Parenteral Nutrition for Neonates

Background
Preterm infants often have growth failure when compared with healthy term infants (1) We are often reassured by subsequent later catch-up growth (2) but this is associated with adverse metabolic health, and renal impairment (3, 4). Growth failure is also associated with neurodevelopmental impairment and cerebral palsy (5, 6). Nutrition is therefore critical and should be implemented as soon as possible after birth. Total parenteral nutrition is where the only source of nutrition is intravenous. In neonatal practice this is less common, and we refer to parenteral nutrition where nutrition is achieved through both enteral and parenteral routes.

Advantages of Standard PN
- Standard PN is always available, so the first IV fluid can be PN, not just dextrose.
- Consistent nutritional practices are safer
- Fewer changes (Vamin is 48 hourly, SMOF 24 hourly) resulting in less nursing time spent changing fluids
- Significant cost improvements compared to individualised regimes
- Individualised PN will still be available for special circumstances (seek consultant advice)

General
Use PN for
- Any infant who is not expected to reach at least 50% of their total fluid intake as tolerated enteral feeds within 24-48 hours. In practice, this will at least mean all babies <34 weeks and those at term who have HIE, significant sepsis or are receiving intensive care
- Nutritional support during gut rest for suspected or confirmed necrotising enterocolitis
- Intestinal failure (short bowel, functional immaturity, obstruction, enteral intolerance)

PN comprises of 2 solutions – one contains amino acids, dextrose and electrolytes, and the other is lipid (SMOF - soybean oil, medium-chain triglycerides, olive oil and fish oil)
PN can be infused by a peripheral IV cannula provided the dextrose concentration is <=12.5%. In babies <800g we usually infuse via a UVC/long line to reduce the risks of thrombophlebitis but this does not preclude the insertion of central lines into larger babies for other reasons.
Calculations /kg are based on the birth weight until this is exceeded by growth (not oedema)

Fluids
For babies <28/40
First day PN - Use no sodium PN
Start fluids at 90ml/kg increasing by 30ml/kg/day to total fluid intake of 150-180ml/kg/day (including enteral). Enteral feeds will normally increase by 10-15ml/kg/day increments twice daily. Note that PN should not be run >150ml/kg/day. Pay attention to Glucose Infusion Rate (GIR) to avoid hyperglycaemia.

For babies >28/40
First day PN - use no sodium PN if <32 weeks, use low sodium if >32 weeks
Start at 60ml/kg increasing by 30ml/kg/day to total fluid intake of 150-180ml/kg/day (including enteral). Enteral feeds will normally increase by 10-15ml/kg/day increments twice daily. Note that PN should not be run >150ml/kg/day

For babies >34/40
If PN indicated on first day, use low sodium PN
If indicated (most babies should be able to achieve sufficient enteral feeds in the first 24-48 hours after birth), then commence at 60ml/kg, increasing to a total of 150ml/kg/day. Enteral feeds will normally increase by 20ml/kg/day increments 2-3 times daily.

Fluids are increased over the first few days. For the most immature babies (<=27 weeks) this fluid schedule is often adapted on the basis of sodium results, blood glucose levels etc and may be adapted from the “routine” increase of 30ml/kg/day etc.

Enteral feeds are commenced as soon after birth as possible (10-15ml/kg/day divided into 2 hourly feeds) for babies <28 completed weeks. More mature babies may start at 15-20ml/kg/day 2 hourly. Enteral volumes are included in total fluid volumes when 20ml/kg/day is being tolerated). Lipid is included in total volumes.

Types of PN
There are two types of amino-acid/dextrose preparation referred to as “no-sodium” and “sodium-containing”. The only lipid type is SMOF.

All <u>preterm</u> babies less than 32 weeks eligible for PN should routinely commence on the zero-sodium PN, with approximately 1-1.5g/kg/day of SMOF (calculated at 12% of total PN volume).

NO-SODIUM CONTAINING BAG

Total Fluid Requirement	60ml/kg/day	90ml/kg/day	120ml/kg/day	150ml/kg/day
SMOF (fats) (g/kg/day)	1.5	2	3	3.5
Nitrogen (g/kg/day)	0.22	0.34	0.45	0.57
Amino acids (g/kg/day)	1.6	2.4	3.2	4
Glucose (g/kg/day)	5.3	8	10.5	13.3
Sodium (mmol/kg/day)	0	0	0	0
Potassium (mmol/kg/day)	0.5	0.8	1.1	1.3
Calcium (mmol/kg/day)	0.5	0.8	1.1	1.3
Magnesium (mmol/kg/day)	0.11	0.16	0.21	0.27
Phosphate (mmol/kg/day)	0.5	0.8	1.1	1.3
Zinc (micromol/kg/day)	1.6	2.4	3.2	4
Chloride (mmol/kg/day)	0	0	0	0
Acetate (mmol/kg/day)	0	0	0	0
Non-protein calories	21	32	42	53
Bag total calories	27	41	55	69
SMOF calories (MAX 40%)	16.5	22	33	38.5
TOTAL Calories	43.5	63	88	107.5

LOW SODIUM CONTAINING BAG

Total Fluid Requirement	60ml/kg/day	90ml/kg/day	120ml/kg/day	150ml/kg
SMOF (fats) (g/kg/day)	1.5	2	3	3.5
Nitrogen (g/kg/day)	0.19	0.3	0.38	0.49
Amino acids (g/kg/day)	1.35	2.1	2.7	3.4
Glucose (g/kg/day)	5.3	8	10.5	13.3
Sodium (mmol/kg/day)	1.2	1.8	2.3	3
Potassium (mmol/kg/day)	0.8	1.2	1.6	2
Calcium (mmol/kg/day)	0.6	0.9	1.2	1.5
Magnesium (mmol/kg/day)	0.08	0.12	0.16	0.2
Phosphate (mmol/kg/day)	0.8	1.2	1.6	2
Zinc (micromol/kg/day)	1.6	2.4	3.2	4
Chloride (mmol/kg/day)	0.6	0.9	1.2	1.5
Acetate (mmol/kg/day)	0.6	0.9	1.2	1.5
Non-protein calories	21	32	42	53
Bag total calories	26	40	53	66
SMOF calories (MAX 40%)	16.5	22	33	38
TOTAL Calories	43	62	86	104

HIGH SODIUM CONTAINING BAG

Total Fluid Requirement	60ml/kg/day	90ml/kg/day	120ml/kg/day	150ml/kg
SMOF (fats) (g/kg/day)	1.5	2	3	3.5
Nitrogen (g/kg/day)	0.19	0.3	0.38	0.49
Amino acids (g/kg/day)	1.35	2.1	2.7	3.4
Glucose (g/kg/day)	5.3	8	10.5	13.3
Sodium (mmol/kg/day)	2.3	3.5	4.7	6
Potassium (mmol/kg/day)	0.8	1.2	1.6	2
Calcium (mmol/kg/day)	0.6	0.9	1.2	1.5
Magnesium (mmol/kg/day)	0.08	0.12	0.16	0.2
Phosphate (mmol/kg/day)	0.8	1.2	1.6	2
Zinc (micromol/kg/day)	1.6	2.4	3.2	4
Chloride (mmol/kg/day)	0.6	0.9	1.2	1.5
Acetate (mmol/kg/day)	1.6	2.3	3	4
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Growth requirements
Protein, carbohydrate and fat are all essential for balanced growth, along with electrolytes and vitamins. Standard PN is not designed for long term total PN

Protein
Aim for 3 - 4g/kg/day amino acid intake as soon as practicable
1.2g amino acid = 1g protein = 0.16g nitrogen
Aim serum urea to be >2mmol/l

Carbohydrate
Aim for 4 – 8mg/kg/min glucose (=6-11.5 g/kg/day)
The commonest cause of hyperglycaemia in the preterm infant is excessive intravenous glucose
By gradually increasing fluids, we aim to avoid hyperglycaemia (and the need for insulin – see guideline)
Many ELBW and IUGR babies may not tolerate >6mg/kg/min in the first few days and a combination of PN and 5% dextrose is often needed to ensure GIR is not excessive. See guideline.

Fat
SMOF 20% is a 3rd generation intravenous lipid which increase the amount of n-3 fatty acids, thereby reducing the ratio n-6:n-3 fatty acids (in accordance with current recommended levels (7)), demonstrates improved tolerability (normalisation of serum triglycerides, enhanced Vitamin E levels and hepatic protection with potential for reduced hyperbilirubinaemia and cholestasis (8)).
It should be commenced immediately with PN at 1g/kg/day and increased daily to a maximum of 3.5g/kg/day

Electrolytes and Water

Sodium and Water - Premature babies are at risk of hypernatraemia in the first 3-4 days mainly due to water losses. Immature babies are therefore nursed in high (80%) levels of humidity to minimise transcutaneous loss of water. We also minimise sodium intake by

- Using no-sodium PN in babies <32 weeks in the first few days and closely monitoring electrolytes
- Prescribing 0.45% sodium flushes
- Not using saline boluses unless indicated e.g. for hypovolaemia in preference to other fluids such as blood

Chloride accumulation is also a challenge for immature babies and can lead to a hyperchloraemic acidosis. We minimise chloride intake by

- Minimising saline intake as above
- Substitution of chloride for bicarbonate in arterial line fluids (see guideline)

Potassium levels may be high in the first few days in extremely preterm infants, but this usually resolves spontaneously. It usually does not reflect renal failure, but relates to immaturity of cellular homeostasis. The no-sodium bag does contain some potassium.

Phosphate is usually relatively deficient in preterm babies and blood levels are often suboptimal in babies on PN. It is not possible to add extra into the PN due to precipitation risks. Therefore once babies are on 150ml/kg/day of enteral feeds, sodium phosphate supplements should normally be routinely prescribed and levels monitored.

Trace Elements
The standard bags of PN (no-sodium, low sodium and high sodium containing PN) do not contain trace elements. Whilst in the short term this is considered to be non-essential, babies receiving longer term total parenteral nutrition will require neonatal, pharmacy and dietetic review to ensure that all nutritional needs are being met and monitored adequately

Blood monitoring
Any baby on PN should normally have at least daily measurement of blood gas, serum urea and electrolytes, LFT and serum bilirubin (lab code NPN) and regular monitoring of blood sugars (frequently if the infant was receiving insulin). Usually once enteral feeds are >50% of total fluids, such intensive monitoring is not needed unless there are ongoing metabolic derangements

Any baby on lipid infusion would have normally have twice weekly measurement of triglycerides and cholesterol (lab code NPN2).

Complications
Line sepsis – ensure careful line insertion and PN sterility. Remove lines promptly when no longer needed – do not use very small volumes of dextrose simply to make up the total fluid requirements.

Extravasation injury – ensure optimal line placement, check frequently, follow extravasation guideline

Key recommendations in the NCEPOD 2010 report were

- Careful and early consideration should be given to the need for PN in neonates and once the decision to commence PN is made it should be started without undue delay. (Comply)
- The first PN given must be appropriate to the neonate's requirements. (Comply)
- Close monitoring of the patient must be achieved so that metabolic complications can be avoided. (Comply)
- Neonatal Units should have an agreed policy for nutritional requirements and use a proforma that includes this information which is tailored for each infant and placed in the case notes. (Comply)
- Hospitals in which neonates are cared for should develop a team approach to ensure safe and effective nutritional support, recognising that this should be a multidisciplinary exercise with sharing of expertise. (Comply)
- There is an urgent need for Neonatal Units across the UK to have a consensus on best PN practice based on current scientific evidence. (Comply with current knowledge base)
- Neonatal units should undertake regular audit of PN practice which should include the complications of PN. (To be achieved)
- The National Institute for Health and Clinical Excellence should develop guidelines on nutritional support for neonates and children in a similar manner to their recommendations for adults. (To be achieved)
- Document catheter site insertion (blue sheet)
- Document catheter tip position (blue sheet)

Supporting Documentation

1. PN prescription charts (no-sodium, low sodium and high sodium containing PN)
2. PN administration charts (no-sodium, low sodium and high sodium containing PN)
3. Standard PN – instructions for use
4. Composition of PN (no-sodium, low sodium and high sodium containing PN)

Guideline Details
Prepared by Peter Reynolds, Neonatal Consultant, Jane Pierson and Deborah Hopper, Paediatric Pharmacists November 2011
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Reviewed Dr Peter Reynolds October 2014, minor updates
Reviewed Dr. Peter Reynolds. Deborah Hopper 2018 – PN contents corrected to current contents, minor amendments

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