Module 19.3

Venous access and line complications

Learning Objectives:

- Learn about the different types of central lines for parenteral nutrition;
- How to choose a venous access catheter for home parenteral nutrition (HPN);
- Insertion of central lines;
- Learn about the most common line complications;

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Key Messages:

- Chose venous access route and device in accordance with the needs of the patient;
- General use of antiseptic/aseptic techniques is of paramount importance in preventing infections;
- Support patient education in HPN procedures to minimise line-related complications;
- Adhere to ESPEN guidelines to manage complications;
- Support clinical studies of venous access for HPN patients.
1. Introduction

Intestinal failure is defined as a condition with reduced intestinal absorption to the extent that parenteral supply of macronutrients and/or water and electrolytes are needed to maintain health and growth. The condition may be transient if gut function can be restored, but home parenteral nutrition (HPN) is indicated for patients with chronic intestinal failure. The most common causes of intestinal failure are resection of the small bowel due to inflammatory bowel disease, a catastrophic event such as mesenteric thrombosis, other small intestinal disorders that cause malabsorption, and conditions with pseudo-obstruction. Also, patients with cancer and intestinal complications or with a more general need for nutritional support may require HPN. The prevalence of HPN is rising and recent data report a broad range of prevalences between 1 and 25 patients/million population in the European countries. The prognosis for patients with benign disease is reasonably good with a 5-year survival of about 75% (1-3). In contrast, the prognosis for the increasing number of patients entering an HPN programme with a malignant disease is poor (4). Overall, the number of patients is low and referral to specialist centres should be considered, but this may not always be possible.

HPN requires a well functioning central venous line, but insertion and the use of lines are associated with complications. Some of these are serious for the patient, requiring admission to hospital, and furthermore increase the cost of the treatment. This LLL manuscript will focus on venous access and the most frequent related complications.

2. Choice of central line for HPN

When considering which type of venous device to use for providing parenteral nutrition a number of issues must be taken into consideration. These include the length of the period of treatment: short-term during a hospital stay, mid-term with continuing treatment after discharge from the hospital, or long-term for those with irreversible intestinal failure? The number of weekly infusions is also important for the choice of catheter. Patients with a previous history of complications related to vascular access may present a particular challenge and this must be taken into consideration. Also, the patient’s preference is important, and must address what is most practical for him or her and how a specific choice will affect body image.

2.1. Venous access for short- and medium-term periods of parenteral support

For treatment periods of up to 3 months, for patients staying in hospital or supported in a non-hospital but medical setting, choose a non-tunneled polyurethane (PUR) catheter inserted into a central vein (subclavian, internal jugular). Catheters may have single or multiple lumens and are designed for continuous use (5).

Medium-term catheters are also non-tunneled and centrally located, but are intended for discontinuous use. In addition to PUR and silicone catheters (Hohn type), PICCs (peripherally inserted central catheters) may be used. All of these can also be used for up to 3 months in out-patients, but self care is difficult with PICC-lines since the exit position from a peripheral vein of the arm often disables one hand. Lower rate of infections have been reported with PICC lines, and the cost compared to ports and conventional central lines is lower (6).

2.2. Venous access for long-term treatment and HPN

Long-term treatment requires a cuffed tunneled central catheter such as a Broviac, Hickman or Groshong or a totally implanted port.
2.2.1. Tunnelled catheters

Catheterisation of the superior vena cava with a tunnelled silicon catheter is the technique most commonly used for long-term parenteral nutrition. The felt cuff of the catheter allows fixation as the subcutaneous tissue adheres to the cuff, which is typically placed about 2.5cm from the exit site. Multiple lumen catheters cannot be recommended for long-term treatment as an increased number of access points theoretically increases the risk of infection. Groshong© catheters have a rounded tip with a pressure sensitive two-way valve at the intravascular end. The valve is closed when the catheter is not used and opens outwards during fluid infusion or bolus injection. The valve can open inwards and blood can be drawn, although this is not a recommended procedure. The advantages of all the tunnelled catheters are that they can be used for several years, connecting to infusions does not require the puncture of the skin (in contrast to implantable ports), and if the external part of the catheter is damaged, it can be replaced using a repair kit.

2.2.2. Implantable ports

Another option for the administration of parenteral nutrition is the totally implantable ports. A stainless steel chamber with a membrane is implanted in a subcutaneous pocket in the chest wall and its catheter part is placed in the subclavian vein with the tip in the superior vena cava or right atrium. The advantage is that the skin covers the port, which is practically invisible, so no dressing is needed and the body image is unchanged. Among the disadvantages is the need for perforating the skin for infusions. Compared to catheters with an external segment ports generally require more frequent replacement. When infected, antibiotic treatment will much less often salvage a port, which then has to be removed surgically (7).

Key points: which type of venous access for HPN
- PICC only for in-patients and not recommended for HPN
- Broviac or Hickman for long term use and for patients needing daily access
- Implantable ports can be used, advantages regarding the body image

2.3. Choice of central vein and insertion procedures

Studies carried out in the intensive care setting indicate that subclavian puncture is associated with a lower frequency of catheter related infections than jugular insertion (8); confirmatory data specific to HPN are currently missing. A key advantage of subclavian cannulation for HPN is that the exit site of the tunnelled catheter can be placed to allow the patient self-management of parenteral nutrition and this is obviously important. There is strong evidence that the use of ultrasound (or angiographically) guided venous puncture reduces the incidence of complications and provides a higher success rate compared to access obtained without using imaging (9). Among the potentially avoidable complications in relation to insertion are arterial puncture, pneumothorax and damage to neck structures.

2.4. Position of the distal tip of the catheter

Parenteral nutrition with its high osmolality requires central venous access and should be infused into the lower third of the superior vena cava or the upper portion of the right atrium. Thus after insertion it is strongly recommended that the position of the tip is verified using x-ray or fluoroscopy. In a retrospective study of 141 central venous lines, the location of the catheter tip was the only factor found to be statistically predictive of malfunction (10). A significant increase in malfunction was observed in cases where the catheter tip was located more than 4cm superior to the junction of the right atrium and the superior vena cava. Malfunctions were least likely in those cases where the catheter tip was located in the right atrium.
The position of the distal tip of the central venous catheter is important for increasing its longevity and minimizing adverse events in patients on HPN.

**2.5. Loss of vascular access**

Patients on HPN for many years may encounter repeated line complications with venous thrombosis, and loss of vascular access may eventually be the result. When the 4 key neck veins (subclavian and internal jugular) have been lost, it will be necessary to consider use of the femoral veins, but infective complications are more common there, and the practicalities of access may also pose problems. Case reports of access by direct puncture of the right atrium or by cannulation of the hepatic veins have been reported (11), as have occasional uses of the azygos and other smaller veins. The use of an external arterio-venous graft for intravenous nutritional support may also be an unconventional option but one that has proved successful where it is used regularly (12). There is an evolving interest in endovascular recannalisation of thrombosed veins, but this remains experimental and limited to a few specialist centres. It is therefore important to consider the possibility of intestinal transplantation when access is compromised. Referral for consideration of transplantation should not any longer wait until only a single vascular access route remains open, since the haemodynamic and nutritional demands of the patient during the peri-operative period may demand greater access if a transplant is performed.

**Key points:**
- Sterile conditions when inserting catheters to reduce infectious complications
- Lower rate of complications with subclavian < jugular < femoral veins
- Ultrasound to guide when inserting
- Avoid using femoral veins due to higher risk of complications
- Catheter tip at junction of vena cava and atrium results in fewer malfunctions.
- If venous access is seriously compromised consider referring for intestinal transplantation

**3. Catheter related infections**

**3.1. Introduction and definitions**

Infectious complications are the most serious problems related to vascular access devices. For patients on home parenteral nutrition such infections add significantly to morbidity and mortality (13). The pathogenesis is bacterial or fungal growth, initially colonising the catheter, both the luminal and the outer surface, which may spread and give rise to a catheter related bloodstream infection (CRBSI) if the pathogens reach the blood-stream. Contaminations of the hub, a broken line or the use of the catheter for non-nutritional purposes are probably the most common endoluminal causes of infection. Micro-organisms migrating along the catheter from the skin or which are introduced during its insertion cause infection of extraluminal origin. The catheter infection rate reported from various HPN centres is in the range 0.3-0.5 episodes per patient year (14-15).

Catheter colonization is defined as growth of more than 15 colony-forming units at semi-quantitative culture or more than $10^3$ colony-forming units (quantitative culture) from a proximal or distal catheter segment in the absence of accompanying clinical symptoms (16).

Exit-site infection involves erythema, tenderness, induration or purulence of the skin within 2cm of the exit site of the catheter.

Pocket infection is defined from erythema and necrosis of the skin over the reservoir of a totally implantable device, or purulent exudates in the subcutaneous pocket containing the reservoir.

Tunnel infection involves erythema, tenderness and induration of the tissues overlying the catheter and extending more than 2 cm from the exit site or the pocket of an implantable device.
Catheter related bloodstream infection is defined from the isolation of the same organism (identical species and antibiograms) from cultures from catheter segments and blood cultures from a peripheral vein, in a patient with clinical symptoms of blood stream infection and no other apparent source of infection. Probable systemic catheter related sepsis is characterised by a colonized catheter associated with clinical signs suggesting septicaemia, despite the lack of positive peripheral blood culture.

3.2. CRBSI diagnosis and treatment

From a clinical point of view it is important to recognize both the local and the systemic manifestations of a catheter related infection. The local signs of infection at the exit site of a tunnelled catheter include redness of the skin, local pain, or discharge of pus from the tunnel, which may appear elevated due to the inflammation. The systemic features cover a broad range of symptoms, but typically the patient will complain of fever and chills that may appear immediately or hours after the infusion of parenteral nutrition is commenced. However, the symptoms can be very non-specific and patients on HPN who present with new complaints should always be suspected to have CRBSI. Some of the non-specific features that may appear include those of cardiopulmonary origin such as dyspnoea and arrhythmias, and a variety of gastrointestinal complaints.

Once a catheter associated infection is suspected blood cultures should be taken to evaluate the possibility of bacteraemia, and generally systemic antibiotic treatment is recommended whilst awaiting the results of the cultures. Cultures of blood from both central and peripheral sites should be evaluated, since it is difficult to determine whether a positive culture of blood from a central line indicates contamination of the hub, colonisation of the catheter or catheter related bloodstream infection.

The longevity of lines should be kept as high as possible since repeated insertion of new lines carries a risk of complications and a cumulative loss of vascular access. Antibiotic lock therapy for 2 weeks is supported by a clinical study and is recommended (17). However, if the patient has clinical signs of septic shock the catheter should be removed immediately.

3.3. Repeated line infections

If patients on long-term HPN encounter repeated line infections, intervention apart from changing the line may be appropriate. Re-education in all necessary procedures should be carried out in all patients with line sepsis. Other measures that have been applied are the use of line locks with antibiotics, urokinase to lyse thrombus, and possibly alcohol and/or strong acid to dissolve debris (18), but no controlled studies of such interventions in HPN are available.

Lock procedures may be used to prevent repeated infections, and a recent study using taurolidine, an antiseptic with broad antimicrobiological activity has successfully been used in a single controlled study using a cross-over design in HPN patients (19). We need more studies to define the precise indication for using this lock procedure.

3.4. Removal of the line

The tunnelled line or port is removed in case of tunnel infection, port abscess, clinical signs of septic shock and if the microbiological diagnosis is of fungal infection. Complications related to the infection, endocarditis or other metastatic infections as well as thrombosis will also dictate line removal. Otherwise efforts should be made to try to save the line using all the standard procedures.

3.5. CRBSI – reducing the risk

Tunnelled catheters and implanted ports are specifically designed to protect the patient from extraluminal contamination and should be used for all patients who need parenteral support for
periods exceeding 3 months. Significant reductions in infection rates have been reported with anti-microbiologically coated central lines (antibiotics and metals), but such devices are only intended for short-term use.

Unless more lumens are absolutely required for patient management single lumen catheters should be preferred as controlled studies show that they reduce infection risk.

Avoid the placement of catheters in the femoral vein since this route is associated with more complications including thrombosis and infection.

The proper and full education of patients and caregivers are of paramount importance in reducing the risks of infection. This is supported by clinical studies in HPN patients. Central lines should not be changed routinely; there are no data demonstrating that this will reduce the risk of infection.

A number of agents including antibiotics, alcohol and citrate, have been used for flushing the line to reduce intraluminal biofilm formation, but evidence of useful effects in HPN is lacking. Tauradine may be an exception, but we await more studies before advocating its general use. The use of heparin for flushing does not reduce the risk of infection.

4. Catheter related venous thrombosis

Probably this complication is under-diagnosed, but few data are available about its prevalence in HPN. A rate of 1 thrombotic event every 20 catheter years was reported in one large study (15). The pathogenesis is probably multifactorial and includes vessel injury during insertion of the catheter, stasis due to indwelling of the device, damage to the endothelium caused by high osmolarity infusions, and catheter-related infections. It is more common when the catheter tip lies high in the superior vena cava.

The primary feature suggesting a thrombotic event is usually malfunction of the catheter. Swelling of the arm and neck and prominence of the superficial veins of the chest may ensue. There is a risk of pulmonary embolism. The diagnosis relies on the clinical picture and can be confirmed by (CT) angiography and sometimes by Doppler ultrasound scans. If not functioning properly or if associated with infection the catheter should be removed, and anti-coagulant treatment should be initiated. Many centres will then continue with a vitamin K antagonist (such as warfarin) for as long as the patient has a central line, but no studies in HPN patients are available. In patients with benign disease a more aggressive approach with systemic thrombolysis and thrombectomy may be considered. Prevention is most important; there should be careful selection of the insertion site and adjustment of the position of the tip of the catheter to ensure it lies in the lower superior vena cava or (best) in the upper right atrium.

Key points: Catheter related infection and thrombosis

- General barrier precautions and education of patients is of paramount importance
- Salvage of lines for continuing HPN is, on average, possible in about 25% of cases with infection
- Infections with fungi require line replacement
- Repeated line infections may be reduced by antibiotic lock (case reports)
- Thrombosis related to the catheter is a relatively rare complication

5. Summary

Broviac or Hickman lines are recommended for long term use and for patients needing daily access. Implantable ports can be used with advantages regarding the body image, but PICCs are only really suitable for in-patients and are not recommended for HPN. Catheters should be inserted under full sterile conditions to reduce infectious complications. There is a lower rate of complications with subclavian than jugular veins and when ultrasound guidance is used. The safest site for the catheter tip is just beyond the junction of the superior vena cava and the right atrium; use of the femoral veins is not recommended. If venous access is seriously compromised referral for intestinal transplantation should be considered.
General aseptic barrier precautions and education of patients is of paramount importance in reducing the incidence of catheter related infections and other complications. Salvage of lines for continuing HPN is, on average, possible in about 25% of cases with infection, but infections with fungi require line replacement. Repeated line infections may be reduced by antibiotic/antiseptic lock. Thrombosis related to the catheter is a relatively rare complication.

6. References


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