PARENTERAL NUTRITION

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- Guideline developed to give information for staff providing clinical care to inpatients requiring parenteral nutrition at the Sydney Children's Hospitals Network.
- This guideline is to be read in conjunction with the following:
  - Central Venous Access Device (CVAD) Practice Guideline
  - Intravenous Fluid Guidelines:
    - **If at CHW**: Intravenous Fluid Management - CHW
    - **If at SCH:** Intravenous Fluid and Electrolyte Therapy - SCH

CHANGE SUMMARY

- New Network guideline. Site-based Parenteral Nutrition guidelines have been rescinded and are replaced by this document.

READ ACKNOWLEDGEMENT

- The following staff should read and acknowledge they understand the contents of this document by sign-off having read it:
  - Pharmacy staff; dietitians; nursing and medical staff caring for patients using parenteral nutrition.
- Department Heads and all other medical and nursing staff working in clinical areas should be aware of this document.

This document reflects what is currently regarded as safe practice. However, as in any clinical situation, there may be factors which cannot be covered by a single set of guidelines. This document does not replace the need for the application of clinical judgement to each individual presentation.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	7th August 2017	**Review Period:** 3 years
Team Leader:	Gastroenteritis Fellow	**Area/Dept:** Gastroenterology

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1 Indications for the Use of Parenteral Nutrition (PN)

1.1 General indications for PN

PN is necessary when a patient cannot meet nutritional requirements with either enteral nutrition, increased intake or the use of oral supplements alone. In infants, 2-3 days, and in older children 4-5 days, without adequate intake is an indication to discuss the appropriateness of starting PN with the PN team. PN should also be considered for patients displaying signs of malnutrition.

If the patient has a functioning gastrointestinal system, enteral nutrition is the preferred feeding route due to the lower associated clinical risks. Refusal of nasogastric tube placement is not an indication for PN.

1.2 Medical or surgical conditions which may require PN

Examples of conditions that may require PN:

- Intestinal failure secondary to:
  - Short bowel syndrome
  - Enteropathy
  - Intestinal neuromuscular diseases, such as chronic intestinal pseudo-obstruction
  - Post-operative abdominal surgery
  - Radiation/cytotoxic therapy
- Severe inflammatory bowel disease
- Chylothorax and chylous ascites
- Hyper-catabolism
  - Extensive burns
  - Severe trauma
- Inability to tolerate enteral nutrition

2 Information for the Patient and Family

The treating team should inform the parent or carer of the indication for starting PN and the likely duration as well as the associated risks and complications that may occur. The nursing staff should provide the family with a factsheet on parenteral nutrition available on the intranet.

3 Initial Assessment

3.1 Baseline growth assessment

Each patient requiring PN must have baseline growth parameters measured and plotted on an age-appropriate growth chart. Children younger than 3 years of age should have their weight (kg), length/height (cm) and head circumference (cm) recorded. Weight, height and body mass index (BMI) should be recorded in patients above 3 years old.

3.2 Parenteral nutrition team consultation

A prescription for PN should only be considered after consultation with the attending physician or surgeon. Once the decision is made that a child requires PN, the PN team should be contacted. The PN team is a multi-professional team consisting of a gastroenterologist, pharmacist and clinical nurse consultant specialised in providing and managing parenteral nutrition. At the Sydney Children's Hospital (SCH) it also includes a dietitian. The PN team will provide a full management service for the administration of PN until its cessation. PN will be prescribed for the primary medical team with the exception of Intensive Care Units and Oncology/BMT patients who will be reviewed by their own teams and dietitians and referred to the PN team as required.

3.3 Initial nutritional assessment

Full nutritional assessment by a dietitian to establish clear nutritional requirements and goals is essential for any patient starting on PN. These goals will include calculations of estimated energy requirements (EER), fluid, protein, carbohydrate and fat requirements, and risk of re-feeding on an individual basis.

3.4 Venous access

The choice of vascular access will depend on the age of the child, the type of PN solution to be administered and the duration. Please refer to section 6.1 for further information.

3.5 Baseline investigations

To be performed before commencement of PN:

- Full blood count
- Electrolytes, urea and creatinine
- Calcium, magnesium and phosphate
- Serum glucose
- Liver function tests
- Cholesterol and triglycerides

4 Parenteral Nutrition Solution Formulations

4.1 Standard solutions

Standard solutions are used if the patient has normal fluid and electrolyte requirements. Compositions of the standard PN solutions available at the SCHN are shown in Table 1.

It is possible to increase the concentration of electrolytes in the PN solutions after consultation with Pharmacy although careful monitoring is required. Running electrolyte replacement as a sideline is another option to be considered as it enables any adjustments required.

Table 1. Composition of the standard solutions available at the SCHN

	Infants < 3 months of age			Children > 3 months of age		
PN solution	**Preterm**	**NPVL**	**NCVL**	**S2-10**	**S4-20**	**S4-25**
Amino acid (%)	3	2	2.3	2	4	4
Glucose (%)	10	10	12	10	20	25
Sodium (mmol/100mL)	3.3	2.5	2.5	4	4	4.5
Potassium (mmol/100mL)	2.2	2	2	2.4	2.4	4
Calcium (mmol/100mL)	1.2	0.7	1.2	1	1	0.5
Magnesium (mmol/100mL)	0.15	0.1	0.15	0.4	0.5	0.5
Phosphate (mmol/100mL)	1	0.7	1	0.9	0.9	1
Chloride (mmol/100mL)	1.35	2.8	2.6	3.9	4.4	6
Zinc (mg/100mL)	0.326	0.19	0.19	-	-	-
Heparin (units/100/mL)	50	50	50	-	-	-
Total kcal (kcal/mL)	0.5	0.46	0.55	0.46	0.92	1.11
Non-nitrogen kcal (kcal/mL)	0.38	0.38	0.45	0.38	0.76	0.95

4.1.1 Fluid requirement

- Maintenance fluid requirements are based on age and body weight. See Intravenous Fluid Management Guideline for further information.
- Conditions that increase fluid needs include fever, gastrointestinal losses, presence of a hypermetabolic state and respiratory distress.
- Do not attempt to correct rapidly changing fluid losses with PN. If large fluid losses are present, these should be replaced with a separate intravenous (IV) infusion of fluid.

Occasionally, stable fluid losses may be incorporated in the fluid calculation for PN (please seek advice from the PN team).

- Consider other fluids being given to the patient over 24 hours, e.g. IV antibiotics, blood transfusions and albumin infusions.
- In children at risk of refeeding syndrome, PN may need to be started at lower volumes (please seek dietitian advice).

4.1.2 Energy requirement

- Energy needs of healthy individuals are the sum of basal metabolic rate (BMR), diet induced thermogenesis, physical activity and growth.
- Energy requirements for patients receiving total PN have been estimated to be approximately 90% of that required when enterally fed due to the thermogenic effect of food.[1]
- Various factors, such as fever, burns, major surgery and sepsis will increase energy requirements.

4.1.3 Protein requirement

- The amino acid requirement is lower in parenterally fed infants and children than in enterally fed infants because the supply bypasses the intestine
- After the second month of life, a minimum amino acid intake of 1 – 1.5 g/kg/day is recommended to avoid a negative nitrogen balance.[1] For critically ill patients the advisable amino acid intake may differ.[2]
- Energy content of protein: 4 kcal/g.

4.1.4 Glucose requirement

- Glucose intake should provide 60 – 75% of non-protein calories in fully parenterally fed patients.[1]
- The glucose load is dependent on the concentration of glucose in the PN solution and the infusion rate. Please refer to Table 2 for the recommended rates of glucose infusion. Maximal hepatic oxidation rates are highest in young infants (18 g/kg/day = 12.5 mg/kg/min).[1,3] Rate of glucose oxidation is also influenced by the patient's metabolic status, acute illness and drug administration.
- Excessive glucose administration should be avoided as it may cause hyperglycaemia. Also if glucose delivery exceeds the oxidation rate, the excess is directed to lipogenesis promoting fat deposition, together with liver steatosis and enhanced production of VLDL triglycerides by the liver.[1,4]
- Energy content of glucose: 3.8 kcal/g.

Table 2. Recommended goal rates of glucose infusion in PN.[1,3]

Age	Goal Rate (mg/kg/min)
< 1 year	10 – 12.5
1 – 10 years	8 - 10
Adolescents	5 - 6

4.1.5 Fat emulsions

- SMOF (30% soybean oil, 30% medium chain triglycerides, 25% olive oil, 15% fish oil) is the fat of choice for the majority of patients.
- Omegaven, a fish oil emulsion rich in omega 3 is sometimes used as specific therapy for PN-related cholestasis after consultation with the PN team. Special Access Scheme (SAS) forms are required.
- Fat emulsions should be introduced gradually into the PN regime starting at 0.5 – 1 g/kg/day. Neonates can be graded up to 3 g/kg/day, older children will require 2-3 g/kg/day, depending on their size.
- The use of fat emulsions prevents the complications of using glucose as the sole non-protein energy source including hyperglycaemia, liver steatosis and essential fatty acids deficiency.[4]
- Energy content of fat: 10 kcal/g.

4.2 Modifications to standard PN solutions

Modifications to standard PN solutions (e.g. glucose, electrolytes) incur additional compounding time and might also reduce the shelf life of the PN solutions. Always consider other alternative strategies before requesting the change. Please contact the PN team and Pharmacy for advice.

4.3 Multivitamins

Multivitamin solutions used in SCHN are shown below and their composition is described in Appendix 1. Vitamins are light sensitive and reduce the shelf life of the PN solution.

- **Vitalipid N Infant**: Fat soluble vitamin in 10% fat. Used for infants and children less than 5 kg. Recommended dose: 4 mL/kg maximum of 10 mL/day.
- **Soluvit**: Water soluble vitamin. Used for infants and children < 5 kg. Recommended daily dose: 1 mL/kg maximum of 10 mL/day.
- **Cernevit**: Combination of fat and water soluble vitamins (except for vitamin K). Used for children greater than 5 kg. Recommended daily dose: 0.5 mL/kg maximum of 5 mL/day.

4.4 Trace elements

Baxter AusPEN Trace Elements are used at SCHN for both neonates and older children. Its composition is described in Appendix 1. Recommended daily dose: 1 mL/kg maximum of 10 mL/day.

5 Ordering PN

5.1 Orders

PN will be prescribed by the PN team for the primary medical team, except in the Intensive Care and Oncology/BMT Units where it is instituted by the relevant teams.

- Orders must be faxed to the Pharmacy Department by 10 am on weekdays. PN will only be dispensed to the ward once original orders are delivered to Pharmacy. PN orders for the weekend must be sent by 10 am Friday. Extra orders will be required for public holidays.
- PN is ordered daily on the Paediatric Parenteral Nutrition order form. At the Children's Hospital at Westmead (CHW) the Neonatal order form is used for infants < 3 months of age. No PN will be supplied without an order form accurately completed, written legibly and signed by a medical officer.
- Standard PN solutions come in 1000 mL and 2000 mL volumes. Please consider these volumes when prescribing it.
- Additional electrolytes, e.g. potassium or sodium, can be added to standard PN solutions by indicating the amount per 100 mL required on the order form after consultation with Pharmacy. However, we do strongly recommend only changing the electrolytes if there is no way of providing a side line.
- PN solutions and fat emulsions are delivered to the wards usually before 5 pm on weekdays.
- Please notify Pharmacy as soon as possible of any changes or cancellations of PN orders to avoid wastage of solutions.

5.2 After hours PN

Only the S2-10 standard PN solution is available after hours. If a patient requires a replacement for a PN solution (e.g. due to spillage or the solution has expired) a medical officer must be contacted to prescribe another S2-10 standard PN solution or IV fluids with 10% glucose and electrolytes to prevent rebound hypoglycaemia.

5.3 Drug and PN compatibilities

- No drugs are to be added to the PN solution, bags or lines.[5]
- Whenever possible other medications should be administered via a separate lumen. If not possible, a drug infusion line can be connected to the PN line at the relevant line change. This line should then remain unbroken until the next line change is due.
- Drug compatibility with PN solution MUST be discussed with the PN pharmacist before administration.

5.4 Stability of solutions

- PN solutions manufactured at SCHN have a maximum expiry date of three days when stored in the fridge and protected from light. Each bag should be kept in their light protective cover.
- All PN solutions should continue to be refrigerated even if they are not used on the date specified. The Pharmacy should be notified on the next working day if a bag is no longer required so that it can be collected.
- The expiry date for fat emulsions not manipulated in Pharmacy is stated on the manufacturer's label.

6 Administration of Parenteral Nutrition

Prior to undertaking PN management, the registered nurse must have successfully completed their central venous access device (CVAD) Accreditation.[6]

Administration of PN carries an increased risk of CVAD associated infectious complications due to the high glucose and fat content of the solutions. Diligence in maintaining aseptic technique during setup, connection and disconnection is essential. Refer to SCHN CVAD guideline.

6.1 Delivery routes for PN

- PN solutions should ideally be delivered via a central venous catheter (CVC) or peripherally inserted central catheter (PICC). At SCH, if the patient does not have a CVAD in place or is unable to have one inserted S2-10 PN solution may be administered via a peripheral line or a midline (**no peripheral PN is to be administered at CHW outside of GCNC**). Non-tunnelled CVCs should only be used for PN administration in ICU settings due to increased risk of infection, dislodgement and extravasation.[7] If a patient requires PN for longer than 2 weeks, then a long-term central line MUST be inserted for ongoing PN administration.[8]
- Glucose content MUST not exceed 10% in a peripheral line or midline, therefore only S2-10 solution can be administered peripherally (**not applicable to CHW**).
- Fat emulsions are isotonic and may be administered peripherally.
- PN must be checked against the PN order form and electronic order by two members of medical or nursing staff one of whom must be an RN prior to hanging. If there is a discrepancy between the PN solution and the orders clarify with the prescribing medical officer and/or the on-call pharmacist.[6]

6.2 Basic principles include

6.2.1 General principles for changing the PN line and bag

- Standard aseptic technique is to be used when changing the IV lines containing PN and fat emulsion solutions; this reduces the risk of infectious complications associated with administration of PN.[6] The more often the system is accessed, the greater the risk of contamination.[7]
- PN lines should always remain intact, that is maintaining a closed system. If a PN line is disconnected the PN solution must be discarded.
- Ideally, the PN line (or the PN lumen of a multi-lumen CVAD) should not be used for the infusion or withdrawal of blood, administration of medications or for monitoring central venous pressure.[6]
- In-line filters are required for PN administration to reduce the risk of microbial, precipitate, or particulate contamination. PN solutions are to be filtered using a 0.22-micron filter and fat emulsions are to be filtered with a 1.2-micron filter.[6,8]

  PN solutions should be out of refrigeration for at least 1 hour[9] prior to commencement to reduce the effect of effervescing of the solution once its temperature rises, this will alleviate ongoing problems with IV pump alerts to “air in line”.
- All PN and fat emulsion solutions must be changed every 24 hours.[7,9,10]
- Line changes (including the filter) for fat emulsions are performed every 24 hrs.[7,9,10] Line changes for PN solutions are performed at least every 72 hours.[7,9,10] Daily line changes are required when the PN is not given continuously over 24 hours.

6.2.2 Procedure for setup and connection of PN

General principles of CVAD management are to be maintained (refer to CVAD guidelines).

1. Maintain a surgically clean field onto which equipment is placed and lines connected.
2. Perform hand-hygiene and put on clean gloves which are designated for CVAD use.
3. Prepare the lines: ensure all clamps are on (including roller clamps); Connect burettes and filters to the lines and then to the multi-valve extension set.

   Note: Multi-valve extension sets are recommended for PN to reduce the risk of contamination, other extension pieces are too long and increase the risk of bacterial growth (this includes bifurcate or “chooks foot” connections)
4. Using 2% chlorhexidine and 70% alcohol swabs, clean the rubber stopper on the fat emulsion solution and allow it to dry, while maintaining aseptic technique insert airway needle (if glass bottle) and spike of IV giving set.
5. Using 2% chlorhexidine and 70% alcohol swabs clean the connection port of the PN bag, allow to dry, and while maintaining aseptic technique insert the spike of IV giving set.

6. Prime the lines with fluid, ensuring all lines are free of air bubbles. It is important to maintain the sterility of the internal pathway of the line; keep the ends of the lines clean and clear of contaminants by placing them back on the aseptic field ready for connection.
7. Remove gloves, perform hand hygiene and don new clean gloves (which are designated for CVAD use).
8. Proceed to accessing of CVAD and connecting PN as per CVAD guidelines.
9. The PN bag and burette should be covered with the light protective bag provided. [6,8]
10. If the PN is running for less than 24 hours, a PN weaning calculator obtained from Powerchart is required to provide the rates of delivery. Zero the IV pump before starting to ensure accurate total fluid delivery.
11. No "slow infusions" should be "caught up" - all discrepancies between flow rates and orders must be documented. If cessation is required, replace with 10% glucose solutions to avoid hypoglycaemic episode, ensure medical staff are notified and confirm with written fluid order.

6.2.3 Blood cultures

If the patient becomes febrile, blood cultures need to be collected from each lumen of the CVAD. If PN disconnection is required for blood collection then PN should be ceased. Whenever possible any routine blood cultures required, should be taken at the time of PN line change. At SCH, home PN patients who have a CVAD for the sole purpose of providing PN, blood sampling from the CVAD is only permitted if performed in conjunction with obtaining blood cultures. If the patient is clinically unstable this may not be achievable and should be discussed with senior medical staff.

6.2.4 Home PN patients

Parents/carers of patients receiving home PN have been extensively trained in the care of their child's CVAD and the administration of PN. The home PN bags, lines and pumps are different to what is normally used in the hospital. When these patients are admitted to the hospital cares and management should be negotiated between nursing staff and parents/carers. If further clarification of this management is required the PN clinical nurse consultant is to be contacted.

7 Monitoring

The following guidelines are the minimal requirements for the commencement of PN. The monitoring regimes must be tailored to the patients.

- Strict fluid balance is to be maintained at all times, as over hydration and dehydration are possible complications of PN therapy.
- Vital observations every 4 hours. The child's condition must always be considered and monitored and follow Recognition of the Deteriorating Child policy. Observations should meet the "Between the Flags" criteria. Increased temperature may indicate potential PN related sepsis. The attending medical officer should be informed.
- All patients commenced on PN must have 8 hourly blood glucose levels (BGL) until established on PN, usually 24 - 48 hours.
- Daily urinalysis for glucose as glycosuria could be an indication of decreased glucose tolerance.[1] If positive, BGL should be measured (finger/heal prick) and the team informed. Specific gravity of urine should be tested to help determine hydration.
- Where the medical condition allows, patients to be weighed at least twice a week. Some patients will require more frequent weight measurements for clinical reasons. Weight should be measured at the same time of day with the same scales. Height/length and head circumference should be measured at least monthly.
- Blood monitoring:
  - Initial daily bloods (first 3 days or until stable): EUC, CMP, HCO_3, serum glucose and triglycerides.
  - Then twice weekly (Mondays and Thursdays): EUC, CMP, HCO_3 and serum glucose.
  - Once weekly (Mondays): LFTs, INR and triglycerides.
- Long-term PN patients: The frequency of monitoring depends upon the patient's age, clinical status, the duration of PN therapy and whether there are signs or symptoms of specific nutrient deficiencies. Guidelines for monitoring stable patients are shown in Appendix 2.

8 Refeeding Syndrome

Refeeding Syndrome is the term used to describe the potentially fatal shifts in fluids and electrolytes which may occur when a child who has recently lost weight or had a prolonged period of starvation commences aggressive nutritional support (whether enterally or parenterally).[11]

Restarting enteral or parenteral feeding provides a glucose load leading to insulin secretion and can precipitate electrolyte imbalance, especially hypophosphatemia, hypomagnesaemia and hypokalaemia. These metabolic disturbances can cause cardiac arrhythmias, seizures,

amongst other life-threatening complications. For more information please refer to the SCH refeeding syndrome guideline.

PN may be started at lower volumes in patients with significant refeeding syndrome risk (please seek PN team or dietitian advice). Supplementation of thiamine and water-soluble vitamins may be necessary prior to commencing feeding. In addition to baseline and initial daily PN blood monitoring, BGL should be checked 4 – 6 hourly initially.

In the event of refeeding syndrome, PN should be stopped and electrolyte abnormalities corrected. When stopping PN, switch patient to an IV solution containing 5% glucose (e.g. 0.9% sodium chloride with 5%glucose). Please contact the PN team for further advice.

9 Other Considerations

9.1 Cycling of PN

Children who require long term PN can benefit from a cycled regimen. Cycling of PN is a method of reducing the hours of administration of PN and must be discussed with the PN team prior to commencement. Possible complications of cycling PN are mainly hyperglycaemia at the commencement of the infusion and hypoglycaemia at cessation.

When on cycling PN it is recommended to check BGL one hour after cessation of PN and prior to reconnection of the PN, for the first 24 hours of cycling and whenever a change is made to the hours the PN is administered. For ongoing management, the Medical Officer will review each case on an individual basis depending on the initial BGL performed.

PN should be gradually weaned[1] over the last 2 hours prior to cessation – the weaning calculator in eMM is to be used to determine the hourly rates to deliver the PN.

New lines and solutions are to be used when restarting the PN.[8]

9.2 Discontinuation of PN

The decision to discontinue PN is made by the attending medical officer in conjunction with the PN team. A general recommendation is to wean the PN progressively as guided by the PN team to prevent complications such as hypoglycaemia. Optimal nutrition should be maintained whilst moving from PN to enteral nutrition. Consult dietitian if required. Please inform Pharmacy that the patient is stopping PN.

10 Potential Complications

- Hyperglycaemia.
- Glycosuria: some young infants have a low renal threshold for glucose and glycosuria may occur despite normal serum glucose levels. An osmotic diuresis and subsequent dehydration might occur unless the glucose concentration in the PN solution is reduced. Electrolyte losses occur rapidly with diuresis and should be carefully monitored.
- Hypoglycaemia: generally due to rapid discontinuation of PN without grading down the infusion rate.

- Fluid and/or electrolyte imbalance.
- Hypertriglyceridaemia.
- PN-related cholestasis may be associated with prolonged administration of PN, lack of enteral intake, previous GI surgery, prematurity and a history of sepsis.
- CVAD related complications: mechanical, sepsis, thrombosis, embolism and extravasation. Please see CVAD guidelines for further information.
- Refeeding syndrome (see above).

11 Key Performance Indicators

Identified KPI's include:

- Incidents documented on Safety Management Data Base (IIMS).
- CVC line infections.

12 References

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Appendix 1

Composition of multivitamins solutions

Vitamins	Vitalipid N Infant (10 mL)	Soluvit N (10 mL)	Cernevit (5 mL)
A (Retinol)	69 microg		3500 Units
D2 (Ergocalciferol)	1 microg (40 Units)		
D3 (Cholecalciferol)			220 Units
C (Ascorbic acid)		100 mg	125 mg
E (Alpha tocopherol)	0.64 mg		11.2 Units
K (Phytomenadione)	20 microg		
B1 (Thiamine)		3.1 mg	3.51 mg
B2 (Riboflavin)		3.6 mg	4.14 mg
B3 (Niacin)		40 mg	46 mg
B6 (Pyridoxine)		4 mg	4.53 mg
B12 (Cyanocobalamin)		5 microg	6 microg
Folic Acid		400 microg	414 microg
Pantothenic acid/		15 mg	17.25 mg
Biotin		60 microg	69 microg

Composition of “Baxter AuSPEN Trace Elements”

Element	Micrograms per mL	Micromoles per mL
Zinc	91	1.4
Copper	38	0.58
Manganese	2.2	0.04
Selenium	3.1	0.04
Chromium	0.25	0.005
Iodine	6.4	0.05

Appendix 2

Laboratory Investigations for patients on long-Term PN or Home PN

Frequency	Laboratory Investigation
Weekly (excludes home PN patients)	• EUC • HCO_3
Monthly or Bimonthly (as required for home PN patients and dependent on patient status)	• EUC • LFT • Ca, $P0_4$, Mg • Triglycerides • FBC • Serum glucose • Iron Studies • Urine electrolytes
Quarterly – in addition to bloods for monthly add these	• Folate • Vitamin B_{12} • Vitamin A • Vitamin D • Vitamin E • Vitamin C • Coagulation screen • Selenium • Zinc
Annual – in addition to monthly & quarterly	• Copper • Manganese • Chromium • Carnitine • Hb A1c • AFP • Plasma amino acids • Urinary iodine • Bone density • CXR • Liver and renal ultrasound • Dental review