PARENTERAL NUTRITION (PN) - CHW

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- Patients with normal fluid and electrolyte requirements should have standard PN ordered
- Lipid emulsion is 80% fluid by volume (20% lipid & 80% free water)
- The ordering of Parenteral Nutrition is the responsibility of the Gastroenterology team, except for infants and children in the Grace Centre for Newborn Care (GNN), Paediatric Intensive Care Unit (PICU) and Oncology patients. The registrar completes the order form which is also signed by the pharmacist.
- For infants <3 months of age – neonatal guidelines apply.
- *Clear fluid* parenteral nutrition (PN) lines may be changed earlier if indicated, but must be changed within 72 hours.
- Lines and filters used to deliver *lipid emulsion* are to be changed every 24 hours.
- S-Onc formula is only to be used for patients who have high energy expenditure, higher protein requirements, early trace element and vitamin requirements, and excessive losses of magnesium and phosphate. Standard PN should be commenced first and changed to S-Onc after 2-3 days if clinically indicated.
- All fluid bags are to be changed every 24 hours.
- All fluids are to be filtered appropriately (0.22 micron for clear fluids & 1.2 micron for lipid emulsion solutions).
- Aseptic non-touch technique (ANTT) and standard precautions are employed when accessing PN lines or dressings.
- Gloves are to be worn as an adjunct to ANTT, they can be sterile or individually packaged non-sterile gloves[8,10].
- Syringes should be 10mL luer lock or larger for use with any PN lines, particularly when flushing a CVC.
- PN should not be commenced on Friday evenings or weekends; this alleviates the problems associated with reduced services after hours. However, clinical judgement regarding the urgency of commencement of PN may indicate commencement on a

Approved by:	SCHN Policy, Procedure & Guideline Committee	Original endorsed by CHW SMG 2001
Date Effective:	1st January 2013	**Review Period**: 3 years
Team Leader:	Clinical Nurse Consultant	**Area/Dept**: Gastroenterology

Friday or weekends; this can be managed in any clinical area.

- Patients who are being considered for home PN are to be managed by or in collaboration with the Gastroenterology Team and the Clinical Nurse Consultant (Nutritional Support).
- Lipids at a dose sufficient to prevent essential fatty acid deficiency should be provided to patients who are Nil by Mouth[1].

CHANGE SUMMARY

Changes to the guideline include:

- Use of aseptic non-touch technique – sterile or non-sterile individually packaged gloves
- Use of 2% Chlorhexidine and 70% Alcohol as the cleaning solution
- Clear fluid parenteral nutrition (PN) lines changes - may be changed earlier if indicated, but must be changed within 72 hours.
- Inclusion of Home Parenteral Nutrition
- Inclusion of prophylactic use of Ethanol to prevent infection
- Changes to nursing monitoring/observation aligned to the Between the Flags project
- PN weaning now 2 hours

READ ACKNOWLEDGEMENT

- Read Acknowledge Only:
  - Department Heads
  - All medical staff
  - All nursing staff
  - All pharmacy staff
  - All dietitians

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1 Summary Guide to Parenteral Nutrition (PN)

1.1 Standard Solution: Children >3 months

If patients have normal fluid and electrolyte requirements, standard PN should be ordered. Use the Standard Solution form for ordering. Use the same guidelines for lipid emulsion and the volume of PN.

1.2 Non-Standard Solution: Children >3 months

Use the Non-Standard column for ordering if the patient has:

- fluid-restrictions
- extra or decreased electrolyte requirements
- increased or decreased protein requirements

1.2.1 Volume

This is generally equivalent to maintenance fluid requirements. **80% of the volume** of lipid emulsion is to be included in the fluid calculations.

- Do not attempt to make up rapidly changing fluid losses with PN; this can be done separately.

1.2.2 Glucose

- Energy 3.8kcal/g (15.9kJ/g)
- Initial concentration 10%
- Grade up by: 1 - 2% per day
- Max concentration 25%

1.2.3 Lipid emulsion

Lipid emulsion is an isotonic fat emulsion. It is a 20% solution (i.e. 20g fat/100mLl). Lipids at a dose sufficient to prevent essential fatty acid deficiency should be provided to patients who are NBM[1].

Children can develop essential fatty acid deficiency in <20 days, with neonates at risk within 2 days of lipid free PN[2]

- Energy 9kcal/g (37.8 kJ/g for lipid but 20% Lipid is 1.8 kCal/mL)
- Initial amount 1g/kg/day
- Grade up by: 1g/kg/day
- Max amount 4g/kg/day
- Max infusion rate 0.5g/kg/hour

Aim to have 30 - 35% of energy from the lipid emulsion.

Lipid emulsion can be infused over an entire 24 hour period

1.2.4 Protein

Synthamin is a 10% amino acid solution (i.e. 10g /100mL) which is used for children aged >3 months, Primene is the amino acid solution used in neonatal PN.

- Energy 4.25kcal/g (17.9 kJ/g)
- Initial amount 1.5 – 2.3g/kg/day
- Grade up by: 0.5g/kg/day
- Max amount 1.5 –2.0g/kg/day (not to exceed 4 g/kg/day)

1.2.5 Electrolytes

Determine daily requirements, taking into account stable losses.

1.2.6 Trace elements

A trace element solution (Neonatal Trace Elements) should be added 3 times per week to any patient who requires PN at a volume >50% of their total fluid requirement. The trace element solution contains selenium, iodine, zinc, copper and manganese.

Dosing:

- ≤ 2 years 1mL/kg/day
- >2 years 0.67mL/kg/day up to a maximum of 20mL/day

1.2.7 Composition of Neonatal Trace elements (CHW)

	Zinc	Copper	Manganese	Chromium	Selenium	Iodine
mcg/mL	91	39	2.6	0.25	3.2	6.4

1.2.8 Multivitamins

If PN is continued for >1 week, or earlier if the patient is malnourished, then a multivitamin solution is provided Mon-Fri (5 days per week). Multivitamins are mixed in the lipid emulsion for improved stability and to minimize peroxide load.

Dosing:

- < 12 yrs old
  - Soluvit N (water soluble vitamins) 1mL/kg, up to a max of 10mL/day
  - Vitalipid Infant (fat soluble vitamins in 10% lipid) 4mL/kg, up to a max of 10mL/day
- ≥ 12 yrs old
  - Cernevit (miscible both in water and lipid) 1 vial daily

1.2.9 Duration of Infusion

The total daily intake of glucose/amino acid/electrolyte solution as well as lipid 20% should be infused continuously over a 24 hours period.

Table I - PN Composition

Component	Daily Requirement (per kg)	Standard Solution (content per litre)	S-Onc Formula (content per litre)
Energy (kcal) • Infants • Older children	 90-100 50-90	 535	 1010
Glucose (g)		100	250
Protein (g) Synthamin 10%)	 1.5 - 2.5	 30	 40
Sodium (mmol)	2 - 3	30	50
Potassium (mmol)	2 – 3	30	30
Chloride (mmol)		52	84
Calcium (mmol)	0.5	9	6
Magnesium (mmol)	0.15	2	6
Phosphate (mmol)	0.5	9	1
Zinc (mmol)	0.6	12	12
Acetate (mmol)		40	33
Fat (g)	3.5	Ordered separately	Ordered separately

2 Indications for the use of Parenteral Nutrition

2.1 General Indications for PN

PN is indicated when nutritional requirements cannot be met by enteral feeding and either:

- likely to continue for more than 5 days

OR

- displays signs of malnutrition

2.2 Medical or Surgical Conditions which may require PN

Some indications for PN in older infants and children may therefore include:

- continuing neonatal gut disorders
- extensive short bowel syndrome
- gastrointestinal fistulae
- chronic idiopathic pseudo-obstruction syndrome
- severe inflammatory bowel disease
- pancreatitis
- peritonitis
- severe malabsorption
- bone marrow and organ transplantation
- pre-operative nutritional support
- post-operative gastrointestinal surgery
- chylothorax and chylous ascites
- severe burns and trauma

It is emphasised that enteral feeding is always preferable to intravenous feeding and should be used whenever possible.

3 Ordering Parenteral Nutrition Solutions

Parenteral nutrition order forms are to be used to prescribe and administer PN; there are a number of forms available for use as listed below:

- M28a – Children >3 months of age
- M28b – Special Oncology Formula Children >3 months of age
- M28c – Infants <3 months
- M28d – Neonates (NICU only)
- M28e – Home Parenteral Nutrition for children

3.1 Who orders PN?

Administration of PN involves a risk to the patient and considerable expense. The prescription form must be completed and signed by the Medical Officer. The Gastroenterology Team must be consulted for all patients requiring PN except in the two Intensive Care Units and the Oncology Unit where it is instituted by the relevant teams.

As for all significant clinical decisions, a prescription of PN should only be considered after consultation with the attending physician or surgeon.

Note: The Gastroenterology Team is not responsible for ordering PN for patients requiring lipid emulsion infusions for metabolic disorders.

Pharmacy Department staff check each patient's daily requirements: it is mandatory and a part of routine clinical pharmacy practice. Therefore it is important to ensure the order forms are accurately completed and written legibly. For more information see "Pharmacy Section".

3.2 Delivery Routes for PN

PN may be delivered via a central venous access device (CVAD) e.g. Central Venous Catheter (CVC) or Peripherally Inserted Central Catheter (PICC); it **should not be given via a peripheral cannula.**

3.3 Central

Using centrally located IV access (CVAD) is indicated when PN is anticipated or if >10% glucose solution is needed. Use of a CVAD is associated with higher risks of infection and complications than the peripheral venous route.

Ideally, the PN line (or the PN lumen of a multi-lumen central venous line) should not be used for the infusion or withdrawal of blood (unless required for blood cultures), administration of medications or for monitoring central venous pressure.

3.4 Standard PN solution

In most cases a standard PN solution can be used and wherever possible the standard solution should be used. This makes the ordering, maintenance and manufacturing of PN much simpler and less expensive.

There are 2 standard solutions available for the older child; 'standard' – 10% glucose and 'S-Onc' – 25% glucose.

An indication for the addition of heparin, vitamin or trace element solution or additional electrolytes or glucose into the formulation must be noted on the order sheet.

3.5 Individually prepared PN solutions ("Non-Standard PN")

Sometimes an individual patient will require specifically prescribed solutions where the concentrations of nutrients need to be significantly different from those present in the standard solutions. These individualised prescriptions for PN are reviewed daily.

Clinical situations in which individual PN solutions may be used include:

- Fluid restriction
- Hyperkalaemia
- Protein restriction
- Metabolic disease
- Renal failure

3.6 Non-Standard PN Solutions

3.6.1 Body weight to be used in calculations

The dietitian can be consulted for calculating nutrition requirements and ideal weight. If the ideal weight is significantly different from the actual weight, this may need to be adjusted. The dietitian can advise on this.

3.6.2 Fluid volume

In general:	**fluid volume = maintenance requirement**

(See also Table VI, as well as the Hospital Handbook)

Do not attempt to correct rapidly changing fluid losses with PN. If large fluid losses are present, then these should be replaced with a separate intravenous infusion of fluid. Very occasionally, stable fluid losses may be incorporated in the fluid calculation for PN. The dietitian should be consulted when PN is being weaned or used in combination with enteral nutrition to ensure that nutritional requirements are being met. There is a risk of either over/under-nutrition when PN fluids are reduced mL for mL when increasing an enteral feed.

Note: 80% of the volume of 20% lipid emulsion is to be included in the fluid calculations.

3.6.3 Glucose

- Initial concentration: 10% solution
- Grade up by: 1 - 2% per day
- Maximum concentration: 15% (generally 12%) the exception to this is when using the S-Onc solutions

Note: If giving via a peripheral cannula, the concentration must not exceed 10%.

Pharmacy staff can only manufacture PN solutions with glucose concentrations of 25% or less.

- Energy content: 15.9kJ/g 3.8kcal/g

3.6.4 Protein

Crystalline amino acids are the source of protein in PN solutions. Two amino acid solutions ("Synthamin 17™" and "Primene™") are used, depending on the age of the child and hence the child's ability to deal with the different profile of amino acids found in each solution. Both solutions have the essential amino acids; however, the Primene has a profile more applicable to the preterm or young infant.

3.6.5 "Synthamin 17" (Baxter)

This solution contains 10% amino acid without electrolytes, except for acetate which is 82mmol/L. It has an amino acid profile that is more suitable for use in older infants and children.

- Initial amount: 0.5g/kg/day
- Grade up by: 0.5g/kg/day
- Minimum amount: 1.5 g/kg/day[3]
- Maximum amount: 4 g/kg/day[3]

In the presence of abnormal protein losses (e.g. in burns injuries), 3 - 4 g/kg/day may be required (see table XII).

- Energy content 17.8kJ/g 4.25kcal/g
  178kJ/100mL 42.5kcal/100mL

3.6.6 *"Primene" – refer to Neonatal.*

3.6.7 Lipid emulsions

Lipid emulsion is an isotonic fat emulsion usually made of soybean oil as a source of polyunsaturated fatty acids stabilised with purified egg phospholipid emulsions as emulsifier. Water is added to make a 20% solution (i.e. 20g per 100 mL) with 2.25% glycerol to maintain isotonicity. The triglyceride particles are approximately the size of a chylomicron). The fat emulsion is used to replace essential fatty acids and to provide approximately 30 - 40% of the patient's energy requirements. It is also a source of phosphorus (16mmol/L organically bound phosphate) and contains approximately 80% water.

- Initial amount: 1g/kg/day
- Grade up by: 1g/kg/day
- Maximum amount: 4g/kg/day
- Maximum infusion rate: 0.5g/kg/hour
- Energy content 840kJ/100mL 200kcal/100mL
  9kCak/g 38kj/g

Note: Lipid emulsion should be infused continuously over 24 hours whenever possible

Lipid emulsions should be introduced gradually into the PN regime. Careful monitoring is required to prevent hyperlipidaemia particularly in presence of systemic infection. Lipid emulsions should not be administered within 12 hours of a general anaesthetic. The use of lipid emulsions may be important in such patients to avoid excessive carbohydrate intakes and to provide essential fatty acids; therefore close monitoring of plasma triglycerides and adjustment of lipid infusion rate is recommended[1].

There is some evidence to suggest that a lipid emulsion infusion is not as well tolerated (i.e. associated with higher levels of triglycerides or free fatty acids) in infants with septicaemia and that macrophage function is compromised when macrophages are incubated with lipid emulsion in vitro. Anaesthetic agents may affect the pulmonary gas exchange in the lungs

and thus the administration of fat emulsion may or may not compound this problem in the pulmonary bed[1].

If fat emulsion is to be administered for longer than 3 months, then regular monitoring of triglycerides is recommended.

3.6.8 Electrolytes and Minerals

Determine the daily requirements for electrolytes, taking into account stable losses. The usual daily requirements are as follows:

- Na 2 - 3mmol/kg/day
- K 2 - 3mmol/kg/day
- Ca 0.5mmol/kg/day
- Mg 0.15mmol/kg/day
- P 0.5mmol/kg/day
- Zn 0.6micromoles/kg/day

Notes for abnormal enteral losses:

When there are unstable, abnormal enteral losses, the extra amounts of Na and K required are calculated from the concentrations of Na and K in the fluid lost (e.g. in ileostomy or gastric fluid).

The extra zinc required is approximately 0.2 micromole/mL of enteral fluid lost.

3.6.9 Multivitamins (Soluvit N, Cervenit, Vitalipid)

If PN is continued for more than a week, or if the patient is malnourished (<85% of ideal weight for height age), then a multivitamin solution is given on a daily basis.

- Soluvit N, Cervenit or Vitalipid Infant is used at CHW.

Soluvit N

- Soluvit N is a water soluble vitamin.
- Should be used for infants and children <12 years.
- Daily recommended dose:
  - 1mL/kg up to a maximum of 10mL/day
- The composition of one vial of Soluvit is shown below in Table II.

Vitalipid Infant

- Vitalipid Infant is a fat soluble in 10% lipid.
- Should be used for infants and children <12years.
- Recommended daily dose:
  - 4mL/kg up to a maximum of 10mL/day
- Composition of 1mL of Vitalipid Infant is shown in Table II.

Cernevit

- Cernevit is mixable in both water and lipid.

- Should be used for children >12years.
- Recommended daily dose:
  - 1 vial
- Composition of one vial of Cernevit is shown in Table II.

Table II Composition of multivitamins

Vitalipid Infant	
Vitamin	**Quantity (mL)**
Vitamin A	69 mcg
Vitamin D2	1 mcg
Vitamin E	0.64 mg
Vitamin K1	20 mcg
Excipients: Soya oil (100 mg), egg lecithin (12 mg), glycerol (22 mg), Sodium Hydroxide to pH 8.0	
Cernevit	
Vitamin	**Quantity (1 vial)**
Retinol (A0	35000 IU
Cholecalciferol (D3)	5.5 mcg
Vitamin E	11.2 IU
Ascorbic Acid (C)	125 mg
Thiamine (B1)	3.51 mg
Riboflavin (B2)	4.14 mg
Pyridoxine (B6)	4.53 mg
Cyanocobalamin (B12)	6.0 mcg
Folic Acid	414 mcg
Dexpanthenoic acid	17.25 mg
Biotin	69 mcg
Niacin	46 mg
Excipients: Glycine (250 mg), Glycocholic acid (140 mg), Lecithin (Soybean) 112.5 mg, Sodium Hydroxide 10% qs and/or 1M hydrochloric acid qs pH 5.9	
Soluvit N (1 vial)	
Vitamin	**Quantity (1 vial)**
Ascorbic Acid (C)	113 mg
Thiamine nitrate	3.1 mg
Riboflavin (B2)	3.6 mg
Pyridoxine (B6)	4.0 mg
Cyanocobalamin (B12)	6.0 mcg
Folic Acid	400 mcg
Pantothenic acid	15 mg
Biotin	60 mcg
Niacin	40 mg
Excipients: Glycine (300 mg), Edetate Sodium (500 mg) preservative methyl-hydroxybenzoate (500 mg)	

If a patient has extra vitamin requirements, these can be ordered in the column for additions.

3.6.10 Other Vitamins

Recommended amounts of Folic acid and Vitamin K1 when Soluvit N or Cernevit is insufficient:

- Vitamin K1 1.0mg
- Folic acid 1.0mg

3.6.11 Trace Elements

Neonatal Trace Elements are used at this hospital for both neonates and older children.

Table III Composition of "Neonatal Trace Elements"

Element	Microgram per mL	Micromoles per mL
Zinc	91.53	1.4
Copper	38.13	0.6
Manganese	2.20	0.04
Selenium	3.16	0.04
Chromium	0.26	0.005
Iodine	6.35	0.05

Daily recommended dose:

- Children < 2 yrs 1mL/kg
- Children 2-16 yrs 0.67mL/kg up to a maximum of 20mL

3.6.12 Heparin

Heparin (1 unit/mL) should be administered via the PN solution if peripheral cannulae or neonatal-type silastic lines are employed. Please contact Pharmacy staff for more information.

3.7 Standard PN Solution Formulations

3.7.1 Application

The Standard Solution PN formula is used if the patient has normal fluid and electrolyte requirements. It is a maintenance formulation for older infants and children at 70 - 100mL/kg per day. Some additions can be ordered e.g. extra glucose, Na, K.

The same guidelines for **body weight**, **fluid volume** and **lipid emulsions** apply as with individual PN solutions.

Examples of the actual composition of Standard Solution PN at various daily volumes and fat dosages are shown in Table IV refer to comparison table for S-Onc.

Table IV: Examples of composition of Standard PN with varying daily doses of lipid emulsion

Total Daily Volume (mL/kg)	50 mL/kg			100 mL/kg		
Lipid emulsion 20%	**Nil**	**3 g/kg**	**4 g/kg**	**Nil**	**3 g/kg**	**4g/kg**
Fat (kcal/kg)		30 (kcal/kg)	40 (kcal/kg)		30 (kcal/kg)	40 (kcal/kg)
(kJ/kg)		125 (kJ/kg)	167 (kJ/kg)		125 (kJ/kg)	167 (kJ/kg)
Glucose (g/kg)	5	5	5	10	10	10
(mg/kg/min)	3.5	3.5	3.5	6.9	6.9	6.9
Protein (g/kg)	1.5	1.5	1.5	3	3	3
Na (mmol/kg)	1.5	1.5	1.5	3	3	3
K (mmol/kg)	1.5	1.5	1.5	3	3	3
Cl (mmol/kg)	2.6	2.6	2.6	5.2	5.2	5.2
Ca (mmol/kg)	0.45	0.45	0.45	0.9	0.9	0.9
Mg (mmol/kg)	0.1	0.1	0.1	0.2	0.2	0.2
P (mmol/kg)	0.45	0.45	0.45	0.9	0.9	0.9
Zn (micromoles)	0.6	0.6	0.6	1.2	1.2	1.2
Acetate (mmol/kg)	2	2	2	4	4	4
Energy (kcal/kg)	27	57	67	54	85.5	96
(kJ/kg)	112	237	280	223	349	391

3.7.2 Modified Standard PN

In some situations it may be useful to order Standard Solution PN with one or two added components e.g. additional Na or K. If more than two modifications are required, then it is preferable to order a completely individualised PN solution.

3.8 Grading up Standard PN

Unlike the situation with regard to Non-Standard PN, Standard Solution PN cannot be "graded up"; although the accompanying lipid emulsion infusion can be “graded up”.

4 Nutritional Requirements

4.1 Overview

A thorough nutrition assessment should be conducted prior to commencing PN[4]. This will provide the basis for estimating nutrition requirements and monitoring throughout the course of PN therapy.

The NHMRC Nutrient Reference Values (NRV’s) provide a guide for estimating macro and micro-nutrient requirements. They are based on average/estimated requirements for healthy people. A dietitian is required to estimate requirements in specific clinical situations.

Nutritional requirements should be considered when determining the method of nutritional support. Nutrient needs depend on the child's age, sex, weight, height, growth patterns, level of activity, specific disease state, initial nutritional status and the anticipated duration of inadequate oral intake.

4.2 Fluid Requirements

Maintenance fluid requirements are based on age and body weight (Table VI). Conditions that increase fluid needs include fever, diarrhoea, vomiting, the presence of a hypermetabolic state and respiratory distress (Table VII). Fluid orders therefore need to be individualised and closely monitored.

Table V Maintenance Fluid Requirement[3]

Age	mL/kg/day
Day 1 of life	60
Day 2 of life	90
Day 3 of life	120
Up to 9 months	120-140
12 months	90-120
2 years	80-90
4 years	70-80
8 years	60-70
12 years	50-60

Table VI Factors Modifying Water Requirement[3]

Extra Required	Less Required
Fever (add 10% for each °C above 37.5°C)	Hypothermia (subtract 10% for each °C below 37°C.)
Hyperventilation	Very high humidity
High ambient temperature	Oliguria/anuria
Extreme activity	Extreme inactivity
Any other abnormal losses (e.g. enteral losses, polyuria)	Fluid retention (e.g. cardiac failure)

4.3 Energy Requirements

Energy needs of healthy individuals are the sum of the following 4 components: Basal metabolic rate (BMR), diet induced thermogenesis, physical activity and growth. Energy needs in the hospital setting are quite different and can be either increased or decreased by: baseline nutritional status, acute or chronic illness/disease, energy intake, energy losses, age and gender[3].

Energy (calorie) requirements for children are based on body size, body composition, rate of growth, level of physical activity and stress. As children grow older, more energy is needed because of increased body size, whereas the energy needed per unit of size decreases due to a slower rate of growth.

Energy requirements for patients receiving PN have been estimated to be approximately 90% of that required when fed enterally, the needs being less because digestion and absorption are bypassed. Various factors, such as fever, burns, major surgery and sepsis, will increase energy requirements, as outlined in Table VII.

Table VII Factors That Increase Energy Requirements

Factor	Increase in energy needs
Fever	10% for each °C above 37.5°C
Cardiac failure	15 - 25%
Major surgery	20 – 30 %
Burn injuries	50 – 100%
Severe sepsis	40 – 50%
Long-term growth failure or protein-energy malnutrition	50 – 100%

4.4 Protein Requirements

The requirement for protein is higher per unit body weight in infants than at any other time in life. If energy intake decreases or energy use increases, then the protein delivered will be partly used as a source of energy and protein synthesis decreases. A diet which provides a minimum of 6 - 8% of total energy intake as high quality protein is recommended for infants and children.

The NRV for protein should be followed, keeping in mind that certain disease states may require more or less protein.

Table VIII Protein Recommendations by Life Stage and Gender[5]

	EAR Estimated Average Requirement	RDI Recommended Daily Intake	AI Adequate Intake
Infants:			
0-6 months			10 g (1.43 g/kg)
7-12 months			14 g (1.60 g/kg)
Children			
1-3 yrs	12 g/day (0.92 g/kg)	14 g/day (1.08 g/kg)	
4-8 yrs	16 g/day (0.73 g/kg)	20 g/day (0.91 g/kg)	
Boys			
9-13 yrs	31 g/day (0.78 g/kg)	40 g/day (0.94 g/kg)	
14-18 yrs	49 g/day (0.76 g/kg)	65 g/day (0.99 g/kg)	
Girls			
9-13 yrs	24 g/day (0.61 g/kg)	35 g/day (0.87 g/kg)	
14-18 yrs	35 g/day (0.62 g/kg)	45 g/day (0.77 g/kg)	

Adapted from Nutrient Reference Values for Australia and New Zealand (page 30) - 2006

Protein requirements can be increased in the hospital setting, so the NRV's should be considered a minimum target for protein provision in PN.

The metabolic response to surgery, trauma and sepsis is in part characterised by a negative nitrogen balance. This may result from protein catabolism being greater than protein synthesis, or synthesis being less than catabolism. Table IX illustrates some possibilities that may result in negative nitrogen balance.

Table IX Nitrogen Balance in Different Clinical Situations

Situation	Synthesis	Breakdown	N Balance
Surgery	↓	-	Negative
Sepsis	↑	↑↑	Negative
Malnutrition	↓↓	↑	Negative
Cancer	↑	↑	Stable or negative

Note: Protein intake should never exceed 4g/kg/day

4.5 Carbohydrate Requirements

A constant source of carbohydrate is required, especially in the infant, as liver and muscle glycogen stores are small. A minimum amount of carbohydrate per day is required to prevent ketosis and use of protein as an energy source. It is recommended that 45 - 55% of the total daily energy intake be provided as carbohydrate.

Thiamine is required for carbohydrate metabolism; it acts as a co-factor to pyruvate dehydrogenase, which is the enzyme that converts pyruvate to acetyl CoA. Provision of carbohydrate without thiamine may result in life-threatening complications. Additionally, overfeeding of carbohydrate may result in elevated triglyceride levels[6].

4.6 Fat Requirements

Dietary fat is a source of energy and of essential fatty acids (for cell structural components and eicosanoid synthesis). It also acts as a vehicle for the intake of fat-soluble vitamins and is involved in the regulation of blood lipid emulsion levels. The exact requirement for fat and the optimum percentage of energy from fat are unknown. In general, 30 - 40% of total energy will come from fat.

In humans, the major essential fatty acid is linoleic acid. The requirement for essential fatty acids is 3% of total energy intake.

Note: Fat intake should never exceed 4g/kg/day

4.7 Vitamin and Mineral Requirements

The NHMRC NRV's provide an estimate of micronutrient requirements[5]. There are additional nutrients that are known to be essential in humans which have not been included in this table because quantitative evidence of their requirements are not well established. Among the vitamins, vitamin K, biotin and pantothenic acid are produced in varying quantities by the gut flora. Biotin deficiency has been reported in infants receiving long-term PN. Vitamin K deficiency can occur with fat malabsorption, when the gut flora has been disrupted or when the gut flora has not been established.

4.8 Iron

Iron is essential to support haemoglobin synthesis. The body is capable of storing large reserves of iron but is limited in its ability to excrete excess amounts. Newborn infants have sufficient iron stores for 4 - 6 months. Parenteral iron bypasses the natural regulatory mechanisms of the gut and iron overload can occur when it is given parenterally. As a result, iron is not added to PN solutions. Supplementation of iron is not standard because the usual course of PN is short in duration and the existing body stores of iron are more than sufficient to meet metabolic requirements.

Patients on long-term PN usually have sufficient gut function to meet their daily iron requirements via oral supplementation.

5 Administration of Parenteral Nutrition

PN solutions are to be replaced every 24 hours[7]; this includes the lipid and clear fluid solutions as recommended by the manufacturer. (Primene & Synthamin). Basic principles include:

- remove all jewelry
- use aseptic non-touch technique (ANTT)
- wear sterile or pre-packaged non-sterile gloves when accessing any line that delivers PN[8-10]
- a 30 second hand wash or 20 second hand rub (refer to Hand Hygiene)

Note: PN should not be commenced on Friday evenings or weekends; this alleviates the problems associated with reduced services after hours. Difficulties usually arise, or are identified within 24 hours of commencement. However **clinical judgement** regarding the urgency for the commencement of PN may require the PN be commenced on a Friday or weekend, this can be managed in any clinical area.

5.1.1 Frequency of intravenous line changes when non-lipid emulsion is being infused

ANTT[11] is used when changing lipid emulsion and non-lipid emulsion containing IV lines; this reduces the risk of contamination and eliminates the risk of infectious complications associated with administration of parenteral nutrition. A patient/parent handout should be given to all families who are having PN in hospital; it has been developed to explain PN and what will happen during admission (it can be printed from this document).

Where possible; PN lines should remain intact, that is maintaining a closed system. Intermittent disconnection is discouraged, it is important to understand that the more often the system is accessed, the greater the risk of contamination. The contamination of lines is of greater concern for lines delivering lipid emulsions, bacteria will multiply more readily in this environment rather than in the glucose & protein solution.

PN solution should be out of refrigeration for 1hour[12] 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".

Literature (based on adult studies) shows it is safe to leave a line in place for up to 96 hours[13,14]. The Hospital has recommended for PN lines containing non-lipid emulsions (Synthamin or Primene) to be **changed at 72 hours**, but may be changed earlier if clinically indicated.

The exception to this is if the child receiving the PN is older than 12 years and has Cernevit multivitamin added to the non-lipid PN solution.

Daily line changes are required when the PN is not given continuously over 24 hours.

Note: Occasionally Cernevit may be approved by the Medical Officer and/or Pharmacist to be administered as a bolus dose.

5.1.2 Frequency of line changes for Lipid emulsion Containing Solution

IV lines (including the filter) used for administration of lipid emulsion containing solution must be changed every 24 hours[14].

5.1.3 Principles for Changing the PN Line & Bag

1. Ensure area is clean and free of excess traffic; that is connecting the PN to the patient in the same room where the PN line and bag change occurs. *NB:* bedside connection is not recommended as this space is recognised as a "safe" non-interventional place for children. Therefore, where possible consider using the treatment room.
2. Maintain a surgically clean field onto which equipment is placed and lines connected.
3. Prepare the lines: ensure all clamps are on (including roller clamps); Connect filters to the lines then to the 3-way tap or add-on needleless connection is placed on the patient side of the line set-up.

> **Note**: 3-way taps or needleless connectors are recommended for PN to reduce the risk of contamination with lipid emulsion solutions, other extension pieces are too long and increase the risk of bacterial growth (this includes bifurcate or "chooks foot" connections)

4. Using 2% Chlorhexidine in 70% alcohol swabs, clean the rubber stopper on the lipid emulsion solution *and allow it to dry*, insert airway needle (if glass bottle) and giving set.
5. Using the same procedure clean the connection port of the PN bag and insert the 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 working field ready for connection.
7. Using the dressing towel as a clean barrier between the CVAD and the body, clean the hub area of the line using 2% Chlorhexidine in 70% alcohol swabs. Allow to dry. It is important to thoroughly clean the entire hub/line area.
8. Clean away from the connection on both the patient and fluid side of the connection, using 2% Chlorhexidine in 70% alcohol swabs.
9. Attach the 3-way tap or needleless connector to the CVC. Ensure it is secure in readiness for connection to the CVC.
10. Ensure the clamp on the CVAD is closed. Disconnect the old line and replace with the clean line.
11. Lines delivering lipid emulsion solutions must be changed every 24 hours[14], the 3-way tap or needleless connector is left insitu to maintain the closed system, there is an increased risk of contamination with lipid emulsion solution than with non-lipid containing solution[13].

> All components of the PN line are to be changed during line change. This includes 3-way taps and needleless connectors.

12. PN should be covered with the light protective bag provided. Ensure the bottom of the bag is folded up to prevent any reflective light from floors etc[15].

13. Cessation of PN will need to be considered if IV antibiotics for a suspected CVC infection as per CVAD guidelines.

5.1.4 Cessation of PN for Day Leave etc

Prior to departure or within 1 hour of cessation of the PN a blood sugar level (BSL) is performed. On the first day of leave or first occurrence of cessation of the PN, the BSL is repeated on return to the ward or 6 hours after cessation of the PN. PN should be gradually weaned[16] over the last 2 hours prior to cessation – the weaning calculator in PowerChart is to be used to determine the hourly rates to deliver the PN. For ongoing management, the medical officer will review each case on an individual basis depending on the initial BSL performed. New lines, bags and lipid emulsion bottles are to be used when restarting the PN[15].

5.1.5 Vital Observations

The child's condition must always be considered and monitored and follow recognition of the deteriorating child. Observations should meet the "Between the Flags" criteria.

5.1.6 Weight

Inappropriate weight gain may occur if PN fluid intake is excessive and both weight loss and sudden weight gains should be reported to the PN team. Weight should be measured at the same time of day, every day and with the same scales[17].

5.1.7 Fluid balance

Strict fluid balance is to be maintained at all times; over-hydration and dehydration are two of the possible complications of PN. Document an accurate record of fluid input[15,16] in the clinical record. Report any negative or positive balances to the relevant medical team.

5.1.8 Urinalysis

Urinalysis can be the first line of detection for possible complications of PN[15,16] For example, glycosuria could indicate glucose intolerance; hence it is essential that urine is assessed to ensure early detection. Usually a daily urinalysis is required, unless the child is on long term and/or home PN.

5.1.9 Blood glucose levels (glucometer)

Hyper- and hypoglycaemia are possible complications of PN, the blood glucose levels must be assessed to ensure early intervention. Where the level is excessively high or low, formal levels must be done[15,16]. [It is important to remember that if blood is collected from the CVC, the PN solution may interfere with the level and give a false reading].

Table X Blood Glucose Monitoring

Frequency	For how long?
6th hourly	First 24 hours
Daily (maybe done with other blood collection)	Thereafter
6th hourly after cessation of PN	24 hours
Cycling PN for day leave or home PN regimen	
1 hour after cessation and on return to ward if on gate leave	for 24 hours or whenever a change is made to the hours the PN is being administered
Not required	When ready for discharge home on PN

5.1.10 Infusion of other solutions

Drugs are **NOT** to be injected into the PN flasks or into the burettes delivering PN. Always ensure the solution to be infused is clear, not cloudy and is the correct solution ordered[15].

No "slow infusions" should be "caught up" - all discrepancies between flow rates & orders must be documented. NEVER CEASE ABRUPTLY - if cessation is required, replace with 5 - 10% Dextrose solutions to avoid hypoglycaemic episode, ensure medical staff notified and confirm with written fluid order.

5.1.11 Blood cultures

Whenever possible any routine blood cultures required, must be taken at the time of line change. This should occur prior to connecting the lines to the patient or collected using peripheral venipuncture.

5.1.12 Storage

Refer to the Pharmacy section for information on storage of solutions and where to obtain extra bags of solution.

6 Monitoring

PN provides a rich source of nutrients to patients who may be critically ill or metabolically unstable. It is therefore important that regular monitoring is performed in order to prevent or detect metabolic complications of PN. Monitoring also allows the nutritional adequacy of PN to be assessed.

6.1 Medical Monitoring

Monitoring by the medical team should include the following (for neonates in Grace please refer to Section 8):

- Medical review at least twice per day by the admitting team (includes review of fluid balance, bodyweight, urinalysis, pathology results etc).
- When commencing or changing PN prescriptions, the actual nutrient intake should be calculated and compared with the recommended intake (see section 4).
- Laboratory tests should be organised and reviewed.

Table XI shows the laboratory tests that should be ordered by the Primary Care Resident Medical Officer and overseen by the Registrar ordering PN (i.e. Gastroenterology team, PICU, Grace Nurseries or Oncology).

Table XI Laboratory investigation schedule for patients on PN

When	Laboratory Investigation required	
Baseline	• FBC • EUC, HCO_3, Creatinine, Glucose • Ca, Mg, PO_4 • LFT	• Fasting Cholesterol and Triglyceride • Ammonia • Zinc
First 3 days or until stable	• EUC • HCO_3 • Creatinine	• Glucose • Triglyceride (when increasing lipid)
Mondays	• EUC • HCO_3 • Creatinine	• Glucose • LFT • Ca, MG, PO_4 • Triglyceride
Thursdays	• EUC • HCO_3	• Creatinine • Glucose

Note: Where indicated, Na and K in enteral losses (e.g. enterostomy or gastric aspirate contents) should be measured.

6.1.1 Long-term PN patients

For patients who receive PN for periods greater than a month, then nutritional status should be checked with particular regard to micronutrient status (including fat soluble vitamins – A, D, E, K – water soluble vitamins B1, B2, B6, C and minerals – Cu, Se Zn). 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 Table XII.

Table XII Laboratory Investigations for Stable 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 • Triglyceride • FBC • Ferritin & Serum Iron
Quarterly – in addition to bloods for monthly add these	• Vitamin B_{12} • Folate • Vitamin A • Vitamin D • Vitamin C • Coagulation screen • Selenium • zinc
Annual – in addition to monthly & quarterly	• copper • manganese • chromium • Carnitine • Bone density • Hb A1c

6.1.2 Long-Term Unstable PN Patients

Patients on long term parenteral nutrition who are metabolically unstable will require more individualised monitoring.

6.2 Nutritional Monitoring

Ideally this should be done by a dietitian in collaboration with the medical team. Initially nutritional assessment should be undertaken in order to determine nutritional status, to establish baseline parameters against which nutritional management can be monitored and to determine goals of nutritional therapy.

6.2.1 Nutritional Assessment

Medical History:

- Nature of condition, severity, duration, extent of metabolic stress, treatment e.g. surgery or chemotherapy, relevant medications, social and psychological state. The bearing of all of these on nutritional status and nutritional requirements must be considered.

Dietary Assessment:

- Diet history to determine nature and pattern of intake, 24 hour food record or 3 day food diary in order to calculate exact intake, if indicated.

Physical Assessment:

- Overall impression of nutritional status, specific symptoms of nutritional deficiencies, pubertal staging (if appropriate) and anthropometry. The latter includes weight, height, length, head circumference, growth velocity, and skin fold thickness, mid arm circumference, body mass index and use of growth charts.

Biochemical/Laboratory Assessment:

- This is necessary to obtain baseline values, detect clinical and sub clinical deficiencies, confirm diagnosis and to monitor tolerance to, and complications of, nutritional therapy.

Calculating Nutritional Requirements:

- Using the above information, the nutritional requirements of the patient should be calculated with respect to fluid, energy, protein, vitamins, minerals and trace elements. Calculations are based on age, sex, weight, clinical condition, treatment and activity.

6.2.2 Nutritional Monitoring

Nutritional monitoring should occur after the initiation of parenteral nutrition and at regular intervals after this. The aims of monitoring are to minimise complications, to confirm the adequacy of nutrition support and to facilitate transition from parenteral nutrition to enteral nutrition.

Medical Monitoring:

- Subsequent changes in condition/treatment which may have a bearing on nutritional requirement, for instance the development of sepsis, anastomotic breakdown, increased losses from fistula or drains. Nutritional requirements and hence nutritional therapy should be modified accordingly.

Dietary Monitoring:

- Calculating dietary intake (if and when appropriate). This should be used as a basis for transition from parenteral nutrition to enteral/oral intake without nutritional deficits and for discontinuing parenteral nutrition. This transition should be hastened by instigating enteral/oral nutrition as soon as feasible and by monitoring adequacy of feeding techniques, food provided and need for additional supplementary products. If oral intake is not possible then enteral tube feeding should be recommended as soon as viable. Tube feeding should be monitored and recommendations made based on volumes tolerated re: the discontinuation of parenteral nutrition. Accurate intake and output documentation is necessary for this. Drugs affecting both oral and enteral intake should be considered. (see "Transitional Feeding")

Physical Monitoring:

- Improvement of nutritional status, correction of nutritional deficiency symptoms, serial anthropometric measurements to indicate maintenance, improvement, catch up growth

or increase in growth velocity as indicated. Observe signs of hydration status, over or underfeeding. Nutrition support should then be modified accordingly. All forms of anthropometry measurement listed may not be appropriate for every patient.

Biochemical/Laboratory Monitoring:

- See the section on Medical Monitoring for specific details.

Nutritional Adequacy:

- Monitoring whether nutritional requirements are being provided on a day to day basis. Volumes infused, interruptions, fluid losses, pyrexia etc should be assessed.

6.3 Nursing Monitoring

Nurses caring for patients with PN are required to monitor for fluid overload, electrolyte imbalance or possible sepsis.

Assessment of neurological status and level of anxiety should be documented in the progress notes for the first 48 hours as required.

7 Pharmacy

7.1 Orders

Orders for PN should be faxed to the Pharmacy Department by 10.30am (fax no. 52702 or 52709). For further information or queries contact the PN pharmacist on ext. 52708. The original copies of the orders will be collected from Camperdown Ward, PICU & Grace Nurseries by the pharmacy staff. The Gastroenterology medical team will deliver the original orders from other wards to Pharmacy with the exception for outlying oncology patients (the Oncology Registrar will be responsible for delivery of the original order).

- Two orders are required on Thursdays (one for Thursday and one for Friday).
- Two orders are required on Fridays (one for Saturday and one for Sunday).
- Additional orders will be needed for public holidays.

Please notify the Pharmacy as soon as possible of any changes or cancellations of PN orders to avoid wastage of solutions and staff time.

7.2 Volume – Considerations When Ordering

The standard solution for children over three months old is available as a 1000mL bag. Each bag has an overage of approx. 90mL (to allow for priming of lines) so the total bag volume is approx. 1090mL. If less than 1000mL of the solution is needed per day then after 24 hours the remaining solution is discarded and a new bag commenced. If more than 1000mL is required then multiples of 1000mL are supplied. The prescriber should consider the patient benefit of prescribing volumes just over multiples of 1000mL (e.g. 1200mL) against the increased nursing time and cost involved in using an extra bag.

7.3 Modification of Standard PN Solutions

Additional electrolytes e.g. potassium or sodium can be added to standard PN solutions by indicating the amount per 1000mL required on the order form. All such additions must be made in the Pharmacy aseptic suite.

Please note that adding to a PN solution will reduce its expiry date to a maximum of three days from the date of addition. This will probably result in wastage of the bag if it is not used.

7.4 Non-Standard PN Orders

Some individualised PN solutions may need to be ordered from Baxter™ Healthcare, a commercial company who specialise in the manufacture of sterile products. For example, the maximum glucose concentration we can filter at the hospital is 15% so all solutions with a greater glucose concentration will have to be ordered from Baxter™. The cut off time for ordering from Baxter™ for same day delivery is 10.30am; therefore, it is important that these orders are received in pharmacy department by 10.15am.

7.5 Drug and PN Compatibilities

Many factors can influence PN and drug compatibility, e.g. concentration, types of lines and where the solutions will mix, the length of tubing the solutions will mix over, the time the solutions will be mixed for, temperature of the solutions and infusion rates. Therefore generalisations about compatibilities are difficult, however Morphine and Ranitidine have been found to be compatible with parenteral nutrition solutions in most instances. Any specific compatibility questions should be directed to the PN Pharmacist ext. 52708.

As a general rule PN solutions should be given via a dedicated line using an in-line filter. In the case of a multiple lumen central venous catheter then a lumen should be dedicated to the PN.

No drugs are to be added to the PN bag outside of the Pharmacy aseptic unit.

7.5.1 Calcium and Phosphate

A number of factors can contribute to the formation of insoluble calcium phosphate precipitates in PN solutions. These include pH, temperature and the presence of other electrolytes. Precipitation may not occur for twelve or more hours after mixing and therefore it is essential that all solutions are carefully inspected before and during administration and that a 0.22 micron filter is used. Pharmacy staff will check precipitation profiles with respect to amino acids and electrolytes for each formulation ordered. As a general rule the concentration of calcium and of phosphate should each not exceed 15mmol per 1000mL.

7.6 Delivery Times

- PN solutions and Lipid emulsion bottles are delivered to the wards between 4.30pm and 5.30pm.
- If a plain standard solution has been ordered, it may be available earlier in the day for collection by the ward concerned. Please phone first to check that the solution is ready before coming to collect.

- Non-Standard solutions and Modified Standard solutions will not usually be available until the delivery times stated above.

7.7 Stability of Solutions

PN solutions manufactured at CHW have a maximum expiry date of three days when stored in the fridge. 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 lipid emulsion bottles is stated on the manufacturer's label.

Before use, the **PN solution must be inspected** by nursing staff for turbidity, precipitation and leakage.

Table XIII After Hours – Availability of PN Solutions

Area	Solution	Comments
PICU	2 x PN standard 1000 mL bags	
Pharmacy Emergency Drug Cupboard	2 x lipid emulsion 20% 100 mL 1 x lipid emulsion 20% 500 mL	
Grace Nursery	1 x PVL-1 500 mL bag 1 x PVL-2 500 mL bag 2 x lipid emulsion 20% 100 mL	NB: neonatal PN bags kept on Grace as ward stock **DO NOT** contain Heparin

Only standard PN solutions are available after hours. If a patient requires a replacement for a non-standard solution (e.g. due to spillage or the solution has expired) then the following are possible alternatives:

- Give standard formula PN.
- Give standard formula PN plus an additional infusion of electrolytes.
- Give Glucose (usually 10%) to prevent rebound hypoglycaemia.
- Contact the on-call Pharmacist to see if the expiry date of the PN solution can be extended.

8 Neonatal Parenteral Nutrition – Special Considerations

General principles of care and management of PN and the lines apply to all infants and children within the Hospital, however the following is for infants being cared for in the Grace Nurseries:

The attending Neonatologist and/or surgeon or specialist physician decides when to commence intravenous nutrition (PN). This is usually after 3–5 days of standard intravenous fluid therapy in infants who will not commence or are not expected to tolerate enteral milk feeding for 5–7 days.

PN orders for infants in Intensive and Extended Care are written by the night registrar. The hospital pharmacy requests the orders are completed by 10.00 am. If possible, the orders for Friday, Saturday, and Sunday should be the same, though of course the amount of lipid emulsion solution can be varied.

8.1 Order form

Use the Parenteral Nutrition (PN) Order Sheet for Neonates <1 Month of Age & Total Parenteral Nutrition (PN) Order Sheet for Neonates 3 Months of Age. Note that intravenous nutrition is ordered as if the infant were nil by mouth and the volume of enteral feeding is subtracted from the total intravenous volume prescribed.

8.2 Indications

The following is an incomplete list of the conditions for which intravenous nutrition may be required

- Birth weight <1000g.
- Necrotising enterocolitis.
- Operative surgery involving the small intestine.
- Chronic respiratory failure requiring prolonged mechanical ventilation.

8.3 Requirements

The usual requirements for the ingredients used in PN and the compositions of the standard formulations are shown in Table XIV: Intravenous Nutrition for Neonates.

Table XIV Intravenous Nutrition for Neonates

Component	Requirement	Content/150 mL/kg/day	
		NPVL 3	NCVC 3
Primene (g)	2.5 – 3.0	3	3
Glucose (g%)	10 – 20	10	12
Na (mmol)	2 – 6	10	12
K (mmol)	2 – 4	3	3
Ca (mmol)	0.5 – 2.0	1	1
P (mmol)	0.8	1	1
Mg (mmol)	0.15	0.15	0.15
Zn (micromole)	7.5	7.5	7.5
Energy (kCal)	100 – 150	63	73

8.4 Energy

The suggested energy requirements of the newborn infant are as follows (1 kCal≈4 kJ):

- Term or preterm infant: 110–120kCal/kg/day
- Small for dates infant: 120–150kCal/kg/day
- Sick infant: 100–110kCal/kg/day

8.5 Glucose, electrolytes and water

The infant's water requirement is determined from the simple intravenous fluid therapy regime prior to the introduction of PN. The amount of glucose that can be given is limited by the route of administration and the infant's glucose tolerance. In general, the maximum Dextrose concentrations used are 10% and 12% via peripheral cannulas and central venous catheters, respectively.

- Glucose = 4kCal/g

8.6 Enteral losses

The sodium and potassium in enteral losses (e.g. enterostomy output or gastric aspirate) may need to be measured and replaced when the output exceeds 10 mL/kg/day. The enteral losses cannot be added to a standard solution; they are either given through a separate intravenous cannula in conjunction with the use of a standard formulation or a non-standard solution is prescribed.

8.7 Standard formulations

If possible, one of the standard solutions should be used but a non-standard solution can be prescribed. The standard solutions deliver the usual daily requirements of sodium, potassium, calcium, phosphorous, magnesium and zinc if the infant is receiving 150mL/kg/day of intravenous fluid. The solutions differ in the amounts of protein and potassium and the concentration of glucose they contain.

In general, infants are commenced on PN when their daily fluid infusion rate is >90–120 mL/kg/day. NPVL ('peripheral venous line') 3 is used if PN is being administered via a peripheral venous cannula and NCVC ('central venous line') 3 is used if there is a central venous catheter and the infant can accommodate the higher glucose infusion rate.

8.8 Protein

Primene is commenced at 1g/kg/day and increased by 1g/kg/d to a maximum of 3g/kg/day.

- Protein = 4kCal/g

8.9 Fat

Fat (Lipid emulsion solution 20%) is commenced at 1g/kg/day and increased by 1g/kg/day to a maximum of 3 – 4g/kg/day.

- Lipid emulsion solution = 10.5kCal/g

The infusion is given through an infusion set which joins the amino acid-mineral-sugar solution at a Y-junction close to the infant.

The amount of intravenous fat an infant receives is limited to 2g/kg/day when one or more of the following apply:

- FiO_2 > 0.60
- Jaundice requiring phototherapy
- Proven sepsis

Intravenous fat should be suspended under the following circumstances:

- FiO_2 1.0
- Jaundice requiring exchange transfusion
- Uncontrolled sepsis

Eighty percent (80%) of the volume of lipid emulsion solution to be administered should be subtracted from the total volume of PN because of the water content of the lipid emulsion.

Lipid emulsion is administered over 24 hours, but this may need to be modified in individual infants if lipaemia in the plasma sample interferes with biochemical investigations.

8.10 Heparin

Heparin, 1unit/mL, is added to the intravenous nutrition because it may reduce the likelihood of line obstruction and facilitate the clearance of fat from the serum.

8.11 Vitamins

Vitamins (Soluvit N and Vitalipid emulsion N Infant) are added to PN after one week of treatment. The recommended dose of Soluvit N is 1mL/kg/day (maximum daily dose 10mL) and of Vitalipid emulsion N Infant is 4mL/kg/day (maximum daily dose 10mL). Soluvit N contains thiamine (Vitamin B1), riboflavine (Vitamin B2), nicotinamide, pyridoxine (Vitamin B6), pantothenic acid, Vitamin C, biotin, folic acid, and cyanocobalamine (Vitamin B12). Vitalipid emulsion N Infant contains the fat soluble vitamins: Vitamin A, Ergocalciferol (Vitamin D), dl-α-Tocopherol (Vitamin E) and phytomenadione (Vitamin K). Vitamins are added to the PN Monday-Friday.

8.12 Trace elements

If intravenous nutrition is required for more than two weeks the infant should be given Neonatal Trace Element Solution (Table XV), 1mL/kg/day, on Tuesday, Wednesday and Thursday. Trace elements are not measured in the blood.

Table XV Neonatal trace element solution

	MW	Mcg/mL	Mmol/mL
Selenium dioxide	111	4.40	0.04
Sodium iodide	149.9	7.42	0.05
Zinc chloride	136.3	189	1.4
Copper sulphate pentahydrate	249.7	148	0.6
Manganous sulphate	169	6.69	0.04
Chromic chloride	266.5	1.32	0.005

8.13 Enteral milk feeds

If the infant is receiving liquid enteral nutrition (orally or enterally) the PN orders are written as though the infant were nil by mouth and the volume of the enteral feeds is subtracted from the total PN volume required.

8.14 Monitoring

8.14.1 Ward

- Body weight is measured daily, recorded in CCIS and plotted on the Low Birth Weight Chart (CS10) if the infant's birth weight is ≤2500g or on the Linear Weight Chart (MR 31a) if the birth weight is >2500g.
- Head circumference is measured weekly.
- Blood glucose levels are performed 6 hourly for 48 hours, twice daily for two weeks and then once daily.
- Urinalysis is performed daily.

8.15 Laboratory

First two weeks

- Plasma Na, K, Cl, HCO_3, urea, creatinine and Ca are measured three times a week (Monday, Wednesday and Friday).
- A full blood count is done once a week (Monday).

After two weeks

- Plasma Na, K, Cl, HCO_3 are measured three times a week (Monday, Wednesday, Friday).
- Plasma urea, creatinine and Ca are measured once a week (Monday).
- A full blood count is done once a week (Monday).
- Liver function tests, P, Mg and total protein and albumin are measured every two weeks (Monday).

8.16 Hyperammonaemia

The plasma ammonia should be measured if the infant becomes lethargic because of the slight risk of hyperammonaemia.

9 PN in Intensive Care and Oncology - Special Considerations

Enteral feeding is still the best form of nutritional support in those patients requiring intensive care, receiving chemotherapy or undergoing a bone marrow transplant. Absent bowel sounds alone do not contraindicate enteral feeding and the presence of gastric aspirate does not necessarily mean that enteral feeds are not being tolerated.

9.1 Access

PN may be delivered into one lumen of a multi-lumen CVC. This lumen should not be used for anything else. Blood should preferably be sampled from another site altogether but, if absolutely necessary, blood may be sampled from another lumen of this catheter. In this case, cease the PN infusion for 5 minutes before sampling.

9.2 Fluid requirements

Indirect calorimetry can be used to measure metabolic rate and respiratory quotient in sedated patients in order to guide energy requirements. Consult the PICU dietitian and intensivist for assistance with the calculation of energy and nutritional requirements.

In PICU patients, never try to make up for abnormal losses by modifying the PN solution. See the separate PICU policy on Water and Electrolytes for details of fluid and electrolyte requirements and management of electrolyte disorders. Because of frequent fluid restriction in PICU patients, it may be difficult to deliver adequate energy. A separate infusion of 50% glucose into a central venous line may be needed.

9.3 Administration of PN

- Start trace elements and vitamins on day 1 (i.e. don't wait 1-2 weeks, particularly with burns patients.)
- Lipid emulsion should be commenced on day 1 for Oncology patients
- Lipid emulsion should be infused for 24 hours per day.
- Consider reducing or ceasing lipid emulsion in septic/bacteraemic patients.

9.4 Monitoring

Triglycerides should be measured daily for at least one week - allow TG level up to 4 or even 5mmol/L. Plasma electrolytes are not affected by moderate hypertriglyceridaemia.

For burns patients, assess selenium weekly. Beware of cardiomyopathy caused by selenium deficiency.

9.5 Oncology patients

- All Oncology patients in the hospital will have PN ordered by the Oncology Registrar except those in PICU when the PICU registrar will order PN
- Standard PN is suitable for the majority of Oncology patients needing short-term PN. The most common additional requirement these patients will need is potassium, either enterally or as a side-line infusion with the PN.
- Individualised PN is usually required for patients undergoing a bone marrow transplant or other critically ill patients.
- Special consideration should be given to patients on a combination of antibiotics, antifungal medication and blood products.
- Fluid volume restrictions will apply for PN therefore may require a higher concentration of glucose and electrolytes in the PN order to ensure that adequate quantities are administered. Specific advice from the PN pharmacist is often required to avoid precipitation of the concentrated solution.

9.5.1 Potassium Requirements:

- Oncology patients frequently need large amounts of potassium. Oncology patients who have a high potassium requirement should have a separate potassium infusion.
- Where there are excessive losses of potassium, phosphate, magnesium and calcium close monitoring until stable is advised. Once the patient recovers, the deficit does not recover immediately, so supplements need to be continued for some time.

9.6 Sodium retention

Patients often receive a lot of sodium in their other fluids and antibiotics, so the sodium requirement in the PN may need to be minimal.

9.7 Lipid emulsions

The lipid emulsion infusion is normally continued even if the patient has abnormalities of liver function, or fever.

9.8 Special Oncology and PICU Formula (S-ONC)

S-Onc formula has been specifically developed to address the specific problems for patients of high energy expenditure, higher protein requirements. Eligible patients include: Fluid restricted patients, Oncology patients especially Bone Marrow Transplants, Burns, Sepsis, Major Surgery, the fluids is prescribed in the same way as Standard PN, but a separate PN Order Sheet is used.

Table XVI Special Oncology PN Solution (S-Onc) – Comparison

Formula per 1000 mL is:	S-Onc	Standard Formula
Synthamin	Protein 40 g = 500 mL Synthamin 13	Protein 30 g = 300 mL Synthamin 17
Glucose 50%	500 mL = 250 g (25% conc)	200 mL = 100 g (10% conc)
Sodium	50 mmol	30 mmol
Potassium	30 mmol	30 mmol
Magnesium	6 mmol	2 mmol
Calcium	6 mmol	9 mmol
Zinc	12 micromol	12 micromol
Phosphate	11 mmol	9 mmol
Chloride	84 mmol	52 mmol
Acetate	33 mmol	40 mmol
Non-nitrogen	3980 kJ	2240 kJ

The Potassium concentration is not increased in s-Onc above the standard formula, despite increased potassium needs of oncology patients, because of the risk to PICU patients. Any extra potassium requirement is given as a separate infusion (see 9.5.1 above).

10 Discontinuing Parenteral Nutrition and Transitional Feeding

10.1 Discontinuing PN

Generally, PN should be weaned gradually, particularly if high glucose concentrations are being used. Once feeds, enteral or oral, have been established and tolerated (see Transitional Feeding) halve the infusion rate for 24 hours then cease. It is important that close blood glucose monitoring continues during and 24 hours after cessation of PN. Lipid emulsion may be discontinued in the same manner.

If PN is ceased abruptly, there is a risk of rebound hypoglycaemia. This can be alleviated by commencing a 10% glucose solution. If signs of hypoglycaemia appear, a peripheral infusion of 10% glucose should be initiated and tapered slowly over the following 12-24 hours.

10.1.1 Guidelines for Tapering PN

The following guidelines are to be used for grading down prior to clamping for gate-passes and when cycling off for extended periods. Please not this is for the clear fluid only – lipids should be ordered for the hours PN is expected to run for.

- 1st hour → Reduce PN rate by 50%
- 2nd hour → Reduce PN rate by 50%

PN Weaning Calculator is available for use in PowerChart – details to be completed by medical staff and attached to the clinical record. For children on a Home PN regimen please contact the CNC Nutritional Support 6612 to advice on weaning used at home.

The blood glucose level should be checked via a glucometer prior to cessation or weaning of PN, this provides a baseline in order to identify any rebound hypoglycaemia. One (1) hour

after cessation another blood glucose level is checked – report any significant increase or decrease. Whilst weaning PN blood glucose levels should be checked 6th hourly – this continues for 24 hours after complete cessation.

10.1.2 CVAD Line Management

All CVAD lines require a heparin lock if disconnected for short or extended periods of time. (Refer to CVAD Practice Guideline)

On return to the ward set up new PN lines, using the fresh PN and lipid emulsion bags. Restart fluids at normal rate as ordered on PN order sheet.

10.2 Transitional Feeding

Patients must be assessed at regular intervals by a dietitian in order to evaluate their suitability to return to enteral intake. This should occur at the first available opportunity if appropriate, as enteral feeding is not only physiologically superior to parenteral nutrition but has been shown to reverse intestinal morphological and functional changes and cholestasis associated with parenteral nutrition. This in turn may lessen the incidence of sepsis associated with bacterial translocation across the gut wall.

Prior to termination of total parenteral nutrition, it should be demonstrated that the patient is capable of maintaining an adequate nutritional intake either orally or via a feeding tube.

The dietitian should be involved throughout, that is before, during and after PN has been commenced, particularly when transition to enteral/oral feeds to ensure nutritional adequacy.

10.2.1 Parenteral Nutrition and Enteral Feeding

- Enteral tube feeding should be considered and continued until the patient is meeting 50% of their energy requirements from these feeds. When this occurs PN can be decreased to half the volume.
- PN should not be ceased until at least 50-75% of requirements are provided via enteral feeds.

10.2.2 Parenteral Nutrition and Oral Food

It should be remembered that an infusion of PN may have physiologically and psychologically affected the child's ability to eat; therefore much encouragement may be needed.

- When oral intake is meeting 50% of total energy requirements halve the PN volume. PN should not be ceased until oral intake meets at least 50-75% of the patient's total energy requirements.
- Consider nutritional supplements or supplemental overnight enteral feeding if the patient is consuming less than 50% of nutritional requirement. PN predominantly at night in order to encourage appetite may be feasible if patient tolerance to higher infusion rates is established over a period of time.
- Discontinue PN when the patient is tolerating 50-75% of energy requirements from food.

Close monitoring of intake/output charts as well as weight is necessary during transitional feeding.

10.3 Cycling PN for Long Term Patients

Children who require long term PN can benefit from a cycled regimen. This allows them the freedom to attend school etc during the day. This mode of delivery means that when children receive PN they receive a large load of a solution with usually a high glucose content and osmolarity. The major complication of cycling PN is disturbance in blood glucose levels, in particular hyperglycaemia at the commencement of the infusion and hypoglycaemia at cessation. Infants, severely malnourished patients and patients with liver disease with minimal hepatic glucose stores are at greatest risk. It is recommended that a gradual weaning off from PN be done.

11 Refeeding

11.1 Refeeding Syndrome

Refeeding Syndrome is the term used to describe the adverse metabolic effects and clinical complications which may occur when a starved or seriously malnourished individual commences aggressive nutritional support.

11.1.1 At-risk Patients

Patients most at risk are those suffering from:

- anorexia nervosa
- recent weight loss > 10-20% body weight
- patients with body weight for height < 80%
- presence of oedema
- prolonged fasting, negligible intake for 7-10 days especially with evidence of stress/trauma
- prolonged IV hydration therapy e.g. Over 7-10 days

11.1.2 Adverse Consequences

Adverse metabolic effects that may occur with the delivery of parenteral or enteral nutrition in these patients include:

- Hypophosphataemia
- Hypokalaemia, hyponatraemia
- Hypomagnesaemia, hypocalcaemia
- Hyperglycaemia
- Refeeding oedema
- Vitamin B1 (thiamine) deficiency
- Pancreatitis
- Fluid retention

11.1.3 Clinical Complications

The clinical complications which may result from these metabolic disturbances are:

- Cardiac failure
- Myocardial infarction/arrhythmia
- Respiratory compromise
- Seizures
- Neurological disorders
- Pancreatitis

11.1.4 Monitoring

In view of the above, monitoring in refeeding syndrome is crucial and includes the following:

- Baseline weight, electrolytes (especially K, Na), P, Mg, Zn, albumin, glucose, lipase, amylase & fluid balance
- Repeating these 6-8 hours after refeeding may be necessary.
- Supplement as guided by blood results.
- Monitor these parameters daily and supplement until stable.
- Supplementation of thiamine and water-soluble vitamins may be necessary prior to commencing feeding.

Nutritional support should commence slowly with small increases in nutrition delivered. At least 7-10 days may be necessary to establish nutrition to full requirements.

12 Risk Management

12.1 Technical

Also refer to CVAD guidelines for more detailed information that is specific to CVC.

Complication/indication	Possible Causes	Action
Bag or Lipid emulsion leakage	• Not thoroughly checking prior to hanging • Accidental piercing	**CEASE INFUSION** • Do not patch • Replace with alternative fluid • Complete IIMS

12.2 Parenteral Solution

Complication / indication	Possible Causes	Action
Cloudy solution	• Precipitation • Mixed with medication	• Do not commence if solution cloudy • Stop infusion if in progress • Monitor vital signs if administered • Notify medical staff and pharmacy staff • Complete IIMS
Information on bag incorrect or wrong bag for patient	• Accidental mislabelling • Incorrect order • Breakdown in communication	• Cease infusion if PN is running – **do not disconnect** • Notify medical staff immediately • If fluid incorrect disconnect and change • Complete IIMS
Insufficient PN solution	• Accidental over-priming of line at commencement • Insufficient fluid in the prepared bag	• Consult medical staff on duty • Contact pharmacist (or on-call pharmacist via AH Nurse Manager) • Reduce the rate and monitor blood glucose levels • Administer alternative fluid e.g. 10% dextrose solution

12.3 Metabolic

Complication/indication	Possible Causes	Action
Cholestasis • Increasing conjugated bilirubin • Elevated GGT • Jaundiced	Unknown	• Avoid overfeeding • Usually resolves with discontinuation of PN • Consider using alternate lipid solution
Hypercalcaemia • Thirst • Polyuria • Muscle weakness • Loss of appetite • Nausea • Vomiting	• Neoplasia • Excessive vitamin D • Administration of calcium • Prolonged immobilisation • Stress	• Administer isotonic saline • Consider inorganic phosphate supplementation and use of corticosteroids and mithramycin • Skin soothing agents e.g. bath oil • Consult Endocrinologist

Complication/indication	Possible Causes	Action
• Constipation • Itching		
Hyperglycemia • BGL > 12 mmol/L	• Pancreativ insufficient • Steroid use • Rapid infusion of dextrose • Sepsis	• Discuss with medical staff • Administer insulin • Monitor BGL • Consider ongoing use of insulin
Hyperkalaemia • Biochemical changes • Cardiac arrhythmias	• Renal insufficiency • Excessive potassium administration	• Cease PN for a period • Reduce the potassium content of PN • Cardiac monitoring
Hyperlipidaemia • Increased triglyceride and/or cholesterol level	• Excessive lipid administration • Overfeeding carbohydrate	• Reduce lipid infusion or carbohydrate intake • Monitor blood triglyceride • Assess total caloric intake • Assess lipid requirements
Hypermagnesaemia • Sharp drop in blood pressure • Respiratory depression or paralysis	• Renal insufficiency • Excessive magnesium administration	• Remove or decrease magnesium in PN • May require mechanical ventilation • Correct fluid deficits • Consider use of IV calcium gluconate • Cardio-respiratory monitoring
Hypernatraemia • Biochemical changes	• Possible underlying disease • Excessive sodium intake • Excessive water loss	• Reduce salt intake • Review fluid replacement
Hyperphosphataemia • Paraesthesia of extremities • Flaccid paralysis • Listlessness • Mental confusion • Weakness • Hypertension • Cardiac arrhythmias	• Decreased renal excretion	• Discontinue the phosphorus in the PN • Cardio-respiratory monitoring • Consider calcium repletion
Hypocalcaemia • Paraesthesia • tetany	• Decreased vitamin D • Hypoparathyroidism • Reduced calcium intake • Increased GI losses • Decreased phosphate intake	• Calcium supplementation • Cardio-respiratory monitoring
Hypoglycaemia • BGL < 4 mmol/L • Feeling unwell • Drowsiness	• Rapid discontinuation of PN and not weaning	• Administer glucose • Monitor BGL
Hypokalaemia • Biochemical changes	• Inadequate potassium • Increase potassium loss	• May require IV potassium infusion • Increase potassium in PN

Complication/indication	Possible Causes	Action
• Cardiac arrhythmias	• Increasing needs	• Cardio-respiratory monitoring
Hyponatraemia • Biochemical changes	• Fluid overload • Excessive diuretic use • Adrenal insufficiency • Inappropriate ADH • Congestive heart failure	• Adjust fluid and sodium intake • monitor
Hypophosphataemia • Respiratory distress • Biochemical changes	• malnutrition • diabetes mellitus • antacid ingestion • increased phosphorus	• administer IV phosphate • additional phosphate to PN • monitor

12.4 Nutrition

Complication/indication	Possible Causes	Action
Essential Fatty Acid Deficiency Dermatitis • Alopecia • Altered neurological state • Altered pulmonary function	• Inadequate fat intake	• Review lipid
Fatty Liver • Moderate elevation of LFT	• Presumed to be infusion of carbohydrate in excess of hepatic oxidative capacity • Overload of calories and/or fat	• Reduce carbohydrate administration • Rule out other causes
Protein Overload • Elevated blood urea nitrogen • Excessive nitrogen excretion	• Continued infusion of protein in excess of requirement	• Reduce amino acid
Thiamine Deficiency • Elevated blood and urine lactate • Blood and urine pyruvate • Arrhythmias • Cardiomegaly • Dyspnoea	• Concentrated glucose infusion with inadequate thiamine intake	• Administer therapeutic dose of thiamine • Monitor

12.5 Fluid balance

Complication/indication	Possible Causes	Action
Dehydration • Decreased urine output • Biochemical changes	• Inadequate administration of fluid • Excessive fluid loss • Over-diuresis	• Increase fluid administration • Monitor fluid balance • Monitor vital signs
Over-Hydration • Biochemical changes • Fluid imbalance • Neurological changes • Peripheral/peri-orbital oedema	• Incorrect administration of fluid • Inability to clear fluid	• Reduce fluid administration • Consider diuretics • Monitor fluid balance • Consider dialysis in extreme cases • Monitor vital signs

Complication/indication	Possible Causes	Action
PN given too quickly • PN fluid level decreased faster than expected • Cardiac/pulmonary compromise • Biochemical changes	• Inappropriate administration of fluid • Possible breach of policy with regard to line management	• Notify medical staff immediately • Cardio-respiratory monitoring • Biochemistry monitoring • Fluid requirement assessed (refer to over-hydration above) • Complete IIMS

13 Home Parenteral Nutrition (HPN)

Patients eligible for HPN should be in a stable condition[1]. This includes stability of the underlying disease, fluid and electrolyte requirements and reliable central venous access[1]. All patients being considered for home PN should have a referral/consultation with the Gastroenterology team and the Clinical Nurse Consultant (CNC) Nutritional Support. HPN can be organised for patients in many settings i.e. metropolitan or rural and is fully funded (the initiating hospital is responsible for costs incurred for the PN solution for first 12 months at which point transfer to local AHS occurs and CHW for all consumable supplies)[18].

- The main indications for prolonged PN and thus HPN in children are primary digestive diseases causing intestinal failure such as there is no minimum age limit to be eligible for home PN – it is a clinically based decision:
  - short bowel syndrome
  - intractable diarrhoea of infancy
  - chronic intestinal pseudo-obstruction
  - inflammatory bowel diseases, especially Crohn's disease[1]
- Primary non-digestive indications such as:
  - immune deficiency including AIDS
  - tumours
  - metabolic diseases
  - end stage liver diseases before [11]

The need for HPN in these diseases is usually shorter than for primary digestive diseases.

The age for safely commencing PN at home depends on each individual condition[1]. Family and social criteria should be fulfilled before formally offering home PN these include:

- motivated family who are willing to undertake a 4-6 week education program
- the home environment is suitable to manage the child at home with PN – this includes capability to store and keep supplies safely, home good electrical sources as well as clean environment (a home visit will be necessary to fulfil this criteria which is undertaken by the CNC)
- an ability to complete competencies related to the home PN education (assessed by the CNC)

The main aspects and differences to home PN are:

- PN is given overnight to allow normal day-time socialisation e.g. attending school or work etc.
- a 3 in 1 solution with 1 administration set is used to deliver the PN
- line set-up does not require a filter or burette to be used
- pumps are set to deliver PN over 10-12 hours without setting an hourly amount
- weaning may be decreased to 2 or 3 hours to meet the needs of family life
- patients who can demonstrate competence in being able to administer their own PN will have the opportunity to be educated alongside their parents
- reduces the risk of line infection and contamination than if hospitalised[11]
- the education for each family is individualised, however the basic principles remain the same; the CNC is responsible for co-ordinating the education for all HPN patients in collaboration with ward staff

13.1 Reducing Line Infection – Prophylactic Ethanol Locks

The aim of introducing a routine 70% ethanol lock is to prevent ongoing catheter related infection (CRI) by disinfecting and clearing the CVC of biofilms[19-26], this protocol should be used as an adjunct to the routine locking solution and practices. Ethanol (70%) demonstrates bactericidal and fungicidal properties against a broad range of gram positive and negative bacteria and fungi and can be instilled daily for no longer than 14 hours as this has been reported in the paediatric population with successful reduction in line CRI [7,20]. The use of routine ethanol lock will be prescribed after discussion with the treating team and department of microbiology and is not a routine CVC management protocol. A 70% Ethanol lock should only be used in compatible CVCs (see Appendix 1), e.g. Hickman Catheter Dual lumen 7 Fr (Silicone) [21,22]. The use of ethanol locks will usually be undertaken in the home environment, therefore parents/carers may be asked to learn the procedure, and education will be carried out by the appropriately qualified staff. The decision to use the Ethanol lock will remain with the Infectious Disease and Gastroenterology teams.

It is important to recognize the potential risks of the use of 70% ethanol with CVCs and how to minimize them; those noted in the literature include:

Table XVII Minimising Potential Risks

Potential Risk	Minimising Risk
70% ethanol instilled into the venous system	Ensure minimal volume for dead space instilled Ensure ethanol aspirated from lumen prior to any flush, access or connection Use cap rather than valve to reduce the risk of accidental flush
Line degradation/mechanical integrity	Ensure the line is compatible with a 70% ethanol solution
Reaction with intravenous lipid solution	Ensure the lumen is adequately flushed with 0.9% sodium chloride before and after instillation of ethanol
Liver dysfunction due to recurrent instillation and flushing of 70% ethanol	Ensure ethanol is aspirated and discarded prior to CVC use.

13.2 Instilling the Ethanol Lock

Set up as normal with the addition onto the sterile field of:

- Extra 10 mL luer lock syringe
- Extra blunt end needle
- 5 mL ampoule 0.9% sodium chloride
- Syringe with pre-filled 70% ethanol (with 70% ethanol measured to fill dead space – no more than 1mL in 10mL syringe)

13.2.1 Additional procedure to CVC:

- Draw up 10mL of 0.9% sodium chloride
- Place syringes on separate sides of the sterile field (to reduce confusion)
- Swab CVC line hub vigorously with chlorhexidine swabs and allow to dry as for any CVC line change or closure
- Attach 10mL syringe and withdraw 1mL of fluid or until blood is withdrawn into syringe barrel – clamp line
- Remove and discard
- Attach 10mL luer lock syringe with 0.9% sodium chloride – pulsatile flush with 10mL as per CVAD guidelines
- Remove and attach syringe with ethanol – administer all of medication – clamp the line while flushing and place a red cap on line.

> The CVC now has an ethanol lock in place – note in clinical record or chart to ensure lock is not flushed when next accessed plus attach the "not for injection" sticker on the line with the lock. **Do Not Flush the Line before removing Ethanol Lock**

Prepare as for normal PN connection – plus add to the sterile field:

- 10mL luer lock syringe
- blunt end needle
- 10mL 0.9% sodium chloride

13.2.2 Removing the Ethanol Lock and proceeding to commence PN:

- As for PN – swabbing line before removing CVC cap
- Clean line to prepare for access.
- Attach 10mL syringe – unclamp, withdraw 1mL of fluid – clamp
- Remove 10mL syringe from line and discard
- Attach 10mL syringe with 10mL normal saline – unclamp, flush, clamp (pulsatile action)

> If progressing to heparinised lock – a pulsating action should be used with the flush of heparinised saline with a positive pressure lock (clamp with last flush).

- Continue with line set-up.

13.3 Which Lumen to Use?

Use one lumen for 7 days then swap to the other lumen for the next 7 days – this will mean one lumen is flushed with ethanol on day one for 12 hours then flushed with heparinised saline to be left in place for 7 days.

Special Note:

Where significant risk of contamination is likely, e.g. leaking ileostomy bag, diarrhoea etc., claves or split septum valves etc. should not to be used. These have the potential to become contaminated with infective material which can lodge in small crevices contained within these systems. It is recommended an IV cap which has no capacity for any access be used; caps with a bung should not be used in these lines.

13.4 Being Hospitalised when on Home PN

Children on home PN will intermittently require hospitalisation; therefore it is important to negotiate care with the parents and child. Many parents may continue to be responsible for commencing and ceasing the PN if the home PN solution is being used, unless otherwise agreed they will be encouraged to use Hospital equipment and supplies. Home PN will be prescribed on a specific Home PN order form which will be completed by the Gastroenterology team.

14 Drug Compatibility and Administration with PN

14.1 PN Solution Administration and Drug Compatibility

Under no circumstances are medications to be added to the PN solution.

Drug-parenteral nutrition compatibility information is variable; due partly to the huge variability in composition of PN solutions, and the range and concentration of drugs which may be administered simultaneously. The compatibility information also changes over time as newer evidence becomes available.

Drug compatibility information, please consult:

- the current Trissel's Handbook on Injectable Drugs 11 or
- contact the PN Pharmacist on ext: 52708 for specific compatibility information or follow the link http://www.ciap.health.nsw.gov.au/

15 Key Performance Indicators

Identified KPI's include:

1. Incidents documented on Safety Management Data Base (IIMS)
2. CVC line infections – Home PN patients

16 Parenteral Nutrition (TPN or PN) – Patient/Carer Handout

Good nutrition can help patients cope with their illness. Many patients can eat and digest food normally. This is ideal!

Some may need to have the food given by a tube into the stomach or small bowel. This can be by a nasogastric tube, gastrostomy or gastrojejunal tube. This is called enteral feeding. There is a separate fact sheet on enteral feeding. A few patients won't be able to digest food when it is given by tube into the stomach. When this is the case, we can give basic nutrients directly in to the blood stream. This is called Parenteral Nutrition (PN) and is made up of the following products:

Clear Fluid Solution - this is sensitive to light and will be covered and includes the following:

- Protein & amino acids (clear fluid) - Synthamin 17 is usually used for children over 3 months of age and Primene is usually used on children 3 months or younger.
- Glucose (sugar)
- Electrolytes, vitamins & minerals

White Solution

- Fat is given intravenously; it is the white solution in the bottle lipid emulsion and is oil mixed with water.

How are the solutions given?

Parenteral Nutrition (PN) is given intravenously, usually through a central line (CVC).

We have special guidelines and policies, which have been, developed to ensure PN is given safely. The following information will give you some idea of what you can expect.

1. When anyone is handling PN they must use an aseptic non-touch technique in order to reduce the risk of infection. Handwashing remains the most important part of asepsis.
2. 2 nurses must first check the PN solution. They will check the bag has no leaks or holes, is in date and also check to ensure the solution is clear and has no pieces floating in it. The nurses will also check to make sure what the doctor has ordered is what has been given.
3. All PN solution bags are changed at least every 24 hours. This includes the lipid solutions in the bottles.
4. The lines and special filters delivering the solutions will be changed. The alternatives are:
    - Clear fluid lines and filters are changed (if being given over 24 hours) every 72 hours.
    - Clear fluid lines and filters (if being given for less than 24 hours) will be changed daily
    - Lipid lines and filters will be changed daily

What to expect:

Regular blood tests will be taken and other observations will continue whilst on the PN. This will include temperature, daily weight & urinalysis as well as checking the site of the central line, port or cannula. You can point out any changes you think are important too.

If the PN infusion is to be run for less than 24 hours per day the solution will be given at a higher rate it is then reduced to a lower rate for the last 2 hours before it is stopped. We reduce the rate to make sure that the high concentration of sugar, which will be given, won't drop too quickly and cause you/your child to feel unwell. We will also check the blood sugar level once we have stopped the PN solution.

Every time any part of the line delivering the PN is broken, for example if blood is taken or lines changed, the staff will make sure they use an aseptic technique to prevent the risk of infection.

We have provided the following for you to complete if you wish:

Date PN Started: ---/---/--- Date PN Stopped: ---/---/---

Rate of Current PN Infusion:

Clear Fluid: _____ mL per hour

Lipid Emulsion: _____ mL per hour

Type of Venous Device (tick ☑ appropriate box):

- ☐ Central Venous Catheter
- ☐ IVAD (port)
- ☐ PICC Line
- ☐ Peripheral Cannula
- ☐ Long Line

Any Questions (write down any questions you want to discuss with your doctor):

_____

_____

If you have any questions regarding the PN solution you or child is receiving please ask your Doctor. There is also a Clinical Nurse Consultant available to answer any queries you may have (ask the staff to contact the CNC for Nutritional Support on page number 6612).

17 Appendix I

17.1 Catheter Compatibility Table

Catheter	Polymer	Compatible with ≥70% Ethanol?
AngioDynamics & Horizon Medical Products		
Dialysis Even More Flow catheter kit	Carbothane	No
DuraFlow dialysis kit	Carbothane	No
DuraFlow straight basic 24 cm hemodialysis kit	Carbothane	No
Port Smart CT 9.6 Fr outer diameter detached silicone catheter	Silicone	No
Triple lumen apheresis CV-332	Polyurethane	No
Arrow International		
9 Fr Central venous access kit two lumen used w/7.5-8 Fr	Polyurethane	No
Central venous catheter SGL 7 Fr 16cm PU SS-14701	Polyurethane	No
Double lumen 7 Fr CVP catheter	Polyurethane	No
Tray – Central venous 18g catheter single lumen over 20g intro scalpel 18g extra thin 4.8 Fr 80cm	Polyurethane	No
Triple lumen 7 Fr 20cm catheter AK-15703-CDC	Polyurethane	No
Triple lumen catheter kit 5.5 Fr 13cm	Polyurethane	No
Triple lumen catheter 7 Fr 30cm (LX)	Polyurethane	No
Triple lumen central venous catheter 7 Fr X 18g	Polyurethane	No
Triple lumen pedi catheter 5.5 Fr 8cm	Polyurethane	No
Bard		
Abramson triple lumen 15mm diameter 15in length drain sump, latex free w/filter	Polyurethane	No
Bard dual lumen port 9.5 Fr	Silicone	Yes
Broviac 6.6 Fr single lumen ingrowth cuff w/ peel stylet	Silicone	Yes

17.2 CVC Dead Space

Single Lumen	Total Length	Volume
2.7 Fr Broviac	71 cm	0.15 mL
4.2 Fr Broviac	71 cm	0.3 mL
6.6 Fr Broviac	90 cm	0.7 mL
6.6 Fr Broviac – Short	90 cm	0.7 mL
9.6 Fr Hickman	90 cm	0.8 mL
Double Lumen	**Total Length**	**Volume**
7 Fr Hickman	65	0.8 mL – Red
		0.6 mL - White
9 Fr Hickman Pediatric	66	1.3 mL – Red
		0.6 mL – White
9 Fr Hickman	90	1.3 mL – Red
		0.6 mL – White
10 Fr Hickman	90	1.3 mL – Red
		1.3 mL - White
12 Fr Hickman	90	1.8 mL – Red
		1.8 mL -White
Triple Lumen	**Total Length**	**Volume**
10 Fr Hickman	97	1.4 mL – Red
		0.8 mL – White
		0.8 mL – Blue
12 Fr Hickman	90	1.6 mL – Red
		0.7 mL – White
		0.7 mL - Blue

Adapted from Bard Access Systems Hickman® Catheters

18 References

1. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R, Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Journal of Pediatric Gastroenterology and Nutrition, Supplement 2, November 2005, S19-S27.
2. National Advisory Group for standards and practice guidelines for parenteral nutrition: Safe Practices for Parenteral Nutrition Formulations. Journal Parenteral and Enteral Nutrition, 1998, Vol 22, No 2, pp: 49-66
3. Kilham H, Isaacs D, (Editors) The Children's Hospital at Westmead Handbook, 2009 - Section 7 – Fluid and Electrolyte Therapy - http://proxy58.use.hcn.com.au/index.php/chapter-7/section-1 or via CIAP
4. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R, Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Journal of Pediatric Gastroenterology and Nutrition, Supplement 2, November 2005, S70-S75.
5. Nutrient Reference Values for Australia and New Zealand – Department of Aging, Health and Disability – endorsed by NHMRC – September 2006 (http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/n35.pdf , accessed Dec 2012)
6. Ukleja A, Romano M, Complications of Parenteral Nutrition, Gastroenterology Clinics of North America, No 36, 2007, 23-46
7. Agency for Clinical Innovation (ACI), Parenteral Nutrition Pocketbook, page 52, 2010
8. Pittiruti M, Hamilton H, Biffi R, Macfie J, Pertkiewicz M, ESPEC Guidelines on Parenteral Nutrition: Central Venous Catheters (access, care, diagnosis and therapy of complications), Clinical Nutrition, Volume 28, pp 365-377, March 2009
9. Castello F, Maher A, Cable G, Reducing Bloodstream Infections in Pediatric Rehabilitation Patients Receiving Parenteral Nutrition, Pediatrics, Vol 128, No 5, pp 1273-1278, November 2011.
10. Nutritional Support Services, Westmead Hospital, Parenteral Nutrition Guide, unpublished – 2011.
11. Infusion Nurses Society (USA), Supplement – Standard 20 Hand Hygiene, Journal of Infusion Nursing, Vol 34(1S), January/February 2011, S26.
12. Infusion Nurses Society (USA), Supplement – Standard 69 Parenteral Nutrition, Journal of Infusion Nursing, Vol 34 (1S), February 2011, S65
13. Gillies D, O'Riordan, Wallen M, Rankin K, Morrison A, Nagy S, Optimal Timing of intravenous administration set changes: a systematic review, The Cochrane Collaboration, 2008 (http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD003588.pub2/pdf , accessed Dec 2012)
14. O'Grady N, Alexander M, Burns L, Dellinger P, Gardland J, Heard S, Lipsett P, Masur H, Mermel L, Pearson M, Raad I, Randolph A, Rupp M, Saint S. Guidelines for the Prevention of Intravascular Catheter-Related Infections, Center for Disease Control (CDC), pp 53, 2011
15. Infusion Nurses Society (USA), Supplement – Standard 48 Administration Set Change, Journal of Infusion Nursing, Vol 34(1S), February 2011, S55-S56.
16. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R, Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Journal of Pediatric Gastroenterology and Nutrition, Supplement 2, November 2005, S1-S87
17. Infusion Nurses Society (USA), Supplement – Standard 69 Parenteral Nutrition, Journal of Infusion Nursing, Vol 34 (1S), February 2011, S84.
18. NSW Health, Drugs - Funding Arrangements for Outpatient Use of High Cost Drugs Not Funded by the Commonwealth (PD2005_395)
19. Crnich C, Halfmann J, Crone W, Maki D, The Effects of Prolonged Ethanol Exposure on the Mechanical Properties of Polyurethane and Silicone Catheters Used for Intravascular Access, Infection Control and Hospital Epidemiology, Vol 26, No 8, pp 708-714, August 2005
20. Maiefski M, Rupp M, Hermsen E, Ethanol Lock Technique: Review of the Literature, Infection Control and Hospital Epidemiology, Vol 30, No 11, pp 1096-1108, November 2009.
21. Nebraska Medical Center, Ethanol Lock Technique for Prevention and Treatment of Central line-Associated Bloodstream Infections (CLA_BSIs), 2009 – downloaded from: http://www.nebraskamed.com/App_Files/pdf/careers/education/asp/TNMC_EtOHLock_final.pdf Dec 2012
22. Mouw E, Chessman K, Lesher A, Tagge E, Use of an ethanol lock to prevent catheter-related infections in children with short bowel syndrome, Journal of Pediatric Surgery, Vol 43 pp 1025-1029, 2008
23. Niel-Weise B, Stijnen T, Broek P, Anti-infective treated central venous catheters for total parenteral nutrition or chemotherapy: a systematic review, Journal of Hospital Infection, Vol 69, pp 114-123, 2008

24. Onland W, Shin C, Fustar S, Rushing T, Wong W, Ethanol-Lock Technique for Persistent Bacteremia of Long-term Intravascular Devices in Pediatric Patients, Archives of Pediatric and Adolescent Medicine, Vol 160 October, p 1049-1053, 2006
25. Opilla M, Kirby D, Edmond M, Use of Ethanol Lock Therapy to Reduce the Incidence of Catheter-Related Bloodstream Infections in Home Parenteral Nutrition Patients, Journal of Parenteral and Enteral Nutrition, 31:4, July/Aug, pp 302-305, 2007
26. Olivereira C, Nasr R, Brindle M, Wales P, Ethanol Locks to Prevent Bloodstream Infections in Parenteral Nutrition: A Meta-Analysis, Paediatrics, Vol 29, No 2, pp 318-329, February 2012.

19 Bibliography

1. Australian Injectable Drugs Handbook, 1st Edition 1997, SHPA.
2. Cober M, Kilu G, Battrain A, Welch K, Kunisaki S, Teitelbaum D, Intravenous Fat Emulsions Reduction for Patients with Parenteral Nutrition – Associated Liver Disease, The Journal of Paediatrics, 2012, March, 160:3, pp 421- 427.
3. Gillies D, O'Riordan, Wallen M, Rankin K, Morrison A, Nagy S, Timing of intravenous administration set changes: a systematic review, Infection Control & Hospital Epidemiology, 2004:25(3): 240-250
4. Trissel L.A., Handbook on Injectable Drugs, 13th Edition 2005, American Society of Hospital Pharmacists.
5. Williams K., Drugs in Parenteral Nutrition, Transactions of the Australian Society for Parenteral and Enteral Nutrition 1991; 3: 11-28.
6. Gerlach A, Thomas S, Murphy C, Stanislaw P, Stawicki P, Whitmill M, Pourzanjani L, Steinberg S, Cook C, Does Delaying Early Intravenous Fat Emulsion during Parenteral Nutrition Reduce Infections during Critical Illness; Surgical Infections, Vol 12, No 1, 2011, 43-47
7. Sequeira J, Smiley D, Newton C, Le N, Gosmanov A, Spiegelman R, Peng L, Osteen S, Jones D, Quyyumi A, Ziegler T, Umpierez G, Subsititution of Standard Soybean Oil with Olive Oil-Based Lipid Emulsion in Parenteral Nutrition: Comparison of Vascular, Metabolic and Inflammatory Effects, Journal of Clinical Endocrinal Metabolism, October 2011, 96(10), 3207-3216
8. Goulet O, Antebi H, Wolf C, Talbotec C, Alcindo L, Corriol O, Lamor, ColombJung V, A New Intravenous Fat Emulsion Containing Soybean Oil, Medium-Chain Triglycerides, Olive Oil, and Fish Oil: A single-Center, Double-Blind Randomized Study on Efficacy and Safety in Pediatric Patients Receiving Home Parenteral Nutrition, Journal of Parenteral and Enteral Nutrition Vol 34 No 5, September 2005, 485-495