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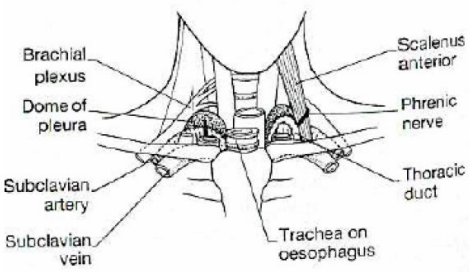
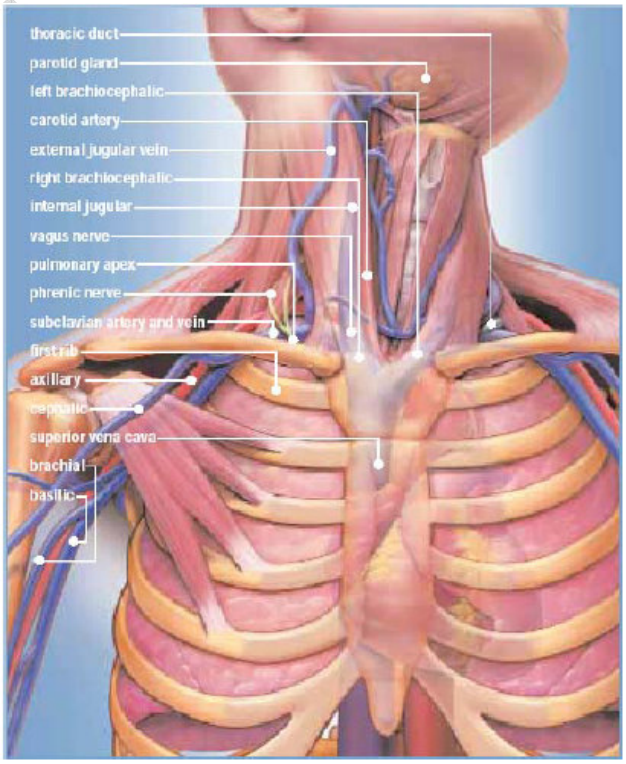
Thank you for completing the assessment in procedures in the Intensive Care Unit.
Please find answers below :

1. Describe the course and relations of the subclavian vein

   The subclavian vein, in the adult approximately 3-4cm long and 1-2cm diameter, begins as a continuation of the axillary vein at the lateral border of the first rib, crosses the first rib and passes in front of the scalene muscle.
   The subclavian vein then continues behind the medial third of the clavicle where it is immobilized by small attachments to the rib and clavicle.
   The subclavian joins the internal jugular vein to form the innominate or brachiocephalic vein, behind the sternoclavicular joint.
   A large thoracic duct on the left, and a smaller lymphatic duct on the right, enter the superior margin of the subclavian vein near this junction with the internal jugular.





2. Describe the anatomy of the major veins of the upper thorax & right atrium

   The right atrium forms the right border of the heart between superior vena cava (SVC) & inferior vena cava (IVC). Venous blood returning from these large vessels and the coronary sinus drain to the right atrium.

   The brachiocephalic veins (also called innominate veins) are formed by the union of the internal jugular and subclavian veins posterior to the medial border of the clavicle on either side. They do not usually have valves. At the inferior border of the first right costal cartilage, the two veins form the SVC. The SVC passes inferiorly and ends at the level of the third costal cartilage where it enters the right atrium. It lies in the right side of the superior mediastinum, anteriolateral to the trachea and posterolateral to the ascending aorta. The terminal half of the SVC is in the middle mediastinum where it lies behind the ascending aorta in the pericardium.

   The right brachiocephalic vein forms posterior to the sternoclavicular joint by the union of the right IJV and the right CSV. It descendsin the superior mediastinum posterior to the manubrium and lateral to the brachiocephalic trunk. The right vagus nerve lies between these vessels and the right phrenic nerve lies posterolateral to the right brachiocephalic vein. At its origin it receives the right lymphatic duct.

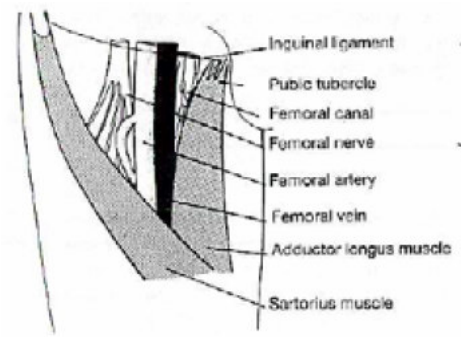
   The left brachiocephalic vein forms posterior to the left sternoclavicular joint by the union of the left internal jugular and left subclavian veins. It passes to the right and inferiorly posterior to the manubriums, to unite with the right brachiocephalic to form the SVC. The left is twice as long as the right as it passes from left to right.

   During its descent it crosses the left common carotid, the braciocephalic trunk, the left vagus nerve and the left phrenic nerve.

3. Describe the anatomy of the femoral triangle

   The femoral triangle is the name given to the anterior aspect of the thigh formed as different muscles and ligaments cross each other producing an inverted triangular shape. Contained within this area, placed medially to laterally, are the femoral vein, artery and nerve ('VAN').

   Looking at the triangle from above, the medial border of the Sartorius forms the lateral border of the triangle, the inguinal ligament forms the superior border and the medial border is formed by the adductor longus. The apex is formed when the medial border of the Sartorius crosses the medial border of the adductor longus. The roof of the triangle is formed by the fascia lata, cribiform fascia, subcutaneous tissue and the skin. The floor of the femoral triangle is muscular and roughly concave formed by the adductor longus, adductor brevis, pectineus and iliopsoas. Running in the deepest part of the floor are the neurovascular structures – femoral vessels and nerve.



4. List the indications for CVC placement

    - vasoactive drug administration
    - assessment of haemodynamic and volume status
    - total parenteral nutrition administration
    - renal replacement therapy (haemodialysis)
    - temporary internal cardiac pacing
    - inability to obtain peripheral venous access, or multiple access required
    - irritant drug administration

5. List the contraindications for CVC placement. Consider various insertion site options in your answer

    There are no absolute contraindications.

    Relative contraindications :
    - coagulopathy – may choose IJ or femoral instead of subclavian
    - inability to lie flat
    - bilateral severe respiratory disease – may choose femoral route – RARE
    - local tissue infection – choose alternate site
    - known or suspected thrombus in vessel – choose alternate site
    - femoral – avoid in intra-abdominal hypertension

6. Outline methods to distinguish between an arterial and venous puncture

    Colour (bright red = arterial; dark = venous)
    Pulsatility (beware TR which will also cause pulsatile flow in IJ)
    Blood gas analysis
    Transduce pressure
    XRay (crossing midline = arterial)

7. On attempting placement of an internal jugular venous catheter, you inadvertently puncture the carotid artery. Describe your management.

    Remove introducer needle
    Directly compress for 5-10 minutes

Beware not to completely occlude flow – just enough pressure to prevent further bleeding
After removing compression monitor for further haemoatoma formation
If haematoma noted, monitor for tracheal displacement or stridor

If vessel has been dilated and CVC placed, contact vascular surgeon.

8. After placing a subclavian CVC on a ventilated patient, the ventilator starts alarming with "high pressure", and the oxygen saturations drop. Describe your management.

   The patient has developed a pneumothorax unless proven otherwise.

   Increase FiO2 to 100%.
   Decrease PEEP to less than 5cmH2O.
   If haemodynamically unstable, needle decompression 2nd intercostal space midclavicular line.
   If stable, obtain CXR and when pneumothorax confirmed, place chest tube or pleurocath
   If CVC is in place, do not remove it.

9. How would you determine if a CVC is correctly placed?

   - lack of pulsatility on insertion, dark blood on aspiration
   - arrhythmias on insertion of wire/line
   - aspirate and flush all lumens
   - CVP pressure waveform on transducing distal lumen
   - tip visualised in SVC on CXR for subclavian & internal jugular lines

10. Describe the advantages and disadvantages for CVC insertion in the subclavian site :
    → advantage : decreased risk of infection
    → disadvantages : technically more difficult, non-compressible if bleeds/coagulopathic, increased incidence of stenosis with large diameter catheters e.g. vascath, increased incidence of pneumothorax

11. Describe the advantages and disadvantages for CVC insertion in the Internal jugular site
    → advantages : clear landmark visualisation & ultrasound easy to obtain; externally compressible
    → disadvantages : higher incidence of carotid artery puncture & dissection; not ideal for trache patients, higher incidence of infection compared with subclavian site

12. Describe the advantages and disadvantages for CVC insertion in the femoral
    → advantages : patient does not need to lie flat; away from airway in an emergency, easily compressible vessel, low risk of induced arrhythmias

→ disadvantages : increased risk of infections & of faecal contamination; less accurate CVP measure; unable to use in patients with intra-abdominal hypertension

13. Describe the advantages and disadvantages for CVC insertion in the brachial site (PICC) :

    → advantages : ease of access, little risk of pneumothorax, pericardial perforation or arrhythmias; low risk of infection
    → disadvantages : cannot be used for volume resuscitation as increased resistance, less accurate CVP measure, less lumen capacity, high risk of vessel thrombosis in arm

14. You are inserting a CVC in a ward patient and experience resistance when you are advancing the guidewire. State reasons for the resistance and what action you would take in this scenario

    If resistance is felt as the guidewire crosses the needle tip, most likely reason is the needle tip no longer being in the vessel wall. It could be dissecting the vessel wall. In this case the wire should be removed and the needle repositioned to have free flow when aspirated.

    Other reasons for resistance early in insertion of the guidewire include thrombosis and vessel stenosis, or obstruction of the vessel by the presence of a concurrent CVC. Congenital vascular anomaly could also result in this complication.

    If the guidewire does not advance easily at any time, it should be gently removed and check introducer needle for free flow of blood when aspirated. If this is absent, remove needle, compress over the site for a few minutes and start again, possibly at another site.

15. Which of the following should be the primary use of real time ultrasound guidance during central venous catheter insertion (tick the correct option):

    Correct answer: All suitable sites (femoral, jugular, brachial)

    Image procedures expedite procedure times after a short learning process. Ultrasound in real time to guide central vascular access insertion increases accuracy, safety and efficacy by:

    - Visualizing the precise target
    - Asses variant anatomy and patency of the vessel
    - Identify alternate or best access
    - Visualize needle progression
    - Reduces technical failure (reducing number of punctures, and mechanical complications)
    - Allows control of the wire before dilatation

    In the past, US has been used as a rescue technique, after failing multiple attempts. Currently and based on international recommendations, it is a primary technique for all suitable sites. The infraclavicular subclavian access requires more specific US

probes (not usually available) and it is technically more difficult and not consider a standard.

16. Tick the most correct statement :

Correct answer: To differentiate artery and vein you should use 2D shape and pulsatility, compressibility in the short access, colour flow Doppler and eventually augmentation techniques

- The most significant knobology adjustments to **improve resolution are reducing the depth and reducing the width sector** of interrogation. The linear probes ("vascular" probes) sector will change with the reduction of the depth. With phase array probes ("cardiac" probe) you can reduce the width of the sector, improving resolution.
- **Colour Doppler signal depends on the angle of insonation** (direction of the blood flow) **and the scale**. Very high scales will not detect flow in a patent vein. The absence of Colour Doppler signal isolated is not diagnostic.
    - **BART**
        - **Blue is flow away from the transducer**
        - **Red is flow towards the transducer**
- Ultrasound assessment must include 2D (shape, pulsatility), Compressibility (performed in short access), Colour Doppler techniques (considering direction of flow, and scales) and possibly augmentation techniques (Valsalva or Trendelemburg, to increase vein dimensions)
    - **Compression on the vein should be done in short access**, since during long access compression there is more risk to fall into one side of the vessel or interrogating another vascular structure
    - Young healthy arteries can show significant compressibility
    - Bradycardic and low cardiac output states is associated to reduced pulsatility of arteries
    - Severe tricuspid regurgitation produces vein pulsatility
    - Arterial pulse can be transmitted to a close by vein

17. Tick the correct option:

Correct answer: Scanning the <u>long access</u> of the vessel allows visualisation of the whole needle pathway

- To interrogate vessels by US, you can use the short and long access. It is recommended to assess compressibility in the short access to prevent sliding and falling onto one side, and ideally identify the other anatomical landmarks and the difference between artery and vein in the same plane.
- When scanning in the short access, the needle and ultrasound beam are not in the same plane. In consequence you will see artefact and only same segments of the needle.
- When scanning in long access, the needle and the ultrasound bean are in the same plane, so it is more likely to see the whole needle pathway.

18. Tick the INCORRECT option:

Answer: 'The long access view of the vessel is ideal for small veins or hypovolaemic patients' is the incorrect option

- Small vessels and hypovolaemic patients are more difficult to assess in the long access. There is more risk for "falling" into one side of the vessel or compressing the vessel using the long access view.

19. Tick the correct option:

Correct answer: Ultrasound guidance for CVC insertion lowers the technical failure rate and number of punctures

Image procedures expedite procedure times after a short learning process. Ultrasound in real time to guide central vascular access insertion increases accuracy, safety and efficacy by:

- Visualizing the precise target
- Asses variant anatomy and patency of the vessel
- Identify alternate or best access
- Visualize needle progression
- Reduces technical failure (reducing number of punctures, and mechanical complications)
- Allows control of the wire before dilatation

Although the use of US reduces the incidence of mechanical complications, it does not eliminate other potential fatal complications such as: air embolus, mediastinal venous laceration, atrial wall erosion, infection, sepsis, transarterial placement of venous access, vascular dissection.

20. Tick the correct option:

Correct answer: Veins are variable in shape, and compressible if patent

- Arteries may not look rounded if the US bean is not perpendicular to the vessel ("oblique" cut)
- Small healthy arteries can have vey thin walls
- The arteries of bradycardic or shock patients may not have very evident pulsatile flow
- Increased vein pressure, Valsalva manoeuvres, or thromboses veins make look very rounded
- Veins may be pulsatile if there is severe tricuspid regurgitation or look pulsatile if they are very close to a very pulsatile artery
- There is significant anatomical variation in neck and femoral vessels, for what the rate of failure of landmarks has been reported to be as high as 35%.

21. Tick the INCORRECT option:

Answer: 'Lymph nodes are variable in shape and compressible' is the incorrect option

VEIN	ARTERY	LYMPH NODE
More variable shape	More rounded shape *Be aware of "oblique" insonation*	Different shapes - sizes
Thinner walls *Thrombosed veins can have thicker walls*	Thicker walls *Young, healthy and small arteries have thinner walls*	
Compressible if patent *Be aware of "falling" on one side of the vessel if long axes interrogation*	Very less compressible *Young healthy and small arteries , and hypovolaemic patients have compressible arteries*	Non compressible
Non pulsatile *Pulsatile if TR* *Looks pulsatile if transmitted from artery*	Pulsatile *Reduced pulsatility if shock, low CO state, bradycardia*	No Doppler signal