East of England Neonatal ODN
(Hosted by Cambridge University Hospitals)

Clinical Guideline:

Authors: Lynne Radbone, Lead Dietitian, East of England Neonatal ODN

Original guideline (2013) developed in conjunction with members of the East of England Perinatal Network Neonatal Nutrition Working Group.

For use in: EoE Neonatal Units
Guidance specific to the care of neonatal patients.

Used by: Medical Staff, Neonatal Nurse Practitioners, Dietitians, Pharmacists

Key Words:

Date of Ratification: September 2022

Review due: September 2025

Registration No: NEO-ODN-2022-10

Approved by:

Neonatal Clinical Oversight Group	
Clinical Lead Matthew James	**Matthew James**

Ratified by ODN Board:

Date of meeting	

Audit Standards:

- 100% infants meeting the absolute indicators within the prescribing criteria commence parenteral nutrition within 8 hours of the decision to commence PN
- 100% infants meeting prescribing criteria receive a minimum of 1.5 – 2.0g/kg/day amino acid on day 1 of PN.
- 100% infants receive standardised PN accurately prescribed using the East of England PN

prescribing proformas, and where deviation from standardised PN occurs the reason for this deviation is clearly recorded in the patient's medical notes.

- 100% infants receive both aqueous and lipid PN that has all components protected from light.
- 100% units have access to a nutrition MDT that comprises at a minimum a Consultant Neonatologist/Paediatrician with an interest in neonatology, a neonatal dietitian and a neonatal pharmacist**.**

1.0 Introduction

Early postnatal growth failure, with associated longer term neuro-developmental implications is frequently encountered in very premature infants and is most evident in the smallest sickest infants. Delivery of intravenous nutrients, as parenteral nutrition, dominates the nutritional management processes in this group. In order to minimise the effects of early nutrient deficit, the development of strategies for effective PN delivery are essential. The publication of guidelines and frameworks for practice, developed by the National Institute for Health and Clinical Excellence (NICE) in 2020, (7) the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) in 2018 (8) and the British Association of Perinatal Medicine (BAPM) in 2016 (9) seek to establish a framework for the provision of appropriate PN for preterm infants and children. These frameworks form the basis of this document and as such are intended to serve as an aid to clinical judgement and not as a replacement.

2.0 Indications for PN

Absolute Indications	Premature infants < 30 weeks gestation or <1.25kg Intestinal Failure (i.e. short gut, pseudo-obstruction) Gastrointestinal Surgery Necrotising Enterocolitis (NEC) Congenital gastrointestinal defects (i.e.gastroschisis, intestinal atresia)
Relative Indications	Any infant ≥30 weeks' gestation or >1.25kg who has not progressed and is unlikely to have established enteral feeding within 72 hours of birth.

Recommendations:

- For **preterm and term infants** Parenteral Nutrition (PN) should be commenced as soon as the decision to provide has been made. This should be within 8 hours and definitely within 24 hours in any infant that meets the specified criteria.

- PN should be commenced for **preterm infants** previously established on enteral nutrition when either feeds have to be stopped and are unlikely to restart within 48 hours, or where feeds have already been stopped for >24 hours and there is unlikely to be sufficient progress with advancing feeds within the next 48 hours.

- PN should be commenced for **term infants** previously established on enteral nutrition when either feeds have to be stopped and are unlikely to restart within 72 hours, or where feeds have already been stopped for >48 hours and there is unlikely to be sufficient progress with advancing feeds within the next 48 hours.

3.0 Summary of Clinical Recommendations:

Fluid and Electrolyte Requirements

- Standardised PN formulations should be compounded in the smallest possible volume to allow provision of nutritional requirements.

- The contribution of intravenous medication and flushes should be considered when determining sodium requirements for PN.

- Sodium and potassium can be given from the first day of life especially when recommended amino acid and energy intakes are provided. The needs of individual infants may deviate markedly from the recommended ranges depending on clinical condition.

- Additional sodium and potassium should ideally be provided as separate intravenous infusions alongside standardised PN bags.

Energy Requirements

- For **preterm and term infants**, if starting PN within the first 4 days of life give a starting range of 40-60Kcal/kg/day gradually increasing over a small number of days

- Most **preterm infants** will meet their energy requirements and approximate intra-uterine lean body mass and growth rates when provided with a maintenance level of up to 120Kcal/kg/day

- Most **term infants** will meet their energy requirements and approximate intra-uterine lean body mass and growth rates when provided with a maintenance level of up to 90Kcal/kg/day

- For **preterm and term infants**, if starting PN more than 4 days after birth give maintenance levels from the first day of PN

- Factors that may reduce/increase requirements should be taken into account when estimating an individual infant's requirement.

Amino acid Requirements

- Where a decision is made to give PN, amino acid provision should commence within 8 hours of that decision being made.
- In **preterm infants** amino acid provision should commence at 1.5 – 2.0g /kg/day on the first day increasing to 3.0 – 4.0g/kg/day.
- If commencing PN more than 4 days after birth for a **preterm infant** give a range of 3.0 - 4.0g amino acid/Kg/day from day 1.
- In **term infants** amino acid provision should commence at 1.0 – 2.0g /kg/day on the first day increasing to 2.5 – 3.0g/kg/day.
- If commencing PN more than 4 days after birth for a **term infant** give a range of 2.5 - 3.0g amino acid/Kg/day from day 1.
- An energy:amino acid ratio of 30-40Kcal/g amino acid (20-30 non-nitrogen Kcal/g amino acid) is required for effective utilisation of protein.
- Amino acid solutions specifically designed for neonates and containing cysteine, tyrosine and taurine should be used for compounding PN for preterm and term infants.

Carbohydrate Requirements

- Glucose should provide 60-75% of total energy (7).
- Glucose requirements should be calculated using endogenous glucose production rates (GPR) and glucose oxidation rates (GOR) to ensure supply is within a safe range.
- For **both preterm and term infants**, if starting PN in the first 4 days after birth glucose intake should commence at 4-6mg/kg/minute (6.0-9.0g/kg/day)
- From day 2 onwards target glucose intake should be 6-11mg/kg/minute (9.0 – 16.0g/kg/day
- For **both preterm and term infants**, if starting PN more than 4 days after birth give a starting range of 6-11mg/kg/min (9.0 – 16.0g/kg/day)
- Maximum glucose infusion for long-term PN should not exceed 16g/kg/day

Lipid Requirements

- For both **preterm and term infants**, if starting PN within the first 4 days of life, Intravenous lipids should commence at 1-2g/kg/day.
- Maximum lipid provision for both **preterm and term infants** should be 3-4g/kg/day.
- Incremental introduction may reduce the risks of hypertriglyceridaemia and retinopathy of prematurity.
- Preterm infants should receive a minimum 0.25g/kg/day linoleic acid in order to prevent EFA deficiency (met by 0.5g [2.5ml]/kg/day Intralipid or 1.5g [7.5ml]/kg/day SMOFLipid).
- Lipid should provide 25-40% non-protein calories.
- 20% intravenous lipid emulsions should be first line choice for preterm infants.
- There is no evidence to support the use of one lipid emulsion over another for routine use in neonates

Vitamin, mineral and trace element requirements.

- For **preterm and term infants** both fat and water soluble vitamins should be given daily, ideally from the commencement of PN in order to maintain standard daily requirements.
- Both fat and water soluble vitamins should be given within the lipid emulsion in order to improve their stability.

Iron, minerals and trace elements.

- For **preterm and term infants** intravenous trace elements should be given from the commencement of PN
- Intravenous iron should not be given to any infant under the age of 28 days
- Infants on sole PN who are 28 days or older should be monitored for iron deficiency and treated if necessary
- Infants receiving PN >21 days should be considered for additional supplementation of zinc.
- Trace elements and fat soluble vitamin levels should be monitored monthly in all infants receiving long term PN

Calcium and Phosphorus

- For **preterm infants** starting PN *within the first 48 hours* after birth:
- Give a starting range of 0.8 – 1.0mmol/kg/day Calcium
- Give 1.0mmol/kg/day Phosphate, increasing to 2mmol/kg/day after 48 hours

- For **preterm infants** starting PN *more than 48 hours* after birth:
- Give a range of 1.5 - 2.0mmol/kg/day Calcium
- Give 2.0mmol/kg/day Phosphate. Careful monitoring of the plasma phosphate concentration is required within the first days of life, with the need for possible higher doses of phosphate ,to prevent severe hypophosphataemia in preterm infants.
- A calcium to phosphate ratio of 0.75:1 – 1:1 should be used for all neonates receiving PN.

Parenteral nutrition in the critically ill preterm and term neonate

- For critically ill **preterm infants** give PN in accordance with the East of England guidelines, commencing at a rate of 40kcal/kg/day, increasing gradually to target requirement.
- For critically ill **term infants** give PN after 48 hours, commencing at a rate of 40kcal/kg, increasing gradually to target requirement.

Standardised parenteral nutrition

- Standardised PN bags are to be used in order to maximise nutrient delivery and to minimise the risk of errors in prescription and compounding.
- The EoE “preterm concentrated” formulation should be used as first line PN to allow for maximum delivery of nutrition within a limited volume.
- The decision to use individualised/bespoke PN should only to be made by a senior clinician in conjunction with a neonatal pharmacist and neonatal dietitian.
- Individually tailored PN solutions should only be used when an infant’s nutritional requirements cannot be met by the available range of standard PN formulations (i.e. in very sick and metabolically unstable patients such as those with complex disorders associated with fluid and electrolyte imbalance or renal failure).

Service Design

- Neonatal PN services should be supported by a specialist MDT, either locally or at network level.
- The team should comprise, at a minimum of a consultant, a neonatal dietitian and a neonatal pharmacist, with access to a wider team as required for the management of babies with complex needs.

PN associated liver disease

- The use of pure fish oil lipid emulsions is not recommended for general use in preterm infants
- Use a composite emulsion containing fish oil as first line lipid in infants with a definitive diagnosis of short gut at commencement of PN or complex gastro conditions where feeds are unlikely to be established within 28 days eg gastroschisis.
- Consider using SMOFLipid in the following infants:
    - Infants at high risk of needing PN for >28 days.
    - PN dependent >28 days even if liver function tests are normal.
    - Significant liver dysfunction before 28 days on PN conjugated bilirubin >50micromol/litre ultrasound evidence of hepatomegaly, or clinical cholestasis (pale stools, dark urine)

Enteral Nutrition

- Trophic feeds should be commenced as soon as clinically indicated in the infant receiving parenteral nutrition.
- Decisions regarding enteral feeds should be made in line with the East of England Enteral Feeding guideline

Monitoring Parenteral Nutrition

- The individual responsible for reviewing biochemical results and taking appropriate action when abnormal values are observed must be clearly identified in each unit.

	Starting and increasing PN	**Maintenance PN**	**Comment:**
Blood glucose	1-2 hours after first starting PN	1-2 hours after each change of PN bag (24 or 48 hourly)	Measure more frequently if: • Previous hypo/hyper glycaemia • Dose of IV glucose is changed • Clinical reasons for concern
Blood pH	daily	Twice weekly	Measure more frequently if: • Previous levels out of normal range • Clinical reasons for concern
Potassium	daily	Twice weekly	Measure more frequently if: • Previous levels out of normal range • IV dose has changed • Clinical reasons for concern
Chloride	daily	Twice weekly	Measure more frequently if: • Previous levels out of normal range • IV dose has changed • Clinical reasons for concern
Calcium	Daily	Twice weekly	Measure more frequently if: • Previous levels out of normal range • IV dose has changed • Clinical reasons for concern

Sodium	daily	Twice weekly	No recommendation
Phosphate	daily	Weekly	Measure more frequently if: • If level has been outside normal range • Clinical reason for concern • Preterm infants born <32+0 weeks
Urea & Creatinine	Daily	Twice weekly	No recommendation
Magnesium	Twice weekly	Twice weekly	No recommendation
Iron status			Measure ferritin, iron and transferrin saturation if a preterm baby is on PN for >28 days
Liver function	weekly	weekly	Measure more frequently if: • Previous levels outside normal range • Clinical reasons for concern
Triglycerides	Daily	weekly	Measure more frequently (but not more than 1x day) if: • Level is >3.0 mmol/l • Baby is at risk of hypertriglyceridaemia

Monitoring recommendations:

- All infants on PN should receive consistent regular monitoring.
- Infants receiving PN long-term, i.e. >3 weeks with minimal or no enteral feeds should receive additional monthly monitoring of trace elements and fat soluble vitamins.
- Triglycerides should be monitored with each increase of IV lipids and weekly after the maximum dose is achieved and tolerated.
- Lipid provision should preferably be reduced, not stopped, when triglyceride levels are above 3.0mmol/L in order to maintain essential fatty acid provision.

Prescribing and Compounding:

General recommendations:

- The decision to initiate PN should be made by a senior clinician.
- The clinician that decides on the nutrient requirements and the PN formulation should sign the prescription
- The standardised EOE Neonatal Network PN bags with electrolytes and trace elements, should be used as default formulations.
- The preterm concentrated formulation will allow for maximum provision of nutrients within limited starting volumes and should be considered as the first line option for preterm PN across the network
- Additional supplements, where required, should be given using a separate intravenous infusion in order to minimise interference with standard PN bags.
- "Fine tuning" of individual electrolyte provision based on detailed calculated mmol/kg requirements is not recommended.
- Fully bespoke or individualised PN should only be used where there is no suitable standardised formulation available to meet unusual nutrient requirements or severe fluid restriction.
- Neonatal PN services should be supported by a suitably experienced specialist multidisciplinary team (either local or within a clinical network) that includes as a minimum, a consultant neonatologist or paediatrician with special interest in neonatology, a neonatal pharmacist and a neonatal dietitian with experience and expertise in neonatal PN.

- PN should ideally be prescribed 48 hourly. Infants with changing electrolyte requirements should, wherever possible be managed with a standard formulation prescribed over 48 hours, supplemented by a separate infusion of electrolytes rather than with a manipulated bag.
- Fluid volume priority should be given to PN in order to maximise nutrient provision, this is more achievable when using the concentrated formulation.
- Both fat and water soluble vitamins should be given with the lipid emulsion to improve vitamin stability. In units where vitamin and mineral additions are to be made locally the following formulation should be adopted:

Intralipid SMOFLipid 20% 37.5ml Vitlipid N Infant 10ml Solivito N (WFI 10ml) 2.5ml 20ml/kg would then provide: Solivito 1ml/kg Vitlipid N 4ml/kg Lipid 3.4g /kg

- Consideration should be given to other routes of vitamin administration if the lipid emulsion is, for some reason, stopped rather than reduced. Solivito can be added to aqueous PN if necessary but this route should only be used if lipid is not being given.
- PN should be prescribed based on birth weight in the first week of life. Thereafter it should be prescribed on the greatest recent weight (birth weight or current weight) as long as there is no significant oedema.
- Any change in infusion rate from that on the label of the PN solution must be within the maximal rate of infusion on the label and be clearly documented on the patient's prescription chart.
- In chronic or acute severe renal failure trace element preparations should be used with caution along with careful monitoring of trace elements.

Administration of PN

- A central line should be used to deliver neonatal PN. It must be inserted according to local/network guidelines with strict adherence to approved aseptic techniques. The line tip position must be confirmed by x-ray (with radio-opaque contrast for long-lines) prior to the

infusion of PN. The preferred position for the central line tip should be either the IVC (level of the diaphragm) or SVC (long-line only). Atrial positioning should be avoided due to the risk of atrial perforation.

- Lines used for PN should not be used for blood sampling.

Peripheral line delivery of PN

- Peripheral venous catheters can be used for either routine administration of PN, but more frequently, in the short term. Peripheral PN should be considered if:
- It would avoid the delay in starting PN beyond the 8 hour preferred window and avoid any interruptions in PN delivery.
- Short term use of PN is anticipated, for example less than 5 days.
- Central line access is impractical.

- If PN is administered via a peripheral line then the maximum osmolarity should be limited.
- The EOE Preterm standard and term standard PN bags are suitable for peripheral infusion. The EOE Concentrated PN bags must never be used for peripheral infusion.

Additions to PN

- Additions should not be made to standardised PN solutions, either lipid or aqueous, contained in infusion bags and/or syringes. Where unavoidable they must only be made on a PAU and never at ward level

Light protection

- Both lipid and aqueous PN solutions should be protected from light. This includes all bags, infusion sets and syringes.
- Where units cannot comply with this recommendation, this should be added to the local Trust risk register.

Infusion time

- Aqueous PN solutions should be infused over 48 hours in stable neonates. Lipid should be infused over 24 hours with syringes changed daily.

Out of hours availability of PN

- Each unit must make arrangements for pre-prepared PN (both aqueous solutions and lipid emulsions) to be available 24 hours a day

Use of filters

- The EOE recommendation is that PN giving set and filters should be changed every 48 hours for aqueous PN and every 24 hours for lipid.

Checking of PN

- PN infusion set up, attachment of the giving set and connection to the patient should be performed using full aseptic non-touch technique (ANTT).
- All PN should be checked against prescription and fluid requirements by two registered nurses, one of whom must be qualified in speciality.

Weaning of PN

- Consider stopping PN within 24 hours once enteral volumes of 140-150ml/kg/day have been achieved for infants born before 28+0 weeks
- Consider stopping PN within 24 hours once enteral volumes of 120-140ml/kg/day have been achieved for infants born at or after 28+0 weeks.

For discussion of evidence supporting recommendations, references and network formulations see East of England Parenteral feeding of Infants on the Neonatal Unit [full guideline]

Exceptional Circumstances Form

Form to be completed in the **exceptional** circumstances that the Trust is not able to follow ODN approved guidelines.

Details of person completing the form:	
Title:	Organisation:
First name:	Email contact address:
Surname:	Telephone contact number:
Title of document to be excepted from:	
Rationale why Trust is unable to adhere to the document:	
Signature of speciality Clinical Lead: Date:	Signature of Trust Nursing / Medical Director: Date:
Hard Copy Received by ODN (date and sign):	Date acknowledgement receipt sent out:

Please email form to: mandybaker6@nhs.net requesting receipt.

Send hard signed copy to: Mandy Baker
EOE ODN Executive Administrator
Box 93
Cambridge University Hospital
Hills Road
Cambridge CB2 0QQ