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CASE STUDY

ULTRASOUND ASSISTED CENTRAL VENOUS CATHETER INSERTION

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ABSTRACT

Central venous cannulation is performed for vascular access, total parenteral nutrition, infusion of irritant drugs, measurement of central venous pressure (CVP), cardiac catheterization, pulmonary artery catheterization and transvenous cardiac pacing. Over the past few years, ultrasound has increasingly gained importance and its role in critical care, especially in vascular cannulation, has now become established. Realtime ultrasound guidance has been shown to increase the success rate and decrease the incidence of complications associated with the insertion of a central venous catheter (CVC) among adults. Point-of-care ultrasound machines with different types of transducers are available. These machines are portable and can thus be used anywhere in the hospital. Another advantage is that they can be placed closer to the operator performing the procedure.

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INTRODUCTION

Central venous cannulation is performed for vascular access, total parenteral nutrition, infusion of irritant drugs, measurement of central venous pressure (CVP), cardiac catheterization, pulmonary artery catheterization and transvenous cardiac pacing. Over the past few years, ultrasound has increasingly gained importance and its role in critical care, especially in vascular cannulation, has now become established. Realtime ultrasound guidance has been shown to increase the success rate and decrease the incidence of complications associated with the insertion of a central venous catheter (CVC) among adults. Point-of-care ultrasound machines with different types of transducers are available. These machines are portable and can thus be used anywhere in the hospital. Another advantage is that they can be placed closer to the operator performing the procedure.

Routes for central venous cannulation

The routes for central venous cannulation include:

- Internal jugular vein (IJV)
- Subclavian vein (SCV)
- Femoral vein (FV)
- External jugular vein (EJV)
- Antecubital veins.

Anatomy of Internal jugular vein (IJV)

The IJV traverses the neck virtually unopposed by bone, making it an ideal vessel for evaluation by ultrasound. It runs vertically in the neck, initially lying lateral to the internal carotid artery (ICA) and then lateral to the common carotid artery, eventually uniting with the subclavian vein (SCV). It lies underneath the bifurcation of the sternal and clavicular heads of the sternocleidomastoid muscle (SCM), which is used as an external landmark when trying to locate the vein (Fig. 1).

Ultrasonographic evaluation

It is important to appreciate the sonographic differences between veins and arteries. Veins are thin-walled, nonpulsatile, easily compressible and, larger than arteries in patients with a normal hydration status. This principle applies both to the central and peripheral vasculature. Also, on Doppler examination, the arterial waveform is pulsatile and shows a rapid systolic upslope and downward slope, with a phase of reverse flow in early diastole followed by a phase of forward diastolic flow. The venous waveform, on the other hand, is continuous.

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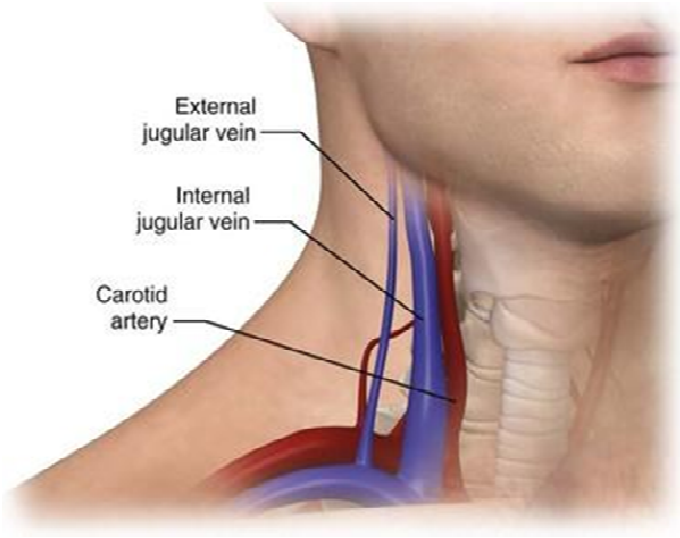

Figure 1. Anatomical relationship of Subclavian vein and internal jugular vein

Internal jugular vein Ultrasound-guided insertion of a CVC has rapidly become the standard approach to cannulation of the IJV in many intensive care units, including ours. Many studies have shown that this method is associated with a reduction in errors and a higher success rate than that achieved with the 'blind' technique, which relies on landmarks of surface anatomy. Figure 2 shows the anatomical relation of the IJV and carotid artery (CA) in three different views on ultrasonographic evaluation.

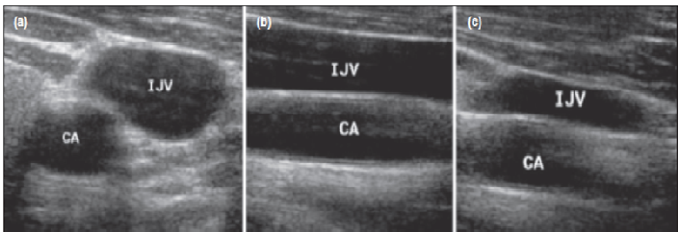

Figure 2. Imaging of the right internal jugular vein and carotid artery (a) short axis imaging (b)long axis imaging(c)oblique axis

- Short-axis (SAX) imaging displays the lateral-right side of the patient on theright aspect of the display screen and the medial structures on the left aspect of the display screen.
- Long-axis (LAX) imaging displaysthe caudalstructures on the right aspect of the display screen and cephalad structures on the left aspect of the display screen.
- Oblique axis – If the transducer is rotated about 30°–40° counterclockwise, oblique imaging displays more lateral-right caudal structures on the right aspect of the display screen, while more medial-left cephalad structures are seen on the left aspect of the display screen.

Technique of venous cannulation

Real-time ultrasound-guided equipment • Central venous catheterization kit – Chlorhexidine antiseptic with applicators – 2% lignocaine solution – Hypodermic needle (25 gauge × 1 inch) – Hypodermic finder needle (22 gauge × 1.5 inch) – Introducer needle (18 gauge × 2.5 inch) – 2 syringes, 5 mL each – Skin dilator – CVP catheter (triple lumen or four lumen) – Gauze pads – J-tipped guide wire with housing and a straightener sleeve – Scalpel with a no. 11 blade – Suture with curved needle 3-0 – Needle holder – Scissors • Sterile gloves, sterile gown, cap and mask • Large sterile drape • Sterile saline suitable for injection • Sterile dressing.

Procedure

- The procedure is explained to the patient and his/her informed consent is obtained.
- The preparation of the patient consists of the following: – The equipment for monitoring the patient's vital signs is connected and oxygen is administered, if indicated. – The patient is placed in the 15°–30° Trendelenburg position.
- The field is sterilized.
- The equipment is prepared. All the ports are flushed with normal saline and the end caps are attached to the proximal and middle ports.
- The landmarks are identified.
- The site where the needle is to be inserted is infiltrated with 5 mL of 2% lignocaine solution. Internal jugular vein The patient is prepared as for traditional central line placement, with strict asepsis. His head can be placed in the conventional rotated position or a neutral head position may be chosen. A potential benefit of a neutral head position is that the IJV assumes a more lateral position to the CA. Aligning the two major neck vessels in a parallel rather than perpendicular position can minimize the risk of arterial puncture, should the needle be advanced too far. This is especially important in patients with low venous filling pressures and vein collapse. The probe is put into a sterile, transparent sheath, inside which is placed a sterile gel so that there should be no air between the sheath and the probe. Vessel cannulation is performed under direct ultrasound guidance.

The transducer is oriented in the same direction as the indicator on the screen. It is used as a reference point when directing the needle towards the vessel of interest. The transducer is placed in transverse orientation over the triangle formed by the two heads of the SCM. The probe is slid distally until the area of interest, i.e. two vessels that appear dark and oval or round, is found. Visualisation of the vein can be achieved either by a short-axis or long-axis approach. In the short-axis approach (Fig. 3), the vessel is identified in the transverse plane and centred under the transducer.

The mid-point of the transducer then becomes a reference point for the insertion of the needle. The needle is inserted at an angle of 45° to the transducer. When the needle is advanced, its tip is visualized as it approaches the anterior wall of the vessel. If the needle is inserted further once it has come in contact with the anterior wall of the vessel, posterior displacement of the vessel wall takes place. The appearance of a flash of blood in the syringe signifies that the needle has entered the vessel. At this point, the transducer is set aside and the rest of the procedure performed normally, using the modified Seldinger technique. In the long-axis approach (Fig. 4), the identification of the vessel involves lining up the transducer over the greatest anterior-posterior diameter of the vessel. It minimizes the risk of inadvertent puncture of the posterior wall of the vessel. The needle is then inserted through the skin just off one end of the transducer, in a plane that is in line with the long axis of the transducer and at an angle of approximately 30° to the surface of the skin. As the needle is

advanced, its progress through the subcutaneous tissue is monitored in real time on the ultrasound screen. After the needle has punctured the anterior wall of the vessel and a flash of blood has appeared in the syringe, the transducer can be set aside and the rest of the procedure is performed as described later.

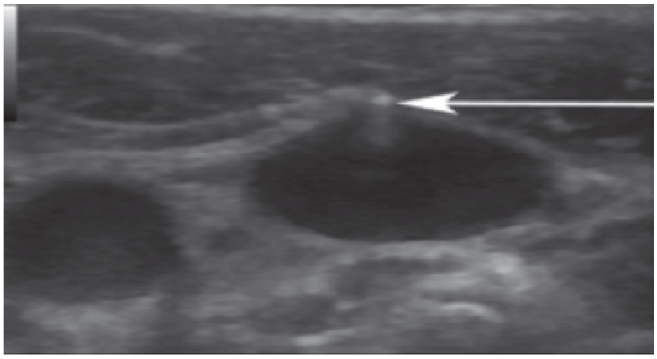

Figure 3. IJV in short axis with needle puncturing lumen

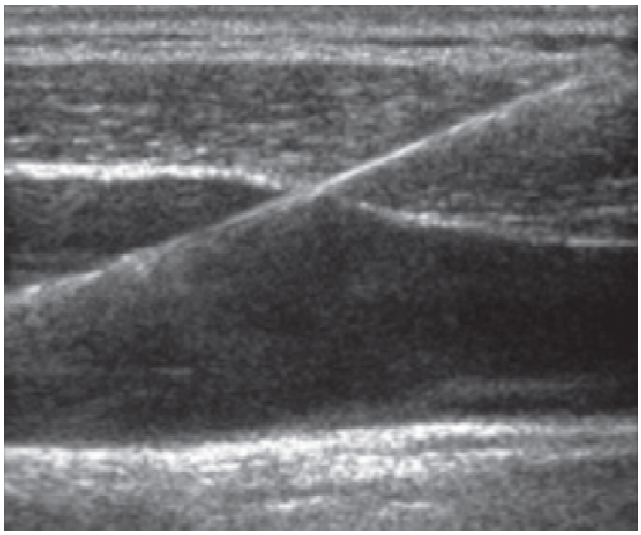

Figure 4. IJV in long axis with needle puncturing lumen

The common steps taken after the needle has entered the vein are as follows

- The guidewire is advanced into the vessel.
- The introducer needle is removed while stabilizing the guidewire.
- The skin is nicked with a scalpel to enlarge the site of puncture.

Catheter insertion: – The dilator is advanced over the guidewire and removed. – The catheter is advanced over the guidewire and the guidewire removed. – Blood is withdrawn from the port to confirm the location of the catheter within the lumen of the vein. – The line and ports are flushed with sterile normal saline.

Final steps: – The catheter is secured at the site of insertion with suture. – The site is covered with a sterile, transparent, occlusive dressing.

After catheter insertion

A chest X-ray is performed to confirm the position of the catheter and rule out pneumothorax or malposition of the catheter. The tip of the catheter should be at the junction of superior vena cava (SVC) with the right atrium, corresponding to the tracheal bifurcation on a chest X-ray. All misplaced catheters should be adjusted to ensure that they are in the correct position. The procedure must be documented. The number of attempts or any complications should also be mentioned. Daily assessment is necessary to ascertain whether there is any local swelling, discharge or other complications, such as pneumothorax, malposition of the catheter and thrombosis.

Complications

Central venous cannulation may be associated with complications which may be immediate (arterial puncture, pneumothorax, local bleeding, air embolism, malposition) or delayed (thrombosis, infection, cardiac perforation, displacement). All possible attempts must be made to prevent these complications.

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