REVIEW

Should ultrasound guidance be used for central venous catheterisation in the emergency department?

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In September 2002, the National Institute of Clinical Excellence (NICE) issued guidelines for England and Wales suggesting that ultrasound guidance should be used for all electives, and should be considered for most emergency, central venous catheterisations.[1] These guidelines propose a major change of practice for most clinicians practising in UK Emergency Departments. There are also resource and training implications. In this paper we systematically review the literature to establish what evidence exists for the routine use of ultrasound guidance in the placement of central venous catheters in adult patients attending the Emergency Department, and provide an overview of the practical elements of this procedure.

Central venous catheterisation (CVC) to obtain central venous access is an essential part of the clinical management of many conditions seen in the Emergency Department.[2]

The procedure is however, associated with significant risks. These risks are increased in association with several characteristics:[3]

- Abnormal patient anatomy (e.g. morbid obesity, cachexia, local scarring),
- The emergency clinical setting (e.g. patients receiving mechanical ventilation, emergencies such as cardiac arrest)
- Co-morbidity (e.g. bullous emphysema, coagulopathy).
- Inexperience of the clinician inserting the CVC

The complications associated with attempted CVC insertion (whether successful or not) include arterial puncture, haematoma, pneumothorax, haemothorax, chylothorax, brachial plexus injury, arrhythmias, air embolus, and catheter malposition. Complication rates have been reported to be as high as 10%, and failure to cannulate the vessel may occur in up to 20% of cases.[3 4]

CVC insertion has traditionally been performed 'blindly' using anatomical landmarks as a guide to vessel position. The commonest sites are the internal jugular (IJ), subclavian (SC), and femoral (FV) veins.

Doppler ultrasound was first used to assist CVC placement in 1984.[5] This method gives an indication of the position of underlying major vessels without visual imaging. The first report of combined real-time visual ultrasonographic imaging for internal jugular catheter placement was by Yonei *et al* in 1986.[6] Since then there has been mounting evidence that the use of real-time 2-D external ultrasound may be valuable in assisting CVC insertion by increasing speed of placement and decreasing complication rates.[7 8] Real-time ultrasound guidance of CVC insertion provides the operator with the added benefit of visualising the target vein and the surrounding anatomic structures (figs 1 and 2), prior to and during insertion of the catheter.

Ultrasound is most commonly used to guide central venous catheterisation using the catheter over wire or Seldinger technique. Portable ultrasound machines that are specifically designed for vascular access are available, though any standard 2-D ultrasound machine with a mid to high frequency (7.7 to 9 MHz) linear array (flat) probe can be used. It is possible for a single user to operate the ultrasound and perform vascular access simultaneously.

The key steps in ultrasound guided venous access are:

1. Preparation of equipment
2. Maintenance of aseptic technique
3. Identification of vascular anatomy (including presence of thrombus, valves, strictures, and abnormal features)
4. Confirming compressibility of veins as opposed to arteries
5. Placement of centre of ultrasound probe over centre of vein
6. Visualisation of needle-tip approaching and penetrating vein
7. Confirmation of successful puncture by aspiration as well as visualisation

Several accessories have been developed to assist with some of these key points. Sterile sheaths prevent potential contamination by the ultrasound probe. The sheath is filled with ultrasonic transmitting gel; the probe is inserted into the sheath and can then be applied to moistened skin. A standard sterile glove can also be used. Needle guides can be attached to the probe to ensure optimal positioning of the needle during insertion.

For most vascular approaches, the field depth of the ultrasound image should be less than 4 cm. The vessel can be viewed in either a transverse or longitudinal plane. Vessels appear dark in contrast to the lighter surrounding

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Abbreviations: CVC, central venous catherisation; ED, emergency department; FV, femoral veins; IJ, internal jugular veins; RCT, randomised controlled trial; RD, risk difference; RR, relative risk; SC, subclavian veins

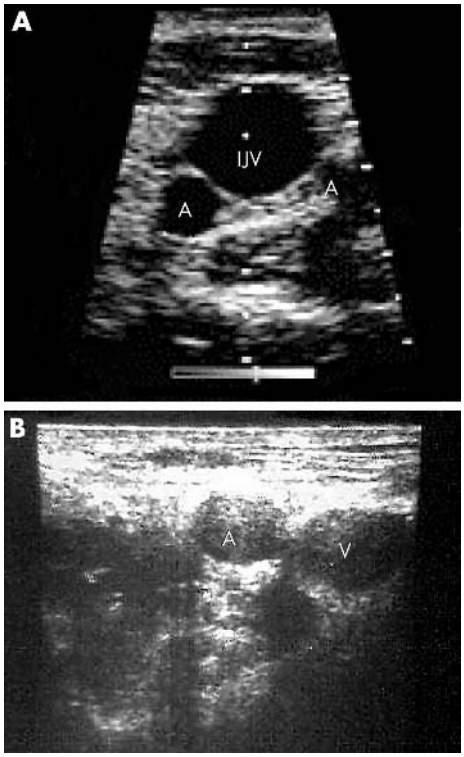

Figure 1 (a) Demonstration of Vascular Anatomy by Ultrasonography: Internal Jugular Vein (IJV) demonstrated above carotid artery (A) bifurcation. (b) Femoral Artery (A) and Femoral Vein (V).

tissues. The needle is introduced passing under the probe so that it is visualised approaching the vessel. The needle direction is the same as the standard approaches to a central vein, and should be angled so that it intersects with the vessel in the plane being visualised. When blood is aspirated, the probe can be withdrawn, and standard catheter placement continues.

The use of ultrasonography by emergency physicians has increased over the past decade.[9] Ultrasound is used in the ED for detecting free intra-peritoneal fluid in trauma, for confirming the presence of abdominal aortic aneurysms, confirmation of intra-uterine pregnancy, diagnosing renal and gallbladder calculi, and the detection of soft tissue foreign bodies.[10–12] More recently there have been reports of the use of ultrasound for guidance of CVC insertion by emergency physicians, with North American guidelines advocating this practice.[10 11]

Table 1 Levels of evidence for various Outcome Measures with the use of Ultrasound Guidance for CVC insertion

Outcome measure	Highest level of evidence (In general)	Highest level of evidence (Emergency Department)
Mortality	None	None
Length of stay in ED/ Hospital	None	None
Reduction in failure rate	Meta-analysis	Not statistically significant
Improved first attempt success rate	Meta-analysis	RCT
Reduced time to cannulation	RCT	RCT
Reduced number of attempts	Meta-analysis	RCT
Reduced complication rate	Meta-analysis	RCT
Cost saving	Economical analysis	None

CVC, central venous cathetorisation; ED, emergency department; RCT, randomised controlled trial.

Figure 2 Ultrasound transducer with needleguide (courtesy of Dymax Corp).

We reviewed the literature systematically for high-level evidence relating to the use of ultrasound guidance for CVC placement by non-radiologists in the non-elective setting, and then to find all evidence relating specifically to the emergency department setting (See Appendix 1).

EVIDENCE FOR ULTRASOUND GUIDANCE IN THE EMERGENCY AND CRITICAL CARE SETTING

Meta-analyses

Three meta-analyses, by Randolph *et al*[7] in 1996, Keenan[8] in 2002, and Hind *et al*[13] in 2003, provide the highest level of evidence for the use of ultrasound guidance in the placement of CVC's. None of these papers focus on critically ill or emergency patients, but all include trials that focus on these patient groups.

Randolph *et al* reviewed 8 randomised-controlled trials (RCTs) of real-time ultrasound in comparison to the landmark technique for CVC placement. Studies were included if they were a randomised clinical trial on adult or paediatric patients, evaluated real-time ultrasound (either Doppler or External 2-D Ultrasound), and included the following outcome measures: speed of placement, number of attempts, rate of success, complication rate or rate of success after failure by another method. This work concluded that ultrasound reduced the failure rate for both IJ and SC CVC placement (RR 0.32, 95% CI 0.18 to 0.55).

There was also a reduction in the complication rate (RR 0.22, 95% CI 0.10 to 0.45), and in the total number of attempts required for successful cannulation (RR 0.60, 95% CI 0.45 to 0.79). The paper did not offer any sub-group analysis for emergency cannulation, nor was there a comparison of Doppler versus External 2-D ultrasound.

Keenan evaluated a total of 18 trials of ultrasound (either Doppler or External 2-D Ultrasound) in comparison to landmark placement of CVC's. Seventeen RCT's and one 'quasi'-randomised controlled trial were included. Eleven trials evaluated the use of External 2-D ultrasound. Keenan concluded that ultrasound guidance led to a significant reduction in failure rate (RD −0.16; 95% CI ±0.09; RR 0.40), number of attempts (Risk Reduction 1.41; 95% CI ±0.36) and arterial punctures (RD −0.07; 95% CI ±0.03; RR 0.299). The success rate for first attempts was significantly higher with ultrasound guidance (RD 0.24; 95% CI 0.08 to 0.39). Subgroup analysis showed that improvement with ultrasound was greater with external 2-D ultrasound than with

Table 2 Meta-analyses

Paper	N/Type	Group	Inter-vention	Outcome	Comments
Randolph *et al*[7] 1996	8 RCTs	Mixed hospital adult & paediatric inpatients undergoing CVC insertion	Doppler- and External-ultrasound guidance, versus Landmark	Reduced IJ & SC failure rate.	No emergency vs routine subgroup analysis.
	513 CVC placements in 493 patients.			Reduced complication rate.	No Doppler vs 2-D ultrasound analysis.
				Reduction in number of attempts.	Variable definitions of failure.
					No blinded studies
Keenan[8] 2002	17 RCTs & 1 Quasi-RCT	Mixed hospital adult & paediatric inpatients undergoing CVC insertion	Doppler ultrasound (898) and External 2-D ultrasound (1194)	Reduced failure rate.	No scoring system or dual assessment for inclusion.
	2092 patients			Reduction in number of attempts.	No emergency vs routine subgroup analysis.
				Reduced arterial puncture rate.	Variable definitions of failure.
				Increased first attempt success rate.	No blinded studies.
				Most improvement with 2-D ultrasound, IJ cannulation, less experienced clinicians.	
Hind *et al*[13] 2003	18 trials	Mixed hospital adult & paediatric inpatients undergoing CVC insertion	Doppler ultrasound (6 trials) and External 2-D ultrasound (11 trials) Both (1 trial)	Lower failure rate and higher first attempt success rate for SC, IJ and FV approaches.	Study quality was assessed by component approach
	1646 patients			Some evidence for Doppler ultrasound for IJ approach.	No emergency vs routine subgroup analysis
					No blinded studies

CVC, central venous cathetoriastion; FV, femoral vein; IJ, internal jugular vein; RCT, randomised controlled trial; SC, subclavian vein.

Doppler, for IJ cannulation more than for other approaches, and when used by clinicians less experienced in CVC insertion. There was no direct comparison of emergency versus routine cannulation.

The systematic review and meta-analysis by Hind *et al* formed the basis for the NICE guidelines published in 2002. This paper includes 18 trials (1646 participants). It showed that 2-D ultrasound guidance for cannulating the internal jugular vein in adults was associated with a significantly lower failure rate both overall (RR 0.14, 95% CI 0.06 to 0.33) and on the first attempt (0.59, 95% CI 0.39 to 0.88). Limited evidence favoured two-dimensional ultrasound guidance for subclavian vein and femoral vein procedures in adults (0.14, 95% CI 0.04 to 0.57 and 0.29, 95% CI 0.07 to 1.21, respectively). Doppler guided cannulation of the internal jugular vein in adults was more successful than the landmark method (0.39, 95% CI 0.17 to 0.92), but the landmark method was more successful for subclavian vein procedures (1.48, 95% CI 1.03 to 2.14).

Randomised controlled trials

There are 19 published RCT's that compare ultrsound guidance with traditional methods for CVC placement. Eight papers include the use of External 2-D ultrsound in emergency or critically ill adult patients. One paper is not discussed on the basis of major methodological flaws.[14] Two of the remaining 7 studies are from an emergency department setting. The five 'non-ED' papers include patients from intensive care, cardio-thoracic, cardiac catheterisation, and mixed trauma, medical, and surgical settings.

Randomised controlled trials (non-emergency department)

All 5 studies report significant benefits from ultrasound guidance in comparison with CVC placement by the landmark technique. The benefits included decreased failure rates, a decrease in the total number of attempts, a reduction in the time taken to successfully cannulate the vessel, increased rates of success at the first attempt, and a decrease in reported complications. None of these studies were blinded and some had important methodological flaws. These results are summarised in Table 3.

Randomised controlled trials (emergency department)

Both emergency department-based RCTs concur with evidence from the 'Non-ED' literature that ultrasound guidance may offer benefits for CVC placement. Hitly *et al* compared the use of 2-D real-time ultrasound with the landmark technique for the placement of femoral CVC's in the setting of cardiopulmonary resuscitation in the ED.[1] Notably, both investigators who performed the ultrasound had only done so on one previous occasion. This small un-blinded study with no power calculations concluded that ultrasound guidance decreased time to cannulation. Although this reduction was small, it included the time required to set up the ultrasound machine. It was also demonstrated that there was a reduction in the number of attempts required for success and fewer arterial cannulations.

Miller *et al* assessed the performance of residents placing CVC's both with and without ultrasound guidance in 'non-arrest' adult patients in the emergency department.[21] These residents had only received two 1-hour lectures on the use of ultrasound as preparation for the study. They looked at 122 patients over a 6-month period, with ultrasound guidance used on even days, and the landmark technique on odd days. They found that ultrasound guidance led to a shorter time for CVC insertion, although they recorded the 'skin to blood' time rather than the total time including the initial ultrasound examination. The total number of attempts was reduced, but there was no reduction in complication rates, which were 14% and 12% for landmark and ultrasound guidance respectively. A major flaw with this paper is that the site of CVC placement was not specified, but left to the discretion of the clinician and there appears to be a major difference between the groups for the choice of insertion site. Therefore it is possible that these groups are not directly comparable. The results are summarised in Table 4.

Other emergency department evidence

There are relatively few papers addressing the use of ultrasound guidance for CVC placement in the emergency department. Other than the two randomised controlled trials, one observational study and a short case series have been published.

Table 3 Non-ED Randomised Controlled Trials

Paper	N/Type	Group	Inter-vention	Outcome	Comments
Mallory *et al*[15] 1990	27 RCT (with partial crossover)	IJ CVC insertion in ICU patients by Senior ICU Staff		Failure rate	Small numbers
			Ultrasound	0/12	No power calculation
			Landmark	6/17 ($p<0.05$)	
				Number of attempts	
			Ultrasound	1.75	
			Landmark	3.12 ($p<0.05$)	
				Success on crossover	
			To Ultrasound	6/6	
Troianos *et al*[16] 1991	160 RCT	CVC insertion in Cardio-thoracic patients		Success Rate	No baseline statistics.
			Ultrasound	77/77	Randomisation process not described
			Landmark	80/83 (NS)	
				First attempt success	
			Ultrasound	56/77	
			Landmark	45/83 ($p<0.05$)	
				Number of attempts	
			Ultrasound	1.4 ± 0.7	
			Landmark	2.8 ± 3 ($p<0.05$)	
				Time to insertion	
			Ultrasound	61 ± 46 sec	
			Landmark	117 ± 136 sec ($p<0.05$)	
Denys *et al*[17] 1993	604 (1230) RCT (302 Ultrasound vs 302 landmark followed by 626 patients Ultrasound only)	IJ CVC insertion in cardiac catheter patients by senior cardiologist		Success rate	Poor randomisation technique (one week blocks of Ultrasound or landmark)
			Ultrasound 1	302/302	No blinding
			Ultrasound 2	626/626	
			Landmark	66/302 ($p<0.001$)	
				Complication rates ($p<0.001$):	
			Ultrasound1/ Ultrasound2/LM	Carotid puncture	
				8/8/25	
				Brachial Plex Injury	
				1/3/5	
				Haematoma	
				0/2/10	
				Total number attempts	
			Ultrasound1	1.2 ± 0.5,	
			Ultrasound2	1.4 ± 0.9	
			Landmark	2.5 ± 2.7 ($p<0.001$)	
				First attempt success	
			Ultrasound1	248	
			Ultrasound2	473	
			Landmark	116 ($p<0.001$)	
Gualtieri *et al*[18] 1995	33 patients 53 placements RCT	SC CVC insertion in ICU patients Operators with <30 procedures.		Success rate	No blinding.
			Ultrasound	23/25	Initial power calculation ignored and trial stopped when significance reached.
			Landmark	12/27 ($p=0.0003$)	Group overlap: experienced operator intervened in 2 cases
				Complication rate	
			Ultrasound	1/25	
			Landmark	11/27 ($p=0.002$)	
				Total number attempts	
			Ultrasound	1.4	
			Landmark	2.5 ($p=0.0007$)	
				CVC kit usage	
			Ultrasound	1.0	
			Landmark	1.4 ($p=0.0003$)	
Slama *et al*[19] 1997	79 RCT	IJ CVC insertion		Success rate	No power calculation.
		ICU patients by Junior doctors	Ultrasound	37/37	No blinding
			Landmark	32/42 ($p<0.01$)	
				Time to insertion	
			Ultrasound	95 ± 174 sec	
			Landmark	235 ± 408 ($p=0.06$;NS)	
				Complication rate	
				No sig. difference	

CVC, central venous catherisation; ICU, intensive care unit; IJ, internal jugular vein; RCT, randomised controlled trial.

Table 4 Emergency Department Trials

Paper	N/ Type	Group	Intervention	Outcome	Comments
Hilty *et al*[2] 1997	20 patients 40 CVC attempts RCT	Femoral Vein CVC insertion in ED patients in cardiac arrest, by Residents		Time to cannulation	No power calculation
			Ultrasound	121±60 seconds	No blinding
			Landmark	124.2±69 (p=0.001)	Small sample size
				Number of attempts	
			Ultrasound	2.3±3	
			Landmark	5±5 (p=0.0057)	
				Arterial puncture rate	
			Ultrasound	0/20	
			Landmark	4/20 (p=0.025)	
				Success rate	
			Ultrasound	90%	
			Landmark	65% (p=0.058)	
Miller *et al*[21] 2002	122 RCT	ED adult patients requiring CVC (IJ, SC & FV routes)		Time to insertion (skin to blood)	Different approaches (i.e. IJ, SC, FV) used in each group without pairing)
			Ultrasound	115±184 seconds	No blinding
			Landmark	512±698 (p<0.0001)	
				Number of attempts	
			Ultrasound	1.55±1	
			Landmark	3.54±2.68 (p<0.0001)	
				Complication rate	
			Ultrasound	14%	
			Landmark	12% (p=0.71,NS)	
Hrics *et al*[22] 1998	40 Descriptive study/Case series	IJ CVC placement in ED patients		Success rate	Exempt from ethical approval
			Realtime ultrasound	7/8	Variable ultrasound technique
			Ultrasound marking site	17/24	No statistical analysis
			Landmark	5/8	No randomisation or controls.

CVC, central venous cathetorisation; ED, emergency department; FV, femoral vein; IJ, internal jugular vein; RCT, randomised controlled trial; SC, subclavian vein.

The series of 2 cases by Hudson in 1997 is the first record of this technique being used in an ED.[20] The observational study by Hrics *et al* reports the use of ultrasound guidance for IJ CVC insertion in ED patients, none of whom were in cardiac arrest.[22] Forty attempts at CVC placement were made in 34 patients, with ultrasound guidance used in 32 attempts and the remaining 8 attempts using the landmark technique. Despite some methodological concerns, the results do seem to show a higher number of first pass successes, successful punctures and successful cannulations in the ultrasound group. A summary is shown in Table 4.

GUIDELINES

The National Institute for Clinical Excellence (NICE) has issued guidelines on the use of ultrasound for CVC placement.[1] These guidelines are based on a review of the relevant literature and a cost effectiveness analysis. They recommend that two-dimensional (2-D) imaging ultrasound guidance should be the preferred method for insertion of CVC's into the IJ vein in adults and children in elective situations, and should be considered in most clinical circumstances where CVC insertion is necessary in an emergency situation. The guidelines state that there is also evidence of benefit from using ultrasound guidance in femoral vein and SC vein cannulation, but that the volume of evidence is much less than for the IJ approach. The report concludes, based on a conservative model, that there may be a cost saving of up to £2 per patient by introducing ultrasound guidance for CVC placement. There is no specific advice relating to ED practice.

Guidelines on the use of ED ultrasound have been published in North America[10 11] and in Australasia.[12] The American College of Emergency Physicians guidelines (2001) include the use of ultrasound guidance for venous access, whereas the Australasian College for Emergency Medicine does not include the use of ultrasound guidance for CVC insertion as a primary indication in its procedural statement.

DISCUSSION

Real-time ultrasound guidance for CVC placement improves success rates, reduces the number of attempts prior to successful placement, and reduces the number of complications associated with catheter insertion. There may even be a cost saving associated with the introduction of this technique. It is less clear whether these conclusions apply in the ED setting. Although both RCT's from the ED setting have shown benefits with ultrasound guidance, neither of these papers focused on the placement of internal jugular catheters, in contrast to the bulk of the other studies. Cost implications may also prevent the routine use of ultrasound guidance for CVC placement in the ED, as the number of procedures performed may be too small. The major impediment to the widespread implementation of ultrasound guidance for CVC placement would seem to be the purchase costs of the ultrasound machines. The purchase cost of a portable 2-D ultrasound machine is currently between £7000 and £15,000 (NICE[12] and personal communications). The additional disposables necessary for the ultrasound guided procedure cost less than £1 per procedure. A cost effectiveness analysis was carried out by NICE's Assessment Group based on what they describe as a conservative model. Estimates made by this analysis indicate that the additional cost of using ultrasound equipment for the CVC placement procedure is likely to be less than £10 per procedure. This extra cost per procedure was balanced against apparent increased costs from complications such as failure and arterial cannulation. The results of the Assessment Group's model suggested that the ultrasound guidance not only avoided 90 arterial punctures for every 1000 patients treated, but also reduced costs by an average of almost £2 per patient. In other words they claimed that ultrasound guidance was found to be both more effective and less costly than the landmark method. The cost of training new operators is not mentioned in the report. This real cost must also be considered and requires further evaluation. The

cost effectiveness analysis assumed that each ultrasound machine was used for 15 procedures per week. Any cost-saving result was lost if the weekly frequency was less than 11, or if the number of procedures carried out by an individual trained practitioner was less than 3 per month on average. A survey of the local practice in the ED at Addenbrooke's Hospital, Cambridge (a University Teaching Hospital which treats 60,000 new patients annually) found that on average, 80 CVC packs are used annually (personal investigation). This level of use would not achieve the numbers necessary to provide a cost saving. Cost effectiveness issues for ED's will be subject to local variation, such as time to access ICU beds and local guidelines.

The problem of cost could be addressed by sharing an ultrasound machine with another hospital department such as Anaesthetics or ICU, or may be minimized by the introduction of ultrasound machines into ED's for other indications such as trauma scanning.

Another factor that must be considered is that none of these studies have addressed the impact of ultrasound guidance on overall patient outcomes such as mortality or length of stay. In addition, many of the complications reported with CVC insertion are relatively minor or easily treated. The demonstrated reduction in the number of attempts required for successful CVC placement is likely to be associated with reductions in pain and discomfort, though this has not been measured.

One finding from sub-group analysis in Keenan's meta-analysis[8] was that inexperienced clinicians and all clinicians in high-risk situations received the greatest benefit from ultrasound guidance. This may be particularly relevant to ED practice where many CVC's are inserted by junior doctors, and where many of the patients are critically ill.

The issue of timing is of particular importance to emergency practice. Keenan looked at the effect of ultrasound guidance on the time taken for CVC placement and did not find any significant difference in pooled results from 9 studies. Most of these studies timed their attempts from skin to aspiration of blood and did not include the time taken to set up the machine and locate the correct site. Encouragingly one RCT carried out in the ED setting did measure the time from the arrival of the ultrasound machine at the bedside until successful cannulation, and found a small reduction in the time required.[1]

Training UK emergency physicians in the use of ultrasound presents our specialty with a significant challenge. Although there are no current UK national guidelines for emergency ultrasound training, the American College of Emergency Physicians has provided a detailed model.[10] They make a distinction between procedural ultrasound and general bedside diagnostic ultrasound use. They recommend that all ultrasound practitioners should undergo initial basic ultrasound training varying in length from 1 to 2 days depending on the number of applications being taught, followed by at least 25 documented and reviewed cases in each of the primary applications. Recommendations for procedural applications state that the physician should be competent in the basic use of ultrasound demonstrated by completed training in at least one other single application. Proficiency may not always be defined by numerical goals, and certain physicians may gain competency at lower or higher thresholds.

In the study by Millar *et al*,[21] the doctors performing ultrasound received only 2 hours of training before independent use of ultrasound, which should encourage those who might shy away from learning this technique. We would recommend attendance at a course covering basic ultrasound skills prior to the clinical use of this application. Such courses are available nationally and internationally. Skill maintenance will be another challenge given how infrequently emergency physicians in the UK insert CVCs. This could be achieved by teaching the technique to emergency department and other specialty staff on a regular basis, either in the ED, ICU or operating theatre setting.

The use of ultrasonography by emergency physicians in the UK is likely to increase in the future. With the increasing availability of ultrasound technology in the ED, and the publication of national guidelines supporting its use, it is likely that ultrasound guidance for CVC placement in the ED will become more common. The evidence currently available supports this technique in general. However, further work is needed to identify the attitudes of UK emergency physicians towards ultrasound, its current use, and future plans for developing expertise in this area, in addition to randomised controlled trials to evaluate patient outcomes and cost effectiveness in the emergency department setting.

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REFERENCES

1 **National Institute for Clinical Excellence**. *Guidance on the use of ultrasound locating devices for placing central venous catheters*. London: NICE, 2002, [NICE Technology Appraisal No 49.].
2 **Hilty WM**, Hudson PA, Levitt MA, *et al*. Real-time ultrasound-guided femoral vein catheterization during cardiopulmonary resuscitation. *Ann Emerg Med* 1997;**29**:331–336.
3 **Mansfield PF**, Hohn DC, Fornage BD, *et al*. Complications and failures of subclavian-vein catheterization. *N Engl J Med* 1994;**331**:1735–1738.
4 **Sznajder JI**, Zveibil FR, Bitterman H, *et al*. Central vein catheterization. Failure and complication rates by three percutaneous approaches. *Arch Intern Med* 1986;**146**:259–261.
5 **Legler D**, Nugent M. Doppler localization of the internal jugular vein facilitates central venous cannulation. *Anesth Analg* 1984;**60**:481–482.
6 **Yonei A**, Nonoue T, Sari A. Real-time ultrasonic guidance for percutaneous puncture of the internal jugular vein. *Anesthesiology* 1986;**64**:830–831.
7 **Randolph AG**, Cook DJ, Gonzales CA, *et al*. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med* 1996;**24**:2053–2058.
8 **Keenan SP**. Use of ultrasound to place central lines. *Journal of Critical Care* 2002;**17**(2):126–37.
9 **Brenchley J**, Sloan JP, Thompson PK. Echoes of things to come. Ultrasound in UK emergency medicine practice. *J Accid Emerg Med* 2000;**17**:170–175.
10 **American College of Emergency Physicians**. American College of Emergency Physicians. ACEP emergency ultrasound guidelines-2001. *Annals of Emergency Medicine* 2001;**38**(4):470–81.
11 SAEM Ultrasound Position Statement 97. Society for Academic Emergency Medicine, 2001.
12 **ACEM Policy document—Use of bedside ultrasound by emergency physicians**. Australasian College for Emergency Medicine, July 1999:21.
13 **Hind D**, Calvert N, McWilliams R, *et al*. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ* 2003;**327**:361.
14 **Teichgraber UKM**, Benter T, Gebel M, *et al*. A sonographically guided technique for central venous access. *Am J Roentgenol* 1997;**169**:731–733.
15 **Mallory DL**, McGee WT, Shawker TH, *et al*. Ultrasound guidance improves the success rate of internal jugular vein cannulation. A prospective, randomized trial. *Chest* 1990;**98**:157–160.
16 **Troianos CA**, Jobes DR, Ellison N. Ultrasound-guided cannulation of the internal jugular vein. A prospective, randomized study. *Anesth Analg* 1991;**72**:823–826.
17 **Denys BG**, Uretsky BF, Reddy PS. Ultrasound-assisted cannulation of the internal jugular vein. A prospective comparison to the external landmark-guided technique. *Circulation* 1993;**87**:1557–1562.
18 **Gualtieri E**, Deppe SA, Sipperly ME, *et al*. Subclavian venous catheterization: greater success rate for less experienced operators using ultrasound guidance. *Crit Care Med* 1995;**23**:692–697.
19 **Slama M**, Novara A, Safavian A, *et al*. Improvement of internal jugular vein cannulation using an ultrasound-guided technique. *Intensive Care Med* 1997;**23**:916–919.
20 **Hudson PA**, Rose JS. Real-time ultrasound guided internal jugular vein catheterization in the emergency department. *American Journal of Emergency Medicine* 1997;**15**(1):79–82.
21 **Miller AH**, Roth BA, Mills TJ, *et al*. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Academic Emergency Medicine* 2002;**9**(8):800–5.
22 **Hrics P**, Wilber S, Blanda MP, *et al*. Ultrasound-assisted internal jugular vein catheterization in the ED. *American Journal of Emergency Medicine* 1998;**16**(4):401–3.

APPENDIX

APPENDIX 1: SEARCH METHODOLOGY

A systematic review of the literature was performed to find high-level evidence for the use of ultrasound guidance in the non-elective setting, and then to find all evidence relating specifically to the emergency department setting. MEDLINE, EMBASE, and CINAHL databases were searched using the OVID interface using the following strategies:

1. (exp Catheterization, Central Venous/or central venous cannulation.mp.) and (exp Ultrasonography/or ultrasound.mp.) LIMIT to (human and (meta analysis or randomised controlled trial or review)) (EMBASE excluded)
2. (exp Catheterization, Central Venous/or central venous cannulation.mp.) and (exp Ultrasonography/or ultrasound.mp.) and (exp Emergency Medicine/or emergency medicine.mp. or emergency physician.mp. or exp Emergency Service, Hospital/or exp Emergency Medical Services/)

The Cochrane database was searched in full. The NICE database was searched for national guidelines. The bibliographies of the articles obtained were then manually searched. Unpublished work and conference presentations were researched by communication with individuals with expertise in the field. Papers, which on review of their abstract or methods section, clearly focused on routine/elective CVC insertion, paediatric patients were excluded. Articles were appraised using criteria published by the Critical Appraisal Skills Programme (CASP), Oxford.

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