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COLLEGE OF ANAESTHESIOLOGISTS
ACADEMY OF MEDICINE OF MALAYSIA

MALAYSIAN SOCIETY OF
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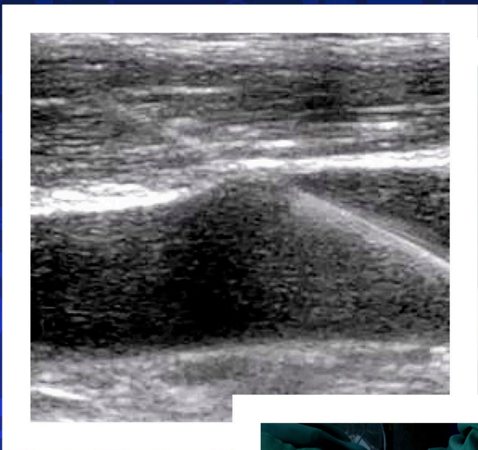
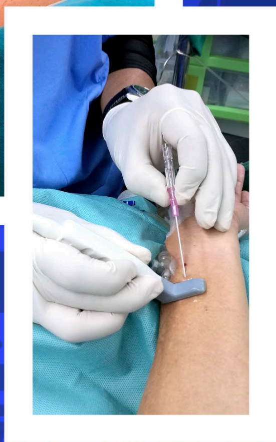
RECOMMENDATIONS FOR ULTRASOUND GUIDED VASCULAR ACCESS





RECOMMENDATIONS FOR ULTRASOUND GUIDED VASCULAR ACCESS (2022)

Ultrasound Special Interest Group
College of Anaesthesiologists
Academy of Medicine of Malaysia

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FOREWORD

Point-of-care ultrasonography is now increasingly available to guide vascular access procedures. Correctly used, ultrasound guidance for vascular access has been shown to improve success rates while reducing iatrogenic injury. Moreover, it may improve patient comfort and satisfaction. Based on evidence and the expert consensus opinion, ultrasound should be used whenever feasible in higher-risk procedures such as internal jugular central venous access and for all elective jugular vein dialysis catheter placements.

I would like to extend my heartiest congratulations to the Ultrasound Special Interest Group (SIG), College of Anaesthesiologists, Academy of Medicine Malaysia, lead by Dr Hasmizy Muhammad, for developing this document on "Recommendations for Ultrasound Guided Vascular Access (2022)". The Ultrasound SIG group has been very active in conducting workshops and webinars on the use of ultrasound in anaesthesiology. This recommendation is one of their efforts in ensuring that the ultrasound-guided vascular access procedures will be appropriately used by professionals and ultimately, will improve the care of our patients.

The contents of this recommendation include not only the theoretical and practical aspects of conducting the procedures but also recommendations on training and competency. This recommendation is published by the College of Anaesthesiologists (CoA) in collaboration with the Malaysian Society of Anaesthesiologists (MSA). It is surely, will be a useful addition to the CoA and MSA recommendations and guidelines developed on various anaesthesiology related safety and quality assurance matters.

Professor Marzida Mansor
President
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Academy of Medicine of Malaysia

FOREWORD

Vascular access, either venous or arterial, is an important aspect of perioperative patient care. Vascular access using landmark techniques can be technically challenging. Point-of-care ultrasound is now increasingly available throughout the country. Ultrasound guidance for vascular access procedures has been proven to improve the success rate of cannulation and reduce the complication rates.

Internal jugular vein catheterization with ultrasound guidance is becoming a standard practice in many hospitals. Nevertheless, some hospitals have not yet embraced this practice. For various reasons, the use of ultrasound as guidance for other vascular access is still low.

Ultrasound guidance improves the quality and safety of vascular access procedures. It should be used routinely, and not only in difficult or complicated cases. Training is necessary for the operators to acquire the competency to perform ultrasound guided vascular access procedures independently.

This recommendation has been developed not only for the Anaesthesiology and Critical Care fraternity but also for the other specialties that perform vascular access, and it is intended to be concise and evidence-based whenever possible.

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SECTION 1: INTRODUCTION

1.1 Ultrasound guidance in internal jugular vein cannulation has been proven to reduce complications and improve success rate compared to the landmark technique.[1]

1.2 For subclavian and femoral vein cannulations, ultrasound guidance reduces complication rates.[2, 3]

1.3 For peripheral intravenous cannulation, ultrasound guidance increases the success rate, particularly with known or predicted difficulty.[4]

1.4 For radial artery cannulation, ultrasound guidance significantly increases the first-attempt success rate.[5]

1.5 This is a recommendation for adult ultrasound guided vascular access

SECTION 2: PRINCIPLES OF ULTRASOUND FOR VASCULAR ACCESS

2.1 General considerations

2.1.1 Prior procedures, the patient's anatomic variations, coagulopathy and risk of potential complications should be considered.

2.1.2 Written or informed consent should be obtained for vascular access as per institutional protocol.

2.2 Transducer/Probe selection

2.2.1 Ultrasound probes used for vascular access vary in size and shape.

2.2.2 High frequency probes are preferred because it provides better resolution of the superficial structures including arteries and veins.

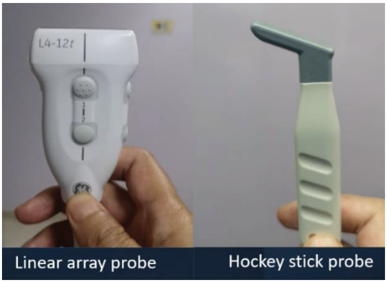


Figure 1: Various types of ultrasound probes for vascular access.

2.3 Modes

2.3.1 Ultrasound modalities for imaging vascular structures and surrounding anatomy are two-dimensional (2D) ultrasound, colour flow Doppler and spectral Pulsed Wave (PW) Doppler.

2.3.2 Two-dimensional (2D) ultrasound short axis (SAX) or long axis (LAX) views of the target vessel will provide information on the appropriate entrance angle and depth for needle cannulation.

2.3.3 The colour flow and spectral PW Doppler are used to confirm the presence and direction of blood flow.

2.3.4 Three-dimensional (3D) ultrasound provides real-time SAX and LAX views allowing simultaneous views of anatomy in three orthogonal planes.

Two-dimensional (2D) ultrasound | Colour Flow Doppler | Spectral Pulsed Wave Doppler

Figure 2: Ultrasound modalities for assessing vascular structures.

2.4 Optimizing image quality

2.4.1 Gain

2.4.1.1 The quality of images displayed on a monitor depends on the selected gain.

2.4.1.2 Increasing the gain makes the image brighter, while decreasing the gain makes the image darker.

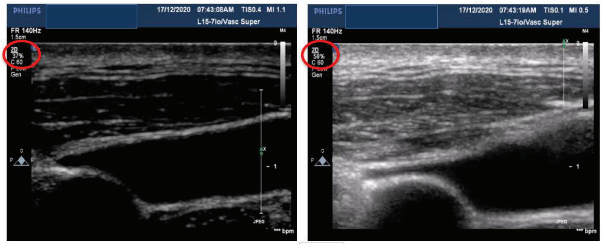


Figure 3: Images of the Right Internal Jugular Vein in SAX view at two different gains.

2.4.2 Depth

2.4.2.1 Correct depth adjustment allows for better target vascular imaging and easier needle tracking through the tissues.

2.4.2.2 As the depth is increased, the target vessel appears smaller.

2.4.2.3 As the depth is decreased, parts of the target vessel and/or surrounding structures may not be visualised.

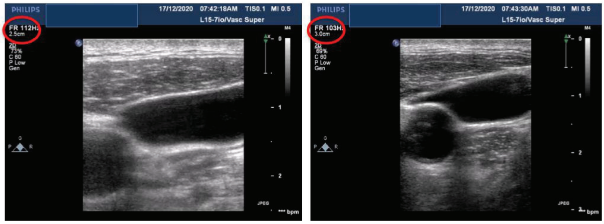
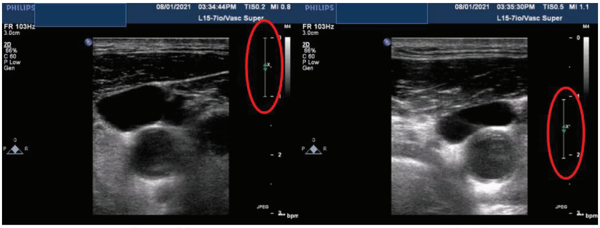


Figure 4: Different depths of the Right Internal Jugular Vein SAX view.

2.4.3 Focus

2.4.3.1 It is important to position the 'focus' at the level of the target vessel of interest as the focal zone has the maximum resolution.



Target vessel out of focus zone   Target vessel in focus zone

Figure 5: Right Internal Jugular Vein SAX view with and without focus.

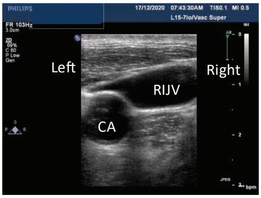
2.5 Image orientation

2.5.1 Most ultrasound probes have an indicator on one of their sides which corresponds to a mark displayed on the screen.

2.5.2 As the orientation mark is usually displayed on the left side of the image, keeping the indicator toward the left side of the provider will prevent confusion on the orientation.

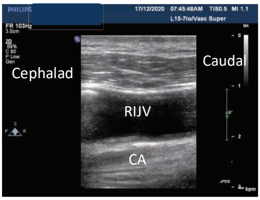
2.5.3 It is advisable to orientate the probe in reference to the patient so that the image displayed is correctly aligned with the physical procedural field.

Hockey stick probe



Short axis view


High frequency linear probe



Long axis view

Figure 6: The ultrasound probe indicator and how it corresponds on the screen in SAX and LAX views.

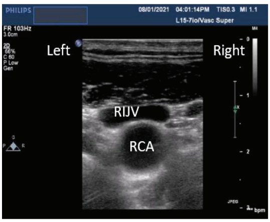
2.6 Planes and views

2.6.1 Vascular structures can be imaged in SAX, LAX, or oblique views.

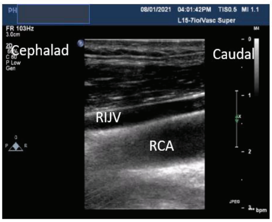
2.6.2 The SAX view provides visualization of the target vessels and surrounding structures in the cross-sectional/transverse orientation.

2.6.3 The LAX view allows visualization of the target vessels and surrounding structures in the longitudinal orientation.

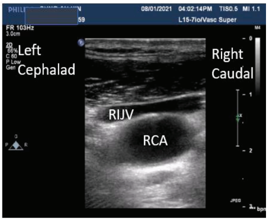
2.6.4 An oblique view demonstrates hybrid visualization halfway between the cross-sectional and longitudinal orientation.



Short axis view



Long axis view



Oblique axis view

Figure 7: Different planes to visualize the vascular structures.

2.7 Differentiating artery and vein

2.7.1 Two-dimensional images

2.7.1.1 Two-dimensional imaging provides vascular morphologic and anatomic characteristics to distinguish between vein and artery.

2.7.1.2 The vein is larger in size with an elliptical shape and more collapsible with modest external surface pressure.

2.7.1.3 The artery has a smaller diameter, a rounder shape and a thicker wall.

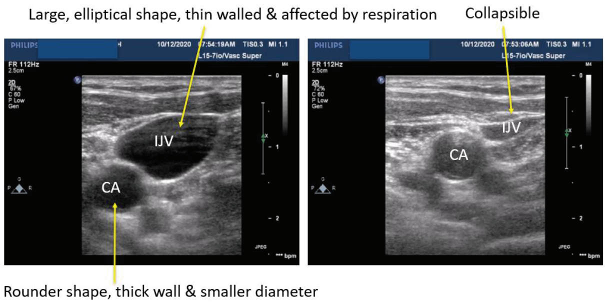


Figure 8: Two-dimensional images of the Right Internal Jugular Vein and Carotid Artery.

2.7.2 Colour flow Doppler

2.7.2.1 Arterial blood flow is pulsatile in either the SAX or LAX view.

2.7.2.2 Venous blood flow is uniform in colour and is present during systole and diastole.

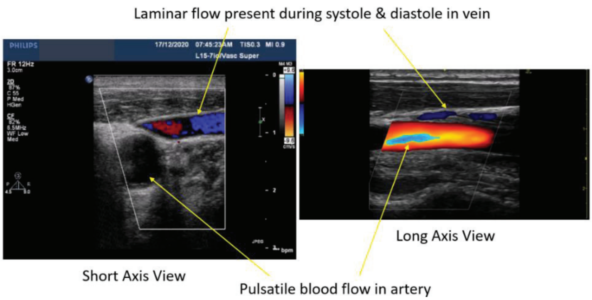
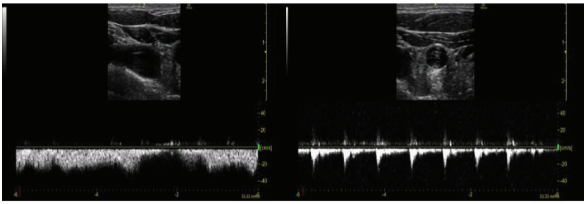


Figure 9: Colour flow Doppler of the Right Internal Jugular Vein and Carotid Artery.

2.7.3 Spectral Doppler

2.7.3.1 PW Doppler reveals a distinctive systolic flow in the artery, and biphasic systolic and diastolic flow with lower velocity in the vein.



PW at Internal Jugular Vein - systolic and diastolic components and lower velocity

PW at Carotid Artery - systolic component and higher velocity

Figure 10: PW Doppler at the Internal Jugular Vein and Carotid Artery.

2.8 Scanning and cannulation techniques

2.8.1 Static Imaging

2.8.1.1 In the static imaging technique, the operator would apply ultrasound to localize the vein and mark the needle insertion site on the skin.

2.8.1.2 Cannulation will be performed similar to the traditional landmark-based approach.

Figure 11. Static imaging technique of Right Internal Jugular Vein cannulation.

2.8.2 Dynamic Imaging

2.8.2.1 Dynamic ultrasound imaging (real-time) under sterile conditions is the most effective ultrasound-guided for vascular access. [6]

2.8.2.2 The needle can be directed toward the target vessel and advanced to the proper depth.

Figure 12. Dynamic imaging technique of Right Internal Jugular Vein cannulation.

2.8.3 Out-of-Plane (OOP) vs. In-Plane Approach (IP)

2.8.3.1 Needle insertion can be performed in either an out-of-plane or in-plane approach.

2.8.3.2 In the Out-of-plane (OOP) approach:

2.8.3.2.1 The needle is placed at a 90^{o} orientation to the probe and inserted at the centre of the probe.

2.8.3.2.2 As the needle is advanced, the needle path follows below the probe and transects the ultrasound beam at only one point.

2.8.3.2.3 **ONE point of the needle** can be seen on the screen as a white dot.

2.8.3.3 In the In-plane (IP) approach:

2.8.3.3.1 The needle is placed in the same orientation as the probe and inserted next to one of its ends.

2.8.3.3.2 The needle path follows below the probe and transects the whole length of the ultrasound beam.

2.8.3.3.3 **Total length of the needle shaft and tip** can be visualized.

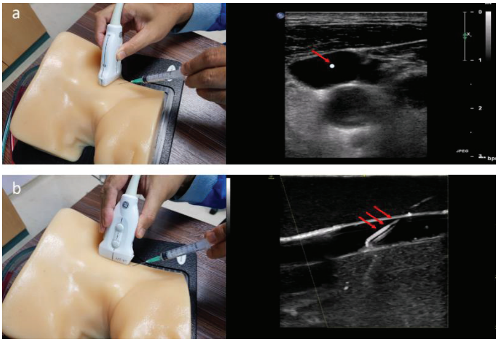


Figure 13. Needle insertion: a) Out-of-Plane approach with one point of the needle seen (red arrow) and b) In-Plane approach with the needle shaft and tip seen (red arrow).

SECTION 3: INFECTION PREVENTION AND CONTROL

3.1 Infection

3.1.1 Ultrasound-guided vascular access should be performed using strict aseptic techniques in accordance with the College guidelines.[7]

3.1.2 For the insertion of a central venous line, 2% chlorhexidine in 70% alcohol is recommended.[7]

3.1.3 The placement of sterile protective covers on the ultrasound probe while performing ultrasound-guided vascular access is essential for infection control. Any acoustic coupling medium should be sterile.

3.1.4 For central catheter technique, sterile barrier precautions (i.e., mask, gown, and drape) should be adopted.

3.2 Preparing a sterile ultrasound probe

3.2.1 Clean the skin surface of the cannulation site thoroughly with an antiseptic solution.

3.2.2 Drape the cannulation site.

3.2.3 Open the probe cover packet.

3.2.4 Place the sterile gel into the sterile sheath.

3.2.5 Put the ultrasound probe inside the sheath and displace any air bubbles between the probe face and the probe cover.

3.2.6 Extend the sterile sheath to cover the probe cable.

3.2.7 Apply the sterile gel over the cannulation site.

3.2.8 Place the covered ultrasound probe over the cannulation site.

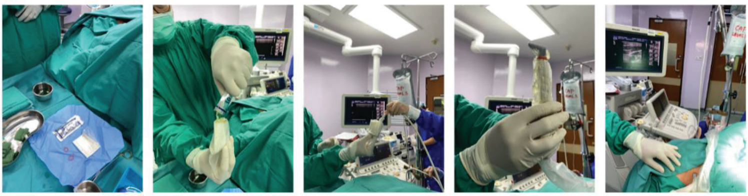


Figure 14: The procedures for sterilising an ultrasound probe and preparing it for dynamic imaging.

SECTION 4: ERGONOMICS

4.1 The operator should maintain a neutral posture to prevent work-related musculoskeletal disorders.

4.2 Neutral posture is a position in which the natural curvatures of the spine are supported, and the body is in proper alignment, reducing stress on the musculoskeletal system.

4.3 During cannulation, the ultrasound machine should be placed in the operator's line of sight, providing the operator with a clear view of the puncture site, needle, and screen with minimal positional adjustment.

Figure 15: The operator in a neutral position has a clear view of the puncture site and the ultrasound screen.

SECTION 5: PRINCIPLE AND CONDUCT OF ULTRASOUND GUIDED CANNULATION

The general conduct of vessel cannulation and catheterization follows conventional landmark techniques except:

5.1 Pre-procedural scan

5.1.1 A pre-procedural ultrasound scan must be done to assess the course, calibre, and patency of the vessel of interest, the presence of thrombus, and determine its relationship to surrounding structures.

5.2 Dynamic needle tip tracking techniques

5.2.1 Slide (probe)-and-(needle) follow technique.

5.2.1.1 Centre the ultrasound probe at the largest anterior-posterior diameter of the target vessel of interest in SAX view.

5.2.1.2 Insert the needle in OOP orientation at a distance slightly longer than vessel depth at an angle of 30-45^{o}.

5.2.1.2 Advance the needle until the needle tip is seen as a 'white dot' and stop.

5.2.1.3 Slide the probe away until the needle tip ('white dot') disappears.

5.2.1.4 Advance the needle until the tip is seen again and stop.

5.2.1.5 Repeat alternating probe alignment and needle advancement while tracking the needle tip until the anterior vessel wall is punctured (seen as a 'Bulls-eye sign').

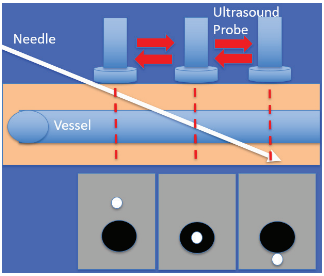


Figure 16: Slide (Probe)-and-(Needle) follow technique.

5.2.2 Tilt (probe)-and-(needle) follow technique.

5.2.2.1 Centre the ultrasound probe at the largest anterior-posterior diameter of the target vessel of interest in SAX view.

5.2.2.2 Insert the needle in OOP orientation at a distance slightly longer than vessel depth at an angle of 30-45^{0}.

5.2.2.3 From the point of scan, tilt probe towards the needle until the needle tip is seen ('white dot').

5.2.2.4 Tilt the probe away from the needle until the needle tip ('white dot') disappears.

5.2.2.5 Advance the needle until the tip is seen again and stop.

5.2.2.6 Repeat "Tilt and follow": alternating probe tilt-away and needle advancement while tracking the needle tip, until the anterior vessel wall is punctured.

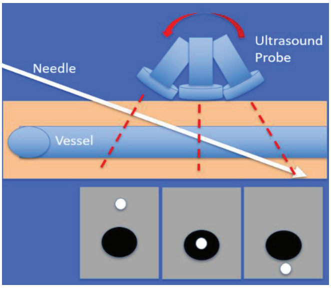


Figure 17: Tilt (Probe)-and-(Needle) follow technique.

5.3 Confirmation of successful cannula placement is indicated by:

5.3.1 Real-time visualization of cannula in the lumen of a target vessel.

5.3.2 Presence of blood in the flash-back chamber or syringe.

5.3.3 Turbulence is observed within the vessel when a saline flush test is performed.

SECTION 6: PRINCIPLES OF ULTRASOUND GUIDED CATHETER INSERTION

6.1 Use real-time ultrasound guidance for puncture of the vessel.
6.2 Confirm the needle/cannula position in the vessel.

6.1 and 6.2 follow the principles as described in section 5.

6.3 Subsequent steps will be done according to the Seldinger technique.
6.4 Ultrasound is used to confirm the intraluminal placement of guidewire prior to tissue dilatation (if required).
6.5 Ultrasound is used to confirm the intraluminal placement of catheter.
6.6 All the above confirmations are performed in both SAX and LAX views

SECTION 7: SITE SPECIFIC CONSIDERATIONS FOR ULTRASOUND GUIDED VASCULAR ACCESS

7.1 Internal Jugular Vein

7.1.1 Anatomy and ultrasound technique:

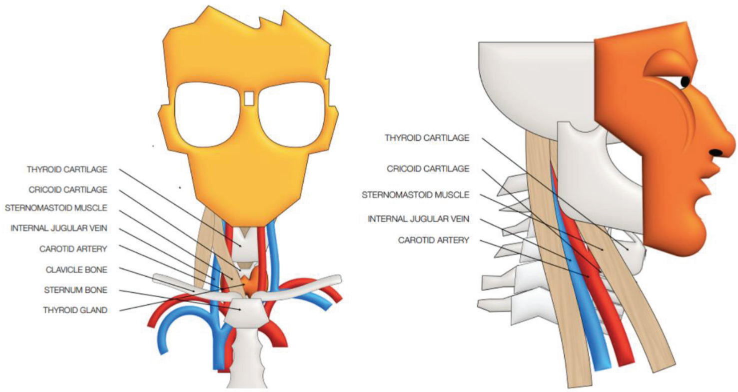


Figure 18: Anatomy of the Internal Jugular Vein

7.1.1.1 The Internal Jugular Vein lies lateral and anterior to the Internal and Common Carotid Arteries.

7.1.1.2 It combines with the Subclavian Vein to form the Brachiocephalic or Innominate Vein at the junction of the neck and thorax.

7.1.1.3 Right Internal Jugular Vein is more favourable than the Left Internal Jugular Vein because of its larger diameter and straighter path to Superior Vena Cava.

7.1.1.4 The patient's head should be kept in midline or rotated not more than 30° contralateral to minimize overlap of the Internal Jugular Vein and Common Carotid Artery.

7.1.1.5 The calibre of the Internal Jugular Vein can be further augmented by putting the patient in a Trendelenburg position and/or asking the awake patient to perform Valsalva or applying Positive End Expiratory Pressure in a mechanically ventilated patient.

7.1.2 Catheter insertion:

7.1.2.1 Conduct of the Internal Jugular Vein cannulation follows the principle of cannulation technique as described in section 5.

7.1.2.2 Conduct of the Internal Jugular Vein catheterization follows the principle of ultrasound guided catheter insertion technique as described in section 6.

Figure 19: Ultrasound of the Internal Jugular Vein; a) guidewire in SAX view, b) guidewire in LAX view and c) catheter in LAX view (red arrow).

7.2 Subclavian Vein

7.2.1 Anatomy and ultrasound technique:

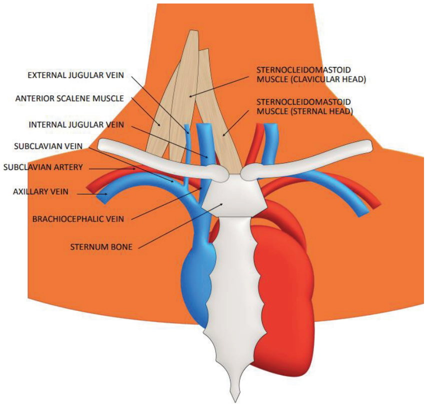


Figure 20: Anatomy of the Subclavian Vein

7.2.1.1 The Subclavian Vein is a continuation of the Axillary Vein that crosses over the first rib and passes in front of the Anterior Scalene muscle.

7.2.1.2 It is deeply located and partially hidden under the clavicle bone.

7.2.1.3 Subclavian Vein can be accessed through either supraclavicular or infraclavicular approach.

7.2.1.4 An ultrasound probe should be placed in the middle part of the clavicle.

7.2.1.5 Both the Subclavian Vein and Subclavian Artery should be identified in the SAX view.

7.2.1.6 In the supraclavicular approach, the thin muscular layer of the platysma and the Subclavian Vein are seen anterior to the Subclavian Artery.

7.2.1.7 In the infraclavicular approach, the pleura is seen as a mobile echogenic line.

7.2.2 Catheter insertion*:*

7.2.2.1 Conduct of the Subclavian Vein cannulation follows the principle of cannulation technique as described in section 5.

7.2.2.2 Conduct of the Subclavian Vein catheterization follows the principle of ultrasound guided catheter insertion technique as described in section 6.

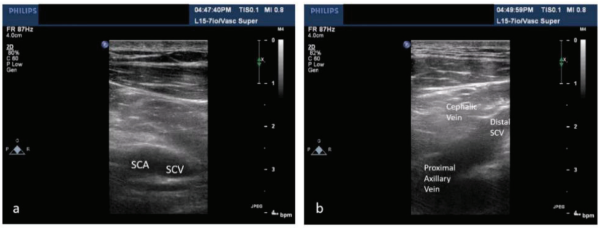


Figure 21: Ultrasound of the Subclavian Vein in the infraclavicular approach: a) SAX view and b) LAX view.

7.3 Femoral Vein

7.3.1 Anatomy and ultrasound technique:

7.3.1.1 The Femoral Vein is the continuation of the Popliteal Vein, after the latter has passed through the adductor hiatus at the medial aspect of the thigh.

7.3.1.2 Femoral Vein cannulation typically refers to cannulation of the Common Femoral Vein, but some may advocate cannulation of the (superficial) Femoral Vein at mid-thigh.

7.3.1.3 The target of the cannulation, the Common Femoral Vein, lies medial to the Common Femoral Artery within the femoral triangle, and distal to the inguinal ligament.

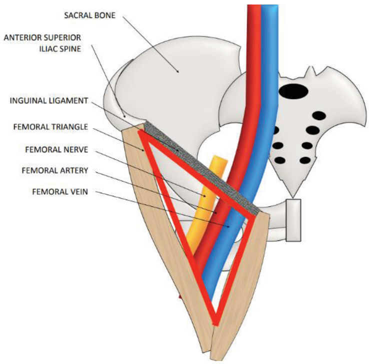


Figure 22: Anatomy of the Femoral Vein and Artery

7.3.1.4 The patient is placed in a frog-leg position, by abducting and externally rotating the hip with knee flexion to augment the size of the Common Femoral Vein for optimum cannulation.

7.3.1.5 The calibre of Common Femoral Vein can be further augmented by putting the patient in a reverse Trendelenburg position.

7.3.1.6 Place the ultrasound probe transversely just distal to the inguinal ligament and the typical “one-vein-one-artery” can be seen.

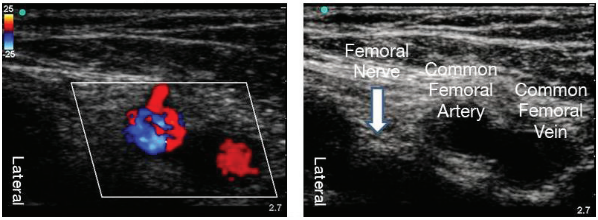


Figure 23: Ultrasound of the Common Femoral Vein at the SAX view.

7.3.1.7 If the probe is placed slightly distal, a typical “Mickey Mouse sign” will be seen, which consists of the Common Femoral Artery, Great Saphenous Vein, and Common Femoral Vein (“Upright Mickey Mouse sign”).

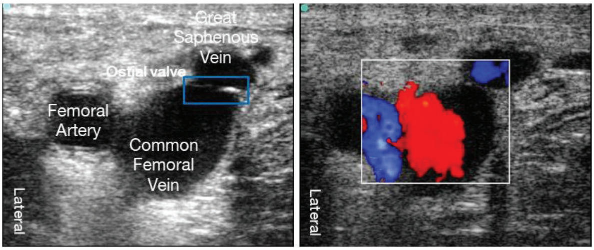


Figure 24: Ultrasound of the Common Femoral Vein reveals an "Upright Mickey Mouse sign."

7.3.1.8 If the probe is placed too distal, branching of the Common Femoral Artery into superficial and deep Femoral Artery will be observed (“Lying Mickey Mouse sign”)

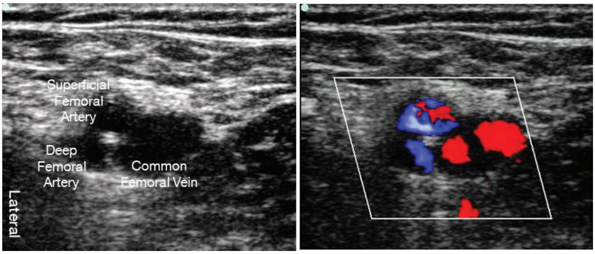


Figure 25: Ultrasound of the Common Femoral Vein reveals a "Lying Mickey Mouse sign".

7.3.2 Catheter insertion:

7.3.2.1 Ideally, the ultrasound probe is placed to look for the "one-vein-one-artery" sign.

7.3.2.2 Catheterization can be done in either a short or long-axis approach.

7.3.2.3 Short axis approach:

7.3.2.3.1 This is the common approach adopted for central venous cannulation.

7.3.2.3.2 After the "one-vein-one-artery" sign is obtained, the position of the probe is optimized.

7.3.2.3.3 Conduct of the Common Femoral Vein cannulation follows the principle of cannulation technique as described in section 5.

7.3.2.3.4 Conduct of the Common Femoral Vein catheterization follows the principle of ultrasound guided catheter insertion technique as described in section 6.

7.3.2.4 Long axis approach:

7.3.2.4.1 After obtaining the "one-vein-one-artery" sign, the ultrasound probe is rotated 90^{o} to position the Common Femoral Vein on the screen in a longitudinal axis.

7.3.2.4.2 Extreme precautions must be taken to ensure that the Common Femoral Vein is targeted and not the Common Femoral Artery.

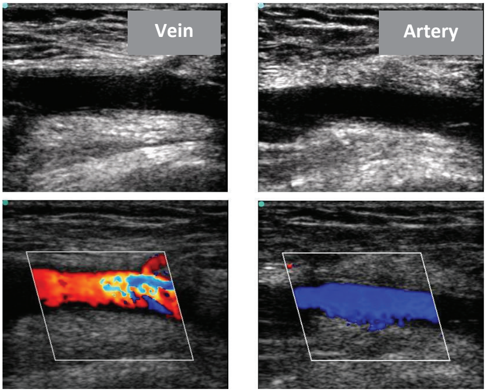


Figure 26: The 2D ultrasound image at LAX view is unable to differentiate between the Common Femoral Artery and Common Femoral Vein. The direction of blood flow will confirm the presence of two different vessels.

7.4 Peripheral Venous Access

7.4.1 Anatomy and ultrasound technique:

7.4.1.1 Any vein with the appropriate diameter and lying at a suitable depth can be selected.

7.4.1.2 However, a vein at a depth between 0.3-1.5 cm with a diameter of ≥ 0.4 cm has a higher probability of successful puncture.[8]

7.4.1.3 Cannula survival probability is higher when placed in the antecubital fossa or forearm.[9]

7.4.1.4 A tourniquet should be applied as proximal in the extremity as possible to optimize venous distention.

7.4.1.5 Appropriate choice of cannula/catheter length and size based on the characteristics of the selected vein.

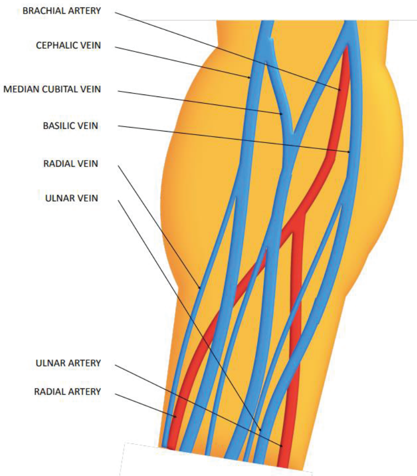


Figure 27: Anatomy of peripheral veins and arteries.

7.4.2 Catheter insertion:

7.4.2.1 Cannula selection should be taken into consideration: the size of cannula should be 20-30% of selected vessel diameter and the length of cannula should at least be [(depth x 1.4) + 2.75] cm.

7.4.2.2 Conduct of peripheral venous cannulation follows the principle of cannulation technique as described in section 5.

7.5 Arterial cannulation

7.5.1 Anatomy and ultrasound technique:

7.5.1.1 Ultrasound guided arterial cannulation is recommended in patients with hypotension, hypovolaemia, vascular diseases, and obesity.

7.5.1.2 Common sites for arterial cannulation are the Radial and Femoral arteries.

7.5.1.3 The Radial Artery is a continuation of the Brachial Artery and it runs along the lateral aspect of the forearm between the Brachioradialis and Flexor Carpi Radialis muscles.

7.5.1.4 It divides into superficial and deep palmar branches just proximal to the wrist and anastomoses with the distal branches of the Ulnar Artery in the hand.

7.5.1.5 Radial Artery is superficial and easy to palpate at the proximal end of the wrist crease.

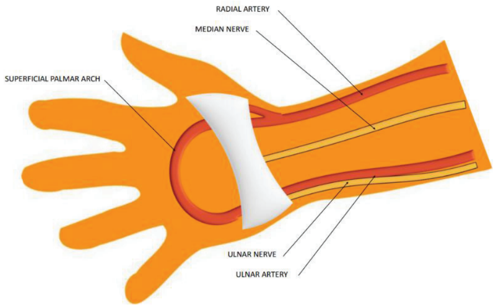


Figure 28: Anatomy of the Radial Artery.

7.1.1 Catheter insertion:

7.1.1.1 Conduct of ultrasound guided arterial cannulation follows the principle of cannulation technique as described in section 5.

7.1.1.2 If a guidewire is used, confirmation of placement follows the principles described in section 6.

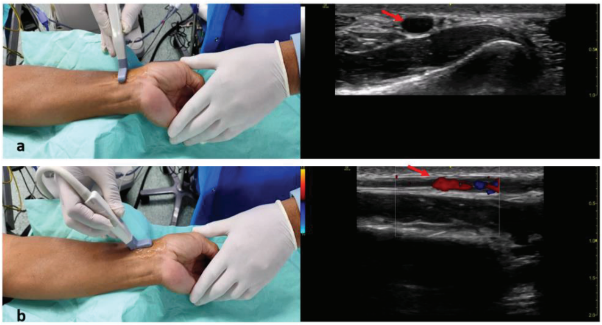


Figure 29: Ultrasound of the Radial Artery; a) 2D in SAX view (red arrow) and b) Colour Doppler in LAX view (red arrow).

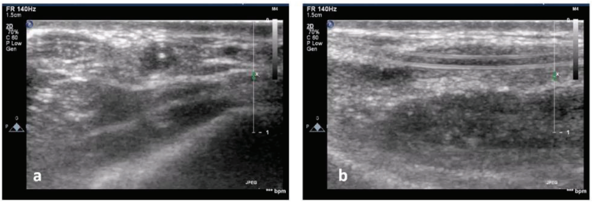


Figure 30: Ultrasound Guided Radial Artery cannulation; a) needle tip is seen at SAX view and b) catheter is seen at LAX view.

SECTION 8: TRAINING AND COMPETENCY

8.1 Training is necessary for the operators to acquire the competency to perform ultrasound guided vascular access procedures independently.

8.2 The training should include both theoretical and practical aspects.

8.3 Each institution should determine a minimum number of supervised ultrasound guided vascular access for the operators to demonstrate competency in the technique before being allowed to perform independently.

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