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Ultrasound guidance of vascular catheterization

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OUTLINE

1. Technical Concepts—How does it work?
2. Parameters Monitored—What information do you get from it?
3. Evidence of Utility—Does it make a difference in outcome?
4. Complications—What harm can it cause?
5. Credentialing—What is the educational or credentialing process, if any?
6. Practice Parameters—When should I/must I use it?

1. TECHNICAL CONCEPTS—HOW DOES IT WORK?

The basic principles of ultrasound are covered in other chapters in this book, but for the sake of completion will be re-reviewed here. There are two basic kinds of ultrasound applicable to vascular access, Doppler and B-mode.

Doppler ultrasound converts sound waves that are reflected from a moving object (e.g, red blood cells within a vessel) into an audio signal. Anesthesiologists are most familiar with this technique when it is used to «hear» a pulse in order to help determine either blood pressure, or the presence or absence of circulation in an extremity (e.g., following vascular bypass). Signals obtained from arteries and veins sound distinctively different and hence can be used to help assist in the identification of vascular structures. Doppler ultrasound can be used alone, or combined with B-mode ultrasound. However, Doppler ultrasound in any form is currently rarely used to assist in vascular catheterization and thus it will not be discussed further.

B-mode ultrasound coverts sound waves that are converted into a gray scale image. «B» stands for «brightness». Signals returned to the transducer are assigned a gray scale based on amplitude. The device's contrast resolution determines the number of shades of gray that will be displayed. Fluid filled structures (e.g., blood, fluid in collections) are hypoechoic and are shown as dark gray or black, soft tissue (e.g, muscle) is more isoechoic and appears gray, while solid structures (e.g., thick tendons, bone) are hyperechoic and appear white (Figure 1). When applied to vascular access, a key use of ultrasound is the identification and differentiation between arterial and venous structures. Vascular structures can further be assessed by their overall shape and most important, compressibility. Patent veins are much more compressible and can often be collapsed with the application of pressure, unlike arteries

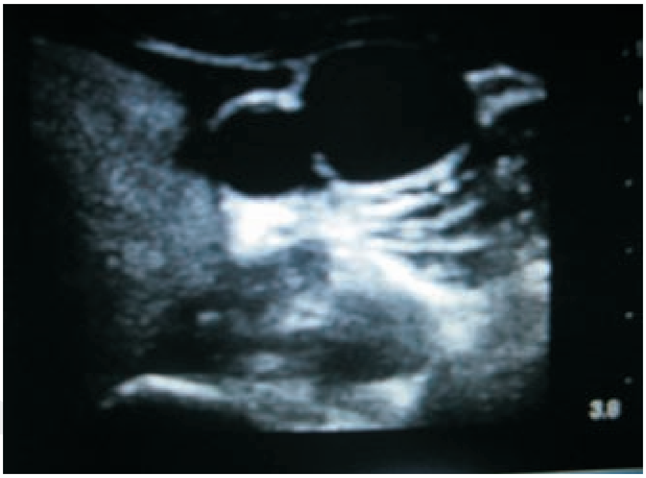


Figure 1. Picture obtained from the ultrasound image of the right neck of a patient. Note the vein lies lateral to the artery in this patient, is larger and not as circularly shaped.

that retain much of their original shape and appearance. Extrathoracic veins will also enlarge more than arteries with Valsalva maneuvers and Trendelenberg positioning. Lastly, pulsatility of vascular structures can be visualized, although arterial pulsation can be transmitted to adjacent structures and extra care needs to be taken in order to avoid confusion.

These devices are used in two main ways, static and dynamic. In static imaging the anatomy is determined and an «x marks the spot» technique is applied. These authors highly recommend against this technique because the relative relationship between surface and deep anatomy can dramatically change with minor change in positioning that may occur between marking and procedure start (Figure 2)[1-3]. We recommend dynamic imaging whereby the probe is covered in a sterile sheath and held in the nondominant hand while the needle stick is performed with the dominant hand.

Other important technical points that are frequently overlooked include:

1) The proper orientation of the probe should be verified at the beginning of the procedure in order to make certain that pressure on the left side of the probe is visualized on the left side of the screen. Probes are often either unmarked or poorly marked with regards to what direction they should be facing.
2) The screen should be positioned in a comfortable place so that the operator can see it within a 30 degree glance from the operative field. This will allow almost simultaneous visualization of surface anatomy and monitor. When performing an internal jugular catheterization we prefer the screen to be located on the ipsilateral side of the bed approximately within arm's reach (Figure 3).
3) Ultrasound jelly must be placed within the condom sheath and on the skin in order to obtain an adequate image.
4) Always start by positioning the vein in the center of the screen and adjust the depth monitored so that the entire needle path can be easily visualized.
5) Pay attention to the actual depth of the vessel by noting the ruler on the screen or the actual size of the image in centimeters that is being projected. Knowledge of depth will help prevent the operator from accidentally entering the pleural space.

The probe can be maneuvered in several ways in order to help the operator obtain the best image and acquire the most information. The four basic maneuvers are pressure, alignment, rotation and tilting; they can be remembered with the acronym PART. Short axis, and long axis techniques may be used (Figure 4), but the short axis approach is more commonly preferred. Some devices allow the simultaneous visualization of both images, which can be quite helpful to the experienced operator, but, in our experience, confuses the less than expert operator. Long axis views will allow the experienced operator to visualize the entire needle along its plane of passage into the vessel, but requires extra care while performing the procedure in order to not confuse the artery and vein which will often not be visualized in the same long axis image. In contrast, the short axis view almost always allows continuous visualization of the artery and the vein.

There are many ultrasound machines and probes on the market, with larger, more complicated machines almost always capable of performing vascular ultrasound if configured properly. Only a few are specifically designed for vascular catheterization. The main determinant factor of suitability for vascular imaging is the type of probe. Vascular ultrasound

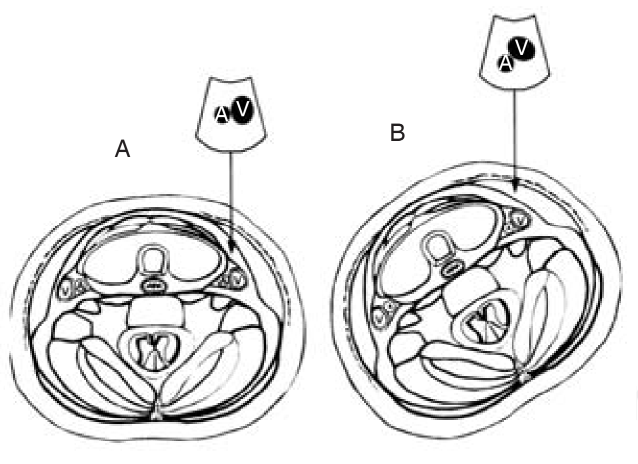
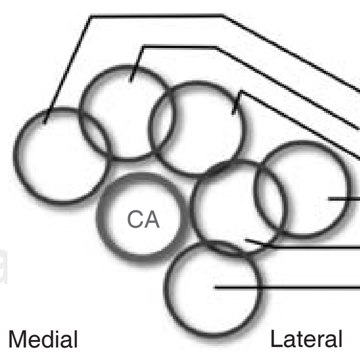


Figure 2. Figure demonstrating the effect of change in head position on over lap or the vein and artery. From Troianos CA, Kuwik R, Pasqual P, et al. Internal jugular vein and carotid artery anatomic relation as determined by ultrasound. Anesthesiology 1996; 85: 43-48 with permission.



Position	Range in %
medial	0-5.5
anterior	0-16 (54*)
anterio-lateral	9-92
far lateral	0-4
lateral	0-84
posterior	0-9
not visible/ thrombosed	0-18

Figure 3. Figure demonstrating the relative position of the vein to the carotid artery (CA) compiled from several studies. From Maecken T, Grau T. Ultrasound imaging in vascular access. Crit Care Med. 2007; 35 :S178-85 with permission.

should generally be performed with a probe that is a 7.5-10MHz linear array transducer that is flat faced resulting in a rectangular or square image that allows adequate visualization of the vasculature structures of interest, especially with regard to depth and relationship to immediately adjacent structures. Color Doppler will further enhance the ability to differentiate arteries from veins and is now commonly available in several devices, but is not absolutely necessary. Of note, the color assigned in Doppler views (traditionally either red or blue) represents only the direction of flow relative to the probe. Thus a vein may be depicted as either red or blue, as may an artery, depending on the angulation of the probe. The probe should not be too large, as this will interfere with its ability to fit into the operative field, especially in pediatric patients and in adults if the neck is particularly short and fat. The shape of probes varies tremendously and the operator should make certain that they are comfortable holding it in their non-dominant hand (Figure 5).

When purchasing a vascular ultrasound device, several important aspects of the monitor and the stand should be taken into account:

1) The device size and portability, especially the footprint of the stand. This will determine whether of not it can be used in tight quarters. Space requirements may vary greatly from one work area to another.
2) The device should function on AC or with a battery. Battery life may be important if the device will travel away from a home base for long periods of time.

Figure 4. Picture demonstrating ideal positioning of patient, operator and monitor. This depicts a preprocedure scan of the left internal jugular vein. Note that the probe is held in the nondominant hand and that the monitor is on the ipsilateral side of the planned procedure, as close to the midline of the operative field as possible.

3) Larger screens allow the image to be magnified. This is helpful when the vasculature is small.
4) The layout of control functions vary tremendously from device to device. One particularly helpful advance is the presence of controls to adjust gain, image magnification, and depth on the probe itself, or on a remote control device that can be sheathed and placed into the operative field. This will allow the operator to work independently.
5) The ability to print or store images which will be germane to documentation, performance improvement efforts and billing.
6) A storage basket on the device pole to hold the sheaths, gels and other extraneous equipment such as printer paper, etc. is necessary.

While devices that incorporate more features almost always appear to be more desirable, these authors feels that if the

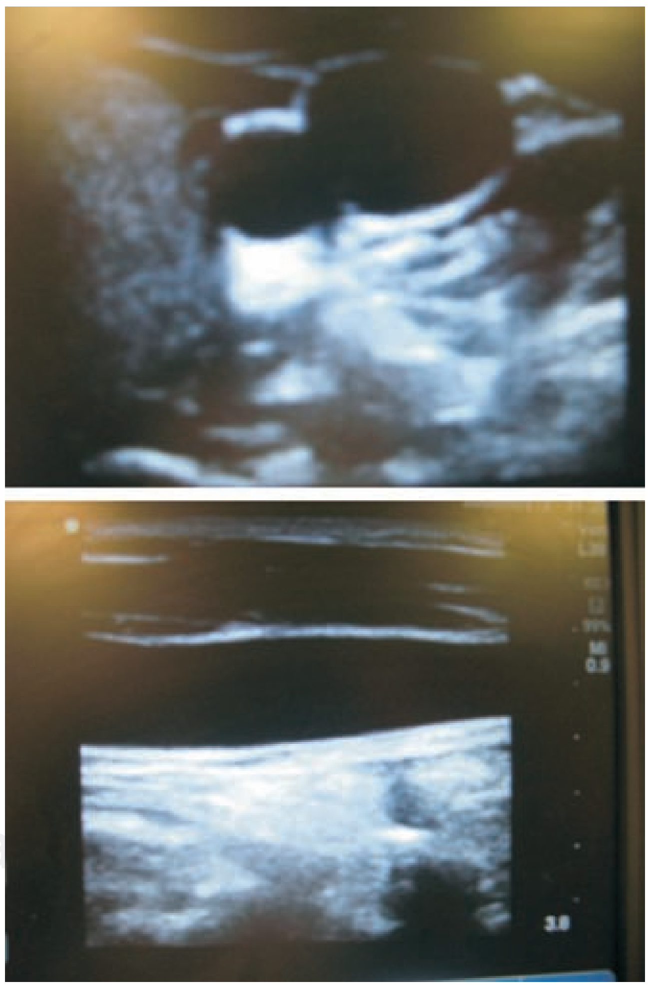


Figure 5. Picture demonstrating short and long axis views of the internal jugular vein.

device will only be used for vascular catheterization, a simpler device with fewer features and controls will not only allow more rapid skill acquisition and acceptance, but will cost less and be less likely to need repair. Simple is frequently better.

2. PARAMETERS MONITORED— WHAT INFORMATION DO YOU GET FROM IT?

We recommend a pre-procedure exam before prepping and draping the selected site. Important information obtained from a pre-procedure exam should include at least the following:

1) The absolute presence of the intended target vessel is established.
2) The vessel's size should be estimated.
3) The vein's relationship to the artery should be carefully noted, particularly what percentage overlay there is and whether the amount of overlay can be improved by turning the head.
4) The presence of echoic material within the vessel suggestive of clot or thrombus should be determined. Similarly, complete, or nearly complete compressibility of the vessel should be observed to rule out venous thrombosis.
5) How does the vessel change in size with Trendelenberg positioning and Valsalva maneuver?
6) In case any of the previous issues present concern, then other potential sites should be similarly interrogated.

It is imperative to be aware that prior catheterizations may have scarred, stenosed or thrombosed the target vessel and a pre-procedure exam may immediately lead to change of site. If the vein appears small despite steep Trendelenberg positioning and Valsalva maneuver, or its anatomy relative to the artery is unsatisfactory and arterial puncture perhaps unavoidable, imaging of the other side should be performed and the comparable risk of the two sides weighed. At very least, if the first site chosen is unsuccessful, the likelihood of success in the backup site could be estimated apriori. Imaging will help the clinician to communicate to the patient the potential for increased difficulty, multiple punctures, and failure. Prior warning of these adverse events seems to increase patient satisfaction.

During performance of the procedure utilizing the dynamic technique, the vessel will be visualized in real time. When lidocaine is injected the needle should be visualized in the expected plane of approach and the formation of a hypoechoic local anesthesia bubble anterior to the vessel should be appreciated. If the vessel is small, coaching the patient to Valslava or steepening the Trendelenberg position will be helpful. The needle should be seen to invaginate the anterior wall of the vessel and usually can be seen to enter the vessel if the relative plane of the transducer and needle tip are lined up correctly. The wire can also be seen within the vessel if these principles are strictly adhered to.

If catheterization is unsuccessful, frequently the vessel can be seen to disappear during attempts and sometimes hematoma formation can be seen too. This information is very helpful in order to abandon that site in a timely fashion and choose another location, which will reduce time, discomfort and potential for complication. Pre-procedural examination will also have allowed for a thoughtful and orderly progression of attempts or decision to not proceed further.

3. EVIDENCE OF UTILITY— DOES IT MAKE A DIFFERENCE IN OUTCOME?

Traditional approaches

Historically, central venous catheter (CVC) insertion has been performed by blind techniques that rely on anatomic landmarks such as the sternocleidomastoid muscle heads and carotid pulse (internal jugular cannulation), the bend of the clavicle (subclavian cannulation) or the inguinal ligament and femoral pulse (femoral cannulation). Such techniques require knowledge of regional anatomy, and assume that this anatomy is readily identifiable and invariant from patient to patient. Landmark-based techniques are generally viewed as safe and effective when performed by an experienced operator in optimal conditions. However, historical data show overall noninfectious complication and failure rates as high as 40% in adult patients[2-6]. Failure can be attributed to three major factors: patient-related factors, anatomic variability and operator inexperience.

Numerous patient-related factors have been associated in the literature with increased risks of complications from CVC placement. These factors include lack of traditional anatomic landmarks in morbid obesity, extremes of age, or previous radiation or surgery that distorts normal anatomy; factors that increase risk of bleeding with arterial puncture such as coagulopathy or thrombocytopenia; and factors that limit the patient's ability to tolerate mechanical complications of insertion such as decreased cardiopulmonary reserve[4,5]. Unsurprisingly, pediatric patients are generally at higher risk for almost all major complications[7,8].

Even in a patient without specific risk factors for difficult cannulation, intrinsic anatomic variability often leads to poor outcomes. This variability is best demonstrated by the example of internal jugular (IJ) CVC insertion. The landmark technique for IJ cannulation relies on either identification of the two heads of the sternocleidomastoid, and, or, the carotid pulse and needle insertion at the apex of the two heads lateral to the palpated pulse. This technique assumes a lateral location of the jugular vein relative to the carotid artery, an assumption only true in a minority of patients (Figure 6). In fact, in most cases, the jugular vein overlaps the carotid artery anteriorly to at least some extent, and may even lie medial to the artery.

Operator experience also plays a significant role in the complication and failure rates of the landmark technique[5,9]. We suggest that approximately 50 line placements are required before an operator can be deemed «competent» to place CVCs independently. Operators who have placed greater than 50 lines have half the complication rate of those who have placed less than 50.

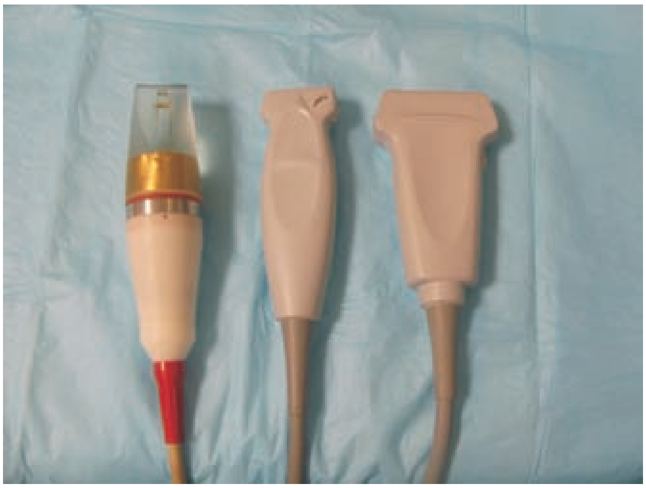


Figure 6. Picture of 3 probes that the author (ABL) uses. On the left is the Bard Site Rite 3, middle is the SonoSite® *iLook™* and on the right the SonoSite® S-ICU*™*. Note the differences in shape and width.

4. COMPLICATIONS—WHAT HARM CAN IT CAUSE?

Ultrasound guidance

Because of the relatively high complication rate of landmark-based CVC placement discussed above, the development of ultrasound-guided techniques for central venous cannulation was greeted with considerable excitement. As discussed elsewhere in this chapter, three broad categories of ultrasound guidance for central venous catheterization exist: Doppler, B- mode static and B-mode dynamic. Doppler, while initially thought to be promising, proved to be inferior to 2D ultrasound guidance and equivalent to landmark techniques in a majority of studies in both adult and pediatric populations[10-13]. As a consequence, the technique has been largely abandoned.

Static ultrasound has been compared to dynamic ultrasound and landmark techniques in several moderate-sized randomized controlled trials in recent years (Table I). Because of the few studies that directly compare static ultrasound to another technique, conclusions about its utility are limited. Static ultrasound was demonstrated to be superior to landmark in one adult and one pediatric study. Data comparing dynamic ultrasound to static ultrasound are equivocal, with dynamic ultrasound appearing to be superior to static ultrasound in several studies, and equivalent in others. Of note, to date there are no studies suggesting statistical or nonsignificant trend towards superiority of static ultrasound. However, additional studies are required to elucidate significant differences between the two.

In contrast to static ultrasound, numerous clinical trials have demonstrated the efficacy of dynamic ultrasound guidance in CVC placement in a variety of clinical settings

Table I. Studies of static ultrasound prelocation in adult and pediatric populations.

First Author Year	Study Type Comparison	Pt type	n	Total success	Mean Attempts	Complications[1]	Conclusions
Chuan WX 2005[32]	RCT SUS vs LM	Infants <12kg	62	80% vs 100%	2.55 vs 1.57	26.7% vs. 3.1%	Benefit to SUS over LM in peds
Hosokawa K 2007[33]	RCT DUS vs SUS	Infants <7.5kg	60	89% vs 100%^{NS}	NR	4% vs 0%^{NS}	NS trend favoring DUS over SUS in peds
Milling TJ 2005[34]	RCT DUS vs SUS vs LM	Adults	201	64% vs 82% vs 98%	5.2 vs 2.9 vs 2.3[2]	13% vs 3% vs 3% ^{NS}	DUS better than SUS better than LM in adults
Hayashi H 2002[35]	RCT DUS vs SUS	Adults w/ VAD	188	96.9% vs. 97.6%^{NS}	NR	1% vs 3.3%^{NS}	DUS equivalent to SUS if VAD
Hayashi H 2002[36]	RCT DUS vs SUS	Adults w/o VAD	53	78.3% vs. 97.6%	NR	13% vs 0%	DUS superior to SUS if no VAD

Abbreviations: RCT – Randomized controlled trial, LM – Landmark; SUS – Static ultrasound prelocation; DUS – real-time dynamic ultrasound; VAD – Ventilator-associated venodilation; pts – patients; NR – not reported; Peds – pediatric.
[1] Major complications unless otherwise note (arterial puncture, pneumothorax, hemothorax) [2]All significant except DUS vs SUS

Table II. Studies of dynamic ultrasound use compared to landmark technique in adult populations.

First Author Year	Study Type Site (if not IJ)	Setting Pt pop'n	n	Total success	Mean Attempts	Complications[3]
Gualtieri E 1995[37]	RCT Subclavian	ICU	53	44% vs 92%	2.5 vs 1.4	0% vs 0%[NS]
Karakitsos D 2006[38]	RCT	ICU	900	94.4% vs 100%	2.6 vs 1.1	6.7% vs 1.1%
Leung J 2006[39]	RCT	ED	130	78.5% vs 93.9%	3.5 vs 1.6	7.7% vs 1.5%
Mallory DL 1990[40]	RCT	ICU	29	65% vs 100%	3.12 vs 1.75	NR
Milling TJ 2006[41]	RCT	ED + MICU	201	64% vs 98%	5.2 vs 2.3	13% vs 3%
Troianos CA 1991[42]	RCT	ORs	160	96% vs 100% [NS]	2.8 vs 1.4	8.43% vs 1.39%[NS]
Hilty WM 1997[43]	Randomized case-control Femoral	ED PEA arrest	40	65% vs 90%	5.0 vs 2.3	20% vs 0%
Miller AH 2002[44]	Prospective quasi-random[4]	ED	122	NR	3.52 vs 1.55	14% vs 12% NS,[5]
Cajozzo M 2004[45]	Prospective quasi-random[6]	NR	196	98.1% vs 91.2%	NR	9.7% vs 0%
Hrics P 1998[46]	Prospective case series	ED	40	62.5% vs 81.3%	2.0 vs 2.0[NS]	0% vs 0%
Wigmore TJ 2007[47]	Prospective case series	OR	284	93.9% vs 99.4%	1.31 vs 1.23[NS]	4.3% vs 1.8%[NS]
Augoustides JG 2002[48]	Prospective case series	OR	462	86.2% vs 97.9%	NR	8.1% vs 5.9%[NS]
Martin MJ 2004[49]	Prospective case series	ICU	484	NR	NR	9% vs 11%[NS,3]
Cajozzo M 2004[50]	Retrospective chart review	Wards Pts >65y/o	72	98.7%	NR	0%

P<0.05 unless otherwise noted
Abbreviations: RCT – Randomized controlled trial; ICU – Intensive care unit; ED – Emergency department; PEA – Pulseless electrical activity; NR - Not reported;

[3] Major complications unless otherwise note (arterial puncture, pneumothorax, hemothorax) [4] Alternating days
[5] Including hematoma [6] Based on operator availability

Table III. Studies of dynamic ultrasound use in pediatric populations.

First Author Year	Study Type	Pt pop'n	n	Total success	Mean Attempts	Complications[7]
Verghese ST 2000[51]	RCT	Pts <10kg for OHS	45	81% vs 94%	2 vs 1[8]	19% vs 6%
Leyvi G 2004[52]	Retrospective	Peds pts for OHS	149	72.5% vs 91.5%	NR	4.9% vs 6.4%

Abbreviations: RCT – Randomized controlled trial, LM – Landmark; SUS – Static ultrasound prelocation; DUS – real-time dynamic ultrasound; pts – patients; OSH – open heart surgery; NR – not reported; Peds – pediatric.
[7] Major complications unless otherwise note (arterial puncture, pneumothorax, hemothorax)
[8] Study reported medians

and patient populations, both adult (Table II) and pediatric (Table III). In the overwhelming majority of studies, dynamic ultrasound use increased overall success rates, decreased the number of attempts required for cannulation and reduced the number of mechanical complications associated with CVC placement. In addition to these general studies, the limitations of landmark techniques described above have prompted a several investigators to examine the safety and efficacy of dynamic ultrasound in a variety of high-risk patient populations (Table IV). In each of these patient populations, dynamic ultrasound has been demonstrated to be safe, effective, and superior to landmark techniques.

To date, three major meta-analyses have been published, each of which confirmed these findings. Randolph*, et al*[14], reviewed the eight randomized controlled trials available at that time, finding that ultrasound use significantly decreased the risk of failed catheter placement regardless of site of insertion (RR 0.32, 95% CI 0.18-0.55), reduced mechanical complications of placement (0.22, 0.10-0.45), and reduced the number of attempts required for successful cannulation (0.60, 0.45–0.79), although there was no significant change in the time to successful placement (95% CI -80.1 to 62.2 secs). Of note, the authors did not distinguish between studies using the audio Doppler, static ultrasound and dynamic ultrasound. However, as noted above, subsequent data suggest that restriction to dynamic ultrasound would only be expected to increase the magnitude of the observed benefit. Additionally, the analysis included studies with varied definitions of «failure», potentially clouding their conclusions.

Keenan, *et al*[15] evaluated eighteen randomized controlled trials including a total of 2092 patients. The analysis differentiated dynamic ultrasound from Doppler, and included studies comparing both to landmark techniques. Once again, this meta-analysis confirmed that dynamic ultrasound use reduced the risk of failure (RR 0.40), number of attempts (absolute risk reduction 1.41), and arterial punctures (RR 0.299) when compared to landmark techniques. The study also concluded that dynamic ultrasound was superior to Doppler in all major parameters studied. Again, the studies included had variable definitions of what constituted failed placement, potentially confounding their analysis.

Table IV. Traditionally high-risk patient populations in which dynamic ultrasound use had been demonstrated to be safe and effective.

Significant coagulopathy[53]
Hematology/oncology patients[54]
Anatomic contraindications to LM insertion (venous stenosis or extremely low CVP, etc)[55]
History of difficult or failed cannulation[56]
Geriatric patients[57]
Pulseless patients undergoing CPR[58]
Unable to tolerate Trendelenburg positioning[59]

Most recently, in a study commissioned by the British National Institute for Clinical Excellence (NICE), Hind, *et al*[16] reviewed the 18 randomized controlled trials of dynamic ultrasound available in 2003, including a total of 1646 patients. This meta-analysis differentiated between technique (dynamic ultrasound vs. Doppler), patient population (adult vs pediatric) as well as insertion site (IJ, subclavian or femoral). As expected, this study confirmed that dynamic ultrasound use reduces failure rates of IJ cannulation in pediatric patients (RR 0.15 95% CI 0.03-0.64) and adult patients (RR 0.14, 95% CI 0.06-0.33), and reiterated the limited data that support dynamic ultrasound over landmark in subclavian and femoral cannulation.

In addition to being superior for patient-related outcomes, dynamic ultrasound may be cost effective from an economic standpoint. However, limited studies exist to support this claim. Calvert, *et al*[17] analyzed data from 20 RCTs and confirmed the superiority of dynamic ultrasound over landmark techniques. They went on to calculate the cost effectiveness of dynamic ultrasound use including initial equipment costs, training costs, and maintenance costs in their analysis as compared to the cost of complications and delayed cannulation. Based on conservative estimates, the authors calculate that for every 1000 CVC placements, dynamic ultrasound use would save approximately £2000 (approximately $4000 in 2008).

Future directions

There are significant data supporting the superiority of dynamic ultrasound in terms of patient outcomes and some data which suggest cost effectiveness. However, there is limited evidence of the level of training or operator experience required to achieve optimal outcomes using ultrasound guidance. The majority of studies cited above included a one to 6 hour training period on ultrasound use prior to randomization to the ultrasound wing of the study. In comparison to historical data on landmark CVC placement, which suggested that up to 50 procedures were necessary to obtain optimal results, some authors have suggested that because of the rapid learning curve observed anecdotally for ultrasound guided CVC placement, 4 hours of training in general ultrasound and its application to CVC placement, and only 5 to 10 proctored examinations is sufficient for competence[18]. However, this assertion has yet to be validated. Several models are described in the literature to facilitate training in ultrasound techniques including cadaveric models[19], and inexpensive homemade systems using materials such as gelatin and latex tubing[20,21]. Use of these models increases ultrasound use by participants, presumably because of increased familiarity of the technique, but quality outcome data are lacking.

Despite the data supporting its use, several surveys conducted as recently as 2007 have demonstrated that implementation of dynamic ultrasound for CVC placement remains limited, with between 11% and 20% of respondents using ultrasound most of the time[22-25]. The most significant barriers to implementation are generally found to be availability of adequate ultrasound equipment and perceived usefulness of dynamic ultrasound among respondents. However, three of the 4 published surveys were conducted in Britain, and may not reflect current trends in the US. Further studies aimed at identifying and overcoming specific barriers to ultrasound use are needed to facilitate its widespread implementation.

Additionally, and of note, to our knowledge no study at this time has demonstrated that ultrasound use significantly alters rates of CVC infection or line sepsis. Nor has it been demonstrated to reduce ICU length of stay or overall patient morbidity or mortality parameters. If these analyses are conducted and prove to be favorable, they may encourage use of ultrasound and decrease barriers to its implementation.

Several recent studies have expanded the traditional role of dynamic ultrasound as a guide for initial puncture of the target vein. These studies suggest that, as practitioners become more comfortable with ultrasound use, it may be used effectively to confirm correct guidewire placement within the vein during the cannulation procedure[26,27], and to rapidly detect the presence of a pneumothorax after the procedure before portable chest X-ray is possible[28]. However, additional studies confirming the reproducibility and reliability of these techniques are needed before use becomes widespread.

5. CREDENTIALING—WHAT IS THE EDUCATIONAL OR CREDENTIALING PROCESS, IF ANY?

In preparation of this chapter an informal survey of several Anesthesiology departments revealed that not a single one required separate credentialing for use of ultrasound to assist in central venous catheter insertion. However, the American Medical Association states that ultrasound imaging privileging should be specifically delineated by Department based on background and training, although this recommendation may have been written without the specific consideration of the very narrow scope of ultrasound for vascular access. Various professional societies have mandated incorporation of ultrasound training in their residency programs, most notably the American College of Emergency Physicians and the American College of Surgeons, but again, the narrow scope of ultrasound solely for vascular access is not the main intent of this mandated training.

Given that ultrasound does require skill acquisition and that incorrect use (e.g., failure to distinguish right from left, recognize intravascular thrombus, etc.) can be associated with an increase in morbidity, we recommend that basic documented training and credentialing should become standard. Given that training and credentialing of central line insertion is already ubiquitous, perhaps simply adding ultrasound use for this procedure in the training and credentialing process makes the most sense. This will be more important if the technique is widely adopted as the standard of care, or even if there is only agreement that it at least should always be available.

6. PRACTICE PARAMETERS—WHEN SHOULD I/MUST I USE IT?

Compelling data from numerous randomized controlled trials and multiple meta-analyses support the superiority of dynamic ultrasound use for CVC placement when compared to landmark techniques. Both intuitively and from the literature, there are a variety of situations in which landmark techniques place the patient at particularly high risk for failure and mechanical complication. In these high risk scenarios, we feel strongly that ultrasound guidance should be considered standard of care. One such situation is a known or anticipated lack of traditional landmarks such as in morbid obesity, prior neck surgery or radiation, or cannulation of sites such as the deep brachial vein which lack definite anatomic landmarks. Other scenarios in which we feel strongly that dynamic ultrasound guidance represents standard of care are: 1) patients that have had multiple prior access procedures (e.g. hematology/oncology patients), because the vein might be thrombosed or stenosed; 2) patients that should be put at the lowest risk of a carotid puncture (e.g., prior vascular intervention or known large plaque); 3) patients that are at higher than usual risk of complication from vascular mishap (e.g., anticoagulated or thrombocytopenic patients).

Based on the data discussed above, governmental organizations have recognized the potential benefit of ultrasound guidance. The United Kingdom's National Institute for Health and Clinical Excellence (NICE) in 2002 recommended this be made standard of care as a major recommendation stating: «Two-dimensional (2-D) imaging ultrasound guidance is recommended as the preferred method for insertion of central venous catheters (CVCs) into the internal jugular vein (IJV) in adults and children in elective situations. The use of two-dimensional (2-D) imaging ultrasound guidance should be considered in most clinical circumstances where CVC insertion is necessary either electively or in an emergency situation»[29]. This recommendation was reviewed, updated and confirmed in 2005. In the United States, the Agency for Healthcare Quality Research (AHRQ) recommended in 2001 that ultrasound guidance be one of 11 procedures that «were rated most highly in terms of strength of the evidence supporting more widespread implementation»[30].

Despite the existing evidence and governmental recommendations, it remains controversial if use of ultrasound guidance should be considered standard of care in all situations, and as discussed above, multiple barriers exist to its wide-spread adoption. Many Anesthesiologist and hospitals do not have ultrasound devices at their disposal, are not adequately trained or do not routinely employ these devices, and, or, have not recognized similar improvement in procedural outcome as demonstrated in the published literature. Benefits to ultrasound guidance may not be realized until operators comfortable with traditional techniques gain experience and comfort with ultrasound guidance. Furthermore, the meta-analyses that have been published to date are limited by the data available at the time of analysis, and because of the rapid evolution of ultrasound availability and use, may no longer be applicable.

At the time of writing, there is an active Cochrane review which will attempt to determine more definitively the efficacy and generalizability of ultrasound guidance for central venous cannulation. We expect this study to confirm what has been previously demonstrated in randomized controlled trials and meta-analyses, which will facilitate a more wide-spread adoption of ultrasound use in central line placement[31].

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