Learning Objectives

- To understand that maximum efficacy and safety of PN can only be achieved when it is carried out by a properly trained and expert Nutrition Team;
- To realise that monitoring, using data recorded in serial form is a vital tool for achieving optimal results;
- To understand how to implement monitoring protocols not only to optimise feeding methods and prescriptions but also to prevent complications or at least to detect them at an early stage, allowing timely action;
- To appreciate the technical, mechanical, clinical and infectious complications of PN and how monitoring helps in their management.

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Key Messages

- The efficacy of PN is dependent on having an expert team to carry it out;
- Clinical and laboratory monitoring are essential tools for the team to achieve optimal results;
• Data should be recorded in an easily retrievable serial form in order to give a dynamic picture of the rate, direction and degree of any change, allowing anticipation of problems and early intervention;
• Proper monitoring not only allows early detection of complications and timely intervention but also continuous adaptation of nutritional support to the needs of the patient;
• The appropriate monitoring protocol may vary according to the patient’s underlying clinical condition;
• PN is potentially associated with technical (e.g. mechanical), clinical (e.g. thrombotic), metabolic (e.g. hyperglycaemia), and infectious complications, which are largely preventable;
• Adherence to strict protocols and guidelines (e.g. in the insertion and care of central lines) and their conduct by trained staff reduces the risk of PN related complications and improves overall outcome.

1. Introduction

Many studies have shown that complication rates of PN can be reduced from 28% or more to 3% or less by the employment of a trained and expert team of doctors, nurses, dietitians and pharmacists (1). The mechanical problems of line insertion are inversely proportional to the experience and expertise of the operator and, in really expert hands, using radiological screening can be reduced virtually to zero. Thrombotic complications can be reduced by: (a) proper positioning of the catheter tip at the junction of the superior vena cava and right atrium, (b) avoidance of feeds with high glucose concentrations, (c) prevention of infection, and (c) use of modern catheters. Since more than 90% of line infections occur through the line by contamination of the hub of the catheter, infections can largely be prevented by: (a) confining handling of the line and catheter post insertion to expert nurses (casual or inexpert handling by others should be forbidden), (b) ensuring that handling of the catheter, hub, or giving set or dressing of the entry site are carried out as surgically sterile procedures. Monitoring and recording should be carried out according to agreed standard procedures and data reviewed at least daily in hospitalised cases.

2. Recording of Data

Merely doing tests, the results of which are stuck in the notes in a haphazard manner, cannot be classed as proper monitoring. Data should be recorded systematically in an easily retrievable and serial form either on charts near the patient’s bed or in digital form on an accessible computer. It is important not only to know the results of current tests but also to be able to see, at a glance, any change from the previous tests giving a dynamic picture concerning rate, direction, and degree of change. This allows anticipation of trends and early warning upon which to base clinical decisions. Standardised systems of this sort also allow easy retrieval of data for audit and research purposes and provide an invaluable weapon when proving the team’s cost-effectiveness to health service managers and grant giving bodies.

3. Monitoring Clinical Indications

The importance attached to each aspect of monitoring and the frequency with which measurements are carried out will depend on the clinical situation. Patients who may require PN can be divided broadly into the following categories.

3.1 Acute and Critically Ill Patients

Acute and critically ill patients, e.g. major trauma, burns, sepsis etc., are seen here. In these patients, monitoring of organ function, vital signs and fluid needs take priority, while nutritional support is conducted in a cautious and conservative manner, striking a balance between trying to conserve lean mass as far as is possible under these circumstances and avoiding the ill effects of nutritional excess, e.g. hyperglycaemia, salt and water excess, increased metabolic rate etc., in a vain attempt to reverse catabolism completely. Some units have the technology to measure metabolic rate by indirect calorimetry and this is undoubtedly an advantage in prescribing an appropriate energy intake for unstable and critically ill patients, e.g. burns. It is nonetheless possible to conduct PN in most patients using predictive formulae, e.g. Harris Benedict or Schofield so long as one recognises the potential for error and variation in acute illness.

3.2 Post-Acute Patients

The patients in the post-acute phase, i.e. >7-10 days post trauma or surgery with persistent GI dysfunction deserve special considerations. These patients are often oedematous with persistent retention of salt and water which impairs recovery of GI function and of mobility, and also have hypoalbuminaemia due to dilution from administered crystalloids and redistribution from the inflammatory process. Initial management and monitoring will be dominated by the need to obtain a diuresis. In patients with short
bowel, fistula, or other causes of excess fluid loss, subsequent management is dominated by the need adequately to replace losses of fluid and electrolyte as well as the provision of adequate nutrition until the underlying condition has resolved and normal oral intake may be resumed. Daily weighing to monitor water balance, fluid balance charts, and regular measurement of serum biochemistry are important monitoring parameters. Paradoxically, initial clinical improvement is shown by weight loss as oedema resolves. Weight gain from restoration of lean mass awaits convalescence and mobility and is a slow process. It is only too easy to gain weight due to fluid retention or fat accumulation, neither of which are clinically desirable. One of the main problems of PN, as opposed to EN where intake is limited by GI tolerance, is that it is only too easy to administer excess salt and water and also excess nutrients. Careful thought should be devoted to all details of PN prescriptions to ensure that they are appropriate to each patient.

3.3 Preoperative Malnutrition
Preoperative malnutrition - in cases not amenable to oral or enteral refeeding are at high risk. The aim is to improve function, e.g. muscle, immune, respiratory etc., to enhance survival and rate of recovery from surgery. This can be obtained by 7-10 days feeding. Some weight gain may occur through restoration of fluid deficit but further weight gain should be avoided as this signifies undesirable excess fluid retention which impairs outcome.

3.4 Chronic Malnutrition
Patients with chronic malnutrition, e.g. Crohn’s and other GI diseases, risk deterioration over time. Such patients often require prolonged PN or even permanent PN at home. Clearly, improved function and real tissue weight gain are desirable objectives. Monitoring may not need to be so frequent or so intense as in more acute conditions.

4. Monitoring Parameters
Parenteral nutrition is indicated in malnourished patients, or patients at risk of developing malnutrition, in whom the gastrointestinal tract is not functioning adequately or is not accessible (2). The goal of PN is to nutritionally replenish malnourished patients and prevent/delay the development of malnutrition. Consequently, the efficacy of PN should be assessed by regularly monitoring of the patient’s nutritional status using well-established parameters and indices (3, 4).

4.1 Clinical Parameters
A daily clinical examination of the patient is important, looking for evidence of oedema, dehydration, sepsis and wound healing among other important signs. The catheter site should be inspected at regular intervals for signs of inflammation or infection. In some series once or twice weekly dressing by the nurse was associated with lower costs and no more infections than daily dressings. Charting of vital signs is crucial, e.g. temperature, pulse rate, respiration, blood pressure etc., supplemented, as appropriate, by other measurements, e.g. central venous pressure, cardiac output etc.
A rise in temperature is, of course, the first indication of possible line sepsis, although this needs to be distinguished from other sources of sepsis. Blood cultures should be taken peripherally and through the line, and if fever persists the line should be locked. If this causes the fever to subside this incriminates the line which may be sterilised with antibiotics or removed and replaced. Records of all central catheters should be kept, including date inserted, date removed, reason for removal, and tip culture (whether or not sepsis is present).
Fluid balance charts give invaluable information concerning fluid input and changes in urine or fistula output or in gastric aspirate. They have inherent inaccuracies however and do not measure insensible loss. This gives rise to cumulative errors in calculating water balance, which is much more accurately assessed by daily weighing as practised by the renal doctors. If change in water balance can be obtained from weighing, then sodium balance can be inferred from changes in plasma sodium since this reflects the ratio of sodium to water in the extracellular space.

4.2 Anthropometric Indices
Weight
As a reflection of real tissue gain or loss this is important in initial assessment and in the long term monitoring of patients at long-term risk of malnutrition or undergoing long periods of PN. In short periods of feeding, i.e. <3 weeks, or in acute and post acute patients, however, its main use is to monitor water balance as discussed above, since significant gain of lean mass is unlikely in these conditions. Weighing is
also helpful for patients at home with large and variable GI fluid losses, e.g. short bowel, allowing them to adjust their own salt and water balance intravenously or by subcutaneous crystalloid infusion (hypodermoclysis). In the elderly or disabled, this may need to be done by a carer.

Arm circumference
Using a tape measure around the upper arm mid-way between the acromion and the olecranon process. This reflects the combined mass of skin, fat, muscle and bone. It is a useful surrogate for weight in patients whom it is difficult to weigh, and by subtracting the triceps skinfold thickness, changes in muscle mass can be calculated.

Triceps skinfold
Unfortunately this is very observer dependent with wide errors in unskilled hands. It is useful in research projects which involve one skilled observer but is much less helpful in normal clinical practice (5).

4.3 Nutrition Screening and Assessment Tools
As the name implies, these are of use in initial assessment and in long term monitoring of patients at risk. They include the older SGA (subjective global assessment) and the newer tools proposed by ESPEN (NRS 2002)(6). The old so called nutritional risk indices are outdated, containing as they do haematological parameters and serum albumin which are almost entirely a reflection of disease severity (7). They are therefore good as prognostic factors but not as nutritional indices. Also the total lymphocyte counts, complement and skin tests are not used anymore, because they have a very low sensitivity (for a more detailed discussion of the available tools for assessing nutritional status please go to Module 3 – Nutritional Assessment and Techniques).

4.4 Function
In malnourished patients, nutritional support, by any means, results in rapid and measurable improvements in physical and mental function within days, long before any change in tissue mass. Simple measurements to record these changes can be performed at the bedside.

As a research tool, involuntary muscle strength can be measured by direct stimulation of the adductor pollicis. In clinical practice, however, hand grip dynamometry, using one of the newer digital machines, gives a good reflection of changes in muscle strength. Respiratory muscle strength is reflected by simple Peak Flow measurements. We do not routinely use skin tests of immune function although serial white blood cell and lymphocyte counts give some reflection of immune function. Mental changes can be detected by an experienced observer and can be scored formally using the POMS or other validated scoring symptoms. These measures of function are the most sensitive indicators of change in nutritional status. Deterioration is detectable at only 5% weight loss in normal subjects and is clinically significant with more than 10% weight loss in patients. As described above the first sign of response to refeeding is an improvement in function, which is probably the mechanism of benefit in perioperative feeding. The fact of a short latent period of effect may explain the superior effect of preoperative immunonutrition compared with postoperative feeding alone.

4.5 Laboratory
This comprises biochemical, haematological, and microbiological data. Biochemical measurements may be daily in acute patients, approximately two or three times weekly in the post-acute and progressively less frequently in convalescent or long term patients.

Plasma sodium concentration of itself is more a reflection of dilution or concentration due to changes in water balance and not of salt balance, but if water balance is known from weighing, then sodium balance can be inferred from changes in plasma sodium concentration. This is invaluable in patients with abnormal GI fluid losses, allowing accurate maintenance of salt and water balance for long periods.

Serum potassium is a good indicator of the adequacy of potassium intake and also gives warning of the development of the refeeding syndrome (see chapter 5.1) as does the serum phosphate.

Chloride and acid base measurements are particularly useful in acute and immediately post acute patients.
Ca, Mg, Zn and Se measurements are of particular value in patients with GI disease and are helpful in guiding replacement. Micronutrient screening is only available in a few laboratories but is helpful in long-term patients.
Blood glucose has become particularly important since the importance of normoglycaemia in determining outcome from critical illness has been demonstrated.

Plasma proteins give less useful information concerning nutritional status than once thought. The acute phase protein C-reactive protein is a most useful reflection of changes in the inflammatory state. As it
rises with the onset of inflammation, the serum albumin falls as it is redistributed by capillary leakage. Hypoalbuminaemia is further exacerbated by dilution with crystalloid infusions. These are the dominant influences on the plasma proteins in the acute, post-acute, or perioperative patient. On the other hand in convalescent or long term feeding the restoration of serum albumin may occur faster with adequate nutrition provided that there is not persistent inflammation or protein losing enteropathy. Liver disease of course may also contribute to hypoalbuminaemia.

Haematological screening should also be performed regularly. Anaemia may have nutritional causes or be secondary to blood loss but is more often the non-specific normochromic normocytic anaemia of inflammatory disease, improving spontaneously as the disease resolves.

Regular microbiological cultures of swabs from relevant sites allow monitoring of colonising organisms and may help to guide treatment. Blood cultures should always be performed if fever develops.

4.6 Practical Considerations

Although it is imperative to monitor the efficacy of PN in order to adapt it to the changing needs of the patient, in some clinical conditions, and particularly in the critical patient, it can be extremely difficult to obtain an objective marker of nutritional replenishment. Nitrogen balance is a sensitive tool to assess the efficacy PN efficacy, but is difficult to measure accurately in clinical practice and is not normally used. Furthermore, it should be remembered that trauma and burn patients develop hypercatabolism, which cannot be reversed by feeding alone, although this does offset the starvation component of disease and therefore helps to slow the loss of lean mass. The aim of management is to reduce the severity of the catabolic stimulus by modern techniques, e.g. control/prevention of infection, nursing in a warm environment, better analgesia/anaesthesia, improve surgical technique etc. These measures in combination with nutritional support have lessened the loss of lean mass in such patients and contributed to better outcome.

In stable conditions, the monitoring of PN efficacy is much easier and allows regular review of the nutritional and metabolic needs of the patients receiving PN. By identifying correctly the patient’s needs, the efficacy of PN is greatly improved and the risk of developing complications significantly reduced.

5. Complications of PN

Parenteral nutrition may be associated with the development of complications, which can be metabolic, technical or infectious. For this reason, PN should be used for the shortest period possible, and oral or enteral feeding should be initiated as soon as is clinically feasible. Indeed, the gastrointestinal route remains the most physiologically appropriate and cost-effective way of providing nutritional support. As emphasised above, the complication rate is significantly reduced in those hospitals where a multidisciplinary specialised Nutrition Support Team has been created. This team includes doctors, pharmacists, nurses, and dietitians. The combined expertise of this personnel is critical in correctly assessing the needs of the patients, preparing the PN bag, safe administration and monitoring for the early signs and symptoms of complications.

5.1 Metabolic Complications

The inappropriate assessment of the caloric needs of the patients may increase the risk of developing the refeeding syndrome, a serious and potentially fatal complication of artificial nutrition. The refeeding syndrome occurs in severely malnourished patients whose energy metabolism is mainly based on the utilization of fatty acids or ketone bodies (8). When these patients are suddenly given a high energy intake, especially from glucose, the attendant increase in insulin secretion promotes the entry into the cells of potassium and phosphate, thereby reducing their extracellular concentrations. In particular, the reduction in phosphate may cause serious derangement of cardiac function. To prevent the refeeding syndrome, severely malnourished patients, in particular, should initially receive only 20 to 30% of their energy requirements, building up to full intake over several days. This should be combined with a high intake of phosphate and potassium, with frequent monitoring of blood levels. A bolus injection of 100 mg of thiamine should also be given.

Hyperglycaemia may occur in patients receiving PN, and if high and persistent enough may induce an osmotic diuresis and dehydration (9, 10). Strict glycaemic control has also been shown to improve mortality in ICU patients, further emphasising the need for the prevention of hyperglycaemia. To prevent this complication, it is important that PN provides only the amount of glucose that each patient can utilize (<5 mg/Kg BW in the critically ill patient). Also, frequent monitoring of glycaemia and glycosuria during the first days of PN is important in the assessment and treatment of hyperglycaemia, particularly in diabetic patients.
Hypoglycaemia may occur during withdrawal from PN, particularly if the infusion rate is not reduced gradually during the last few hours of PN infusion before stopping it (10).

Hypertriglyceridaemia may develop in patients receiving lipid-containing PN, and may lead to the occurrence of pancreatitis (11). Also, it should be remembered that some clinical conditions, including liver cirrhosis, are associated with a reduced clearance of exogenous triglycerides. Monitoring of triglyceridaemia weekly may be useful in helping to prevent the development of this complication.

Hepato-biliary complications of PN, which range from liver steatosis to cholestatic liver disease, which may progress to liver cirrhosis and liver failure, are observed mainly in patients receiving long-term PN (for a more detailed discussion of these complications, please go to Topic 19 - Home Parenteral Nutrition).

The pathogenesis is multifactorial, but the decrease in the enterohepatic cycle of bile acids, associated with bacterial overgrowth, appears to play a critical role. To prevent this complication, the cyclic delivery of PN and the minimising of energy intake (particularly from carbohydrates) may be useful, as well regular monitoring of hepatic function. More importantly, promotion of some oral intake/enteral nutrition, to stimulate biliary secretion and avoid stasis, is critical in reducing the risk of developing hepato-biliary complications (12).

PN-induced bone disease occurs in approximately 30% of patients receiving long-term PN (for a more detailed discussion of these complications, please go to Topic 19 - Home Parenteral Nutrition). In these patients, bone density should be measured regularly (13).

The inadequate delivery of micronutrients and vitamins may cause subclinical and clinical deficits of these nutrients, resulting in neurological and/or muscular symptoms and signs, delayed wound healing and other clinical problems.

Among the above mentioned metabolic complications, some should be considered clinically important relevant and deserving of prompt intervention (see Table 1).

### Table 1 Definition of clinically relevant metabolic complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycaemia</td>
<td>&gt;12 mmol/L (even this may be too high)</td>
</tr>
<tr>
<td>Hypoglycaemia</td>
<td>&lt;3 mmol/L</td>
</tr>
<tr>
<td>Ketoacidosis</td>
<td>Arterial pH &lt; 7.30 + &gt;2 dipstick for urinary or serum ketones</td>
</tr>
<tr>
<td>Hyperosmolar hyperglycaemic non-ketosis</td>
<td>Very high blood glucose + serum osmolality &gt; 305 mOsm/L + absence of urinary ketones, serum osmolality raised &gt; 295 mosm</td>
</tr>
<tr>
<td>Na, K, Cl, Ca, Mg, P disorders</td>
<td>Serum values outside the reference range</td>
</tr>
<tr>
<td>Hypertriglyceridaemia</td>
<td>&gt;150% of upper reference limit measured &gt; 8 hrs after lipid emulsion (check milky plasma)</td>
</tr>
<tr>
<td>Hyperazotemia</td>
<td>Blood urea &gt; twice upper limit of reference (may also reflect excessive nitrogen intake)</td>
</tr>
<tr>
<td>Hypercholaemic acidosis</td>
<td>Serum Cl &gt; 115 mmol/L + arterial pH &lt; 7.30</td>
</tr>
<tr>
<td>Hepatic dysfunction (AST, ALT, alkaline phosphatase, bilirubin)</td>
<td>&gt; twice the upper limit of reference</td>
</tr>
<tr>
<td>Fluid overload</td>
<td>Heart failure, oedema or weight gain &gt; 0.45 kg/day for 3 or more consecutive days</td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>Prothrombin time and/or partial thromboplastin time &gt; 150% of upper limit of reference</td>
</tr>
</tbody>
</table>

The risk of complications depends not only on the competence of the nutritional team but also on the patient’s clinical condition. The more severely ill the patient, the greater the risk of complications. Furthermore, the patient’s clinical condition influences the type of complication, e.g. the refeeding syndrome is more likely in a severely malnourished patient. As a consequence, the monitoring schedule should be tailored to the patient’s condition. As a general rule, during the early phase (3-5 days), stepwise increments of macronutrients should be introduced slowly until estimated and/or tolerated nutrient requirements are achieved. Blood glucose, urea, sodium, potassium, magnesium, phosphorus, ionized calcium, should be obtained daily, at least initially (10). In critically ill patients, arterial blood gases should also be monitored daily. Thereafter in hospitalised patients, the full set of laboratory parameters should be obtained 2-3 times weekly. For home PN, the intervals between measurements can be considerably extended.
5.2 Technical Complications
Catheter or cannula insertion is associated with a risk of technical complications, which are different for central and peripheral PN.

5.2.1 Technical Complications of Peripheral PN
Cannulas and midline catheters are used to infuse peripheral PN. To prevent mechanical complications (catheter kinking), site selection should avoid the need for excessive flexion (14). The most common complication of peripheral PN is phlebitis (3 to 31%). In some cases, the consequences of phlebitis can be very serious, including local suppuration, local tissue necrosis, bacteremia and sepsis. In this respect, the insertion site should be monitored daily to check for early signs of phlebitis. Therapies not appropriate for peripheral devices include continuous vesicant chemotherapy, parenteral nutrition fluids with more than 10% dextrose and/or 5% protein, solutions and/or medications with pH less than five or greater than nine and solutions and/or medications with osmolarity greater than 500mOsm/L. Cannulae should be daily changed, since the risk of phlebitis increases when they are left in place >72 hrs. Midline catheters have been associated with lower rates of phlebitis than short peripheral catheters. Paediatric sialastic catheters have also been used in adults for peripheral PN and can be left in place for several days without increased risk. A diminution of the endothelial reaction to infused fluids and trauma can be achieved by adding heparin (1000 IU/L) and/or hydrocortisone (5-10 mg/L) to the regimen, reducing the rate of thrombosis to 8%.

5.2.2 Technical Complications of Central PN
Central venous catheters (CVC) and peripherally inserted central catheters (PICC) are used to infuse central PN. The insertion of a central catheter is associated with early and late complications. The former are mainly technical complications and include: failure of insertion, local haematoma or abscess, misplacement and migration, catheter embolism, arrhythmias, haemothorax, pneumothorax, central venous thrombosis and/or thromboembolism. The risk of developing technical complications during catheter insertion is reduced if the catheter is placed by qualified and trained personnel. Also, the use of ultrasound/Doppler scanning of the venous anatomy significantly reduces the risk of complications (Fig. 1).

Figure 1 Ultrasound scanning of the venous anatomy prior to Midline insertion
Late mechanical complications of central catheter insertion include blockage of the catheter (urokinase, sodium hydroxide, hydrochloric acid or 70% ethanol lock may be used to unblock the lumen). Catheters can occasionally fracture in their intraluminal part and embolise. Some evidence of central vein thrombosis is common (up to 50%) when assessed by ultrasound imaging, but major thromboses causing clinical manifestations are uncommon. In severe cases, however, it can be a dangerous complication, leading to a high rate of morbidity and mortality. The risks of thrombosis can be reduced by appropriate selection of the insertion site, proper catheter tip location, i.e. at the junction of the right atrium and superior vena cava, and meticulous insertion. The use of modern less rigid catheters and the avoidance of feeds with high glucose concentration have also
contributed to a reduction in thrombosis. It is not known whether, in all cases, attempts should be made to dissolve any thrombus using plasminogen activator, urokinase or streptokinase, but in some cases the attempt may be justified.

5.3 Infectious Complications
Infection remains the most serious complication of PN, and particularly of central PN. Catheter-related blood-stream infection (CRBSI) is the preferred term to define septic complications of intravascular catheters. From a practical point of view, some convenient definitions to be used when referring to these complications:

- **local infection**
  - Catheter colonization, when growth of microbial pathogen is found in a specimen without general or local signs of infection;
  - Exit site, tunnel and pocket of totally implanted devices infection;
- **invasive infection**
  - CRBSI, which is the most dangerous complication and may occur any time when a central venous catheter is in place.

5.3.1 Pathogenesis
A catheter can be colonized on its outer surface, in its lumen or both. The most common causes of endoluminal colonization are:

- colonization of the catheter hub (far the most common);
- broken or leaking line due to poor connections;
- contaminated nutritional admixture (during preparation, infusion, connection, additives added in the ward, rare with adequate pharmacy support);
- use of the central venous catheter for other purposes by inexpert users (e.g., blood sampling). With strict aseptic protocols, the use of the line by experts, e.g. experienced nutrition nurses, for blood sampling or drug administration has a relatively low risk. Multi-use lines in ICUs, however, should probably be replaced at least weekly as they have a high contamination rate after a few days.

The most common causes of extraluminal contamination are:

- migration of microorganisms along the catheter from the cutaneous exit site;
- direct contamination during catheter insertion (“third day surgical fever”);
- haematogenous seeding, especially in critical care settings, e.g. organisms from abdominal sepsis colonising the line from the bloodstream.

The clinical picture of CRBSI has local and/or general manifestations, whose presence should be regularly monitored. The local signs include: redness, pain, swelling, or drainage of serous or purulent fluid at the exit site. Tunnel suppuration presents as a painful, inflammatory string along the subcutaneous tunnel. The general signs may be non-specific, and they cover a wide spectrum from subfebrile status up to signs of septic shock and organ failure. Fever is often accompanied by chills (rigors), and symptoms often appear 1-3 hours after starting a new infusion. Non specific signs as nausea, vomiting, lethargy, mental and vision disturbances have also been reported.

A maximum rate of 0.45-1 infectious episodes/year of central venous catheter use for hospital PN, and 0.1-0.5 infectious episodes/year of central venous catheter use for home PN appear generally acceptable as they may be inevitable even under optimal conditions. The important thing is early recognition and action.

5.3.2 Prevention
The most important preventive measures are as follows (15, 16, 17):

- A high level of training of staff responsible for the insertion and maintenance of catheters;
- The strict avoidance of any handling of the catheter or line by inexpert staff, be they doctors or nurses;
- quality assurance and continuing education;
- correct choice of site of insertion (lower extremity insertion sites are associated with a higher risk for infection than are upper extremity sites);
- type of catheter material (polyurethane catheters have been associated with fewer infectious complications than polyvinyl chloride or polyethylene);
- hand hygiene and aseptic technique;
- skin antisepsis (preparation of insertion site with 2% aqueous chlorhexidine gluconate lowered bloodstream infections rates compared with 10% povidone-iodine or 70% alcohol);
• catheter site dressing regimens (transparent, semipermeable polyurethane dressings have become a popular means of dressing catheter insertion sites, allowing for continuous inspection of the exit site).

Administration sets used for PN should be changed every 24 hours or immediately upon suspicion of contamination or when the integrity of the product or system has been compromised. PN administration sets should be changed using aseptic technique and observing universal precautions.

The use of antimicrobial/antiseptic impregnated catheters and cuffs has yielded conflicting results but may be used in patients at high risk of infectious complications (e.g., critically ill patients). No benefit has been demonstrated from the use of systemic antibiotic prophylaxis, nor for the use of antibiotic/antiseptic ointments at the exit site.

To prevent CRBSI, antibiotic lock prophylaxis has been attempted by flushing and filling the lumen of the catheter with an antibiotic solution and leaving the solution to dwell in the lumen of the catheter. Clinical studies have demonstrated the usefulness of such prophylaxis in neutropenic patients with long-term catheters.

It is important to note that catheter replacement at scheduled time intervals as a method to reduce CRBSI has not lowered rates.

6. Summary

The cost effectiveness and outcome of PN is dependent on its being conducted by a trained team working to agreed protocols including a proper monitoring programme with measurements being carried out in a systematic manner appropriate to the clinical problem involved. Data should be recorded in an easily retrievable serial form to allow a dynamic picture of the patients progress. Such a programme helps to guide feed prescriptions and to prevent complications or give early warning of their onset, allowing timely intervention

References


Useful links

Center for Disease Control and Prevention, Atlanta, GA, USA (www.cdc.gov)
European Society of Clinical Nutrition and Metabolism (www.espen.org)
European Vascular Access Network (www.evanetwork.org)
Gli Accessi Venosi Centrali a Lungo Termine (www.gavecelt.org) (Italian website good source of guidelines)
National Institute of Clinical Evidence (www.nice.org.uk)
Royal College of Nursing (www.rcn.org.uk)