Procedures in Practice

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PERCUTANEOUS CENTRAL VENOUS CANNULATION

Central venous cannulation in surgical practice and intensive care has become more common with the impetus derived from experience in cardiac surgery and developments in disposable plastic catheters and cannulae. The procedure may, however, result in serious hazard and even death. There are numerous approaches to the central veins, and the methods and equipment described here have been chosen as those most likely to be safe and successful in the hands of an inexperienced houseman called on to cannulate an adult either breathing spontaneously or receiving lung ventilation.

Indications and contraindications

Contraindications

- Local sepsis
(all routes)
- Bleeding diathesis or anticoagulant treatment
(subclavian and internal jugular veins)
- Severe pulmonary disease
(subclavian vein)
- Carotid artery aneurysm
(internal jugular vein)

Central venous pressure is the resultant of venous blood volume, right ventricular function, and venous tone. Rapid changes in blood volume, especially associated with impaired right heart function, are the most common reason for monitoring central venous pressure. Peripheral venous pressures do not reflect these changes reliably. In an emergency only a central vein may be accessible for administration of a rapid life-saving infusion. This route is also widely used for long-term intravenous alimentation.

There are no contraindications to the method per se. Venepuncture should be avoided, however, at any site at which there is sepsis. Apical emphysema or bullae contraindicate infraclavicular or supraclavicular approaches to the subclavian vein. A carotid artery aneurysm precludes using the internal jugular vein on the same side. Furthermore, it may be wise to reconsider central venous cannulation in hypocoagulation and hypercoagulation states or if there is septicaemia.

Procedure

Sterility—Sterility should be maintained during the insertion of the cannula. The skin should be carefully cleaned—for example, with 0.5% chlorhexidine in 70% alcohol—and sterile towels applied round the site. The operator should wear a mask, gown, and gloves, and in an emergency gloves at least should be worn. Although some catheter systems are designed to be used ungloved, in practice contamination may sometimes occur through an error or technical difficulty.

Equipment—(1) Catheter through cannula. A cannula on the outside of a needle is placed in the vein and the needle withdrawn. A catheter, previously checked to match the internal diameter of the cannula, is then threaded into the vein. When the catheter is in position the cannula is withdrawn. If the catheter has no stylet dissecting forceps may be necessary to feed it forward. (2) Catheter over needle. In an arm vein the needle and catheter are placed in the vein, the needle (which is attached to a wire) withdrawn, and the catheter advanced into position. Long needles and cannulae (100 mm) are available for use in the internal jugular and subclavian veins. (3) Catheter through needle. This is the simplest method and still widely used. It has been condemned because improper use may result in the catheter being sheared off. The needle is inserted in the vein and the catheter then advanced slowly by threading it forward or unwinding it if it is coiled on a drum, avoiding force if any obstruction to progress is felt. Only after the needle is withdrawn should the catheter be pulled back, always by gripping it beyond the needle tip and never by pulling it through the needle.

A stylet is useful to thread the catheter forward and to indicate the length of catheter in the patient. The presumptive position of the tip can be estimated and the catheter withdrawn so that the tip lies above the nipple line. A precoiled catheter (the drum) can be more frequently placed in the superior vena cava.

Methods

The techniques are described in order of safety and effectiveness. In each, air embolism is avoided by maintaining the venous pressure above atmospheric by position or a tourniquet on the limb. If the patient is conscious the skin should be infiltrated with a local anaesthetic using a fine needle.

Arm veins—The median (basilic) arm veins are the safest approach to the central venous system. The cephalic vein curves sharply to join the axillary vein through the deep fascia at the shoulder, which may impede passage of a catheter. This results in less successful central placement, but it is still worth attempting. The veins are distended by a tourniquet. The head is turned to the same side to compress the neck veins, and the arm is abducted. The catheter should be of 600 mm minimum length. When the tourniquet is released air embolism may occur, so depress the proximal end of the catheter below the level of the patient's elbow.

External jugular vein—The external jugular vein runs from the angle of the mandible to behind the middle of the clavicle and joins the subclavian vein. The patient is placed in a 20° head-down position with the head turned to the opposite side. The most prominent vein is chosen. If neither vein becomes visible or palpable cannulation is inadvisable. In about half the attempts the catheter cannot be threaded into an intrathoracic vein, but successful central placement may be helped by digital pressure above the clavicle, by depressing the shoulder, or by flushing through the catheter. The use of excessive force should be avoided. Satisfactory measurement of central venous pressure is sometimes possible from the external jugular vein.

Intraclavicular subclavian vein

Diameters of needles or cannulae and lengths of catheters recommended for each route of insertion

Route of insertion	Outside diameter of needle or cannula	Minimum length of catheter (mm)
Arm vein	14G	600
External jugular vein	16 or 14G	200
Internal jugular vein	14G	150*
Subclavian vein	14G	150*

*Long cannulae are available.

Internal jugular vein—The internal jugular veins run behind the sternomastoid close to the lateral border of the carotid artery. The vein may be cannulated with a low incidence of major complications by an approach well above the clavicle. The patient is placed in a 20° head-down position with the head turned to the opposite side. The right side is preferred to avoid injury to the thoracic duct and is also easier for the right-handed operator. The sternomastoid muscle, cricoid cartilage, and carotid artery are identified. With the other hand the carotid artery is palpated and protected at the level of the cricoid cartilage. The needle is attached to a saline-filled syringe and inserted just lateral to the artery. The needle is directed towards the feet parallel to the midline with the syringe raised 30° above the skin. Gentle aspiration is maintained as the needle is advanced. A flush of blood into the syringe signifies entry into the vein. If the artery is punctured use firm compression for five minutes.

Intraclavicular subclavian vein—The subclavian vein is particularly suitable for administering long-term parenteral nutrition. It is widely patent even in states of circulatory collapse, so that subclavian venepuncture may be the only route for rapid infusion. Puncture and catheterisation of the subclavian vein is a blind procedure. Serious harm can be inflicted on nearby vital structures, and deaths have been reported. The most common complication is pneumothorax. The procedure, therefore, should not ordinarily be performed by an inexperienced operator without close supervision. The subclavian vein lies in the angle formed by the medial one-third of the clavicle and the first rib, in which the subclavian vein crosses over the first rib to enter the thoracic cavity. The patient rests supine, tilted 20° head down. Either side may be used, although the right side is preferable. The patient's head is turned to the opposite side. The midpoint of the clavicle and the suprasternal notch should be identified. The distance between the skin puncture and the vein necessitates using a long needle and cannula. The needle is attached to a saline-filled syringe and inserted below the lower border of the midpoint of the clavicle. The needle tip is advanced close to the undersurface of the clavicle, aiming at the suprasternal notch. While the needle is advanced gentle aspiration should be maintained, and a flush of blood indicates that the vein is entered. If the attempt is unsuccessful, further attempts may be made, altering the direction of the needle only when it has been withdrawn to just beneath the skin. A chest radiograph should always be taken to check for pneumothorax.

Checking and testing—Blood should be aspirated to ensure that the catheter is in a vascular space before injecting fluid. If the line is connected to a bottle of fluid that is lowered below the patient blood should flow freely under the influence of gravity. On connection to a column of fluid for measurements of central venous pressure the fluid column should show slow oscillations related to respiration and quicker oscillations related to the heart beats. A chest radiograph should be taken to confirm that the position of the tip is above the right atrium, preferably not more than 2 cm below a line joining the lower borders of the clavicles.

Management

Fixing the catheter—Once satisfactorily placed, the catheter should be fixed carefully to prevent inadvertent withdrawal or movement further into the vein. Firm fixation probably also reduces the incidence of thrombophlebitis. Adhesive tape (1 cm width) is crossed over to grip the catheter firmly, away from the venepuncture site. An alternative, especially for longer-term use, is to secure the catheter with a skin suture.

Asepsis—The most scrupulous attention to detail is needed to keep venous catheters infection free. Strict aseptic technique during the insertion of the catheter is mandatory. For long-term parenteral nutrition the site where the catheter enters the skin may be led away from the vein by creating a subcutaneous tunnel. Additions to intravenous fluids should preferably be introduced in the aseptic laboratory of the pharmacy. The intravenous giving set should be changed daily, an aseptic technique being used while connecting it to the catheter. Injecting drugs into the venous catheter and taking blood samples through stopcocks should be avoided if possible. Regular bacteriological monitoring of the venepuncture site should be carried out. It is important to be vigilant to detect catheter-related infections. If an infection occurs the catheter should be removed immediately.

Clotting—It is important to maintain flow through the catheter to prevent reflux of blood and clotting. After taking intermittent measurements of venous pressure it is a common fault to forget to turn on the infusion again, resulting in a catheter blocked by clot. The catheter must then be replaced.

Complications

IMMEDIATE

Arterial puncture
Pneumothorax
Cardiac arrhythmias
Injury to thoracic duct
Injury to nerves

IMMEDIATE OR LATER

Air embolism
Catheter embolus

LATER

Myocardial perforation and tamponade
Hydrothorax
Infection
Venous thrombosis

Complications of central venous catheterisation mostly fall into two categories—firstly, those that occur at the time of catheterisation and result from injury to some vital structure; and, secondly, those that occur at a later stage and are associated with catheter-related thrombophlebitis and infection. In addition to these two groups air embolism, catheter embolism, cardiac arrhythmias, and perforation of the myocardium may occur at any time. When arm or external jugular veins are used serious immediate complications are rare. The veins are usually visible and palpable. Catheters lying in peripheral veins, however, often lead to thrombophlebitis if left in position for more than one or two days. Most immediate and serious complications are a feature of blind venepuncture of the subclavian and, to a less extent, internal jugular veins. Injury to many structures related to the thoracic inlet has been reported: pneumothorax, haemothorax, arterial puncture, and damage to the thoracic duct and phrenic nerve. The complication rates reported after catheterisation of the deep veins range between zero and 15% and are probably dependent on the experience of the operator.