Learning Objectives

- To select the best venous access for PN administration considering the advantages and risks of each site;
- To describe the protocols (insertion and manipulation of the catheter, administration set, pump, filter, etc. for assuring the safe administration of PN;
- To consider the best types of PN bags to assure adequate administration.

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Key Messages

- The subclavian vein should be the site of first choice for inserting a catheter for PN administration;
- A peripheral route can be used for short periods of PN (with low osmolality solutions);
- Strict protocols are mandatory for handling of the central venous catheter;
- Pump for regulating the flow is recommended; the use of filter is still debatable;
- The selection of PN bags (hospital-made or commercialized ready-to-use) should be based on the patient's needs and expected duration of PN.
1. Introduction

Parenteral nutrition (PN) is used to provide nutritional support to subjects who are unable to be fed orally or enterally. A period of intestinal insufficiency is the main indication for short-term PN in hospitalized patients.

In some rare cases of life-threatening intestinal failure, long-term PN may be safely given at home. The solutions used in total parenteral nutrition provide all nutrients, including carbohydrates, aminoacids, fat, electrolytes, minerals and vitamins, are by necessity very hypertonic, being 3-8 times the normal osmolality of serum.

Infusion of such solutions into small vessels or into vessels with low blood flow, therefore, provokes damage and rapid thrombosis of the vein. The development of total parenteral nutrition has therefore necessitated techniques to gain access to veins with high blood flow, such as the superior vena cava, the right atrium, the inferior vena cava, or a surgically created arterio-venous fistula.

The development of some new pharmaceutical compounds, however, with a lower osmolality allows the use of a peripheral route for infusing parenteral nutrition, at least for a short period.

2. History

The most common vascular access used for TPN is the percutaneously placed subclavian vein catheter (Fig. 1). This technique was first introduced in 1952 by Aubaniac, who found that it provided rapid access to the central venous system, with minimal complications, in patients suffering from military injuries (1).

![Subclavian vein catheterization](image1.png)

**Figure 1 Subclavian vein catheterization**

The use of the subclavian catheter for intravenous nutritional support was initially proposed by Dudrick and colleagues in 1969 (2).

Afterwards, others described the use of the internal jugular vein (Fig. 2-3), the external jugular vein, the basilica vein and even the right atrial appendage.
Figure 2 Internal jugular vein anatomy

Figure 3 Catheterization of internal jugular vein

Although first described in 1949 by Duffy, the use of an inferior vena caval catheter via the femoral vein has found little clinical application because of the high risk of infection and thrombosis (3) (Fig. 4).
3. Basic Principles for Central Venous Catheter (CVC) Placement

3.1 Proper Patient Preparation

Before the placement of central venous catheter (CVC) for administering PN, the nurse and the physician should adequately explain to the patient the reason for the catheter placement and the technique to be used. As for any other procedure, proper information given to the patient may lower anxiety, fears or misconceptions.

When properly informed, most of the patients will not require sedation but only local anesthetic infiltration.

The patient should be told to expect some discomfort, even with a local anaesthetic. The placement of a CVC is generally performed with the patient lying in bed, in a supine position. Generally, the head is turned away from the cannulation site in order to facilitate the vein cannulation.

With regard to the hospital facilities, the placement of a CVC is performed either in the patient’s room or - preferably in a dedicated operating room.

3.2 Proper Timing of Catheterization

Placement of a central venous catheter for PN should always be done on an elective basis in a well informed patient, in a proper environment and by an experienced physician, in order to limit the risk of complications (Table 1).
Table 1 Complications in relation to insertion of CVC

- Local infection or haematoma
- Bleeding from the subcutaneous tunnel and the puncture site
- Arterial puncture
- Haemothorax
- Pneumothorax
- Haemopericardium and cardiac tamponade
- Cardiac arrhythmias
- Misplacement and migration of the catheter
- Venous embolism
- Air embolism

3.3 Proper Skin Preparation

The area of proposed cannulation is first shaved carefully, if needed. The physician must cleanse the hands with antiseptic soap and should wear a mask and gown i.e. for a surgically sterile procedure (Fig. 5).

Figure 5 Hand cleansing

A wide area around the proposed cannulation site should be thoroughly cleaned with an antiseptic soap (Fig. 6).

Figure 6 Skin disinfection

A sterile draping should follow.
The number of people in the room should be limited to the assisting nurse to avoid airborne contamination, and all those present must wear masks.

3.4 Availability of Proper Equipment and Supplies
It seems cost-effective to develop a catheter insertion tray that consists of basins, clamps, syringes, and sponges. In addition to the tray materials, a cart containing the various preparation solutions, gowns, gloves, masks and catheters greatly assists the catherization (Fig. 7).

Figure 7 Material for vein catheterization

4. Central Venous Cannulation
Landmarks used in a central vein catheterization should be based on anatomical relationships (4) (Fig. 8).

Figure 8 Landmarks for central vein catheterization

The subclavian vein can be approached through a supraclavicular or infraclavicular route. After adequate patient preparation, a small wheal of local anesthetic should be placed at the proposed puncture site (Fig. 9).
Figure 9 Local anaesthesia

The needle is then advanced through the anesthetized skin toward the target area (Fig. 10-11).

Figure 10 Needle insertion

Figure 11 Vein cannulation
As the needle is advanced, intermittent aspiration of the syringe confirms passage into the vein by a rapid rush of blood into the barrel of the syringe.
Once the needle has been advanced into the vein, a guidewire is advanced through the needle, and the needle is subsequently removed (Fig. 12).

**Figure 12 Wire insertion**

Care must be taken during this procedure to avoid an aspiration. Failure of the guidewire to advance easily usually means that the needle is no longer within the vein or that it is against the vein wall.

Once the guidewire is in place, the catheter is passed over the wire, and the wire is removed. Following the presumed proper placement of the central venous catheter, a chest X-ray is necessary to document the position of the catheter and to rule out the presence of a pneumothorax. In practice, a 5% dextrose solution should be connected until the X-ray is obtained. After proper catheter placement, a sterile dressing should be applied. Utilization of the internal and external jugular veins for CVC is less often recommended than the subclavian veins but is quite effective.

Because of the higher positioning of the puncture site on the neck, difficulties in maintaining a sterile dressing limit the long-term use of jugular lines (Fig. 13).

**Figure 13 Sterile dressing**

In addition, the small size of the external jugular vein can result in thrombosis of the system. There is a higher risk of thrombophlebitis using the basilic vein. The catheters do limit the mobility of the arm and are somewhat less comfortable. The use of the femoral vein should be reserved for patients with thrombosis of the upper central veins.
These patients must be monitored carefully for the development of phlebitis and particularly for possible pulmonary embolism. On rare occasions, when superior vena caval thrombosis is present and the risks of using the inferior vena cava are too high, catheters have been placed via a small anterior thoracotomy through the right atrial appendage into the right atrium (5).

The advantages and inconveniences of each anatomical site are listed in Table 2. Ultrasound-aided insertion and catherization by a clinical expert may reduce the risk of procedure-related complications (6).

4.1 Position of the Distal Tip
Positioning the distal tip of the catheter at the junction of the superior vena cava and the right atrium is recommended. Radiography or fluoroscopy is required to confirm the position of the distal tip and any procedure-related complications, such as pneumothorax, prior to commencing PN (Fig. 14).

5. Central Venous Catheters

5.1 Material Used for Venous Catheters
Plastic used for venous catheters should be biologically biocompatible, physically and chemically stable and well tolerated by the organic tissues and mechanisms of defence. The characteristics of the 3 types of plastic used for venous catheters are described on Table 2 (7).

<table>
<thead>
<tr>
<th>Subclavian</th>
<th>Internal jugular</th>
<th>Brachial</th>
<th>Axillar</th>
<th>Femoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk of complication at placement</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Risk of septic complication</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Risk of thrombosis</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Ranking for first choice</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

5.2 Types of Catheter

5.2.1 Catheters for Peripheral Veins
Depending on the use of commercialized low osmolality all-in-one solutions, the peripheral route may be used for the administration of parenteral nutrition, at least for the short-term (8) (Fig. 15).
In adults, catheters with a calibre from 18 to 22 Gauge are commonly used. Catheters with a length less than 80 mm have a universal luer lock connection. It is recommended to use first the peripheral veins which are distally located on the hands or arms. Veins of the feet or legs should be avoided due to the high risk of septic and thrombotic complications.

5.2.2 Catheters for Central Veins
The most commonly used catheters are composed of polyurethane (Table 3).

Table 3 Types of plastic venous catheters

<table>
<thead>
<tr>
<th>Chemical inertia</th>
<th>Bio-compatibility</th>
<th>Hemo-compatibility</th>
<th>Mechanical performance</th>
<th>Bio-stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teflon®</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Silicone</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>++</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
</tbody>
</table>

The catheter length varies from 60 cm for a brachial insertion to 13 cm for a subclavian or internal jugular vein.

There are catheters with single, double or triple lumens. For the last, the calibre of 2 of the lumens is 18 Gauge and 14 Gauge for the third.

The efficacy of antiseptic impregnated catheter (chlorhexidine, silver-sulfadiazine) for lowering the risk of bloodstream infection is still a question of debate (9).

For patients requiring the administration of PN, it is highly recommended to use a double lumen catheter in order to avoid mixing of parenteral solutions and other drugs (Fig. 16).
Indeed, except for a few drugs, mixing drugs with the PN solution may provoke physical or chemical instability of the solution.

5.2.3 Long-term Parenteral Nutrition
For patients who require long-term PN, there are various vascular access devices (see Home Parenteral Nutrition for details). In some cases, the vascular device can also be used for chemotherapy.

5.2.3.1 Skin-tunnelled Central Venous Catheter
As proposed by Broviac et al and Hichman et al, the superior vena cava is catheterized with a tunnelled, silicone rubber catheter. Fixation is achieved through the ingress of adhesions from the subcutaneous tissues into a felt cuff, which is attached to the catheter and positioned within the skin tunnel (Fig. 17).

5.2.3.2 Subcutaneously Inserted Central Venous Ports
The catheter ends in a lightweight, subcutaneous port, incorporating a reservoir chamber covered by a thick silicone septum. Access to the venous system is achieved by inserting a non-coring needle (hypodermic needles damage the silicone) through the skin and septum into the reservoir (Fig. 18).

![Subcutaneous port](image)

**Figure 18** Subcutaneous port

### 5.2.3.3 Peripherally Inserted Central Venous Catheters (PICC-lines)
It is only acceptable for short periods of HPN, due to limitations of physical activity and self-management (10) (Fig. 19).

![PICC-line](image)

**Figure 19** PICC-line

### 5.2.3.4 Closed Distal Tip
Groshong® catheters, which have a closed, rounded distal tip incorporating a three-position valve, are another option. The valve is closed when the catheter is not in use, but opens outward during infusions and inwards if blood is withdrawn. As reflux of blood into the catheter tip is avoided, saline - rather than heparin flushes - is recommended in order to maintain patency between infusions. Groshong® catheters are available as a cuffed, tunnelled catheter, an implantable port or as a peripherally inserted central catheter.
6. Handling Connections of Nutritional Bags

1. Position the patient in his bed in a semi-recumbent position; the patient and the nurse should wear a mask (Fig. 20);

2. Wash hands with antiseptic hand wash (Fig. 21). Prepare the working surface with physical and bacteriological cleaning;

3. Open a large non-sterile drape and place it over the patient’s chest (Fig. 22);

4. Mix the bag and hang it (Fig. 23). Wash hands again with antiseptic solution.
5. Open the packaging; add the sterile material as well as gauze soaked with disinfectant (Fig. 24);

6. Open and place the sterile drape on the other one. Place the distal end of the administration set on the sterile drape and flush the system (Fig. 25). Wash hands again with antiseptic hand wash.

7. Disinfect the distal tip of the catheter with a gauze soaked with disinfectant, close the set administration and clamp the catheter (Fig. 26);
8. Wear sterile gloves (Fig. 27);

9. Disconnect the administration set; disinfect the catheter hub. Connect the new administration set (Fig. 28);
10. Protect the connector and the hub with gauze (Figs. 29 and Fig. 30). Open the catheter;

11. Adapt the flow rate using the pump or the manual regulating device (Fig. 31).

Obviously, this protocol may be adapted to local recommendations.

7. Administration Sets

Administration sets that are used for the administration of parenteral nutrition are similar to those used for intravenous infusions. It is recommended to replace the administration set every day in case of lipid-based PN and every 2-3 days if the bags do not contain lipid emulsions (11). The use of a multi-lumen catheter allows one lumen to be reserved for parenteral nutrition and the other for fluids, electrolytes and intravenous medications (12). It is recommended that 1.2-micron filters be used because they filter out not only precipitates but also coalesced oil droplets and other particles, preventing them reaching the lungs (13). There are also filters incorporated in the administration set that provide the advantage of diminishing line manipulation (especially in the case of Home Parenteral Nutrition). The use of a pump for regulating the flow is also recommended.

8. Preparation and Choice of Parenteral Solutions

This aspect of the administration of PN is developed in another chapter. However, clinicians should be awarded that the main problems in PN preparation are emulsion stability and calcium phosphate precipitation. Some authors have recommended the separate administration of lipids. But, calcium phosphate precipitation can be avoided by using organic phosphates and most PN emulsions are stable if we follow preparation protocols.
When lipids are administered separately, two different lines (or lumen) should be used to avoid stability problems. In practice, the use of separate bottles requires multiple manipulations, has a high risk of microbial contamination and is poorly adapted to the patient’s requirements (Fig. 32).

*Figure 32 Separated bottles*

“All-in-one” PN solutions have some advantages:

1) they need less line manipulations;
2) they are less costly;
3) they need only one administration pump;
4) micro-organisms reproduce with more difficulty than in lipids alone.

Besides the use of separated bottles - which is not recommended - physicians have two options-

- either the hospital-made PN bags or the ready-to-use PN.

For the hospital made solutions, the composition and amounts of nutrients have been determined by the local pharmacist and physician. The bags are prepared at the local Hospital Pharmacy, following strict protocols (Fig. 33). In most of the cases, hospital made solutions are compounded in a one-chamber bag; they can be binary or telnar (lipid based). Vitamins and trace elements are supplemented by the pharmacist and electrolyte content may be adapted to each individual. The bags are ready to use; they should be stored in a fridge and used within 5 to 7 days.

*Figure 33 Hospital made bags*

The guarantee of aseptic technique is based on the following:
- strict following of the PN preparation protocol;
- use of laminar flow cabins in a specific clean area;
- quality of solutions;
- validation of the elaboration process;
- microbiological controls;
- training of personal.

Concerning the commercialized “ready-to-use” solutions, the composition and amount of nutrients have been determined by the various commercial companies that ensure both emulsion stability and the absence of compatibility problem (Fig. 34, 35, 36).
There are multi-chamber (2 or 3) bags made by pharmaceutical companies with pre-defined compositions. While most of them should be infused via a central vein, there are also ready-to-use bags that have been designed for peripheral administration (14). Trace elements and vitamins should be added either by the pharmacist or by the nurse in the Pharmacy or on the ward before administration. The multichamber system offers a long shelf life of 12 months at room temperature. The choice between the “ready-to-use” and the hospital-made all-in-one bags should be based on the algorithm described on Table 4.
Table 4 Algorithm for selecting the nutritional bags

<table>
<thead>
<tr>
<th>Algorithm</th>
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<tbody>
<tr>
<td><strong>Parenteral nutrition as supplement and/or</strong></td>
</tr>
<tr>
<td><strong>for short duration</strong></td>
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<tr>
<td>↓</td>
</tr>
<tr>
<td><strong>Standard nutritional requirements</strong></td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td>&quot;<strong>Ready-to-use</strong>&quot; 2 or 3 commercialized</td>
</tr>
<tr>
<td>chambers bags</td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td><strong>Vitamins and trace elements to be added</strong></td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td><strong>Additional electrolyte may be needed</strong></td>
</tr>
<tr>
<td><strong>Parenteral nutrition in case of severe</strong></td>
</tr>
<tr>
<td><strong>underlying diseases and long-term</strong></td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td><strong>Specific nutritional requirements</strong></td>
</tr>
<tr>
<td>↓</td>
</tr>
<tr>
<td><strong>All-in-one bags prepared by the local</strong></td>
</tr>
<tr>
<td><strong>pharmacist</strong></td>
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<td>↓</td>
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<tr>
<td><strong>Tailored prescription which is adapted to</strong></td>
</tr>
<tr>
<td><strong>each individual</strong></td>
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</tbody>
</table>

9. Summary

Administration of parenteral nutrition via a central venous catheter was first used in the late sixties. Indeed, due to the high osmolality of parenteral nutrition solutions, they must be infused via large veins in order to avoid thrombophlebitis and thrombosis. The subclavian vein seems to be the first choice but other sites such as the internal jugular vein, the basilica and axillar and - in rare cases - the femoral vein can also be used. Recent development in low osmolality "all-in-one" solutions allow the administration of PN via peripheral veins, at least for short term feeding. The placement of central venous catheter should be done by an expert physician, in a well informed patient and in an appropriate environment. Handling of central venous catheters should followed strict protocols and be performed by trained personnel.

References

4. Grant JP. Anatomy and physiology of venous system vascular access: implications. JPEN 2006;3(suppl 1):S7-12.

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