Lancashire & South Cumbria NHS
Neonatal Network

Title:	Lancashire & South Cumbria Neonatal Network Parenteral Nutrition (PN) Guideline
Reference number	PW-ODN-04
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Target Audience	LSC Neonatal Units – Clinicians & Pharmacists
Ratified by:	LSC NSG (After agreement from CEG members)
Date Ratified:	21.9.21
Review Date:	21.9.22
Version:	Final
Document status:	Emailed to LSC units and uploaded to website 5.10.21

Date	Version	Author	Notes
August 2021	v0.1	As above	Shared with LSC CEG for review. No changes at present but concentrations to be reviewed over next 12 months.

Parenteral Nutrition (PN) Guidelines

Contents

1. Introduction

This document sets the standard to improve nutritional intake of PN by maximising kilocalorie and protein intake of PN by using standard concentrated formulations and infusion rates.
This document should be used in conjunction with the standardised Lancashire & South Cumbria Neonatal Common Infusion Guideline.

The standardisation of PN across the network would lead to:

1. **Improved nutrition to babies by protecting PN volume even when baby receives other infusions**
2. **Minimising infusion errors by using standardised formulations**
3. **Minimising delays in transfers as standard infusions can be administered by the transport team**

2. Indications for PN

Maintaining nutritional intake is an essential part of intensive care in the preterm infant as nutrient reserves are low (theoretically < 4 days in infants that are less than 1kg). Parenteral nutrition (PN) is an effective way to deliver all of the infant's specific nutritional requirements parenterally to maintain growth whilst establishing enteral feeds.

The hazards of therapy include line complications and infection, cholestatic jaundice and metabolic disturbance. The risks have to be balanced with potential benefits. The benefits require PN to be used for at least 7 days so PN should not be administered unless full enteral feeding is unlikely to be achieved within 7 days.

Eligibility for PN (see separate guidelines for ordering PN):

1. **Any infant born <30 weeks gestation or <1.25kg (PN to start on as soon after birth as possible: supply of Start-up bag available on the unit for new admissions)**

2. **Any infant 1.25-1.5kg who is unlikely to achieve full enteral feeds by day 7 E.g. severe intrauterine growth retardation (IUGR) and those with abnormal doppler studies, hydrops fetalis etc. (nutritional assessments on days 1, 3 and 5 with PN starting immediately if day 7 full enteral feeding unlikely to be achieved)**

3. **Infants greater than 1.5kg who are likely to require more than 7 days PN. PN started before day 5 will require consultant initiation**

4. **Babies who have gastrointestinal problems during their admission e.g. Necrotising enterocolitis (NEC), gastroschisis or have been place nil by mouth for other reasons such as severe sepsis.**

3. Standardised concentrated neonatal PN regimens (ScNPN)

The intravenous nutritional needs of preterm infants are complex and reflect the heterogeneity of the NICU population. Early studies indicated that preterm infants did better on individualised PN prescriptions rather than standard regimens. However, the introduction

of pharmacy aseptic unit capacity planning and the increasing predictability of the majority of preterm PN prescriptions have led to the reintroduction of standard neonatal PN regimens.

The standard concentrated PN formulation is designed to meet the unique nutritional requirements of the preterm infant (see Appendix 1) and is introduced as early as possible and increased in steps until full PN is reached at day 5.
Note - Refer to separate PN constituents document for detailed breakdown of ingredients available on the unit.

Table 1: PN & Supplementary Fluid Volumes

		Total Daily Volume mL/kg/day	Aqueous PN Volume mL/kg/day	Lipid Syringe Number	Total Lipid & Vitamin Volume mL/kg/day	Supplementary Volume mL/kg/day
Start-up Regimen	**Day 1**	**90**	**60**	**N/A**	**0**	**30**
	Day 2	**120**	**60**	**Lipid Syringe 1**	**10**	**50**
Maintenance Regimen	**Day 3**	**120**	**75**	**Lipid Syringe 2**	**15**	**30**
	Day 4	**150**	**90**	**Lipid Syringe 3**	**20**	**40**
	Day 5	**150**	**100**	**Lipid Syringe 3**	**20**	**30**

The constituents are:

- Aqueous PN Bag,
  (contains amino acids as Vaminolact, trace elements as Peditrace, glucose and electrolytes)
- Lipid PN syringe
  (contains SMOFlipid 20%, Vitlipid N Infant & Solivito N)

plus

- "Supplementary infusion" of Glucose 10% or non-nutritive medication such as inotropes

This optimises nutritional intake and prevents nutrition being seriously compromised during periods of fluid restriction or multiple drug infusions. However, careful assessment of all drug infusions will be required before prescribing the supplementary infusion.

4. Choosing a ScNPN regimen

4.1 Aqueous Regimen

The greatest difficulty with standard PN formulations in the neonatal period relates to widely varying and rapidly changing electrolyte levels, particularly sodium. To overcome this problem there are 3 standard aqueous PN formulations, consisting of the following macronutrients:

- Carbohydrate
- Protein
- Electrolytes
- Trace Elements

Nutritionally identical except for electrolyte contents:

Start-up Aqueous PN Bag:	Minimal electrolyte additions; sodium, calcium, magnesium & phosphate
Maintenance Aqueous PN Bag:	Typical (preterm) daily maintenance electrolyte requirements
High Sodium Aqueous PN Bag:	Maintenance electrolytes with additional sodium

The three standard aqueous regimens are available daily from pharmacy on named patient basis and Start-up Aqueous PN Bags are available from stock for immediate day 1 use.

Table 2: Start-up Aqueous PN Bag

		Electrolyte Composition								
	Day of Life	Aqueous Volume mL/kg/day	Sodium mmol/kg/day	Potassium mmol/kg/day	Calcium mmol/kg/day	Magnesium mmol/kg/day	Phosphate mmol/kg/day	Chloride mmol/kg/day	Acetate mmol/kg/day	Pedtrace mL/kg/day
Start-up Bag	Day 1	60	**1.04**	**0**	**0.48**	**0.192**	**0.52**	**0**	**0**	**0**
	Day 2	60	**1.04**	**0**	**0.48**	**0.192**	**0.52**	**0**	**0**	**0.48**

The Start-up bag contains minimal sodium and no potassium. It is designed to be used in the first 1-2 days of life in most preterm infants whose sodium intake needs to be minimised and who seldom require potassium supplementation before Day 3. Also useful in treating or avoiding hyperkalaemic states especially acute renal failure where fluid and sodium intakes may also have to be minimised.

Table 3: Maintenance Aqueous PN Bag

		Electrolyte Composition								
	Day of Life	Aqueous Volume mL/kg/day	Sodium mmol/kg/day	Potassium mmol/kg/day	Calcium mmol/kg/day	Magnesium mmol/kg/day	Phosphate mmol/kg/day	Chloride mmol/kg/day	Acetate mmol/kg/day	Pedtrace mL/kg/day
Maintenance Bag	**Day 3**	**75**	**3**	**1.5**	**0.765**	**0.14**	**1.5**	**0**	**1.5**	**0.6**
	Day 4	**90**	**3.6**	**1.8**	**0.91**	**0.168**	**1.8**	**0**	**1.8**	**0.72**
	Day 5	**100**	**4**	**2**	**1.01**	**0.186**	**2**	**0**	**2**	**0.8**

The maintenance bag for a preterm infant contains 4mmol/kg/day of sodium on full PN and this reflects the typical needs of a preterm infant from Day 5 onwards. This is higher than the sodium maintenance dose for term infants (2-3mmol/kg/day) unless there are additional sodium losses (e.g. stoma, diuretics). However, term infants very rarely need PN and those that do often have abnormal requirements.

Table 4: High Sodium Aqueous PN Bag

		Electrolyte Composition								
	Day of Life	Aqueous Volume mL/kg/day	Sodium mmol/kg/day	Potassium mmol/kg/day	Calcium mmol/kg/day	Magnesium mmol/kg/day	Phosphate mmol/kg/day	Chloride mmol/kg/day	Acetate mmol/kg/day	Pedtrace mL/kg/day
High Sodium Bag	**Day 4**	**90**	**7.3**	**1.8**	**0.9**	**0.168**	**1.8**	**5.5**	**1.8**	**0.72**
	Day 5	**100**	**8.1**	**2**	**1**	**0.186**	**2**	**6.1**	**2**	**0.8**

The High Sodium bag is designed for preterm infants with high, usually renal, sodium losses commonly seen in the 2nd and 3rd week of life and sometimes persisting for several weeks. Also a short term option for any infant deemed to be in temporary sodium deficit. (**Warning:** hyponatraemia due to fluid overload must be excluded before embarking on high sodium supplementation levels).

4.2 Lipid Regimen

Intravenous lipid is supplied by pharmacy as a separate PN component from the Aqueous PN bag. There is no requirement for a lipid free period, infusions should be administered over 24 hours
It will be supplied as one of three standard syringes (see-table 5) containing:

- SMOFlipid 20%, Vitlipid N Infant & Solivito N
- The fat content alters in the lipid regimen whilst the vitamin dose is based on 1mL/kg/day water soluble vitamins (Solivito N) and 4mL/kg/day fat soluble vitamins (Vitlipid N Infant) per day as shown in table 5.

Table 5: Lipid PN Syringe

	Composition					
	Day of Life	Lipid Syringe Number	Total Lipid & Vitamin Volume mL/kg/day	SMOFlipid® 20% mL/kg/day	Vitlipid® Infant mL/kg/day	Solivito® N mL/kg/day
Lipid Syringe	Day 1	N/A	0	0	0	0
	Day 2	Lipid Syringe 1	10	5	4	1
	Day 3	Lipid Syringe 2	15	10	4	1
	Day 4	Lipid Syringe 3	20	15	4	1
	Day 5	Lipid Syringe 3	20	15	4	1

4.3 Supplementary infusions

The supplementary infusion (see table 1) allows much greater flexibility in managing fluids and drug infusions without compromising nutrition.

The infusion rate of the supplementary fluid, i.e. Glucose 10% will be altered according to the fluids requirements of the infant (prescribed on the morning Ward Round) and any additional drug infusions.

All drug infusions are part of the supplementary fluid allowance. Drug infusions should be prescribed in Glucose 10% if possible (see common infusion policy). When fluids are restricted or drug infusions are made up in Glucose 5% or Sodium Chloride 0.9% there will be a small reduction in calories available from carbohydrate. If total daily volume increases above 150mL/kg/day, alter the supplementary infusion rate to account for this.

Note: Only when the volume of drug infusions exceeds the volume available in the supplementary infusion will the PN infusion rate be altered. Ensure all drug infusions are prescribed at the maximum concentration possible, to avoid a reduction in the PN infusion.

If the volume of PN administered needs to be reduced the infusion rate of the Lipid regimen should be decreased first.

5. Prescribing and administering PN

The 3 separate PN components - aqueous regimen, lipid regimen and supplementary infusion are continuously administered over 24 hours at the prescribed rates (described in table 1). PN bags are changed every 24 hours.
PN prescriptions are required in pharmacy generally NO LATER THAN 11.30am to allow the bag to be ready for the changeover time. PN prescriptions will be prescribed on the daily ward round.

Full PN is achieved by day 5. If the start of PN is delayed for ANY REASON (e.g. transfer from another hospital, failure to start at birth) the PN should be prescribed at a rate according to the age of the patient (e.g. an infant transferred/started on day 3 should start on the day 3 PN regimen at 75mL/kg/day, NOT day 1 PN regimen).

This means ALL infants eligible for day 1 PN should be on full PN by day 5 regardless of the start date.

5.1 Starting PN at birth

In infants <1.25kg and/or <30 weeks gestation, PN should be started as soon as IV access is established (UVC preferred but peripheral cannula acceptable).

A supply of the Start-up aqueous PN bags is available in the unit fridge for starting new admissions. DO NOT delay starting PN until the evening changeover. For infants born after midnight, the Start-up aqueous bag of PN will be changed before 24 hours has been completed and should be replaced at the next changeover with another Start-up bag without Peditrace . Lipid should be commenced at this stage.

5.2 Starting PN after day 3 of life or restarting PN

Those infants not starting PN on day one of life (i.e. larger and more mature infants, infants transferred from another hospital, failure to start at birth or infant who have stopped enteral feeds due to NEC or sepsis and need to restart PN) should have PN prescribed according to the age of the patient. These infants should be able to tolerate a faster introduction of PN by starting on Maintenance PN regimen, NOT Start-up PN regimen.
E.g. infants starting PN on day 3 of life should start on day 3 Maintenance PN regimen at a volume of 75mL/kg/day NOT day 1 Start-up PN regimen.

ALL infants eligible for PN should be on full PN by day 5 regardless of the start date.

5.3 PN and growth on day 10

Infants may have their total fluids increased to 165mL/kg/day (if fluids not already at this level) if clinically indicated, by increasing the rate of supplementary infusion by 15mL/kg/day to 45mL/kg/day.

6. Monitoring during PN administration

Table 6: Biochemical Monitoring

Biochemical Monitoring	**Frequency**	
	Acutely ill infant or until full PN volume reached	**Stable infant**
Blood Glucose / urinalysis	Regularly throughout the day	Alternate days
Blood gases	Daily	**As clinically indicated**
Bilirubin	Daily	Daily
CRP	Daily	Alternate days
Urea and Electrolytes including Chloride	Daily	Alternate days
Calcium, Phosphate, Magnesium	Daily	Alternate days
Liver function tests	Twice weekly	Twice weekly
FBC	Twice weekly	Twice weekly
Triglycerides and lipid profile	**Not routinely checked**	Not routinely checked
Other Monitoring		
Line checks	At each handover	At each handover
Infusion rates	At each handover	At each handover
Fluid input / output	At each handover	At each handover
Weight	Daily	Alternate days
Length	Weekly	Weekly
Head circumference	Weekly	Weekly

Monitor CRP and electrolytes daily until greater than half enteral feeds.

Electrolytes can be measured on alternate days until intravenous fluids cease. Further monitoring may be indicated for other reasons (e.g. diuretics, oral electrolyte supplements).

7. Managing metabolic disturbances during PN administration

7.1 Hyperglycaemia (see also separate insulin guidelines)

Hyperglycaemia (as defined by two Blood Glucose readings >12mmol/L) should be controlled by:

1. Starting an insulin infusion.
2. If insulin is at the maximum dose/rate, reduce the glucose concentration in the supplementary infusion (and any drug infusions) to 5%. (Particularly if daily fluids exceed 150mL/kg/day).
3. If hyperglycaemia remains uncontrolled (following two further glucose readings) the aqueous PN infusion rate should be reduced in steps and the supplementary infusion

rate should be increased to compensate (e.g. if aqueous PN rate is reduced by 15mL/kg/day, increase glucose 5% infusion rate by 15mL/kg/day).

Note Take care when reducing the IV glucose infusion to avoid sudden hypoglycaemia. Titrate the aqueous PN against the Glucose 5% supplementary infusion to avoid sudden hypoglycaemia.

7.2 Hypoglycaemia (see also separate guidelines)

In infants on PN, the response to hypoglycaemia can be achieved by a staged increase in the concentration of IV glucose infused.

1. The glucose concentration of the supplementary infusion should be increased to 15% initially.
2. If hypoglycaemia persists, the glucose concentration of the supplementary infusion should be increased to 20%
3. If hypoglycaemia persists the rate of the Aqueous PN bag infused should be reduced (continue Lipid PN syringe) and the supplementary infusion rate of glucose 20% should be increased to compensate. (E.g. if PN rate reduced by 1.5mL/hour, increase glucose 20% infusion rate by 1.5mL/hour). This titration can continue until the rate of the total or Aqueous PN infusion is 0.1mL/hr.
4. If hypoglycaemia persists, stop PN/lipid and switch to Glucose 20% and consider including electrolyte supplements.
5. If hypoglycaemia still persists, consider commencing an infusion of Glucose 25%

7.3 Hypernatraemia (>148mmol/L)

Assess fluid balance, weight and hydration. If clinically dehydrated both sodium and water are usually in deficit and so both need replacing. Do not rehydrate using salt poor fluids; this can cause rapid onset hyponatraemia. True sodium overload is uncommon and is usually due to over-supplementation or renal insufficiency. If this occurs, this can be managed by using the standard Start-up aqueous PN bag.

7.4 Hyponatraemia (<132mmol/L)

Assess fluid balance, weight and hydration. 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 infusion rate. If it is felt there is a true sodium deficit and this is not being corrected by the current PN regimen then sodium losses should be calculated by:

Sodium Correction over 24 hours can be calculated using the following formula:

Number of mmol of Sodium for correction = (Target Sodium – Actual Sodium) x 0.6 x Wt (kg)

Table 7: Guidance for sodium replacement (exclude fluid overload before supplementing sodium)

Sodium level (mmol/L)	Supplementary sodium infusion required until next PN prescription (assumes currently on Maintenance bag)	Next PN prescription
132-142	None required. Continue to monitor sodium trend.	Maintenance bag
128-131	Small deficit. Change PN prescription if no increase in Sodium	Consider High Sodium PN bag or supplementary infusion of sodium
124-127	Medium deficit. **Discuss with consultant if concerns**	High Sodium bag or supplementary infusion of sodium
<124	**Discuss with consultant**	High Sodium bag or supplementary infusion of sodium
<120	**Discuss with consultant**	High Sodium bag or supplementary infusion of sodium

Sodium can be replaced by;

1. Selecting the High Sodium PN bag with extra sodium for the next PN prescription to provide the baby with the following supplements

Table 8: Content of High Sodium PN bag

Sodium Content of PN	**High Sodium PN Bag**	
Volume of PN	90mL/kg/day	100mL/kg/day
mmoL/kg/day	7.3	8.1

2. Using the standard sodium concentrations (below) to supplement sodium

For sodium deficits: select SODIUM SUPPLEMENT on smart pump software

Add 12mmol/kg Sodium Chloride (2.4mL/kg of Sodium Chloride 30%) to Glucose 10% to make up 48mL infusion (see monograph)

The rates can be altered following the table below:

Table 9: Supplementary Sodium Infusion

Supplementary Sodium Infusion	Small Deficit	Medium Deficit	Large Deficit	Extra Large Deficit*	Extreme Deficit*
mmol/kg/day	1.5	3	6	9	12
mL/hour	0.25	0.5	1	1.5	2
mL/day	6	12	24	36	48

<u>Sodium supplements are given in addition to the sodium prescribed in the PN</u>;

Total sodium administered = Sodium content from the PN + additional supplementary sodium infusion as above
(mmol/kg/day)

It is anticipated that extra-large and extreme sodium supplements will only be used in situations where there are unusually high sodium losses (e.g. via a stoma) and require Consultant approval.

7.5 Hyperkalaemia (>7mmol/L)

Stop any potassium supplementation infusions. Switch to standard Start-up bag (no potassium) immediately. See separate policy for treatment of hyperkaleamia.

7.6 Hypokalaemia (<3mmol/L)

Replace deficit by using supplementary potassium infusion. Aim to correct over 24 hours. If potassium less than 2mmol/L and/or cardiac rhythm disturbances present then urgent replacement regime required (see separate policy under electrolyte management).

For potassium deficits: select POTASSIUM SUPPLEMENT on smart pump software

Add 4mmol/kg Potassium Chloride (2mL/kg of Potassium Chloride 15%) to Glucose 10% to make up 48mL infusion.

Table 10: Supplementary Potassium Infusion

Supplementary Potassium Infusion	**Small** **Deficit**	**Medium** **Deficit**
mmol/kg/day	1	2
mL/hour	0.5	1
mL/day	12	24

Potassium supplements are given in addition to the potassium prescribed in the PN;

Total Potassium administered = (mmol/kg/day) Potassium content from the PN + additional supplementary potassium infusion as above

Table 11: Guidance for potassium replacement

Potassium level (mmol/L)	**Supplementary Potassium infusion required until next PN prescription (assumes currently on Maintenance bag)**	**Next PN prescription**
3.5--5	None required. Continue to monitor potassium trend.	Maintenance bag
3-3.4	Small deficit - Continue to monitor potassium trend.	Consider supplementary infusion of Potassium
2.5-3	Medium deficit - **Discuss with consultant**.	Consider supplementary infusion of Potassium
<2.5	**Discuss with consultant**	Supplementary infusion of Potassium

7.7 Hypercalcaemia (corrected calcium >3mmol/L)

Stop any supplementary infusions containing calcium. Hypercalcaemia may be secondary to hypophosphataemia particularly if the latter is severe or persistent. The treatment in these

cases is to supplement phosphate not to stop calcium. Discuss PN prescription with consultant and pharmacist.

7.8 Hypophosphataemia

If babies on parenteral nutrition are not maintaining their phosphate above 1.7mmol consider additional supplementation, aiming for level of greater than 2mmol/L.

Replace phosphate deficit by using Potassium Acid Phosphate (1mmol/ml POTASSIUM and 1mmol/ml PHOSPHATE, 10ml ampoule). Aim to correct over 24 hours. ECG monitoring required during infusion. Remember to check how much phosphate / potassium is being given via the PN.

Dose: 0.25-0.5mmol/kg/day dose adjusted as necessary, up to a maximum 1mmol/kg daily. The infusion solution should be **thoroughly mixed**. Administration rate should not exceed 0.05mmol/kg/hour.

For central administration: Injection must be diluted before use: maximum concentration of potassium & phosphate is 100mmol per litre (0.1mmol/mL), i.e. each 1mL to be diluted to at least 10mL.

For peripheral administration (only if central administration not possible): Injection must be diluted before use: maximum concentration of potassium & phosphate is 40mmol per litre (0.04mmol/ml), i.e. each 0.4mL to be diluted to at least 10mL.

Suitable diluents: 0.45% sodium chloride, 0.9% Sodium chloride, 5% or 10% glucose.

NOT to be run with parenteral nutrition infusions.

Cautions: Renal impairment, diabetes mellitus, cardiac disease, dehydration, hyperkalaemia, extensive tissue damage/necrosis. Concurrent use of NSAIDs and diuretic can also instigate renal failure

Side effects: Hypotension: especially with rapid infusion. Hyperkalaemia, hypocalcaemia, acute renal impairment, oedema (including pulmonary). Thrombophlebitis and calcification at infusion site; tissue necrosis on extravasation. Hyperphosphataemia leading to hypocalcaemia, hypocalcaemic tetany.

Ordering & storage: potassium acid phosphate should be ordered, supplied and recorded as a controlled drug, as it is a concentrated potassium salt for dilution and infusion.

7.9 Hyperlipidaemia

If hyperlipidaemia is suspected, due to liver dysfunction (deranged LFTs, pale stools) or lipaemic blood samples, consider checking triglyceride levels and if triglycerides are greater than 2.8mmol/L, the lipid infusion rate should be reduced according to the guidance in the table below.
Following reductions in lipid infusion rates (for hyperlipidaemia), the lipid infusion rate should be increased again in increments of 5mL/kg/day if the repeat triglyceride levels fall below 2.8mmol/L.
Repeat incremental increases until the maximum infusion rate is achieved.
If triglyceride levels exceed 2.8mmol/L again then infusion rates will require reducing again (see table).

Do NOT reduce lipid infusion below 5mL/kg/day, as this contains all the vitamins in the first instance).
If lipid needs to be stopped the Solivto-N should be placed in the aqueous bag at the next change. Please speak to the pharmacist. Add 1mL of Solivito-N for each 100mL of bag aqueous volume to achieve 1mL/kg/day at a volume of 100mL/kg/day.

Table 12: Adjustment of Lipid due to elevated Triglycerides

Triglyceride level (mmol/L)	Adjustment to lipid infusion	Next Triglyceride measurement
≤2.8	None required.	Routine (7 days)
2.8-3.5	Reduce lipid infusion by 5mL/kg/day	3 days
3.5-4.0	Reduce lipid infusion by 7.5mL/kg/day	3 days
>4.0	Reduce lipid infusion to 5mL/kg/day Do NOT completely stop lipid infusion (contains vitamins)	2 days
Severe sepsis	Discuss with consultant (consider reducing/stopping lipid infusion by 7.5mL/kg/day; for 48 hours)	3 days

The lipid infusion rate should be reduced (for 48 hours) in severe acute sepsis (e.g. unstable circulation, blood clotting disturbance). Hyperlipidaemia can interfere with split bilirubin measurement and cause spurious hyponatraemia (this may show lipaemic sample on bloods) particularly on blood gas analyser samples.

7.10 Miscellaneous

Poor handling of the amino acid load can lead to persistent metabolic acidosis especially in the very preterm in the first 2 weeks. This can be managed with sodium bicarbonate infusions although other causes of metabolic acidosis must be excluded first. The sodium content of sodium bicarbonate must also be considered in the calculations for daily sodium requirements.

8. Vascular access

Given that PN is a hyperosmolar solution and the aim is for it to be given for at least 7 days, ideally PN should be given through a Umbilical Venous Catheter (UVC), percutaneous long line (including femoral line) or surgical central line.

A UVC (preferably double/triple lumen) may be used for up to 7 days after birth. A definitive long line should be inserted at the earliest opportunity if a UVC is not successfully placed.

A UVC should be electively replaced with a percutaneous long line before 7 days is if it is clear that PN will be required beyond day 7.

Early PN should NOT be delayed simply because central venous access has not been established. Peripheral PN is acceptable for a short period because early PN volumes are much lower in the first 72 hours of the regimen. Long line access must still be attempted at the earliest opportunity in these patients.

Occasionally, central venous access is not possible. In these cases, peripheral PN is preferable to no PN. Surgical central venous access should be considered if more than 3 days of PN is anticipated and further long line attempts are unsuccessful.

Rarely, intravenous access is so precarious that Glucose 10% is used to prolong the life of a peripheral cannula. This is an emergency measure only and should not be used for more than 24 hours. This measure is simply to buy time to allow a surgical line to be placed.

Recurrent long line infection sometimes requires short periods (less than 48 hours) without a long line to help eradicate the infection. Peripheral PN may be used in these situations with lipid.

Where there are vascular access difficulties this should be discussed on the consultant ward round. When PN is administered via a peripheral cannula the risk of extravasation injury needs to be balanced against the risks or difficulties associated with obtaining/maintaining central venous access, and the nutritional needs of the infant. Any infant receiving peripheral PN should have careful monitoring of the cannula site. The reasons for peripheral PN should be reviewed on the consultant round each morning.

IMPORTANT: When PN is administered via a peripheral cannula the risk of extravasation injury needs to be balanced against the risks or difficulties associated with obtaining/maintaining central venous access, and the nutritional needs of the infant. Osmolarities greater than 1000mOsm/L have been associated with increased complications including thrombophlebitis and infiltration. Infusion of lipid via the same peripheral catheter as the aqueous component may have a vascular protective effect. PN bags described in this policy have an osmolarity of greater than 1000mOsm/L. NEVER infuse PN through a scalp vein cannula.

There must be vigilance towards infection in infants on PN particularly in those with central venous access (daily/ alternate day CRP indicated; there should be a low threshold for infection screen).

9. Introducing enteral feeds

Enteral feeds should be progressed according to the local enteral feeding guideline. The PN (120mL/kg) and supplementary infusion (30mL/kg) should continue until the total daily volume of trophic feed exceeds 24mL/kg/day. Thereafter, as the trophic feed volume increases the supplementary infusion should be stopped first and then the PN tapered downwards according to the enteral feed increments.
When reducing the PN volume the aqueous and the lipid should be reduced in proportionate volumes (e.g. for Day 5 regimen reduce by a ratio of 5:1 aqueous to lipid).

Table 13: Amount to subtract off PN when increasing milk

Amount of Milk (mL/kg/day)	Amount of Milk (mL//kg/hour)	Amount to take off Aqueous PN (mL//kg/hour)	Amount to take off Lipid PN (mL/kg/hour)
36	1.5	1.27	0.23
48	2	1.7	0.3

60	2.5	2.12	0.38
72	3	2.55	0.45

When the enteral volume exceeds 120mL/kg/day the PN can be stopped.

10. Stopping PN

PN should not be ordered if 120mL/kg/day of enteral feeds are likely to be reached during next 24 hours. The current bag should be continued until the usual expiry time (24 hours) is completed. Generally, the central line (except broviac lines) can be removed when enteral feeds greater than 120mL/kg/day but this must be discussed with a consultant. Continued replacement with Glucose 10% either centrally or peripherally should be discussed on the ward round.

Enteral nutrition should continue to progress and breast milk fortifier should be added according to the enteral feeding guideline to ensure that the infant meets their nutritional requirements.

11. References

1. Koletko B, Goulet O, Hunt J et al. 1. Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Supported by the European Society for Paediatric Research (ESPR). J Paediatr Gastroentrol Nutr 2005;41(Suppl 2):S1-87.

2. Morgan C, Herwitker S, Badhawi I, et al. SCAMP: Standardised, Concentrated, Additional Macronutrients, Parenteral nutrition in very preterm infants: a phase IV randomised, controlled exploratory study of macronutrient intake, growth and other aspects of neonatal care. BMC Pediatr. 2011;11:53–64.

3. Improving practice and reducing risk in the provision of parenteral nutrition for neonates & children. A report from the Paediatric Chief Pharmacists group - November 2011 http://www.rpharms.com/support-pdfs/minimising-risk-pn-children-(6).pdf

4. The Provision of Parenteral Nutrition within Neonatal Services – A Framework for Practice December 2015 - BAPM

APPENDIX 1

Summary of preterm nutritional requirements

Protein / Amino acids

The neonatal period requires the highest intake of amino acids in life to meet demands. Intrauterine protein accretion rate is 2g/kg/day until 32 weeks gestation and 1.8g/kg/day thereafter. All preterm infants requiring PN should be started on protein (prescribed as amino acids) from day 1 in order to avoid a negative nitrogen balance.

In a premature neonate, optimal growth is achieved by a protein intake of 3.5g/kg/day (4.0g/kg/day of amino acid).

Studies suggest that protein intake levels as high as 4g/kg/day are safe. There is also evidence that early protein supplementation in PN results in improved growth and head circumference.

Protein is prescribed as:-

Day	Total fluid mL/kg/day	Aqueous PN mL/kg/day	Protein g/kg/day
1	90	60	2.2
2	120	60	2.2
3	120	75	2.8
4	150	90	3.3
5	150	100	3.7

There is no correlation between high urea levels and protein/nitrogen intake in neonates. High urea levels are more likely to be associated with dehydration, lower gestational ages and lower weights. It is not necessary to decrease the nitrogen in the PN based purely on increasing urea levels.

Energy

Preterm babies require at least 40-50kcal/kg/day for basal metabolic requirements and 85-100kcals/kg/day parenterally to grow and ensure maximum protein accretion.
Non protein energy should be obtained from carbohydrate and lipid in adequate amounts to spare protein (amino acids) to support cell maturation, remodeling, growth, activity of enzymes and transport proteins for all body organs.
Energy is necessary for all vital functions of the body at molecular, cellular, organ and systemic levels. Carbohydrate (primarily glucose) is the principle source of energy for the brain and heart until lipid oxidation develops over several days / weeks after birth. A higher protein energy ratio is necessary in the preterm infant to approximate normal intrauterine growth rates. Lean tissue is predominantly produced during early gestation, which continues through to term. During later gestation fat accretion as adipose tissue occurs.

Energy provided by standard concentrated PN (inclusive of supplementary Glucose infusions)

DAY	Total Volume mL/kg/day	Aqueous volume mL/kg/day	SMOFlipid® 20% Volume mL/kg/day	Vitlipid® Infant & Solivto® N Volume mL/kg/day	Supplementary Glucose 10% mL/kg/day *	Energy Kcals/kg/day
1	90	60	0	0	18	45
2	120	60	5	5	38	63
3	120	75	10	5	18	71
4	150	90	15	5	28	94
5	150	100	15	5	18	97

*** (Volume Glucose 10% infusion remaining after 12mL subtracted for Heparin in Sodium Chloride 0.45% for arterial line)**

APPENDIX 2

Calculating TPN rates