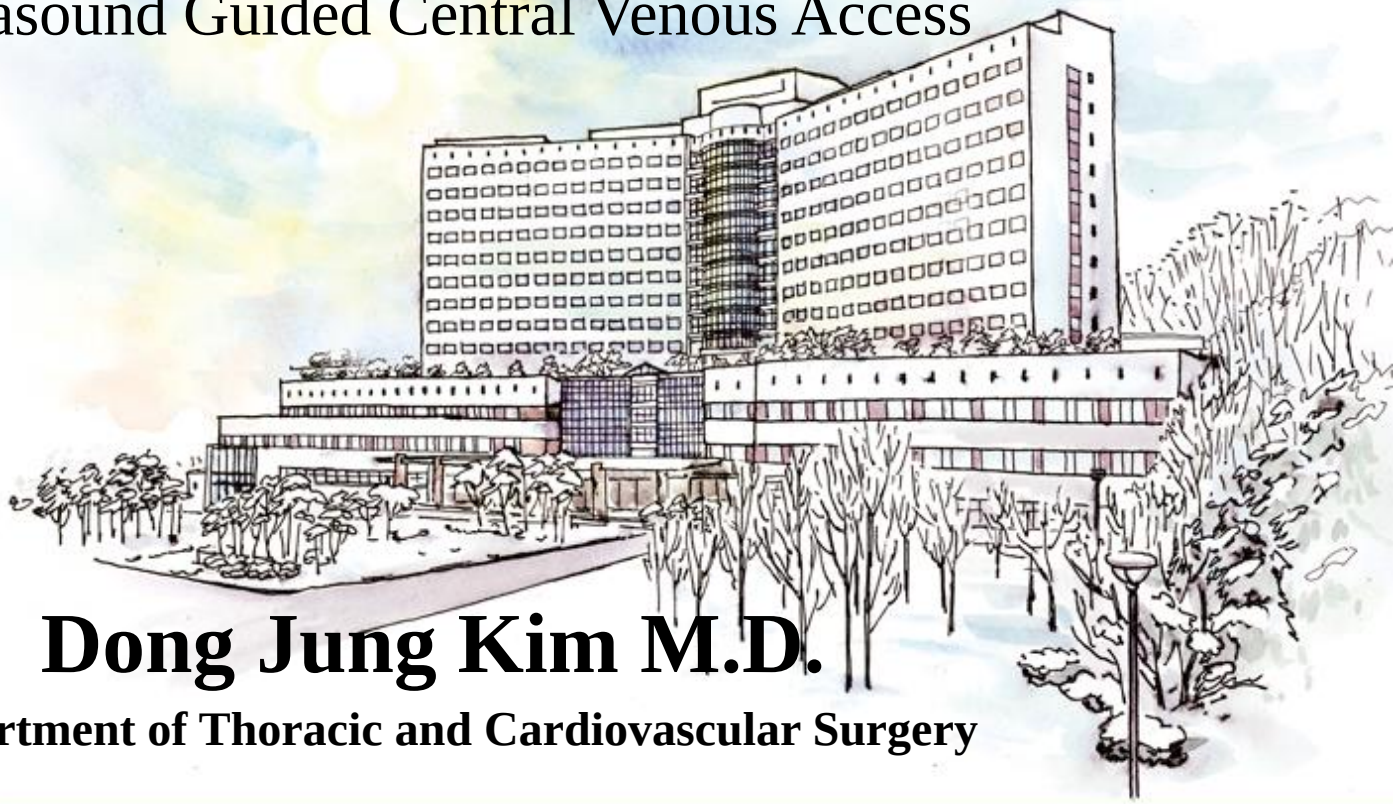
흉부외과 전공의 연수강좌

Vessel : SONO guided procedure

Ultrasound Guided Central Venous Access



SNUH
SEOUL NATIONAL UNIVERSITY
BUNDANG HOSPITAL

Dong Jung Kim M.D.

Department of Thoracic and Cardiovascular Surgery

Vascular ultrasound in ICU

- SONO guided procedures
  - Central line insertion (including HD catheter)
    - Internal jugular vein, Subclavian vein, Femoral vein
    - PICC (Peripherally Inserted Central Catheter)
  - Arterial catheterization
    - Radial artery, Brachial artery, Femoral artery
    - Distal perfusion in patients on VA ECMO
- Fluid responsiveness
  - Increase in common carotid artery flow with PLR

Contents

- Ultrasound guided vascular access : The basics

- Central venous cannulation
  - Internal jugular vein
  - Subclavian vein
  - PICC insertion

Overview

- Ultrasound guidance for CVC placement
  - Introduced in the 1980s
  - Increased success
  - Enhanced safety
  - Effectiveness in comparison to anatomic landmark based techniques

Complication : Landmark method

Complication	Internal jugular	Subclavian	Femoral
Arterial puncture %	10.6	5.4	6.25
Hematoma %	8.4	5.4	–
Pneumothorax %	2.4	4.9	–
Hemothorax %	1.7	4.4	–
Malposition %	–	11	–
Infection rate per 1000 catheter-days	8.6	4	15.3
Thrombosis rate per 1000 catheter-days	1.2 – 3	0 – 13	8 – 34

(Intensive Care Med 38(7):1105-1117, 2012)

Overview

- Ultrasound guidance for CVC placement
  - Several international guidelines advocate routine use of ultrasound guidance
  - often remains poorly taught
  - left out of training curricula
  - Inexperienced and less skilled practitioners frequently experience significant difficulties

Advantages

- Reduce the incidence of complications
  - Inadvertent puncture and cannulation, hematoma, post. wall puncture, pneumothorax or hemothorax
  - Avoidance of primary damage
    - caused by injury to collateral structures from the needle
  - Avoidance of secondary damage
    - caused by misplaced guide wires, dilators, and catheters

Advantages

- Preprocedural scan
  - to identify abnormal anatomy, thrombosis, or valves
- Reduces frequency of punctures and facilitates first-pass cannulation
- Postcannulation scan
  - to confirm correct placement of the guide wire and catheter in the intended vessel

Practice guidelines

NICE National Institute for Health and Care Excellence

NICE guidance

Guidance on the use of ultrasound locating devices for placing central venous catheters

Technology appraisal guidance
Published: 4 October 2002
nice.org.uk/guidance/ta49

Practice guidelines

1 Guidance

1.1 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.

1.2 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.

1.3 It is recommended that all those involved in placing CVCs using two-dimensional (2-D) imaging ultrasound guidance should undertake appropriate training to achieve competence.

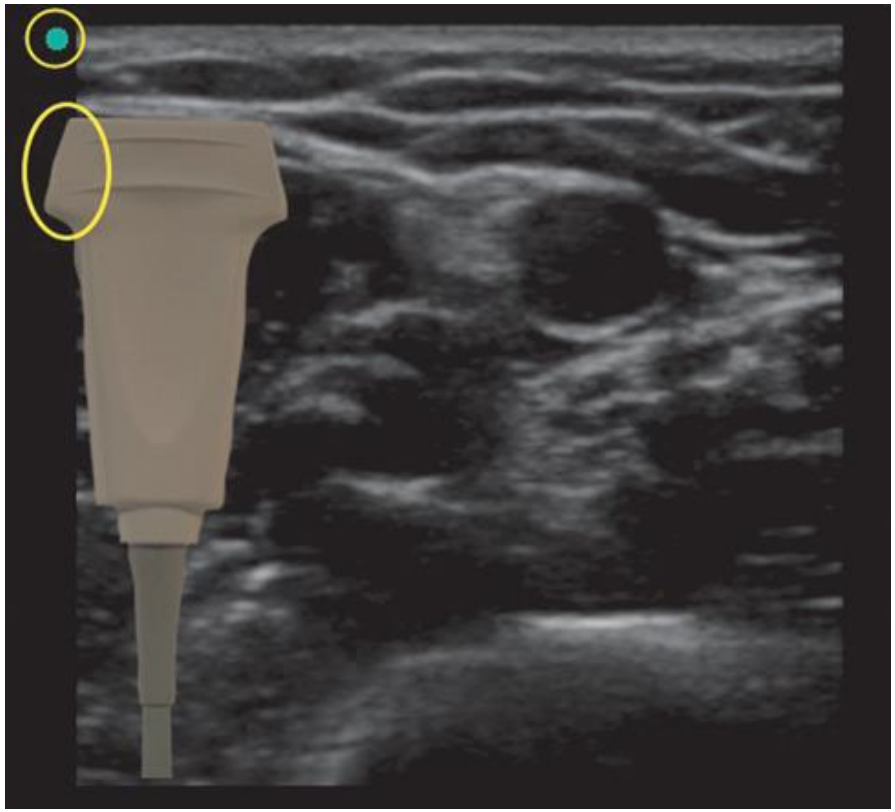
1.4 Audio-guided Doppler ultrasound guidance is not recommended for CVC insertion.

(Guidance on the use of ultrasound locating devices for placing central venous catheters, 2002)

Ultrasound transducer

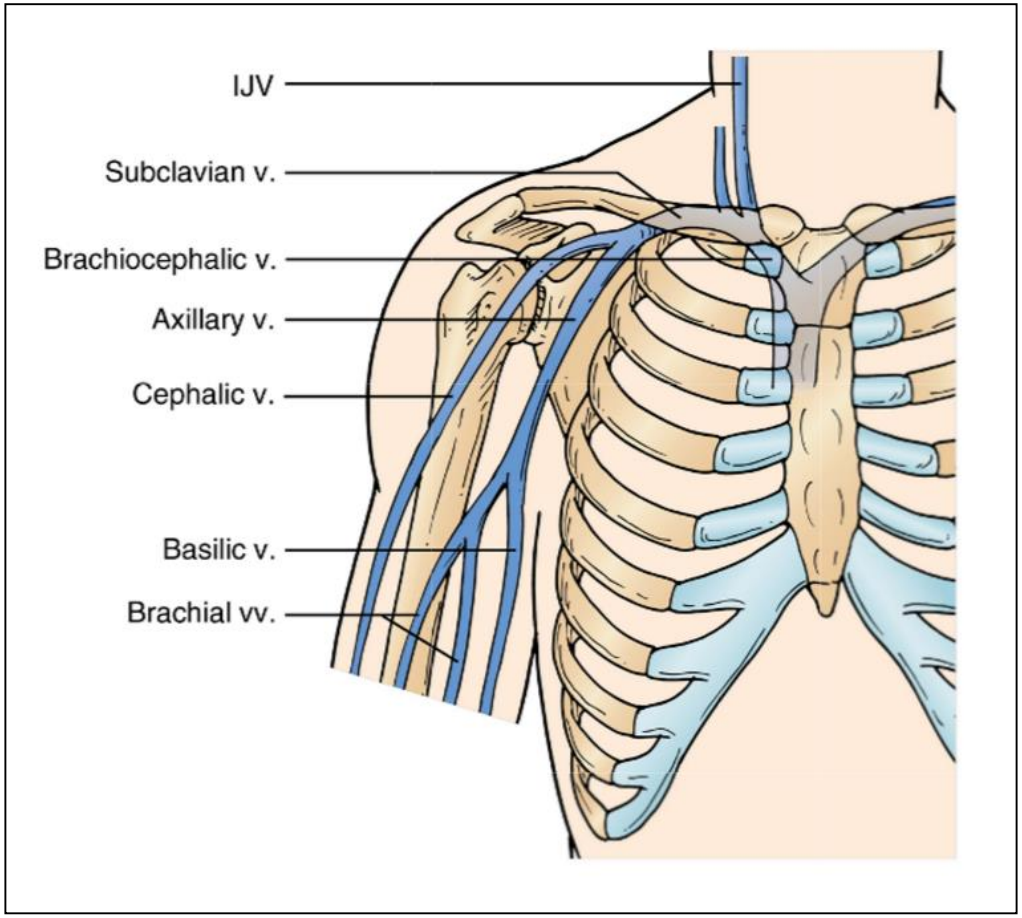
- Center : linear 5-12 mHz transducer, most often used for vascular imaging
- Left : Hockey stick, can be useful in tight locations
- Right : curved, lower frequency, greater tissue penetration in obese patients

Probe orientation



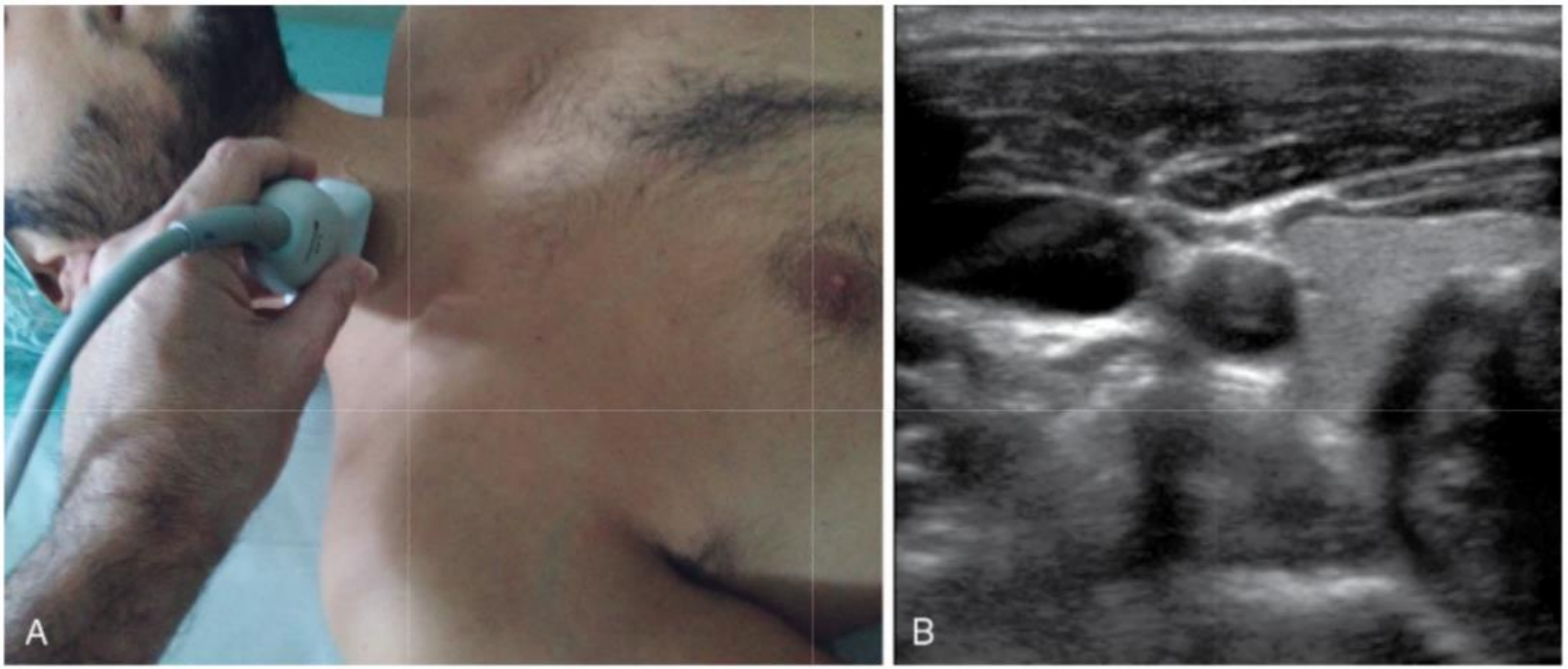
US probe marker and marker on the US machine screen are aimed in the same direction

Venous anatomy



(Critical Care Ultrasound, 1e)

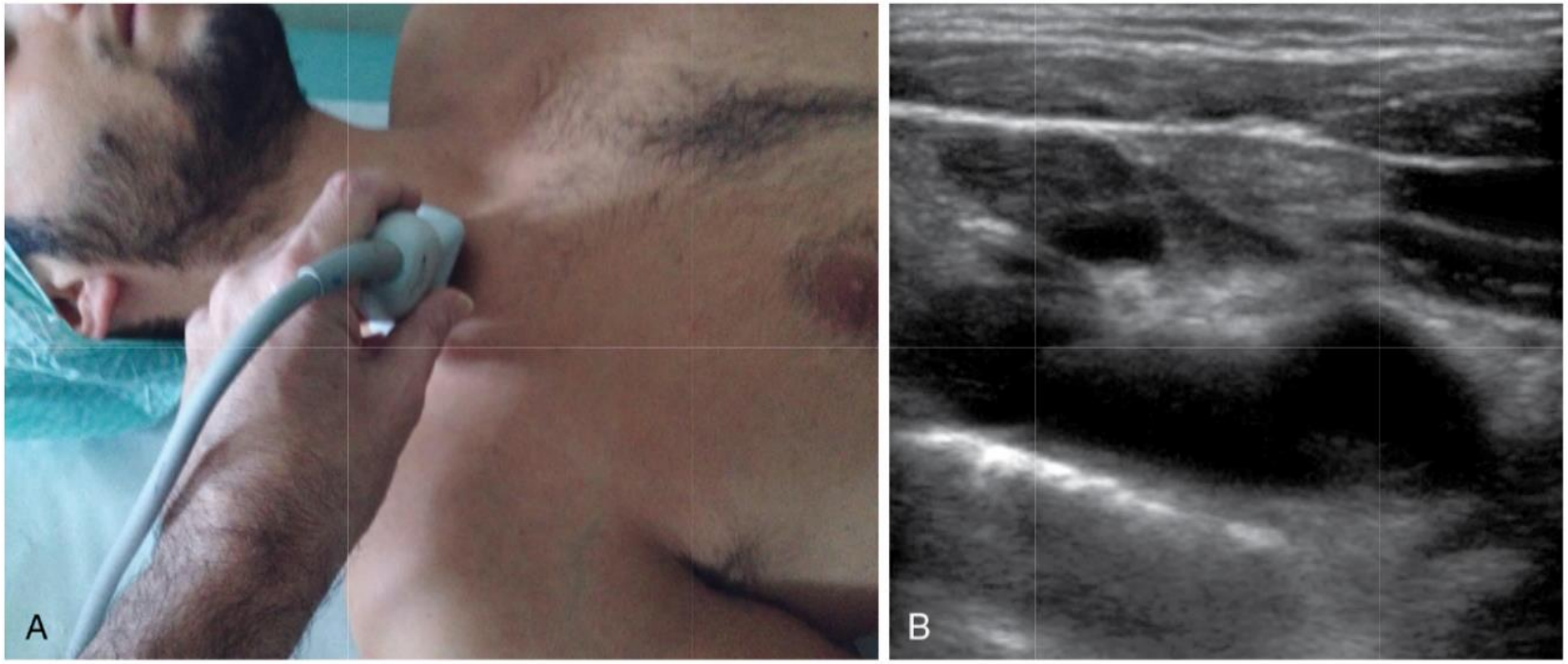
Central vein assessment (1)



- A : Probe positioned at the midneck
- B : Visualization of the internal jugular vein and carotid artery

(Critical Care Ultrasound, 1e)

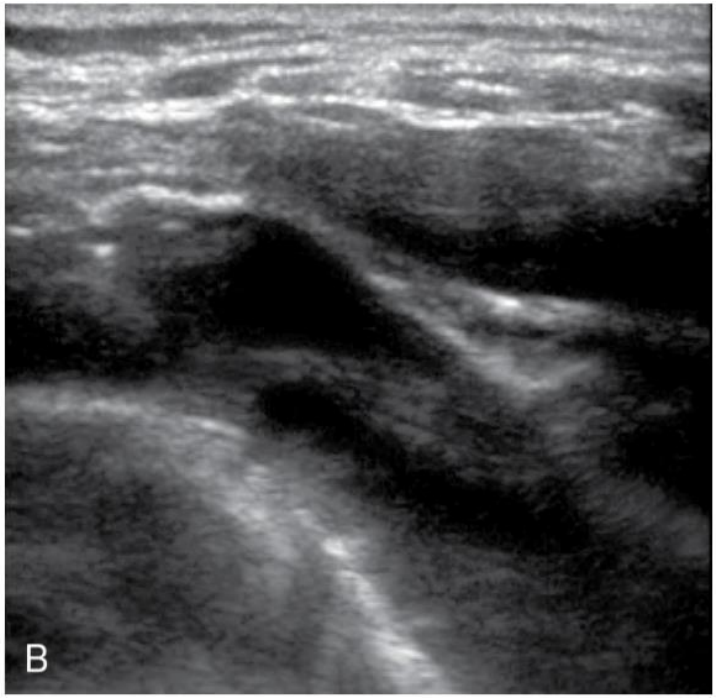
Central vein assessment (2)



- A : Probe sliding down to the sternum
- B : Visualization of the lower tract of internal jugular vein and subclavian artery

(Critical Care Ultrasound, 1e)

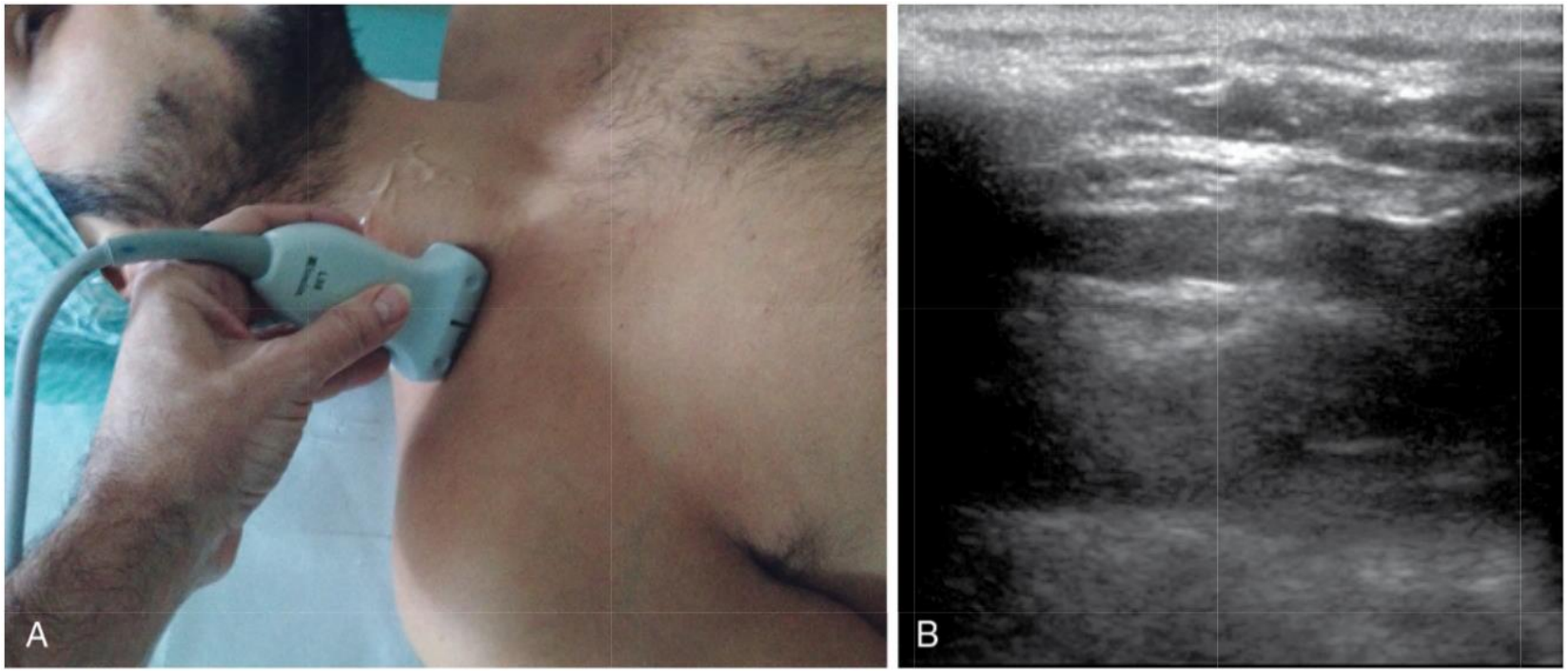
Central vein assessment (3)



- A : Tilting the probe to an almost frontal plane
- B : Visualization of the brachiocephalic vein

(Critical Care Ultrasound, 1e)

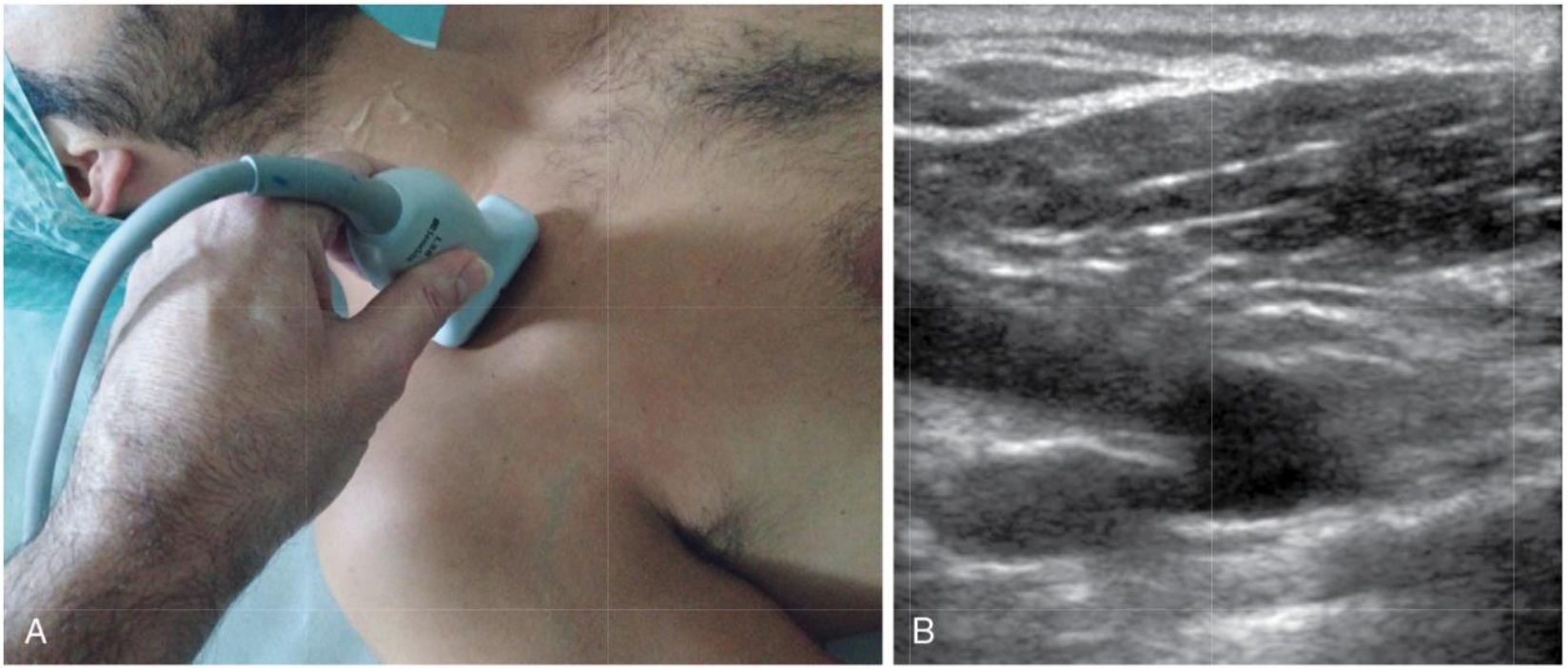
Central vein assessment (4)



- A : Sliding the probe laterally above the clavicle
- B : Visualization of the subclavian vein and external jugular vein

(Critical Care Ultrasound, 1e)

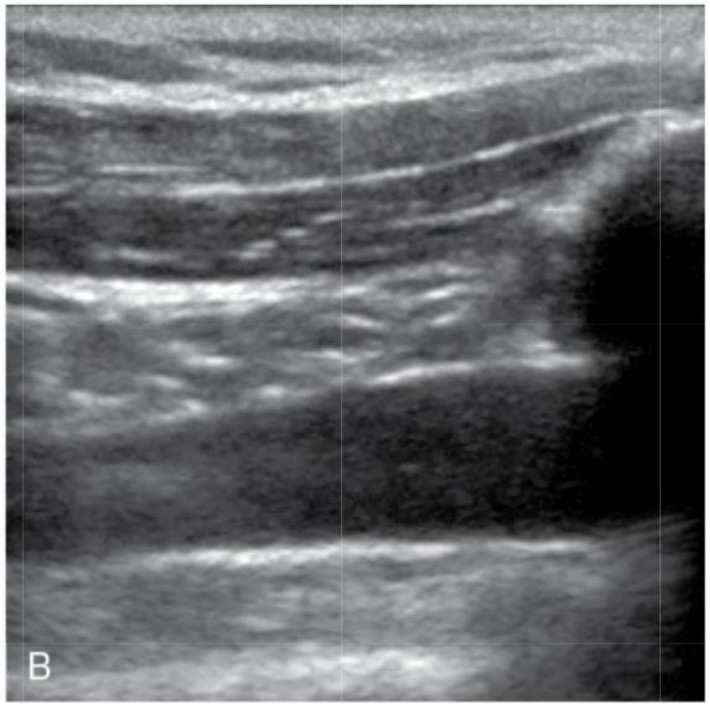
Central vein assessment (5)



- A : Probe below the lateral third of the clavicle
- B : Visualization of the axillary vein, the axillary artery, and the cephalic vein

(Critical Care Ultrasound, 1e)

Central vein assessment (6)

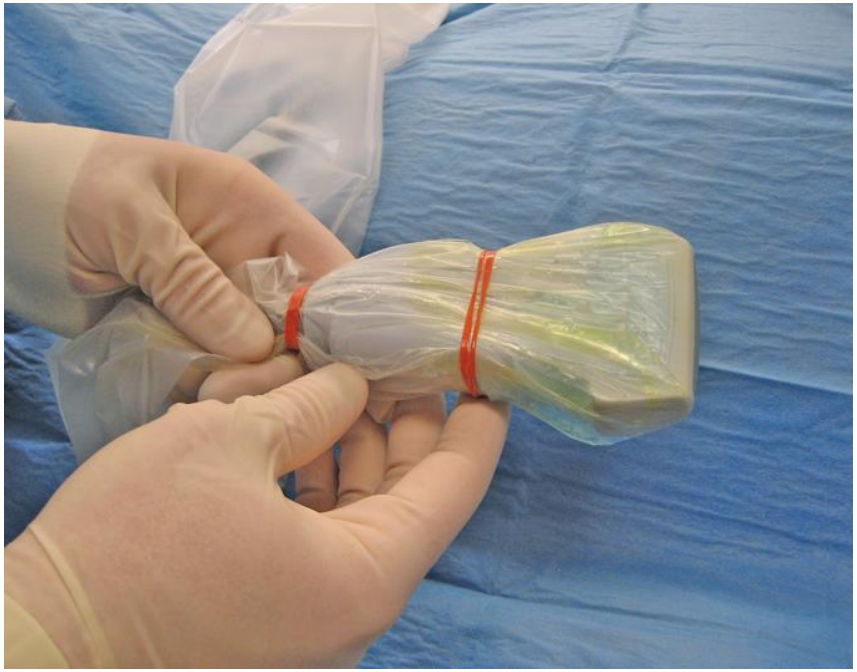


- A : Rotating the probe below the clavicle
- B : Visualization of the axillary vein in the long axis

(Critical Care Ultrasound, 1e)

Probe preparation

Apply sterile probe cover over US probe



Secure the cover with rubber bands

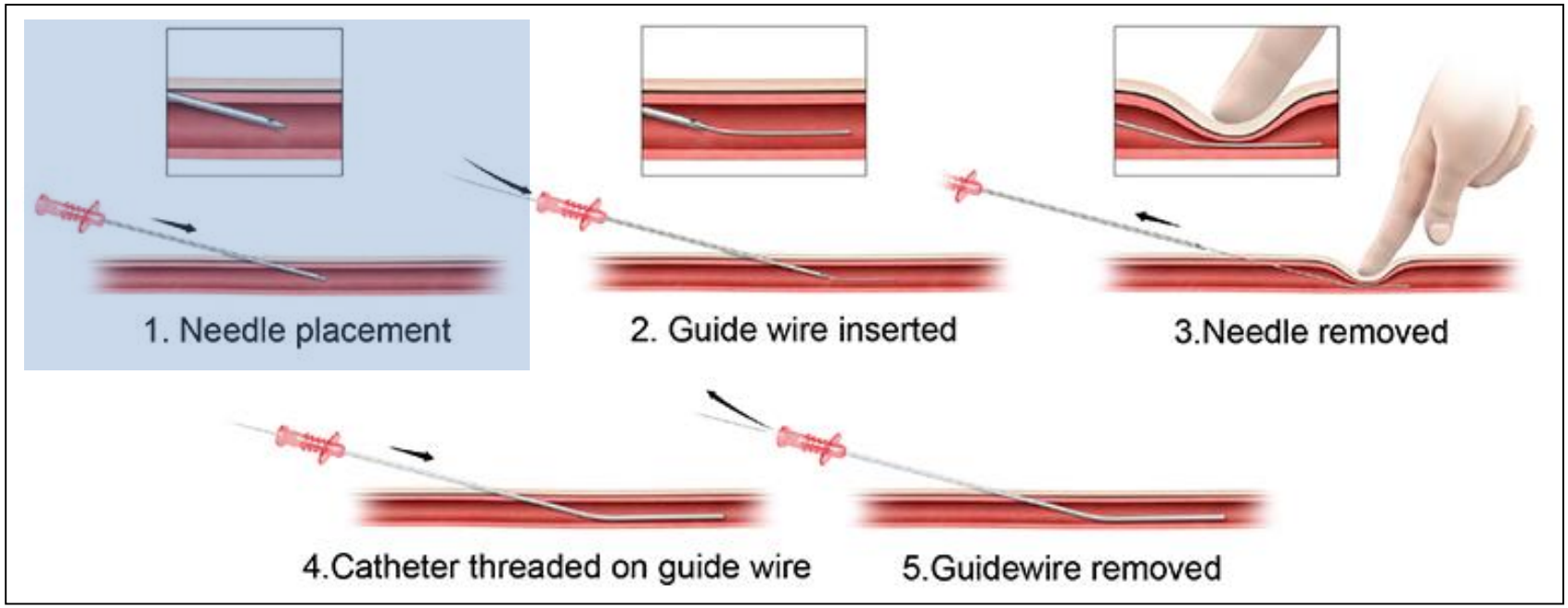
(Emergency Medicine Procedures, 2e)

Equipment setup

Ultrasound machine is placed downstream of the operator in a direct line of sight

(Critical Care Ultrasound, 1e)

Seldinger technique



(Introduction to Diagnostic Radiology, 2015)

Static vs Dynamic

- Static approach
  - uses ultrasound to determine the vessel location and patency, assess surrounding structures
  - mark the location to provide optimum placement for needle introduction.
  - Procedure without real-time ultrasound

Static vs Dynamic

- Dynamic approach
  - Procedure is performed using real-time ultrasound observation of needle entry and placement
  - With a sterile technique that includes sterile gel and sterile probe covers
  - Superior to static approach in most situations

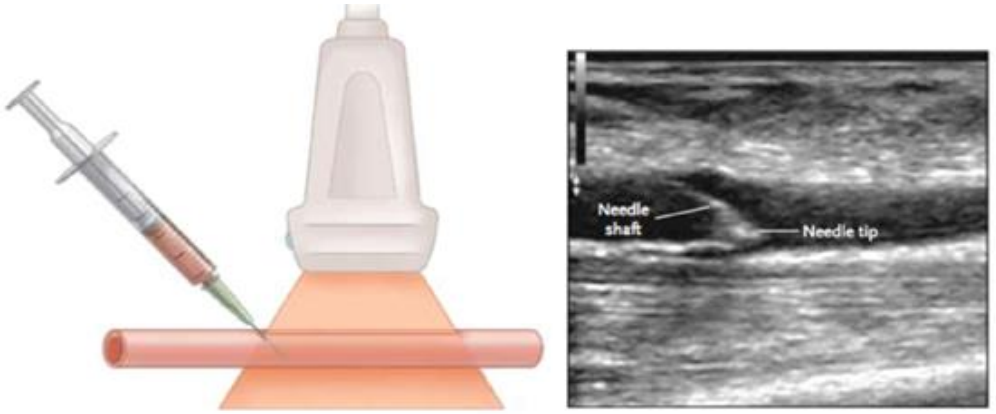
One-Person vs Two-Person

- Two-person dynamic approach
  - One person performs the ultrasound while another person performs the procedure
- One-person dynamic approach
  - The person performing the procedure holds needle with one hand while directing the ultrasound probe in the other hand
  - For most advanced practitioners

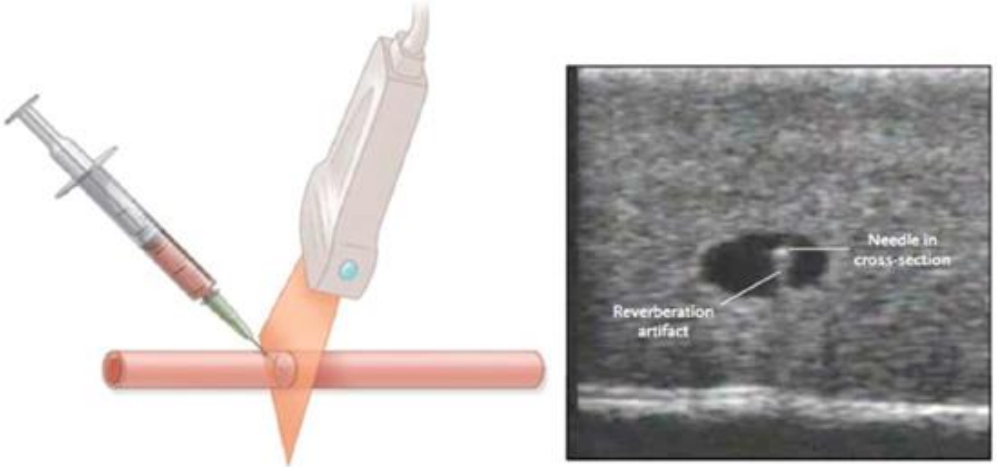
One-Person dynamic approach

(Critical Care Ultrasound, 1e)

Planes of ultrasound visualization



In plane view of needle (Long axis of vessel)



Out of plane view of needle (Short axis of vessel)

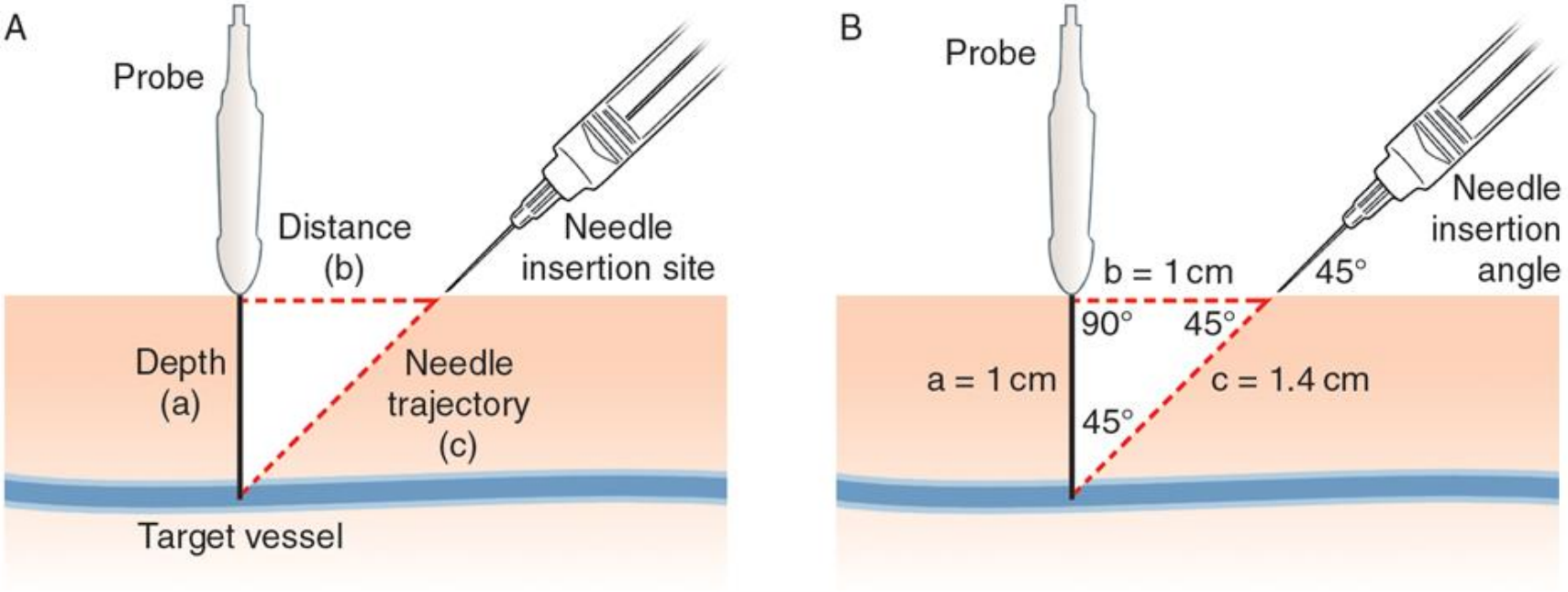
Long-Axis vs Short-Axis

- Long-axis (in plane)
  - Continuous visualization of entire needle and tip
  - Precise real-time control
  - improve the safety of procedure
  - minimize inadvertent injury
  - More challenging with deeper structures
  - requires further training

Long-Axis vs Short-Axis

- Short-axis (out of plane)
  - More widely used technique
  - Visualization of associated at-risk structures
  - Simultaneous anterior-posterior and medial-lateral views of the vessel
  - Position of needle tip is more difficult to ascertain
  - requires considerable experience and practice

Short axis approach

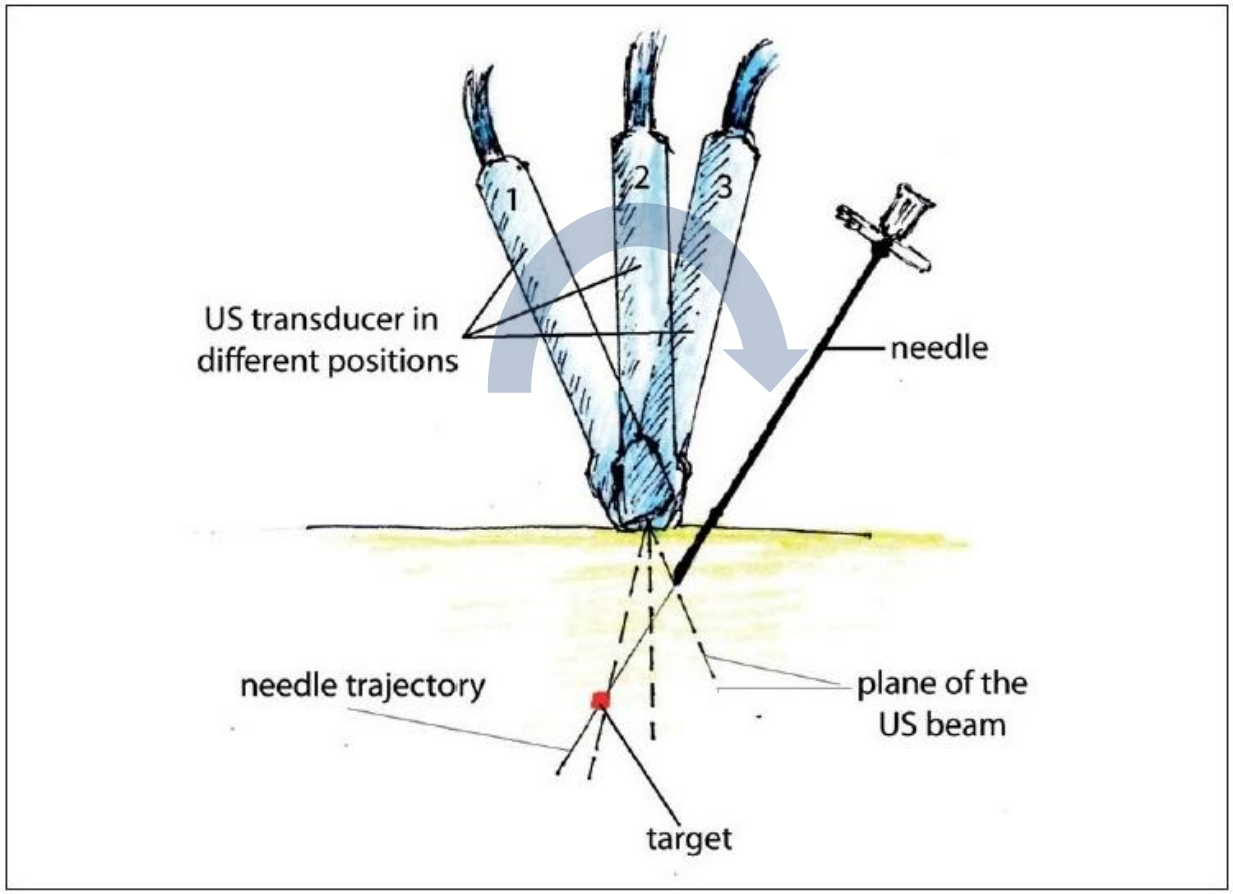


(Emergency Medicine Procedures, 2e)

Needle visualization

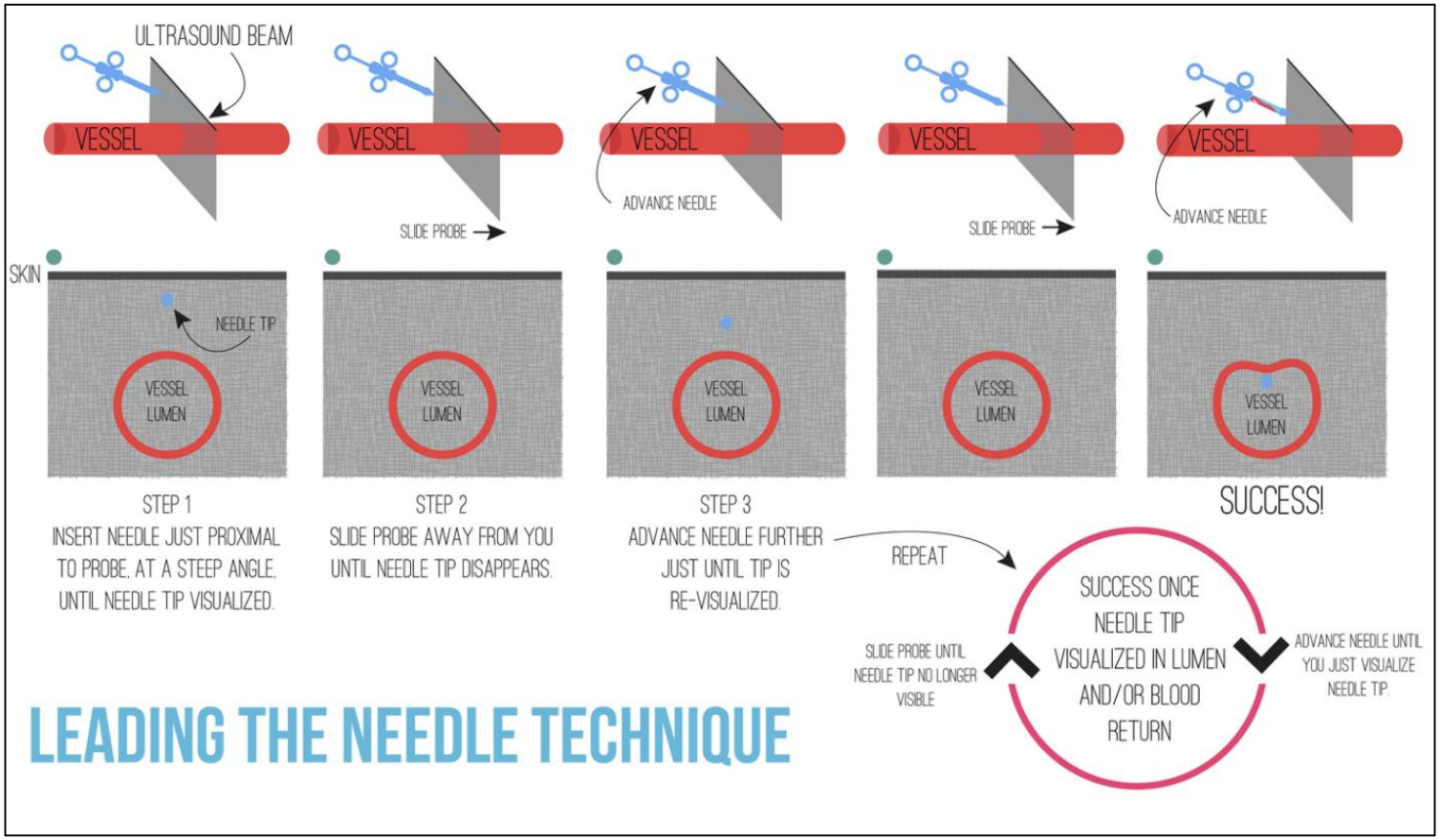
- Visualizing the tip of the needle
  - can be challenging, yet is essential
  - Especially during out of plane needle placement
- Improving tip of needle visualization
  - Gradual tilting of the probe
    - allows the operator to follow the tip of needle
  - Sliding a probe without tilting
    - alternative way of keeping needle tip in the view

Needle visualization : tilting



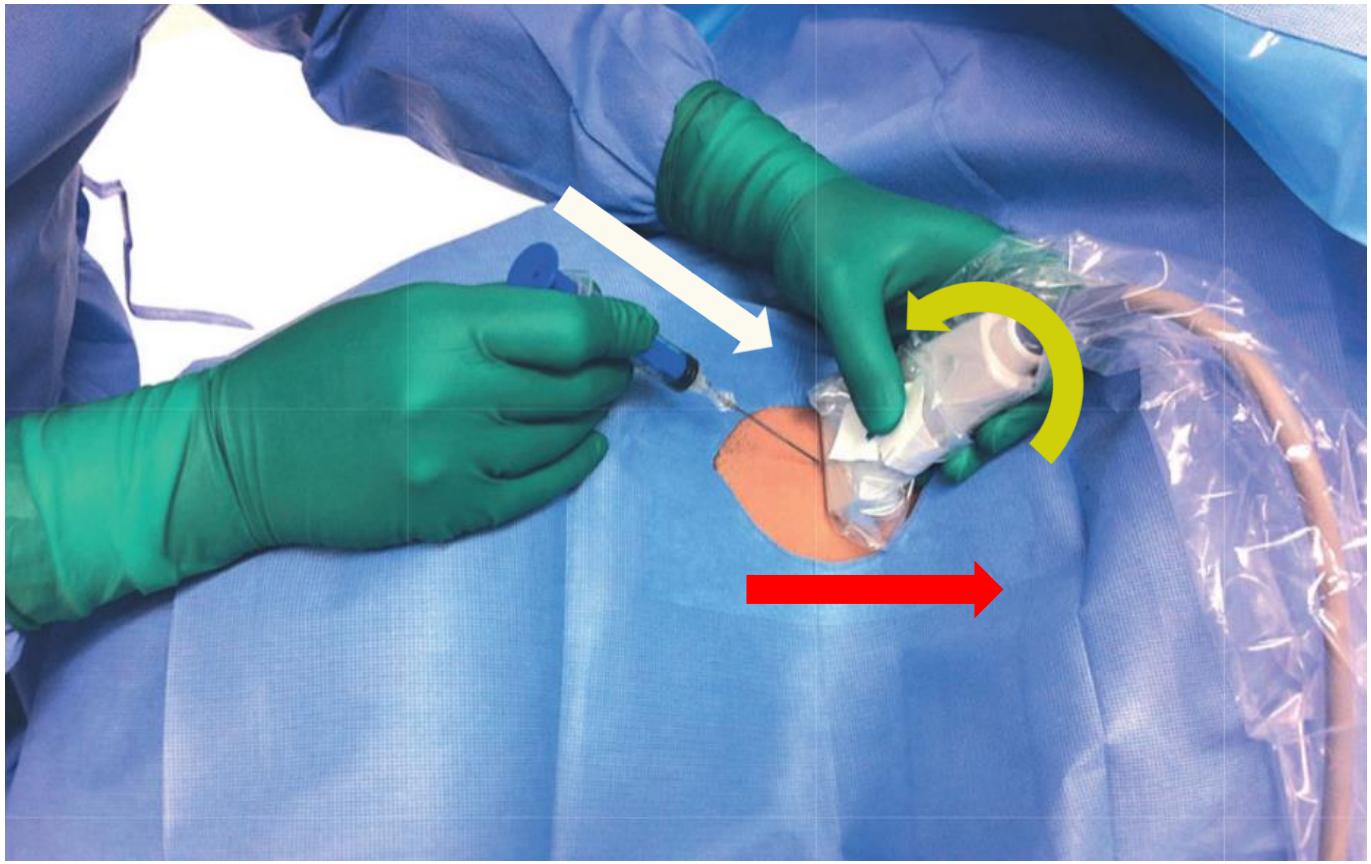
(Int J Shoulder Surg. 2010 Jul;4(3):55-62)

Needle visualization : sliding



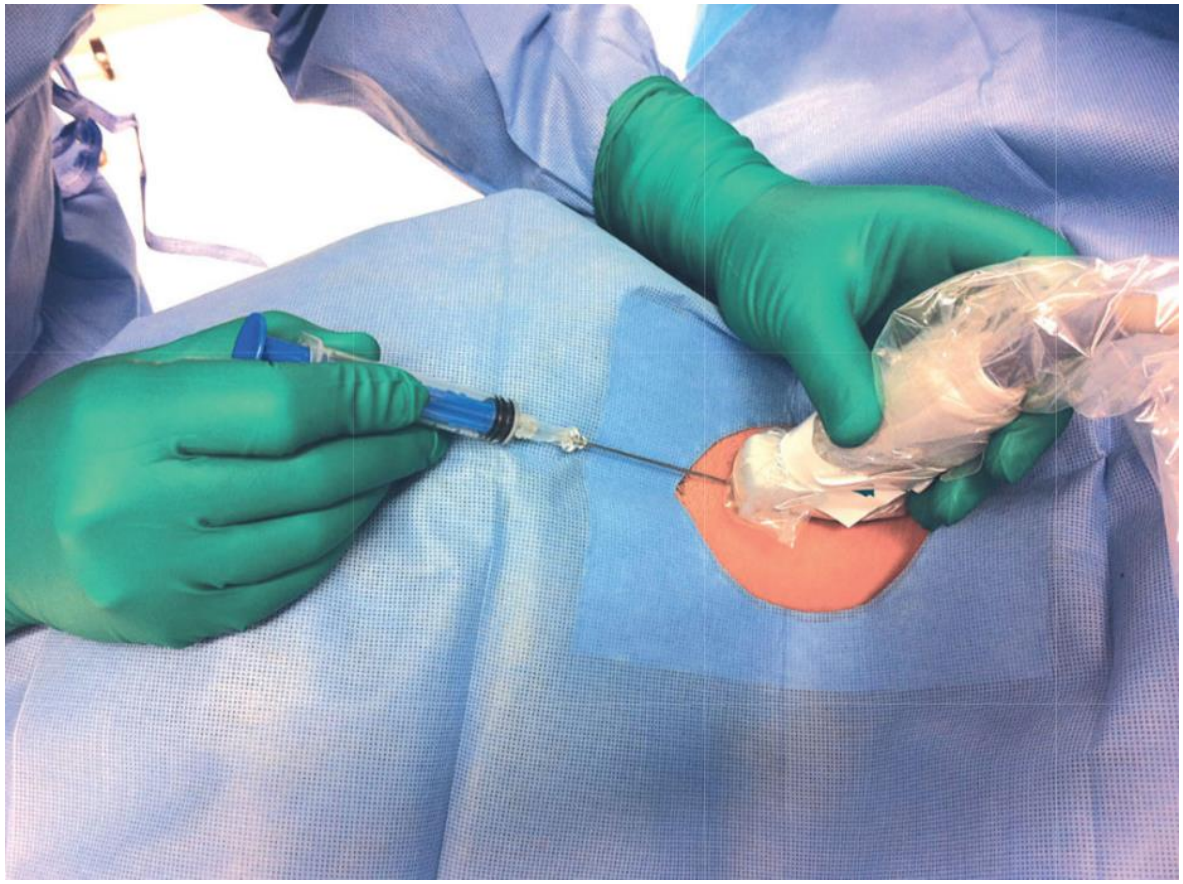
(Ultrasound Leadership Academy, 2014)

Short axis dynamic approach



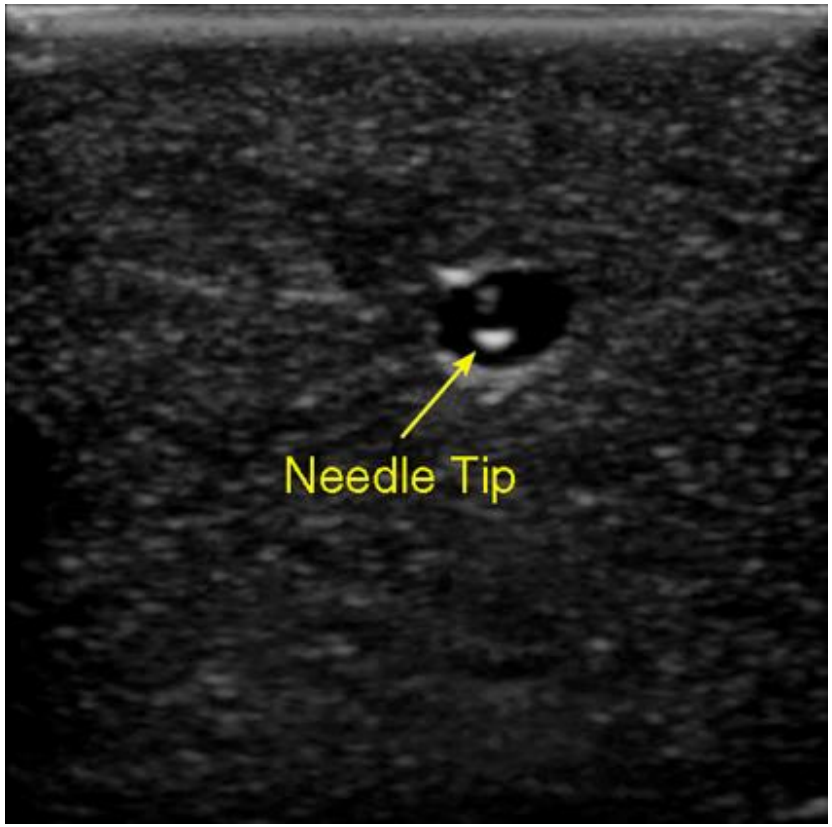
(Critical Care Ultrasound, 1e)

Long axis dynamic approach

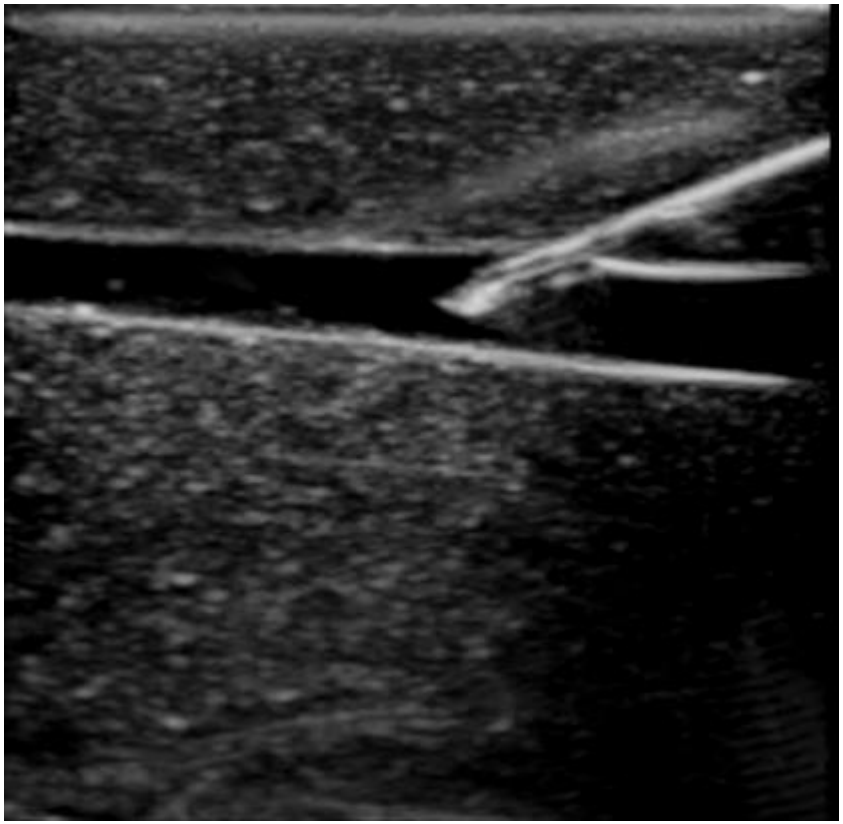


(Critical Care Ultrasound, 1e)

Needle visualization



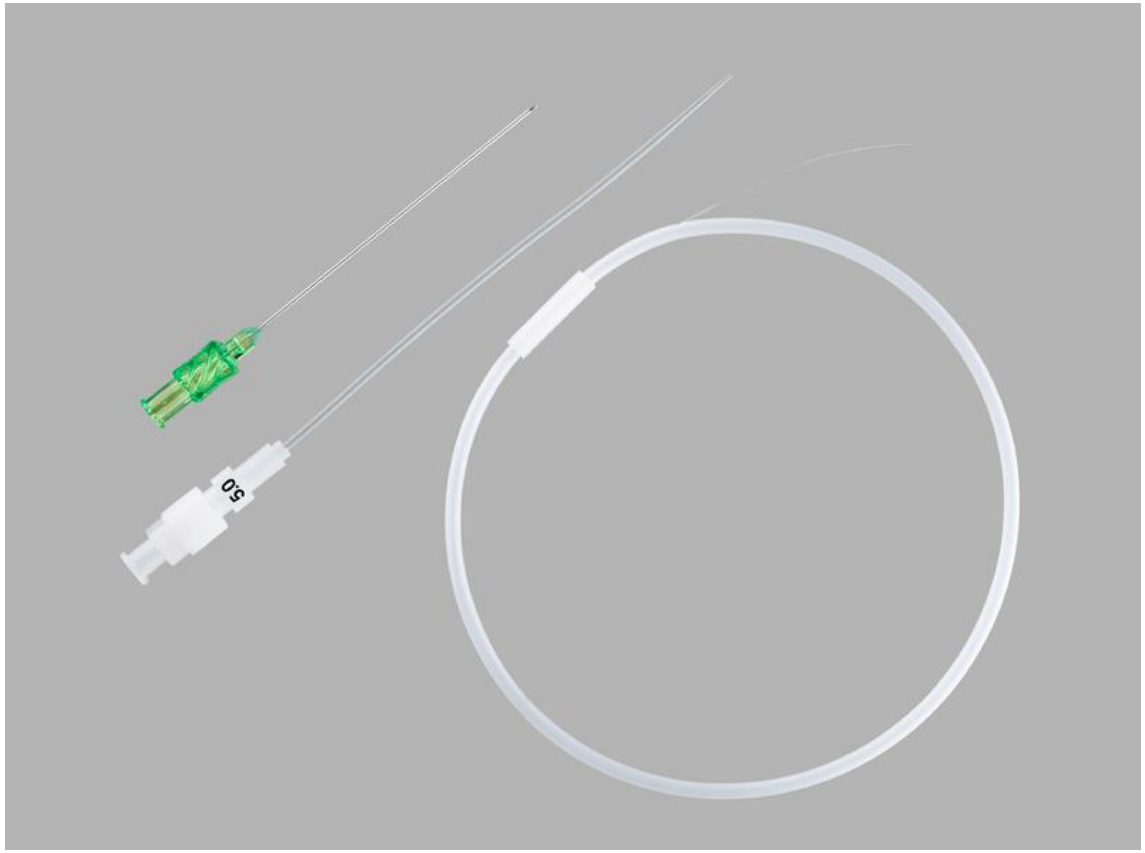
Short axis



Long axis

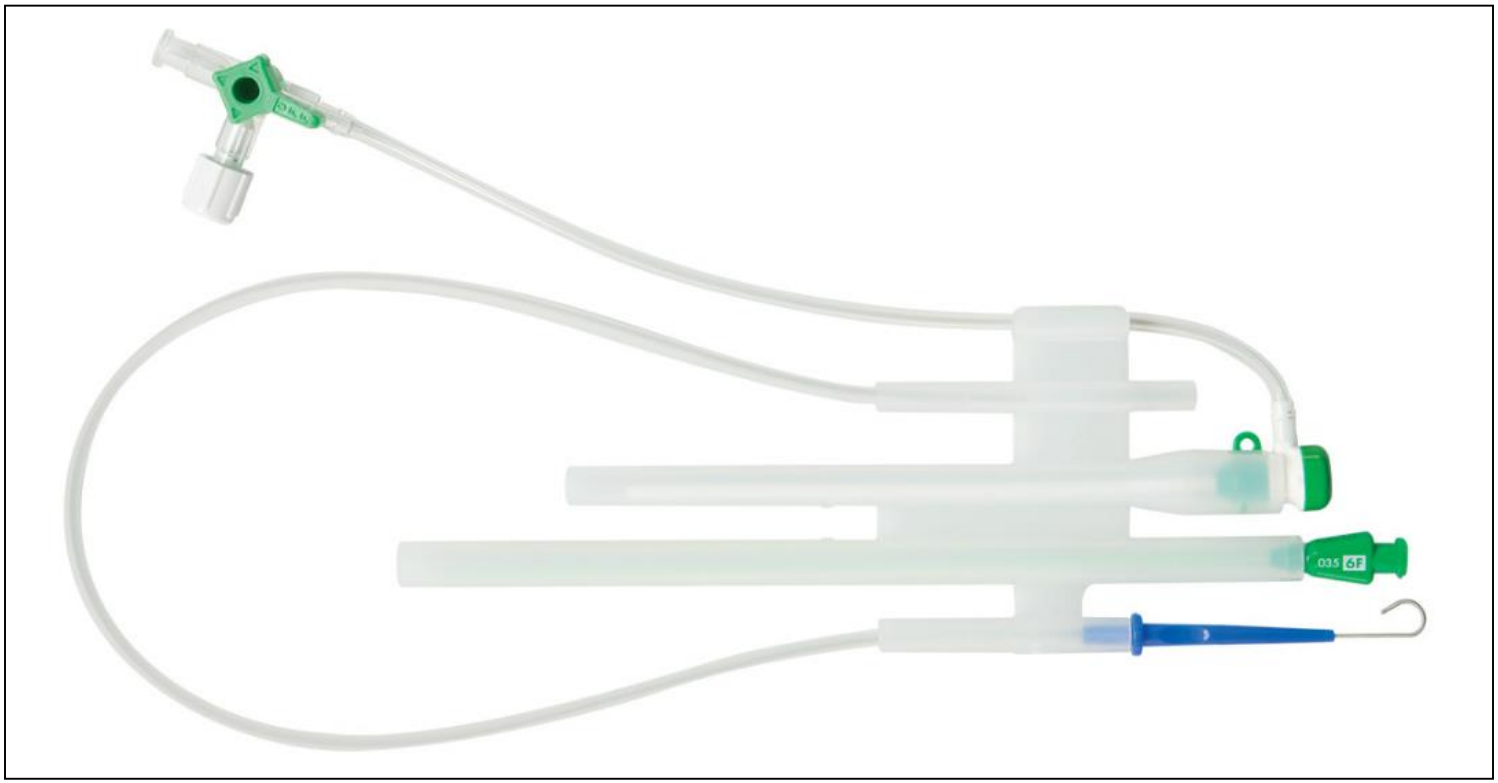
(Emergency Medicine Procedures, 2e)

Micropuncture Access



Needle : 21G, 7cm; Guide wire : 0.018″, 40cm; Catheter : 4~5Fr, 10cm

Vascular sheath



Sheath : 4~8Fr, 7~10cm; Guide wire : 0.035″, 50cm

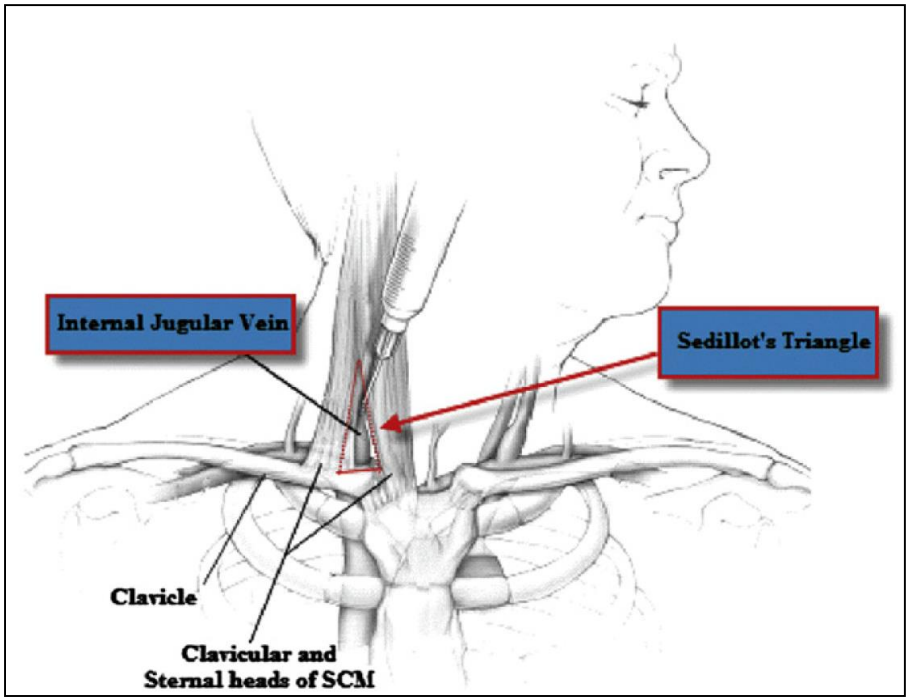
Internal Jugular Vein Cannulation

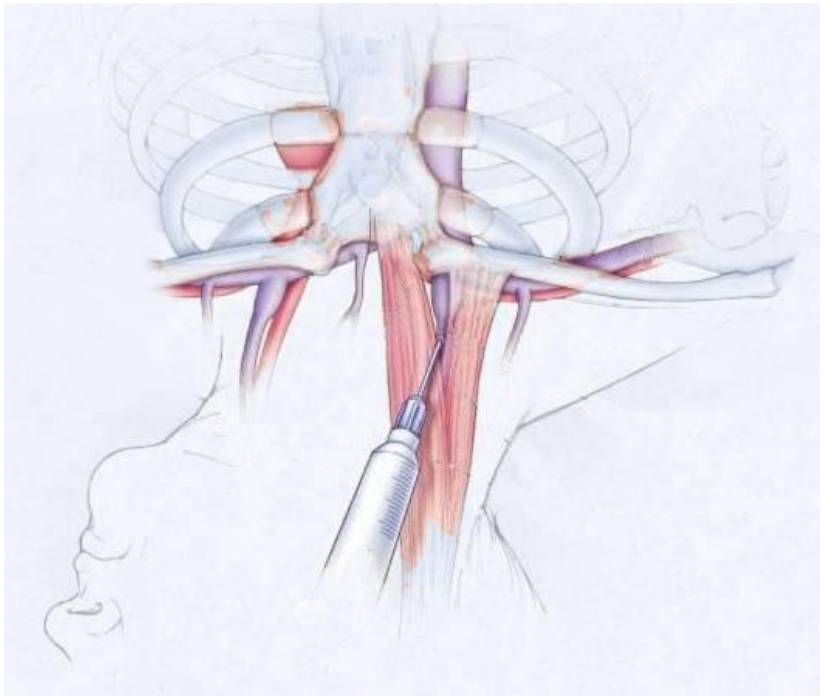
- USG is recommended
  - Higher success rate on the first needle pass
  - Reduced complications from collateral damage
  - Decreased procedural time

Internal Jugular Vein Cannulation

- USG is recommended
  - Failure rate of 7~19% has been demonstrated with traditional anatomic landmark approaches
  - Success rate of less than 25% per attempt has been reported when initial blind punctures have failed
  - Anatomic variability in 36% of the population
  - Puncture of carotid artery with even 21G needle can lead to catastrophic sequela

Anatomic landmark

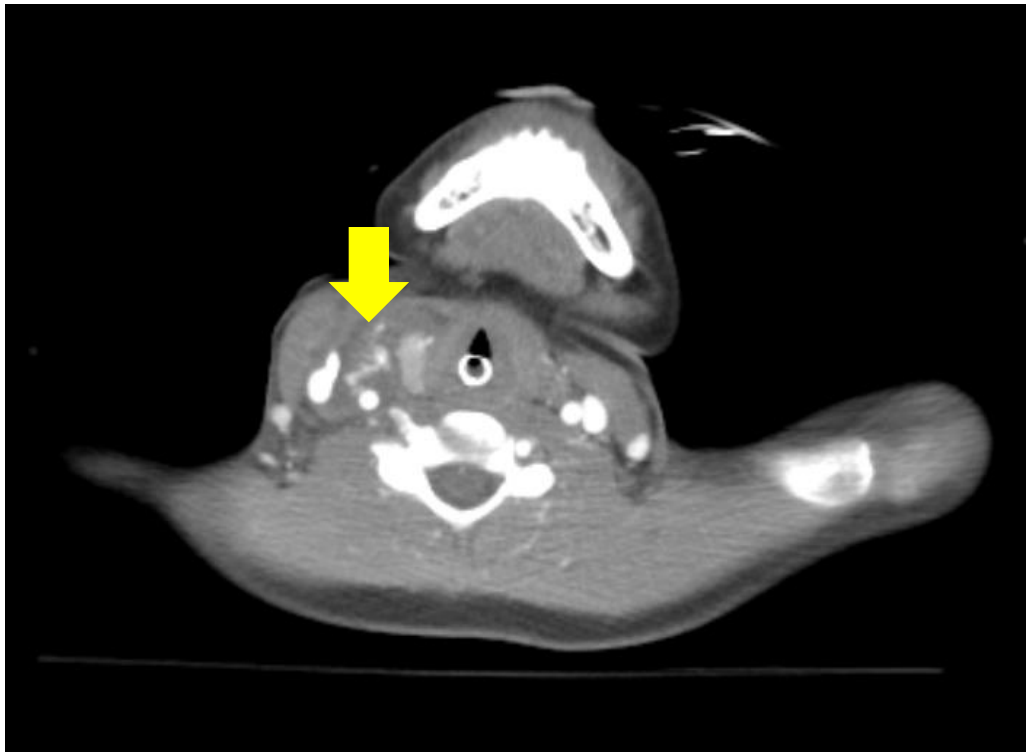




Variable overlap btw CCA & RIJV

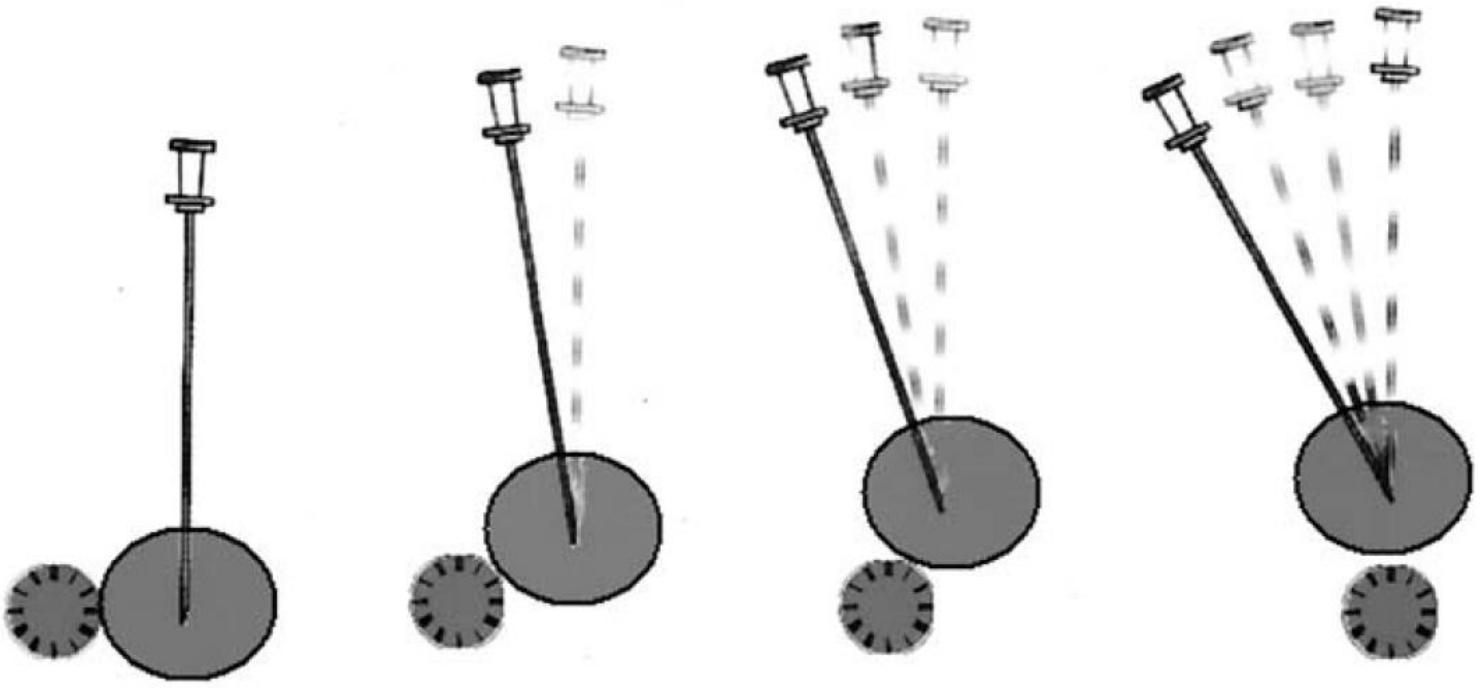
(J Vasc Interv Radiol 1998;9:333-8)

Inadvertent puncture



Active bleeding in the right common carotid artery

Transducer positioning

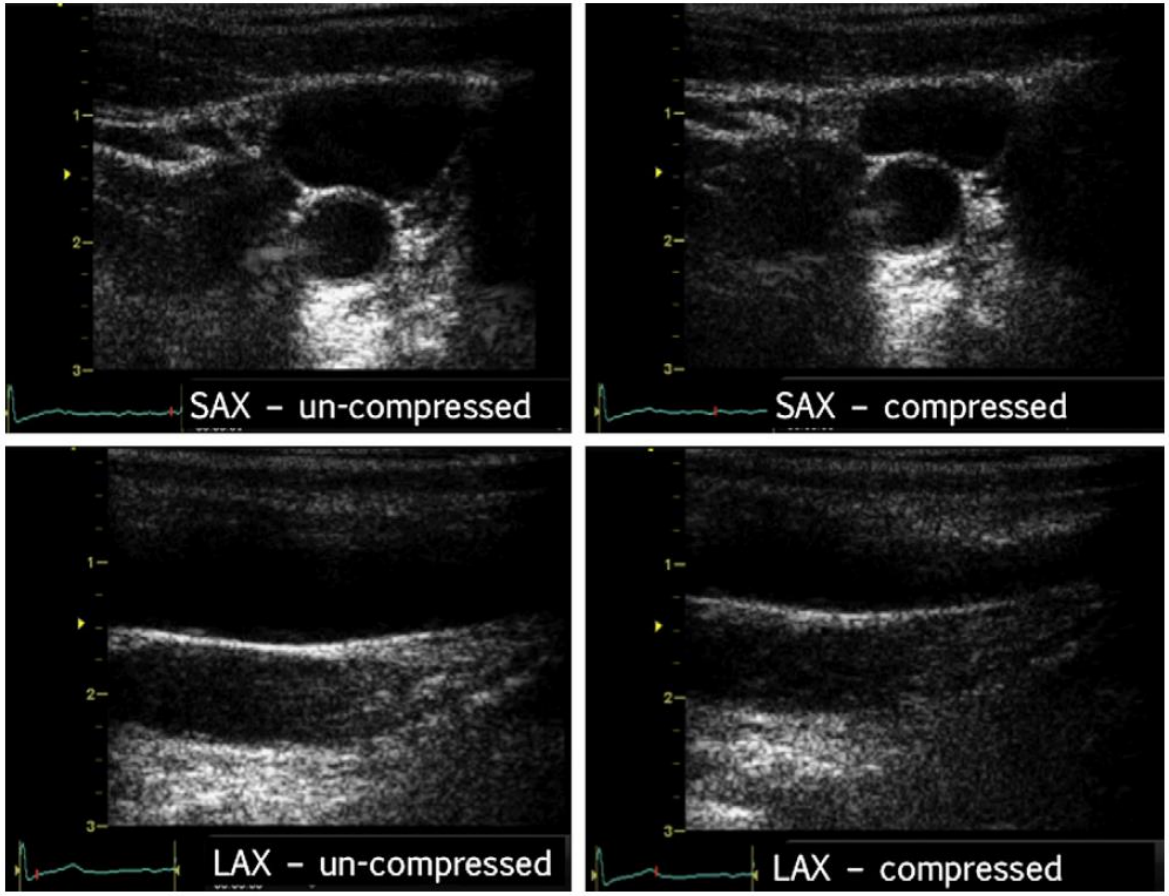


(Cardiovasc Intervent Radiol. 2005 May-Jun;28(3):303-6.)

Internal Jugular Vein Cannulation

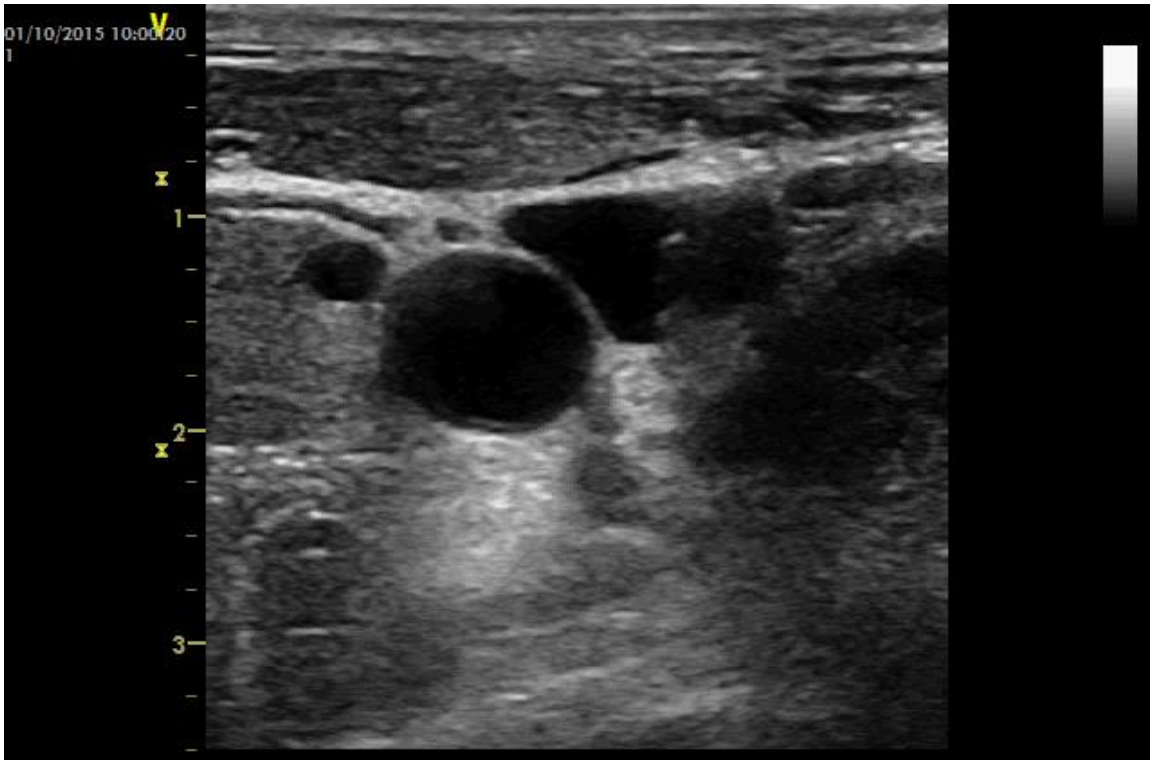
- Long axis approach
  - Precise control of the needle should lessen the likelihood of arterial or pleural puncture
  - provide a more conveniently located exit site in the lower part of the neck
- Short axis approach
  - More commonly used
  - usually results in a midneck exit site with potential difficulty in securement and dressings

Vessel identification



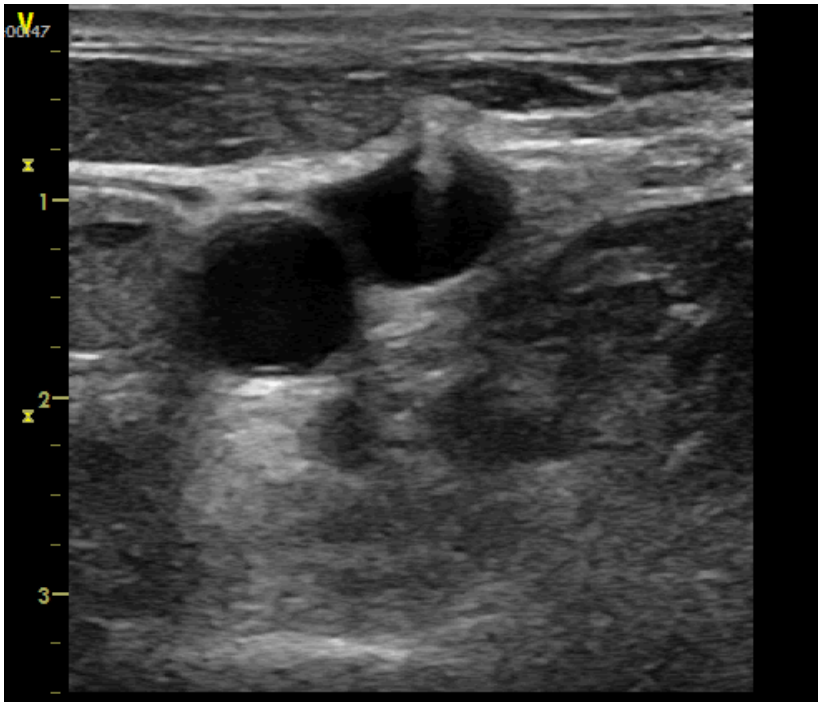
(J Am Soc Echocardiogr 2011;24:1291-318.)

Needle placement



Short axis approach

Guide wire confirmation



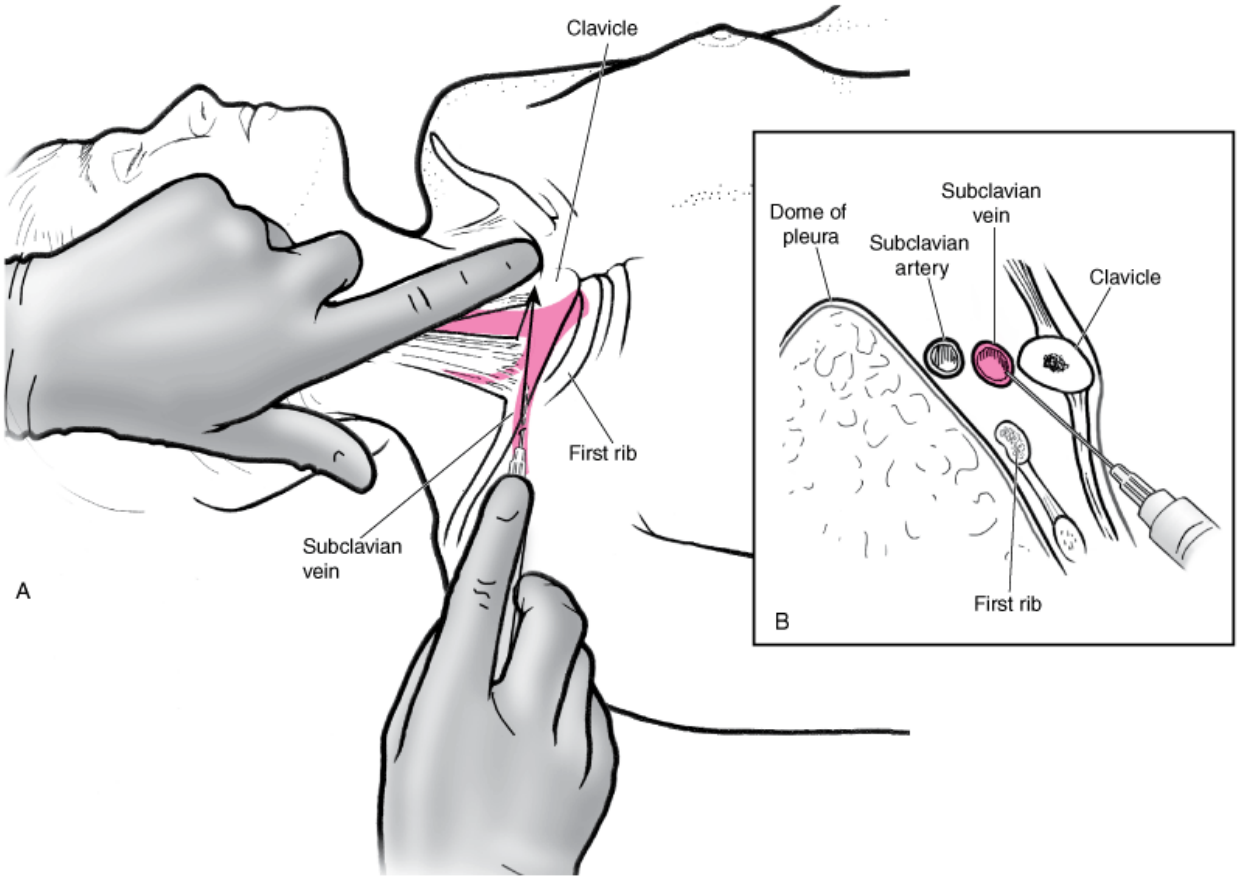
Short axis

Long axis

Subclavian Vein Cannulation

- Routine use of USG is not mandated
  - Most of its course lies behind the clavicle, which impedes ultrasound visualization
  - SCV is close to the pleura, subclavian artery, and brachial plexus
  - Landmark-based techniques for SCV cannulation are associated with up to 12% complication

Anatomic landmark



(Emergency Medicine Procedures, 2e)

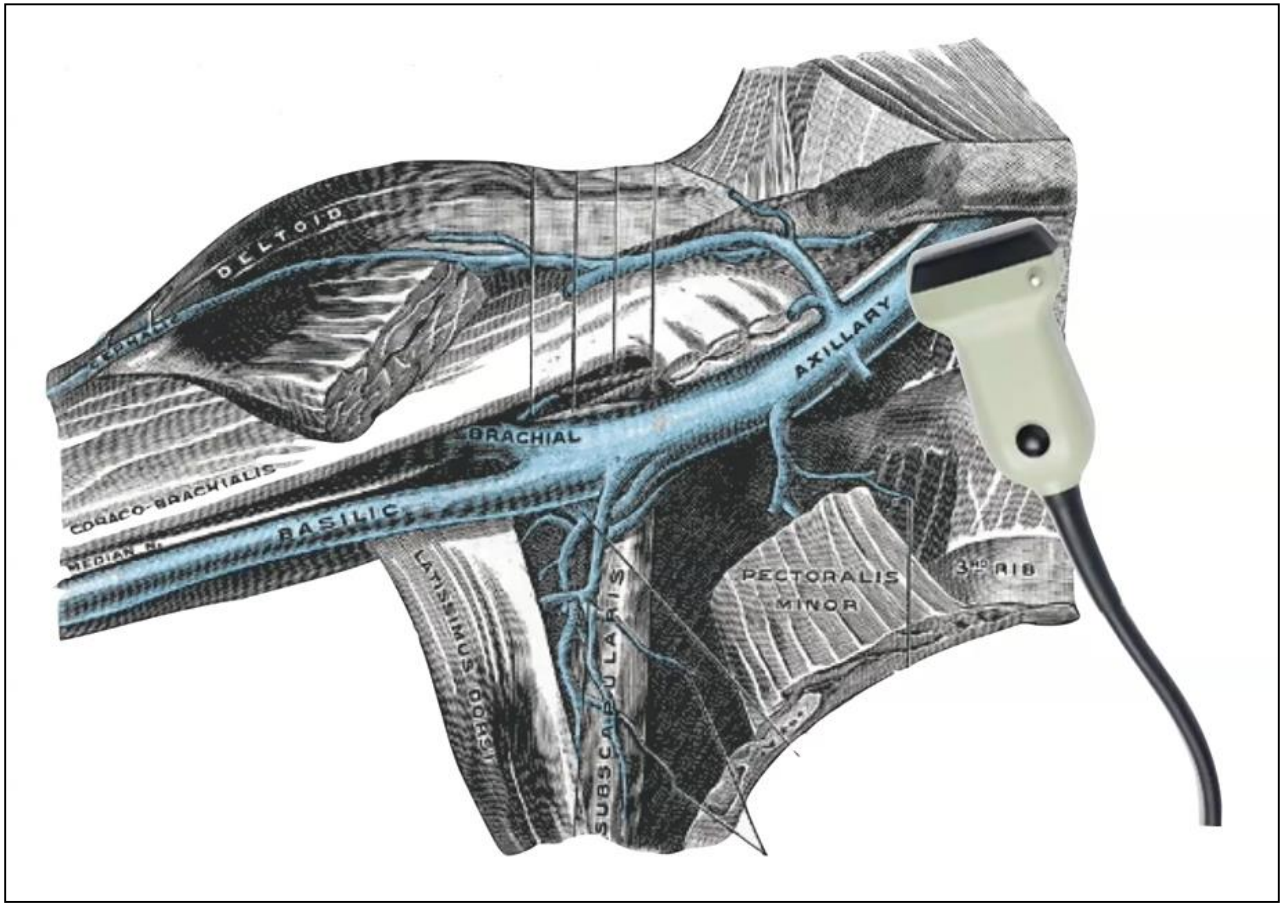
Subclavian Vein Cannulation

- Axillary vein
  - Many clinicians are actually accessing axillary vein
  - SCV is the continuation of the axillary vein and runs from the apex of the axilla across the first rib in the subclavian groove
  - lies entirely outside the rib cage

Subclavian Vein Cannulation

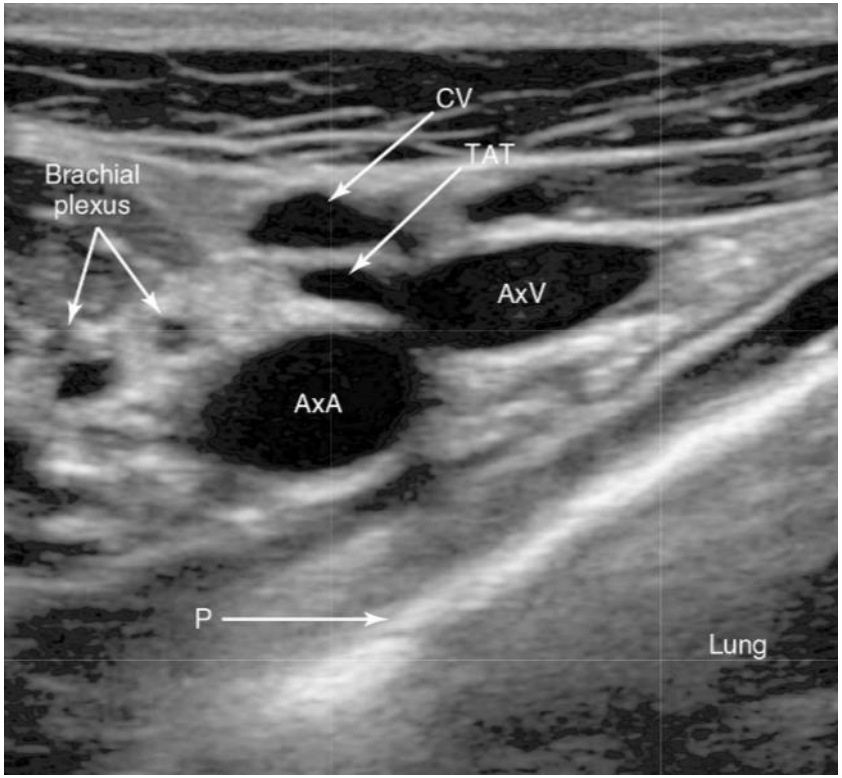
- Axillary vein
  - Infra-clavicular approach
    - Easy visualization with ultrasound
  - Greater distance between the pleura and vein
    - avoid pleural or lung damage
  - Real-time needle visualization
    - avoid injury to axillary artery and brachial plexus

Infra-clavicular approach



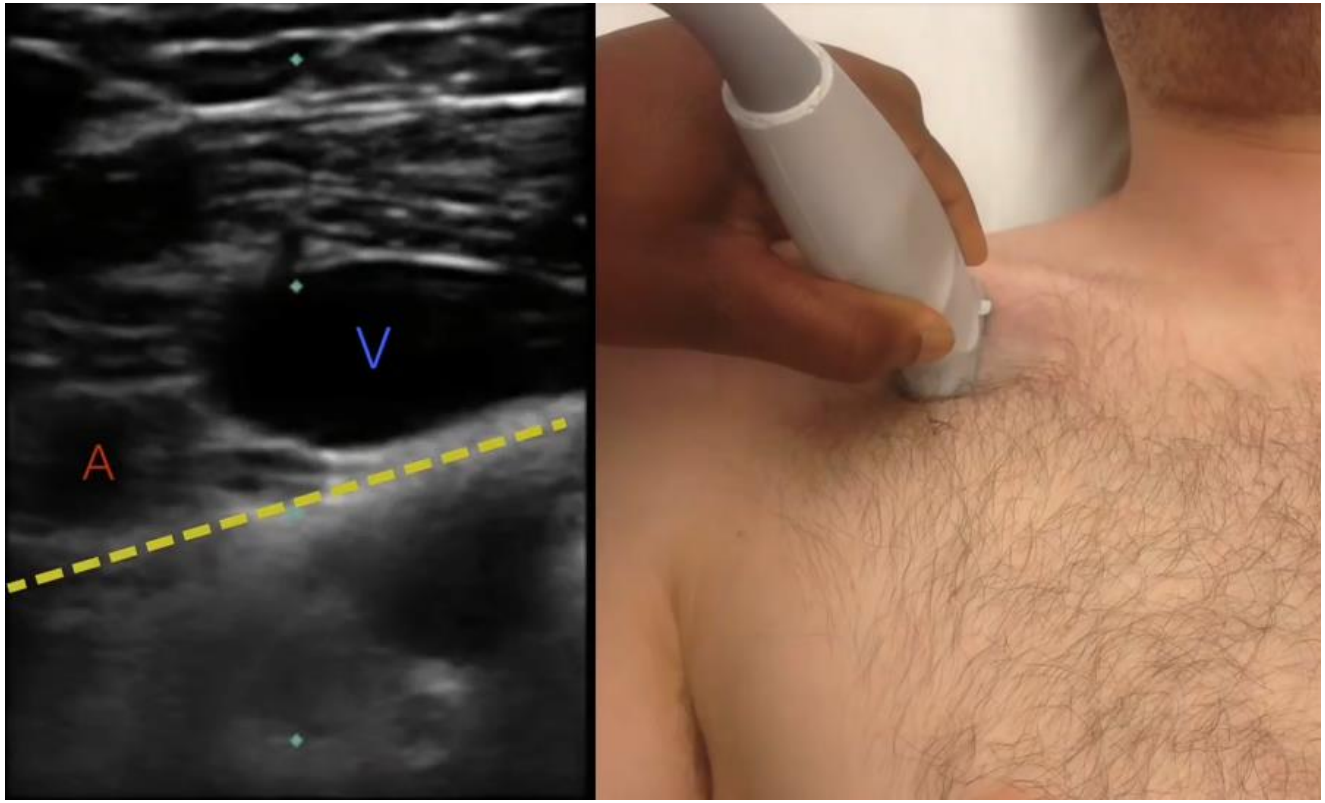
(Grant's Atlas of Anatomy)

Infra-clavicular approach



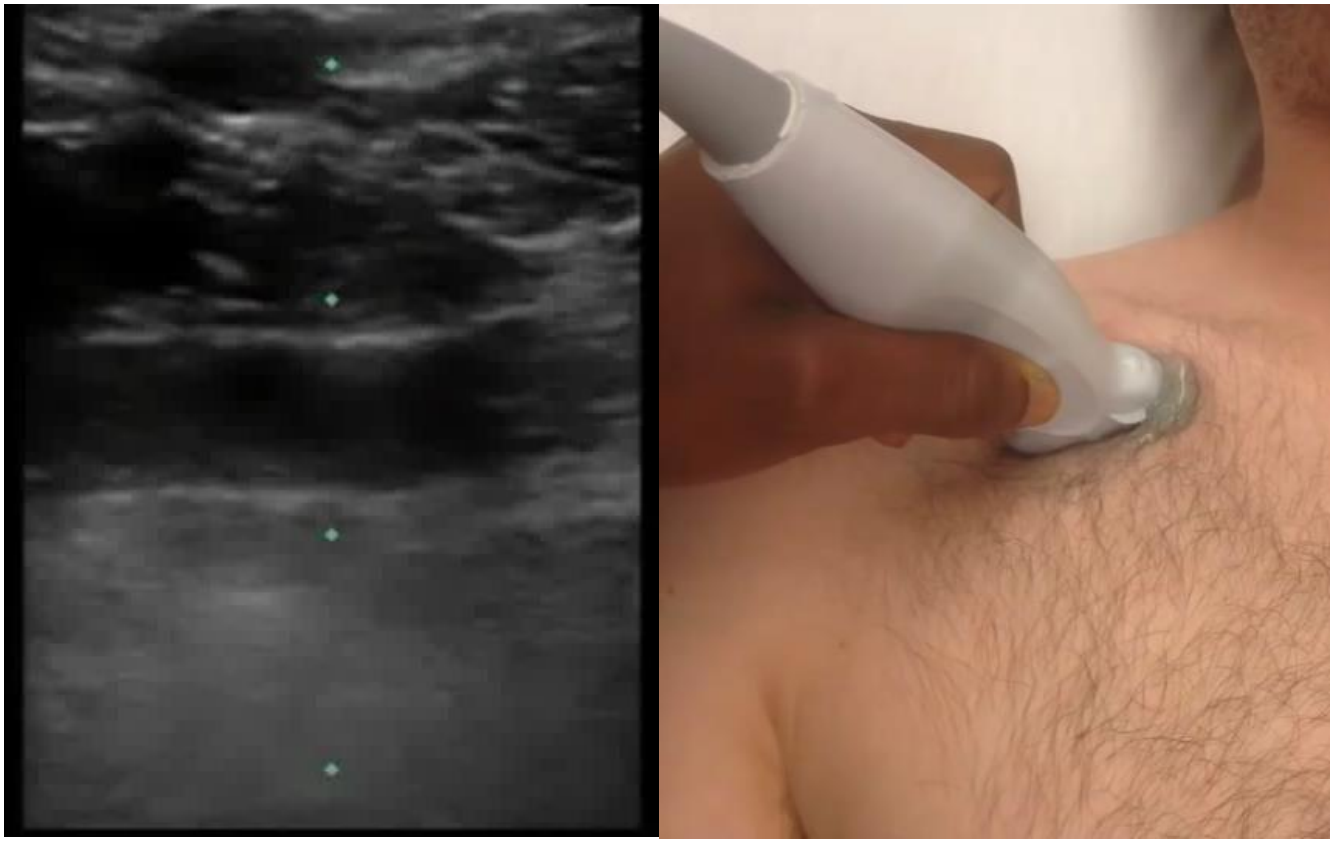
Right axillary artery (AxA) and vein (AxV) with the thoracoacromial trunk (TAT) branch in front, the cephalic vein (CV), and the pleura (P)

Short axis view



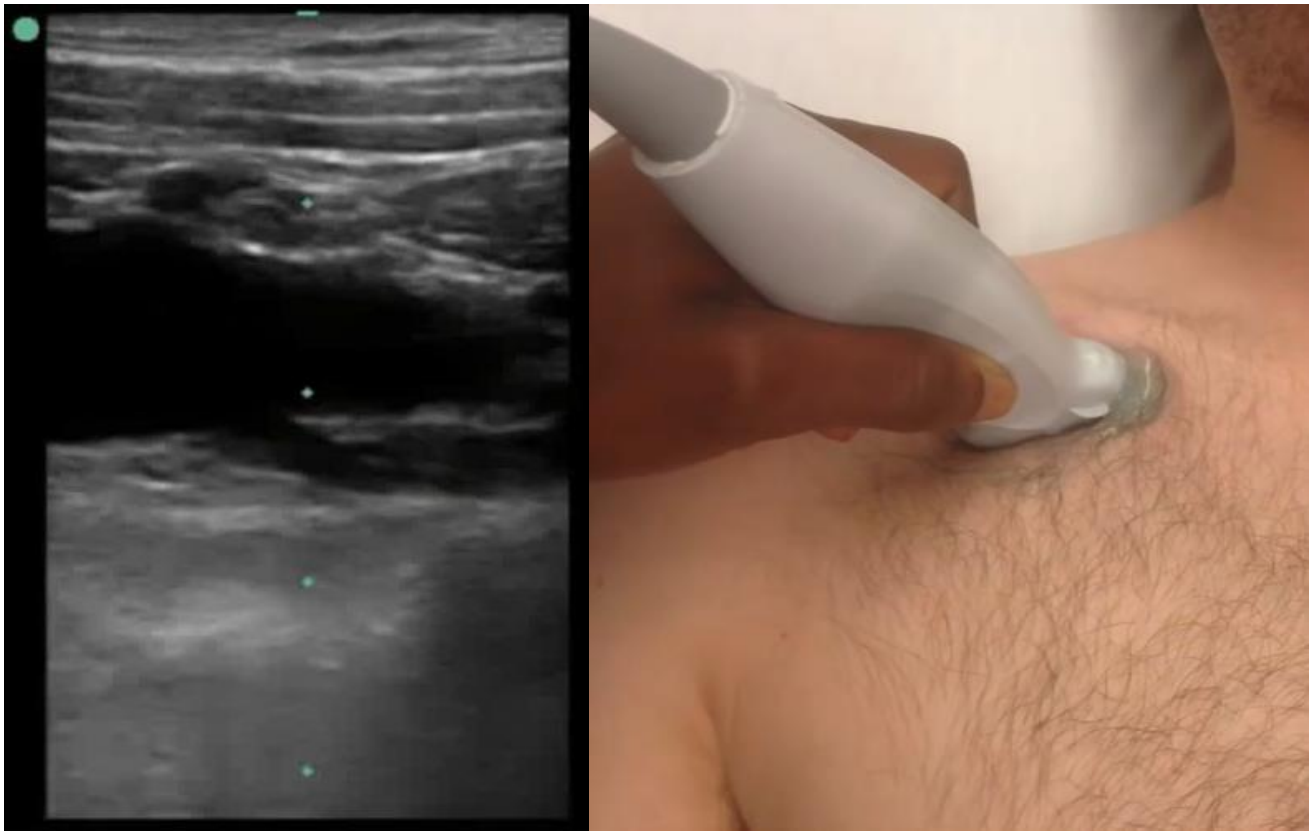
Axillary artery and vein over pleura

Long axis view



Axillary artery

Long axis view



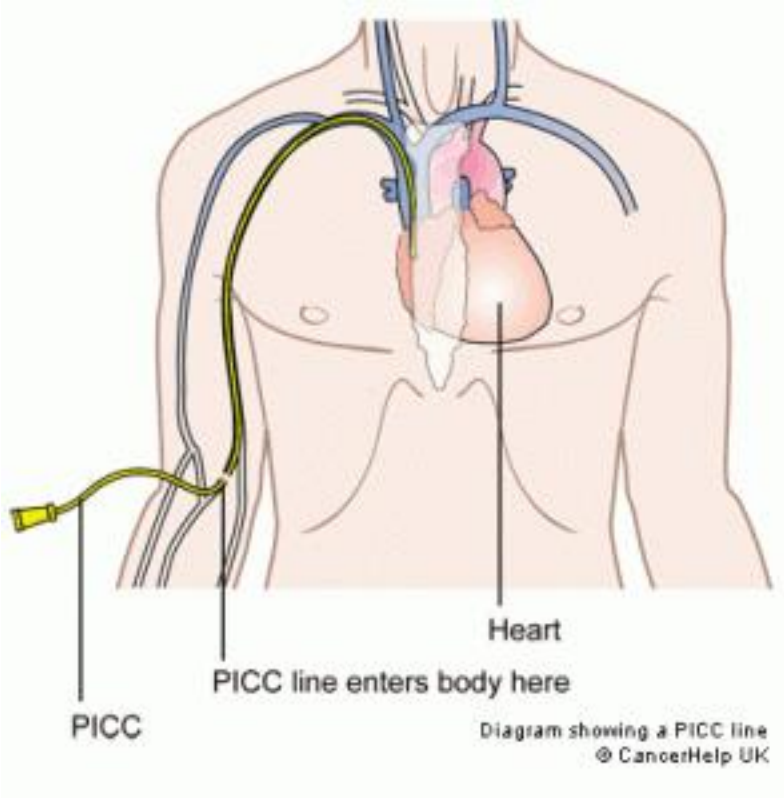
Axillary vein

Needle placement

Long axis approach

PICC

- Peripherally Inserted Central Catheter
- The need for prolonged intravenous therapy
- Insertion under US guidance into upper arm vein using modified Seldinger technique
- By radiologist, under fluoroscopy guidance



Upper arm veins

- Basilic vein
  - Most frequently accessed vein
  - runs in the groove between the humerus and the biceps muscle
  - usually has a large diameter (4~6 mm)
  - is located rather superficially (depth :10~25 mm)
  - Relatively distant from arteries and major nerves

Upper arm veins

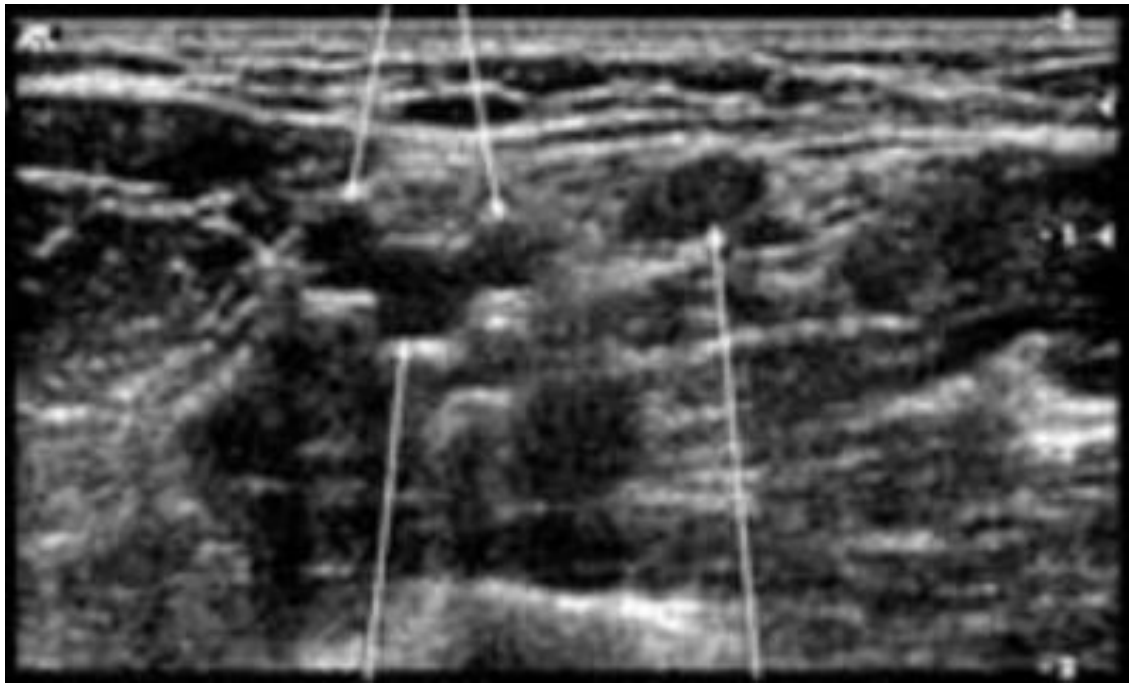
- Brachial veins
  - Alternative option
  - generally travel close to the brachial artery and the median nerve
  - Their number may range between two and four
  - are smaller (with diameters ranging from 1 to 4 mm)
  - usually travel medially and deeper than basilic vein

Upper arm veins

- Cephalic vein
  - Along the lateral side of the upper part of the arm quite superficially
  - displays a nonlinear trajectory
  - is not appropriate for PICC insertion

Upper arm veins

Brachial Veins



Brachial Artery

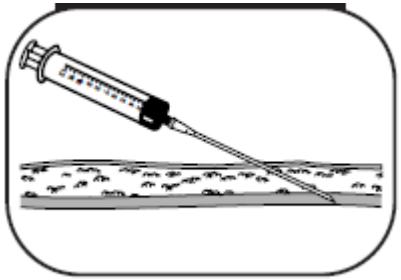
Basilic Vein

Choice of appropriate vein

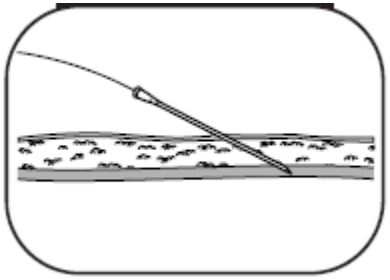
- Location
  - Mid to upper part of arm
  - Not deeper than 30 mm from surface of skin
- Size
  - At least 3X larger than catheter's size
    - To minimize the risk for venous thrombosis
  - Vein diameter (mm) should be larger than external diameter of catheter in Fr units
    - 3 Fr catheter should be placed in a vein 3 mm or larger

(Critical Care Ultrasound, 1e)

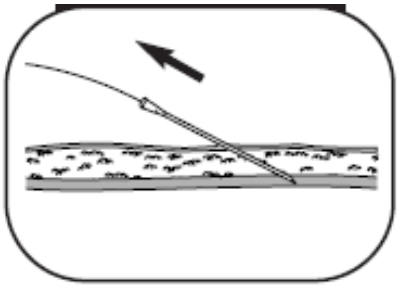
Modified Seldinger Technique



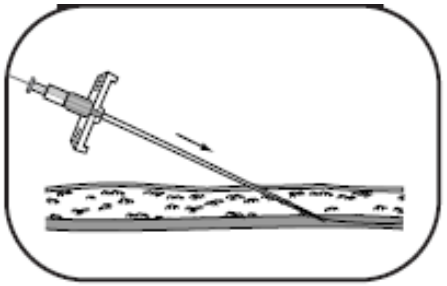
Venipuncture with small-gauze needle



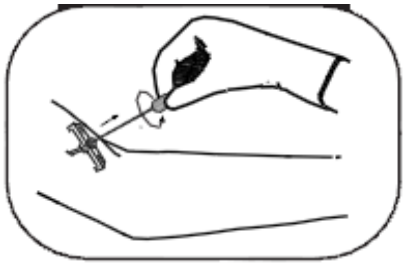
Insertion of thin guide wire through needle



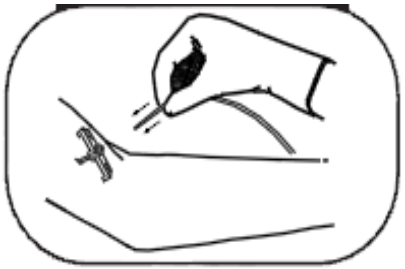
Removal of needle



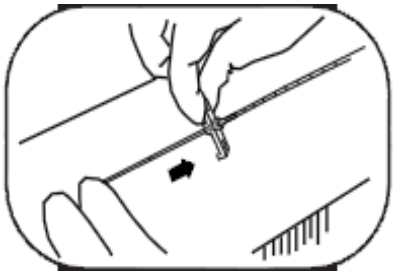
Insertion of microintroducer -dilator over the guide wire

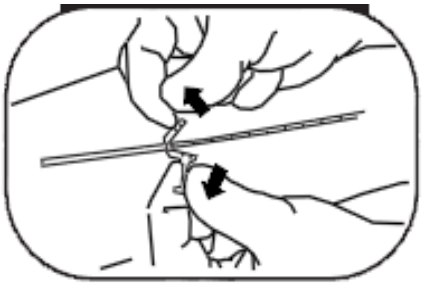


Removal of wire & dilator



Insertion of catheter through introducer





Retraction & removal of microintroducer sheath

Modified Seldinger Technique

(Critical Care Ultrasound, 1e)

Correct tip positioning

- Malposition : 7.9%

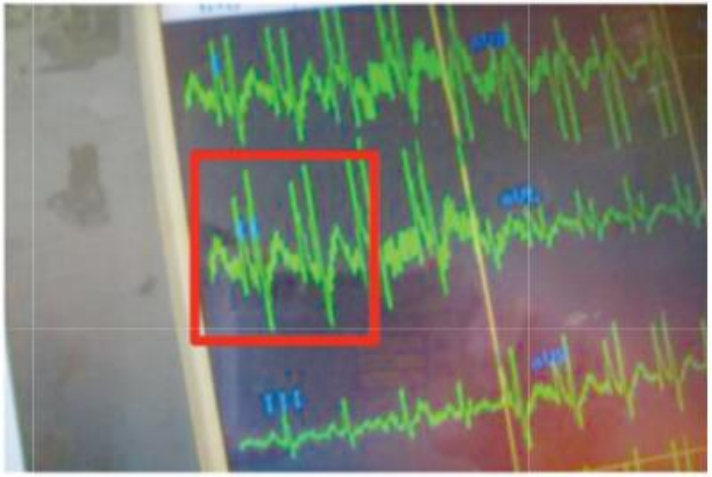
(Exp Ther Med. 2013 Oct; 6(4): 891–893)

- Ipsilateral IJV should be compressed
  - to facilitate passage of catheter from subclavian vein into brachiocephalic vein
- Ultrasound scan
  - Absence of the catheter in the IJV on both sides
  - TTE : guide wire in RA, A4C view

Method for assessing tip position

- Fluoroscopy
  - unavailable in ICU
- Portable X-ray
- Intracavitary ECG
  - Real-time intra-procedural assessment of catheter tip positioning
  - uses the catheter itself as an intra-cavitary electrode
  - Inexpensive, effective, simple and safe

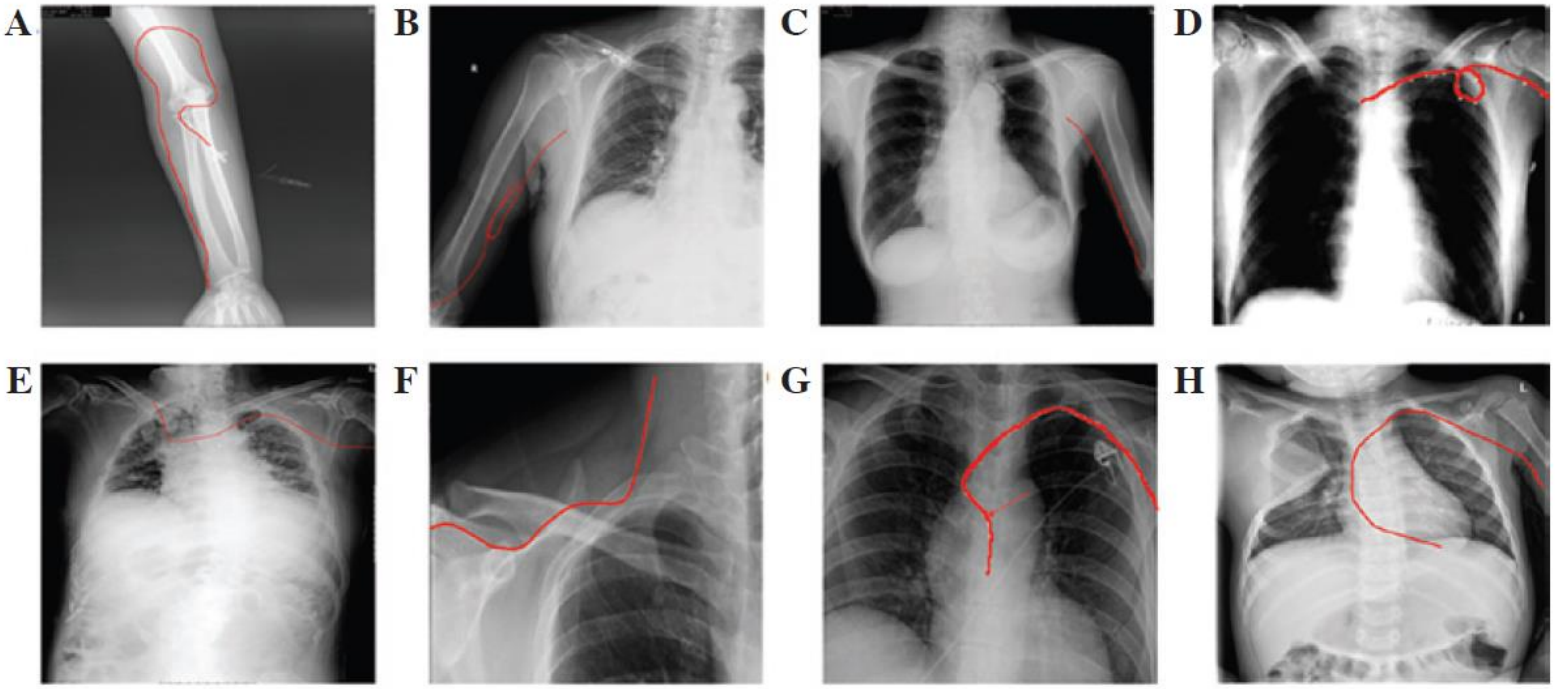
Intracavitary ECG



Maximal height of P-wave detectable when the catheter tip is at cavo-atrial junction

(Critical Care Ultrasound, 1e)

Malpositions of PICC

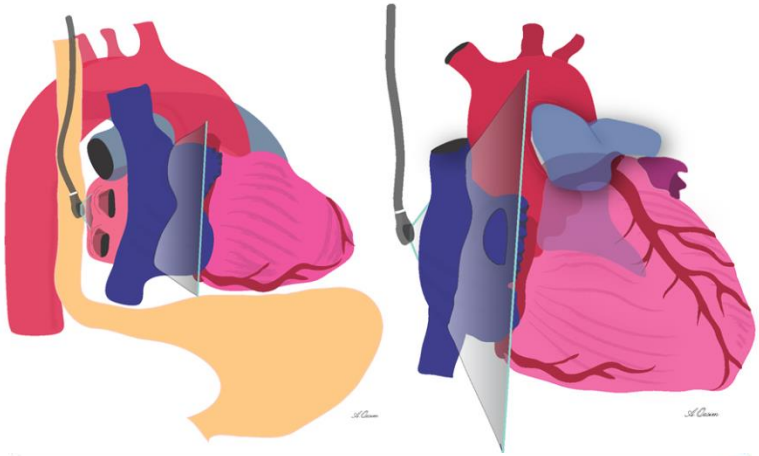


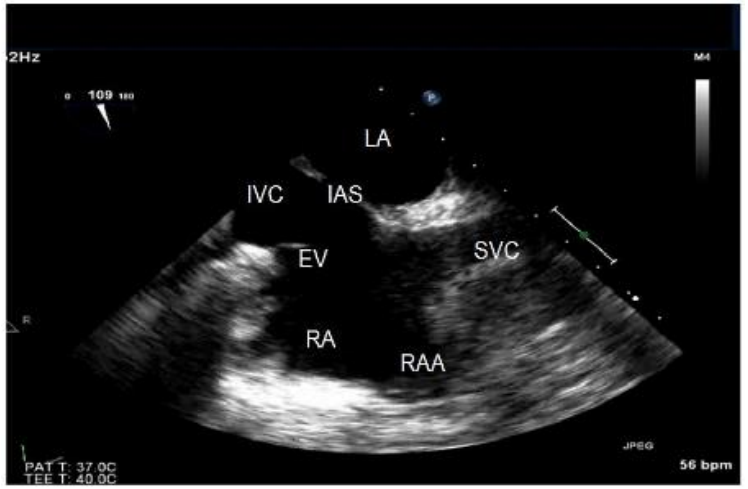
(A) bending in forearm; (B) bending in basilic vein; (C) stopping at armpit; (D) bending in subclavian vein; (E) entering contralateral subclavian vein; (F) entering jugular vein; (G) entering azygos vein; (H) entering right ventricle

(Exp Ther Med. 2013 Oct; 6(4): 891–893)

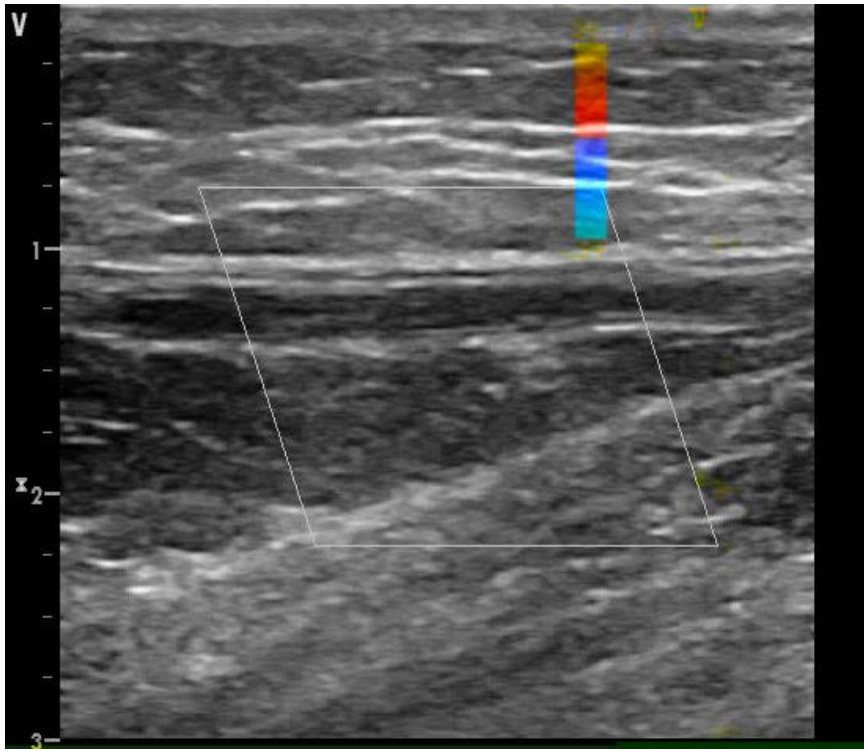
TEE : Mid-esophageal Bicaval View

- Mid-esophageal view (30cm)
- Multiplane angle forward to 90° to 110°
- Rotate the probe clockwise (toward right sided structures)
- View to look for PFOs, ASDs
- Excellent view to evaluate SVC, RA, IVC



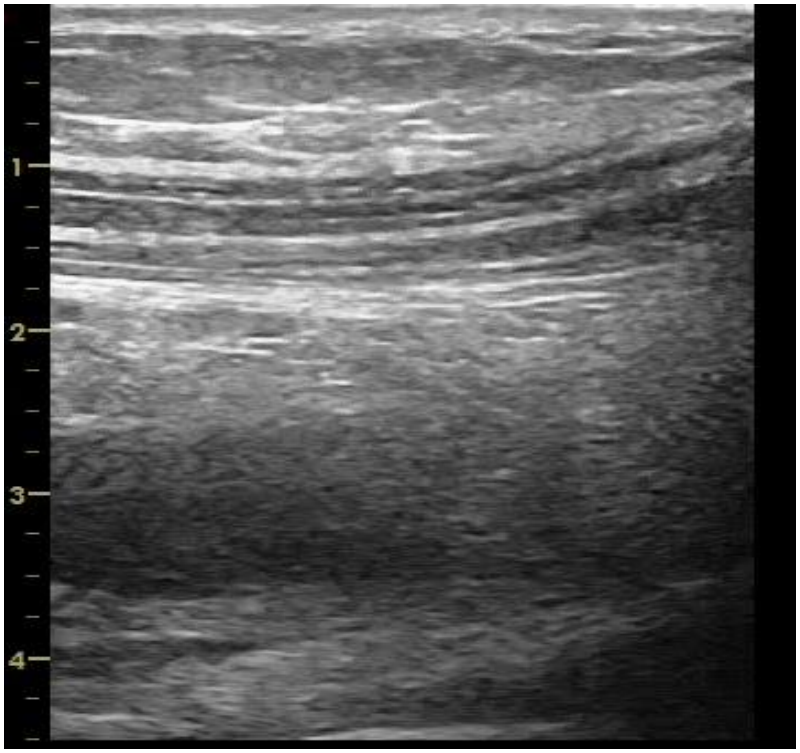


Bedside PICC insertion

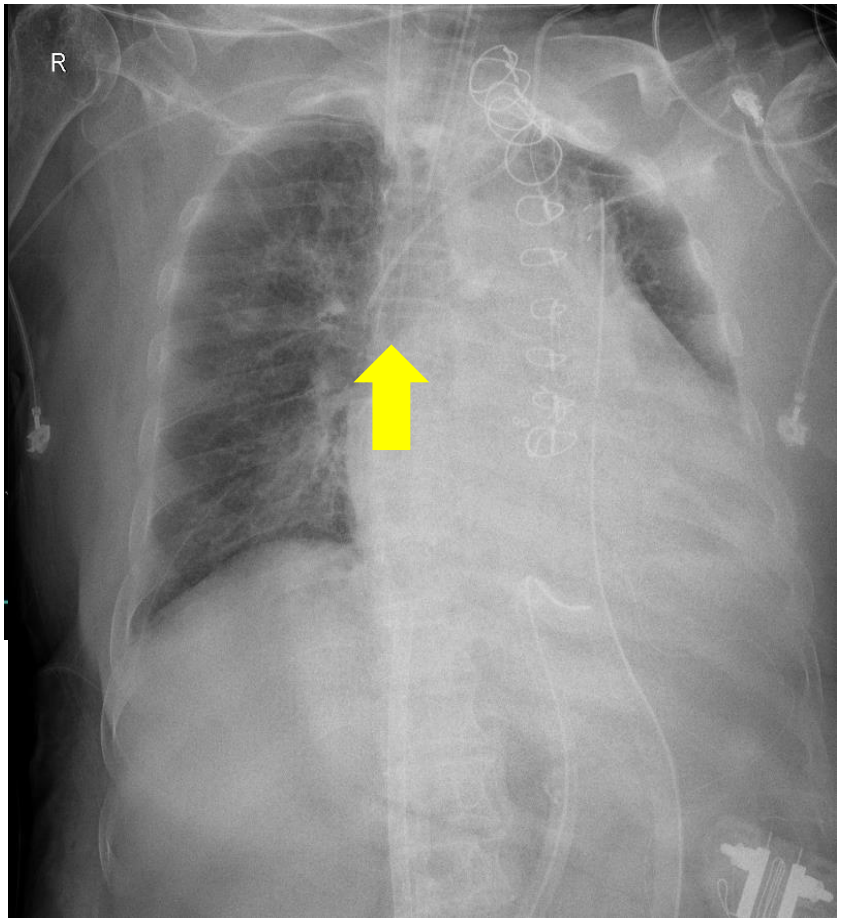


s/p AVR, postop. VA ECMO support, POD #16

Bedside PICC insertion



Bedside PICC insertion



Summary

- Ultrasound guided central venous access
  - Safe and effective in comparison to anatomic landmark based techniques
  - is recommended in the international guideline
  - Essential technique
    - Assessment of vessel
    - Needle tip tracking with ultrasound
  - requires considerable experience and practice


practice
MAKES
Perfect