Clinical Guideline

TOTAL PARENTERAL NUTRITION (TPN) GUIDELINE

SETTING
Bristol Royal Hospital for Children

FOR STAFF
Medical staff, Nursing staff, Dietitians, Pharmacists

PATIENTS
Term neonates, infants, children and adolescents on inpatient wards at the Bristol Royal Hospital for Children

GUIDANCE

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1 INTRODUCTION

Parenteral nutrition (PN) is the administration of nutrition directly into the bloodstream. PN is usually indicated when sufficient nutrient supply cannot be provided orally or enterally to prevent or correct malnutrition or sustain appropriate growth. PN may provide the full nutritional requirements or partial nutritional requirements when it is used in conjunction with oral/enteral nutrition. PN is invasive and associated with clinical risk. It should only be used when there is no alternative method of feeding.

Examples of risks involved in the use of PN

<table>
<thead>
<tr>
<th>Clinical</th>
<th>Procedural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid overload or dehydration</td>
<td>Errors in dosage calculations</td>
</tr>
<tr>
<td>Venous catheter complications - line sepsis, thrombosis, thrombophlebitis, extravasation, line breakage</td>
<td>Errors in administration – wrong rate, not giving all parts of PN, contamination, incorrect storage, mixing with other drugs</td>
</tr>
<tr>
<td>Metabolic disturbances, e.g. hypo- or hyperglycaemia, hypertriglyceridaemia</td>
<td>Errors in manufacturing, potential for contamination of bag</td>
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<td>Electrolyte disturbances</td>
<td>Errors in prescription writing</td>
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<tr>
<td>Liver disease associated with PN</td>
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<tr>
<td>Refeeding syndrome</td>
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The aim of this guideline is to provide clear, evidence based guidance and procedures for using PN in hospital. This is to ensure safe and optimum management of parenterally fed infants, children and adolescents and minimise the risks associated with this form of nutrition support.

2 QUICK REFERENCE GUIDE

Extended until April 2022
2.1 Indications
- There are a number of indications for PN, such as:
  - Neonates/infants with necrotising enterocolitis who need full gut rest
  - Intestinal failure, e.g. short bowel syndrome due to gut resections or intestinal atresia, chronic intestinal pseudo-obstruction
  - Post-abdominal surgery or abdominal trauma if gut rest is required
  - Hypercatabolic states, e.g. extensive burns, if enteral feeding fails
  - Neonatal collapse with coarctation, unbalanced circulation, and chylothorax that cannot be managed with specialised enteral feeds
  - Inadequate enteral/oral nutritional supply due to severe/persistent vomiting, cancer treatment, radiation/chemotherapy gut injury, severe persistent diarrhoea where tailoring enteral feeds is unsuccessful

2.2 Contraindications and cautions
PN should be used with particular caution in:
- Renal impairment (may be fluid-, protein-, potassium-, phosphate- and sodium-restricted)
- Liver disease (may be fluid- and sodium-restricted)
- Metabolic acidosis or alkalosis
- Patients with limited fluid volume available for nutrition
- Electrolyte disturbances (see prescribing guidelines, Y-site/extension sets and appendix 1, fluid)
- Refeeding syndrome (see appendix 2.5)

Acid-base and electrolyte abnormalities should be corrected prior to starting PN if possible, particularly in the case of refeeding syndrome (see appendix 2.5).

Allergies to fish, egg, soya, peanut protein and methylhydroxybenzoate may preclude use of some of the constituents of PN (see prescribing guidelines, Allergies).

2.3 Initiation of PN
The decision to initiate PN should be made by a senior clinician. Unless it is contraindicated, prior to requesting PN medical staff should liaise with the ward dietitian to ensure that the infant/child has an appropriate trial of enteral feeding. A plan for PN should be made prior to initiation of treatment and documented in the medical notes. This should include:
- Expected duration of PN
- Desired outcome of PN
- What IV access is available or will be inserted for the administration of PN – see administration guidelines section 4.1
- Other oral/enteral/parenteral nutrition or fluids to be given alongside PN or whether the patient is nil-by-mouth

The following must also be considered:
- If PN is to be given via a peripheral cannula it will be unable to deliver total nutritional needs (see section 4.1), insertion of a central venous line is strongly recommended.
- Carers and patients (where appropriate) should be informed of the reason for PN, likely duration, potential side effects, likely impact on them and the family and what the procedure entails.
- Consideration should be given to the risk of refeeding syndrome (see appendix 2.5).

2.4 Monitoring
Monitoring is an essential component of successful PN therapy in order to ensure nutritional requirements are met, measure the effectiveness of PN and minimise complications.

Patient monitoring
- Weight, height/length, head circumference, plotted on a centile chart prior to initiation of PN and repeated as per table overleaf or as requested.
- Daily oral/enteral and intravenous input (including IV flushes and medications) and urine/vomit/aspirates/stoma/drain output using fluid balance charts.
- Daily bowel output, recorded using fluid balance chart or bowel output chart.
- Daily CVC exit site and dressing check for redness, tenderness, swelling, leakage or inflammation.
- Heart rate, temperature, respiratory rate and blood pressure every 4 hours until PN prescription is stable (i.e. no further changes in ingredients on Parenteral Services Unit (PSU) insert sheet or volume/type of standardised PN administered).

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Glucose monitoring

Increasing glucose dose

- Blood glucose should be checked once daily (whilst PN is running) for the first week of PN or other times the amount of glucose is increased, to check for hyperglycaemia.
- PSU PN prescriptions show the glucose dose in g/kg per day. Specific standardised PN products have a fixed glucose concentration per ml – the glucose dose increases as the volume administered increases.
- Measure blood glucose via hand-held meter or gas analyser and consider >11mmol/L as significant.
- If a patient has a level >11mmol/L, recheck result and if still high perform a urine dip for glucose. If dipstick is positive for urine this suggests the patient has some difficulty handling the glucose load.
- Monitoring may cease when measurements are stable unless there is other advice from clinical team.
- Persistent hyperglycaemia may require adjustment of the carbohydrate content in PN and rarely co-administration of insulin (see hyperglycaemia).
- Avoid stopping PN suddenly as it may precipitate hypoglycaemia. Seek advice from the ward dietitian or nutrition support team (NST) before giving insulin.

Reducing duration of PN or stopping PN

- Blood glucose level should be taken via finger prick 30 – 60 minutes following cessation of PN in patients on cyclical PN (i.e. infusion of aqueous phase is <24 hours).
- Check this for 1-2 days following a reduction in PN infusion duration.

Trace elements and vitamins

Monitoring for trace elements and vitamins is required only if on PN >4 weeks, or at baseline if there are suspected pre-existing imbalances. See long term monitoring for further advice.

Triglycerides

- Check triglyceride level weekly just prior to starting next day’s bag of PN.
- More frequent monitoring is recommended if the lipid dose exceeds usual maximum doses, in sepsis, in the catabolic or critically ill, or if there is unexplained severe thrombocytopenia. See lipids and hypertriglyceridaemia for further information.

Biochemistry

Routine biochemical monitoring should take place in all patients on PN. Baseline blood tests and measurements should be taken prior to initiation of PN and periodically as per table overleaf. Those at risk of refeeding syndrome may have significant metabolic abnormalities and may need monitoring more frequently (magnesium, potassium and phosphate monitoring is particularly important) - seek advice from the ward dietitian or NST.

Haematology

Do not order a full blood count (FBC) more than once weekly as part of routine PN monitoring. Patients are vulnerable to anaemia secondary to repeated venesection.
PN monitoring
* Sample directly prior to hanging the next PN infusion. # CRP should be checked at the same time as copper, selenium, manganese, zinc or ferritin.

Derangement from normal ranges should be discussed with the consultant, ward pharmacist or dietitian.

Who to contact if there is a problem with blood monitoring/results
Monday-Friday 9am-5pm
Clinical team, ward pharmacist, NST
Out of hours
Emergency duty pharmacist, on-call registered medical officer (RMO)

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**Inadequate enteral intake or enteral route contraindicated**

**Baseline Assessment**
- Senior decision to initiate PN
- Document reason for PN, desired outcome, expected duration and other nutrition/fluid/electrolytes via other routes in notes
- Assess for contraindications and cautions
- Provide information to child/family
- Insert suitable IV access

**Initiation**
- Pharmacist and doctor/non-medical prescriber (NMP) check baseline blood results
- **Bespoke PN**: use trust protocol for patient weight, tailor to dietetic advice and blood results
- **Standardised PN (insufficient PSU capacity)**: supplemented bag (>30kg or at discretion of nutrition team) or multi-chamber bag without additions
- Prescribe 1-3 days at a time (3 if starting on Fri)
- Daily blood monitoring as per guideline
- Monitor physical status as per guideline, including fluid in/output and blood sugar

**Continuation**
- Follow guideline for frequency of monitoring
- Take bloods night before prescribing or urgently in the morning as above
- Pharmacist and doctor/NMP check blood results prior to prescribing
- **Bespoke PN**: tailor prescription to outcome of monitoring, enteral intake, complications etc.
- **Standardised PN**: tailor volume administered/rate of administration, switch to bespoke PN if necessary

**Seek further advice from ward dietitian**
- Discuss with ward dietitian or refer to refeeding guideline
- Assess refeeding risk and nutritional complexity
- Inform ward pharmacist and nurse
  - Day prior to initiation or as soon as practicable

**Take baseline blood test, weight, height/length, head circumference (if <2yrs)**
- Day prior to initiation or by 10am in morning
- If taking bloods in the morning, send to pathology urgently in red bag via POD or with porter

**Bespoke PN**: Pharmacist sends prescription to PSU by 12noon (mon-fri)

**Standardised PN**: Doctor/NMP prescribe on fluid prescription, pharmacist provides to ward

**PSU make PN (mon-fri) and send direct to ward by 6pm with porter**
- Sat and sun bags will arrive by Friday.

**Nurse(s) administer PN**
- As per Total Parenteral Nutrition TPN Setup 2 Nurse Technique Checking and Administration OR
- Total Parenteral Nutrition TPN Setup 1 Nurse Technique Checking and Administration

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3.1 Constituents of PN

PN is historically provided in 2 parts due to physical/chemical instability which may occur when all components are stored in a single bag, particularly for regimens used in infants. In this case there is an aqueous bag and a lipid bag or syringe. Sometimes the whole PN product is presented in one bag (‘all-in-one’), including SMOF kabiven, SMOF Ven or Nutriflex products (being rebranded as Lipoflex during 2019) and most home PN (HPN). ‘All-in-one’ bags are sometimes provided as 3 separate chambers (1 cloudy, 2 clear) which require mixing on the ward prior to administration.

See appendix 3 for examples of constituents that may be present in PN. PN may be prescribed as a ‘bespoke’ regimen, meaning the constituents of the PN have been prescribed at the specific amounts required for that patient on that day, or a standardised regimen (see below 3.4).

3.2 Allergies

Contra-indications on the basis of allergy4-11

(x = contra-indicated)

<table>
<thead>
<tr>
<th>Product</th>
<th>Type of allergy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fish</td>
</tr>
<tr>
<td>SMOF Lipid, SMOF kabiven</td>
<td>x</td>
</tr>
<tr>
<td>Intralipid</td>
<td>x</td>
</tr>
<tr>
<td>Solivito N</td>
<td></td>
</tr>
<tr>
<td>SMOF Ven range</td>
<td>x</td>
</tr>
<tr>
<td>Vitlipid infant and adult</td>
<td>x</td>
</tr>
<tr>
<td>Supplemented Nutriflex/Lipoflex range *</td>
<td>x</td>
</tr>
</tbody>
</table>

*Supplemented Nutriflex lipid special/Lipoflex special or Nutriflex lipid plus/Lipoflex plus

If a patient who requires PN is allergic to egg, soya or peanut protein seek advice from NST regarding management of lipids.

3.3 Prescribing bespoke PN

The prescription should be completed by the clinical team caring for the patient in conjunction with a pharmacist and dietitian (if possible) or NST after physical assessment of a patient’s clinical condition and review of blood results. It is generally advisable to prescribe 1 day at a time for the first 3-4 days, taking the PN ordering schedule with PSU into account (see below) or up to the first 3 days at once if starting PN on a Friday. Note that daily monitoring and results should be reviewed over weekends. See appendix 1, fluid for advice on giving part of a PN bag or giving PN over a longer period of time to adjust for unexpected blood results.

Patients should be monitored frequently when PN is first initiated and less frequently once monitoring parameters are stable (see monitoring). The frequency of PN prescribing is often dictated by the frequency of monitoring.

Bespoke PN prescribing:

- Use Paediatric PSU prescription.
- PSU prescription must reach PSU by noon on the day of manufacturing. PN for Thursday/Friday and Saturday/Sunday must be ordered by noon Thursday and Friday respectively.

There are standard regimens based on the European Society for Paediatric Gastroenterology Hepatology And Nutrition (ESPGHAN) guidelines which may assist prescribing (see BRHC protocols), although advice should be sought from a dietitian or NST for these patients:

- intestinal failure
- patients in intensive care
- patients expected to have high energy needs (e.g. burns, cystic fibrosis, other pulmonary disease or cardiac disease)
- patients at high risk of refeeding syndrome or if catch-up growth is desired

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• patients who are particularly overweight

Actual weight should be used unless the patient is grossly oedematous or thought to be acutely dehydrated, in which case the best estimate of body weight should be used. If the patient is very overweight ideal weight for height should be used (discuss with dietitian). For neonates, birth weight should be used until actual weight exceeds birth weight\(^\text{12}\). See appendix 1 for guidance on the nutritional content of PN.

**Alterations**

If an alteration to bespoke PN prescription is required after the product has been made, contact the NST or ward pharmacist (inside working hours). Outside working hours seek advice from the emergency duty pharmacist. The constituents can’t be changed but it may be appropriate to reduce the amount of PN which is administered or increase the hours it is given over in this manner:

- PSU prescription - prescriber to amend volume or infusion duration (or both) by completing section at bottom of prescription with new aqueous and lipid flow rates.

### 3.4 Prescribing pre-filled or standardised PN and home PN

Pre-filled or standardised PN is commercially available PN containing fixed ratios of components, including:

- unlicensed aqueous bags containing nitrogen, glucose and electrolytes e.g. Babiven products (separate lipid to be used alongside). Since summer 2019 Babiven products are temporarily named ‘ITH concentrated and ITH term’.
- licensed multi-chamber bags (MCBs) containing glucose, nitrogen, lipid and electrolytes which need to be mixed together by ‘rolling’ prior to administration e.g. SMOFKabiven products
- unlicensed premixed all-in-one bags containing nitrogen, glucose, electrolytes, fat-soluble and water-soluble vitamins and trace elements. Some products are referred to as ‘supplemented’ due to the vitamin and trace element content, e.g. SMOFVen, supplemented Nutriflex/Lipoflex. Nutriflex is being rebranded as Lipoflex during 2019.

HPN is made by an external company for a specific patient and usually contains the specific amount of nitrogen, glucose, electrolytes, fat-soluble and water-soluble vitamins and trace elements appropriate for that patient.

Supplemented Nutriflex/Lipoflex, SMOFVen, SMOFKabiven and Babiven (+lipid) products may be prescribed in certain situations, such as:

- Out of working hours, in accordance with Use of Parenteral Nutrition Pre-filled Bags (standard babiven and smофkabiven bags). Since summer 2019 Babiven products are temporarily named ‘ITH concentrated and ITH term’.
- If PSU capacity for making bespoke PN has been exceeded or a request for PN has come outside of PSU manufacturing hours – at pharmacist discretion.
- Other situations at pharmacist discretion, if they and/or a dietitian have deemed the content of the product to be appropriate for a specific patient.

Standardised regimens for children are usually but not exclusively:

- <10kg - an aqueous PN bag (e.g. Babiven/ITH concentrated or term) run alongside lipid.
- <30kg - MCB (short term only as they contain no vitamins or trace elements), or supplemented product (if advised by NST).
- ≥30kg - ‘supplemented’ product or MCB (short term).

Standardised PN prescribing:

- Always specify the full name as there are multiple SMOFKabiven and Babiven products available which are not equivalent, e.g. ITH/Babiven concentrated, ITH/Babiven maintenance, SMOFKabiven peripheral, SMOFKabiven central. Check carefully whether the product you have prescribed is suitable to be administered via central or peripheral routes by referring to the prefilled PN bag guideline or the label on the bag.
- The name of the product, volume and flow rate must be prescribed on a fluid chart as in appendix 5.

HPN prescribing:

- This is possible if the patient brings in their own HPN or NST arranges for it to be delivered to the hospital.
- Patients may not receive the same constituents every day or may receive PN on only some days of the week - refer to a copy of the HPN prescription and keep a copy in the bedside folder. The most common variation is for some days to be fat-containing (cloudy bag) and some days fat-free (clear bags).
- Parents may carry a copy of HPN prescription or it can be obtained by contacting a member of NST or your ward pharmacist.
- When the HPN prescription is not available check carefully with a parent what bag(s) are usually given on each day of the week. The product label shows the volume to be infused and the hours it should be infused over.
- The name of the product, volume and flow rate must be prescribed on a fluid chart as in appendix 5 for up to

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three days at a time at weekends or for stable patients during the week. HPN bags are labelled with a code consisting of numbers and letters – use this and the words ‘Home parenteral nutrition’.

3.6 Compounding, delivery and storage

Bespoke PN is made in PSU based in the Bristol Haematology & Oncology Centre (BHOC). PN will be delivered to the ward usually by 6pm. Multiple bags may be delivered during the week if the patient is stable and prescriptions have been written in advance. Saturday and Sunday bags are generally delivered on Friday, or sometimes earlier in the week. PN must be stored in a suitable fridge on arrival to the ward (between 2-8°C) unless it is due to be given within an hour.

See section 4.2 administration for further information.
### 4.1 Venous Access

**Central lines**

PN should run through a central venous catheter (CVC) wherever possible to reduce the risk of extravasation and thrombophlebitis. The line tip position should be confirmed by x-ray. Ideally there should be a dedicated nutrition line or lumen (if multi-lumen line), if in any doubt about which line to use discuss with the ward pharmacist or NST. The type, size and lot number of the CVC inserted should be documented in the patient’s notes. Nurses should have completed central line and PN administration training before handling PN as per *Total Parenteral Nutrition TPN Setup 2 Nurse Technique Checking and Administration*. Refer to *Central venous catheter guidelines for pediatrics* for advice on performing weekly bung and dressing changes.

**Suitable CVCs**

- CVCs may have single, double or triple-lumen. Single lines are more common in long-term PN.
- Percutaneously inserted central catheters (PICCs) and tunnelled catheters, e.g. Hickman lines for long-term PN
- Temporary central lines inserted via internal jugular, subclavian or femoral routes
- Subcutaneous implantable ports for short term use – bear in mind if ports get infected they are difficult to treat (discuss with specialist oncology nurse or NST)
- Appropriately sited umbilical venous or arterial catheters (neonates) for short term use

**Accessing the line and blood sampling**

- Syringes of 10ml or greater should be used to access a CVC as the high flush pressure generated by syringes smaller than 10ml can rupture the line.
- Avoid taking blood samples from the PN lumen/line if possible to reduce the risk of line infection and catheter occlusion. However this should be balanced against: 1.) discomfort of peripheral venepuncture and 2.) expected frequency of PN blood sampling. Smaller children may require peripheral sampling to avoid anaemia.
- Check with the clinical team for the patient, NST or ward pharmacist if unsure whether blood should be sampled out of the PN line.
- For triple- or double-lumen lines accessing a lumen other than that used to administer PN is not considered to be using the PN line.

If there is any difficulty aspirating blood or blood samples are observed to be dilute, there is increased swelling around the line site, significant pain or the patient’s condition deteriorates stop using the CVC and seek advice from the clinical team as soon as is possible. If there is a suspected or actual occlusion, or for information on CVC replacement or repair see *Central venous catheter guidelines for pediatrics*.

**Peripheral lines**

Peripheral venous catheters should be avoided for routine administration of PN. Full nutritional needs will usually not be met due to the low osmolarity tolerated via this route.

**Limitations of peripheral lines:**

- Maximum glucose concentration 12.39% and maximum osmolarity 900 mOsm/L, higher than this increases the risk of extravasation and thrombophlebitis.
- Hourly IV cannula assessment (PIPA) must be undertaken and documented.
- Thrombophlebitis often limits tolerance.

PN not suitable to be administered via peripheral lines is labelled by PSU with ‘to be given via central line only’.

### 4.2 Set-up and practicalities of managing PN

**Prior to infusion**

PN products should be stored in a temperature-monitored fridge (between 2-8°C). If bags have been refrigerated on the ward prior to infusion, they should be left to stand at room temperature for 1 hour to minimise the risk of hypothermia. If bags have arrived from PSU that day they do not need to be left to stand prior to administration.

**Volume of PN product and overage**

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PSU and other manufacturers of named-patient PN provide an overage to account for priming with giving sets or syringe connectors. PN which is obtained off the shelf, e.g. Nutriflex/Lipoflex, SMOFVen, SMOFKabiven, and ITH/Babiven concentrated or term are available in set volumes and overage must be added to the volume the patient requires,
e.g. baby weighing 6.1kg requires 80ml per kg of ITH/Babiven term = 488ml
Available bag size is 500ml
Assume 25ml volume required for giving set = 25ml overage
Patient would require 2 x 500ml bags, or dose to be rounded down to 77ml/kg at clinical discretion of prescriber
(77ml/kg x 6.1 = 469.7ml)

Light protection
PN is supplied with/in a light-resistant bag to minimise light-induced lipid peroxidation and/or vitamin degradation whilst in use. These bags should be used to protect all parts of PN during the infusion.

How to light-protect during infusion:
- Orange bag - PSU Lipid bags, intralipid bags.
- Blue and/or silver bag – PSU aqueous PN, ITH/Babiven concentrated or term, HPN fat-containing ‘all-in-one’ bag, SMOFKabiven bags), Home PN fat-free/clear bag, SMOFVen bags.
- Other products may come with their own light-protecting bag, e.g. Nutriflex/ Lipoflex products.
Some light-protective bags are kept in the Children’s Hospital emergency cupboard.

Giving sets and filters
PN giving sets and filters must be changed every time a bag is changed (maximum PN aqueous bag duration 48 hours). Change lipid giving sets every 24 hours. Lipid bags or all-in-one PN should be infused using a 1.2 micron filtered giving set. Aqueous PN (from PSU or standardised bags) is not currently routinely filtered. If the child is requiring additional IV therapy, e.g. antibiotics, an administration set should be connected below the filter.

Pauses and disconnections
If the PN administration set is disconnected from the patient at any time the PN and giving set must be discarded. A PN infusion should never be restarted if disconnected. If there is an accidental disconnection discard the PN, flush and lock the line as usual, seek medical advice in case replacement fluids or emergency PN is required.
Contact the ward pharmacist if in working hours. It is appropriate to pause the PN infusion if required when the patient is in theatre provided the giving set is not disconnected. PN can also be paused for blood sampling or for the administration of medication (see Y-site/extension sets).

Checking procedure
PN should be administered in accordance with the trust guideline Total Parenteral Nutrition TPN Setup 2 Nurse Technique Checking and Administration or Total Parenteral Nutrition TPN Setup 1 Nurse Technique Checking and Administration (as appropriate to ward area) following the principle of aseptic non-touch technique.

Prior to commencing PN the product should be checked for leakage and precipitate and the PSU insert sheet checked for glucose concentration to ensure it is compatible with the patients vascular access. The table below indicates what needs to be checked when setting up PN:

<table>
<thead>
<tr>
<th>Patient name, number, date of birth</th>
<th>Product</th>
<th>Original Prescription</th>
<th>Insert sheet from PSU</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
<td></td>
</tr>
<tr>
<td>Day number of TPN (i.e. Day 2)</td>
<td>☑️</td>
<td>☑️</td>
<td>☑️</td>
</tr>
<tr>
<td>Expiry</td>
<td>☑️</td>
<td></td>
<td>☑️</td>
</tr>
<tr>
<td>Rate</td>
<td>☑️</td>
<td></td>
<td>☑️</td>
</tr>
<tr>
<td>Total volume to infuse</td>
<td>☑️</td>
<td>Estimated ml/kg</td>
<td>☑️</td>
</tr>
<tr>
<td>Number of hours to infuse</td>
<td>☑️</td>
<td></td>
<td>☑️</td>
</tr>
</tbody>
</table>

Any discrepancies must be discussed with pharmacy or medical staff before administration. At all shift changes nursing staff should recheck the aqueous and lipid infusion rates are correct against PN bag/syringe labels and infusion pump setting and that IV lines are secured.

Sign and document the start time of PN on the relevant PN prescription.

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Use of Y-site/double and triple extension sets and intravenous medicines

If possible give additional electrolytes, fluids or medications through a separate intravenous line to PN or a separate lumen to PN (for multi-lumen line). Repeated manipulation of the PN line to give other drugs increases the risk of infection. When use of another line is impracticable, other IV products may need to be given via a Y-site on the same line or lumen that PN runs through. PN may not be able to provide all the electrolyte replacement needs if there are electrolyte disturbances, particularly if PN has been made in advance of recent blood results or or standardised PN is used, and additional electrolytes may be required.

General guidance:

- Standard pre-made fluid and electrolyte bags, such as plasmalyte, sodium chloride 0.45% and sodium chloride 0.9% are generally suitable to be given via Y-site while PN is running.
- Avoid running medications via a Y-site at the same time as PN if possible.
- If there is difficulty deciding which medication to give via each line then refer to Medusa, the IV medication folder on the ward, the BRHC guideline Y-Site compatibility of Intravenous Infusions or the ward pharmacist for information on compatibility. Medusa is available through the pharmacy homepage or the list of apps on connect.
- Products containing calcium, phosphate or sodium bicarbonate should never be given through the same line as PN while the PN is running as there is a high risk of incompatibility with the PN.
- PN may need to be paused for the administration of boluses or infusions via the Y-site. For patients on 24-hour PN or for patients receiving relatively long drug infusions consideration should be given to how this reduces the volume of PN administered.
- Seek advice from the clinical team, ward pharmacist or NST if there are concerns that the necessary volume of PN cannot be given due to access concerns.

Ceftriaxone and PN16:

- Neonates up to 28 days: Do not administer PN and ceftriaxone on the same day even if via different lines or PN is paused during ceftriaxone administration due to the risk of calcium-ceftriaxone precipitation.
- Children >28 days: Avoid ceftriaxone if possible. If no other antibiotic is appropriate ceftriaxone and PN may be administered one after the other, provided different IV lines are used or there is a flush between them. If pausing PN long enough to give ceftriaxone is not clinically appropriate for the patient it may be given whilst PN is running provided a separate infusion site is used.

All additions to PN bags can only be made in PSU – additions must NEVER be made at ward level

Catheter guidelines for paediatrics

Lock solutions used should be as Central venous catheter guidelines for paediatrics for the specific type of line inserted, unless the patient usually receives HPN or has been recommended a specific line lock by infectious diseases or NST. HPN patients may already be receiving alternative lock solutions, such as Taurolock® or ethanol (see appendix 2.1) due to a previous CVC infection or occlusion, in which case that lock should be used.

4.3 Infusion rates, wind-down, weaning off PN and titration

Aqueous PN solutions should run over a maximum of 48 hours and infusions containing lipid should be changed and infused over a maximum of 24 hours.

Infusion rates

PN should not be given at a faster rate than the prescription or PSU insert sheet except for when wind-down is occurring (see below). It is common for the volume and nutritional content of PN given to reduce slowly over a period of days or weeks in conjunction with increasing oral/enteral feeds (titration or weaning), usually with the aim of transitioning to full food/feeds and discontinuing PN altogether.

Wind-down

Some patients may require a wind-down of PN to prevent or manage rebound hypoglycaemia once PN is stopped. This is most likely needed for infants requiring PN for months or transitioning to HPN. The initial infusion rate is higher than the PSU insert sheet rate by 2-3% (maximum 3%), and the rate for the last hour is approximately half the initial rate. Wind-down rates should be prescribed on the bottom section of the PSU PN prescription as follows:

1. Aqueous PN at xml/hour for first (total duration-1) hours, then ½ xml/hour for the last hour. This should be calculated to ensure they receive all/most of the PN volume required.
2. Lipid at usual rate

   e.g. Patient having 22 hours of aqueous PN at 6.2ml/hour requires 22 x 6.2ml = 136.4ml. As a wind-down they need 6.3ml/hour x 21 hours then 3.3ml/hour x 1 hour (total infused = 135.6ml).
Weaning and titration

Weaning from PN is the general principle of progressively reducing the nutrition given via PN. Titration of PN is usually carried out by maintaining the same total fluid volume between IV and oral/enteral routes and recalculating the PN volume to be administered each time the oral/enteral volume increases. This only works from a nutritional perspective if both the enteral fluid and PN have the same energy content in kcal/ml. It is rare that this is the case and may be inappropriate in most patients particularly those who are eating solid food. Also, protein and energy taken by enteral routes are not 100% absorbed into the systemic circulation like PN. PN can usually be safely discontinued in infants and children when the patient reaches two-thirds of their target oral/enteral intake or once 75% of target oral/enteral target is reached in neonates. Please consult the NST or ward dietitian for advice on weaning PN without compromising nutritional intake.

If the PN infusion rate is changed always ensure both the aqueous and lipid phases (where relevant) change proportionately by calculating the ratio of aqueous volume to lipid volume.

Titration: Double check rate calculations and physical rate change (2 healthcare professionals), document and sign for on titration chart. Further guidance is available in A Guide to Calculating Parenteral Nutrition when Titrating with Feeds and charts for documenting volumes/rates are available here.

Weaning by prescribing new flow rate on PSU PN prescription: Double check physical rate change (2 nurses) and sign on prescription.

If there is any doubt as to the method of titration or weaning check with the patient’s clinical team or ward pharmacist.

4.4 Cyclical PN

Cyclical PN means the PN is given over less than 24 hours per day. It may be suitable for infants who would otherwise be sleeping through most of the night (when on milk) and children providing they are already tolerating full PN and are clinically and biochemically stable. Providing a break in provision of PN may allow children to experience hunger, which may be suppressed by continuous PN and may reduce the incidence of Intestinal Failure Associated Liver Disease (IFALD). Occasionally a child may be prescribed PN over less than 24 hours to allow all of their PN to be administered over a 24-hour period when the same line is being used for PN and IV drugs – breaks of >60 minutes off PN may require blood glucose monitoring as below.

Sudden discontinuation of a high glucose infusion increases the risk of hypoglycaemia, particularly in children <2 years’ so blood glucose should be checked 30-60 minutes after the end of the infusion until results are stable. If blood glucose is between 3 and 2.5mmol/L it should be tested again in 20-30 minutes. If blood glucose is <2.6mmol/L it should be treated as hypoglycaemia as per BRHC guideline Hypoglycaemia guideline: investigation and management of acute presentation (unless there is a different plan documented in the notes).

Potential strategies to prevent low blood sugars include:

- Giving enteral feeds, snacks or milk up to 15-20 minutes before the end of the PN infusion (unless nil-by-mouth)
- Winding down (as above).

4.5 Parent administration of Home PN

Some parents/carers are permitted to administer HPN to their child whilst in hospital at the discretion of gastroenterology and the specialist nutrition nurse. This is particularly useful in the process of training prior to going home on PN for the first time.

Ideally parent/carers own infusion pumps and giving sets should be used.

When parents/carers are administering HPN it should be prescribed as detailed in section 3.5 but nurses do not need to sign on the prescription for putting it up.

5 LONG-TERM MONITORING
5.1 Trace elements and vitamins

If on PN long term i.e. >4 weeks check every 3 months:

- Trace elements (copper, selenium and zinc), ferritin and CRP. Check trace elements prior to initiation if there are suspected pre-existing imbalances.
- Fat soluble vitamins (A, D, E and INR to check for vitamin K deficiency)
- Vitamin B12 and folate

Check every 6 months:
- Parathyroid hormone
- Thyroid function tests

Check annually:
- Manganese (take CRP at same time)

Some patients may require additional tests at the discretion of NST such as urinary calcium excretion

Specific conditions that increase the risk of trace element abnormalities

<table>
<thead>
<tr>
<th>Condition/disease</th>
<th>Copper</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns</td>
<td>Risk of deficiency</td>
<td>Risk of deficiency</td>
</tr>
<tr>
<td>Cholestasis</td>
<td>Risk of toxicity</td>
<td></td>
</tr>
<tr>
<td>Prolonged diarrhoea, large stoma/enterocutaneous fistula/intestinal drain output</td>
<td>Risk of deficiency</td>
<td>Risk of deficiency</td>
</tr>
<tr>
<td>Severe skin disease</td>
<td></td>
<td>Risk of deficiency</td>
</tr>
</tbody>
</table>

Any derangement from the normal range should be discussed with the consultant, ward pharmacist or dietitian.

5.2 Blood sampling

Specialised blood sampling advice (personal communication Department of Clinical Biochemistry Jul 2019)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Collection Tube</th>
<th>Volume of plasma</th>
<th>Volume of blood</th>
<th>Tube appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selenium</td>
<td>Lithium heparin sample</td>
<td>1ml</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>Lithium heparin sample</td>
<td>1ml</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Lithium heparin sample</td>
<td>0.5ml</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Lithium heparin sample</td>
<td>0.5ml</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Vitamin A + E</td>
<td>Lithium heparin sample</td>
<td>0.4ml</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>Dark Pink</td>
<td>N/A</td>
<td>0.3ml</td>
<td></td>
</tr>
</tbody>
</table>

6 APPENDICES

Extended until April 2022
1. Recommended nutritional content of PN

Energy

ESPGHAN guidelines include estimated energy requirements for age and degree of illness (see table below), which are generally appropriate as a starting point. Other methods which are more specific include giving a proportion of the estimated average requirement (EAR) for age (i.e. 90 – 100%), or using resting energy expenditure (REE) with/without factors which either increase or decrease REE. Conditions which may increase energy requirements include cystic fibrosis, other pulmonary disease, cardiac disease, trauma, burns and biliary atresia. Conditions associated with lower energy requirements include mechanical ventilation/sedation and immobility. Children with growth failure may require higher than usual calories if catch-up growth is desired.

Critical illness

The authors of a multicentre trial comparing delayed versus early introduction of PN in paediatric intensive care suggest that PN should be avoided in the first week on PICU. NST do not support this approach due to poor study design – PN may be started during the first week on PICU provided the patient has undergone initial interventions to stabilise them and there is sufficient fluid allowance.

In the table below ‘acute phase’ can be considered as the early days of an intensive care admission whilst fully ventilated and sedated, and the period of weaning off these interventions and preparing for transfer to a ward or high-dependency unit (HDU) as ‘stable phase’. REE is a more precise measure of energy requirement during the acute phase, and can be calculated using Schofield’s equation.

Schofield’s equation

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1 year</td>
<td>59.5 x (weight in kg) – 30</td>
<td>58.3 x (weight in kg) – 31</td>
</tr>
<tr>
<td>1–10 years</td>
<td>22.7 x (weight in kg) + 50</td>
<td>20.9 x (weight in kg) + 46.6</td>
</tr>
<tr>
<td>10–18 years</td>
<td>17.7 x (weight in kg) + 658</td>
<td>13.4 x (weight in kg) + 99</td>
</tr>
</tbody>
</table>

Energy requirements

<table>
<thead>
<tr>
<th>Total energy (kcal/kg/day)</th>
<th>0-1 yrs including neonates</th>
<th>1-7 yrs</th>
<th>7-12 yrs</th>
<th>12-18 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ward or HDU patient</td>
<td>75-120*</td>
<td>65-75</td>
<td>55-65</td>
<td>30-60</td>
</tr>
<tr>
<td>Acute phase (PICU)</td>
<td>45-50</td>
<td>40-45</td>
<td>30-40</td>
<td>20-30</td>
</tr>
<tr>
<td>Stable phase (PICU)</td>
<td>60-65</td>
<td>55-60</td>
<td>40-55</td>
<td>25-40</td>
</tr>
</tbody>
</table>

*Term neonates are likely to need in region of 100 kcal/kg/day

Energy requirements per kg decrease with age and therefore, for example, even within the 12-18 year age range the older the child the lower the energy provision per kg should be.

Protein

Nitrogen dose (minimum-maximum)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Unit</th>
<th>Neonates</th>
<th>1 month - 3 yrs</th>
<th>3-12 yrs</th>
<th>Adolescents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>g/kg/day</td>
<td>0.21-0.42</td>
<td>0.21-0.4</td>
<td>0.16-0.32</td>
<td>0.16-0.32</td>
</tr>
</tbody>
</table>

Amino acid converted to nitrogen based on using Vaminolact or Vamin 18 (≥3 years): bespoke PN for <10kg uses Vaminolact and PN for ≥10kg uses Vamin 18. Lower threshold for neonates and children up to 3 years is 1.5g amino acid/kg/day.

- Protein is prescribed as grams of nitrogen
- Each gram of amino acid = 0.89g protein or 0.14-0.16g nitrogen (nitrogen content can vary depending on the amino acid solution used)
- Utilisation of protein depends on having enough energy. 30-40 kcal energy is required per 0.14g-0.16 of nitrogen.
• The protein requirements in PN are less than enteral requirements as the intestine is bypassed.

Conditions where there is a need to consider increasing protein requirements: sepsis, thermal injury, surgery, trauma, and high stoma losses, primary renal disease. Steroids and diuretics may increase protein loss.

Conditions in which to consider lower protein dose: renal disease, hepatic failure, and certain inborn errors of metabolism e.g. maple syrup urine disease (MSUD), urea cycle defects and phenylketonuria (PKU). Liaise with relevant specialist clinical teams, i.e. renal team, metabolic team.

Carbohydrate

As described in ‘energy’ above the amount of carbohydrate in PN may need to be lower in intensive care, as it contributes a lot of energy to PN, and there are two distinct phases with different energy requirements within an intensive care stay. ESPGHAN 2018-recommended doses are low compared to historic practice, necessitating a significant proportion of energy to come from lipid. There should be consideration of the maximum doses in the table below, however these may need to be exceeded sometimes (including some BRHC PN protocols) to provide enough energy. The absolute is 17.3g/kg/day in neonates as this approximates maximal glucose oxidation rate. Ensure glucose is monitored via urine or blood as in monitoring when high doses are used.

Carbohydrate dose range (minimum-maximum)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Unit</th>
<th>Age and/or weight</th>
<th>Acute phase (PICU)</th>
<th>Stable phase (PICU)</th>
<th>Ward or HDU patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>g/kg/day</td>
<td>Term neonate</td>
<td>Target 7.2 - 14.4</td>
<td>3.6 - 17.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 days-10kg</td>
<td>2.9 - 5.8</td>
<td>5.8 - 8.6</td>
<td>8.6 - 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-30kg</td>
<td>2.2 - 3.6</td>
<td>2.8 - 5.8</td>
<td>4.3 - 8.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31-45kg</td>
<td>1.4 - 2.2</td>
<td>2.2 - 4.3</td>
<td>4.3 - 5.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;45kg</td>
<td>0.7 - 1.4</td>
<td>1.4 - 2.9</td>
<td>2.9 - 4.3</td>
</tr>
</tbody>
</table>

- Carbohydrate is prescribed as glucose and should provide 50-75% of non-protein energy.
- Glucose dose in PN should start low and increase up to the target amount over 3-4 days in neonates and more quickly in infants and children.
- Excessive glucose may cause increased CO2 production and minute ventilation, lipogenesis, increased fatty tissue and liver steatosis.
- Glucose oxidation may be reduced in critically ill children. Monitor blood sugar closely.
- Lower maintenance doses should generally be used in hyperglycaemia, sepsis, liver disease or cholestasis. Consider reducing dose in a septic neonate to the ‘day 1’ dose.
- Glucose dose may need to be modified if medications that alter carbohydrate metabolism are prescribed, e.g. steroids, somatostatin analogues, tacrolimus. Consider referral to NST for advice on management.
- In cyclical PN the maximum glucose rate is 1.2g/kg/hr.

Lipid

- Lipid is needed to ensure appropriate energy and essential fatty acid (EFA) provision. It should provide 25-50% of non-protein energy in PN.
- Maximum lipid dose 4g/kg per day in infants (including pre-term infants) and 3g/kg/day in older children.
- There is no evidence that gradual increments of lipid improve tolerance and the British Association of Perinatal Medicine advises pre-term and term neonates can start on 2g/kg/day, although initiation of 2-3g/kg/day from birth is linked to a higher rate of hypertriglyceridaemia in pre-term neonates (no data in term babies).
- Intralipid® consists of pure soya-bean emulsion.
- SMOFlipid® is a complex mixed lipid emulsion using soya-bean, medium chain triglyceride, olive oil and fish oil.
- Other mixed lipid emulsions include Lipofundin®, which is contained in supplemented Nutriflex Lipid Special (Lipoflex Special) and Nutriflex Lipid Plus (Lipoflex Plus).
- Intralipid has been widely used for decades in children but is now recommended only for short-term use as mixed lipid emulsions are possibly associated with less adverse effects. Avoid intralipid in cholestasis.
- Mixed lipid emulsions should be used for patients with sepsis or those who are critically ill.
- SMOFlipid is recommended for patients who are likely to require PN >4 weeks.
- The manufacturer of SMOFlipid recommends a maximum infusion rate 0.125 g fat/kg /hour neonates and infants and 0.15 g fat/kg/hour children. As this rate is exceeded for doses >3g/kg/day in neonates/infants, patients should have serum triglycerides monitored regularly.
- Critical illness or sepsis – metabolism of lipids may be impaired, but lipid is needed as an energy source as glucose metabolism may also be impaired. Always provide at least enough lipid to prevent essential fatty acid...
deficiency (see below)3.

- Monitor serum triglycerides more frequently for patients during critical illness or catabolic states, sepsis or patients with a high glucose or lipid dose and adjust lipid dose if levels are high7. See hypertriglyceridaemia for interpreting levels.
- The minimum dose to avoid essential fatty acid deficiency in term neonates/infants/children is 0.1g/kg/day linolenic acid3 (equivalent to approximately 0.6g/kg/day as SMOF or 0.18g/kg/day intralipid).
- Monitor triglyceride levels in severe thrombocytopenia or coagulopathy and consider decreasing lipid dose7 – see hypertriglyceridaemia. Overly-rapid infusion or high doses of lipid may present as “fat overload syndrome” with headaches, fever, jaundice, coagulopathies, hepatosplenomegaly, respiratory distress and thrombocytopenia3.

Fluid

Total fluid requirement is dependent on many factors including age, weight, urine output, transepidermal losses and renal function. Maintenance fluid requirement may be calculated using the rule of thumb:

| Neonates* and infants up to 160ml/kg | <10kg 100ml/kg | 10-20kg 1000ml + 50ml/kg for each kg >10kg | >20kg 1500ml + 20ml/kg for each kg >20kg |

*Neonatal fluid homeostasis in the first few weeks of life naturally undergoes various changes including initial diuresis and weight loss, consolidation until birthweight is regained followed by stable growth above birth weight3. Fluid allowance on day 1 of life should be in the region of 60ml/kg/day3,12 and increased each day as tolerated.

In calculating the fluid volume for PN consideration should be given to:
- Oral/enteral fluid intake
- Intake from medications (particularly those given IV)
- Losses, e.g. insensible, urine, from stoma, vomiting, diarrhoea
- Current fluid balance

Insensible losses may be increased by fever (5 mL/kg/day lost for each degree of temperature >38°C), extensive burns or a rapid respiratory rate1. Fluid may need to be restricted in cardiac disease, bronchopulmonary dysplasia, head trauma, renal failure1, sepsis, meningitis, the first 48 hours postoperatively and in intensive care.

Some infants <10kg may require >100ml/kg to achieve nutritional goals, especially those <3 months of age and/or patients with intestinal failure. Maximum osmolarities for safely administering PN or a paucity of stability data may limit the amount by which PN can be concentrated. The ward pharmacist and NST will liaise with PSU regarding minimum suitable fluid volumes.

Sometimes only part of a PN bag should be administered when giving all would compromise fluid balance or cause problems with electrolyte balance. See section 3.3 ‘alterations’ for information. For example, over the weekend serum potassium is high, the RMO prescribes 75% of the original PN volume over 24 hours along with 0.9% saline making up the other 25%.

Electrolytes and minerals3

ESPGHAN guidelines suggest the following:

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Unit</th>
<th>0-6 mths</th>
<th>7-12 mths</th>
<th>1-18 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>mmol/kg/day</td>
<td>2 - 3</td>
<td>1 - 3</td>
<td>1 - 3</td>
</tr>
<tr>
<td>Potassium</td>
<td>mmol/kg/day</td>
<td>1 - 3</td>
<td>1 - 3</td>
<td>1 - 3</td>
</tr>
<tr>
<td>Calcium</td>
<td>mmol/kg/day</td>
<td>0.8 - 1.5</td>
<td>0.5</td>
<td>0.25 - 0.4</td>
</tr>
<tr>
<td>Phosphorus (phosphate)</td>
<td>mmol/kg/day</td>
<td>0.7 - 1.3</td>
<td>0.5</td>
<td>0.2 - 0.7</td>
</tr>
<tr>
<td>Magnesium</td>
<td>mmol/kg/day</td>
<td>0.1 - 0.2</td>
<td>0.15</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The balance of calcium to phosphorus is important for optimal bone accretion – avoid providing large amounts of phosphate without also considering the need for extra calcium. Adolescents who have completed the teenage growth spurt may not require as much calcium or phosphate as the period of rapid bone accretion is over - ‘adult’ electrolytes may be appropriate. Girls are likely to have completed puberty by 16 years and boys by 17 years (RCPCH growth charts), however take care in cases of delayed onset puberty. ESPEN guidelines7 suggest these electrolytes for adults on home PN, which may also be appropriate for older adolescents (at clinical discretion):
<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Unit</th>
<th>1-1.5</th>
<th>0.1 – 0.15</th>
<th>0.3 – 0.5</th>
<th>0.1 – 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>mmol/kg/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>mmol/kg/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (phosphate)</td>
<td>mmol/kg/day</td>
<td></td>
<td>0.1 – 0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>mmol/kg/day</td>
<td></td>
<td>0.3 – 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>mmol/kg/day</td>
<td></td>
<td>0.1 – 0.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Some provisos apply:
- Take into account that some drugs contain significant amounts of sodium, e.g. IV antibiotics.
- When PN is first initiated in neonates, particularly if giving low calories, there is a tendency for phosphate to be drawn into cells and good amounts of phosphate are required, e.g. Ca:Phosphate ratio of 1 or less.
- Sodium requirements are likely to be higher in some types of intestinal failure. Urinary electrolytes should be used to aid decision-making around sodium dose when intestinal losses are high or malabsorption is suspected.
- Some chemotherapy leads to shedding of magnesium via the kidneys necessitating higher than usual doses of magnesium.

Before changing the electrolyte levels the following should be considered:
- How long has the previous change been in effect?
- How much of the PN bag has been administered?
- What is the trend or serial change in electrolytes rather than individual results?
- What are the urine electrolytes?
- Are there other factors e.g. excess fluid losses or sodium from drug infusions?
Make gradual rather than large changes to avoid dramatic shifts in levels

Metabolic bone disease, characterised by incomplete bone mineralisation and manifesting with problems such as osteopenia or fractures may arise as a result of insufficient supply and/or utilisation of calcium, phosphate. Increases in alkaline phosphatase in a child on long-term PN should be scrutinised in case it indicates mineral resorption from bone. Parathyroid hormone may need to be checked - refer to NST for advice.

Acetate and chloride
The sodium in PN may be ordered as the acetate or chloride salts, or a combination of both. Other components of PN, such as other electrolytes solutions and nitrogen-containing solutions may contribute acetate and chloride. The PSU insert sheet will display the overall mmol amounts of acetate and chloride. Children who are acidotic should be given a chloride/acetate ratio of 1:2 or less. For children with alkalosis consideration should be given to minimising the acetate content of PN.

Vitamins and trace elements
An adequate supply of vitamins, minerals and trace elements is essential for growth and development. Vitamins should generally be given daily. All vitamins, minerals and trace elements in bespoke PN are added to PN bags by the PSU and must not be done at ward level. Supplemented standardised PN also contain vitamins and trace elements. Trace elements may be given to neonates from day one of PN.

Iron
Iron is not routinely added to bespoke PN for children <40kg and iron-deficiency anaemia may develop after prolonged PN. Anaemia may also commonly result from excessive venesection. Iron is contained in additrace®, which is used for children >40kg (and sometimes >30kg in supplemented PN off-label).

If iron deficiency develops, enteral iron is preferred to parenteral iron if it is tolerated and likely to be tolerated. Do not give iron in the first 3 weeks of life or for PN duration < 3 weeks. If enteral iron is contraindicated or fails to correct anaemia, parenteral iron is indicated either via periodic iron infusions or adding iron to PN although adding iron to PN may lead to stability problems and carries a risk or iron overload. Seek advice from NST before adding iron into PN.

Zinc
Zinc is provided in peditrace® or additrace®. Sometimes serum zinc is found to be low – usually in situations where there are increased losses eg in intestinal failure, fistulae and exudate in burns patients. Additional zinc can be given within PN by adding zinc sulfate injection. Seek advice from NST.
2. Managing PN associated complications

2.1 Suspected Line Sepsis

Possible signs and symptoms of line sepsis include episodes of fever, chills, flu'-like symptoms, a rise in c-reactive protein (CRP), metabolic acidosis, thrombocytopenia, glucose instability, tachycardia or shortness of breath\(^3\). Fever of > 38.0°C on > one occasion > least 30 minutes apart or > 38.5°C on one occasion is considered as significant. There may or may not be localised signs of an exit site infection\(^17\). However, patients on PN undergoing major surgery are likely to have post-op fever and raised inflammatory markers. This may not therefore be line sepsis; senior review may be indicated to decide about the need for antibiotics.

Assume and treat as a line infection whilst investigating other causes. Take blood cultures samples from all catheter lumens and a peripheral vein, ideally before initiating antibiotics\(^18\). If there is no Y-site connector to enable blood sampling, PN should be disconnected and that bag discarded. Label samples clearly to indicate which site they were taken from. Urine MC&S, bloods including FBC, CRP, U&E, LFTs and other tests should be taken as indicated (e.g. stool culture, LP).

Distinctions should be made between patients expected to be on long-term PN for intestinal failure and those who are receiving PN more short-term. Any patient receiving HPN who presents with fever with no clear source should be presumed to have line sepsis and started on antibiotics as below. For other patient groups empiric IV antibiotics should be initiated as per Antibiotic guidelines for paediatric surgery, or Management of infections in Haematology and Oncology patients.

Long-term intestinal failure patients

Patients will be under the care of a paediatric gastroenterologist and receive PN at home or will be discharged on PN. Running out of accessible line sites and overwhelming sepsis are potentially fatal.

The following general principles apply:
Each patient will have a plan for managing sepsis. Parents/carers should carry a copy and it may be available on their evolve notes under ‘special information’.

Management is focused on salvaging the PN line as the patient is dependent on the line for a significant proportion of their fluids/nutrition.

PN should be paused during the initial assessment of sepsis/suspected sepsis to enable blood cultures to be taken.

Systemic antibiotics should be initiated as soon as possible and administered down the PN-line/lumen(s), and if there are multiple lumens they should be alternated through each lumen.

The empiric choice is Piperacillin/tazobactam 90mg/kg q8hour with gentamicin (see Aminoglycoside guideline in children for dosing advice), provided the patient is not penicillin-allergic. Antibiotics may need to be altered as per sensitivities once blood culture results are back.

- If the patient is penicillin-allergic seek advice from microbiology on suitable alternatives.
- Clear fluids may be administered IV through the affected line or another suitable catheter if necessary until PN resumes – contact the paediatric gastroenterology team or on-call doctor to review.
- PN should not be withheld for >24 hours.
- A paediatric gastroenterology SpR, consultant paediatric gastroenterologist or the NST will decide when to resume PN. PN should be given via the usual PN line or lumen.
- Duration of antibiotics will be determined on an individual basis by the paediatric gastroenterology team or NST in conjunction with microbiology.
- Microbiology may recommend antibiotic line locks. These must be prescribed on a drug chart. Refer to Intravascular related sepsis protocol for paediatrics (suspected and documented infection) for information.
- Antibiotic line locks should be used on all lumens of the CVC regardless of which lumen was infected.
- Lack of adequate response to systemic antibiotics after 48-72 hours, severe sepsis, clinical relapse after initial improvement, supplicative complications, endocarditis, fungaemia and infections involving S aureus or Pseudomonas may be an indication to remove the PN line. Do not remove PN line without discussing first with a paediatric gastroenterologist or the NST.

Other patient groups

- PN should be paused during the initial assessment of sepsis/suspected sepsis to enable blood cultures to be taken.
- Initiate broad spectrum IV antibiotics through the affected line as soon as possible after taking blood cultures (refer to Antibiotic guidelines for paediatric surgery or specialist guidance for haematology/oncology patients in Management of infections in Haematology and Oncology patients). Antibiotics may need to be altered as per sensitivities once blood culture results are back.
- If the affected line has multiple lumens antibiotics should be alternated through each lumen.
- PN may be replaced with clear fluids for up to 24 hours. If considering withholding PN >24 hours, discuss first with the NST.

Strategies to minimise line sepsis

- Strict hand hygiene
- Chlorhexidine 2% and 70% alcohol application at line insertion and dressing change
- Promptly remove any unnecessary venous catheters
- Use maximum sterile barriers during line insertion
- Consider reassessing the parents/carers for their aseptic technique as required

Locking lines with Taurolock®

HPN patients with recurrent sepsis may be prescribed Taurolock® rather than heparin sodium to lock the PN line. Taurolock® contains anticoagulant and antimicrobial substances. The active ingredients are taurolidine and citrate. Instil the necessary line lock volume as per below (depending on the line type and size) and withdraw prior to initiating the next treatment. Taurolock® must be prescribed on an inpatient medication chart. Accidental flushing through is not harmful to the patient and does not interfere with blood results.

<table>
<thead>
<tr>
<th>Catheter type/volume</th>
<th>Broviac 2.7 Fr - 6.6 Fr</th>
<th>Single lumen Hickman 6.5Fr, 9.5 Fr</th>
<th>Double lumen Hickman 7.0Fr, 9.0Fr, 10Fr, 12Fr</th>
<th>Implantable ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lock volume</td>
<td>0.5ml</td>
<td>1ml</td>
<td>1ml</td>
<td>2ml</td>
</tr>
</tbody>
</table>

Extended until April 2022
2.2 Extravasation

For general advice on extravasation management see guideline Extravasation and infiltration – identification and management in neonates and paediatric patients. PN solutions are acidic due to glucose and amino acid content, with electrolytes also contributing some osmolar load. Extravasation should be suspected if there is swelling, pain or discomfort, discoloration of infusion site or infusion pump alarming for an occlusion.

2.3 Line occlusion

For general advice on unblocking CVCs, see guideline Central venous catheter guidelines for paediatrics. Methods to prevent line occlusion include:

- Minimising blood sampling
- Use a push/pause technique for line flushing
- Flushing with sodium chloride between all therapies and blood sampling
- Flushing CVCs with heparin at least weekly when not in use (see 1.2 ‘Lock solutions’ within Central venous catheter guidelines for paediatrics for volume and strength of heparin)
- Avoiding syringes of <10ml volume

If the above is not successful seek advice from the NST or ward pharmacist.

Locking lines with Ethanol

Ethanol at 70% concentration may be helpful for dissolving lipid deposits in CVCs or as an antimicrobial agent to prevent line infections. Ethanol is usually obtained as 90% or 100% (absolute alcohol) concentration which requires further dilution with water for injection to obtain 70% concentration.

General advice:

- See volumes above under ‘Locking lines with Taurolock’ for volume to instill.
- Avoid mixing ethanol with heparin as this may form a precipitate.
- Aspirate the lock don’t flush through.
- Avoid in severe liver disease.
- Adverse effects, particularly but not limited to ethanol being flushed through, include flushing, nausea, altered taste, visual blurring or feeling faint. Transient liver function test changes have been reported.
- Do not use in polyurethane catheters, which includes many short-term lines used at BRHC, e.g. Vygon multicath triple lumen lines and Bard power PICCs. Groshong and Cook tunnelled catheters are made of silicone which is compatible with ethanol.

There have been reports in literature of catheter occlusion or fracture associated with ethanol locks, which may theoretically be worsened by longer dwell times and use in polyurethane catheters. There is a paucity of evidence regarding the most appropriate technique for either occlusions or antimicrobial prophylaxis/treatment. The approaches below may be followed but seek further information from NST.

For CVC occlusion:
A dwell time of 1-2 hours, followed by aspiration has been suggested with a second dose administered shortly afterwards if the line is still sluggish.

As an antimicrobial:
It can be used regularly - from once weekly to once daily. The minimum effective dwell time is 2 hours.

2.4 Venous thromboembolism

Thrombosis relating to CVCs can involve the catheter tip, length of the catheter or the blood vessel. Symptoms may range from difficulty drawing back blood from the line/flushing line to symptoms associated with the occlusion of a major vessel such as swelling of the head/neck/lower limb. See ‘line occlusion’ above for management of lines which are difficult to bleed or flush. Guidance should be sought from the haematology team before initiating any treatment for suspected thromboembolism of a vessel.

2.5 Refeeding syndrome

Extended until April 2022
Specialist advice should be sought from the NST/ward dietitian as soon as practicable before or just after initiating PN for patients at high risk of refeeding syndrome. It is more likely to occur in malnourished patients who have lost more than 10% of their body weight over the previous 2 months. Patients can become at risk after more than 72 hours without nutrition. If hypophosphatemia is present, it should be corrected before starting PN as the glucose in PN may cause phosphate to move intracellularly and reduce serum phosphate further. Symptoms of refeeding include oedema, confusion, resting tachycardia and low serum phosphate. See guideline Management of Refeeding Syndrome for full guidance.

The general principles of management are:

- Prescribe and administer thiamine prior to starting PN.
- Give at least the age-recommended amounts of phosphate in first day of PN (see appendix part 1).
- If potassium, magnesium and/or phosphate levels reduce once the child is on PN but there are no clinical signs of refeeding keep on the same calories per day until electrolytes are replaced and normalised.
- If there are clinical signs of refeeding return to the day 1 calorie provision and only increase once the patient is clinically stable.

2.6 Hyperglycaemia

Before amending PN rate or prescription consider:

- Are there any reasons for impaired glucose metabolism e.g. sepsis, stress response, steroids, tacrolimus.
- Glucose intake from fluids, reconstitution of IV drugs, dietary intake (sweets, fruit juice etc).
- Accuracy of glucose measurements e.g. finger prick technique, contamination of samples.

Address non-PN causes of hyperglycaemia where possible and ensure samples are valid – repeat samples if any concerns.

Management

Definition of hyperglycaemia (neonates, infants, children):

Blood glucose > 11mmol/L, although there is some evidence that levels >8mmol/L are associated with worse outcomes in neonates, infants and children in an intensive care setting so thresholds in PICU may be lower.

Management:

- Check for glycosuria by dipping urine for glucose. If positive, some action needs to be taken, if negative continue to monitor blood glucose (and dip urine for high results).
- Seek advice from NST.
- Reduce glucose dose in bespoke PN or amount of standardised PN administered, but note this leads to lower calories. Minimum glucose dose 3.6g/kg/day in neonates (although more is usually required to prevent hypoglycaemia), for other age groups refer to section on carbohydrate. It may be appropriate to halve the amount of glucose and gradually increase to 75% of the original dose followed by 100% if blood glucose is satisfactory and there are no clinical signs of hyperglycaemia e.g. glycosuria, polyuria, polydipsia.
- Co-administer insulin alongside PN only under consultant advice. Seek advice from endocrinology.

2.7 Hypertriglyceridaemia

It is not well defined in literature whether triglyceride levels should be taken whilst lipid is being infused or not - for practical purposes levels can be interpreted when lipid is running provided measures are taken to avoid frank contamination with PN. There may be an association between acute pancreatitis and serum triglycerides >11.4mmol/L.

Lipid dose should be adjusted (or glucose if relevant – see below) if marked hyperlipidaemia occurs (>3mmol/L in neonates/infants or >4.5mmol/L in older children). The risk of hypertriglyceridaemia is greater in malnourished patients as they have a reduced clearance of triglycerides.

Management of a high triglyceride level:

- Check whether the line was flushed prior to the sample being taken.
- If the sample was lipaemic repeat either on or off lipid.
- In other cases repeat after 4-hour break off lipid as this helps demonstrate whether the patient can clear lipid adequately or not. This requires lipid to be infused over 20 or less hours.
- Seek advice from NST or ward pharmacist on the next working day regarding amendments to PN. Do not withhold lipid unless the patient is clinically unwell or the level is >10mmol/L.
- Considerations for prescribers and ward pharmacists:
  - If glucose dose is high (refer to carbohydrate above) reduce the amount of glucose given before altering lipid dose as excess carbohydrate can lead to hypertriglyceridaemia. Consider glucose load from other...
infusions and reconstitution of IV drugs.

- Generally reduce lipid dose rather than stopping lipid altogether unless the patient is clinically unwell or the level is particularly high (check validity of sample first).
- Check whether the patient has recently had propofol which may elevate triglyceride levels, or if there is a clinical reason for impaired lipid clearance such as sepsis or familial hypertriglyceridaemia.
- Consider halving the lipid dose or reduce to the last dose associated with normal triglyceride levels.
- Recheck triglycerides 1-2 days after dose change of lipid and/or glucose

2.8 Intestinal Failure associated liver disease (IFALD)

IFALD may affect children with IF receiving long-term PN, and can present as early reversible disease or end-stage liver failure. Diagnosis is often made in the presence of long-term PN-dependency, IF and cholestasis. There are various theories as to the cause of IFALD. Risk factors include:

- prematurity
- recurrent infections
- lack of enteral feeding
- longer total exposure to PN
- small bowel bacterial overgrowth
- surgical interventions, e.g. ileal resection
- having continuous PN over 24 hours
- imbalance of PN constituents
- use of antibiotics

Measures to prevent IFALD or other adverse effects of PN on hepatobiliary function:

- Initiate and maximise enteral/oral feeding
- Use cyclical PN as soon as the patient is clinically stable (see cyclical PN)
- Avoid excessive intake of glucose and/or fat in PN
- Avoid over-feeding
- Avoid intralipid in the presence of cholestasis

Diagnosis

- Specialist advice should be sought from a paediatric gastroenterologist
- Isolated raised ALT or AST, GGT up to 150IU/L in a child with IF is unlikely to be IFALD
- If total bilirubin is >20 micromol/L in a patient on long-term PN, retest and refer to gastroenterology if bilirubin does not decrease

Management

- Promoting oral/enteral feeding and reducing reliance on PN is the mainstay of treatment.
- In patients on HPN strategies such as reducing the average daily dose of lipid and/or calorie intake and the number of hours PN is infused over are often utilised to prevent and treat IFALD.
- Medications that reduce small bowel bacterial load (e.g. metronidazole) may be indicated if intestinal stasis and signs of bacterial overgrowth are present.
- Ursodeoxycholic acid may be helpful in the presence of biochemical signs of cholestasis.
- Pure fish-oil containing lipid is not currently recommended for initiation in inpatients.
### 3. Constituents of PN

<table>
<thead>
<tr>
<th>Constituents of PN</th>
<th>General PN constituents</th>
<th>Contained in</th>
<th>Examples of constituents</th>
<th>Examples of products</th>
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</thead>
<tbody>
<tr>
<td>Macronutrients</td>
<td>Carbohydrates</td>
<td>Aqueous solution or all-in-one PN solution</td>
<td>Glucose</td>
<td>Vamin 18, Vaminolact</td>
</tr>
<tr>
<td></td>
<td>Amino acids</td>
<td>Lipid solution or all-in-one PN solution</td>
<td>Soya bean lipid emulsion, medium chain triglycerides, olive oil, fish oil, alpha-tocopherol</td>
<td>Intralipid 20%, SMOFLipid 20%</td>
</tr>
<tr>
<td>Micronutrients</td>
<td>Vitamins</td>
<td>Aqueous solution or all-in-one PN solution</td>
<td>Water soluble vitamins (C, B group, folic acid), fat soluble vitamins (A, D, E, K)</td>
<td>Solivito N, Vitlipid</td>
</tr>
<tr>
<td></td>
<td>Trace elements</td>
<td>Aqueous solution or all-in-one PN solution</td>
<td>Selenium, zinc, copper, manganese, iodine, fluoride</td>
<td>Peditrace, Additrace</td>
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<tr>
<td>Electrolytes</td>
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<td>Aqueous solution or all-in-one PN solution</td>
<td>Potassium, phosphate, calcium, sodium, magnesium</td>
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<tr>
<td>Other</td>
<td></td>
<td>Aqueous solution or all-in-one PN solution</td>
<td>Water, acetate, chloride, iron</td>
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#### PN additions

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Quantity per ml (conventional)</th>
<th>Quantity per ml (other)</th>
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<tr>
<td>Peditrace®</td>
<td>Paediatric trace elements</td>
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<tr>
<td>Selenium</td>
<td>2 µg</td>
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<td>Manganese</td>
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<td>Copper</td>
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<td>Iodine</td>
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<td>Water soluble vitamins</td>
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<td>Ascorbic acid</td>
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<tr>
<td>Thiamine</td>
<td>0.25 mg</td>
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<tr>
<td>Riboflavin</td>
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<tr>
<td>Pyridoxine</td>
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<tr>
<td>Nicotinamide</td>
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<tr>
<td>Vitamin B12</td>
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<tr>
<td>Panthenolic acid</td>
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</tr>
<tr>
<td>Biotin</td>
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<tr>
<td>Folic acid</td>
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<td></td>
</tr>
<tr>
<td>Vitlipid N Infant®</td>
<td>Fat soluble vitamins</td>
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<tr>
<td>Vitamin A (as retinol)</td>
<td>69 µg (230 IU)</td>
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</tr>
<tr>
<td>Vitamin D (ergocalciferol)</td>
<td>1 µg (40 IU)</td>
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<tr>
<td>Vitamin E</td>
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<td>Vitamin K (phytomenadione)</td>
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</tr>
<tr>
<td>Additrace®</td>
<td>Adult trace elements</td>
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<td>Chromium</td>
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<tr>
<td>Copper</td>
<td>2 micromoles</td>
<td>127 µg</td>
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<tr>
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<tr>
<td>Iodine</td>
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<tr>
<td>Fluoride</td>
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<tr>
<td>Molybdenum</td>
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<tr>
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<tr>
<td>Vitlipid N Adult®</td>
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<tr>
<td>Vitamin A (as retinol)</td>
<td>99 µg (330 IU)</td>
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<tr>
<td>Vitamin D (ergocalciferol)</td>
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</tr>
<tr>
<td>Vitamin E</td>
<td>0.91 mg (1 IU)</td>
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</tr>
<tr>
<td>Vitamin K (phytomenadione)</td>
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</tr>
<tr>
<td>Nutratain®</td>
<td>Adult vitamins</td>
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<tr>
<td>Ascorbic acid</td>
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<tr>
<td>Thiamine</td>
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<tr>
<td>Riboflavin</td>
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<tr>
<td>Pyridoxine</td>
<td>0.6mg</td>
<td></td>
</tr>
<tr>
<td>Nicotinamide</td>
<td>4mg</td>
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<tr>
<td>Vitamin B12</td>
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<tr>
<td>Panthenolic acid</td>
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<tr>
<td>Biotin</td>
<td>5 µg</td>
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<tr>
<td>Folic acid</td>
<td>60 µg</td>
<td></td>
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</tbody>
</table>

*Extended until April 2022*
Vitamin A (as retinol) | 100 µg (330 IU)  
Vitamin D (ergocalciferol) | 0.5 µg (20 IU)  
Vitamin E | 0.91 mg (1 IU)  
Vitamin K (phytomenadione) | 15 µg  

Nutreyl®  
Nutrients | Content |  
--- | --- |  
Chromium | 0.02 micromoles |  
Copper | 0.47 micromoles |  
Iron | 1.6 micromoles |  
Manganese | 0.1 micromoles |  
Iodine | 0.1 micromoles |  
Fluoride | 5 micromoles |  
Molybdynem | 0.02 micromoles |  
Selenium | 0.09 micromoles |  
Zinc | 15.3 micromoles |  

Prefilled PN / Standardised PN  
For the contents of SMOFKabiven peripheral and ITH/Babiven concentrated or ITH/Babiven term see Use of Parenteral Nutrition Pre-filled Bags (standard babiven and smofkabiven bags).

SMOFKabiven Central denoted with numbers for bag sizes: 4 = 493ml, 8 = 986ml, 12 = 1477ml, 16 = 1970ml  

<table>
<thead>
<tr>
<th>Per kg quantity</th>
<th>60ml/kg</th>
<th>50ml/kg</th>
<th>45ml/kg</th>
<th>40ml/kg</th>
<th>35ml/kg</th>
<th>30ml/kg</th>
<th>25ml/kg</th>
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<tbody>
<tr>
<td>Nitrogen (g)</td>
<td>0.49</td>
<td>0.41</td>
<td>0.37</td>
<td>0.32</td>
<td>0.28</td>
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<tr>
<td>Glucose (g)</td>
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<td>5.71</td>
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<td>Fat (g)</td>
<td>2.28</td>
<td>1.90</td>
<td>1.71</td>
<td>1.52</td>
<td>1.33</td>
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<tr>
<td>Na (mmol)</td>
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<td>2.03</td>
<td>1.83</td>
<td>1.62</td>
<td>1.42</td>
<td>1.22</td>
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<tr>
<td>K (mmol)</td>
<td>1.83</td>
<td>1.52</td>
<td>1.37</td>
<td>1.22</td>
<td>1.07</td>
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<td>0.76</td>
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<td>Ca (mmol)</td>
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<tr>
<td>Mg (mmol)</td>
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<td>0.25</td>
<td>0.23</td>
<td>0.20</td>
<td>0.18</td>
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<td>Phosphate (mmol)</td>
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<td>Acetate (mmol)</td>
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<td>3.71</td>
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<td>Total energy (Kcal)</td>
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<td>39.09</td>
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Supplemented Nutriflex Lipid Plus = Lipoflex Plus. Contents listed from 1250ml bag, supplemented by addition of 10ml each of Nutreylt and Nutratain. Total volume 1266ml.

<table>
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<th>Per kg quantity</th>
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<th>50ml/kg</th>
<th>45ml/kg</th>
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<tr>
<td>Nitrogen (g)</td>
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<td>Fat (g)</td>
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<td>1.60</td>
<td>1.40</td>
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<tr>
<td>Na (mmol)</td>
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<td>1.80</td>
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<tr>
<td>K (mmol)</td>
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<td>0.84</td>
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<tr>
<td>Ca (mmol)</td>
<td>0.19</td>
<td>0.18</td>
<td>0.16</td>
<td>0.14</td>
<td>0.13</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Mg (mmol)</td>
<td>0.19</td>
<td>0.18</td>
<td>0.16</td>
<td>0.14</td>
<td>0.13</td>
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<td>0.48</td>
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<td>Chloride mmol</td>
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<td>Acetate (mmol)</td>
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<td>1.98</td>
<td>1.80</td>
<td>1.62</td>
<td>1.44</td>
<td>1.26</td>
<td>1.08</td>
</tr>
<tr>
<td>Total energy (Kcal)</td>
<td>60.72</td>
<td>55.66</td>
<td>50.60</td>
<td>45.54</td>
<td>40.48</td>
<td>35.42</td>
<td>30.36</td>
</tr>
</tbody>
</table>
**Supplemented Nutriflex Lipid Special = Lipoflex Special.** Contents listed from 1250ml bag, supplemented by addition of 10ml each of Nutryelt and Nutratain. **Total volume 1266ml.**

<table>
<thead>
<tr>
<th>Per kg quantity</th>
<th>55ml/kg</th>
<th>50ml/kg</th>
<th>45ml/kg</th>
<th>40ml/kg</th>
<th>35ml/kg</th>
<th>30ml/kg</th>
<th>25ml/kg</th>
<th>20ml/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (g)</td>
<td>0.44</td>
<td>0.40</td>
<td>0.36</td>
<td>0.32</td>
<td>0.28</td>
<td>0.24</td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>Glucose (g)</td>
<td>7.92</td>
<td>7.20</td>
<td>6.48</td>
<td>5.76</td>
<td>5.04</td>
<td>4.32</td>
<td>3.60</td>
<td>2.88</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>2.2</td>
<td>2.00</td>
<td>1.80</td>
<td>1.60</td>
<td>1.40</td>
<td>1.20</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Na (mmol)</td>
<td>2.95</td>
<td>2.68</td>
<td>2.41</td>
<td>2.14</td>
<td>1.88</td>
<td>1.61</td>
<td>1.34</td>
<td>1.07</td>
</tr>
<tr>
<td>K (mmol)</td>
<td>2.07</td>
<td>1.88</td>
<td>1.69</td>
<td>1.50</td>
<td>1.32</td>
<td>1.13</td>
<td>0.94</td>
<td>0.75</td>
</tr>
<tr>
<td>Ca (mmol)</td>
<td>0.23</td>
<td>0.21</td>
<td>0.19</td>
<td>0.17</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Mg (mmol)</td>
<td>0.23</td>
<td>0.21</td>
<td>0.19</td>
<td>0.17</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Phosphate (mmol)</td>
<td>0.88</td>
<td>0.80</td>
<td>0.72</td>
<td>0.64</td>
<td>0.56</td>
<td>0.48</td>
<td>0.40</td>
<td>0.32</td>
</tr>
<tr>
<td>Chloride (mmol)</td>
<td>2.64</td>
<td>2.40</td>
<td>2.16</td>
<td>1.92</td>
<td>1.68</td>
<td>1.44</td>
<td>1.20</td>
<td>0.96</td>
</tr>
<tr>
<td>Acetate (mmol)</td>
<td>2.64</td>
<td>2.40</td>
<td>2.16</td>
<td>1.92</td>
<td>1.68</td>
<td>1.44</td>
<td>1.20</td>
<td>0.96</td>
</tr>
<tr>
<td>Total energy (Kcal)</td>
<td>64.9</td>
<td>59.00</td>
<td>53.10</td>
<td>47.20</td>
<td>41.30</td>
<td>35.40</td>
<td>32.45</td>
<td>29.50</td>
</tr>
</tbody>
</table>

**SMOFVen 11.** Contains 10ml additrace, 1 ampoule (equivalent of 10ml) solivito and 10ml vitlipid adult. **Total volume 2053ml (SMOFVen 8 = 1540ml volume).**

<table>
<thead>
<tr>
<th>Volume</th>
<th>60ml/kg</th>
<th>55ml/kg</th>
<th>50ml/kg</th>
<th>45ml/kg</th>
<th>40ml/kg</th>
<th>35ml/kg</th>
<th>30ml/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (g)</td>
<td>0.32</td>
<td>0.29</td>
<td>0.26</td>
<td>0.24</td>
<td>0.21</td>
<td>0.18</td>
<td>0.16</td>
</tr>
<tr>
<td>Glucose (g)</td>
<td>5.85</td>
<td>5.36</td>
<td>4.87</td>
<td>4.38</td>
<td>3.90</td>
<td>3.41</td>
<td>2.92</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>2.37</td>
<td>2.17</td>
<td>1.97</td>
<td>1.78</td>
<td>1.58</td>
<td>1.39</td>
<td>1.19</td>
</tr>
<tr>
<td>Na (mmol)</td>
<td>1.87</td>
<td>1.72</td>
<td>1.56</td>
<td>1.40</td>
<td>1.25</td>
<td>1.09</td>
<td>0.93</td>
</tr>
<tr>
<td>K (mmol)</td>
<td>1.40</td>
<td>1.29</td>
<td>1.17</td>
<td>1.05</td>
<td>0.94</td>
<td>0.82</td>
<td>0.70</td>
</tr>
<tr>
<td>Ca (mmol)</td>
<td>0.12</td>
<td>0.11</td>
<td>0.10</td>
<td>0.09</td>
<td>0.08</td>
<td>0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>Mg (mmol)</td>
<td>0.23</td>
<td>0.21</td>
<td>0.19</td>
<td>0.18</td>
<td>0.16</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>Phosphate (mmol)</td>
<td>0.58</td>
<td>0.54</td>
<td>0.49</td>
<td>0.44</td>
<td>0.39</td>
<td>0.34</td>
<td>0.29</td>
</tr>
<tr>
<td>Chloride (mmol)</td>
<td>2.70</td>
<td>2.47</td>
<td>2.25</td>
<td>2.02</td>
<td>1.80</td>
<td>1.57</td>
<td>1.35</td>
</tr>
<tr>
<td>Acetate (mmol)</td>
<td>1.84</td>
<td>1.69</td>
<td>1.54</td>
<td>1.38</td>
<td>1.23</td>
<td>1.07</td>
<td>0.92</td>
</tr>
<tr>
<td>Total energy (Kcal)</td>
<td>54.45</td>
<td>49.91</td>
<td>45.37</td>
<td>40.91</td>
<td>36.36</td>
<td>31.76</td>
<td>27.27</td>
</tr>
</tbody>
</table>

### 4. Enteral Nutrition

Where ever possible, patients on parenteral nutrition should also receive oral/enteral nutrition, even if only minimal amounts are tolerated.

Any enteral feeding promotes gut growth, function and normal bowel flora. It encourages normal gut hormonal secretion and encourages entero-hepatic circulation which is likely to reduce IFALD. Furthermore, children can develop food avoidance behaviour if oral motor skills are not continued while receiving parenteral nutrition. Milk fed infants can be offered non-nutritive feeds by dummy dips even if no other volume of feed can be tolerated. Older children should be offered small volumes of milk based feeds or bites of dissolvable solids provided they are not contraindicated. Please refer to the ward dietitian or NST for advice.

For further information on enteral nutrition refer to the [Enteral Feeding (Paediatric)](https://example.com).
5. PSU insert sheet and PN prescription examples

**PSU insert example**

---

**TPN Prescription:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Total for PN (g)</th>
<th>per Kilogram (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>954 kcal</td>
<td>44.6 kcal/kg</td>
</tr>
<tr>
<td>Total N</td>
<td>3.85 g</td>
<td>1.77 g/kg</td>
</tr>
<tr>
<td>Glucose</td>
<td>166 g</td>
<td>7.52 g/kg</td>
</tr>
<tr>
<td>Lipid</td>
<td>17.5 g</td>
<td>0.82 g/kg</td>
</tr>
<tr>
<td>Sodium</td>
<td>4.43 mmol</td>
<td>2.06 mmol/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>30.9 mmol</td>
<td>1.46 mmol/kg</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.99 mmol</td>
<td>0.05 mmol/kg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.12 mmol</td>
<td>0.05 mmol/kg</td>
</tr>
<tr>
<td>Phosphates</td>
<td>11.07 mmol</td>
<td>0.52 mmol/kg</td>
</tr>
<tr>
<td>Zinc</td>
<td>21.20 mmol</td>
<td>0.99 mmol/kg</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.11 mmol</td>
<td>0.05 mmol/kg</td>
</tr>
<tr>
<td>Chloride</td>
<td>4.67 mmol</td>
<td>0.22 mmol/kg</td>
</tr>
<tr>
<td>Acetate</td>
<td>4.73 mmol</td>
<td>0.22 mmol/kg</td>
</tr>
<tr>
<td>Copper</td>
<td>2.23 mmol</td>
<td>0.10 mmol/kg</td>
</tr>
<tr>
<td>Iron</td>
<td>0 µmol</td>
<td>0 µmol/kg</td>
</tr>
<tr>
<td>Volume</td>
<td>752.64 ml</td>
<td>36.42 ml/kg</td>
</tr>
</tbody>
</table>

**Formula:** Amino acids, glucose and electrolytes

**Volume and infusion rate for lipid syringe(s) or bag**

**Total volume of PN prescribed**

For nurse(s) administering/ checking

Please sign to confirm the above regimen. File in patient's notes when infusion complete.
Home PN prescription examples

Extended until April 2022
**Volume to be infused per day (formulation 1)**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Total Qty in ml</th>
<th>Total Qty infused</th>
<th>Qty infused/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (incl. glutamine)</td>
<td>0.5g</td>
<td>0.38g</td>
<td></td>
</tr>
<tr>
<td>Glutamine (as d-glucose)</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Magnesium Sulfate 50%</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Zinc Sulphate 50 umol/ml</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Calcium Chloride Triomethine</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Water for Injections</td>
<td>207.27ml</td>
<td>207.27ml</td>
<td>0.84g</td>
</tr>
<tr>
<td>Fe Chloride 1.78 umol/ml</td>
<td>1.69g</td>
<td>1.69g</td>
<td></td>
</tr>
<tr>
<td>Varnish EF</td>
<td>213.22ml</td>
<td>213.22ml</td>
<td>0.94g</td>
</tr>
<tr>
<td>Glucose 50%</td>
<td>282.6ml</td>
<td>282.6ml</td>
<td>1.22g</td>
</tr>
<tr>
<td>Sodium Chloride 5%</td>
<td>8.28g</td>
<td>8.28g</td>
<td></td>
</tr>
<tr>
<td>Sodium Phosphate 21.6%</td>
<td>8.54g</td>
<td>8.54g</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>759.57ml</td>
<td>759.57ml</td>
<td>3.19g</td>
</tr>
</tbody>
</table>

**Infusion duration (formulation 1)**

- Volume to be infused: 759.57ml
- Min. Infusion duration: 12.00 hr
- Infusion frequency: 5.00 times/week

**Extended until April 2022**

---

**Volume to be infused per day (formulation 2)**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Total Qty in ml</th>
<th>Total Qty infused</th>
<th>Qty infused/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (incl. glutamine)</td>
<td>0.5g</td>
<td>0.38g</td>
<td></td>
</tr>
<tr>
<td>Glutamine (as d-glucose)</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Magnesium Sulfate 50%</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Zinc Sulphate 50 umol/ml</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Calcium Chloride Triomethine</td>
<td>0.00g</td>
<td>0.00g</td>
<td></td>
</tr>
<tr>
<td>Water for Injections</td>
<td>207.27ml</td>
<td>207.27ml</td>
<td>0.84g</td>
</tr>
<tr>
<td>Fe Chloride 1.78 umol/ml</td>
<td>1.69g</td>
<td>1.69g</td>
<td></td>
</tr>
<tr>
<td>Varnish EF</td>
<td>213.22ml</td>
<td>213.22ml</td>
<td>0.94g</td>
</tr>
<tr>
<td>Glucose 50%</td>
<td>282.6ml</td>
<td>282.6ml</td>
<td>1.22g</td>
</tr>
<tr>
<td>Sodium Chloride 5%</td>
<td>8.28g</td>
<td>8.28g</td>
<td></td>
</tr>
<tr>
<td>Sodium Phosphate 21.6%</td>
<td>8.54g</td>
<td>8.54g</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>759.57ml</td>
<td>759.57ml</td>
<td>3.19g</td>
</tr>
</tbody>
</table>

**Infusion duration (formulation 2)**

- Volume to be infused: 759.57ml
- Min. Infusion duration: 12.00 hr
- Infusion frequency: 2.00 times/week

**Number of times per week to be given (formulation 2)**

- 11 Dec 2017
- Stability: 18 days
- Stability ref: JPN86073086

---

**Number of times per week to be given (formulation 1)**

- 11 Dec 2017
- Stability: 18 days
- Stability ref: JPN86073086
### Fluid chart examples (Top – Off-shelf PN, Bottom – Home PN)

#### UNIVERSITY HOSPITALS BRISTOL NHS FOUNDATION TRUST & NORTH BRISTOL NHS TRUSTS IN-PATIENT PAEDIATRIC INTRAVENOUS FLUID PRESCRIPTION SHEET

**UNIQUE PATIENT IDENTIFICATION LABEL**
- **Surname:** Patient
- **Unit No:** T111135
- **Sex:** M/F
- **Address:** Date of birth: 1/6/08

**Ward:** Apollo
**Consultant:** ADoctor

**Weight:** 35 kg
**Date:** 2/1/18

**GUIDANCE FOR INTRAVENOUS FLUID THERAPY**
- **Check Bristol Royal Hospital for Children Guidelines**
- **NOTE:** Neonates & some acutely ill children may have different “maintenance” requirements or require fluid restriction

**Volume of Intravenous “maintenance”:**
- <10kg = 100ml/kg/day, or 4ml/kg/hr
- 10-25kg = 100ml/kg/day plus 50ml/kg/day for each kg > 10kg, or 4ml/kg/hr plus 2ml/kg/hr for each kg > 10kg
- 26kg = 150ml/kg plus 50ml/kg/day for each kg > 20kg, or 9ml/kg/hr plus 4ml/kg/hr for each kg > 20kg
- Up to a usual maximum of 2500ml/day for males & 2000ml/day for females

**Fluid bolus for shocked children:** required volume (ml) = Weight (kg) x 20 (or Weight (kg) x 15 in setting of trauma)
- Use only 0.9% saline or 4.5% Human Albumin Solution in settings of sepsis

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Intravenous fluid</th>
<th>Volume (ml)</th>
<th>Address/ Electrolytes incl. dose</th>
<th>Rate (ml/hr)</th>
<th>Signature</th>
<th>Designation</th>
<th>Batch / bottle number</th>
<th>Date &amp; Time started</th>
<th>Date &amp; Time stopped</th>
<th>Given by</th>
<th>12 hr Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/1/18</td>
<td>1800</td>
<td>Supplemented Lipoflex Lipid Plus</td>
<td>1266</td>
<td></td>
<td>53.0</td>
<td>A. Doctor</td>
<td>SpR</td>
<td>12345</td>
<td>Bleep 1234</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### UNIVERSITY HOSPITALS BRISTOL NHS FOUNDATION TRUST & NORTH BRISTOL NHS TRUSTS IN-PATIENT PAEDIATRIC INTRAVENOUS FLUID PRESCRIPTION SHEET

**UNIQUE PATIENT IDENTIFICATION LABEL**
- **Surname:** Patient
- **Unit No:** 1111111
- **Sex:** M/F
- **Address:** Date of birth: 1/6/08

**Ward:** Penguin
**Consultant:** ADoctor

**Weight:** 8.6 kg
**Date:** 31/12/17

**GUIDANCE FOR INTRAVENOUS FLUID THERAPY**
- **Check Bristol Royal Hospital for Children Guidelines**
- **NOTE:** Neonates & some acutely ill children may have different “maintenance” requirements or require fluid restriction

**Volume of Intravenous “maintenance”:**
- <10kg = 100ml/kg/day, or 4ml/kg/hr
- 10-25kg = 100ml/kg/day plus 50ml/kg/day for each kg > 10kg, or 4ml/kg/hr plus 2ml/kg/hr for each kg > 10kg
- 26kg = 150ml/kg plus 50ml/kg/day for each kg > 20kg, or 9ml/kg/hr plus 4ml/kg/hr for each kg > 20kg
- Up to a usual maximum of 2500ml/day for males & 2000ml/day for females

**Fluid bolus for shocked children:** required volume (ml) = Weight (kg) x 20 (or Weight (kg) x 15 in setting of trauma)
- Use only 0.9% saline or 4.5% Human Albumin Solution in settings of sepsis

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Intravenous fluid</th>
<th>Volume (ml)</th>
<th>Address/ Electrolytes incl. dose</th>
<th>Rate (ml/hr)</th>
<th>Signature</th>
<th>Designation</th>
<th>Batch / bottle number</th>
<th>Date &amp; Time started</th>
<th>Date &amp; Time stopped</th>
<th>Given by</th>
<th>12 hr Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/1/18</td>
<td>1800</td>
<td>Home PN</td>
<td>919</td>
<td></td>
<td>76.6</td>
<td>A. Doctor</td>
<td>SpR</td>
<td>12345</td>
<td>Bleep 1234</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**INSTRUCTIONS**
- While all prescriptions in BLOCK CAPITALS are approved names.
- Drug infusions to be prescribed on IV infusion prescription chart. Blood to be prescribed on blood product prescription chart.
- All intravenous fluids should only be prescribed with reference to patient's electrolyte concentrations (Na⁺, K⁺, Cl⁻, HCO₃⁻), glucose concentration, and renal function (urea, creatinine), which should be checked regularly i.e. at least every 24 hours if on intravenous fluids.
- If evidence of hypokataemia (Na⁺ < 135mmol/l) or hypokataemia (Na⁺ > 150mmol/l), electrolytes should be measured every 4-6 hours.
- All intravenous fluid prescriptions should be reviewed every 12 hours and no bag or bottle should run for more than 24 hours, except TPN which can run for up to 48 hours. Each bag or bottle of intravenous fluid needs to be separately prescribed.

**Editorial Note:**
- Extended until April 2022

---

**Version 4.2**
**From:** Nov 19 – **To:** Nov 21
**Author(s):** Paediatric Nutrition Team, Bristol Royal Hospital for Children
**Page:** 30 of 38
### 7 Bespoke PN protocols

#### Birth-1 month (TERM)

<table>
<thead>
<tr>
<th>Day number</th>
<th>1</th>
<th>2</th>
<th>3+ (low volume)</th>
<th>3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (g/day)</td>
<td>0.21</td>
<td>0.30</td>
<td>0.42</td>
<td>0.34</td>
</tr>
<tr>
<td>Carbohydrate (g/kg)</td>
<td>8</td>
<td>11</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Fat (g/kg)</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>% non-N calories from Carbohydrate</td>
<td>58</td>
<td>54</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>Protein</td>
<td>1.5</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total Calories / Kg</td>
<td>52</td>
<td>77</td>
<td>97</td>
<td>88</td>
</tr>
</tbody>
</table>

*As V Armenold

**Note:** Consider returning to day 1 carbohydrate and lipid dose temporarily until condition improves – be guided by blood sugar.

---

**Electrolytes (ranges):** To cover baseline needs, additional may be required to cover losses or optimise clinical condition. For example, magnesium requirements are often high in intestinal failure, patients with an arrhythmia or at risk of arrhythmia may require a sodium level close to 2 mmol/L.

**Sodium (mmol/L/day):**
- Birth – 6 months: 2 (0.1-0.10)
- 6 - 12 months: 2 (0.15-0.2)
- 1 – 12 years: 2 (0.25-0.3)
- Adult: 2 (0.4-0.5)

**Potassium (mmol/L/day):**
- Birth – 6 months: 2 (0.4-0.6)
- 6 - 12 months: 2 (0.6-0.8)
- 1 – 12 years: 2 (0.8-1.0)
- Adult: 2 (1.0-1.2)

**Calcium (mmol/L/day):**
- Birth – 6 months: 0.8 (0.5-1.0)
- 6 - 12 months: 0.5 (0.5-1.0)
- 1 – 12 years: 0.5 (0.5-1.0)

**Phosphate (mmol/L/day):**
- Birth – 6 months: 1 (0.4-0.6)
- 6 - 12 months: 0.8 (0.4-0.6)
- 1 – 12 years: 0.5 (0.5-1.0)

**Magnesium (mmol/L/day):**
- Birth – 6 months: 0.2 (0.0-0.5)
- 6 - 12 months: 0.5 (0.0-0.5)
- 1 – 12 years: 0.5 (0.0-0.5)

**Note:** As per Pediatric Patients.
Bespoke Parenteral Nutrition Protocols Bristol Royal Hospital for Children
These are a guide for starting values. Some patients may alternatively have calories determined by the nutrition support team (NST) or in conjunction with a dietitian.

10-19.5kg

<table>
<thead>
<tr>
<th>Day number</th>
<th>1</th>
<th>2+</th>
<th>2+ (low volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen* g/Kg (0.21-0.4&lt;3 yr, 0.16-0.32 &gt;3yr)</td>
<td>0.21</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>Carbohydrate g/Kg (2.2-10)</td>
<td>6</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td>SMOFLipid g/Kg (0-3)</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>% non-N calories from Carbohydrate</td>
<td>62</td>
<td>62</td>
<td>55</td>
</tr>
<tr>
<td>Peditrace</td>
<td>1 ml/Kg (Max 15ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soluviso N</td>
<td>1 ml/Kg (Max 10ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vittelipid Infant / Adult (&gt;11 year)</td>
<td>1 ml/Kg (Max 10ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Calories/Kg</td>
<td>44</td>
<td>74</td>
<td>62</td>
</tr>
</tbody>
</table>

*As Vamin 18

20-29.9kg

<table>
<thead>
<tr>
<th>Day number</th>
<th>1</th>
<th>2+</th>
<th>2+ (low volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen* g/Kg (0.16-0.32)</td>
<td>0.17</td>
<td>0.3</td>
<td>0.24</td>
</tr>
<tr>
<td>Carbohydrate g/Kg (2.2 - 9)</td>
<td>5.5</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>SMOFLipid g/Kg (0-3)</td>
<td>1.2</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>% non-N calories from Carbohydrate</td>
<td>65</td>
<td>64</td>
<td>56</td>
</tr>
<tr>
<td>Peditrace</td>
<td>1 ml/Kg (Max 15ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soluviso N</td>
<td>1 ml/Kg (Max 10ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vittelipid Infant / Adult (&gt;11 year)</td>
<td>1 ml/Kg (Max 10ml/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Calories/Kg</td>
<td>38</td>
<td>64</td>
<td>56</td>
</tr>
</tbody>
</table>

*As Vamin 18

ELECTROLYTES (ranges): to cover baseline needs, additional may be required to cover losses or optimise clinical condition. For example: magnesium requirements are often high after chemotherapy, sodium requirements are often high in intestinal failure, patients with an arrhythmia or at risk or arrhythmia may require serum levels of potassium, calcium and magnesium at the upper limit of normal. See appendix for cautions and information regarding acetate/chloride salts.

<table>
<thead>
<tr>
<th></th>
<th>Sodium (mmol/kg/day)</th>
<th>Potassium (mmol/kg/day)</th>
<th>Calcium (mmol/kg/day)</th>
<th>Magnesium (mmol/kg/day)</th>
<th>Phosphate (mmol/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 12 years</td>
<td>2 (0 - 4)</td>
<td>2 (0 - 4)</td>
<td>0.25 (0 - 0.4)</td>
<td>0.1 (0 - 0.5)</td>
<td>0.5 (0 - 1)</td>
</tr>
</tbody>
</table>

Nutrition support team Date: Sep 2019 Review date: Sep 2021
Bespoke Parenteral Nutrition Protocols Bristol Royal Hospital for Children

These are a guide for starting values. Some patients may alternatively have calories determined by the nutrition support team (NST) or in conjunction with a dietitian.

### 30-45kg

<table>
<thead>
<tr>
<th>Day number</th>
<th>1</th>
<th>2+</th>
<th>2+ (low volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen* g/Kg (0.16-0.32)</td>
<td>0.17</td>
<td>0.26</td>
<td>0.17</td>
</tr>
<tr>
<td>Carbohydrate g/Kg (1.4-6.5)</td>
<td>4.5</td>
<td>6.5</td>
<td>5.5</td>
</tr>
<tr>
<td>SMOFLipid g/Kg (0.3)</td>
<td>1</td>
<td>1.7</td>
<td>1.8</td>
</tr>
<tr>
<td>% non-N calories from Carbohydrate</td>
<td>64</td>
<td>60</td>
<td>55</td>
</tr>
</tbody>
</table>

**Peditrace [up to 40kg] OR**

1 ml/Kg (Max 15ml/day)

**Additrace (- 40kg)**

10ml/day standard (max 20ml/day)

**Solivite N**

1 ml/Kg (Max 10ml/day)

**Vitlpid Adult**

1 ml/Kg (Max 10ml/day)

**Total Calories/Kg**

32 50 44

*As Vamin 18

Day 2+ Nitrogen: Consider up to 0.32g/kg in a teenager going through puberty—seek advice from dietitian.

### >45kg

<table>
<thead>
<tr>
<th>Day number</th>
<th>1</th>
<th>2+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen* g/Kg (0.16-0.32)</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>Carbohydrate g/Kg (0.7-1.5)</td>
<td>3.5</td>
<td>5.5</td>
</tr>
<tr>
<td>SMOFLipid g/Kg (0.3)</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>% non-N calories from Carbohydrate</td>
<td>58</td>
<td>56</td>
</tr>
</tbody>
</table>

**Additrace**

10ml/day standard (max 20ml/day)

**Solivite N**

1 ml/Kg (Max 10ml/day)

**Vitlpid Adult**

1 ml/Kg (Max 10ml/day)

**Total Calories/Kg**

28 43+

*As Vamin 18

Day 2+ Nitrogen: 0.17g/kg minimum, consider 0.21-0.24g/kg if has surgical wound/fistula or recent surgery. Consider up to 0.32g/kg in a teenager going through puberty—seek advice from dietitian.

**ELECTROLYTES** (ranges): to cover baseline needs, additional may be required to cover losses or optimise clinical condition. For example: magnesium requirements are often high after chemotherapy, sodium requirements are often high in intestinal failure, patients with an arrhythmia or at risk or arrhythmia may require serum levels of potassium, calcium and magnesium at the upper limit of normal. See appendix for caution and information regarding acetate/chloride salts.

<table>
<thead>
<tr>
<th></th>
<th>Sodium (mmol/kg/day)</th>
<th>Potassium (mmol/kg/day)</th>
<th>Calcium (mmol/kg/day)</th>
<th>Magnesium (mmol/kg/day)</th>
<th>Phosphate (mmol/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 12 years</td>
<td>(2 - 0 - 4)</td>
<td>(2 - 0 - 4)</td>
<td>(0.25 - 0 - 0.4)</td>
<td>(0.1 - 0 - 0.5)</td>
<td>(0.5 - 0 - 1)</td>
</tr>
<tr>
<td>13 - 18 years</td>
<td>(2 - 0 - 3)</td>
<td>(2 - 0 - 3)</td>
<td>(0.15 - 0 - 0.4)</td>
<td>(0.1 - 0 - 0.5)</td>
<td>(0.4 - 0 - 1)</td>
</tr>
</tbody>
</table>

*Adolescents. There is insufficient evidence for maximum daily doses of electrolytes. Adolescents going through the growth spurt of puberty need large doses of calcium and phosphate. Doses for 13-18 years partially based on recommendations for long-term adult PN (ESPEN 2009).

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NOTES

Acetate or chloride salts
The sodium in PN may be ordered as acetate or chloride salts, or a combination of both. Other components of PN, such as nitrogen-containing solutions may contribute acetate and chloride. Patients with high loss of chloride salts (e.g. high gastric output not replaced by usual replacement fluid) or low chloride levels may have higher than usual requirement for chloride. Patients with high loss of bicarbonate (e.g. high intestinal loss from stump, fistula, wound) or low bicarbonate levels may have higher than usual requirement for acetate.

Converting standard to bespoke PN
The appropriate protocol depends on the reason for switching from standard PN. It is important to check what volume of standard bag was infused (rather than prescribed) and work out the per kg macronutrient and electrolyte provision. Seek advice from NST or a dietitian if required. Here are some possible strategies for switching:

- For electrolyte or fluid volume reasons only – if calories/nutrition has been acceptable match to nearest protocol in terms of nitrogen/carbohydrate/glucose infused via standard bag. Tweak electrolytes doses/fluid as appropriate to patient. If nutritional provision was suboptimal treat as below.

- Due to adverse response/suboptimal macronutrients (e.g. hypo/hyperglycaemia, patient needs more nitrogen) – compare what was being infused from standard bag to PN protocol for patient size/day of PN and tweak (e.g. 25kg patient, standard bag on day 1 of PN gave 3.2g/kg/day carbohydrate, patient was hypoglycaemic. PN protocol shows 5.5g/kg/day on day 1 - try 5.5g/kg/day on first day of bespoke and if tolerated increase to day 2 dose). Also take into account specific advice from dietitian or NST.

- When standard bag was used only out of hours/as a stop gap – if macronutrients need to be optimised switch to a PN protocol day that steps up the calories ~20-40% for neonates/infants and ~30-50% for children ≥ 1 year. If calories/nutrition has been suitable switch to the protocol day which gives the closest amount of calories.

Haemofiltration
Haemofiltration in PICU can lead to electrolyte shifts which may not be possible to account for with PN. Haemofiltration using a citrate-based solution (as anticoagulation) removes significant quantities of divalent ions (Calcium, Magnesium). If the solution used for haemofiltration is low in calcium or magnesium these electrolytes will need to be supplemented in the return port to prevent deficiency, particularly in cardiac patients. This is preferable to increasing the amount provided in the PN as the filtration will continue to remove a large proportion of the electrolytes. The return haemofiltration port may also be used to supplement other electrolytes such as phosphate.

Beware that when haemofiltration stops fluid allowance is likely to drop dramatically and electrolyte requirements will change – avoid ordering PN ahead of time if there is any uncertainty.

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Clinical infusion rates/concentration limits

Also consider cumulative dosage/rates from other infusions.

<table>
<thead>
<tr>
<th>Product</th>
<th>Maximum rate of administration</th>
<th>Maximum concentration (central)</th>
<th>Maximum concentration (peripheral)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Neonate (term) 12mg/kg/min (≤0.72g/kg/hour). Other ages not well defined. When cycling PN (giving &lt;24 hours per day) maximum rate 1.2g/kg/hr – this should be achieved by careful up-titration of infusion rate (see BRHC Total Parenteral Nutrition Guideline).</td>
<td>24.99%</td>
<td>12.39%</td>
</tr>
<tr>
<td>Sodium</td>
<td>Not known. Follow Fluid Management In Paediatric Patients regarding maximum recommended daily shifts in serum sodium. Locally neonates with high losses have been known to receive up to 16mmol/kg/day.</td>
<td>N/A</td>
<td>299 mmol/L</td>
</tr>
</tbody>
</table>
| Potassium | 0.2mmol/kg/hour initially. There is local experience of giving potassium up to 0.5mmol/kg/hr (max 20mmol/hour) via central lines with ECG monitoring for rates >0.2mmol/kg/hour. Exceptions to usual maximum rate:
- long-term PN/home PN patients usually on infusion rate exceeding 0.2mmol/kg/hour are unlikely to need ECG monitoring (discuss with consultant). | 500mmol/L (only on PICU, HDU and BMT) however in clinical practice PN potassium concentration this high is very unlikely. | 40mmol/L |
| Magnesium | Safe maximum rate is high enough that infusion rate from PN not considered a risk. | N/A | 200mmol/L |
| Phosphate | 0.05mmol/kg/hr initially. There is local experience of giving phosphate up to 0.5mmol/kg/hr in PICU/high dependency with ECG monitoring. PN phosphate rates are often not much higher than 0.05mmol/kg/hour and are unlikely to warrant ECG monitoring (if in doubt discuss with consultant). Exceptions to usual maximum rate:
- premature neonate max dose 3.5mmol/kg/day (many doses exceed max rate)
- infants (particularly if premature at birth) on long-term PN/home PN
These patients should not need ECG monitoring but warrant careful up-titration of dosage. | N/A | 100mmol/L |
| Calcium | 0.045 mmol/kg/hr initially. Exceptions to usual maximum rate:
- premature neonate max dose 3.5mmol/kg/day (many doses exceed max rate)
- infants (particularly if premature at birth) on long-term PN/home PN
These patients should not need ECG monitoring but warrant careful up-titration of dosage. | N/A | 45mmol/L |

References: ESPGHAN/ESPEN/ESPR/CSFEN working group on paediatric parenteral nutrition guidelines 2018, BRHC Total Parenteral Nutrition Guideline, Medusamonographs, BRHC electrolyte derangement guidelines, personal communication with Parenteral services unit.

Nutrition support team Date: Sep 2019 Review date: Sep 2021
### Cautions or contraindications for PN constituents

<table>
<thead>
<tr>
<th>Product</th>
<th>Caution or contra-indication</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Cautions and management: see BRHC <a href="#">Total Parenteral Nutrition Guideline</a></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Consult metabolic team before initiating PN in phenylketonuria (PKU), maple syrup urine disease (MSUD) or urea cycle defects (UCD) as some amino acid solutions may be unsuitable. Cautions and management: see BRHC <a href="#">Total Parenteral Nutrition Guideline</a></td>
<td></td>
</tr>
<tr>
<td>SMOFlipid</td>
<td>Contra-indicated if allergic to fish, egg, soya or peanut protein. Other cautions and management see BRHC PN guideline</td>
<td>Discuss with nutrition support team (might not be able to provide lipid source in PN)</td>
</tr>
<tr>
<td>Vitlipid</td>
<td>Contra-indicated if allergic to egg, soya or peanut protein. Caution: Chronic renal impairment (potential for vitamin A toxicity)</td>
<td>Allergy: Discuss with nutrition support team (might not be able to provide fat-soluble vitamin in PN). Discuss with consultant/seek advice from renal team. May need to avoid or give lower dose. If not giving vitlipid usually need to provide vitamin D via alternative route.</td>
</tr>
<tr>
<td>Solvito N</td>
<td>Contra-indicated if allergic to methylhydroxybenzoate</td>
<td>Give PN without water-soluble vitamins. Consider oral provision if appropriate. If nil-by-mouth on PN for &gt;1 week discuss with dietitian.</td>
</tr>
<tr>
<td>Sodium</td>
<td>Caution: Acute or chronic renal impairment, cirrhosis, hypertension, cardiac failure. Potential for hyperchloraemia/acidosi if large doses of sodium provided as chloride form only, particularly in infants.</td>
<td>Consider using lower doses. To avoid acidosis: consider providing mixture of sodium chloride and acetate.</td>
</tr>
<tr>
<td>Potassium</td>
<td>Caution: Renal impairment</td>
<td>Consider using lower doses.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Caution: Renal impairment</td>
<td>Consider using lower doses.</td>
</tr>
<tr>
<td>Phosphate</td>
<td>Caution: Renal impairment</td>
<td>Consider using lower doses or none (NB lipid source will contribute some phosphate)</td>
</tr>
<tr>
<td>Calcium</td>
<td>Avoid in malignancy associated with hypercalcaemia. Caution: History of nephrolithiasis, renal impairment (risk of hypercalcaemia and renal calculi), sarcoidosis</td>
<td>Consider using lower doses.</td>
</tr>
</tbody>
</table>

*Nutrition support team Date: Sep 2019 Review date: Sep 2021*
RELATED DOCUMENTS

- Aseptic non touch technique policy
- Central venous catheter guidelines for paediatrics
- Antibiotic guidelines for paediatric surgery
- Total Parenteral Nutrition TPN Setup 1 Nurse Technique Checking and Administration
- Total Parenteral Nutrition TPN Setup 2 Nurse Technique Checking and Administration
- Y-Site compatibility of Intravenous Infusions
- Intravascular related sepsis protocol for paediatrics (suspected and documented infection)
- Hypoglycaemia guideline: investigation and management of acute presentation
- A Guide to Calculating Parenteral Nutrition when Titrating with Feeds
- Use of Parenteral Nutrition Pre-filled Bags (standard babiven and smofkabiven bags)
- Management of Refeeding Syndrome
- Enteral Feeding (Paediatric).

AUTHORISING BODY

Paediatric Nutrition Governance Group

SAFETY

N/A

QUERIES

Contact Nutrition Support Team: Amy Phipps Ext 27864/ Bleep 6819 or Lizzie Hutchison Ext 22801 or Alison Dinning or Lauren McVeigh Ext 22801, Bleep 2780 or 1024.

Extended until April 2022