

## LRI Children's Hospital

Parenteral Nutrition in Term neonates, children and adolescents  
(excludes patients on NNU) (Part 3 of 4)

### Supporting Information

Staff relevant to:	Health Professionals who administer PN to Children and Young People at UHL and applies to children and young people cared for in the Children's Hospital
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## **1. Introduction and who Guideline applies to**

Parenteral nutrition (PN) is nutrition that is delivered to the circulation without using the gut. It is complex and expensive. A multidisciplinary approach to the management of these patients is needed to optimise therapy and reduce complications. Close liaison between the patient's clinical team and the ward Dietitian or Paediatric Gastroenterologist on service is vital to achieve optimum care.

This guideline applies to all Health Professionals who administer PN to Infants, Children and Young People cared for in UHL Childrens Hospital, including those aged 16-25 on Ward 27 (Teenage, Young Adult Cancer Unit) or in EMCHC. Young adults aged 16-18 years who are being cared for on all other UHL wards requiring PN should be referred to the Leicester Intestinal Failure team (LIFT)

### **Related documents:**

For administration of PN in:

- **Adults - Parenteral Nutrition via a Central Venous Catheter UHL Policy B22/2015**
- **Neonates - Parenteral Nutrition UHL Neonatal Guideline C28/2018**

This guideline is in 4 sections:

- 1) **UHL [Parenteral Nutrition - Initiation UHL Childrens Hospital Guideline C42/2018](#)**
  - a. Indication                                      Will TPN be beneficial?
  - b. Vascular Access                                Is a central line present or planned?
  - c. Nutritional requirements                    Is there enough volume available?
- 2) **UHL [Parenteral Nutrition - Monitoring and Weaning UHL Childrens Hospital Guideline C43/2018](#)**
  - a. Monitoring                                      Are these assessments feasible?
  - b. Troubleshooting                                What can go wrong?

### 3) This document **Parenteral Nutrition – Supporting Information UHL Childrens Hospital Guideline C44/2018**

Appendices of forms and basis for advice

### 4) **UHL Parenteral Nutrition – Administration by Nurses UHL Childrens Hospital Guideline C45/2018**

#### **Nutritional Components for Paediatric PN**

There are 8 main nutritional areas for consideration: Fluid, energy, protein, carbohydrate, lipid, electrolytes, vitamins and trace elements - refer to the tables at the end of this section for details on the weight based standard regimens.

#### **Fluid**

Check for **pre-existing conditions** that may require fluid restriction such as renal, heart or liver failure. Disturbances of haemodynamic status, electrolytes and acid-base balance should be stabilised and corrected **BEFORE** parenteral nutrition is commenced. (N.b. Information on refeeding syndrome can be found in section 5). Parenteral nutrition is introduced gradually over a period of 3 to 4 days depending on the size, age and maturity of the patient.

Below is the general guide for fluid requirements according to the weight of the child:

<b>weight (kg)</b>	<b>&lt;2</b>	<b>2.1-3</b>	<b>3.1 - 5</b>	<b>5.1 - 10</b>	<b>10.1- 15</b>	<b>15.1- 20</b>	<b>20.1- 30</b>	<b>30.1- 40</b>	<b>40.1- 50</b>
<b>Fluid ml/kg/day</b>	Up to 150	120 - 150	120	100	100-80	80-70	75-60	60-45	45-40

Fluid requirements vary with the age and weight of the child and should be adjusted according to the regimens. Alterations in fluid volume from the advised regimens need to be discussed with the Paediatric/ Neonatal Pharmacist.

#### **Energy**

Energy is required for metabolic function and growth. It is derived from both protein and non- protein sources. Energy requirements change with different underlying disease and nutritional status.

Estimation of caloric requirement can be difficult and is best obtained from a dietitian.

#### **Amino acids**

Amino acids (AA) as nitrogen are required to form proteins. A supply of AA is required to maintain nitrogen balance and growth.

**1g of Nitrogen is equivalent to 6.25g of Protein**                      **7.02g amino acid gives 1g Nitrogen**

The selection of different brands of amino acids depends on the age/weight of the patient.

	<b>Solutions</b>
Neonates and Infants (up to 10kg)	Vaminolact Aminoven Infant
Paediatric (>10kg)	Vamin 18EF Aminoven 25

Other amino acid mixtures are available and may be useful in certain conditions e.g. Aminoven 25

AGE OF CHILD	PROTEIN REQUIREMENTS g/kg/day
Low birth weight	3-4
Full term	2-3
Up to 1 year	1.5-2.5
1-10 years	1-2
Adolescent boys	0.9
Adolescence girls	0.8
Critically ill child/adolescent	1.5

- The nitrogen (amino acid) requirement is generally increased over a 2-3 day period.
- If urea levels are high, the protein may need to be restricted. If the patient has renal impairment the fluid volume may need to be adjusted. Contact the Pharmacists for both these situations.
- If the protein is reduced by 1g/kg/day then the PN fat and glucose content should also be reduced in order to maintain the nitrogen: non nitrogen energy ratio at the value of 1: 180 to 200 – see Appendix 4

#### **Very fluid restricted, metabolic or renal patients**

Vamin 18 (electrolyte free) (V18EF) is available. If the urea is very high the protein should be restricted. Both fat and protein should be restricted to ensure the nitrogen (g): non nitrogen energy (kcal) ratio is 1:200. In patients with renal problems the fluid may also need to be altered.

The administration of protein in a range higher than 4g/kg/day may result in abnormal amino acid profiles. When protein at 6g/kg/day is given to low birth weight neonates, untoward effects such as azotemia, pyrexia, a higher rate of strabismus, and lower IQ have been reported

#### **Glutamine (Dipeptiven)**

- Use in PN should be discussed with a member of the nutrition team and the patient's Consultant if it is anticipated that a patient will be on PN for over a month. Also patients with short bowel should be considered for PN with dipeptiven from day 1 of PN
- The dose is 400mg/kg/day of glutamine included in the protein g/kg/day requirement. Do not add dipeptiven to PN if patient has severe liver failure, severe kidney failure or metabolic acidosis.
- Glutamine can behave as an essential amino acid in clinical settings where there is marked metabolic stress, such as occurs after short bowel surgery.
- The amino acid is a key substrate involved in many metabolic processes including inter-organ nitrogen transfer, protein synthesis, gluconeogenesis, acid-base homeostasis and nucleic acid biosynthesis.
- Glutamine is also a substrate for glutathione synthesis, thereby playing a role as an antioxidant and scavenger, and is the major fuel of intestinal mucosal cells and immune cells, including those located in the gut associated lymphoid tissue.
- Depletion of glutamine stores might lead to severe complications, such as infection, poor wound healing, impaired immunity, increased intestinal permeability, and finally multiple organ failure.
- Glutamine hence has an important role to play in PN. In a current double blind randomised study, glutamine supplement in PN improved survival, indicating that early use

## Carbohydrates

Carbohydrate (as glucose) is the main source of energy, and provides around 40- 60% of the energy supply.

This is provided in the form of glucose which is available as solutions of varying concentrations.

- 5% glucose 200 kcal per litre
- 10% glucose 400 kcal per litre
- 20% glucose 800 kcal per litre via **central IV cannula or long line**
- 50% glucose 2000 kcal per litre via **central IV cannula or long line**

AGE	TOTAL DAILY ENERGY REQUIREMENTS kcal/kg
Extremely low birth weight <1kg	105-115
Very low birth weight <1.5kg	90-110
Stable near term neonate	100-120
0-1 year	90-100
1-3 year	95
4-6 year	85
7-10 year	66
11-14 year	47
15-18 year	41

- Ill children (with disease, surgery, fever or pain) may require additional energy above the maintenance value, and comatose children may require less energy (because of lack of movement).
- Energy in a child is required for both maintenance of body metabolism as well as for growth. Energy requirements vary with age, because of the great variability of energy needs.
- Carbohydrate should compromise 40% to 50% of the caloric intake in infants and children. Small amounts should be used in infants who are otherwise receiving nutrition support to suppress protein metabolism.
- Blood glucose monitoring should be carried out, but tolerance should not be a problem if the regimen is introduced slowly as directed
- If glucose is not tolerated in the standard amount in the regimens then the protein content of PN should be amended accordingly.
- If the blood glucose continues to increase the amount of glucose in the PN can be reduced to the last tolerable glucose quantity.

PN glucose delivery should not exceed the maximum rate of glucose oxidation as this can cause complications such as hyperglycaemia and liver steatosis.

Maximal infusion rates of carbohydrate:

Neonates – 2 years	13mg/kg/min
Children	7mg/kg/min
Critically unwell children	5mg/kg/min
Children on cyclical PN	20mg/kg/min

Usually one aims to ensure total non-nitrogen energy to nitrogen ratio is about 1: 200 for all patients

## Lipids

Lipids are essential components of cell membranes and steroids. Lipid requirements depend on the gestational age.

Age	Solutions
Neonates under 14 days of TPN	Intralipid 20% (soya base)
Neonates over (or anticipated) over 14 days of TPN Children (except some metabolic patients)	SMOF lipid (fish oil base)

- Intralipid is a fat emulsion prepared from fractionated soyabean oil and egg phospholipids available as a 20% solution (2.0 Kcal/ml)
- It is high in essential fatty acids and has a low osmolality.

Maximal infusion rate of lipid:

Neonates and Infants	0.17g/kg/hour
Children	0.13g/kg/hour

- Always infuse lipid at the rate stated on the syringe or bag label. The exception is when the PN is being weaned
- Plasma triglycerides must be checked daily initially to assess for efficient lipid intake – refer to monitoring table for more detail.
- The amount of fat that was last tolerated can be estimated by looking at trends in triglyceride levels and the amount of fat in the PN bag.
- If fat is not tolerated in standard regimens amounts then they should be reduced.
  - If this occurs then the protein content of PN should be amended accordingly to maintain the non-nitrogen energy to nitrogen energy ratio is about 1:200.
  - Fat is reduced usually by 1g/kg/day if it has to be reduced.
  - Triglyceride levels <3mmol/litre is acceptable for patients weighing less than 9.9kg.
  - Triglyceride levels < 4mmol/litre is acceptable for patients weighing more than 9.9kg.
  - Do not assume all raised liver enzymes are due to the fat content in the PN. There are other causes which need to be ruled out. Please refer to the consultant; the patient can also be referred to the PN team

## Electrolytes

Particularly with infants, it is important to accurately evaluate the fluid, electrolyte and carbohydrate load provided by any other infusion therapy (including medicines and enteral feeds) and abnormal fluid and electrolyte losses such as high GI losses that may increase requirements.

### Common requirements by weight

Weight (kg)	<2	2.1 - 3	3.1 - 5	5.1 - 10	10.1- 15	15.1- 20	20.1- 30	30.1- 40	40.1- 50
Sodium mmol/kg/day	5 [3 to 6]	3 to 4	3	3	3	3	3	2 to 3	2 to 3
Potassium mmol/kg/day	2.5	2.5	2.5	2.5	2.5	2	2	1 to 2	1 to 1.5
Calcium mmol/kg/day	1.5	1	1	0.6	0.2	0.2	0.2	0.2	0.2
Magnesium mmol/kg/day	0.2 to 0.3	0.2	0.2	0.2	0.2	0.15	0.15	0.15	0.15
Phosphate mmol/kg/day	1.5	1.5	1	0.8	0.4	0.4	0.4	0.4	0.4
Acetate mmol/kg/day	2				Up to 6mmol/kg/day based on requirement				

Calcium and phosphorus requirements should be considered together.

### Common requirements by age

Age	0- 3mths	4- 6mths	7- 9mths	10- 12mths	1-3 years	4-6 years	7-10 years	11- 14 years	15- 18 years
Sodium mmol/day	1.9	1.7	1.7	1.7	1.9	1.6	15-50 total	20- 70 total	25- 70 total
Potassium mmol/day	4.2	3.1	2.2	2.0	1.7	1.5	24-50 total	40- 80 total	50- 90 total
Calcium Mmol/day	13	13	13	13	8.8	11	14	25	25
Magnesium mmol/day	1.7	2.1	2.5	2.5	2.7	3.7	6.7	9.5	10.3
Phosphate mmol/day	13	13	13	13	8.8	11	14	25	25
Acetate mmol/day	No recognised requirement								

### Guide for common electrolyte losses:

Secretion	Sodium mmol/l	Potassium mmol/l	Bicarbonate mmol/l
Gastric	50	15	0-15
Pancreatic	130	5	110
Bile	143	5	38
Ileal output	140	11	Variable
Diarrhoea	30-140	30-70	20-80

## Trends for changing electrolytes

It is important to monitor trends and therefore results from several days need to be available. Changes should be made cautiously.

Water and electrolyte requirements should be adjusted in paediatric patients undergoing surgical procedures or who have on going losses from stomas or other sites. They must be checked daily if the child is unstable.

Particular care must be taken in assessing electrolytes needs of the patient as dilutional fluids may contain electrolytes (e.g. 0.9% sodium chloride).

These need to be corrected prior to starting PN. If PN has been started, sometimes you might have to stop PN whilst correcting the electrolytes.

## Sodium

- Major extracellular cation and modulates the maintenance of these compartments Increase or decrease in steps of 1 or 2mmols/kg/day.
- Added in the form of sodium chloride and requests should be made for the total amount required in mmol/kg/day. Deduct any already provided by the other solutions
- Consider losses due to vomiting, diarrhoea, fistulas, gastric suctioning, excessive sweating, and in cystic fibrosis patients.
- Renal losses may be due to osmotic diuresis and nephritis. Consider hypernatraemia due to large sources of sodium such as antibiotics.
- Consider sodium from other sources e.g. antibiotics, diluent, flushes

## Potassium

- Major intracellular cation and its concentration depends on the activity of Na/K-ATPase
- Increase or decrease in steps of 0.5 or 1 mmol/kg/day, unless the potassium is very high in this case no potassium is added until the cause of the high potassium has been investigated.
- Added in the form of potassium chloride and requests should be made for the total amount required in mmol/kg/day. Deduct any already provided by the other solutions
- Potassium is reliant upon adequate magnesium – additional magnesium may be required to maintain suitable levels.
- Consider stoma losses and losses from vomiting and diarrhoea.
- Consider drugs which may cause hypokalaemia such as diuretics, corticosteroids, insulin, cisplatin, gentamicin etc.
- Consider drugs which may cause hyperkalaemia such as potassium infusions, oral potassium or ACEI (angiotensin converting enzyme inhibitor).

## Calcium

- Changes should be made initially in steps of 0.1mmol/kg/day to 0.2mmol /kg/day, either reduce or increase in these amounts.
- Added as calcium chloride injection as shown in the prescription chart tables
- Requirements may be affected by increased losses due to pancreatic insufficiency, reduced secretion of parathormone, use of diuretics, and use of citrate in stored blood which can bind calcium and may be clinically significant if patient requires massive blood replacement.

## Phosphate

- Consider small increments of 0.1mmol/kg/day to 0.2mmol/kg/day – larger changes with care
- Added as Potassium/ Sodium Acid Phosphate as shown in the prescription chart tables. Calcium and phosphate are often required in quantities higher than that present in the



standard regimen. This can cause great problems because of precipitation and therefore any special requirement should be discussed with the Pharmacist.

- Adjustments takes 2-3 days to stabilise
- If patients have been underfed for sometime and have insufficient phosphate is supplied with PN “refeeding syndrome” may drop the levels as phosphate shifts into the cells. Refer to the Troubleshooting section for more information.

### Magnesium

- Changes should be made initially in steps of 0.1 mmol/kg/day to 0.2 mmol/kg/day
- Added as magnesium sulfate

### Chloride

- Major extracellular anion found in plasma, lymph, connective tissue, cartilage and bones
- If persistent acidosis is a problem, the chloride load of the PN (which may worsen any acidosis) can be reduced by using the acetate and glycerophosphate salts of sodium and potassium – Discuss with a Neonatal/ Paediatric Pharmacist.

### Vitamins

- Fat soluble vitamins (A, D, E, K)
- Water soluble vitamins (B and C).

It is difficult and expensive to provide individual vitamins according to requirements. Pre-mixed fat soluble (Vitlipid) and water soluble (Solivito N) vitamins are used and are dosed according to weight.

Weight (kg)	<2	2.1-3	3.1-5	5.1-10	10.1-15	15.1-20	20.1-30	30.1-40	40.1-50	
Solivito N	1ml/kg (max 10ml)				10ml total					
Vitlipid (infant/adult)	Infant 4ml/kg		Infant 10ml total					> 11yrs &>30kg Use adult		

- The recommended doses for intravenous vitamin often exceed oral vitamin due to interaction with tubing, photo degradation and increased renal losses.

### WATER SOLUBLE VITAMINS

- Given as SOLIVITO N in the dose recommended; one tenth of a vial per kg/day up to a maximum of one vial a day, added to the lipid to meet basal requirements of water soluble vitamins.
- If fat is not prescribed then the Solivito N will be added to the amino acid / glucose solution which must then be protected from light degradation

### FAT SOLUBLE VITAMINS

- Given as Vitlipid N infant in the recommended dose of 10ml daily for children over 2.5Kg. For those patients weighing less than 2.5kg the dose is 4ml/kg. Vitlipid N adult will be used if the child is over 11 years old. The dose is one ampoule daily

## Trace elements

Trace elements have diverse roles but are mainly involved in enzymatic and immunological reactions. The major trace elements are: chromium, copper, iodine, manganese, iodine, selenium and zinc.

It is difficult and expensive to provide individual trace element according to requirements. A pre-mixed trace elements (Peditrace/Additrace) is used and is dosed according to weight.

Below is a guide to the provision of trace elements:

Weight (kg)	<2	2.1-3	3.1-5	5.1-10	10.1-15	15.1-20	20.1-30	30.1-40	40.1-50
Trace elements	Peditrace 1ml/kg (max 15ml)					Peditrace 15ml total			Additrace 10ml total

- PEDITRACE will be the mineral supplement for all patients weighing less than 40Kg. It contains trace elements in addition to those found in the amino acid solution.
  - The dose is 1ml/Kg to a maximum of 15ml
  - However it does not contain a source of Fe, Mb or Cr for those patients on long term PN, usually over four weeks of PN or home PN patients. In these patients one should monitor the above mentioned parameters very closely.
- ADDITRACE will be the mineral supplement for all patients over 40Kg

### **3. Education and Training**

Any staff (including agency staff) who have not undertaken specific medication administration training and competence assessment, must receive local training before being involved in the administration of central line medication to patients under 16 years of age. (LMC 5<sup>th</sup> edition)

Medical Staff Introduction of the ordering and review of PN at induction; Specialist training regarding use and content within day to day ward teaching

Nursing Staff All staff who undertake administration of PN must:

- a) Have been assessed as competent to administer medications to children via a central venous access device. This is achieved by attending a children's IV study day and completing the 'Administration of Central Intravenous Medications to Infants and Children' competency assessment.
- b) Have attended a Children's Central Line/PN theory study day or equivalent local training and completed the 'Administering Parenteral Nutrition to Infants and Children' competency assessment
- c) Competency for blood sampling from a central line can be achieved by attending Children's Central Line/PN theory study day or equivalent local training and completing 'blood sampling via central venous access device' competency assessment

Staff who are new to the Trust who have been trained and assessed elsewhere:

- a) Provide evidence accepted by their Line Manager of the training and assessment of competence. If the member of staff is unable to provide suitable evidence they may be required to undertake UHL training. This must be discussed with the Line Manager and Children's Education Team
- b) Staff member must read relevant Trust policies and undertake additional local training relating to equipment and documentation as required
- c) Undertake a one off LCAT assessment of competency within own ward/department

Pharmacy Staff - Successful completion of Assessment of Competency in ordering Neonatal and Paediatric PN

#### **4. Monitoring Compliance**

<b>What will be measured to monitor compliance</b>	<b>How will compliance be monitored</b>	<b>Monitoring Lead</b>	<b>Frequency</b>	<b>Reporting arrangements</b>
Monitoring of Central Line Infection on all Children on PN 100%	Line infections highlighted by UHL reporting system	Medical & Pharmacy Teams	Monthly/Quarterly	Local Quality & Safety Board
Procedure used by all staff administering PN to children (under 16yrs)	Peer review by LCAT assessment	Ward Sisters	Monthly/Quarterly	Senior Nurses Board

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UHL Patient ID Band Policy Trust Ref: B43/2007

UHL Policy for Consent to Examination or Treatment Trust Ref: A16/2002

UHL Infection Prevention & Control Policy Trust Ref: B4/2005

UHL Health and Safety Policy Trust Ref: A17/2002

UHL Control of Substances Hazardous to Health (COSHH) Policy Trust Ref: B10/2002

UHL Personal Protective Equipment Policy (PPE) Trust Ref: B9/2004

UHL Assessment and Administration of Medicines by Nurses and

Midwives Policy Trust Ref: B13/2009

UHL IV Policy Preparation and Administration of Intravenous Medications and Fluids to Adults, Babies, Children and Young People Trust Ref: B25/2010

## **6. Key Words**

Parental Nutrition Central Lines, Medication, Infusions, Aseptic Non-Touch Technique, Babies, Children, Young People, Children's Nurses

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**The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs. As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.**

<b>CONTACT AND REVIEW DETAILS</b>	
<b>Guideline Lead (Name and Title)</b> David Harris – Senior Pharmacist Hemant Bhavsar - Consultant Anne Willmott - Consultant Rebecca Zseli – Children's Gastroenterology Specialist Nurse	<b>Executive Lead</b> Chief Medical Officer
<b>Details of Changes made during review:</b> <b>No changes</b> <b>Format update only</b>	

## Appendix 4 - Calculating Nitrogen (g): Non-Nitrogen Energy (NNE) Ratio

Ideal ratios:

Neonate 1:200-250                      Child    1:200                      Adult    1:150

Calories provided by 1 gram of:

Fat:                      10 kcal                      Protein:                      4 kcal                      Carbohydrate: 4kcal

To calculate NNE:

$$\text{NNE} = \text{Kcal from fat} + \text{kcal from glucose} = (\text{g fat} \times 10) + (\text{g glucose} \times 4)$$

Example of how to work out maximum protein to give in order to ensure the correct ratio is achieved

NNE/ratio x 6.25

- Fat provided is 3g/kg/day
- Glucose provided is 16g/kg/day
- Reduce fat to 2g/kg/day if TG elevated and deranged LFT

Kcal from non-nitrogen (fat and glucose)

$$= (2 \times 9) + (4 \times 16)$$

$$= 18 + 64$$

$$= 82 \text{ kcal}$$

The protein we required

$$= 82/200 \times 6.25$$

$$= 0.41 \times 6.25$$

**=2.5g protein in order to achieve a 1g Nitrogen: 200 NNE ratio**