently adopting ultrasound (42% versus 9%), and there was a lack of ultrasound teaching during residency training (14% versus 5%). No differences were noted between residency programs with and without an emergency ultrasound fellowship.

Discussion

Our study provides insight into recent trends in the use of ultrasound guidance for central venous catheterization by EM residents. Overall, it is encouraging to know that the use of ultrasound guidance increased significantly in recent years at academic institutions. Possible explanations include adoption of consensus recommendations by the Council of Emergency Medicine Residency Directors, implementation of ultrasound milestones, and competency

assessment. Implementation of hospital-specific protocols aimed at patient safety might have improved physician compliance with ultrasound use for central venous catheterization. However, it is still not used for all central line placements despite endorsements from government

Table 2. Self-Reported Frequency of Use of Ultrasound Guidance for Central Venous Catheterization

Frequency of Use of Ultrasound Guidance, %	Residents Reporting Using Ultrasound Guidance, %	
	2007	2013
<20	40	6
21–40	16	4
41–60	19	10
61–80	12	18
81–100	13	62
	$P < .001$	

Table 3. Self-Reported Frequency of Use of Ultrasound Guidance for Central Venous Catheterization in Programs With an Emergency Ultrasound Fellowship

Frequency of Use of Ultrasound Guidance, %	Residents Reporting Using Ultrasound Guidance, %	
	2007	2013
<20	48	6
21–40	18	2
41–60	20	9
61–80	7	19
81–100	7	64
	$P < .001$	

Table 4. Self-Reported Frequency of Use of Ultrasound Guidance for Central Venous Catheterization in Programs Without an Emergency Ultrasound Fellowship

Frequency of Use of Ultrasound Guidance, %	Residents Reporting Using Ultrasound Guidance, %	
	2007	2013
<20	31	8
21–40	13	12
41–60	17	15
61–80	18	11
81–100	21	54
	$P < .03$	

Table 5. Barriers to Use of Ultrasound Guidance for Central Venous Catheterization Reported by Residents

Barrier	Residents, %		P
	2007	2013	
Not enough faculty using ultrasound	42	9	<.001
Not enough teaching during residency training	14	5	.008
Technically challenging to learn	15	12	.4
Not enough time during a busy shift	53	52	.8

and professional societies. The translation of evidence into clinical practice regarding the use of ultrasound for central venous catheterization still faces many challenges. The possible reasons for underuse of ultrasound guidance include a lack of expertise and training in the use of ultrasound, limited access to ultrasound equipment, and prior training in performing central venous catheterization by using traditional landmark approaches at different anatomic sites. These factors highlight the need for ongoing education and emphasis on the use of ultrasound guidance in EM residency programs.

To increase the use of ultrasound for central venous catheterization, it is critical to understand the barriers reported by EM residents. Similar to the results of other surveys, our study found that a lack of faculty adoption of ultrasound was one of the important barriers to implementing ultrasound guidance in the residents' practices.²⁶ Prior surveys indicate that availability of ultrasound equipment at academic centers, unlike community ED settings, is not a major barrier.²⁷ Developing validated systematic methods that could be widely disseminated across training programs is potentially the best way to overcome the barriers and lead to universal acceptance of this technique. Training efforts should also focus on increasing the awareness of current literature pertaining to ultrasound-guided central venous catheterization and the use of ultrasound guidance even during a high-patient volume shift. Simulation offers another potential avenue for widespread dissemination.

A previous study suggested that most practicing emergency physicians who work in nonacademic settings do not use ultrasound guidance for central venous catheterization.²² Lack of training in ultrasound was reported as one of the important barriers to using ultrasound guidance in their practices.²² Emergency physicians who have been trained in this technique become more comfortable adopting the procedure and are more likely to use it after graduation. Improving ultrasound education and compliance during residency training is crucial for increasing the use of ultrasound guidance for central venous catheterization in nonacademic settings.

Our study results suggest that the presence of an emergency ultrasound fellowship program has a positive impact on the use of ultrasound guidance for central venous catheterization. It has been shown that emergency ultrasound fellows can have a substantial impact on resident ultrasound education, faculty expertise, and credentialing in bedside ultrasound.²⁶ Emergency ultrasound fellows spend a considerable amount of time in the ED using ultrasound and interacting with residents, thereby

leading to increased use of ultrasound guidance for central venous catheterization. Emergency medicine residency programs should make efforts to increase the involvement of ultrasound fellows in resident education to teach ultrasound-guided central venous catheterization.

There were several limitations in our study, including a small sample size. We used a convenience sample of residency programs, which might have introduced a selection bias. Since all 5 residency programs included in this study had an active emergency ultrasound training program, our results may not be generalizable to residency programs with less robust ultrasound training and community ED settings. The survey was not mandatory; hence, it is also possible that residents who use ultrasound guidance for central venous catheterization were more motivated to complete the questionnaire, in which case the frequency of ultrasound use reported in this study would be higher than in EM residents at other programs. However, in both years, response rates were high. All of the questions included in our survey were closed ended, which might have introduced a potential for a response bias. Responses to our questions regarding the frequency of ultrasound use were also prone to a recall bias. The reported results in our study are dependent on the accuracy of the self-reported data, which are vulnerable to error, especially with residents in a 4-year training program. The residents might have overestimated or underestimated the use of ultrasound guidance. Our questionnaire was pilot tested; however, it was not validated. Additionally, the questions did not distinguish the use of ultrasound for internal jugular, subclavian, and femoral vein catheterization.

In conclusion, the use of self-reported ultrasound guidance for central venous catheterization significantly increased from 2007 to 2013 at academic institutions. Most residents were aware of the benefits of using ultrasound guidance. Although faculty adoption of ultrasound for central venous catheterization remains a barrier, it has decreased.

References

1. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ* 2003; 327:361.
2. Milling TJ Jr, Rose J, Briggs WM, et al. Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: the Third Sonography Outcomes Assessment Program (SOAP-3) trial. *Crit Care Med* 2005; 33:1764–1769.
3. Karakitsos D, Labropoulos N, De Groot E, et al. Real-time ultrasound-guided catheterisation of the internal jugular vein: a prospective comparison with the landmark technique in critical care patients. *Crit Care* 2006; 10:R162.

4. Lamperti M, Bodenham AR, Pittiruti M, et al. International evidence-based recommendations on ultrasound-guided vascular access. *Intensive Care Med* 2012; 38:1105–1117.
5. Keenan SP. Use of ultrasound to place central lines. *J Crit Care* 2002; 17:126–137.
6. Fragou M, Gravvanis A, Dimitriou V, et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. *Crit Care Med* 2011; 39:1607–1612.
7. Leung J, Duffy M, Finckh A. Real-time ultrasonographically-guided internal jugular vein catheterization in the emergency department increases success rates and reduces complications: a randomized, prospective study. *Ann Emerg Med* 2006; 48:540–547.
8. Wu SY, Ling Q, Cao LH, Wang J, Xu MX, Zeng WA. Real-time two-dimensional ultrasound guidance for central venous cannulation: a meta-analysis. *Anesthesiology* 2013; 118:361–375.
9. Troianos CA, Hartman GS, Glas KE, et al; Councils on Intraoperative Echocardiography and Vascular Ultrasound of the American Society of Echocardiography; Society of Cardiovascular Anesthesiologists. Special articles: guidelines for performing ultrasound-guided vascular cannulation—recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. *Anesth Analg* 2012; 114:46–72.
10. Agency for Healthcare Research and Quality. Making health care safer II: an updated critical analysis of the evidence for patient safety practices, March 2013. Agency for Healthcare Research and Quality website. <http://www.ahrq.gov/research/findings/evidence-based-reports/services/quality/patientsftyupdate/ptsafetyIIchap18.pdf>. Accessed September 24, 2014.
11. British National Health Service, National Institute for Health and Care Excellence. Guidance on the use of ultrasound locating devices for placing central venous catheters, September 2002. National Institute for Health and Care Excellence website. <http://www.nice.org.uk/guidance/TA49>. Accessed September 24, 2014.
12. Centers for Disease Control and Prevention. Guidelines for the prevention of intravascular catheter-related infections, 2011. Centers for Disease Control and Prevention website. <http://www.cdc.gov/hicpac/pdf/guidelines/bsi-guidelines-2011.pdf>. Accessed September 24, 2014.
13. Canadian Association of Emergency Physicians. CAEP position statement: emergency department targeted ultrasound, 2006 update. Canadian Association of Emergency Physicians website. http://caep.ca/sites/default/files/caep/files/ultrasound_positionstatement_-_jul21.05.pdf. Accessed September 24, 2014.
14. American College of Surgeons. Revised statement on recommendations for use of real-time ultrasound guidance for placement of central venous catheters, February 2011. American College of Surgeons website. http://www.facs.org/fellows_info/statements/st-60.html. Accessed September 24, 2014.
15. National Quality Forum. Ultrasound guidance for internal jugular central venous catheter placement, September 2011. National Quality Forum website. <http://www.qualityforum.org/QPS/QPSTool.aspx>. Accessed September 24, 2014.
16. Tovey G, Stokes M. A survey of the use of 2D ultrasound guidance for insertion of central venous catheters by UK consultant paediatric anaesthetists. *Eur J Anaesthesiol* 2007; 24:71–75.
17. McGrattan T, Duffy J, Green JS, O'Donnell N. A survey of the use of ultrasound guidance in internal jugular venous cannulation. *Anaesthesia* 2008; 63:1222–1225.
18. Jefferson P, Ogbue MN, Hamilton KE, Ball DR. A survey of the use of portable ultrasound for central vein cannulation on critical care units in the UK. *Anaesthesia* 2002; 57:365–368.
19. Bailey PL, Glance LG, Eaton MP, Parshall B, McIntosh S. A survey of the use of ultrasound during central venous catheterization. *Anesth Analg* 2007; 104:491–497.
20. Girard TD, Schectman JM. Ultrasound guidance during central venous catheterization: a survey of use by house staff physicians. *J Crit Care* 2005; 20:224–229.
21. Backlund BH, Hopkins E, Kendall JL. Ultrasound guidance for central venous access by emergency physicians in Colorado. *West J Emerg Med* 2012; 13:320–325.
22. Buchanan MS, Backlund B, Liao MM, et al. Use of ultrasound guidance for central venous catheter placement: survey from the American Board of Emergency Medicine longitudinal study of emergency physicians. *Acad Emerg Med* 2014; 21:416–421.
23. Craig S, Egerton-Warburton D, Mellett T. Ultrasound use in Australasian emergency departments: a survey of Australasian College for Emergency Medicine fellows and trainees. *Emerg Med Australas* 2014; 26:268–273.
24. Matera JT, Egerton-Warburton D, Meek R. Ultrasound guidance for central venous catheter placement in Australasian emergency departments: potential barriers to more widespread use. *Emerg Med Australas* 2010; 22:514–523.
25. American College of Emergency Physicians. Emergency ultrasound guidelines. *Ann Emerg Med* 2009; 53:550–570.
26. Adhikari S, Fiorello A. Emergency ultrasound fellowship training: a novel team-based approach. *J Ultrasound Med* 2014; 33:1821–1826.
27. Moore CL, Gregg S, Lambert M. Performance, training, quality assurance, and reimbursement of emergency physician-performed ultrasonography at academic medical centers. *J Ultrasound Med* 2004; 23:459–466.