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ULTRASOUND GUIDED VASCULAR ACCESS

A meta-analysis of 8 randomised clinical trials by Randolph et al in 1996 demonstrated significant improvement in success and reduction in complication rates when Ultrasound was used to guide Internal Jugular and Subclavian central line placement. The trials contained an amorphous group of audio Doppler and 2D ultrasound compared to standard landmark techniques. Subsequently in 2001 the Agency for Healthcare Research and Quality in the United States reported that the Use of Ultrasound for central venous cannulation was one of eleven practices identified which would improve patient safety. The following year the National Institute of Clinical Excellence in the United Kingdom recommended the use of real-time Ultrasound guidance for the insertion of internal jugular central venous catheters and its use considered in most clinical circumstances when CVC insertion was necessary. This is perhaps not surprising given they used essentially the same data. Hind and Calvert who were part of the Nice group then published a meta-analysis of eighteen randomised controlled trials demonstrating reduced failure rate (relative risk 0.14, 95%CI:0.06-0.33; P<0.0001), increased success at first attempt (relative risk 0.59, 95%CI: 0.39-0.88) and reduced complication rates (relative risk 0.43, 95%CI 0.22-0.87). No study has yet shown a reduction in mortality or length of hospital stay. The case for Ultrasound guidance and Internal Jugular cannulation is convincing, but data for the subclavian and femoral routes is less clear. In Australia the CARI group (Care of Australians with Renal Impairment) put forward a directive that Haemodialysis lines should be inserted under direct vision either at open surgery or percutaneously using Ultrasound.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randolph et al 1996</td>
<td>8 RCTs</td>
<td>513 CVCs 493 patients</td>
<td>Reduced failure, Reduced complications, Reduced attempts</td>
</tr>
<tr>
<td>Keenan 2002</td>
<td>17 RCT &amp; 1 Quasi-RCT</td>
<td>2092 patients</td>
<td>Reduced failure, Reduced arterial puncture rate, Increased 1st attempt success</td>
</tr>
<tr>
<td>Hind et al 2003</td>
<td>18 trials</td>
<td>1646 patients</td>
<td>Reduced failure rate, Increased first pass success</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cost benefit analysis, Reduced Cost</td>
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</tbody>
</table>

The largest study to date by Karakitsos involved 900 critical care patients randomly allocated to landmark or Ultrasound based techniques. The experience of operators was comparable for both techniques but Ultrasound achieved a higher success rate (100% vs 94.4%;p<0.001), reduced carotid puncture (1% vs 11%) reduced haematoma (0.4% vs 8.4%), reduced pneumothorax (0% vs 2.4%). They also reported a lower blood stream infection rate (10% vs 16%).

Results for the Paediatric patients have been more mixed. Susan Verghese reported a better success rate (100%US :75% Landmark); reduced arterial puncture (0% vs 25%) and reduced number of attempts (1.3±0.6: 3.3±2.9) for Internal Jugular cannulation in infants. Cate Grebenik reported higher failure rates for Ultrasound techniques compared to landmark in skilled Cardiothoracic anaesthetists; attributable in part to a lack of training and suggested the NICE guidelines may not apply to children. Other papers support the findings of Verghese.
Why Ultrasound improves success

Conventional central venous line placement has been guided by anatomical landmarks. These are used to construct an approach path which ideally passes through the intended vein. Most published approaches are associated with a high success rate (85% or better), and success improves with the skill of the operator. Nevertheless Ultrasound has demonstrated reasons for failure. A commonly used landmark technique (Bailey PL et al) has been shown to favour more a medial needle direction that would make arterial penetration more likely, whilst Ultrasound can eliminate this risk (Riopelle et al). Methods which involve palpation of the carotid artery will induce a reduction in the cross sectional area of the vein making cannulation more difficult (Mallory et al). The degree of head rotation is important in avoiding carotid artery puncture, since as the head rotates away from the site of puncture, the vein increasingly overlaps the carotid artery. (Sulek CA, et al, Anesthesia & Analgesia 1996 82: 125-128). This has also been reported with increasing age (Troianos et al Anesthesiology 1996;85:43-8).

In addition to variation in vessel position, abnormalities of the vessel itself can also be diagnosed prior to any attempt at cannulation. This is most reported in Haemodialysis patients in whom abnormalities or the vessel are more prevalent and may result in a change of approach. Forauer et al reported an 18% incidence of Jugular occlusion, 11% non-occlusive thrombosis, 5% stenosis and 1% anatomical variation in 79 patients. This resulted in a change of approach to line placement in 26% of patients. Hatfield and Bodenham reported patients with cannulation difficulty in which Ultrasound demonstrated and anatomical factor in 16 (50%). Ultrasound was used successfully in 22 of 22 patients (100%) in this group. A small vein is more difficult to cannulate. Recognition of this enables measures to increase the vein’s cross sectional area. This may be by increased head down tilt, Valsalva manoeuvre, IV fluids or pressure over the liver or abdomen. If these measures are not successful then an alternative cannulation site may be chosen.

The above discussion focussed on the static findings for which Ultrasound confers benefit. Whilst it is possible to use Ultrasound to mark the position of the vein, the benefit of Ultrasound is greatest when used real-time to guide the needle during cannulation. The needle can be guided either using short axis imaging of the needle or long axis needle imaging. Both of these methods require skill and a knowledge of the principles of imaging. A needle inserted perpendicular to the ultrasound beam will be seen as a bright spot with a shadow deep to it, but to image the tip at all times is more difficult. Using a high angle of approach increases the chance of the needle tip being close to the viewed area and is preferred. Following the tip by tissue movement and probe angulation assists in confirming the needle position. Using strategy of trigonometry as outlined by Ban Tsui makes error less likely. He suggests measuring the depth of the target and then making an approach at a 45degree angle from the same distance to the side of the probe. A longitudinal approach is better since the vein and needle can both be seen throughout the cannulation and during passage of the seldinger wire. This can be difficult when the probe may reduce space for the needle such as in infants.

Whilst Ultrasound has been shown to reduce the incidence of carotid artery puncture, this remains a risk. Dilatation and insertion of a large bore cannula into the artery whilst rare (0.0995-0.775%) can be a disaster if not appropriately managed (Shah et al). The colour of withdrawn blood is not reliable in differentiating arterial blood and Ultrasound confirmation of the guidewire in the jugular vein or measurement of pressure should be sought. Ezaru et al have reported a total of 9348 central venous catheters over a 15 year period with no cases of arterial injury. Arterial puncture rate in 2006 was 5% (28 or 511 patients) with blood flow and colour allowing recognition in 24. The remaining 4 patients were recognised by manometry.

ASA Guidelines 2012

Internal Jugular Cannulation.

Anatomy

The Internal Jugular vein enters the neck at the jugular foramen and leaves the neck behind the head of the clavicle. At the jugular foramen it lies posterior to the internal carotid artery (entering the skull at foramen ovale) and as it courses down the neck it lies lateral and then anterior to the carotid artery. At the lower third of the neck it is assumed to be antero-lateral to the artery and this is the level where puncture is usually performed.

You can see in the image on the right that the carotid artery is not the only vessel we need to be aware of the subclavian artery lies above the clavicle and first rib and gives origin to a several other vessels (thyroid, vertebral, dorsal scapular suprascapular arteries). Any of these could be injured when performing IJ cannulation. The dome of the pleura also may ascend above the first rib and pneumothorax is a possibility especially in short necked individuals or where the needle is passed too deep.

The left hand illustration is from Benumof and shows 12 described landmark approaches. Note that the needle passes medial to lateral for those in the mid to upper neck and lateral to medial for the low landmark approach. Ultrasound allows you to explore the neck and look at the size, patency and direction of the vein, and its position relative to arteries and pleura.

Figure 1. Anatomy of veins and arteries in the neck. Note arterial vessels deep to the vein.
1. **Select probe & settings.**
   a. Small footprint Linear (L25) or curvilinear (C11) for long axis imaging
   b. Linear array (L25 or 38 –Sonosite) for short axis
   
   **Exam setting on Vascular or Vein**
   Use highest resolution setting (Res) 8-14Mhz
   Select **Depth** –usually start at 3cm depth. Jugular vein is usually only 1-2cm deep.
   Start with **Autogain.** Adjust **Gain** to provide good image using lowest gain.
   
   **Check Index mark and tap probe to confirm probe orientation.** Alternately using the probe on the skin in short axis will quickly determine orientation, namely by making sure that when you move the probe to the right the image moves to right.

2. **Position US machine**
   By ipsilateral chest. Ideally try to have your eye, needle, probe and monitor in your line of sight.

3. **Position your sterile workspace**
   Your trolley workspace should be on the side of your needle holding hand. This means to your right if right handed and to your left if left-handed. This assists in passing things from trolley to needle without turning round.

4. **Prepare sterile field**
   Chlorhexidine 2% in Alcohol 70% solution. Clean from centre of neck down to include the sternal notch, then below the clavicle then up to Mastoid. Use large area drape.

5. **Place US probe in sterile sheath.**
   You can pre gel probe and drop into the sheath or place sterile gel in sheath first. Stretch sheath over probe ensuring a thin layer of gel covers probe. Get rid of any bubbles which will degrade the US image. Use elastic bands to secure sheath over probe.

   ![Figure 2 Inserting probe into sheath](image)

6. **Position patient**
   Head should be rotated no more than 20 degrees to the opposite side. Place probe at cricoid level holding the probe between thumb and index/middle fingers. Use the ulnar border of your hand as a support on the clavicle so very little pressure is placed on the probe. **Excess probe pressure will collapse the vein.**

7. **Pre – Scan**
   Identify thyroid, carotid artery and jugular vein. The relationship of IJ to carotid artery is variable. This variability may be true or may be due to over-rotation of the head, and/or viewing the jugular with the probe held on the lateral side of the neck, i.e. Operator dependent.
(Note: Keep probe as close to vertical as possible. Head rotation and probe position determine the relative position of vein and artery. Due to the convex shape of the neck it is often difficult to get the probe flat. Rotating the probe to parallel with medial 1/3 of clavicle helps. Try it yourself on a patient.

Figure 3. Probe position will affect relative position of vessels (from Riopelle et al Anesth Analg 2005;100:512-9)

Figure 4. Relative position of vein to artery. From: Maecken T, Grau T Crit Care Med 2007;35(Suppl):S178-85

THEREFORE adjust probe position such that the vein is lateral to the carotid as in the image above. Scan cranially then caudally to assess the course of jugular vein. Find a position where the vein is most lateral to the vein. This is the desired level for puncture and is usually in the mid neck level. Scan down to the clavicle and look for arterial vessels below your intended puncture point and deep to the vein (thryocervical trunk and subclavian artery). Angulate probe back towards the head to scan into the root of the neck and identify the IJ / Subclavian vein junction / IJ valve and proximal SVC as it passes behind the sternum. This technique allows you to follow guidewires or catheters into the SVC.
Colour Flow Doppler may help identify vascular structures. Should you find a suspicious structure near the vein use Colour Doppler to confirm whether there is flow and whether it is arterial or venous. (Note: Angulate probe back and forth to be certain as flow perpendicular to the probe will not provide a Doppler signal.)

Ensure the vein is acceptable. The vein should be a good size, free from haematoma, stricture or scarring from previous line insertions. If the vein is small, place patient head down and check valsalva response if the patient is awake. The vein should increase in size during a Valsalva. In ventilated patients, a breath hold can be used to increase the cross sectional area during puncture of the vein but beware of apex of lung. Pressure on the liver may also expand the J vein

**Veins of less than 5mm are difficult to cannulate. If the vein is scared, small or does not expand with these above maneuvers then please review whether the other side is a better option. It is likely that scar is involving the vein (whether or not you can see it ) and CVL insertion will be more difficult and injury is more likely.**

8. **Position yourself**
Where you stand may have a bearing on the direction your needle takes through the Ultrasound image. Ideally the needle track should pass into the vein and at no stage be in danger of entering the carotid or Subclavian arteries. Starting relatively high (probe at cricoid,) the puncture site should prevent your 6cm needle from reaching the pleura–of course this will not be true in short neck individuals. A lateral to medial track is more likely if you stand to the right of the patient when performing a RIJ puncture – see below.

![RIJ Positioning](image)

**Figure 5. Ideal position for operator dependent on handedness**

9. **Select Puncture site**
To eliminate risk of arterial puncture (carotid, subclavian, vertebral arteries) and other structures e.g pleura. You should now know where these structures are.

10. **Needle passage and Probe movement to track needle tip.**
The supplied 18g needle or 20g needle with cannula. There is much to commend using the latter as you will need to remove the needle to insert the guidewire thus eliminating the problems associated with the Raulerson syringe. (no pulsatility or colour features of arterial blood)

**Centre the vein in the monitor screen.** Armed with your 3D knowledge of the patient’s anatomy you can direct the needle into the vein. You can read off the depth of the anterior vein wall from the depth scale on right side of the monitor. If your needle enters the skin at that distance from the probe and your needle is angled at 45 degrees it should enter the vein (and become visible just as it passes below the probe. The anterior vein wall will be depressed by the advancing needle.
Figure 6. SAX view of needle depressing anterior vein wall. Needle tip position is not confirmed. Note below the needle is a shadow. This is always vertical since that is the direction of the sound waves. It does NOT indicate the direction of the needle.

TIPS: a) If the probe is imaging from the lateral side of the neck enter skin towards the medial side of the probe and keep the needle vertical. The needle will then be moving from top left to bottom right of your image for a RIJ puncture.
   Follow the tip. (See figure on Page 3)

   b) Rotate the probe so it lies perpendicular to a line joining needle entry point and the ipsilateral nipple and pass the needle in this direction. This reduces the risk of passing the needle medially.

A common error is to continue passing the needle without moving the probe, expecting to see the needle appear inside the vein. This will only happen if you move the probe to follow the tip or you use long axis in-plane needle imaging. Failure to do this is one cause of inadvertent arterial puncture. In one study the posterior vein wall was penetrated in 64% of cannulations. So as you advance the needle angle the probe backwards and forwards following the tip of the needle. Aspirate to confirm intravenous placement. IF using the supplied 20g cannula advance this into the vein. This is probably safer than the 19g needle in the Arrow kit.

10. Confirm you are in the vein
    i. By Ultrasound confirm needle tip position
    ii. Disconnect syringe and check flow is not arterial. Measure pressure with transduction probe if any uncertainty.
    iii. The Raulerson syringe enables the wire to be passed into the vein through the syringe barrel, but does not allow you to see arterial pressure. The green transduction probe enables you to connect to your monitoring to check intravascular pressure.

IF YOU ARE IN AN ARTERY  See: MANAGEMENT OF ARTERIAL PUNCTURE

11. Pass Guidewire
    The guidewire should pass easily into the vein. The J tip should point medially to reduce the risk of subclavian placement. A blue mark on the wire denotes how much wire to pass into the vein. Insert the wire 15 cm. Arrhythmia indicates you are in the heart and thus risk perforation of a heart chamber or rarely a serious arrhythmia like VF, so if you get this pull the wire back till the rhythm normalizes.

    IT IS NOT THE DESIRED END-POINT. If there is any difficulty in passing the wire STOP.
12. **Check** guidewire position. Perform scan and follow wire in its course in the neck ensuring the posterior vein wall is not punctured and the wire is entering the SVC at the root of the neck. *Published data suggests that if you do not follow the wire down the IJ vein with US for some distance (to make sure it has not gone out the back wall of the vein and into an artery), or if you do not transduce the catheter or needle (and get a good CVP waveform) that you will miss 20% of all arterial punctures.*

13. **Dilate** the tract to the vein – You only need to pass 5-6cm of dilator

14. **Pass the catheter** into the vein

15. **Suture** in place and check patency of all lumens with saline.

**Complications:**

- **Malposition** 2% - Distance to RA 16.4cm mean. Lines placed at 13cm unlikely to be within the pericardial reflection. See: Bodenham. A BJA 2013 March
- **Arterial puncture** 0.5% (May lead to CVA, AV fistula, Airway obstruction)
- **Pneumothorax** 0.1% (Significant PTX is detectable by Ultrasound intra-operatively)
- **Cardiac tamponade**
- **Vessel perforation** – increased risk with stiff large bore and multilumen catheters. Lines placed from left side must lie vertically in SVC or be withdrawn back to L brachiocephalic v
- **Catheter related infection.**

**POINTS TO REMEMBER**

a. Ensure you pass needle in the direction of ipsilateral nipple. Inexperienced users often position themselves in such a way as to pass the needle in a direction through the vein and towards the artery. This is especially likely when using SAX imaging.

b. In SAX you see tissue movement. A bright spot DOES NOT mean needle tip, it merely signifies some part of the needle is cutting the US beam. Try to image needle tip by probe angulation. Make small jabs with needle, and confirm position with each. This is best learned in a tissue phantom.

c. In one study 64% of operators penetrated the posterior vein wall in the SAX method because they did not follow the needle tip.

d. Remember the image is a thin 2d slice through the neck. A pre-scan should always be performed to truly appreciate the anatomy. Identify thyroid, lymph nodes, muscles, vagus nerve (between posterior wall of vein and carotid artery) etc. Use each opportunity to learn Sonoanatomy to improve your technique and understanding.
Long Axis Cannulation of the Jugular Vein

Using this approach you can observe the needle as it passes into the vein. Needle visibility is best at insertion angles less than 45 degrees to skin. Smaller necks do not allow large probes so use the L25 or C11 probes.

Using similar principles to the description above, once you have performed your scan of the neck rotate the probe (takes practice) keeping the vein in view. Having done this angulate the probe medially to confirm the artery and then angulate back onto vein. Note difference in the wall characteristics of the two. Once you have confirmed the target vein do not look away. If you do your probe can move and you may then target the wrong vessel.

**IMPORTANT;**
The attractiveness of this technique is totally negated if you fail to focus on the vessel you are cannulating. ALWAYS ensure you can recognize the vein (thin walled, a, c and v wave pulsation, and position with respect to the artery. Change of calibre with probe pressure does not confer certainty that the vessel is a vein since the artery may roll from under the probe giving the appearance of compression.

Figure 7. Long axis cannulation. Image on right shows guidewire in the vein. Scan caudally to check posterior wall has not been penetrated.
Axillary Vein Cannulation

Anatomy

Figure 8. Axillary artery and vein (From Grant’s Anatomy)

The axillary vein arises at the confluence of basilic and brachial veins in the axilla and runs deep to the pectoral muscles to the first rib where it becomes the subclavian vein. During this passage it becomes progressively more superficial and in closer proximity to the axillary artery. The brachial plexus lies superiorly medially and sub pectorally becomes closely associated with the axillary artery. The medial cord may lie between artery and vein at the level of the coracoid. Long axis US cannulation should have the point of entry into the vein medial this and thus nerve injury should not occur.

Technique:

This vessel is normally 3-4cm deep and should only be performed by competent ultrasound users.

Figure 9. Position of probe in delto-pectoral groove and Colour Doppler or vein
1. Select probe & settings  
   a. Small footprint curvilinear (C11 – Sonosite) or  
   b. Linear array (L38 – Sonosite)  

Use Mid resolution setting 7-14Mhz (GEN)  
Select Depth – usually start at 5 cm depth  

2. Position US by contralateral shoulder  


4. Confirm probe orientation by tapping one side of scanner head  

5. Identify the deltopectoral groove below the coracoid process.  
   a. SAX  Scan across the vessel in SAX and identify axillary artery superiorly and vein inferiorly. The artery is pulsatile and thick walled, the vein is thin walled and varies with breathing. Valsalva and head down position or IV fluid load can improve visualization. (Sharma et al. *British Journal of Anaesthesia* 2004;93:188-92)  
   
   b. LAX  Place probe in deltopectoral groove perpendicular to skin. Angulate probe slowly cranially/caudally to find vessels. Confirm artery superior and vein inferiorly. The vein is deeper laterally as it traverses the axilla. Identify Pleura medial and deep. (Sandhu et al *Anesth Analg* 2004;99:183-7)  

6. Select site of puncture to minimize risk to artery and brachial plexus  

7. Perform puncture of vein advancing the needle SLOWLY and imaging the needle tip at all times – For SAX imaging use an angle of 60-80 degrees, for LAX a needle angle of 45 degrees is best. Often needs a short stabbing motion to puncture vein wall  

8. Confirm puncture by aspiration and presence of needle in vein. Pass Seldinger wire with J tip pointing towards the heart.  

9. Complete cannulation as usual.  

10. Check line placement by scanning lower neck to confirm catheter is not in IJV and passes into chest.  

**TIP:** Asking the patient to turn their head to the side of the cannulation to shut off the IJV orifice decreases the incidence of going up the IJV.  

*Figure 10. Needle approaching Axillary vein through Pectoral muscles. Pleura not visible.*
Femoral Vein cannulation.

Anatomy

The classical teaching is that the femoral vein lies medial to the femoral artery in the groin. (Mnemonic NAVVAN from one side to other of body nerve, artery, vein, vein, artery, nerve) This is true at the level of the inguinal ligament but 2-4cm below the inguinal ligament the femoral artery overlaps the femoral vein. In addition the profunda femoris artery lies directly behind the femoral vein. Before embarking on the puncture interrogate the area to build up a 3D picture in your mind of the structures. Scan cranially to find the common femoral vein and artery.

Study the figure below and note the femoral vessels undergo a rotation as they pass distally, the long saphenous entering medially 1 cm below the inguinal ligament and the profunda femoris not seen in the anatomical image but shown on US.

Figure 11. Femoral triangle. Note artery crosses vein as it passes distally.
Technique

1. Select probe & settings
   a. Small footprint curvilinear (C11 - Sonosite) for long axis imaging
   b. Linear array (L38 –Sonosite) for short axis
   Use highest resolution setting (Res) 7-14MHz
   Select Depth - usually start at 5 cm depth
2. Setup US by contralateral ASIS
4. Confirm probe orientation by tapping one side of scanner head
5. Position patient
   The cross sectional area of the vein and the incidence of arterial overlap are decreased if the leg is externally rotated and flexed
   a. SAX  Scan across the vessel just below the inguinal ligament and identify Femoral artery and vein. As scanner moves distally, femoral artery divides and superficial femoral artery overlies the vein. Long saphenous vein enters the femoral vein. Best site for cannulation is at the inguinal ligament superior to the entry of the long saphenous vein. Cath lab use the skin crease as the cannulation entry point.
   b. LAX  Identify Femoral artery and vein in SAX then rotate probe to long axis and observe femoral vein enter pelvis under inguinal ligament. The vein dives down at this point and a needle angle of 45-60 degrees is required.

Figure 61. Images from inguinal ligament (left) and 3cm distal (right)

Figure 12. Long axis of needle entering common femoral vein
7. Confirm vessel to be punctured is vein. It should be non-pulsatile, compressible and thin walled. (Usually 2D imaging suffices. Colour phase Doppler imaging may be helpful to identify pulsatility of artery. Remember colour denotes DIRECTION of FLOW with respect to probe – Blue Away Red Towards (BART).

8. Perform puncture of vein. Image needle tip at all times – For SAX imaging use an angle of 60-80 degrees, for LAX a needle angle of 45-60 degrees is best. Often needs a short stabbing motion to puncture vein wall.


10. Pass dilator and complete cannulation as usual.
Brachial Vein Cannulation

e.g. For placement of PICC's or large bore volume lines when veins invisible.

1. Select probe & settings
   c. Small footprint curvilinear (C11 – Sonosite) for long axis imaging
   d. Linear array (L38 – Sonosite) for short axis

   Use highest resolution setting 7-14Mhz
   Select Depth – usually start at 2-2.5 cm depth


4. Confirm probe orientation by tapping one side of scanner head

5. Basilic vein
   SAX - Scan across Ante-cubital fossa medially. Identify Brachial artery, Median cubital vein and superficially and more medially the Basilic vein. This vein has no adjoining arterial and nervous structures and is usually of reasonable size (5-7mm). Follow vein up and down arm to confirm direction. Insert 20g cannula into vessel aspirating with 5ml syringe to confirm placement. Use shallow angle appropriate to the depth of vein and distance of skin penetration from probe. Pass seldinger wire into vein then continue with dilatation and cannulation.

6. Brachial vein
   i. SAX - The brachial vein is found in the groove between biceps and triceps on the medial side of the arm. The Brachial artery is adjacent to it, and also the median and ulnar nerves. I use this vein only if I cannot find a suitable basilic vein as described above. Use 20g cannula at 45 degree angle attached to 5ml syringe aspirating during needle advancement until blood is aspirated.

   ii. LAX – Palpate the biceps/triceps groove and identify brachial vessels, and nerves in short axis then rotate probe to long axis and confirm vein by lack of pulsatility, response to pressure and change in size with valsalva or tourniquet release. Insert needle and cannula in line with probe and into vein
MANAGEMENT OF ARTERIAL INJURY

Small bore needles 20-22g are not usually associated with complications after arterial puncture. Should you be unfortunate enough to dilate and place a large bore (>7Fr) line into a major artery follow this pathway (Guilbert et al. J. Vasc Surg 2008;48:91)

Call Vascular Surgery
Heparin ??

MANAGEMENT OF CATHETER-RELATED CERVICOThoracic ARTERIAL TRAUMA

ONCE SUSPECTED
- Leave catheter in place if large caliber (≥ 7 French)
- Obtain Vascular Surgery consultation
- Postpone any elective surgery

Catheter still in place?

YES

SITE OF SUSPECTED ARTERIAL INJURY SURGICALLY EASILY ACCESSIBLE?

YES
- Open exploration if large-caliber catheter
- Direct arterial repair
- Intraoperative duplex
- Prompt neurological evaluation

NO
- Consider immediate imaging
- If site of arterial injury difficult to expose, consider percutaneous treatment with covered stent or percutaneous closure device
- Prompt neurological evaluation

NO

Consider immediate imaging to evaluate the arterial injury
Prompt neurological evaluation
Serial clinical follow-up for airway and neurologic changes and control of hypertension