

PARENTERAL NUTRITION

DEFINITION

Parenteral nutrition [(PN) or Total PN (TPN)] is the intravenous infusion of some or all nutrients for tissue maintenance, metabolic requirements and growth promotion in neonates unable to tolerate full enteral feeds

Seek advice from your local TPN pharmacist

INDICATIONS FOR PN

Short-term supply of nutrients:

- Extremely low birth weight, <1000 g
- Very low birth weight (<1500 g) **AND** clinically unstable, absent/reversed end-diastolic flow or full enteral feeds seem unachievable by day 5
- Any baby on inotropic support
- Necrotising enterocolitis (10-14 days)
- Temporary feeding intolerance

Prolonged non-use of gastrointestinal (GI) tract >2 weeks;

- Usually commenced in surgical centre before transfer back to neonatal unit:
- relapsing or complicated necrotising enterocolitis
- surgical GI disorders (e.g. gastroschisis, large omphalocele)
- short bowel syndrome

PRESCRIBING PARENTERAL NUTRITION

Peripheral vs central PN (long line/UVC)

Peripheral PN

- Limited by glucose concentration (usually no more than 10-12%)
- Indicated if full enteral feeds likely to be **obtained** relatively soon
- some post-surgical infants
- larger infants tolerating enteral feeds relatively quickly
- short episodes of feeding intolerance or suspected NEC

Central TPN

- Requires placement of a central catheter (see **Long line** guideline) with tip in either superior vena cava or inferior vena cava

Central TPN [Long lines and UVC (umbilical venous catheters)] can introduce infection and septicaemia

TPN prescription

- Most units have specific PN bags that are used to allow nutrients to be increased over 4 days. These may be added to (but nothing may be removed) by discussing with TPN pharmacist **and obtaining consultant signature to confirm**
- Modify PN infusion according to requirements and tolerance of each infant and taper as enteral feeding becomes established

Daily requirements

<2.5 kg	Day 1	Day 2	Day 3	Day 4	Comment
Amino acid (g/kg/day)	1	2	3	3 (3.5*)	
Carbohydrate (g/kg/day)	6-15 (based on maintenance fluid volume)	↑ by 2 each day			If possible, calculate Day 1 glucose from maintenance infusion
Fat (g/kg/day)	1	2	3	3.5 (4)	*Not routine for neonates <1.5 kg

2.5–5 kg	Day 1	Day 2	Day 3	Day 4	Comment
Amino acid (g/kg/day)	1	2	2.5	2.5	
Carbohydrate (g/kg/day)	6-14 (based on maintenance)	↑ by 2 each day	14	14	If possible calculate day 1 glucose from maintenance infusion
Fat (g/kg/day)	1	2	3	3.5	

	<2.5 kg	2.5–5 kg
Na (mmol/kg/day)	3 (range 2-4)**	3 (range 2-4)
K (mmol/kg/day)	2.5	2.5
Ca (mmol/kg/day)	1	1
PO ₄ (mmol/kg/day)	1.5	1
Mg (mmol/kg/day)	0.2	0.2
Peditrace (mL/kg/day)	0.5 (day 1), 1 (day 2 onwards)	0.5 (day 1) 1 (day 2 onwards)
Solvito N (mL/kg/day)	1	1
Vitilipid (infant)	4 mL/kg/day	10 mL daily (total)

**** do not add supplemental sodium on days 1-2 if <32 weeks before naturesis has occurred (measure urine Na levels daily)**

Glucose – maximum concentration:

- Peripheral PN 10-12%
- Central PN up to 20-25% (may rise occasionally)

Volume

- Maintenance up to 150 mL/kg/day (see **Intravenous fluids** guideline for fluid requirement) maximal fluid volume varies with individual management
- Remember to account for volume, electrolyte and glucose content of other infusions (e.g. UAC/UVC fluid, inotropes, drugs)

Calories

- Healthy preterm requires 50 kcal/kg/day for basal energy expenditure (not growth) and 1–1.5 g protein to preserve endogenous protein stores
- 60 kcal/kg/day will meet energy requirements during sepsis
- 90 kcal/kg/day and 2.7–3.5 g protein will support growth and positive nitrogen balance

NUTRITIONAL SOURCES

Glucose (provides 3.4 kcal/g)

- Initiated at endogenous hepatic glucose production and utilisation rate of 4–6 mg/kg/min; [8–10 mg/kg/min in extremely low birth weight (ELBW) infants]. Osmolality of glucose limits its concentration

Protein (provides 4 kcal/g)

- At least 1 g/kg/d in preterm and 2 g/kg/d in ELBW decrease catabolism
- 3–3.5 grams protein/kg/d and adequate non-protein energy meets requirements for anabolism

Fat (provides 2.0 kcal/mL)

- Fat >4 g/kg/day only in very preterm with normal triglycerides not septic, not on phototherapy
- fat should ideally provide 35–40% of non-protein nitrogen calories
- To minimise essential fatty acid deficiency, hyperlipidaemia, bilirubin displacement, and respiratory compromise, lipid infusion rates ≤ 0.15 g/kg/h are recommended to span over 24 hr
- in neonates, maximal removal capacity of plasma lipids was shown to be 0.3 g/kg/hr
- delivery of 3 g/kg/d of a 20% lipid emulsion equates to an infusion rate of 0.125 g/kg/hr

Energy

- Carbohydrate (glucose) and fat (lipid emulsions) provide necessary energy to meet the demands and, when provided in adequate amounts, spare protein (amino acids) to support cell maturation, remodelling, growth, activity of enzymes and transport proteins for all body organs
- PN requirement for growth 90-115 kcal/kg/day

Electrolytes

- Sodium, potassium, and chloride dependent on obligatory losses, abnormal losses and amounts necessary for growth, and can be adjusted daily
- If neonate <32 weeks, do not add sodium until they have started their naturesis, monitored by daily urine Na+
- Infants given electrolytes solely as chloride salts can develop hyperchloraemic metabolic acidosis (consider adding acetate to PN, where available)

Vitamins

- Vitamin and mineral added according to best estimates based on limited data

SPECIAL NEEDS

Hyperglycaemia

- If hyperglycaemia severe or persistent, start insulin infusion: Actrapid 0.01–0.05 units/kg/hr

Osteopenia

- If infant at risk of, or has established, osteopenia, give higher than usual intakes of calcium and phosphorus
- consult dietitian and/or TPN pharmacist regarding prescribing information
- permissible concentrations depend on amino acid and glucose concentrations in TPN solution

Metabolic acidosis

- For management of metabolic acidosis, add acetate as Na or K salt if available: ask local TPN pharmacist
- choice of salt(s) will depend on serum electrolytes

Increase calories for:

- Infection
- Chronic lung disease
- Healing
- Growth
- Babies who have experienced IUGR

Decrease calories for:

- Sedation
- Mechanical ventilation

MONITORING

Daily	<ul style="list-style-type: none"> • fluid input • fluid output • energy intake • protein • non-protein nitrogen
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	<ul style="list-style-type: none"> calories
Daily	<ul style="list-style-type: none"> urine glucose blood glucose (if urine glucose positive)
Twice weekly*	<ul style="list-style-type: none"> urine electrolytes weight
Weekly	<ul style="list-style-type: none"> length head circumference
Twice weekly*	<ul style="list-style-type: none"> FBC Na K glucose urea creatinine albumin bone bilirubin ** blood gas (arterial or venous)
Weekly	<ul style="list-style-type: none"> serum TG** magnesium zinc**

* Initially daily and decrease frequency once stable unless indicated for other birth weight or gestation-specific guidance (see intravenous fluid guideline)

** In prolonged TPN more than 2 weeks

COMPLICATIONS

Catheter related: (see Long-lines guideline)

- Peripheral catheters: extravasations and skin sloughs
- Septicaemia

Electrolyte abnormalities

- Electrolyte and acid-base disturbances

Metabolic

- Hyper/hypoglycaemia, osmotic diuresis
- Metabolic bone disease: mineral abnormalities (Ca/PO₄/Mg)
- Hyperlipidaemia and hypercholesterolaemia
- Conjugated hyperbilirubinaemia

PN-associated cholestatic hepatitis

- Infants having prolonged TPN (>10-14 days) can develop cholestasis, probably owing to TPN toxicity combined with reduced oral feeding, and often transient, usually manifest as rising serum bilirubin (with increased direct component) and mildly elevated transaminases, leads to deficiencies of fatty acids and trace minerals
 - even small enteral feeds will limit or prevent this problem
 - add trace minerals
 - consider other causes direct hyperbilirubinaemia (TPN-induced cholestasis is diagnosis of exclusion)
 - if stools alcoholic (putty grey) or very pale, refer urgently to liver unit

WEANING PN

- When advancing enteral feedings, reduce rate of PN administration to achieve desired total fluid volume
- Assess nutrient intake from both PN and enteral feed in relation to overall nutrition goals