Editing file

Vascular Access

Objectives:

- Examine the construction of the commonly used venous catheters.
- Anatomical considerations regarding peripheral and central venous access.
- Choice of catheter size.
- Prepare and set-up an IV infusion set.
- The choice of sites for placement of IV catheters.
- What are the different sites suitable for central venous catheter and arterial catheter placement?
- Universal precautions.
- Indications and complications of central venous access
- Indications and complications of arterial access

Color index:

- Red: important /
- Black: content slides
- Gray: extra
- Green: dr. Notes

IMPORTANT

Anesthesia 438 teamwork

Vascular Access

Medical Asepsis:

- Removal or destruction of disease causing organisms or infected material:


1. Sterile technique (surgical asepsis)


2. Clean technique

Antiseptics and Disinfectants:

- Chemical agents used to kill specific microorganisms.
- Some chemical agents have antiseptic and disinfectant properties

Disinfectants

(e.g. Bleach)

- Used on non-living objects
- Toxic to living tissue

Antiseptics

(e.g. alcohol, iodine)[1]

- Applied to living tissue
- More dilute to prevent cell damage

Universal Precautions:

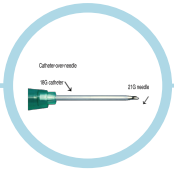
Universal standard precautions on every patient:

- Observe **hand washing** and gloving procedures [2].
- **Face shields** indicated during clean procedure.
- **Sterile gowns** plus above all for sterile procedures [3].

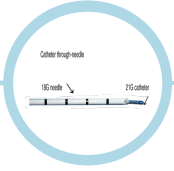
Types of IV catheters

Hollow needles

- Butterfly type [4]



Indwelling plastic catheter over hollow needle



Indwelling plastic catheter inserted through a hollow needle

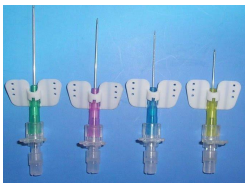
- Intracath

1- Iodine is bacteriostatic (reduce the no. of organisms doesn't kill the bacteria) and after applying it you have to wait for 5mins to let it dry . Alcohol is bactericidal (kills the bacteria) applied to kill the leftover microorganism on the skin.
2- For clean procedure —> non sterile gloves and hand washing, for sterile procedure (e.g. arterial line) —> sterile gloves.
3- Have to wear gown in any procedure that involves exposure to the internal tissue like like CVP or epidural insertion.
4- Commonly used in the NICU.

Vascular Access

Needles:

- Vary in length and gauge
- Larger gauge means smaller needle



The colors are universal.
18 gauge, 20 gauge for adults or good veins or transfusion of large volume of fluid or blood transfusion
22 gauge, 24 gauge for infants/pediatric

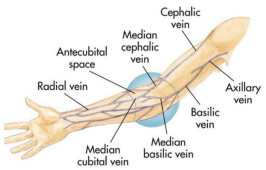
Peripheral IV Insertions

Insertions

Common sites

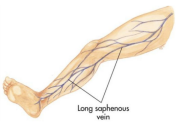
- Hands and arms [1]
- Antecubital fossa (AC space)

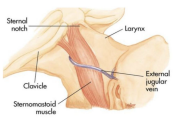
AC space : Not a routine site(not practical) ?
It crosses the joint , flexion may destroy the cannula.
Catheters should not cross joints.



Alternate sites

- Long saphenous veins [2]
- External jugular veins [3]





Embolism and infection rates are higher

Avoid sites

that have injury or disease:

- Trauma [4]
- Dialysis fistula

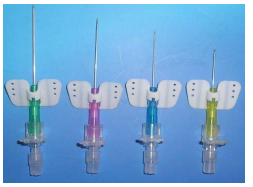
may destroy the AV fistula due to infection or thrombosis.

- History of mastectomy [5]

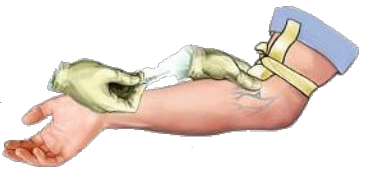
1- More pronounced in the dorsal side of the hand.
2- Close to the medial malleolus
3- When you tilt the patient's head down the vein will be more prominent and easily accessed. Used in difficult situations (not preferable place) or in pediatric cases.
4- At the site of insertion like skin break, surgery on the same limb
5- In mastectomy we remove the lymph nodes of the same side. In case of extravasation or infection it may not clear very easily or be more damaging . So better to avoid insertion in the same side

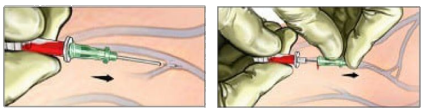
Vascular Access

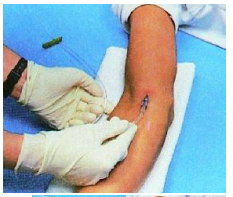
Peripheral IV Procedure:

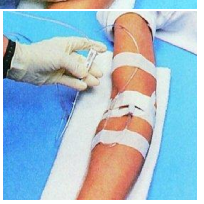


1. Explain procedure
2. Assemble equipment
3. Inspect fluid for contamination appearance, and expiration date
4. Prepare infusion set
    - Attach infusion set to bag of solution
5. Clamp tubing and squeeze reservoir on infusion set until it fills half way
6. Open clamp and flush air from tubing
7. Close clamp
8. Maintain aseptic technique IV drip
9. Select catheter:
    - Large-bore catheter used for fluid replacement -> 14 to 16 gauge
    - Smaller bore catheter used for "keep open" lines -> 18 to 20 gauge
10. Prepare other equipment
11. Put on gloves Clean procedure (hand washing + non-sterile gloves)
12. Select site
13. Apply tourniquet above antecubital space To cause the veins to engorge(more prominent)so easier access
14. Prepare site
15. Cleanse area with alcohol or iodine wipes (per protocol)
    - Check for iodine allergy
16. Stabilize vein with your fingers (thumb and index) to prevent double puncture of the vein
17. Apply pressure and tension to point of entry
18. Bevel of the needle : up in adults - may be down in infants and children
19. Pass needle through skin into vein from side (indirectly) or directly on top
20. Advance needle and catheter about 2 mm past point where blood return is seen in hub of needle
21. Slide catheter over needle and into vein
22. Withdraw needle while stabilizing catheter
23. Lock in protective sheath if present
24. Apply pressure on proximal end of catheter to stop escaping blood
25. Obtain blood samples if needed
26. Release tourniquet
27. Attach IV tubing
28. Open tubing clamp and allow fluid infusion to begin at prescribed flow rate if the catheter is in the right place the fluid will flow freely without the need to put a pressure
29. Cover puncture site dressing
30. Antibiotic ointment if indicated by protocol
31. Anchor tubing To prevent dislodgement
32. Secure catheter
33. Document procedure (type and size of catheter, which side did you insert the catheter and in which limb, mention that there's no double puncture, extravasation or dislodgement, vital signs, any complications like redness itching...etc.)
34. Monitor flow if not running freely or there is difficulty it may be displaced or blocked









Vascular Access

Local complications

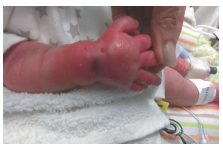
- Pain and irritation
- Infiltration and extravasation (immediate complication)
- Phlebitis
- Thrombosis and thrombophlebitis
- Hematoma formation (immediate complication)
- Venous spasm
- Vessel collapse
- Cellulitis
- Nerve, tendon,ligament, and limb damage

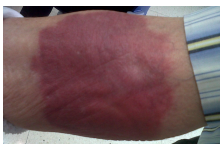
Infiltration [1]

Causes:

- Dislodgement of catheter or needle cannula during venipuncture [2]
- Puncture of vein wall during venipuncture (double puncture of the vein)
- Extravasation: Leakage of solution into surrounding tissue from insertion site
- Poor vein or site selection
- Irritating solution inflamed vein intima [3]
- Improper cannula size [4]
- High delivery rate or pressure
- Poorly secured IV [5]

Sign and symptoms:





- Cool skin around IV site
- Swelling at IV site
  - With or without pain
- Sluggish or absent flow [6]
- Infusion flows when fluid is pushed forcefully
- No backflow of blood into IV tubing when clamp is fully opened and solution container is lowered below IV site (reconfirmation of the infiltration)

1- Serious complication of IV insertion. Happens in the time of the procedure or later on . Might cause arterial compression and occlusion of the blood supply or compression of the nerves, sometimes we may need surgical incision to release the pressure on these imp. structures.
2- Happens especially if the catheter was inserted in unstable area such as between joints, it may dislodge and enter the subcutaneous tissue
3- Hypertonic solutions like bicarbonate, potassium solution, some antibiotics or solution with high PH which may burn the skin or vein
4- Most common cause -> cannula bigger than the vein
5- Displace easily
6- Normally the flow should run freely without resistance

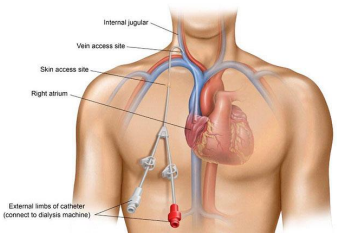
Vascular Access

Management:

- Lower fluid reservoir to check for presence of backflow of blood into the tubing
  - Absence of backflow suggests infiltration
- Discontinue IV infusion
- Remove needle or catheter
- Apply a pressure dressing to the site to reduce swelling
- Choose new site
- Initiate IV therapy with new equipment
- Document [1]

Central IV Insertions [2]

- Requires special training
- Authorization from medical direction
- Not for rapid fluid replacement in pre-hospital setting [3]
- Within scope of paramedic practice in some EMS systems
- Prepare as for peripheral veins [4]



Common sites include [5]

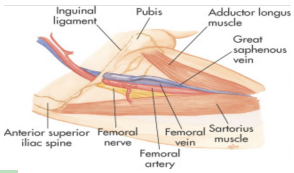
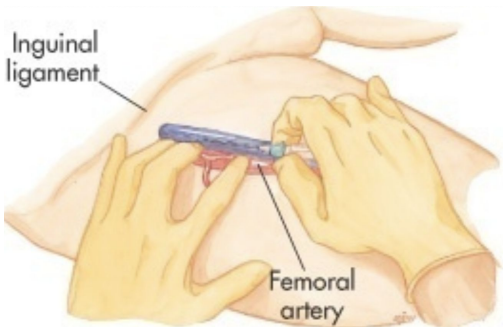
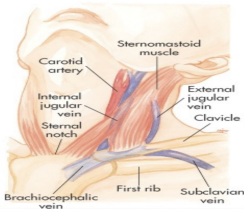
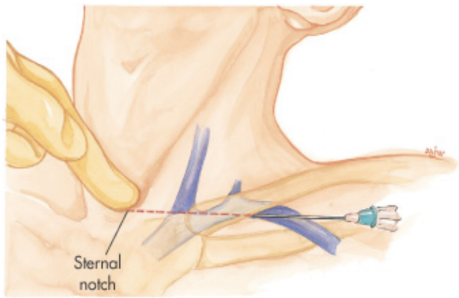
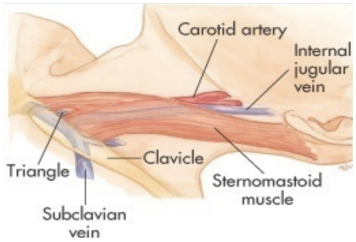
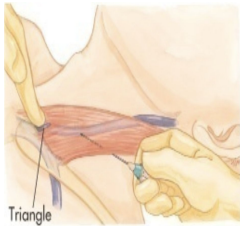
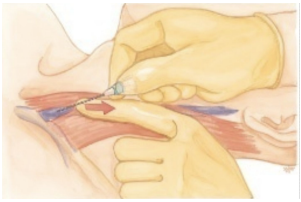
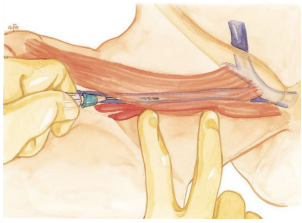
- Femoral vein
  to get access to IVC
- Internal jugular vein
  to get access to SVC
- Subclavian vein
  to get access to SVC

Success depends on

- Patient's body position
- Knowledge of anatomy
- Familiarity with the procedure and equipment

1- Keep monitoring the area regularly for any skin break, infection, any compromise or compression of the vein, nerve, or artery
2- To get access to big veins e.g. IVC or SVC. Done on awake or anesthetized patient. Used for monitoring or taking samples.
3- e.g. trauma cases (peripheral IV access is preferred),
4- The difference is CVC is sterile procedure requires: hand washing, sterile glove, sterile gown, mask + sterile equipments
5- Axillary vein also can be used to access SVC as well

Types of central Venous Access

Vein	Anatomy	Cannulation MCQs
Femoral vein [1]	 VAN Feel the pulse(artery) below inguinal ligament and go medial it is the femoral vein lateral is the femoral nerve	
Subclavian vein [1]	 Under (posterior) to the medial third of the clavicle	Can get access to the vein behind the clavicle. Needle direction is to the manubrium sterni and the needle entry is below the medial ⅓ of the clavicle. 
Internal Jugular vein [1]	 It descends in the carotid sheath lateral to the internal carotid artery. and then lateral to the common Carotid artery. Behind the sternocleidomastoid muscle and between the two heads of it.	Posterior approach: (from the posterior border of sternocleidomastoid muscle) High Approach (Direction of needle insertion to the contralateral nipple) Risk of : -Puncturing vertebral artery -Injury to cervical plexus  Central approach: (in between the two heads of sternocleidomastoid) near the apex of the lungs. Risk of: -Pneumothorax -Hemothorax -Air embolism Which are fatal complications  Anterior approach: (from the anterior border of sternocleidomastoid) its higher approach (close to the carotid artery) (Direction of needle insertion to the ipsilateral nipple) Risk of: -Carotid puncture -Extravasation If you go deep may lead to Vertebral artery puncture. 

1- Can be inserted blindly but nowadays Ultrasound guidance has become standard to use it because it helps to avoid complications and increase the success rate

Vascular Access

Central Venous Access:

Advantages/indications:

- Available when peripheral vessels collapse [1]
- Access to central pressure measurement (In-hospital procedure) check volume status e.g., in pulmonary edema cases
- Safer vasopressor administration [2]
- Administration of irritant fluids [3]

Disadvantages:

- Excessive time for placement
- Sterile technique if not it might end up with sepsis
- Special equipment
- Skill deterioration
- High complication rate: Pneumothorax, arterial injury, abnormal placement, carotid puncture
- Chest x-ray should be obtained immediately [4]
- Can't initiate during other patient care activities
- Not generally considered to be a useful prehospital technique
- Lower flow rates than peripheral IV (not good for rapid infusions)

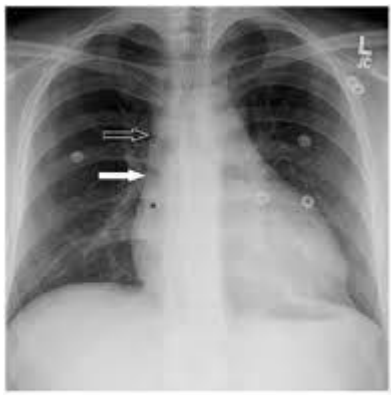


Fig. 5 – Frontal chest radiograph demonstrating the right lateral wall of the superior vena cava (open arrow) and the junction of the lower SVC with the superior convexity of the right cardiac border (SVC-RAA junction) (closed arrow). The cavoatrial junction (*) lies approximately 1–2 cm below SVC-RAA junction in adults.

1- e.g. morbidly obese patients or chemotherapy patients or if peripheral veins are already being used
2- If the patient is on inotrope (eg, epinephrine or norepinephrine) if given peripherally it will take longer time to reach the central circulation
3- e.g. Bicarbonate, potassium solution, all chemotherapy these substances can destroy the peripheral vein easily (thrombophlebitis, if extravasation can damage the skin as well)
4- To confirm that the catheter is in the right place (SVC), and rule out pneumothorax. The best position of the catheter should be at the lower level of the second rib or upper border the third rib, below this you may enter the right atrium and increase chances of arrhythmias

Vascular Access

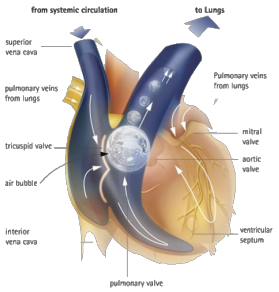
Complications

- **Femoral vein:**
  (Local complications, Systemic complications)
- **Internal jugular and subclavian veins:**
  (Local complications, Systemic complications)

Systemic complications

- Contamination and infection
- Hypersensitivity reactions
- Sepsis [1]
- Emboli (blood clot, air, and catheter)
- Speed shock

Air Embolism:[2]

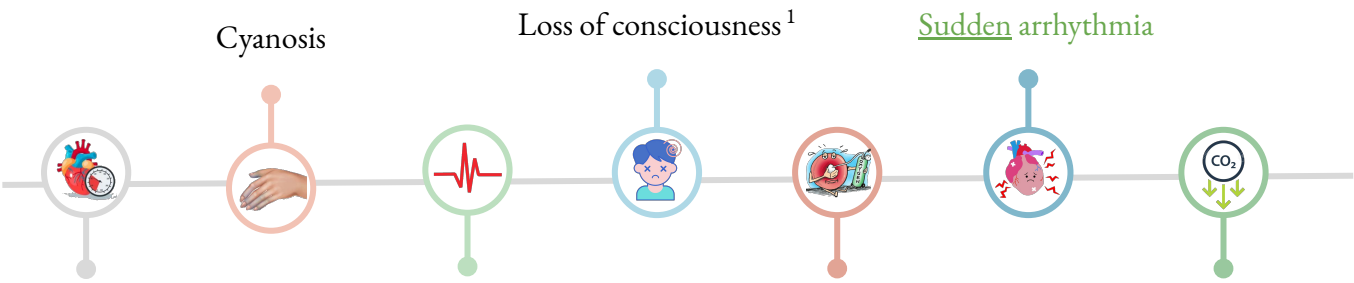


- Uncommon but can be fatal
- Air enters the bloodstream through catheter tubing [3]
- Risk greatest with catheter in central circulation:
  Negative pressure may pull air in
- Air can enter circulation
  - During catheter insertion
  - If tubing is disconnected
- If enough air enters the heart chamber [4]: (depends on how much air and the speed of the air)
  - Blood flow is impeded.
  - Shock develops

1- Line sepsis (lead to admission to the ICU) , so be very careful in fixation, giving drugs, or attaching and do everything in a sterile way
2- Increase incidence of air embolism in head and neck surgeries.
3- During insertion and later on as well, so be very careful while handling the catheter to avoid air embolism.
4- After entering the heart the bubble will enter the pulmonary artery, if it is big enough it will occlude the whole artery and blood will not flow from right to left atrium leading to sudden decrease in cardiac output so it will manifest as shock like condition and it will happen suddenly after the patient was hemodynamically stable

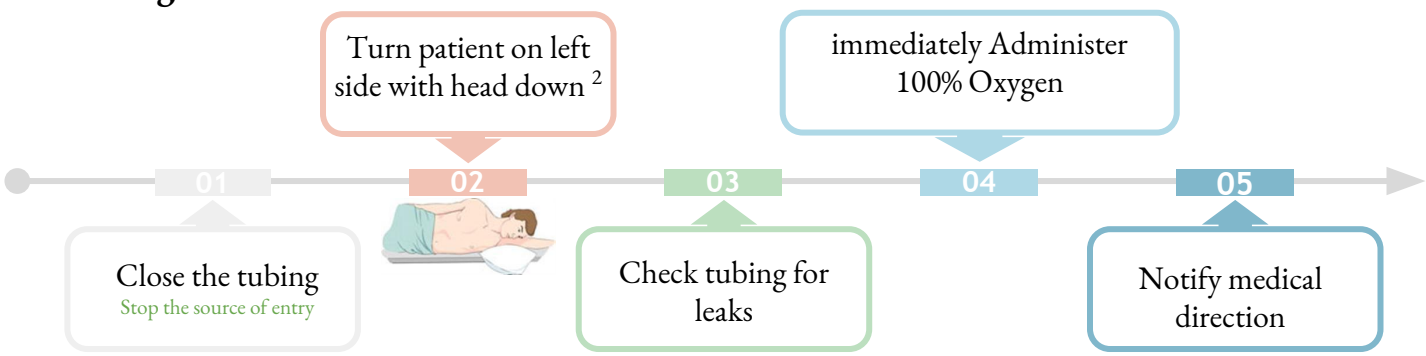
Air Embolism

Sign and symptoms:



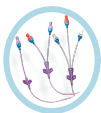
* rule out other causes like if the patient is a trauma case suspect bleeding (S&S of air embolism develop suddenly without any evidence of blood or fluid loss)

Management:



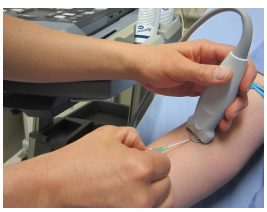
Indwelling Vascular Devices:

Heparin or saline lock [3]

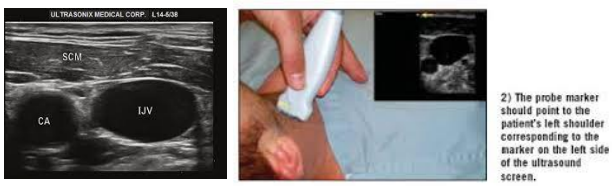


Single-, dual-, and triple-lumen catheters [4]

Venous access insertion:[5]



US guided IV insertion



US guided CVC insertion

1- Due to decreased blood supply to the brain
2- This will the allow bubble to move to the apex of the heart by the gravity and restore blood flow to the pulmonary artery, then you can put your catheter on and aspirate the bubble.
3- It stops over spelling of the blood after inserting the catheter
4- The more the lumens, the more the chances of infection which might lead to sepsis
5- US allows insertion of catheter with minimal complications rate
-How to prevent air entry while doing the procedure? While doing the procedure air can enter to the circulation if the tip of the catheter is above (higher) than the heart and it's open so prevent it by lowering the tip of the catheter below the heart and close it
-Detection of air embolism: Imaging takes time (CT, MRI), The most common way of detection is clinical judgment and sudden drop in end tidal co_2, also by auscultation using stethoscope and you will hear the gurgling sound (bubbling sound)

Vascular Access

Arterial line placement

Provide Continuous BP monitoring

Arterial blood sampling

Arterial line placement indications:

Inability to use indirect BP monitoring (eg, in patients with severe burns or morbid obesity) [1]

Continuous arterial beat to beat change in BP monitoring
-more accurate than NIBP (non invasive blood pressure monitoring)

Frequent blood sampling [2]

Frequent arterial blood gas sampling [3]

Contraindications for arterial line:

Absolute	Relative
• Absent pulse • Thromboangiitis obliterans (Buerger disease) • Full-thickness burns over the cannulation site or skin break or infected skin • Inadequate circulation to the extremity • Raynaud syndrome • Any Peripheral vascular disease	• Anticoagulation • Atherosclerosis • Coagulopathy • Inadequate collateral flow e.g. old diabetics • Infection at the cannulation site • Partial-thickness burn at the cannulation site • Previous surgery in the area • Synthetic vascular graft

1- Indirect BP monitoring =measured using non-invasive pressure cuff
2- ICU patients for monitoring and frequent blood sampling
3- Like In major vascular surgeries, cardiac surgeries and neurosurgeries or in patients you're expecting large fluid shift. And in critical patients like ischemic heart disease.

Vascular Access

Technical considerations:

Not entirely without risks

Requires appropriate knowledge of the anatomy and procedural skills.

Arterial line placement is considered a safe

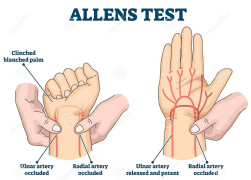
Major complications that is below 1%.

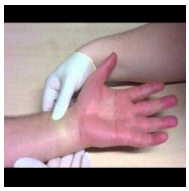
Common site of cannulation:

- **Radial**
- Ulnar
- Brachial and axillary
- Posterior tibial
- **Femoral**
- **Dorsalis pedis arteries**

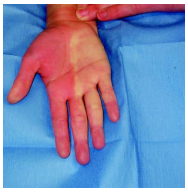
Allen test

- The Allen test is a worldwide used test to determine whether the patency of the radial or ulnar artery is normal.
- It is performed prior to radial cannulation or catheterization.
- The test is used to reduce the risk of ischemia to the hand [1].
- Instruct the patient to clench his or her fist OR hand tightly.
- Using your fingers, apply occlusive pressure to both the ulnar and radial arteries, to obstruct blood flow to the hand.
- While applying occlusive pressure to both arteries, have the patient relax his or her hand, and check whether the palm and fingers have blanched. If this is not the case, you have not completely occluded the arteries with your fingers





Positive



Negative

1- It is used to ensure the adequacy of blood supply of the hand and to ensure that the arterial cannulation will not compromise the blood supply.

Vascular Access

Release the occlusive pressure on the ulnar artery

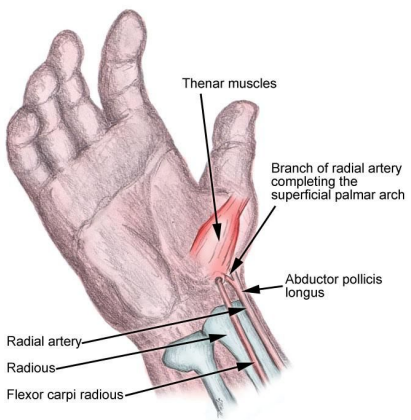
Positive modified Allen test: hand flushes within 5-15 seconds it indicates that the ulnar artery has good blood flow [1] ; this normal flushing of the hand is considered to be a **positive test.**

Negative modified Allen test: [2]
If the **hand does not flush within 5-15 seconds**, it indicates that ulnar circulation is inadequate or nonexistent; in this situation, the radial artery supplying arterial blood to that hand should not be punctured.

Anatomic Consideration:

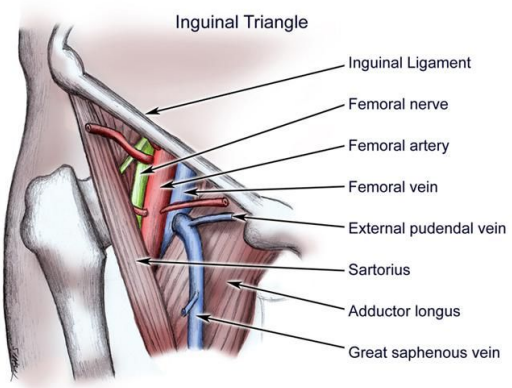
Radial Artery

- Originates in the cubital fossa from the brachial artery
- At the wrist, the radial artery sits proximal and **medial** to the radial **styloid process** and just **lateral** to **the flexor carpi radialis** tendon.



Femoral Artery

- Originates at the inguinal ligament from the external iliac artery
- **Medial** to the femoral **nerve** and **lateral** to the femoral **vein** and lymphatics.

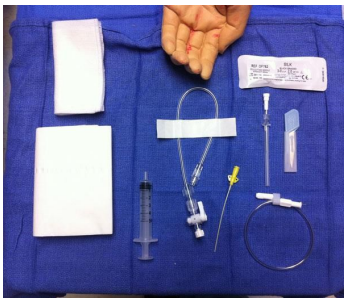


1- Also means good collateral circulation
2- If -ve test, it is better to avoid arterial line. You may lose the hand if done

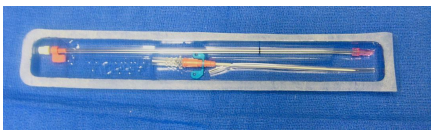
Vascular Access

Arterial line placement

1- Equipment:



1. Sterile gloves, gauze, and towels
2. Chlorhexidine or povidone-iodine skin preparation solution
3. 1% Lidocaine needle
4. 5-mL syringe
5. Appropriate-sized cannula for artery
6. Scalpel (No. 11 blade)
7. Non-absorbable suture (3-0 to 4-0)
8. Adhesive tape or strips
9. Sterile non-absorbable dressing
10. Three-way stopcock
11. Pressure transducer kit
12. Pressure tubing
13. Arm board of appropriate size for the patient (eg, neonate, pediatric, adult)
14. Needle holder
15. Intravenous (IV) tubing T-connector



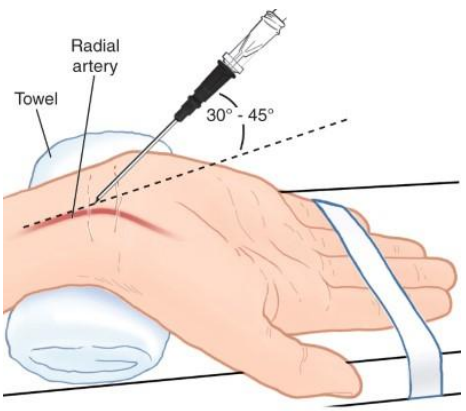
2- Patient preparation:

Unconscious patient may not be a problem
- Anesthesia/ Sedation is not required.

Conscious patient
- provided LA -lidocaine 1%. [1]

Uncooperative patient
- sedation or general anesthesia may be required.

3- Positioning:



The patient is placed in the supine position.

The arm is placed up on a flat surface in neutral position, with the palm up and the wrist adequately exposed.

The wrist is dorsiflexed to 30-45° and supported in this position with a towel or gauze under its dorsal aspect.

1- Because it's More painful than vein

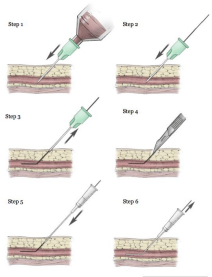
Vascular Access

4- The most commonly used methods:

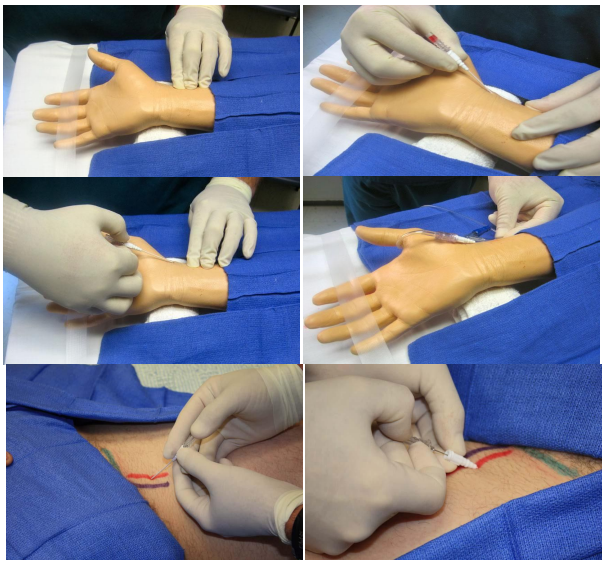
- Catheter over needle
- Catheter over wire (including direct Seldinger and modified Seldinger techniques)

5 steps for Seldinger techniques: IMPORTANT

1. Get access to the artery with the needle → blood will come out
2. Put the wire into the needle
3. Remove the needle
4. Once the needle is removed put the catheter over the wire and place it to the artery
5. Remove the wire
6. Fix the catheter

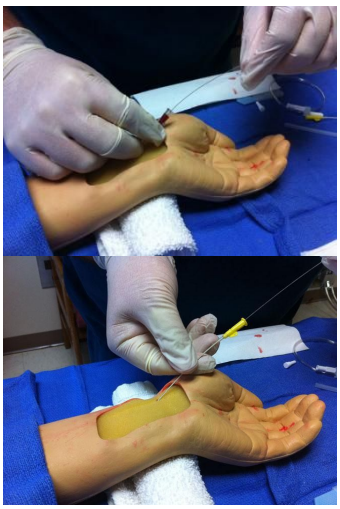


Catheter over needle technique [1]



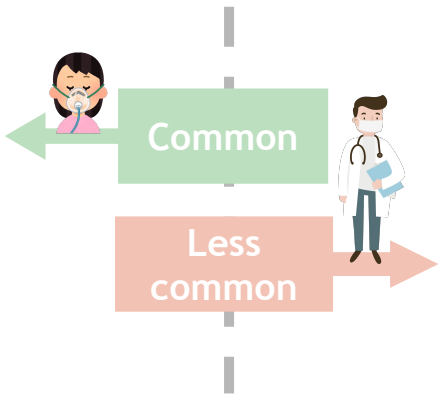
Radial artery cannulation (Seldinger) [2]

Advancement of catheter over guidewire.



Complications of Arterial line

- Temporary radial artery occlusion (19.7%)
- Hematoma/bleeding (14.4%)



- Localized catheter site infection (0.72%), The risk increases with the length of time the catheter is in place
- Hemorrhage (0.53%)
- Sepsis (0.13%)
- Permanent ischemic damage (0.09%)
- Pseudoaneurysm formation (0.09%)

1- like peripheral venous access
2- Seldinger technique is used for central venous catheter as well as Arterial line catheter

Lecture Quiz

answers: 1(C) 2(C) 3(E) 4(D) 5(D)

Question 1: The most common complication of inserting a central venous catheter is:

A. Carotid artery puncture
B. Thrombosis
C. Cardiac arrhythmias
D. Air embolism

Question 2: An important consideration in using the subclavian approach for central venous access includes the:

A. Ease of compressibility if a hematoma or laceration develops
B. Lower risk of pneumothorax when compared to internal jugular approach
C. Ability of the vessel to remain patent in the setting of hypovolemia
D. Increased risk of damaging the brachial plexus when compared to internal jugular approach

Question 3: A 53-year-old female patient is anaesthetised for an emergency laparotomy. She is obese with a BMI of 39. After induction of anaesthesia a central venous catheter is placed via the right subclavian vein following two failed attempts via the right internal jugular vein. About 30 minutes after starting the procedure, the airway pressure and heart rate increase and the oxygen saturation decreases to 88%. The most likely cause is:

A. A displaced endotracheal tube.
B. Severe bronchospasm.
C. Kinking of the endotracheal tube.
D. Anaphylaxis
E. Tension pneumothorax.

Question 4: When considering the advantages and disadvantages of different sites for arterial cannulation such as radial, ulnar, femoral, brachial, and dorsalis pedis, the:

A. Radial artery provides the principal source of blood to the hand
B. Cannulation of ulnar artery is commonly associated with damage to the median nerve
C. Dorsalis pedis artery is commonly used during emergencies and low-flow states
D. Cannulation of the femoral artery risks local and retroperitoneal hematoma

Question 5: You have inserted a central venous catheter via the right internal jugular vein in a 40-year-old male patient about to undergo a laparotomy. The best method to confirm the correct placement of this central venous catheter would be:

A. Measurement of pH of the blood sample drawn from the catheter.
B. Measurement of $PaCO_2$.
C. Measurement of pressure in the catheter using a pressure transducer.
D. Chest X-ray.
E. Aspiration of dark red blood from all the lumens of the catheter.

Explanation File

Good Luck

Team Leader:

Rema Almutawa

This lecture was done by:

- Norah Almazrou
- Sedra Elsirawani
- Rema Almutawa
- Amirah AlZahrani
- Elaf Almusahel

Quiz Editor Reviewer note taker