Parenteral Nutrition
Simpsons Centre for Reproductive Health

Parenteral Nutrition (PN) is the supply of intravenous nutrition when the enteral or oral route is inadequate to meet full nutritional requirements. It is made up of two components:

- **A lipid solution** providing fat with vitamins (***See Appendix 1.0***).
- **An aqueous solution** providing amino acids, glucose, electrolytes and trace elements.

There are 2 aqueous bags available routinely on the neonatal unit:

Sodium free bag	**10.0% Glucose and 2.27g protein/100ml**
Standard bag	**12.5% Glucose and 2.88g protein/100ml**

The following bag is also available but only used occasionally:

Central bag	**16.0% Glucose and 3.1g protein/100ml**

Appendix 2.0 gives an overview of the nutritional content of these bags.

This guideline covers the practical management of PN for preterm infants as well as babies born at term, up to 28 days after birth. In conjunction with clinical judgment, it serves to ensure PN is provided safely and meets nutritional recommendations as documented by NICE (2020) while also taking into consideration guidance from ESPGHAN et al (2018). ***See Appendix 3.0*** for an overview of nutritional requirements for term and preterm infants.

PN is the cornerstone of early nutritional care for vulnerable preterm infants due to their limited stores at birth and the time required to establish adequate enteral nutrition to meet their needs. It should also be considered in any infant who is unlikely to meet their nutritional needs in a timely fashion via the enteral route.

This document highlights the criteria for starting PN however there may be additional valid reasons as per consultant discretion.

Prescribing

Indications for PN

- Infants <1000g or <28 weeks should start PN as soon as possible after birth. An emergency bag should be considered to avoid any delays in starting nutrition.
- Infants 1000 - 1250g on the slow enteral feeding regimen should have PN ordered via pharmacy at the next available opportunity.
- PN is not routine for infants >1250g but can be started at consultant discretion.
- All infants who are unlikely to establish sufficient enteral nutrition quickly e.g., babies with a congenital gut disorder or with critical illness such as sepsis (NICE 2020) at consultant discretion.

Relative contraindications to PN

- Infants who are seriously ill, especially if acidotic or hypotensive, or have thrombocytopenia or coagulopathy.
- Infants with septicaemia or necrotising enterocolitis (NEC) may be started on PN at consultant discretion and lipid may need to be run at a reduced rate until they clinically improve.

How to start:

- Prescribe SMOF lipid solution and the relevant aqueous PN solution equivalent to infant's daily fluid requirement minus other essential fluid infusions.
- **Both aqueous and lipid are included in the prescribed fluid volume.**
- If starting PN in the first 4 days after birth, volume should be gradually increased to meet full requirements e.g., over 4 days (NICE 2020).
- If starting PN more than 4 days after birth, there is no need to gradually increase volume over a few days (NICE 2020) meaning that full nutritional requirements can be quickly met.
- If PN volume has been incremented in the previous 12 hours, then **no further changes should be made until 6pm the following day**.
- Additional fluid on top of PN/lipid may be needed to meet the desired fluid target.
- When prescribing PN/lipid on the fluid chart, the prescriber should refer to the green Neonatal PN Order Form to confirm what has been ordered from pharmacy aseptic for that day.
- Keep one intravenous line for PN only (no antibiotics or other drugs, no piggybacking), except in extreme circumstances at consultant request. Consult clinical pharmacist as required.

Incrementing PN volume:

- Changes to PN volume should generally happen at 6pm (i.e. when PN arrives on the unit).

Table 1.0: Unit policy for overall fluid recommendations during first few days after birth for reference:

	≥750 g birthweight to 1500g	> 1500 g birthweight
Day 1	75 ml/kg/day	60 ml/kg/day
Day 2	100 ml/kg/day	80 ml/kg/day
Day 3	125 ml/kg/day	100 ml/kg/day
Day 4 – 7	Increase up to 150ml/kg/day	120 ml/kg/day

* If < 750g start with 100 ml/kg/day and review fluids after 4 hours (see below).
* May need to increase above 150 ml/kg/day if insensible losses are high.

Aqueous Bags (See Appendices for more detailed information)

Preterm infants

Sodium Free Bag (10% Glucose and 2.27g Protein/100ml)

- Infants < 28/40 should start on the Sodium free bag after birth.
- Refer to the flowchart for PN volume increments.
- This bag is not designed to meet nutritional requirements for preterm infants for more than 48 hours and should be changed on day 2 of PN at 6pm or sooner if Na <145.
- Please note electrolyte additions are not possible.

Standard Bag (12.5% Glucose and 2.88g Protein/100ml)

- Infants > 28/40 should start on the Standard bag (12.5%).
- Refer to the flowchart for PN volume increments.
- Electrolyte additions can be made to this bag as per serum biochemistry - discuss with MDT as required.
- Consider the maximum thresholds for electrolyte additions as per the information on the ordering sheet. ***For potassium additions do not exceed 4mmol/100ml peripherally.***

Central Bag (16% Glucose and 3.1g Protein/100ml)

- This bag is rarely used. Please discuss with MDT if you feel there is an indication for this bag.
- Refer to the flowchart for PN volume increments.
- Additional phosphate and calcium should be added to this bag for preterm infants to meet their requirements. ESPGHAN (2018) recommend a minimum of 1.6mmol/kg/day of calcium and 1.6mmol/kg/day phosphate. These should be monitored and adjusted as required.
- There is no potassium added to this bag so an appropriate amount should be added. Note, growing preterm infants require 2 – 5mmol/kg/day for < 1500g and 1 – 3mmol/kg/day for > 1500g (ESPGHAN 2018).

Term Infants

Sodium Free Bag (10% Glucose and 2.27g Protein/100ml)

- This bag is not for use in term infants.

Standard Bag (12.5% Glucose and 2.88g Protein/100ml)

- Refer to the flowchart for PN volume increments.
- Electrolyte additions can be made as required. ***For potassium additions do not exceed 4mmol/100ml peripherally.***

Central Bag (16% Glucose and 3.1g Protein/100ml)

- Refer to the flowchart for PN volume increments.
- Phosphate and calcium levels in this bag meet the minimum requirements for term infants.
- There is no potassium added to this bag so an appropriate amount should be added. For reference, growing term infants require 1.5 – 3mmol/kg/day of potassium (ESPGHAN 2018).
- With any electrolyte adjustments please be guided by serum levels.

Lipids

SMOF lipid® solution

- This is a composite intravenous lipid emulsion (ILE) which is comprised of **S**oya Bean (30%), **M**edium chain triglycerides (30%), **O**live Oil (25%) and **F**ish oil (15%) with added vitamins.
- Water soluble vitamins (Solivito) and fat-soluble vitamins (Vitlipid) are added to SMOF lipid.
- Start lipid as soon as it is available unless it is contraindicated.
- The daily SMOF lipid solution dose is infused over 24 hours (there is no evidence of benefit in having a lipid free interval prior to morning blood sampling).
- Essential fatty acid (EFA) deficiency can occur in preterm infants within 2-3 days if an adequate volume of lipid is not given. Infants require at least 0.25g/kg/day of Linoleic acid which is met with 1.5g/kg/day of SMOF lipid solution/day (0.375ml/kg/hour).

Table 2.0: Volume of SMOF lipid solution prescription

Day of PN	Volume of SMOF lipid solution (ml/kg/hr)	Fat provided from SMOF lipid solution(g/kg/day)
1	0.5	2
2	0.5	2
3	0.75	3

Triglycerides

- Check triglycerides on day 4 of lipids.
- Once stable triglycerides should be checked weekly.
- Where triglyceride levels are >3mmol/l, lowering, not stopping the lipid dosage is recommended (See Table 3.0).
- If lipid infusion is interrupted for more than 2 - 3 days, consideration should be given to the provision of vitamins. Discuss with neonatal pharmacist/dietitian.
- Check triglycerides when a baby becomes seriously ill (particularly if there is significant metabolic acidosis, hypotension, thrombocytopenia, or coagulopathy).
- When sending biochemistry samples, always record in the clinical information section that the baby is on PN. The lab will then automatically check for visible lipaemia.

Table 3.0 Guide for lipids adjustment based on triglyceride levels

Triglyceride Level (mmol/l)	Action
<3	Continue current prescription
>3 – 4	Reduce lipid by 0.25ml/kg/hour (e.g. if on 0.75ml/kg/hour, reduce to 0.5ml/kg/hour). Recheck triglyceride in 24 hours.
>4	Hold lipid for 24 hours and repeat triglyceride level. Once triglyceride level <2.7mmol/l, restart lipids at 0.25ml/kg/hour and gradually increase by increments of 0.25ml/kg/hour. Repeat triglyceride level to ensure lipids are well tolerated.

Specific considerations

Renal Disease (Erin Shillinglaw – Specialist Paediatric dietitian, PCCU)

There are no specific nutritional recommendations or requirements for babies with acute or chronic kidney disease who require PN. The cause of kidney disease can result in catabolism and nutrition should be prioritised where possible. The nutritional regimen should be adjusted in the context of serum electrolytes and discussion with the renal MDT. The following principles should be considered:

1. Nutritional need will, almost, always exceed the fluid volume allowed unless polyuric.
2. Protein should never be restricted unless serum Urea is greater than 20mmol/l on 2 consecutive occasions.
3. A rising serum Urea, with a static, or falling, serum Creatinine is indicative of catabolism and nutrition and / or protein should be increased
4. Raised serum electrolytes, particularly K and PO_4, are routinely treated with a low electrolyte formula. This should be discussed in the context of the full clinical picture.
5. Vitamin A excretion is reduced in kidney disease therefore additional supplementation should be discussed with the renal MDT

Surgical +/- stoma

Babies who have had abdominal surgery +/- a stoma formed, may require PN for a prolonged period, thus putting them at greater risk of PN associated liver disease. Sometimes strategies are employed to prevent and manage liver dysfunction e.g. reducing lipid volume, cycling of lipid etc however this decision should be discussed with the multidisciplinary team (MDT) as a number of factors should be considered.

Weaning onto enteral feeds while reducing the PN volume is also key to the prevention and management of liver disease. This weaning process should be individualised and will not follow the usual incremental enteral feeding charts. Please see the stoma principles guidance on Badgernet to support understanding of this and consult the wider MDT involved.

Ordering and Availability

Ordering PN

- PN can be ordered from the pharmacy aseptic unit **before 11am on weekdays**.
- For routine PN, the night medical team should prescribe the PN for the following day.
- For weekends, the prescriptions for Friday, Saturday and Sunday needs to be done on **Thursday** night.
- Changes can be made to the weekend prescriptions if clinically needed – if this is the case, the pharmacy aseptic department should be contacted as early in the day as possible (ext. 22906), ideally before 10am. ***While the pharmacy aseptic unit will always try to accommodate changes, this is subject to discussion and assessment of current workload.***
- At the **weekend** new start PN orders should ideally be scanned down to pharmacy aseptic **before 10am** and a phone call (ext. 22906) should be made to ensure they are aware.
- The SMOF lipid solution syringe/bag must be changed every 24 hours
- The aqueous PN solution may be infused for up to 48 hours. Usually, sufficient aqueous solution should be ordered to last 48 hours (a 48hr bag)
- If rapid changes in electrolyte requirements are predicted, a 24-hour bag may be ordered.
- An amber line should be used to run lipids if possible

Pharmacy staffing

- A pharmacist (bleep 2256) will review infants requiring PN each morning on the unit on weekdays (excluding public holidays).
- There is no pharmacist cover on the unit at the weekend, but the aseptic pharmacist can be contacted on ext. 22906 up until 12noon on Saturday and Sunday.
- If there are any concerns, or special requirements regarding PN, contact the pharmacist as early in the day as possible to discuss.

Dietetic staffing

- The dietitian will review infants on PN regularly when attending ward rounds.
- Infants on long term PN and unstable infants will be reviewed more frequently in liaison with the pharmacy, medical and nursing teams.
- The dietetic team are available Mon – Fri within office hours on 0131 312 1075.

Emergency bags

There are emergency bags of aqueous PN available on the unit for use, out of hours, when the pharmacy aseptic service is not available. Please take extra care when selecting the PN from the fridge as there are two different types of PN bags available:

1. **10% Sodium Free**
2. **12.5% Standard bag**

- If an emergency bag is used, please scan a request to the pharmacy aseptic unit stating "emergency bag(s) used" and specifying the bag type (10% or 12.5%) and numbers used.
- Make sure a green Neonatal PN order form is written for the PN regimen required for that baby (aqueous solution and lipid) for the next day.
- Out of hours (Emergency) aqueous PN bags can be continued for 48 hours if the correct giving set (containing the 0.2µ filter) is used, there is adequate volume and there is no clinical reason to make a change.

Monitoring Protocol

Blood gas

- Check electrolytes daily.

Serum U and Es:

- Check every 3 days in the first week and then weekly as required.
- Check 24 hours after making changes to additives.

Neonatal Screen (NNS)

- Check weekly.
- Check conjugated bilirubin after 28 days.

Triglycerides

- See lipid section

Further investigations:

Further blood testing may be required which should be discussed with a senior clinician if clinically indicated.

Longer term PN Monitoring

Patients on longer term PN will require additional nutritional bloods tests. As per guidance from the PGHAN team within RHCYP (Edinburgh) the following tests are suggested for infants fed on PN for > 3 months:

- Ferritin
- Iron Studies
- Vitamin B12
- Folate
- Zinc
- Copper
- Vitamins A, D and E
- PTH

Weaning off PN

- Enteral feeding volume can be included in the total volume when they are being tolerated beyond trophic amounts (i.e. ≥12 ml/kg/day) which means the aqueous PN rate should be reduced accordingly.
- Enteral vitamins (Abidec/Dalivit) are generally started when the infant is on 90ml/kg/day of milk.
- If lipid dose has been temporarily reduced due to a high triglyceride level please discuss with the dietetic/pharmacy team if enteral vitamins are required.
- If a PN regimen contains electrolyte additions, consider if this needs to be continued enterally as PN is weaned to a smaller volume. e.g. sodium supplements. Discuss with the pharmacist if needed.
- When enteral feeds reach 120ml/kg/day, consider stopping PN

Proportion of lipid can be calculated/reduced as follows:

When aqueous PN volume is:	SMOF lipid solution
≥ 90ml/kg	0.75ml/kg/hour (3g fat/kg)
≥ 60 – 89ml/kg	0.50ml/kg/hour (2g fat/kg)
≥ 30 – 59ml/kg	0.25ml/kg/hour (1g fat/kg)
<30ml/kg	Stop lipid

This guidance may not apply to babies with high output stomas / babies whose growth is of concern - please discuss with dietitian/ pharmacist as required.

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