وزارة الصحة
Ministry of Health

NEONATAL PARENTERAL NUTRITION

CLINICAL PRACTICE GUIDELINES

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1. STATEMENT OF PURPOSE

1.1 To provide essential information for healthcare professionals involved in the provision and administration of parenteral nutrition (PN) in neonates.

1.2 To improve the management of neonatal patients requiring PN support.

2. RELATED DOCUMENTS

2.1 **1431-201 CPP** High Alert Medication

2.2 **1431-290 CPP** Parental Nutrition

3. RELATED ACCREDITATION STANDARDS

3.1 **CBAHI 3rd edition:** MM.5, MM.27, & MM.32.6

3.2 **JCI standards 7th edition: MMU.5**

4. ABBREVIATIONS AND DEFINITIONS

4.1 **PN:** Parenteral Nutrition is the provision of nutrients via the intravenous route. PN is used for neonates who cannot receive their full nutritional requirements via enteral nutrition.

4.2 **EN:** Enteral nutrition

4.3 **GI**: Gastrointestinal

4.4 **PPN:** Peripheral Parenteral Nutrition

4.5 **CPN:** Central Parenteral Nutrition

4.6 **CVADs**: Central venous catheter devices

4.7 **AA:** Amino acid

4.8 **GIR:** Glucose infusion rate

4.9 **ILE:** Intravenous lipid emulsion

4.10 **EFAs:** Essential fatty acids

4.11 **NEC:** Necrotizing enterocolitis

4.12 **IUGR:** Intrauterine growth restriction

4.13 **ASPEN:** American Society for Parenteral and Enteral Nutrition

4.14 **TNAs:** Total nutrition admixtures

4.15 **CRBSI:** Catheter-related bloodstream infection

4.16 **SBS:** Short bowel syndrome

4.17 **EFAD:** Essential fatty acid deficiency

5. GUIDELINES/ PROTOCOL/PATHWAY

5.1 Introduction

5.1.1 Neonatal PN plays an essential role in the management of sick and growing preterm and term infants. PN can be used as the sole source of nutrition support for infants who cannot be fed or as an adjunct to enteral feeding. Preterm infants are a particularly vulnerable population because they are born at a time, if they had remained in utero, of rapid intrauterine brain and body growth. The impact of early malnutrition can have long-lasting negative effects on central nervous system development and growth. The quality of PN and its early initiation are critical in providing the most adequate substrates for appropriate development.

5.1.2 All Neonatal ICU department Physicians, Pharmacist, And Nursing Staff shall follow and adhere to this guideline.

5.1.3 All the Neonatal Parenteral Nutrition plan, orders, and monitoring must document in the patient's medical record, and manual incase system in down.

5.2 Indications of PN:

5.2.1 Absolute indications:

5.2.1.1 Functional immaturity, e.g. preterm infants <32 weeks gestation or <1,500 g, to supplement advancing enteral nutrition

5.2.1.2 Intestinal failure, e.g. pseudo-obstruction, short bowel

5.2.1.3 Post-gastrointestinal surgery

5.2.1.4 Necrotising enterocolitis (NEC)

5.2.1.5 Congenital gastrointestinal defects, e.g. gastroschisis, intestinal atresia

5.2.1.6 Critically ill: initiate PN when EN is unable to meet energy requirements for energy expenditure and growth.

5.2.2 Relative indications:

5.2.2.1 Preterm infants ≥32 weeks gestation or ≥1,500 g who are not expected to receive adequate enteral intake (i.e. ≥75% of nutritional requirements) within approximately 2 - 3 days

5.2.2.2 Term infants or children who are not expected to receive adequate enteral intake within 3 - 5 days

5.3 Time frame for initiating PN in neonates:

5.3.1 Very low birth weight infant (birth weight less than 1,500 g) or < 32 weeks: begin PN promptly in the first day of life (ideally within 8 hours)

5.3.2 For preterm babies 32 – 37 weeks or weighing 1500 – 2500 g; initiate PN after 24 – 48 hours if expected not to have full enteral feed within 3 days

5.3.3 For full-term babies > 37 weeks or weight > 2500 g; initiate PN after 2-3 days if expected to have full enteral feed within 5 days

5.3.4 For babies who were on enteral feeding and stopped for any reason, you can use the same schedule above

5.4 Energy requirements (Appendix 1)

5.5 Fluid Requirement (Appendix 1)

5.6 Constituents of Parenteral Nutrition (Appendix 1)

PN solutions contain some or all of the following constituents

5.6.1 Amino Acids (Protein / Nitrogen)

5.6.1.1 Proteins are the major structural and functional components of all cells in the body and are made up of chains of amino acids

5.6.1.2 In the amino acid (AA) solutions currently used, each gram of AA contains approximately 4 kcals

5.6.1.3 Neonates are in high need for certain AAs (conditional essential), for this reason it is important to use an AA solution that is primarily designed for this patient group

5.6.2 Carbohydrate

5.6.2.1 Carbohydrate is the main source of energy in PN, it is recommended that approximately 60 - 75% of non-protein energy comes from carbohydrate

5.6.2.2 Each gram of dextrose contains 3.4 kcal

5.6.2.3 Glucose provision can be calculated as the glucose infusion rate (GIR), expressed as mg/kg/minute. GIR= (% of Dextrose X ml/kg/day) / 144

5.6.2.4 Glucose intake of 10% on day 1 of postnatal life for both preterm and term infants is common practice

5.6.3 **Intravenous Lipid Emulsion (ILE)**

5.6.3.1 ILEs are used in neonatal PN as a non-carbohydrate source of energy, to provide a source of essential fatty acids (EFAs)

5.6.3.2 It is recommended that approximately 25 - 40% of non-protein energy comes from lipids in patients receiving PN as a sole source of nutrition

5.6.3.3 The energy provided per gram of lipid in PN is approximately 10 kcal

5.6.4 **Electrolytes** (Appendix 1)

5.6.4.1 The main electrolytes included in PN necessary for the maintenance of many cellular functions are:

5.6.4.1.1 Sodium (Na)

5.6.4.1.2 Potassium (K)

5.6.4.1.3 Calcium (Ca)

5.6.4.1.4 Magnesium (Mg)

5.6.4.1.5 Phosphate (P)

5.6.4.2 Electrolytes may be given to maintain normal serum concentrations or to correct deficits

5.6.4.3 Consider other sources of electrolytes such as intravenous fluids and medications when ordering PN

5.6.4.4 Adequate calcium, phosphate, and magnesium, together with vitamin D essential for bone mineralization, to support linear growth and to protect against rickets fractures

5.6.4.5 Electrolytes should be prescribed in the form of complete salts rather than individual ions to minimize the risk of dosing errors and ensure accurate preparation and administration.

5.6.5 **Calcium and Phosphate**

5.6.5.1 The precipitation of calcium and phosphorus is a common interaction that is potentially life-threatening

5.6.5.2 The risk of precipitate formation is greater with:

5.6.5.2.1 Increased solution temperature and pH

5.6.5.2.2 Higher concentrations of calcium and phosphorus

5.6.5.2.3 Lower concentrations of amino acids and dextrose

5.6.5.2.4 Use of the chloride salt of calcium

5.6.5.2.5 Improper mixing sequence when adding calcium and phosphorus salts

5.6.5.2.6 The presence of other additives (including ILEs)

5.6.5.3 Steps to minimize the risk of calcium and phosphate precipitation in PN admixtures include:

5.6.5.3.1 The use of calcium gluconate instead of calcium chloride because it is less reactive

5.6.5.3.2 Use organic phosphate salt

5.6.5.3.3 Adding phosphate salts early in the mixing sequence, adding calcium last or nearly last, and agitating the mixture throughout the admixture process to achieve homogeneity

5.6.5.3.4 PN admixtures with a lower final pH should be used when clinically appropriate

5.6.5.3.5 Higher final concentrations of dextrose and AA and lower final concentrations of lipids favor a lower admixture pH.

5.6.5.4 AA product-specific solubility curves that are available from the manufacturer or primary literature should be consulted for calcium and phosphorous solubility.

6.6.6. Chloride and Acetate

6.6.6.1 Amount of chloride and acetate based on acid-base balance

6.6.6.2 Because the addition of bicarbonate to acidic PN admixtures may result in the formation of carbon dioxide gas and insoluble calcium and magnesium carbonates, sodium bicarbonate used in PN admixtures is not recommended. Use of a bicarbonate precursor salt such as acetate usually is preferred.

6.6.6.3 Acetate is metabolized in the liver to produce bicarbonate on a 1:1 molar ratio

6.6.6.4 Chloride in PN (as sodium chloride or potassium chloride) can be partly replaced by acetate (as sodium acetate or potassium acetate) to reduce metabolic acidosis and/or hyperchloraemia

5.6.6 **Trace Elements** (Appendix 1)

5.6.6.1 Many trace elements are an important part of metalloenzymes and function as cofactors in a variety of regulatory metabolic pathways

5.6.6.2 Injectable trace elements are available as single trace element solutions and as multiple trace element combinations

5.6.6.3 Requirements for trace elements also vary on the basis of the patient's clinical condition

5.6.6.4 Higher doses of supplemental zinc likely are necessary for patients with high-output ostomies or diarrhea because the GI tract is the predominant excretion route for zinc.

5.6.6.5 Manganese and copper are excreted through the biliary tract, chromium, molybdenum, and selenium are excreted renally

5.6.6.6 Multi-trace dosage may require alteration in patients with increased gastrointestinal or skin losses or with hepatic or renal dysfunction

5.6.6.7 Additional zinc injectable solution in case of administration to preterm infants should be added to reach a total zinc parenteral intake of 400 mcg/kg/day

5.6.7 **Vitamins** (Appendix 1)

5.6.7.1 Both water-soluble and fat-soluble vitamins are added to PN

5.6.7.2 Water-soluble vitamins are the B group of vitamins and vitamin C; and fat-soluble vitamins are vitamins A, D, E, and K

5.6.8 **Other additives**

5.6.9 **Heparin**

5.6.9.1.1 Heparin is added to PN in a dose of 0.25 – 1 U/ml to maintain patency of the catheter and reduce vein irritation

5.6.9.1.2 Use of low dose heparin 1 unit/ml of two in one PN formulation to stimulate lipoprotein lipases activity has been suggested as a potential therapeutic intervention to treat ILE-associated hypertriglycemia in neonates but there are no convincing elements to suggest the use of heparin with the aim of improving the clearance of lipids

5.6.9.1.3 The risk associated with heparin delivery via PN outweighs the clinical benefit because of the potential compounding error. Therefore, it should not be given with lipid infusions on a routine basis, unless indicated for other reasons

5.6.9.1.4 The practice of adding heparin to parenteral nutrition for neonates is not recommended by the ASPEN or ESPEN guidelines. Any decision to include heparin should be based on careful clinical judgment and individual patient needs

5.6.9.2 **Carnitine**

5.6.9.2.1 Carnitine facilitates the transport of long-chain fatty acids across the mitochondrial membrane, improving the possibility of oxidation.

5.6.9.2.2 Carnitine supplementation (10 – 30 mg/kg/d) indicated for patients on long-term PN more than 4 weeks; hypertriglyceridemia; premature infants < 32 -34 weeks gestational age, and carnitine deficiency

5.7 Routes of PN administration

Peripheral route

5.7.1 Peripheral parenteral nutrition (PPN) is an option for mild to moderate stressed patients in whom adequate GI tract function is expected to return within 10-14 days.

5.7.2 Potential PPN candidates should not be fluid-restricted or require large nutrient amounts.

5.7.3 Lower concentration of dextrose (10-12.5% final concentration), and micronutrients must be used for peripheral route administration.

5.7.4 The risk of phlebitis is greater with solution osmolarities greater than 1000 mOsmol/L for neonates.

5.7.5 It is possible to give PN with an osmolality around 1100 mOsm/kg for up to 10 days via peripheral veins.

Central route

5.7.6 Central Parenteral Nutrition (CPN) is the preferred route for PN delivery and is used predominantly for patients who require PN for a period of more than 7 to 14 days.

5.7.7 CPN is the preferred route for patients who have large nutrient requirements, poor peripheral venous access or fluctuating fluid requirements

5.7.8 Unlike peripheral veins, central veins have a higher blood flow, which quickly dilutes the hypertonic solution, PN can with higher osmolarities

5.8 Ordering and Prescribing Parenteral Nutrition

5.8.1 In all cases, the following should be included on the PN prescription/order:

- PN volume (ml/kg/day) or (ml/day)
- Central/peripheral access (if glucose concentration is greater than 12.5%, a central access must be used)
- Working weight / dosing weight (kg)
- Amino acid (g/kg/day)
- Glucose (mg/kg/min) or (%)
- Lipid (g/kg/day)
- Electrolytes as salt (mmol/kg)
- Water-soluble vitamins
- Fat-soluble vitamins
- Trace elements
- Other requirements (as necessary), e.g. heparin, carnitine, thiamine

5.8.2 Starter PN must be initiated at birth if indicated for a maximum duration of 1 day as it is intended to bridge infants until delivery of patient-specific PN

5.8.3 Stater PN must only be initiated for patients who meet the following criteria:

- Birthweight less than or equal to 1.500 g

- Gestational age less than or equal to 30 weeks

5.8.4 Starter PN should be prepared as a standard volume of 100 ml containing the following:

- 10 % Dextrose
- 2.5 % Amino Acids
- No electrolytes

5.8.5 PN may be ordered by a consultant or any NICU physician

5.8.6 PN volume should be determined after subtracting all other patient's fluids from total fluid intake, up to 10% may be added as extra PN volume if needed

5.8.7 While the patient is on both PN and enteral or oral feed and there was any interruption of feed for any reason, use starter PN and contact the PN pharmacist for new PN if needed to prepare it early

5.8.8 PN is a 7-day service, all PN should be ordered before 1 PM, any patient need PN after working hours can be given starter PN or IV fluids

5.8.9 PN prescriptions must be reviewed and verified by a PN pharmacist prior to transmitting to the PN compounding process

5.9 Delivery and Storage of Parenteral Nutrition

5.9.1 PN should be collected by the nurse from the pharmacy before 5 PM

5.9.2 All PN should be stored in a designated medication refrigerator 2 to 8°C

5.9.3 The aqueous solution and lipid solution should be removed from the fridge in advance, approximately one hour prior to commencing the infusion. This allows it to come to a suitable temperature for infusion

5.10 Administration of Parenteral Nutrition by Nurse (Appendix 1)

5.10.1 PN solutions should be administered using volumetric pumps which are capable of accurately delivering low flow rates and have occlusive and air-in-line alarms to minimize infusion-related complications

5.10.2 PN can be infused via a peripheral (short-term use only) or central venous access device (CVAD).

5.10.3 Ideally, the venous line used for PN should not be interrupted for giving antibiotics or medications; a separate IV line should be used

5.10.4 If co-infusion is unavoidable through the same line, medication stability and compatibility with the PN must be established and verified before administration

5.10.5 PN solutions (solution, and lines) should be protected from light to prevent peroxidation and degradation of light-sensitive vitamins

5.10.6 The infusion set and lipid infusion line should be changed every 24 hours

5.10.7 Use a 0.2 micron filter for aqueous PN solution and a 1.2 micron filter for lipid-containing PN.

5.10.8 ASPEN recommended using a 1.2 micron in-line filter for the administration of total nutrients admixture (TNAs), dextrose- amnio acid admixtures, and ILE. For TNAs, place the filter as close to the catheter hub as possible. For dextrose-amino acid admixtures below the Y-site where the dextrose-amino acid admixture and ILE co-infuse.

5.11 Transitioning from Parenteral Nutrition to Enteral Nutrition

5.11.1 There should be a gradual transition from PN once a clinical decision has been made to commence enteral nutrition.

5.11.2 Full PN volumes should continue until at least 25% of nutritional requirements are met from enteral or oral nutrition.

5.11.3 Both the lipid infusion and aqueous PN infusion should be continued until the neonate tolerates at least 120 ml/kg/day enteral nutrition

5.12 Monitoring of Parenteral Nutrition by prescriber

5.12.1 Monitoring is essential to assess tolerance of PN as well as nutritional adequacy to support growth. Special attention is required when PN is being increased or adjusted especially if the patient is clinically unstable, or if PN is to be provided long term.

5.12.2 Anthropometry should be checked regularly as a measure of growth.

5.12.3 Fluid balance, including input and output from all sources, must be monitored daily and provision of fluid and electrolytes adjusted as required.

5.13 Complication of Parenteral Nutrition

5.13.1 **Infectious Complications**

5.13.1.1 Infection is one of the most common and potentially fatal complications of CVADs

5.13.1.2 Effective prevention of catheter-related infections requires strict adherence to antiseptic techniques

5.13.1.3 When Infection is suspected PN should be stopped and central blood cultures obtained, ideally a peripheral blood culture should be obtained at the same time

5.13.1.4 CVAD should be removed if indicated

5.13.1.5 Empirical antibiotic therapy for catheter related blood stream infection (CRBSI) should be started. The choice of antibiotics should be based on local antimicrobial guidelines

5.13.1.6 Antibiotics should be changed to narrow spectrum once the infective organism has been identified

5.13.1.7 The duration of antibiotics is guided by the identified organism

5.13.2 Refeeding Syndrome

5.13.2.1 Refeeding syndrome is a potentially fatal complication observed in preterm infants with severe IUGR commencing PN after birth

5.13.2.2 Refeeding syndrome is characterized by acute electrolyte imbalances, most notable hypophosphataemia, hypokalaemia, hypomagnesaemia and hypoglycaemia.

5.13.2.3 To reduce risks of refeeding syndrome:

- Initiate nutrition at a maximum of 40%–50% goal, but usually starting the glucose infusion rate around 4–6 mg/kg/min and advancing by 1–2 mg/kg/min daily as blood glucose levels allow until reach patient goal
- Check serum potassium, magnesium, and phosphorus before initiation of nutrition
- Monitor every 12 hours for the first 3 days in high-risk patients. May be more frequent based on clinical picture and replace low electrolyte
- Patients may be at risk of thiamine deficiency, therefore supplementation with thiamine and a multivitamin is essential

- Maintenance requirement of thiamine for PN: Premature neonates: 200 to 350 mcg/kg/day, term neonates: 1.2 mg/day

5.13.3 Metabolic Bone Disease

5.13.3.1 PN-related metabolic bone disease has been described in patients on long-term PN. It manifests with a decrease in bone mineral density, osteoporosis, pain and fractures.

5.13.3.2 Regular measurements of urinary calcium, plasma calcium, phosphorus, alkaline phosphatase, parathyroid hormone and vitamin D concentrations are advised.

5.13.3.3 Regular assessment of bone mineralisation should be undertaken in children on long-term or home PN.

5.13.4 Hepatobiliary Complications

5.13.4.1 Patients requiring long-term PN are at high risk of developing PN-associated liver disease PNALD and in most cases it is moderate and reversible.

5.13.4.2 **Risk factors include:**

5.13.4.2.1 Absence of enteral nutrition

5.13.4.2.2 Short bowel syndrome (SBS) which may be associated with disruption of bile acid enterohepatic circulation, and bacterial overgrowth

5.13.4.2.3 Recurrent septic episodes

5.13.4.2.4 Prematurity

5.13.4.2.5 Excessive carbohydrate intake and/or continuous PN infusion leading to hyperinsulinism and subsequently to steatosis

5.13.4.3 **Prevention and treatment of cholestasis:**

5.13.4.3.1 Introduce enteral nutrition as soon as possible, even if only minimal amount.

5.13.4.3.2 Try to cycle PN as soon as clinically possible, may be poorly tolerated in acutely ill neonates

5.13.4.3.3 Consider decreasing lipid infusions if unexplained and sustained rise of conjugated bilirubin occurs (> 2 mg/dl)

5.13.4.3.4 Ursodeoxycholic acid (10-15 mg/kg/dose orally every 12 hours) might be indicated in patients with a continuous rise of transaminases, conjugated bilirubin and alkaline phosphatase

5.14 PN product shortage consideration

5.14.1 Assess each patient as to the indication for PN and provide nutrition via the oral or enteral route when possible.

5.14.2 **PN Amino Acids product shortage considerations**

5.14.2.1 Only use Neonatal/Pediatric-specific amino acids or disease-specific amino acids for the indicated patient populations.

5.14.2.2 Different brands of amino acids products are not always directly substitutable, they may have different pHs, different calcium-phosphorus solubilities, different amounts of phosphorus, as well as other characteristics that should be considered.

5.14.3 **PN Lipid Injectable Emulsion product shortage considerations**

5.14.3.1 Prioritize supply of soybean oil-based ILE as follows: Neonatal patients should continue the same ILE therapy as before the shortage to minimize the risk of adverse effects associated with essential fatty acid deficiency (EFAD) in this high-risk patient population. Priority for ILE during critical shortages should be given to neonates followed by pediatric patients and finally, adolescent patients.

5.14.3.2 Monitor closely patients receiving PN for developing EFAD during shortages. Increase awareness and assessment for signs and symptoms of EFAD. Signs and symptoms of EFAD include, but are not limited to, diffuse dry, scaly rash, alopecia, thrombocytopenia, anemia, and impaired wound healing. Biochemical evidence of EFAD is confirmed by a triene-to-tetraene ratio greater than 0.2. Using topical oils for prevention and treatment of EFAD has produced mixed results. Safflower and sunflower seed oils had beneficial results whereas vegetable oil (corn oil) did not.

5.14.3.3 In the event of a four-oil (soybean oil, medium chain triglycerides, olive oil and fish oil) ILE shortage use standard soybean oil-based ILE dosing and frequency to meet patients' EFAs needs.

5.14.4 PN Multivitamin product shortage considerations

5.14.4.1 Consider switching to oral or enterally administered multivitamins when oral/enteral intake is greater than 50% of needs (excluding patients with malabsorption syndromes).

5.14.4.2 Reserve pediatric intravenous multivitamins for children less than 2.5 kg or less than 36 weeks gestational age.

5.14.4.3 Consider use of adult intravenous multivitamins for children during the shortage; use 5 mL of adult multivitamins in all children weighing greater than or equal to 2.5 kg or gestational age of 36 weeks and older while saving the pediatric product for smaller neonates in order to conserve the supply. Supplement intravenous vitamin K daily (Preterm neonates: 10 mcg/kg/day, Term neonates: 200 mcg/day). The vitamin K content of the adult multivitamin product should be noted when supplementing with additional vitamin K.

5.14.4.4 If no pediatric intravenous multivitamins are available, infants less than 2.5 kg or less than 36 weeks gestation should receive an adult intravenous multivitamin at a daily dose of 1 mL/kg up to a maximum of 2.5 mL/day.

5.14.4.5 When using adult intravenous multivitamin products in neonates be aware that these products contain propylene glycol, polysorbate, and aluminum, which may be toxic to neonates.

5.14.4.6 If neither pediatric nor adult intravenous multivitamins are available, administer individual parenteral vitamin entities in doses that are appropriate for the patient's age and weight. Thiamine, ascorbic acid, pyridoxine, and folic acid should be given daily.

5.14.5 PN Trace Elements product shortage considerations

5.14.5.1 Consider switching to oral or enterally administered multi-trace element supplement products when oral/enteral intake is initiated.

5.14.5.2 Reserve intravenous trace elements for those patients receiving solely PN-dependent or those with a therapeutic medical need for intravenous trace elements.

5.14.5.3 If intravenous multi-trace element products are no longer available, administer individual parenteral trace element entities.

5.14.5.4 Reserve Neonatal intravenous multi-trace element products for neonatal patients.

5.14.5.5 The routine use of intravenous Adult multi-trace element products in pediatric and neonatal patients is not recommended.

6. APPENDICES

6.1 Appendix 1

7. REFERENCES

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Appendix 1:

- **Table 1: Recommended Parenteral Energy Intake by ASPEN 2018**

	Age	Energy initial (Kcal/kg)	Energy Goal (Kcal/kg)
Preterm	< 34-0/7 Week	45-60	90-111
Late Preterm	34-0/7 to 36-6/7 Week	40-55	100-110
Term	≥37-0/7 Week	40-50	90-108

- **Table 2: Fluids Requirements in Neonates**

Neonate	Initial Administration	Advancement	Goal
Preterm < 1.5 kg	80-100 ml/kg/day	10-20 ml/kg/day	150- 180 ml/kg/day
Preterm > 1.5 kg	60-80 ml/kg/day	10-20 ml/kg/day	130- 160 ml/kg/day
Term	50-70 ml/kg/day	10-20 ml/kg/day	120-140 ml/kg/day

- **Table 3: Dosing for Initiation and Advancement of PN Macronutrients**

Infants (<1 y)	Initiation		Advance By		Goals	
	Preterm	Term	Preterm	Term	Preterm	Term
Protein (g/kg/d)	1.5-2 (3-4 Max)	1–2	_	_	3 – 3.5	2.5–3
Dextrose (mg/kg/min)	6–8 4-6	6–8 3-5	1–2	1–2	8-10 (Max 12)	7-10 (Max 12)
ILE (g/kg/d)	1–2	1–2	1–2	1–2	3 - 4 (Max 0.15 g/kg/h)	3–4 (Max 0.15 g/kg/h)

- **Table 4 PN Electrolyte Daily Dosing:**

	Preterm Neonates	Infants/Children
Sodium	2-5 mmol/kg	2-5 mmol/kg
Potassium	2-4 mmol/kg	2-4 mmol/kg
Calcium	1-2 mmol/kg	0.25-2 mmol/kg
Phosphorus	1-2 mmol/kg	0.5-2 mmol/kg
Magnesium	0.15-0.25 mmol/kg	0.15-0.25 mmol/kg
Acetate	As needed to maintain acid base-balance	
Chloride	As needed to maintain acid base-balance	

- **Table 5: PN Trace Element Daily Dosing**

Trace Element	Preterm Neonates	Term Neonates 3-10 kg
Zinc	400 mcg/kg	250 mcg/kg
Copper	20 mcg/kg	20 mcg/kg
Manganese	1 mcg/kg	1 mcg/kg
Chromium	0.05-0.3 mcg/kg	0.2 mcg/kg
Selenium	2 mcg/kg	2 mcg/kg

- **Table 6: PN Daily Multiple Vitamin Requirement Dosing for Neonate**

Vitamin	Preterm Neonates	Term Neonates
Thiamine (Vitamin B1)	200–350 mcg/kg/d	1.2 mg/d
Riboflavin (vitamin B2)	150–200 mcg/kg/d	1.4 mg/d
Niacin (vitamin B3)	4–6.8 mg/kg/d	17 mg/d
Vitamin B6	150–200 mcg/kg/d	1000 mcg/d
Folate (Vitamin B9)	56 mcg/kg/d	140 mcg/d
Vitamin B12	0.3 mcg/kg/d	1 mcg/d
Vitamin C	15–25 mg/kg/d	80 mg/d
Pantothenic acid (Vitamin B5)	1–2 mg/kg/d	5 mg/d
Biotin (vitamin B7)	5–8 mcg/kg/d	20 mcg/d
Vitamin A	700–1500 IU/kg/d	2300 IU/d
Vitamin D	40–160 IU/kg/d	400 IU/d
Vitamin E	2.8–3.5 IU/kg/d	7 IU/d
Vitamin K	10 mcg/kg/d in PN +500 mcg IM at birth	200 mcg/d +500 mcg IM at birth

- **Table 7: Recommended Monitoring Parameters While Patient on PN**

Parameter	Baseline	Initiation	Critically ill patient	Stable patient
Wight	Yes	Daily	Daily	2-3 X per week
Intake and output	Yes	Daily	Daily	Daily unless fluid status is assessed by physical exam
CBC with differential	Yes		Weekly	Weekly
INR, PT, PTT	Yes		Weekly	Weekly
Electrolytes: Na, K, Cl, CO_2, Mg, Ca, Phosphorus, BUN, Cr	Yes	Daily X 3	Daily	1-2 X per week
Serum triglyceride	Yes	Day 1	Weekly	Weekly
Serum glucose	Yes	Daily X 3	Daily	1-2 X per week
Capillary glucose		As needed	≥3 X Day until consistently < 150mg/dl	As needed
ALT, AST, ALP, total bilirubin	Yes	Day 1	Weekly	Weekly
Nitrogen balance	As needed		As needed	As needed

- **Table 8: Recommended lipid/triglyceride monitoring and recommendation**

TG Level	Recommended PN Lipid Intake
Infants: < 2.26 mmol/l (200 mg/dl)	• Advance lipid intake as normal • Assess TG 24 - 48 hours after each increase of 1 g/kg/day lipid until the recommended lipid intake tolerated • When recommended lipid intake is tolerated, assess TG once weekly
Infants: > 2.26 mmol/l (200 mg/dl) Without infusion **Infants: > 3 mmol/L (265 mg/dl) During infusion**	• Reduce the dose or discontinue the lipid infusion for 4-6 hours to allow for TG clearance • Reduce lipid intake to dose previously tolerated / associated with normal TG level • Recheck TG after 24 hours • If plasma TG levels are above the limits, lowering not stopping the dosage is generally recommended. In exceptional cases lipid infusion may need to be discontinued temporarily • Inclusion of carnitine (10-20 mg/kg/day) is essential for the transport of long chain fatty acid into mitochondria and appropriate metabolism