ACI NSW Agency for Clinical Innovation

PARENTERAL NUTRITION POCKETBOOK:
FOR ADULTS

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FOREWORD

The Agency for Clinical Innovation (ACI), formerly the Greater Metropolitan Clinical Taskforce (GMCT), was established by the NSW government as a board-governed statutory health corporation in January 2010, in direct response to the Special Commission of Inquiry into Acute Care Services in NSW Public hospitals. The ACI drives innovation across the healthcare system by using the expertise of its clinical networks to design, cost and recommend innovative, evidence-based improvements to public health care services in NSW, for implementation on a state-wide basis.

Parenteral nutrition (PN) is a life sustaining therapy for patients who cannot eat or tolerate enteral nutrition. However, there are significant infection risks and complications associated with intravenous feeding. The ACI was approached by clinicians providing PN to develop a resource to support colleagues working in facilities where PN is less frequently used and to identify best care practices for PN for NSW public health facilities.

The project, funded by the GMCT (now ACI), commenced in early 2008 and has been a collaborative effort by the ACI's Gastroenterology and Nutrition Networks. The PN working group involved clinicians from across NSW, including medical practitioners from a number of specialties, nurses, dietitians, pharmacists and consumers.

On behalf of the ACI, I would like to thank the Chair of the working group, Professor Ross Smith and all the members for their dedication and expertise in developing this PN Pocketbook.

Hunter Watt
Chief Executive,
Agency for Clinical Innovation

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PREFACE

Parenteral nutrition (PN) refers to the intravenous infusion of specialised nutrition solution. This method of feeding may be required when the gastrointestinal tract is not functional or leaking, cannot be accessed, or the patient cannot be adequately nourished by oral or enteral means.

In NSW, there are major variations in the way PN is administered in public hospitals. Furthermore, hospitals in outer metropolitan and rural regions of NSW may have limited support in the area of PN and its administration. Commercially premixed solutions can provide adequate nutrition over short periods but for more complex patients, it is important to have a flexible system to personalise parenteral nutrition available in larger hospitals. This pocketbook aims to provide principles of PN therapy for adult patients to ensure consistency throughout NSW wherever patients are managed. Children have very specific nutritional requirements which are individualised to their age, clinical condition and disease. Therefore, PN in paediatrics is not addressed as part of this book.

PN is complex and expensive and should therefore be used with good clinical guidance. The pocketbook provides guidance for clinicians on the indications for PN, nutrition assessment of the PN patient, determining PN requirements, initiating PN, monitoring complications and ceasing PN.

PN is best managed by a multidisciplinary team that should be guided by an interested clinician (gastroenterologist, GI surgeon and intensivist), but that importantly involves nutrition nurses, dietitians and pharmacists, together with biochemistry and microbiology laboratory support if necessary. In smaller hospitals these roles can be shared.

I would like to thank all those who volunteered to undertake the tasks of reviewing a large volume of the literature to complete what has been a successful project.

Professor Ross Smith
Chairman of ACI TPN working group
Professor of Surgery, Northern Clinical School University of Sydney

1. PRINCIPLES OF NUTRITION SUPPORT

1.1 Malnutrition & Principles of Nutrition Support

Malnutrition is common in hospitalised patients. Prevalence rates of malnutrition reported in Australian hospitals are around 30%[1,2].

Nutritional status can decline significantly over the course of a patient's admission, due to a combination of reduced nutrition intake and increased requirements secondary to the impact of the disease process (altered metabolic requirements, increased nutrient losses and reduced consumption, digestion and absorption).

Timely and appropriate nutrition support aims to prevent malnutrition in those at risk and treat those who are malnourished.

Malnutrition is associated with increased morbidity and mortality; increased length of hospital stay and hospital costs; and increased risk of infections, delayed wound healing, impaired respiratory function, electrolyte disturbances and post-operative complications.

1.2 Malnutrition Screening

Malnutrition screening enables the early identification of patients who may benefit from nutrition support. Leading nutrition groups worldwide recommend routine nutrition screening of hospitalised patients[3,4,5].

There are several validated nutrition screening tools available, the most well-known being the MUST and MST[6,7,10]. Nutrition screening should be undertaken on admission and repeated on a regular basis for long-stay patients. Patients should have their nutrition history and weight recorded and those at risk should be flagged and referred for further nutrition assessment and intervention. An automated screening tool has been developed and validated in upper gastrointestinal (GI) surgical patients[8].

If screening indicates the patient is at increased risk of malnutrition, a thorough assessment should be done (Refer to Section 2).

1.3 Indications for Nutrition Support

Nutrition support (oral, enteral or parenteral) should be considered for all patients who are malnourished or are at risk of malnutrition.

To diagnose malnutrition, use the ICD-10-AM Sixth Edition criteria[11].

E43 Unspecified severe protein energy malnutrition

- In adults, BMI < 18.5 kg/m^2 or unintentional loss of weight (≥10%) with evidence of suboptimal intake resulting in severe loss of subcutaneous fat and/or severe muscle wasting.

E44 Protein-energy malnutrition of moderate and mild degree

- In adults, BMI < 18.5 kg/m^2 or unintentional loss of weight (5–9%) with evidence of suboptimal intake resulting in moderate loss of subcutaneous fat and /or moderate muscle wasting.
- In adults, BMI < 18.5 kg/m^2 or unintentional loss of weight (5–9%) with evidence of suboptimal intake resulting in mild loss of subcutaneous fat and/ or mild muscle wasting

To identify those at risk of malnutrition[9]:

- Have eaten little or nothing for more than five days and/or are likely to eat little or nothing for the next five days or longer
- Have increased nutritional needs from causes such as catabolism, high nutrient losses or poor absorptive capacity

The above indications should be considered in light of results of a full nutrition assessment.

1.4 Indications for Parenteral Nutrition

Parenteral Nutrition (PN) can sustain life when patients are unable to take sufficient nourishment via the gastrointestinal tract for prolonged periods. However, PN is associated with significant risks and complications. Alternative methods of nourishing patients should be considered in every case. A nutrition support algorithm is presented in Figure 1.

Where possible, oral or enteral nutrition are preferred options.

PN is necessary when the patient cannot be sustained with either increased intake of oral supplements or enteral nutrition alone. The use of PN should be considered when normal oral intake or enteral nutrition cannot be started after a period of five days.

Short-term PN is appropriate in malnourished and/or severely catabolic patients unable to be adequately nourished enterally. In this patient group, the risks of complications of nutrition depletion are greater and PN should be started earlier.

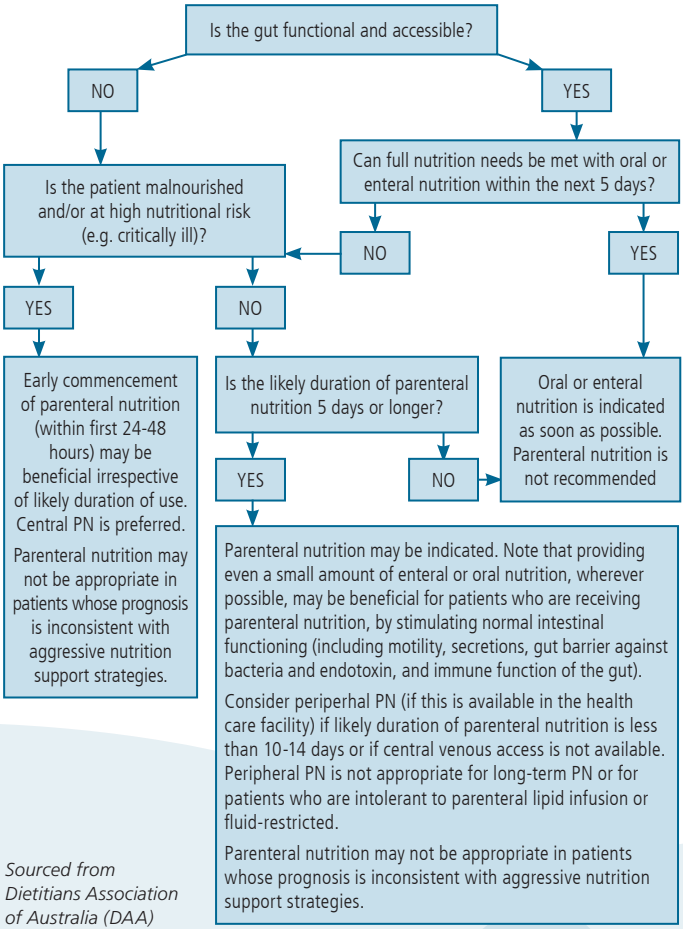
As PN is an invasive therapy, it must be used in a manner which limits the risk of sepsis, catheter insertion complications and metabolic complications.

PN is also a relatively expensive treatment which can only be justified for patients with clearly defined indications.

The basic indication for using PN is a requirement for nutrition when the gastrointestinal tract is either:

- not functional or leaking (e.g. obstruction, ileus, fistulae, dysmotility)
- cannot be accessed (e.g. intractable vomiting with inability to establish jejunal access)
- the patient cannot be adequately nourished by oral or enteral means (e.g. in malabsorption states such as short bowel syndrome, radiation enteritis or inability to establish full enteral feeding)[9].

Figure 1: Nutrition Support Algorithm[12]



Sourced from Dietitians Association of Australia (DAA)

1.5 When is it not appropriate to use Parenteral Nutrition?

PN may not be appropriate in well nourished, non-catabolic patients where enteral nutrition is likely to be established within five days.

PN may not be appropriate where the prognosis is inconsistent with aggressive nutritional support.

Ethical and legal principles must be considered in decisions involving the withholding or withdrawing of nutrition support. PN should not be used to prolong life when there is little prospect of good quality in the eyes of the patient, the patient's family and the medical team.

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2. NUTRITION ASSESSMENT OF THE ADULT PN PATIENT

The purpose of performing a nutrition assessment on the patient commencing PN is to determine nutritional status, identify nutrient and metabolic risks and establish a nutrition care plan regarding methods of nutrition support.

Nutrition assessment is a comprehensive approach to gathering pertinent data in order to define nutritional status and identify nutrition-related problems. The assessment often includes patient history, medical diagnosis and treatment plan, nutrition and medication histories, nutrition-related physical examination including anthropometry, nutritional biochemistry, psychological, social, and environmental aspects[1].

The following information should be collected as part of a comprehensive assessment:

Table 1:

PARAMETER EXAMPLES	TYPICAL INDICATORS
Clinical Medical and surgical history Severity of illness and duration	Conditions such as trauma, major abdominal surgery, chronic illness with acute complications, sepsis, losses (e.g. fistula, wounds, diarrhoea) altered mental state and large wounds increase risk of malnutrition and increase patient requirements.
Gastrointestinal factors	See *Indications for parenteral nutrition.* Note presence of anorexia, nausea, vomiting, abdominal distension, diarrhoea, gastrointestinal or hepatopancreaticobiliary obstruction or a fistula.

PARAMETER EXAMPLES	TYPICAL INDICATORS
Medication history	Has the patient been on medication which has the potential to affect nutritional status, either through gastrointestinal side effects (e.g. nausea) or neurological side effects (e.g. confusion), or through direct drug-nutrient interactions.
Fluid balance	Dehydration, large losses, oedema, ascites, significant discrepancies in intake/output on fluid balance chart.
Physical examination	Visual appearance of muscle wasting, loss of subcutaneous fat, frailty, pallor, pressure ulcers, oedema, etc. Manifestations of likely vitamin deficiency e.g. angular stomatitis, glossitis, bleeding gums
Anthropometry Body weight, height, BMI	WHO BMI classifications[2] Underweight: BMI<18.5 kg/m^2 Healthy weight: 18.5 - 24.9 kg/m^2 Overweight: 25-29.9 kg/m^2 Obese: > 30 kg/m^2 *Note that BMI is an acceptable approximation of total body fat at the population level, but not always an accurate predictor in individuals e.g. liver disease[3]. In addition Asian, Indian and Indigenous Australian populations may need to have a lower cut-off for healthy weight, Pacific Islanders probably require a higher BMI cut-off of 26, and for adults over 65 years a higher BMI range of 22-26 is associated with better health status[4,5,6].*

PARAMETER EXAMPLES	TYPICAL INDICATORS
Unintentional recent weight loss	*Significant weight loss:* • 5% weight loss in one month • 10% weight loss in six months *Severe weight loss:* • >5% body weight in one month, • 10% in three months[7]
Current weight trend	If the patient is regaining some of the weight lost (fat or muscle rather than fluid gain), degree/risk of malnutrition is decreased.
Body composition	• Use of skin fold thickness measurement • Mid-arm muscle circumference • Calf circumference (There is a broad range of sophisticated methods for the measurement of body compartments. They are most useful in monitoring home PN requirements.)
Nutrition History Food intake	History/duration of poor oral intake or prolonged fasting periods Current intake compared with usual intake Other factors affecting intake e.g. dysphagia, taste changes, poor dentition, abdominal pain and/or depression Consideration of micro and macro nutrient intake is necessary here

PARAMETER EXAMPLES	TYPICAL INDICATORS
Risk of re-feeding syndrome	Assessment of a patient's risk of refeeding syndrome is important in determining how aggressively parenteral nutrition can be advanced *(For more detailed information on refeeding syndrome, see Section 4)*
Biochemical data	See *"Monitoring of Parenteral Nutrition in Ward Patients" (Section 7)*
Functional level Muscle strength, fatigue	Ability to perform own Activities of Daily Living Quality-of-life indicators Respiratory function - peak flow and FEV_1 Hand dynamometry if available
Immune function	Full blood count (consider effect of infection or haematological disorder)
Social and environmental	Psychosocial factors (e.g., social support; eating disorders; language barriers; family dynamics; personal, ethnic, cultural, or religious dietary prescriptions; substance abuse; psychiatric disorders) Socioeconomic factors (e.g., personal financial situation and reimbursement sources) Patient preferences and directives with regard to intensity and invasiveness of care; emotional response to current illness The patient's home environment Educational level or learning ability Activity pattern and lifestyle.

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3. VENOUS ACCESS FOR PN IN THE ADULT PATIENT

Successful delivery of PN requires a dedicated lumen and appropriate vascular access.

The type of catheter and choice of vein depends on several factors including:

- risks associated with the placement method
- potential complications (thrombotic, infectious and mechanical)
- ease of site care
- number of infusions
- anticipated duration of therapy.

There are a number of considerations that need to be made when choosing the route of venous access. These include:

- history of patient (history of thrombosis, multiple previous intravenous lines resulting in damaged veins and limiting the choice of either peripheral or central venous access, lymphoedema)
- individual circumstances e.g. haematological stability, allergies
- resources available e.g. access to skilled professionals, nutrition support teams, vascular access teams
- osmolarity and pH of the solution
- risk of infection
- duration of PN
- type of line access available
- other IV therapies required by the patient, as a multilumen catheter may be needed.

If time and circumstances allow, discuss the options for different types of venous access devices (VAD) with the patient.

The intention of this document is to discuss inpatient PN therapy. If the patient is planned for home PN, please refer to the AuSPEN Home Parenteral Nutrition guidelines for appropriate vascular access[1].

It is beyond the scope of this document to discuss the pros and cons of each VAD, however a brief summary is provided. Please also refer to your local Central VAD policy for guidance.

3.1 Central Venous Access

Most PN solutions have a high osmolarity and are therefore only suitable for delivery via a central venous line.

The main veins used for access to the central venous system are:

- subclavian veins
- internal and external jugular vein
- cephalic and basilic veins
- femoral veins (least preferred).

Tip Placement

The tip should end between the lower third superior vena cava and the atrial caval junction. When access to the superior vena cava is contraindicated, the inferior vena cava may be used.

A chest X-ray is necessary to confirm the position of the tip when:

a) the position of the tip has not been checked during procedure (x-ray or ultrasound)

b) the device is placed using the blind subclavian approach or other techniques carrying risk of pneumothorax

c) there is documented prior use of a catheter.

It is important to monitor the site for signs of thrombosis, thrombophlebitis, phlebitis, infection and/or displacement.

Types of Central Venous Access Devices

Non-tunnelled, non-cuffed catheters (central line)

- intended for short-term use
- may be inserted via subclavian, internal jugular or femoral vein
- may be antimicrobial impregnated
- account for the majority of catheter-related bloodstream infections.

Peripherally Inserted Central Catheters (PICC)

- typically used in the hospital, for mid-term therapy or when central venous access is indicated
- the exit site is on the arm. As with other central catheters, the tip is placed in the distal superior vena cava. A PICC should not be confused with other catheters placed in the arm (e.g. peripheral or midline)
- are not tunnelled and are only secured by external adhesive securement
- typically placed via basilic, cephalic or brachial vein.

Tunnelled

- follow a tract under the skin before entering a central vein and have a cuff
- most common type of long-term HPN access
- often called by a brand name (e.g. Broviac®, ,Hickman®)
- lower rate of infection than non-tunnelled catheters
- typically placed by a surgeon or interventional radiologist.

Implanted port catheters

- also called a "Port" or "Port-a-Cath"
- commonly used for intermittent access and not recommended for PN unless already *in situ*
- the port of an implanted catheter is completely under the skin
- typically placed into subclavian or internal jugular vein by a general surgeon or interventional radiologist.

3.2 Peripheral Venous Access

Peripheral access may be considered using either small gauge or midline, for short periods of time. Do not use veins in lower limbs. It is important to monitor the site for signs of phlebitis, infection and/or displacement. Hospitals should ensure that they have the appropriate protocols in place to administer and monitor peripheral PN safely.

There are two types of peripherally placed catheters:

- teflon/plastic cannulae
- midlines into the basilic or cephalic veins.

PN can be delivered into peripheral veins using normal cannulae, but these must be rotated regularly to prevent thrombophlebitis. Peripherally placed cannulae are best managed with regular rotation of catheters from side to side and using low osmolarity PN solutions (700 mOsm/L), which reduce damage to the vein endothelium (phlebitis) and risk of thrombosis. This limits the amount of nutrition that can be provided. It may be useful at the introduction of PN when short term nutritional support is required.

PN can be provided via a midline with similar success to central PN, provided the line is fine bore, and a "3 in 1" solution which has an osmolarity of ≤ 900 mOsm/L is used[2]. To achieve this, the amount of lipid needs to be about 66% of non-protein calories (or 50% total calories) using a higher concentration of amino acids. With such a peripheral solution providing 110-120 kcal:1gN, postoperative patients can preserve their muscle mass[3]. While this is a greater amount of lipid than generally recommended, it has been used in a number of studies without increased morbidity.

An improved thrombophlebitis rate can be achieved with a mid-line placed about 15 cm into the basilic vein. There are a number of advantages to midlines because they can be placed without radiological guidance and can be monitored clinically for any tenderness over the vein. These lines should be 2-3F in size and can only be used for continuous infusion for rates up to 120 ml/h.

They cannot be used for resuscitation. Studies have demonstrated a reduced risk of sepsis with the use of midlines and they can be safely inserted and managed by nursing staff without the need for referral to the radiology department.

3.3 Care and Management of Vascular Access

Considerations for vascular access and ongoing care of line and site are important. Aseptic techniques and compliance with recommendations for equipment and dressing changes are essential if microbial contamination is to be prevented. Whenever the insertion site is exposed or the intravenous system is broken, aseptic technique should be practiced[4]. Please follow your institution's policy for central VAD management.

- If using single lumen catheter for PN, the line must be dedicated for PN only during administration
- PN must not be stopped for diagnostic tests and interventions
- If necessary, arteriovenous (AV) fistular access for PN may be considered
- Be aware of other potential complications that may impact on the device, such as catheter occlusion, precipitate, thrombosis

Refer to institution guidelines for care and management of VADs.

Minimising Risk of Catheter Infection

Sepsis is the most common and serious complication of a central venous catheter. To reduce the risk of infection consider:

- single lumen when appropriate
- using PICC
- appropriate site selection
- ultrasound-guided vein puncture
- maximal barrier precautions during insertion
- education and training of all staff in central venous access device (CVAD) management

- adequacy of hand washing
- use of 2% chlorhexidine
- appropriate dressing of exit site
- adequacy of securement of CVAD
- cleaning of hubs/needle-free injectors
- changing of administration sets
- in high risk patients, consider using antibiotic-impregnated CVAD.

Dressing of VAD exit site

It is important to have appropriate dressing and monitoring of the exit site to prevent infection. Securing the catheter to prevent to and fro movement is recommended. Please refer to your institution guidelines.

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4. PN REQUIREMENTS FOR THE ADULT PATIENT

PN requirements should always be calculated based on the individual needs of the patient. Variations in nutritional requirements are dependent on the patient's body weight, age, sex, activity and metabolic requirements. Assessment should be performed by staff trained in nutrition assessment, such as a dietitian.

4.1 Patients at Risk of Refeeding Syndrome

When initiating PN it is important to consider if the patient is at risk of refeeding syndrome as this will require a slow introduction of nutrition support with close assessment and monitoring of nutrition requirements.

Refeeding syndrome is the state of very low blood levels of phosphate, potassium and magnesium which occurs when a patient is fed rapidly after a period of prolonged fast[1]. The intracellular space suddenly expands with the uptake of glucose and other nutrients, causing a rise in intracellular electrolytes and a corresponding fall in extracellular electrolytes.

Serum electrolytes can fall to such a low level that the function of many important systems are impaired and may result in cardiac arrhythmia and death. At lesser degrees the low phosphate and magnesium levels may result in impaired oxygen transport and impaired white cell function, increasing the risk of sepsis.

A patient is defined as being a high refeeding risk if he/she has one or more of the following[1]:

- BMI less than 16 kg/m^2
- unintentional weight loss greater than 15% within the last 3–6 months
- little or no nutritional intake for more than 10 days
- low levels of potassium, phosphate or magnesium prior to feeding.

Or if the patient has two or more of the following:

- BMI less than 18.5 kg/m^2
- unintentional weight loss greater than 10% within the last 3–6 months
- little or no nutritional intake for more than 5 days
- a history of alcohol abuse or drugs including insulin, chemotherapy, antacids or diuretics.

If a patient is considered at high risk of developing refeeding problems[1]:

Provide intravenous supplements of potassium (likely requirement 2–4 mmol/kg/day), phosphate (likely requirement 0.3–0.6 mmol/kg/day) and magnesium (likely requirement 0.2 mmol/kg/day intravenous, 0.4 mmol/kg/day oral) unless pre-feeding plasma levels are high.

Blood should be taken a few hours after PN infusion commences. Daily monitoring is required and supplementation may be necessary until electrolyte levels are stabilised. Sometimes more frequent monitoring will be required in acute cases. Blood results should be checked before an increase in PN infusion rate is considered.

Provide thiamin 200–300 mg daily immediately before and during the first 10 days of PN, or full dose daily intravenous vitamin B preparation (if necessary) and a balanced multivitamin/trace element supplement once daily.

Start nutrition support at a maximum of 10 kcal/kg/day for the first 24 hours, increasing caloric input slowly with the aim of reaching the goal requirements by days 4-7. Biochemistry should be monitored twice daily. The time taken to reach goal rate will depend on the patient's biochemistry and the cardiovascular effects of the malnourished state e.g. fluid overload, heart failure.

4.2 Patients Not at Risk of Refeeding

PN may be commenced at the goal rate, however refer to monitoring (Section 7).

4.3 Types of PN Solutions Available for Adult Ward Patients

Traditionally PN has been provided as modular components (i.e. amino acids, glucose and lipid emulsions) infused separately. There are now "2 in 1" (glucose and amino acids) and "3 in 1" (amino acids, glucose and lipid) solutions commercially available. "3 in 1" PN solutions are now commonly used as standard base formulae for adult ward patients.

There are several advantages to using commercially pre-prepared "3 in 1" solutions. They are readily available, stable, easy to use and time saving. There are also potential savings in the cost of nutrient delivery. These "3 in 1" solutions contain carbohydrates, amino acids, lipids and electrolytes, in quantities designed to meet basic requirements of ward patients.

Whilst additions to the commercial "3 in 1" bags are possible under controlled, aseptic conditions, a disadvantage is the inability to remove substances from the pre-prepared bags. Patients with specific nutritional requirements that cannot to be met with a standard "3 in 1" solution may require the use of modular solutions.

It is important that the individual's nutritional requirements are assessed on an ongoing basis to ensure standard "3 in 1" solutions are appropriate, or if a more specifically designed solution is required.

Constituents of Typical "3 in 1" PN Solutions

There is a wide variety of "3 in 1" PN solutions available with varying nutritional compositions. The following values represent typical ranges of nutrients contained in commercially available solutions.

Table 2: Constituents of Typical "3 in 1" PN Solutions

CONSTITUENT	PER 1L OF PN SOLUTION*
Energy	900 – 1200kcal
Glucose	100 – 175g
Protein	35 – 50g
Lipid	25 – 50g
K+	25 – 35 mmol
Na+	30 – 40 mmol
Mg	2.5 – 5 mmol
PO4-	7.5 – 20 mmol
Fluid	1L

* The volume of a typical standard PN solution bag is 2 – 2.5 L.

4.4 PN Macronutrient Requirements for the Adult Ward Patient

The majority of patients are on PN for less than two weeks, when the aim of the PN is to limit losses while the patient's gut recovers. In this circumstance, being conservative with the amount of nutritional replacement is the safest option because overfeeding can have significant complications. However, underfeeding can also be detrimental because there is inadequate substrate to reverse the catabolic process, to improve the immune deficit and to improve muscle strength, thus defeating the purpose of providing PN. In the malnourished or in the case of longer term patients being treated for two or more months, this issue becomes very important for recovery.

Over a two-week period, changes in fat and muscle mass can be measured with anthropometric techniques or more accurate body composition measures to determine the net result of input and output.

When calculating nutrition requirements, care should always be taken not to overestimate the patient's requirements. Significant risks are associated with overfeeding, including liver dysfunction, hyperglycaemia, respiratory failure, hyperlipidaemia, acidosis and other longer term complications. It should be remembered that there is no urgency to give the full nutrition. If there is suspicion of complications from overfeeding, the PN should be reduced for 1-2 days to let the abnormal findings settle and then recommenced once the patient has recovered.

Energy

Energy requirements are usually determined using a range of standard predictive equations. These consider the patient's age, sex, height and weight and may make adjustment for the patient's degree of stress. For the majority of patients the stress can be resolved over a few days. Calorie requirements are expressed in terms of kcal/kg and refer to total calories. Patient's requirements should be reviewed on a regular basis, taking into account their clinical condition (see Section 7: Monitoring Patients on PN).

A safe starting point is 25kcal/kg/d (total calories) as an initial goal rate. Once reached this should be reviewed to assess the patient's tolerance, progress and nutritional needs.

In the case of severe stress or significant protein energy malnutrition, requirements may be higher. Ongoing monitoring is particularly important in these patients to prevent over- or underfeeding and to assess the patient's tolerance, progress and nutritional needs. An upper limit of 35kcal/kg/d should not be exceeded. Such patients can be referred to an expert centre (teaching hospital).

Determining Weight Value in Estimating Requirements

Actual weight should be used if the patient is underweight or normal weight.

If the patient is severely underweight, actual weight should be used initially. Once the patient is stable and if the nutritional status is not improving, the energy requirements should be gradually increased. An upper limit of 35kcal/kg/day should not be exceeded.

In overweight/obese patients, adjusted body weight should be used as a guide to estimating nutritional requirements, as 25kcal/kg may significantly overestimate requirements.

Adjusting for overweight/obesity

A common method is to use an adjusted weight where[2]:

$$\text{Adjusted weight} = \left(\frac{\text{Actual weight} - \text{Ideal weight}}{2}\right) + \text{Ideal weight}$$

Ideal weight can be calculated using the Hamwi equation[3]:

Males: 48.1kg for the first 152.4cm of height, + 2.72kg for each additional 2.54cm

Females: 45.4kg for the first 152.4cm of height, + 2.27kg for each additional 2.54cm.

Energy Recommendation	
Basic (short term, unstressed) requirements:	25kcal/kg/day[1,4]
Stressed/increased requirements:	Up to 35kcal/kg/day.
Obese patients:	Use adjusted weight
Refeeding:	For patients at risk of refeeding see section 4.1

Protein

Consensus statements from ASPEN, ESPEN, NICE and BAPEN[1] provide broad protein ranges but do not provide clear guidance for clinicians.

Specific recommendations are difficult to make due to:

- the small number of studies examining this question
- differences in energy:nitrogen input provided and in nutritional status of patients.

In order to ensure the patient is receiving adequate levels of protein:

- patients need to be assessed on an individual basis taking into consideration prior nutritional status, disease status/severity of illness, projected length of time on PN
- patients need to be monitored regularly for tolerance (intolerance is indicated by a rising blood urea concentration) and adequacy, and protein input adjusted accordingly.

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1 ASPEN: 2002

For the unstressed adult patient with adequate organ function requiring specialised nutrition support, 0.8g/kg/day may be adequate, but requirements may rise with metabolic demands to levels about 2g/kg/day (or, rarely, even higher) (p23A).

BAPEN: 1996

Nitrogen balance can be obtained in most patients with 0.2 g N/kg body weight. Whereas some patients may utilize more nitrogen, exceeding 0.3g/kg does not confer benefit and may be dangerous.

NICE: 2006

In situations of metabolic stress, requirements may be higher although the Guideline Development Group (GDG) would not recommend the provision of levels greater than 1.5g/kg/day or 0.24g nitrogen/kg) (p109)

ESPEN: 2009

In illness/stressed conditions a daily nitrogen delivery equivalent to a protein intake of 1.5g/kg ideal body weight (or approximately 20% of total energy requirements) is generally effective to limit nitrogen losses (ESPEN Guidelines on Parenteral Nutrition: Surgery 2009).

When PN is indicated, a balanced amino acid mixture should be infused at approximately 1.3-1.5g/kg ideal body weight per day in conjunction with an adequate energy supply. (ESPEN Guidelines on Parenteral Nutrition: Intensive Care 2009)

Recommendation

Initial starting rate: 0.16-0.24g of Nitrogen/kg/d (1.0-1.5g/protein/kg/d)[1,4]

Upper limit: 0.32g Nitrogen/kg/d (2g/protein/kg/d)

Considerations

- The patient's PN requirements need to be monitored regularly and adjusted accordingly to prevent under- or overfeeding.
- Some patients may need more protein (up to 2g protein/day or 0.32g N/kg/day) e.g. burns, sarcopenia. Amounts above this are not recommended. The patient must be monitored for tolerance, progress and nutritional needs, and signs of under- or overfeeding.
- Care should be taken when using pre-mixed solutions. Achieving protein requirements may result in excess calories being provided.
- Health professionals not experienced with PN should consult tertiary referral hospitals.

Carbohydrate

Glucose is the preferred carbohydrate energy source. The maximal capacity to oxidize glucose is 6 mg/kg/min (35 kcal/kg/d from glucose). Infusion of carbohydrates above this rate may induce complications such as hyperglycemia and fatty liver.

Lipid

Lipids provide an additional source of energy and essential fatty acids. In PN solutions, lipids are an emulsion of phospholipids and triglycerides.

Lipids can be administered separately or as part of a "3 in 1" delivery system. Lipid is best delivered through a "3 in 1" delivery system. Using 20-30% rather than 10% lipid emulsions in the PN mix reduces the proportion of phospholipids, which reduces the adverse influence on the immune system. Rapid infusion of separately hung bottles results in lipaemia and clearance of the lipid through the reticulo-endothelial system.

This results in liver dysfunction and reduced clearance of endotoxins by the liver and lung.

It is generally recommended that PN be started slowly at 1g lipid /kg/d, and blood monitored for lipaemia. After the first day the infusion rate can be increased depending on the patient's requirements. The lipid infusion rate should not exceed a maximum of 2g/kg/day. Patients with severe liver and renal dysfunction should not exceed 1g/kg/day. Lipid should ideally be given as a continuous infusion over 24 hours which is better tolerated, metabolized more effectively and allows for the clearance of the lipid as a chylomicron. Higher infusion rates are associated with complications such as fat overload syndrome and lipaemia which may damage the liver.

For patients on cyclic PN, if lipaemia develops an hour after cessation of the PN, reduce the amount of lipid being infused. Refer to the manufacturer's information on appropriate rates of lipid infusion.

For central PN, the average is 30% of total calories from lipid. However, this can be up to 50% in some cases. The greater amount of lipid reduces glucose intolerance. Lipid tolerance is reduced in some conditions such as pancreatitis, unstable diabetes, hyper-triglyceridaemia and severe liver disease.

For peripheral PN, solutions may contain lipid up to 40-60% total (66% non-protein) calories to reduce the osmolarity of their PN solution and minimise the risk of thrombosis or damage to the vein epithelium[5,6,7].

Traditionally lipid emulsions are based on soy which contains triglycerides high in omega 6 polyunsaturated fatty acids (PUFA). These have been shown to be pro-inflammatory by increasing prostaglandin synthesis. New lipid emulsions can be found in a number of different forms, including olive oil and SMOF (a mixture of soybean oil, medium chain triglycerides, olive oil and fish oil). The olive oil provides monounsaturated fatty acids which are immunologically neutral.

The medium chain fatty acids are considered to be more easily converted into energy. Fish oil provides ω-3 fatty acids which reduce the inflammatory response. These more complex lipids may improve the nutritional value of PN, but long term studies are not yet published and there is no conclusive evidence of the benefits of these lipid emulsions at this time.

Recommendation	
Initial:	1g lipid/kg/d
Maximum:	2g lipid/kg/d (Patients with liver dysfunction: 1g lipid/kg/day max)[1,8,9]
Or	
Central:	average 30% of total calories as lipid (up to 50%)
Peripheral:	solutions may contain lipid at 40-60% of total energy [5,7]

Fluid

Fluid requirements will depend on the following considerations:

- clinical condition
- fluid status/balance (dehydration or fluid overload)
- other sources of fluid input e.g. IV, oral, enteral
- fluid losses e.g. drains, urine, vomiting, diarrhoea, fistula.

4.5 PN Micronutrient Requirements for the Adult Ward Patient

Micronutrients need to be provided daily to the PN patient. Some commercially available bags already contain micronutrients in the solution, whereas others require that they be added.

Ideally, additions to PN should be undertaken by a qualified pharmacist in a clean-room environment using an aseptic technique under a laminar flow hood. However if this is not available, it may be necessary to run the micronutrients as a separate intravenous infusion. If this is the case, they should be infused over at least eight hours to minimise renal losses and side effects. Additions should be done as per manufacturer instructions.

There are a number of different trace element solutions available (both single ingredient and multi-ingredient preparations). The manufacturer of the product should be contacted for advice regarding compatibility with PN solutions, information regarding the volume of compatible intravenous solutions, recommended concentration and recommended infusion rates.

Daily requirements for trace elements and vitamins have been produced by AuSPEN[11]. These are currently being reviewed. A review of trace element requirements has been included in Table 4. These requirements are similar to AuSPEN, with the exception of manganese which is lower than previous AuSPEN recommendations. Consideration needs to be given to patients with clinical conditions which may result in increased or decreased requirements. Monitoring of trace micronutrient status is essential.

Recommendation

Vitamins and trace elements should be included daily, in specified amounts from the onset of PN. Commercial products are available which provide a balanced trace element additive. Similarly intravenous vitamin products with recommended daily requirements of water- soluble and fat-soluble vitamins are commercially available. Vitamin K needs to be given as a further additive.

Table 3: PN Daily Requirements for Trace Elements and Vitamins

MICRONUTRIENT	REQUIREMENT/DAY (AuSPEN[11])	REQUIREMENT/DAY (Full detail in Table 4)
Trace Elements		
Zinc (Zn)	50-100µmols (3.3-6.6mg)	2.5-6.4mg
Copper (Cu)	5-20µmols (0.3-1.2mg)	0.3-1.5mg
Selenium (Se)	0.4-1.5µmols (31.6-118µg)	20-80µg
Iron (Fe)	20µmols (1mg)	(only if true Fe Deficiency present)
Manganese (Mn)	5µmols (275µg)	60-100µg
Chromium (Cr)	0.2 - 0.4µmols (10-20µg)	10-20µg
Molybdenum (Mo)	0.4µmols (38µg)	20-200µg/d if suspected deficiency
Iodide	1.0µmols (0.13mg)	0-0.13mg
Electrolytes		
Sodium	100mmols	–
Potassium	60-80mmols	–
Calcium	5mmols	–
Magnesium	8mmols	–
Phosphorus	20-40mmols	–
Vitamins		
A	1000mmols	–
D	5mmols	–

MICRONUTRIENT	REQUIREMENT/DAY (AuSPEN[11])	REQUIREMENT/DAY (Full detail in Table 4)
E	10mg	–
K	0-1mg	–
C	100mg	–
Thiamine	3mg	–
Riboflavin	3.6mg	–
Pyridoxine	4mg	–
Niacin	40mg	–
B12	5mg	–
Pantothenic acid	15mg	–
Biotin	60mg	–
Folic Acid	400mg	–

Trace Element Allowances in PN Therapy

Trace elements are essential nutrients that act as coenzymes and cofactors involved in metabolism. It is difficult to measure the exact amount in PN solutions and in the blood because of the low levels. It is better to measure enzyme activity particularly for zinc, selenium and copper.

The most common trace element deficiencies seen in PN occur with zinc, selenium and copper. These trace elements are most likely to be low in patients with diarrhoea (particularly patients with short bowel syndrome) and patients in intensive care. Such patients may require increased amounts in their PN solution. Patients with severe malnutrition are also at risk of developing deficiencies when renourished.

Trace element needs for the individual patient on PN are dictated by pre-existent nutritional status, losses in stool and urine and nutrient bioavailability[9].

When considering the dosing of trace elements, adjustments may need to be made in certain settings, as an individual's requirements may vary based on factors such as organ function, disease state, metabolic condition, administration route and medication usage.

Giving excess trace elements to individuals who do not need them may be harmful. Therefore it is important to monitor these stressed individuals even over the first two weeks of PN support.

Contamination

Many of the components of the PN formulation have been shown to be contaminated with trace elements such as zinc, copper, manganese, chromium, selenium and aluminium[10].

As the contamination level of various compounds of PN can significantly contribute to total intake, serum concentration should be monitored with long term use[10].

As a result of contamination, patients receiving long term PN therapy are at risk of trace element toxicity, which is why serum monitoring is necessary[10].

Table 4: Trace Element Allowances in PN Therapy

TRACE ELEMENT	PN DOSE	TOXICITY DOSE	SPECIAL CONSIDERATIONS	DEFICIENCY SIGNS
Chromium	10-20µg[10, 21]	–	Increased dose: Stress including physical trauma, and burns[25], Infection[27] Decreased dose: Renal failure/ impairment[24]	• Glucose intolerance, insulin resistance, hyperglycaemia, glycosuria, weight loss, metabolic encephalopathy with confusion, ataxia, paresthesias and peripheral neuropathy, increased respiratory[24, 31]. • Deficiency should be suspected in patients on PN with progressive impairment of glucose tolerance[24].
Copper	0.3-1.5mg[21,24,29,31]	–	Increase dose: 0.4-1.3mg in excessive gastrointestinal losses[24, 27, 29, 31] Decreased dose: for patients with liver dysfunction[31]	• Hypochromic microcytic anaemia and neutropenia[24, 27, 31] diffuse osteoporosis, delayed bone age, widened cupped metaphyses with breaks, subperiosteal hematomas, ossifications in the shafts of long bones, diaphyseal fractures, oedema of the limbs with pseudoparalysis, neurologic abnormalities, and hyperlipidemia[23] • Depigmentation, kinked hair, vascular degeneration and osteopenia with skeletal abnormalities[24]
Iodine	0-1µmol/day[11, 21]	–	–	• Hypothyroidism, goiter (earliest clinical feature), cretinism, impaired reproductive outcomes, increased childhood mortality, impaired mental and physical development[32,33]

TRACE ELEMENT	PN DOSE	TOXICITY DOSE	SPECIAL CONSIDERATIONS	DEFICIENCY SIGNS

Iron	Only if true Fe deficiency present[21]	Single doses of iron sucrose >500mg are not recommended[15, 19]	• Menstruating women, and patients with blood loss may be more prone to developing Fe deficiency[31]	• Iron deficiency has three stages where the majority of physical indicators and symptoms are not seen until the final stage (iron deficiency anaemia). It is important to interpret iron studies in the context of the patient's clinical condition.
				• The first sign of iron deficiency is "low serum iron" which is indicated by low serum ferritin and a decrease in iron-binding capacity.
				• In the acute phase response, ferritin high and transferrin low
				• Iron deficiency is indicated by low serum transferrin saturation, increased erythrocyte protoporphyrin concentrations, and increased serum transferrin receptors
				• Iron-deficiency anaemia (final stage) symptoms include:
				  • Decrease work capacity
				  • Delayed psychomotor development in infants
				  • Impaired cognitive function
				  • Impaired immunity
				  • Adverse pregnancy outcomes

TRACE ELEMENT	PN DOSE	TOXICITY DOSE	SPECIAL CONSIDERATIONS	DEFICIENCY SIGNS
Manganese	Maximum 60-100µg/d[10, 22]	500µg/d excessive[22]	• Manganese should not be supplemented if the patient has liver disease with an elevated bilirubin[22] or decreased bile excretion + hepatobiliary disease[10, 32, 33, 34]	• Impaired glucose tolerance, impaired growth, impaired reproduction function, alterations in carbohydrate and lipid metabolism, hypocholesterolemia, scaly dermatitis, hair depigmentation, reduced vitamin K dependent clotting proteins, decreased bone mineral density[32, 33]
Molybdenum	Only in the rare instance of suspected deficiency at ~20-200µg/day[24, 27]	–		• Molybdenum deficiency is rare or nonexistent in adult PN patients, • tachycardia, tachypnea, headache, central scotomas, nausea, vomiting, vision problems/night blindness, disorientation and coma[24, 31]
Selenium	20-80µg/day[10, 21]	>1500µg considered toxic[21]	• Increased dose: 300-1000µg/day may benefit mortality in the first month with general ICU patients[14, 35]	• Increases in plasma T4 and decreases in T3, Keshan disease (results in cardiac myopathy, heart failure, arrhythmias, premature death)[21, 32, 34], Kashin-Beck disease (cartilage condition), low blood and hair levels, impaired immune function[34, 35] • Skeletal muscle myopathy[21] • Selenium and iodine deficiency combined increases risk of cretinism[32]

TRACE ELEMENT	PN DOSE	TOXICITY DOSE	SPECIAL CONSIDERATIONS	DEFICIENCY SIGNS
Zinc	2.5 - 6.4mg[10, 17, 21, 27]	Toxicity range: 23 - 300mg[18, 24, 30]	• Increased dose: Acute catabolic stress/burns[27], Diarrhoea syndromes/ Chronic diarrhoea or high output fistulae[24] • Patients with low pancreatic output due to disease or surgical resection might be at increased risk of toxicity[24]	• Clinical manifestations similar to those of acrodermatitis enteropathica; seborrheic or psoriatic skin lesions of the nasolabial folds and scrotum, followed by non-scarring alopecia, glossitis and stomatitis[24] • Diarrhoea and depression and/or confusion may present 3-6 weeks after the appearance of the skin lesions. Hyperammonemia may occur with even marginal deficiency, which could potentially exacerbate acid-base disorders and hepatic encephalopathy[24] • Impaired wound healing, loss of taste (hypogeusia), behaviour disturbances, night blindness and immune deficiency[28]. • Glucose intolerance[23] • Immunological defects of lymphopenia and depressed T-cell responses[21]

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5. PN FOR THE CRITICALLY ILL ADULT PATIENT

There is increasing awareness that early nutrition support in critically ill patients is desirable. Despite this, many aspects remain unclear. Early enteral nutrition is the preferred route, but if not successful PN should be considered. Practice varies as to when to commence PN, but emerging evidence suggests a significant mortality benefit for commencing early PN, compared to EN that is delayed for longer than 24hours[1].

Due to poor outcomes with high caloric PN, a reasonable approach early in the course of critical illness is to use moderate calorie levels of 25kcal/kg/day with careful attention to glucose control. Increase the calories cautiously as the critically ill patient recovers.

There has been considerable research interest in the potential of nutritional components to modify the disease process in critical illness. Many of the studies have been small and have used varying combinations and ratios of macro and micro nutrients, making interpretation difficult. No clear recommendations for glutamine, micronutrients, antioxidants and modified lipids can be made at this time.

Key Recommendations

- Early enteral nutrition is the first option in patients with an intact GI tract
- PN should be considered in critically ill patients when EN will be delayed, but there are insufficient data to recommend supplementation of EN with PN when EN is adequate.
- Basic energy requirements in critical illness are 25kcal/kg/day
- Prevention of hyperglycaemia by avoiding overfeeding and initiation of insulin where appropriate
- Micronutrients including vitamins and trace elements should be added in usual daily requirements unless specific deficiencies are known.

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6. PN SOLUTION STABILITY/ COMPATIBILITY ISSUES

Compounding PN or making additions to a pre-prepared bag has the potential to cause solution instability, compounding errors, inclusion of contaminants or infective agents[1]. Compounding of PN and/or additions to PN should be done in a clean-room environment using aseptic techniques by an appropriately qualified pharmacist. PN is an ideal growth medium for micro-organisms and there have been instances of fatalities after infusion of compounded PN[2].

Limits

There are limits to the amount of individual components that can be added to the solution. Failure to observe additive limits or compounding proportions could break the emulsion in the case of a "3 in 1" solution, or cause precipitation and/or vitamin degradation.

Information regarding compounding proportions or whether a drug/ vitamin/trace element can be added to a PN solution should be sourced from the manufacturer. The manufacturer will also be able to give guidance on electrolyte additive ranges. If there are no data on additive stability/ compatibility or on electrolyte ranges, then additions should not be made.

Storage requirements for PN solutions before and after additions

PN solutions and ingredients used in compounding PN should be stored at temperatures and conditions recommended by the manufacturer before compounding or additions have been made. After compounding or if additions have been made, PN should be stored under refrigerated conditions until required by the patient (store between 2-8 degrees Celsius). Lipid solutions MUST NOT BE FROZEN as this can be fatal to patients. The lipid emulsion cracks and results in a fat embolus.

Expiry times of compounded PN and additions should be guided by information from the manufacturer regarding stability and compatibility and clean-room environment in which it is prepared (local conditions). Before infusion, PN bags should be removed from fridge for about one to two hours before hanging[1].

Light protection

Light and heat can influence chemical stability e.g. vitamins A and E are light sensitive[3]. Lipids undergo oxidisation when exposed to light[4]. PN should be protected from light by using light protective covers available from the manufacturer. After hanging the bag, the bottom corners of the cover can be folded up and taped to the bag to prevent reflected light.

Hang time

The maximum time for a solution bag to hang is 24 hours and any remaining solution should be discarded. Stand-alone lipid emulsions hung separately have a maximum hang time of 12 hours[5].

Compatibility with administrations

Non-PVC administration sets should be used for delivery of solutions containing fat emulsions. This is due to the extraction of phthalate plasticisers from PVC administration sets when exposed to fat.

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7. MONITORING ADULT PATIENTS ON PN

Monitoring during PN is particularly important because the patient is at greater risk of toxicity, deficiency and other complications.

Key aspects of monitoring include:

- risk of refeeding syndrome
- indicators of overfeeding
- hyperglycaemia and hypoglycaemia
- micronutrient deficiency and toxicity
- complications of line access including line infection
- other long term complications (see Section 8)

A stable patient indicates a patient who is at target rate of PN and the clinical indicator in question is stable within a clinically acceptable range.

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Table 5: Monitoring Patients on Parenteral Nutrition

PARAMETER	PURPOSE	INITIAL	STABLE
Nutrient intake from oral, enteral or parenteral nutrition	To ensure that the patient is receiving adequate / appropriate nutrients to meet requirements and to consider if PN is still appropriate.	Daily	2 x week
Fluid Balance Charts	To monitor fluid status and ensure the patient is not becoming over/under hydrated	Daily	Daily
Weight	To monitor fluid status, and to determine whether nutritional goals are being achieved	Daily	2 x Week
Observations: Temperature, blood pressure, pulse, respiratory rate	Monitor for infection and fluid balance	4 hourly	4 hourly
Glucose	To assess glucose tolerance and identify need for insulin requirements.	6 hourly	Daily. Monitor for risk of hypoglycaemia when ceasing PN particularly in patients receiving insulin.
Sodium, potassium, urea, creatinine	Assessment of renal function and fluid status and risk of refeeding syndrome	Daily	2 x week
Magnesium, Phosphate	Refeeding risk, depletion and toxicity	Daily	2 x week
Liver Enzymes and Bilirubin (LFTs)	Overfeeding or hepatobiliary dysfunction	Daily	2 x week
CRP	To assess the presence of an acute phase reaction (APR) as protein, trace element and vitamin results may be altered	2-3/week until stable	Weekly

PARAMETER	PURPOSE	INITIAL	STABLE
Full blood count and MCV	Indicator of infection or sepsis anaemia, blood loss, iron & folate.	2 x week	Weekly
Cholesterol / Triglyceride	Overfeeding, calories, lipids and or glucose	Baseline (prior to starting PN)	Weekly
Zinc	Risk for trace element deficiency/toxicity Acute phase response causes Zn ↓ and Cu ↑	On starting PN	Every 2 weeks
Copper	Risk of toxicity in biliary dysfunction.	On starting PN	Every 2 weeks (if available)
Selenium	Deficiency likely in severe illness and sepsis, or long-term nutrition support	On starting PN	Every 2 Weeks (if available)
Iron studies	Assess iron status. Deficiency common in long term parenteral nutrition	on starting PN	Monthly
Folate, B12	Assess if serum folate/B12 sufficient	On starting PN	Monthly
Manganese	Excess provision to be avoided red blood cell or whole blood better measure of excess than plasma	On starting PN	Monthly (if available)
25-OH Vit D	Low in high-risk groups	On starting PN	Monthly
Bone densitometry	To diagnose metabolic bone disease. To be used together with lab tests for metabolic bone disease	Not routinely done in short term PN patients.	On starting home PN Then every 12 months[1]

8. COMPLICATIONS

Liver Dysfunction

It is acceptable for markers of liver function to rise slightly after the commencement of PN, but these biochemical markers should return to normal once PN ceases. If biochemical markers continue to rise, the following need to be considered:

(Note: Underlying sepsis may cause liver dysfunction. This may be from the abdomen or low grade organisms culturing the central line.)

Hepatic Steatosis

This is the most common liver dysfunction in adults receiving PN, defined as an accumulation of fat in the hepatocytes and characterized by a non-specific rise in liver function tests. The main reason for hepatic steatosis is excessive calories and specifically an excess of carbohydrate calories (a fat-free bag). Although more rare, it can occur when fat is included[4].

Gall Bladder and Biliary Complications (Cholestasis and Cholethiasis)

These are more common in paediatric PN patients, but are also likely in adults who have a complete lack of enteral/oral nutrition, short bowel, on long-term PN nutrition or are overfed total calories. The impaired release of, or a complete obstruction of, bile is characterised by a rise in bilirubin, ALP and GGT (although these can be elevated due to other reasons).

Management of Liver Dysfunction

1. Ensure a balance of carbohydrate, lipid and amino acid in the parenteral formula.
2. Do not exceed overall calories. For patients with liver dysfunction, the maximum amount of fat is 1g/kg/day and the maximum of carbohydrate is 4g/kg/day.

3. Initiate oral or enteral nutrition, even if it is very small amounts, as this stimulates gall bladder emptying.
4. Cyclic PN (i.e. running it over a smaller period of time each day, usually 8-14 hours) provides fasting time to reduce insulin levels and help reduce liver dysfunction. Note that care must be taken as this means a higher infusion rate when the PN is running and this can also result in hyperinsulinemia and fatty acid deposition[3]. Intermittent/ cyclic PN should only be trialled for long term patients and those displaying clear signs of gall bladder dysfunction.
5. Some research into the role of the amino acid carnitine indicates it may prevent hepatic steatosis but there is no clear evidence on adults at this point.
6. Choline deficiency has also been reported as a cause of hepatic steatosis in PN patients. It does appear that choline supplementation may be beneficial but more research is needed before changes in practice are made.
7. Initiate blood cultures.

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9. TRANSITIONAL FEEDING

The decision to recommence oral or enteral nutrition requires an assessment of GI tract anatomy, function and absorption and requires multidisciplinary input. If the patient is re-introduced to oral or enteral feeding and is absorbing and tolerating this, the PN rate can be titrated down in proportion to their oral/enteral energy and protein intake.

10. CEASING PN

PN may be ceased for a number of reasons:

- recommencing or established oral/enteral feeding
- line sepsis
- withdrawal of therapy
- unresolving acute liver failure.

When ceasing PN, it is important to monitor for hypoglycaemia.

In adults, if the patient is not on insulin therapy, a reasonable and fairly conservative approach is to decrease the PN rate by 50% and continue to infuse for 1-2 hours before ceasing.

This step-down process avoids the need for strict glucose monitoring after PN is discontinued. It is no longer considered essential to cease PN by tapering the rate down over many hours or even days. This practice used to be recommended in the era when excessive amounts of glucose in PN were used, occasionally leading to rebound hypoglycaemia after PN was ceased abruptly. With the advent of "3 in 1" solutions and change in practice to avoid high glucose loads, several small studies have demonstrated that abrupt discontinuation of PN does not cause hypoglycaemia in the majority of patients[1-5].

For patients on an insulin infusion or subcutaneous insulin, more care needs to be taken when ceasing PN. Insulin dosing will need to be adjusted accordingly. If PN must be ceased suddenly, then a glucose infusion should be established for 12 hours after the last insulin dose. If the patient has Type 1 diabetes, insulin should continue to be given along with carbohydrate either in the form of intravenous glucose infusion or oral/enteral carbohydrate. A consultation with the endocrinology team should be sought.

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GLOSSARY

ACI	Agency for Clinical Innovation
ASPEN	American Society for Parenteral and Enteral Nutrition
AuSPEN	Australasian Society for Parenteral and Enteral Nutrition
BAPEN	British Association for Parenteral and Enteral Nutrition
BMI	Body Mass Index
CVAD	Central venous access device
DAA	Dietitians Association of Australia
EN	Enteral nutrition
ESPEN	European Society for Clinical Nutrition and Metabolism
FEV1	Forced Expiratory Volume in the first second
MUFA	Monounsaturated fatty acid
NICE	National Institute for Health and Clinical Excellence
PICC	Peripherally inserted central catheter
PN	Parenteral nutrition
PUFA	Polyunsaturated fatty acid
VAD	Venous access device
WHO	World Health Organisation

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