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Royal Cornwall Hospitals NHS Trust

Parenteral Nutrition Standardised Concentrated, Neonatal Clinical Guideline

V3.0

(Local Adaption of South West Neonatal Network Guideline)

December 2022

1. Aim/Purpose of this Guideline

1.1. Significantly preterm infants are born with an immature gut and are consequently unable to digest sufficient milk to meet their nutritional requirements for 10-14 days post birth. They also have limited nutrient stores, so are therefore at a high risk of accumulating significant nutrient deficits and consequential poor growth which is associated with poor neurodevelopmental outcome in later life.

1.2. Parenteral Nutrition (PN) is an important aspect of neonatal care by which the infant's specific nutritional requirements can be met intravenously. Evidence confirms that providing optimal nutrition early can minimise growth failure and associated neuro- cognitive effects. PN is also essential for infants who may not tolerate enteral feeds such as those with congenital or acquired gut disorders.

1.3. The aim of this guideline is to provide clear, evidence-based guidance and procedures for using PN on the neonatal unit. This is to ensure safe and optimum management of parenterally fed infants and minimise the risks associated with this form of nutrition support.

1.4. This version supersedes any previous versions of this document.

Data Protection Act 2018 (General Data Protection Regulation – GDPR) Legislation

The Trust has a duty under the Data Protection Act 2018 and General Data Protection Regulations 2016/679 to ensure that there is a valid legal basis to process personal and sensitive data. The legal basis for processing must be identified and documented before the processing begins. In many cases we may need consent; this must be explicit, informed, and documented. We cannot rely on opt out, it must be opt in.

Data Protection Act 2018 and General Data Protection Regulations 2016/679 is applicable to all staff; this includes those working as contractors and providers of services.

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2. The Guidance

2.1. Standardised PN for the SW Neonatal Network

In developing standardised concentrated neonatal PN for the region we have tried to incorporate all of the latest evidence (e.g. NICE, BAPM) in a simplified and easy to follow way. The aim is to separate nutrition and hydration to ensure that the infant will receive the recommended daily intakes of nutrients to promote growth, and will not be affected too much by drug infusions and fluid volume restrictions. Changes in fluid requirements will be managed by an additional infusion of glucose 5% or 10%, if required.

The volumes of the bags available at RCHT and glucose concentration can be seen in the table below. Further information on the bag content and osmolarity may be found in appendix 3. Osmolarity can be reduced further by co-infusing with lipid. As usage of the parenteral nutrition bag for term infants is likely to be very low we **do not** keep stock at RCHT but stock can be obtained within 72 hours.

Bag name	Volume	Glucose concentration
SW Neonatal Preterm Starter/Potassium Free PN	350mL	12%
SW Neonatal Preterm Maintenance PN	600mL	10.8%
SW Neonatal Term PN	800mL	12%

Standardised bags should always be used when administering PN as they optimise nutrient delivery and minimise the risk of error in prescribing and compounding. Using 48 hour bags reduces the number of times the lines are accessed and thus reduces line infection rates.

Lipid syringes will be manufactured “in-house” or may be ordered from an external supplier, as capacity dictates, to the recipe below. In order to be able to start lipid infusions (including water and fat soluble vitamins) as soon as possible after birth stock syringes will be held on NICU.

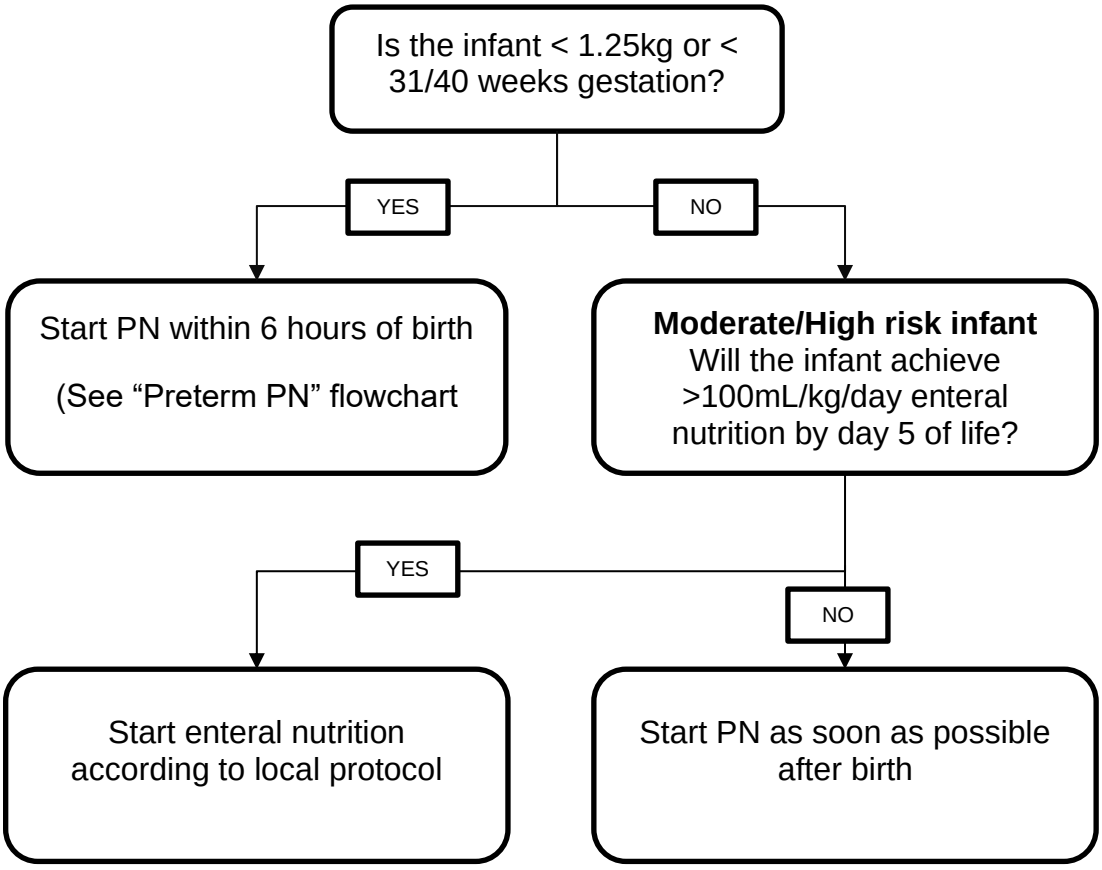
Ingredient	Volume (mL)
SMOF lipid	30
Vitlipid infant	8
Solivito N	2
Total volume in a 50mL syringe	**40**

2.2. Indications for use

PN should be administered to the following infants:

- All infants admitted to NICU < 1.25kg or < 31/40 weeks gestation
- Infants ≥ 31/40 weeks gestation or ≥ 1.25kg who are not anticipated to be on > 100mL/kg/day enteral feeds within 5 days. Assessment should be made by 72 hours of age.
- Infants with intestinal disease precluding feeding e.g. necrotizing enterocolitis (NEC), gastroschisis, intestinal atresia

If indicated from birth (see flowchart below), PN should be started within the first 24 hours of life, ideally within 6 hours of birth or from confirmation of line placement.



If restarting PN after full enteral feeds or if not starting PN at time of birth:

- Maximum starting rate is step 3 of the appropriate PN flowchart (Preterm or Term)
- Preterm infants: start parenteral nutrition if:
    - Enteral feeds have to be stopped and it is unlikely they will be restarted within 48 hours
    - Enteral feeds have been stopped for more than 24 hours and there is unlikely to be sufficient progress with enteral feeding within a further 48 hours
- Term infants: start parenteral nutrition if:
    - Enteral feeds have to be stopped and it is unlikely they will be restarted within 72 hours
    - Enteral feeds have been stopped for more than 48 hours and there is unlikely to be sufficient progress with enteral feeding within a further 48 hours.

2.3. PN prescribing

Neonatal PN should be prescribed on the paediatric fluid chart as a separate aqueous bag and a lipid syringe. The rate of each must be prescribed. Additionally, the flag “TPN (Total parenteral nutrition) Infusion – see paper chart” should be added to EPMA.

2.4. Supply/availability SW Neonatal PN bags and lipid syringes

In order to be able to start aqueous PN and lipid infusions (including water and fat soluble vitamins) as soon as possible after birth (target within 6 hours) stock aqueous bags (preterm starter and maintenance), and lipid syringes will be held on NICU for initiation both during working hours and out- of-hours. Additional bags may be ordered from pharmacy using the pharmacy ordering portal (POP). Lipid syringes will be delivered to the unit on Wednesday and Friday. Additional stock should be ordered via the ward pharmacist or via Technical Services on Ext 8390. **Please note** that the lipid syringes are ordered from an external supplier and if additional supplies are required these take a minimum of 24 hours to obtain. The pharmacy team must be made aware if additional supplies are required at the earliest opportunity.

2.5. Availability of bespoke PN

Due to infrequent usage and the ability to maintain staff competence pharmacy technical services are unable to provide bespoke parenteral nutrition for the neonatal unit, and standard bags should be used wherever possible. Where this is deemed unsuitable, advice must be sought from a tertiary centre.

2.6. Availability of SW Neonatal Term bags

As PN is rarely prescribed for term neonates at RCH, SW neonatal term bags are not kept in stock routinely. However, stock can be obtained from the manufacturer within 72 hours. SW Neonatal preterm maintenance bags can be used in term neonates for up to 5 days at a maximum rate of 80mL/kg/day (see flow chart, appendix 4). More prolonged use is not ideal as the infant would receive excessive protein. If PN is initiated in a term baby using a preterm bag, ensure SW neonatal term bags are available for use on the unit in order to progress to 'Step 4' of the flow chart when the PN volume increases to 100ml/kg/d. If it is anticipated that they will need TPN for more than 5 days, please discuss with the neonatal pharmacist at the earliest opportunity to allow term bags to be ordered.

2.7. PN prescribing and weights

PN should be prescribed according to the relevant flow chart using the infant’s current gestation and prescribing weight. Flow charts for Preterm and Term babies are located in appendix 4 of this guideline. Check that the correct flowchart is in use for the Baby’s gestation.

Ensure PN is prescribed using an appropriate weight:

- Do not use a weight lower than birth weight (unless hydropic)

- Once birth weight is regained, the average weight increase should be in the region of 15g/kg/day and PN prescriptions should keep up with weight increases. Prescribing weights should be checked daily.

- If the infant is significantly oedematous the prescribing weight may be less than the actual weight however this should be reviewed regularly. Centile charts may help guide estimates of appropriate prescribing weights.

2.8. Administration of PN

2.8.1. Venous access

- Neonatal TPN should be administered centrally. On tertiary advice, in exceptional circumstances, if peripheral PN is given the aqueous phase **must** be co-administered with the lipid to reduce osmolarity.

- Ideally the line should be used solely for PN, although this is not always possible in neonates due to difficulties in venous access.

- No medication should be given down the same lumen as the PN without checking compatibility (e.g. via Medusa, neonatal formulary or the emergency drug sheet). If in any doubt then assume that they are not compatible and contact pharmacy.

- Bolus medication may be given by stopping PN, with a flush of sodium chloride before and afterwards. *However*, access to lines should be minimised to reduce risk of infection.

- In fluid restricted infants or those receiving multiple iv infusions, please refer to the network guideline Appendix 1 for advice.

2.8.2. PN set-up

- PN should be removed from the fridge at least 1 hour prior to use.

- Aseptic Non-Touch Technique (ANTT) must be used when setting up PN. Aqueous PN bags should be infused via a 0.2 micron filter and can be connected to the patient for a maximum of 48 hours.

- Lipid syringes can only be connected to the patient for a maximum of 24 hours.

- Additional care is required to ensure that PN is administered at the correct rate as giving PN too quickly can cause significant harm to the patient. The following checks should be carried out when putting up a new bag of aqueous PN and/or a lipid syringe and at handover of each shift:

- Identify the aqueous PN (bag) and the lipid (syringe).
- Ensure that aqueous PN (bag) and the lipid (syringe) are both running at the correct rate. This should be checked against the EPMA prescription.
- As part of this check it should be confirmed that the correct giving set (aqueous bag or lipid syringe) is being administered via the correct pump.
- Complete the PN checklist.

- The nursing staff who set up the PN, must record the administration of both the aqueous bag and the lipid syringe on EPMA.
- All elements of parenteral nutrition must be protected from light
  - The aqueous bag must be covered with the light proof bag provided throughout storage and during the use
  - The lipid syringe must be covered during storage and during infusion using the light proof cover supplied by pharmacy
  - Amber giving sets must be used for both aqueous and lipid infusions.
- Lipid syringes are unlicensed and often made in-house under section 10. As such we need to record the batch number and expiry of each lipid syringe that a baby receives. Every time a syringe is removed from the neonatal fridge the record sheet provided with the syringes must be completed detailing the patient details and date used.

2.9. Monitoring

Routine biochemical monitoring should take place in all infants on PN as it is crucial to prevent and treat instabilities potentially caused by PN.

When taking blood samples to monitor the preterm or term baby's neonatal parenteral nutrition:

- Collect the minimum blood volume needed for the tests
- Co-ordinate the timing of blood tests to minimise the number of blood samples needed

Below is a suggested schedule of monitoring however requirements may differ for individual infants and situations.

	First week			Stable PN			
	Daily	Twice weekly	Weekly	Daily	Twice weekly	Weekly	Monthly
Infusion site-assess	✓			✓			
Fluid balance	✓				✓		
Blood glucose*	✓			✓			
Urine glucose	✓			✓			
Urine electrolytes*							✓
Electrolytes (Na, K,	✓				✓		
Urea, Creatinine	✓				✓		
Calcium	✓				✓		
Phosphate	✓				✓		
Magnesium	✓				✓		
Alkaline	✓				✓		
Triglyceride*		✓				✓	
LFTs	✓					✓	
Albumin	✓						
Bilirubin	✓					✓	
Conj. Bilirubin			✓			✓	
Acid base balance	✓				✓		
Trace elements*							✓
Vitamin A, D, E*							✓
Iron profile*							✓
Weight		✓			✓		
Head circumference			✓			✓	

* See special considerations

2.9.1. Special considerations

2.9.1.1. Blood Glucose

Measure blood glucose levels 1-2 hours after first starting PN, and then 6-12 hourly whilst increasing PN.

Blood glucose monitoring can then be reduced to 12 hourly when on full PN and stable.

Follow guidance in Appendix 1 for managing hyperglycaemia.

2.9.1.2. Triglyceride monitoring

For infants that are severely septic , then triglycerides should be monitored once they are receiving 10mL/kg/day lipid (1.5g/kg/day), and then again at 20mL/kg/day (3g/kg/day). From then on it should be routinely measured at least once weekly. It is not necessary to stop lipid infusion before testing.

All other infants should have triglycerides measured at least twice weekly during the first week of PN, and then once weekly thereafter.

More frequent monitoring may be required in certain circumstances, for example if an infant has had previously high triglyceride levels, is septic, catabolic or critically ill, or has severe and unexplained thrombocytopenia.

2.9.1.3. Urinary Electrolytes

Sodium is thought to be critical to growth and measuring urinary sodium can be a useful indicator of whole body sodium status.

If an infant required supplementation, urinary sodium should be checked weekly until it is above 20mmol/L.

2.9.1.4. Iron

Do not give intravenous iron supplements to preterm or term babies on neonatal parenteral nutrition who are younger than 28 days.

For preterm babies on neonatal parenteral nutrition who are 28 days or older, monitor for iron deficiency and treat if necessary.

Measure ferritin, iron and transferrin saturation if a preterm baby is on parenteral nutrition for more than 28 days.

2.9.1.5. Monitoring long term PN

Long term PN is rare at RCH. For further information on monitoring, please refer to tertiary centre guidance.

2.10. Weaning PN

As enteral feeds increase, wean all glucose infusions (5% and 10%) to zero. Then follow the table below:

When Enteral feeds reach	Wean Lipid infusion to	Titrate Aqueous phase to
30mL.kg/day	15mL/kg/day	Total fluid allowance
As enteral feeds increase to	**Wean lipid infusion to**	**Titrate Aqueous phase to**
60mL/kg/day	10mL/kg/day	Total fluid allowance
90mLkg/day	Zero* (unless peripheral)	Total fluid allowance
120mL/kg/day	Zero* (unless peripheral)	Total fluid allowance

***** Unless running peripherally, in which case keep at 10mL/kg/day

The aqueous phase can be stopped once tolerating 120ml/kg/day enteral feeds or continued at 30ml/kg/day and weaned until tolerating 150ml/kg/day enteral feeds.

NB: – some high-risk infants may continue on a small amount of aqueous PN and lipid to support growth.

If fluids are liberalised to 165mL/kg/day or 180mL/kg/day as enteral feeds increase, then maintain full rate PN as long as possible before titrating.

Example:

Total fluid allowance 165mL/kg/day
When enteral feeds reach 45mL/kg/day, wean lipid infusion to 15mL/kg/day and titrate aqueous phase to total fluid allowance.

3. Monitoring compliance and effectiveness

Information Category	Detail of process and methodology for monitoring compliance
Element to be monitored	Key Changes to Practice
Lead	Dr Chris Warren; Consultant Paediatrician
Tool	Audit: adherence to guidelines will be monitored as part of the ongoing audit process on a Word or Excel template
Frequency	As dictated by audit findings
Reporting arrangements	Consultant led Neonatal Guidelines group
Acting on recommendations and Lead(s)	Neonatal Lead to act upon any deficiency to improve induction programme in liaison with Obstetric Governance Lead to inform midwifery staff of any deficiencies in the process. This should occur after the audit.
Change in practice and lessons to be shared	Any changes in practice required will be incorporated/amended into new guidance for new Paediatric Doctor induction which is reviewed annually.

4. Equality and Diversity

4.1. This document complies with the Royal Cornwall Hospitals NHS Trust service Equality and Diversity statement which can be found in the 'Equality, Inclusion & Human Rights Policy' or the Equality and Diversity website.

4.2. Equality Impact Assessment

The Initial Equality Impact Assessment Screening Form is at Appendix 4.

Appendix 1. Governance Information

Information Category	Detailed Information
Document Title:	Parenteral Nutrition Standardised Concentrated, Neonatal Clinical Guideline (Local Adaption of South West Neonatal Network Guideline) V3.0
This document replaces (exact title of previous version):	Parenteral Nutrition Standardised Concentrated, Neonatal Clinical Guideline V2.0
Date Issued/Approved:	December 2022
Date Valid From:	December 2022
Date Valid To:	December 2025
Directorate / Department responsible (author/owner):	Chris Warren; Consultant Paediatrician Sabrina Tierney; Lead Paediatric Pharmacist
Contact details:	01872 252590
Brief summary of contents:	Guidelines on the use of Neonatal Parenteral Nutrition (PN) at RCHT
Suggested Keywords:	Neonatal Parenteral Nutrition, Neonatal PN
Target Audience:	RCHT: Yes CFT: No CIOSICB: No
Executive Director responsible for Policy:	Chief Medical Officer
Approval route for consultation and ratification:	Neonatal Guidelines Group
General Manager confirming approval processes:	Caroline Chappell
Name of Governance Lead confirming approval by specialty and care group management meetings:	Caroline Amukusana
Links to key external standards:	None required
Related Documents:	None required
Training Need Identified?	Yes, teaching sessions delivered on neonatal unit to medical and nursing staff.

Information Category	Detailed Information
Publication Location (refer to Policy on Policies – Approvals and Ratification):	Internet and Intranet
Document Library Folder/Sub Folder:	Clinical/ Neonatal

Version Control Table

Date	Version Number	Summary of Changes	Changes Made by
20th Dec 2017	V1.0	Initial issue	Chris Warren, consultant paediatrician; Jackie Pope, Lead pharmacist Paediatrics
January 2020	V2.0	Updated to new trust format.	Chris Warren, consultant paediatrician
Oct 2022	V3.0	Full review to mirror regional guidance Update to include new formulation of PN bags to follow current NICE guidance	Sabrina Tierney, Lead pharmacist paediatrics Holly Byatt, Neonatal dietitian

All or part of this document can be released under the Freedom of Information Act 2000

This document is to be retained for 10 years from the date of expiry.
This document is only valid on the day of printing

Controlled Document

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Appendix 2. Equality Impact Assessment

Section 1: Equality Impact Assessment (EIA) Form

The EIA process allows the Trust to identify where a policy or service may have a negative impact on an individual or particular group of people.

For guidance please refer to the Equality Impact Assessment Policy (available from the document library) or contact the Equality, Diversity & Inclusion Team rcht.inclusion@nhs.net

Information Category	Detailed Information
Name of the strategy / policy / proposal / service function to be assessed:	Parenteral Nutrition Standardised Concentrated Neonatal Clinical Guideline (Local Adaption of South West Neonatal Network Guideline) V3.0
Directorate and service area:	Neonatal
Is this a new or existing Policy?	Existing
Name of individual completing EIA (Should be completed by an individual with a good understanding of the Service/Policy):	Neonatal Audit and Guidelines Group
Contact details:	01872 252590

Information Category	Detailed Information
1. **Policy Aim - Who is the Policy aimed at?** (The Policy is the Strategy, Policy, Proposal or Service Change to be assessed)	Standardisation of neonatal PN across the SW Neonatal Network. Safe administration and management of neonatal patients requiring parenteral nutrition at RCH.
2. **Policy Objectives**	To provide clear guidance on the initiation of PN and to ensure appropriate monitoring of patients.
3. **Policy Intended Outcomes**	Standardised safe practice.
4. **How will you measure each outcome?**	Audit and Datix review
5. **Who is intended to benefit from the policy?**	Neonates and their families. Medical, Pharmacy and Nursing staff.

Information Category	Detailed Information
6a. Who did you consult with? (Please select Yes or No for each category)	• Workforce: Yes • Patients/ visitors: No • Local groups/ system partners: No • External organisations: No • Other: No
6b. Please list the individuals/groups who have been consulted about this policy.	**Please record specific names of individuals/ groups:** Neonatal Guidelines group
6c. What was the outcome of the consultation?	Approved- 11 October 2022
6d. Have you used any of the following to assist your assessment?	**National or local statistics, audits, activity reports, process maps, complaints, staff or patient surveys:** No

7. The Impact

Following consultation with key groups, has a negative impact been identified for any protected characteristic? Please note that a rationale is required for each one.

Where a negative impact is identified without rationale, the key groups will need to be consulted again.

Protected Characteristic	(Yes or No)	Rationale
Age	No	
Sex (male or female)	No	
Gender reassignment (Transgender, non-binary, gender fluid etc.)	No	
Race	No	Any information provided should be in an accessible format for the parent/carer's needs – i.e. available in different languages if required/access to an interpreter if required

Protected Characteristic	(Yes or No)	Rationale
Disability (e.g. physical or cognitive impairment, mental health, long term conditions etc.)	No	Those parent/carers with any identified additional needs will be referred for additional support as appropriate - i.e to the Liaison team or for specialised equipment. Written information will be provided in a format to meet the family's needs e.g. easy read, audio etc
Religion or belief	No	All staff should be aware of any beliefs that may impact on the decision to treat and should respond accordingly
Marriage and civil partnership	No	
Pregnancy and maternity	No	
Sexual orientation (e.g. gay, straight, bisexual, lesbian etc.)	No	

A robust rationale must be in place for all protected characteristics. If a negative impact has been identified, please complete section 2. If no negative impact has been identified and if this is not a major service change, you can end the assessment here.

I am confident that section 2 of this EIA does not need completing as there are no highlighted risks of negative impact occurring because of this policy.

Name of person confirming result of initial impact assessment: Neonatal Audit and Guidelines group

If a negative impact has been identified above OR this is a major service change, you will need to complete section 2 of the EIA form available here:
Section 2. Full Equality Analysis

Appendix 3. Managing Metabolic Complications

Hyperglycaemia *(Blood glucose level x2 >11mmol/L – one must be peripheral)*

1) Ensure all additional glucose infusions are reduced to 5% glucose, including drug infusions if compatible

2) If still hyperglycaemic, decrease aqueous PN rate by 30ml/kg/day and supplement volume with 5% glucose

3) If still hyperglycaemic, consider insulin after discussion with the level 3 unit (see insulin guideline) (Ensure minimum glucose infusion rate is no less than 6mg/kg/min).

Hypoglycaemia

1) Increase the concentration of all additional glucose infusions in a step wise manner from 10% to 15% to 20%. Ensure all drug infusions are in 10% glucose if compatible.

2) If still hypoglycaemic, decrease aqueous PN by 30ml/kg/day and supplement with 20% glucose

3) If still hypoglycaemic, stop PN and replace fluid volume with glucose 20% with electrolytes, where required

Hypernatraemia

1) Assess fluid balance, weight and hydration status.

2) Ensure arterial line is kept patent with heparinised 0.45% sodium chloride (not 0.9%)

3) For immediate action, consider changing aqueous PN to SW Neonatal Preterm Starter/Potassium Free PN. If true sodium over supplementation discuss with the Consultant and the Neonatal Pharmacist.

Hyponatraemia

1) Assess fluid balance, weight and hydration status.

   Water overload must be considered before supplementation of sodium is prescribed. In these cases fluid restriction is usually required and can be achieved by reducing the supplementary glucose 10% infusion rate.

2) If it is felt there is a true sodium deficit and this is not being corrected by the current PN regimen (ensure aqueous PN is not sodium free) then sodium losses should be calculated and replaced by using the standard sodium concentrations in the table below to supplement sodium.

3) Ensure arterial line is kept patent with heparinised 0.9% sodium chloride (not 0.45%)

There are 5 standard sodium concentrations made up in glucose 10%. **For central use only.** These supplementary sodium infusions allow replacement of sodium in addition to the sodium prescribed in the PN.

Sodium level (mmol/L)	Supplementary sodium infusion required (via central line only)	
132-135	Small deficit	Add 10mmol Sodium Chloride (2mL of 30% Sodium Chloride) to 48mL glucose 10% to make up to 50mL infusion containing 0.2mmo/mL of sodium chloride. Infusion rate 0.1mmol/kg/hr (0.5mLkg/hr) gives sodium supplementation of 2.4mmol/kg/day
128-131	Medium deficit	Add 20mmol Sodium Chloride (4ml of 30% Sodium Chloride) to 46ml glucose 10% to make up 50ml infusion containing 0.4mmol/ml of Sodium Chloride. Infusion rate 0.2mmol/kg/hr (0.5ml/kg/hr) gives sodium supplementation of 4.8mmol/kg/day
124-127	Large deficit	Add 30mmol Sodium Chloride (6ml of 30% Sodium Chloride) to 44ml glucose 10% to make up 50ml infusion containing 0.6mmol/ml of Sodium Chloride. Infusion rate 0.3mmol/kg/hr (0.5ml/kg/hr) gives sodium supplementation of 7.2mmol/kg/day
<124	Very large deficit	Add 40mmol Sodium Chloride (8ml of 30% Sodium Chloride) to 42ml glucose 10% to make up 50ml infusion containing 0.8mmol/ml of Sodium Chloride. Infusion rate 0.4mmol/kg/hr (0.5ml/kg/hr) gives sodium supplementation of 9.6mmol/kg/day
<120	**Discuss with consultant**	Add 50mmol Sodium Chloride (10ml of 30% Sodium Chloride) to 40ml glucose 10% to make up 50ml infusion containing 1mmol/ml of Sodium Chloride. Infusion rate 0.5mmol/kg/hr (0.5ml/kg/hr) gives sodium supplementation of 12mmol/kg/day

NB glucose 5% can be used as the diluent in case of hyperglycaemia

Maximum concentration of sodium chloride for peripheral administration is 308mmol/L, or 15mmol per 50mL syringe. Concentrations exceeding this MUST be administered via central venous access.

Hyperkalaemia

1) Ensure that the hyperkalaemia result is true, i.e., not haemolysed.

2) Stop any additional potassium infusions.

3) For immediate action, consider changing aqueous PN to SW Neonatal Preterm Starter/Potassium Free PN. If true potassium over supplementation discuss with the Consultant and the Neonatal Pharmacist.

Hypokalaemia

1) Ensure aqueous PN bag contains potassium.

2) Replace deficit by using supplementary potassium infusion. Aim to correct over 24 hours. For central use only.

3) Magnesium levels should also be checked and corrected if required

Supplementary potassium infusion Via central line only
Add 10mmol Potassium Chloride (5mL of 15% Potassium Chloride) to 45mL glucose 10% to make up 50mL infusion containing 0.2mmol/mL of Potassium Chloride. Infusion rate 0.1mmol/kg/hour (0.5mL/kg/hour) gives potassium supplementation of 2.4mmol/kg/day

NB glucose 5% can be used as the diluent in cases of hyperglycaemia

Occasionally, larger potassium requirements are needed (eg stoma losses, diuretics). These should be met by using the standard solution above and increasing the RATE of infusion as described below.

Supplementary potassium infusion Via central line only
Infusion rate 0.2mmol/kg/hr (1ml/kg/hr) gives potassium supplementation of 4.8mmol/kg/day
Infusion rate 0.3mmol/kg/hr (1.5ml/kg/hr) gives potassium supplementation of 7.2mmol/kg/day

Maximum concentration of potassium chloride for peripheral administration is 40mmol/L, or 2mmol per 50mL syringe. Concentrations exceeding this MUST be administered via central venous access.

Hypercalcaemia (corrected calcium >3mmol/l)

1) Check serum phosphate levels. Hypercalcaemia may be secondary to hypophosphataemia particularly if the latter is severe or persistent. The treatment in these cases is to supplement phosphate.

2) If the phosphate level is within range, then any infusion containing calcium may need to be stopped, including PN. NB: all SW Neonatal PN bags contain calcium.

3) Discuss with the Consultant and the Neonatal Pharmacist.

Hypocalcaemia (corrected calcium <1.5mmol/L, or ionised calcium <1mmol/L)

1) Check acid-base balance as metabolic alkalosis decreases ionised calcium levels.

2) Magnesium levels should also be checked and corrected if required

3) Change to SW Neonatal preterm maintenance PN (if not already prescribed, and suitable for the patient), as it contains significantly more calcium that the starter bag.

4) If serum calcium level is still low, then administer 2mL/kg calcium gluconate 10% (0.46mmol/kg) intravenously over 10 minutes. DO NOT administer down the same intravenous line as the PN

5) If higher amounts of calcium are required discuss with neonatal consultant and neonatal pharmacist.

Hyperphosphataemia

1) Calcium levels should also be checked and corrected if required

2) If true hyperphosphataemia and immediate action is required then stop aqueous PN and change to SW Neonatal Preterm Starter/Potassium free PN.

3) Discuss with the Consultant and the Neonatal Pharmacist.

Hypophosphataemia (<1.5mmol/L)

1) Potassium levels should be checked and corrected if required

2) Check acid-base balance as metabolic acidosis increases urinary excretion of phosphate

3) Change to SW Neonatal Preterm maintenance PN bag (if not already prescribed and suitable for the patient), as it contains more phosphate and optimise rates if possible.

4) Discuss with the Consultant and the Neonatal Pharmacist.

5) If infant tolerating more than half enteral feeds then consider enteral phosphate supplementation.

Hypermagnesaemia

1) If immediate action is required then stop aqueous PN and change to SW Neonatal Preterm Starter/Potassium free PN

2) Discuss with the Consultant and the Neonatal Pharmacist.

Hypomagnesaemia

1) Ensure potassium and calcium serum levels are within the normal range

2) Change to SW Neonatal Preterm maintenance pn (if not already prescribed, and suitable for the patient), as it contains more magnesium than SW Neonatal starter bag, and optimise rates if possible.

3) Consider magnesium supplementation with 0.4mmol/kg magnesium sulphate intravenously over 10minutes.

Hyperlipidaemia (>2.8mmol/L)

For infants<26/40 CGA or those that are severely septic, then triglycerides should be monitored once they are receiving 10mL/k/day (1.5g/kg/day), and then again at 20mL/kg/day (3g/kg/day). From then on it should be routinely once weekly.

All other infants should have triglycerides measured twice weekly during the first week of PN and then once weekly thereafter.

More frequent monitoring may be required in certain circumstances, for example if an infant has had previously high triglyceride levels, is septic, catabolic or critically ill, or has severe and unexplained thrombocytopenia.

If infant is severely septic consider stopping the lipid infusion and discuss with the Consultant and the Neonatal Pharmacist.

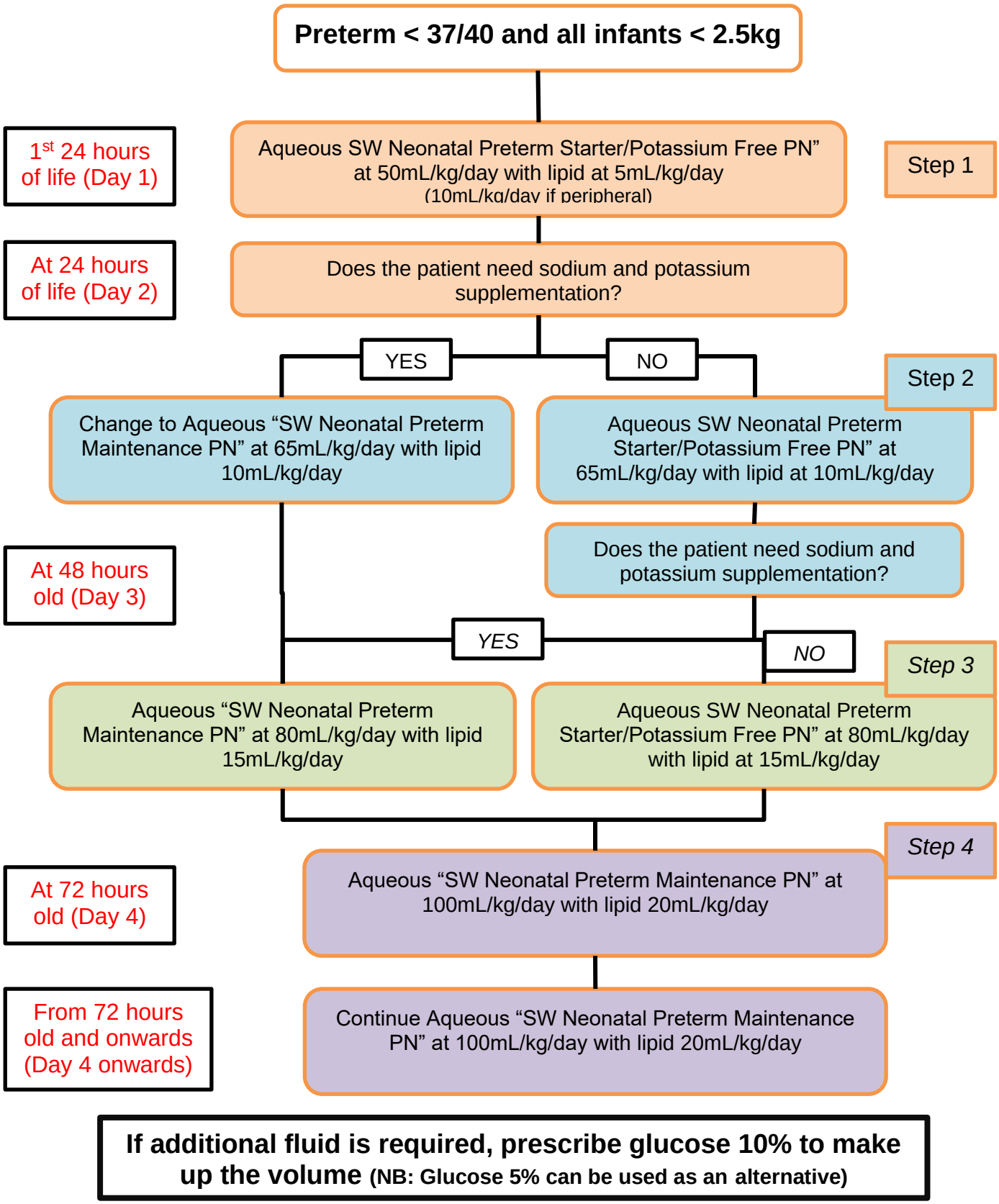
Triglyceride level (mmol/L)	**Action required**	**When to re-measure triglyceride**
≤ 2.8mmol/L	None	Weekly
2.9 – 3.5 mmol/L	Reduce lipid infusion by 5mL/kg/day	In 3 days
3.5 – 4 mmol/L	Reduce lipid infusion by 10mL/kg/day	In 2 days
> 4 mmol/L	Reduce lipid infusion to 5mL/kg/day or consider stopping	In 2 days

Once repeat triglyceride measurement is 2.8mmol/L increase lipid infusion rate by 5mL/kg/day and repeat measurement every 2 days until target lipid infusion rate is reached. If the level > 2.8mmol/L on a repeated test then repeat according to the table above then reduce the rate.

Appendix 4. FLOWCHARTS

Flowchart for starting PN in preterm infants < 37/40 and all infants <2.5kg

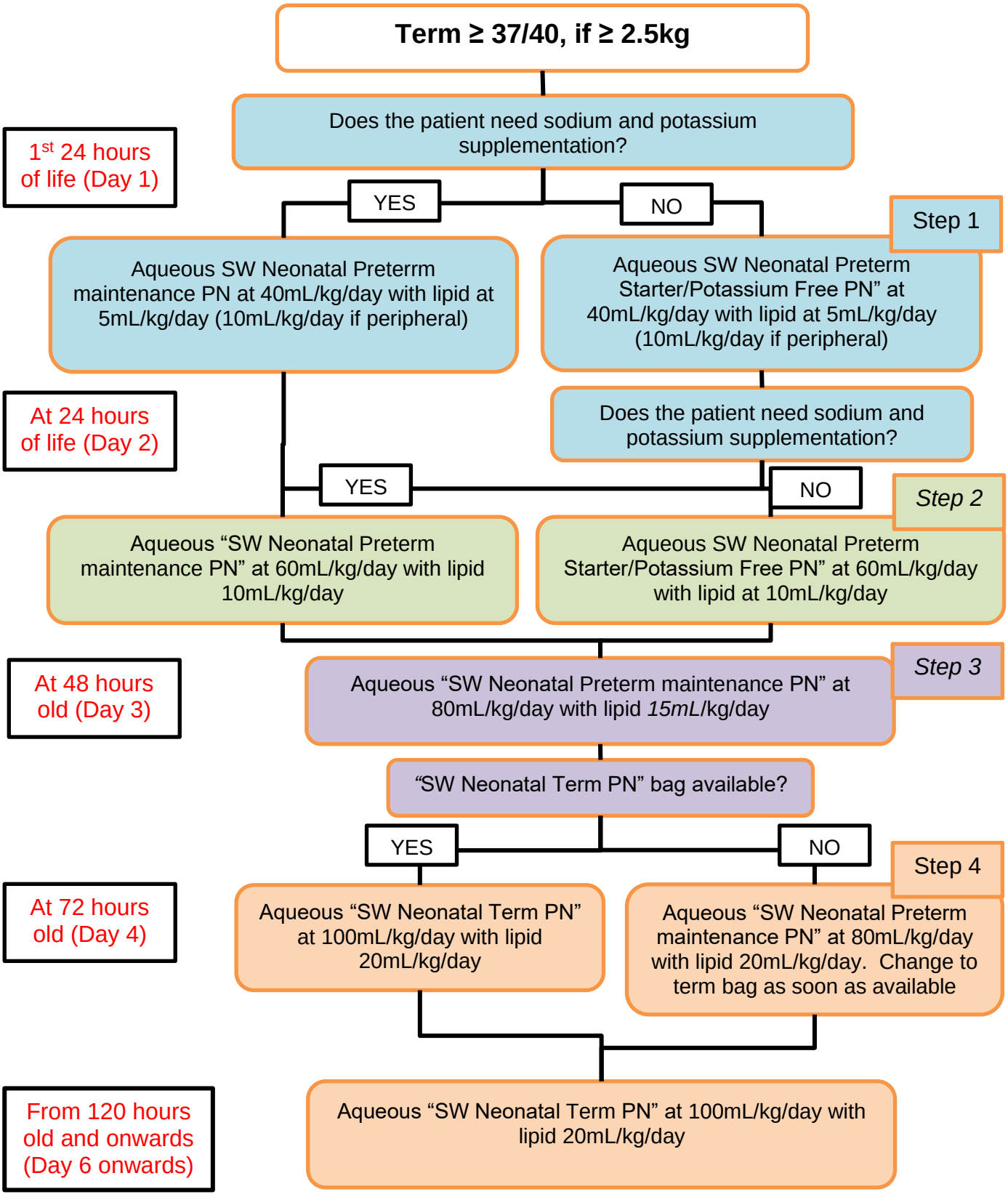
If restarting PN after full enteral feeds or if not starting PN at time of birth max starting rate is step 3



If additional fluid is required, prescribe glucose 10% to make up the volume (NB: Glucose 5% can be used as an alternative)

Flowchart for starting PN in term infants ≥ 37/40 if ≥ 2.5kg

If restarting PN after full enteral feeds or if not starting PN at time of birth max starting rate is step 3



If additional fluid is required, prescribe glucose 10% to make up the volume (NB: Glucose 5% can be used as an alternative)

Appendix 5. Nutritional content of PN bags

Concentrated PN for pre-term infants, and infants <2.5kg

Flow rates	SW Neonatal Preterm Starter/Potassium Free PN		
Aqueous bag	50 ml/kg/day	65 ml/kg/day	80 ml/kg/day
Lipid syringe	5 ml/kg/day	10 ml/kg/day	15 ml/kg/day
	Contents per kg/day at above rates		
Nitrogen	0.32 g	0.42 g	0.51 g
Amino acids	2 g	2.6g	3.2 g
Glucose	6 g	7.8 g	9.6 g
Glucose	4.17 mg/kg/min	5.42 mg/kg/min	6.67 mg/kg/min
Sodium	0.5 mmol	0.65 mmol	0.8 mmol
Potassium	0 mmol	0 mmol	0 mmol
Calcium	0.42 mmol	0.54 mmol	0.67 mmol
Phosphate	0.25 mmol	0.33 mmol	0.4 mmol
Magnesium	0.06 mmol	0.08 mmol	0.1 mmol
Chloride	0.41 mmol	0.54 mmol	0.66 mmol
Acetate	0 mmol	0 mmol	0 mmol
Peditrace®	0.5	0.65	0.8
Lipid	0.75 g	1.5 g	2.25 g
Vitlipid Infant®	1 ml	2 ml	3 ml
Solivito N®	0.25 ml	0.5 ml	0.75 ml
Non-nitrogen calories (kcal/kg/day)	32.5 kcal	48.2 kcal	63.9 kcal
Kcal/g protein	16.25	18.54	19.97

Concentrated PN for pre-term infants, and infants <2.5kg

Flow rates	SW Neonatal Maintenance PN		
Aqueous bag	65 ml/kg/day	80 ml/kg/day	100 ml/kg/day
Lipid syringe	10 ml/kg/day	15 ml/kg/day	20 ml/kg/day
	Contents per kg/day at above rates		
Nitrogen	0.36g	0.45g	0.56g
Amino acids	2.28g	2.8g	3.5g
Glucose	7.01g	8.63g	10.79g
Glucose	4.87mg/kg/min	6mg/kg/min	7.49mg/kg/min
Sodium	2.6mmol	3.2mmol	4mmol
Potassium	1.3mmol	1.6mmol	2mmol
Calcium	1.14mmol	1.41mmol	1.76mmol
Phosphate	1.3mmol	1.6mmol	2mmol
Magnesium	0.13mmol	0.16mmol	0.2mmol
Chloride	0.38mmol	0.47mmol	0.58mmol
Acetate	1.3mmol	1.6mmol	2mmol
Peditrace®	0.65	0.8	1
Lipid	1.5g	2.25g	3g
Vitlipid Infant®	2mL	3mL	4mL
Solivito N®	0.5mL	0.75mL	1mL
Non-nitrogen calories (kcal/kg/day)	45kcal	60kcal	77.1kcal
Kcal/g protein	19.8	21.43	22

Concentrated PN for term infants, if >2.5kg

Flow rates	SW Neonatal Preterm Starter/Potassium Free PN		
Aqueous bag	40 ml/kg/day	60 ml/kg/day	80 ml/kg/day
Lipid syringe	5 ml/kg/day	10 ml/kg/day	15 ml/kg/day
	Contents per kg/day at above rates		
Nitrogen	0.26 g	0.38 g	0.51 g
Amino acids	1.6 g	2.4 g	3.2 g
Glucose	4.8 g	7.2 g	9.6 g
Glucose	3.33 mg/kg/min	5 mg/kg/min	6.67 mg/kg/min
Sodium	0.4 mmol	0.6 mmol	0.8 mmol
Potassium	0 mmol	0 mmol	0 mmol
Calcium	0.33 mmol	0.5 mmol	0.67 mmol
Phosphate	0.2 mmol	0.3 mmol	0.4 mmol
Magnesium	0.05 mmol	0.07 mmol	0.1 mmol
Chloride	0.33 mmol	0.5 mmol	0.66 mmol
Acetate	0 mmol	0 mmol	0 mmol
Peditrace®	0.4	0.6	0.8
Lipid	0.75g	1.5g	2.25g
Vitlipid Infant®	1 ml	2 ml	3 ml
Solivito N®	0.25 ml	0.5 ml	0.75 ml
Non-nitrogen calories	27.7kcal	45.8kcal	63.9kcal
Kcal/g protein	17.3	19.1	20

Concentrated PN Concentrated PN for term Infants, if >2.5kg

Flow rates	SW Neonatal Term PN			
Aqueous bag	40 ml/kg/day	60 ml/kg/day	80 ml/kg/day	100 ml/kg/day
Lipid syringe	5 ml/kg/day	10 ml/kg/day	15 ml/kg/day	20 ml/kg/day
	Contents per kg/day at above rates			
Nitrogen	0.18 g	0.27 g	0.36 g	0.45 g
Amino acids	1.13 g	1.69 g	2.25 g	2.81 g
Glucose	4.8 g	7.2 g	9.6 g	12 g
Glucose	3.33 mg/kg/min	5 mg/kg/min	6.67 mg/kg/min	8.33 mg/kg/min
Sodium	1.6 mmol	2.4 mmol	3.2 mmol	4 mmol
Potassium	0.8 mmol	1.2 mmol	1.6 mmol	2 mmol
Calcium	0.6 mmol	0.9 mmol	1.2 mmol	1.5 mmol
Phosphate	0.8 mmol	1.2 mmol	1.6 mmol	2 mmol
Magnesium	0.08 mmol	0.12 mmol	0.16 mmol	0.2 mmol
Chloride	0.8mmol	1.2mmol	1.6mmol	2mmol
Acetate	0.8mmol	1.2mmol	1.6mmol	2mmol
Peditrace®	0.4	0.6	0.8	1
Lipid	0.75 g	1.5g	2.25 g	3g
Vitlipid Infant®	1 ml	2 ml	3 ml	4 ml
Solivito N®	0.25 ml	0.5 ml	0.75 ml	1 ml
Non-nitrogen calories	27.7kcal	45.8kcal	63.9kcal	78.2kcal
Kcal/g protein	24.6	27.1	28.4	29.2

PN bag details, i.e. glucose concentration and osmolarity data

Type of bag	% Glucose Concentration	Osmolarity of aqueous phase (mOsm/L)	Volume of aqueous phase	Osmolarity of lipid (mOsm/L)	Volume of lipid phase	Aqueous and lipid combined osmolarity (mOsm/L)	Shelf life (days)	Licensing
SW Neonatal Preterm Starter/Potassium Free PN 350ml	12	1040.2	40	270	5	954.62	60	Unlicensed
		1040.2	40	270	10	886.16		
		1040.2	50	270	5	970.18		
		1040.2	50	270	10	911.83		
		1040.2	60	270	10	930.17		
		1040.2	65	270	10	937.51		
		1040.2	80	270	15	918.59		
SW Neonatal Preterm Maintenance PN 350ml and 600ml	10.8	1017	65	270	10	917.40	60	Unlicensed
		1017	80	270	15	899.05		
		1017	100	270	20	892.50		
SW Neonatal Term PN 800ml	12	1010.1	40	270	5	927.87	84	Unlicensed
		1010.1	40	270	10	862.08		
		1010.1	60	270	10	904.37		
		1010.1	80	270	15	893.24		
		1010.1	100	270	20	886.75		
					In summary	<900mOsm/L[7]		
						900-950mOsmol/L[2]		
						>950mOsm/L		