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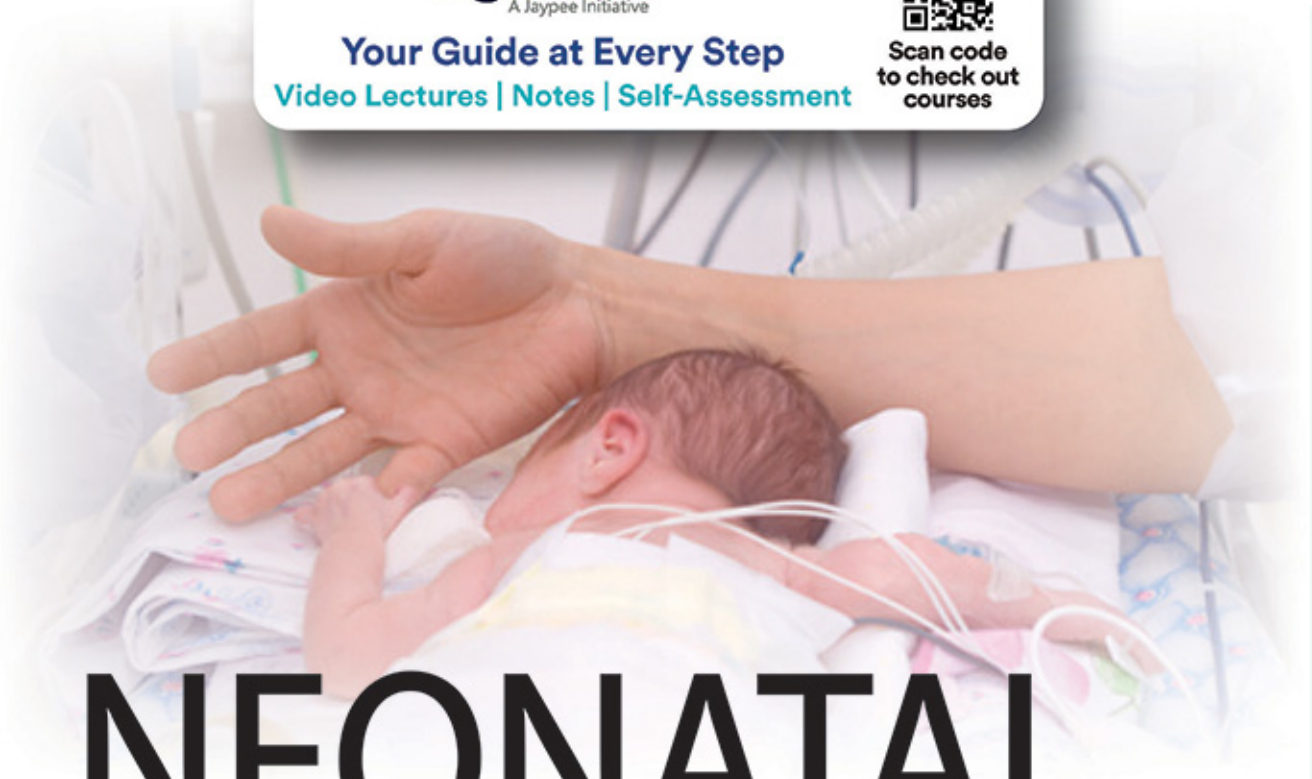

NEONATAL ICU Protocols

Previously Known as Handbook on Neonatal ICU

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4

Chapter

Parenteral Nutrition

Anumodan Gupta, Sachin Kumar Dubey, Umesh Vaidya

INTRODUCTION

- Optimum nutrition is essential for survival, physical growth, mental development, productivity, health, and well-being across the entire life span.
- Parenteral nutrition (PN) or intravenous (IV) nutrition is an important part of critical care. Nutritional support prevents a catabolic state that is associated with critical illness and hastens recovery.
- Parenteral nutrition thus supports nutritional needs till adequate enteral nutrition is established.

GOALS OF PARENTERAL NUTRITION

Provision of:

- Adequate calories for energy expenditure and growth.
- Adequate carbohydrates with lipids and protein intake for a balanced ratio.
- Essential nutrients including minerals, electrolytes, vitamins, and trace elements.

INDICATIONS

Common indications in neonates are shown in **Table 1**. PN should be started at the earliest. PN can be stopped once enteral nutrition provides 75% of calorie needs.

Table 1: Indications of parenteral nutrition.

Prematurity <28 weeks and/or <1,000 g	Prematurity <32 weeks and/or <1,500 g who are unable to achieve full enteral feeds by day 3
Prematurity >32 weeks and/or >1,500 g who are unable to achieve at least 50% enteral feeds by day 5	Necrotizing enterocolitis (stages II and III)
Surgical neonates (exomphalos, intestinal surgeries, gastroschisis)	Short bowel syndrome
All neonatal and infant catabolic states (weight loss, poor muscle mass) where enteral feeding is limited or not possible	

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STEPS IN STARTING PARENTERAL NUTRITION

- Identify patient.
- Assess nutritional needs. Energy requirements for growth for preterm and term neonates on PN are 110–120 kcal/kg/day and 90–110 kcal/kg/day, respectively. It should be ensured that minimum 30 kcal/kg/day is provided for every g/kg of protein. This is calculated as a calorie-nitrogen ratio (CNR).
- Calculate PN.
- Prepare PN.
- Administer PN.

Components and dispensing for parenteral nutrition calculations: Purpose of PN is to provide the neonate macronutrients **(Table 2)** as well as micronutrients.

MICRONUTRIENTS

- *Vitamins:* Start on day 1 of PN. As per European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) recommendations, vitamins are added to the lipid emulsion during compounding. In India, pediatric multivitamin infusion (MVI) is not

Table 2: Macronutrients.

Carbohydrates	*Lipids*	*Proteins*
Dextrose as a part of PN is on the lines of routine intravenous fluids (60% calorie intake)	• Lipids are energy dense and isoosmolar. They provide 30% (range 25–40%) of the caloric intake on PN • Apart from calories, lipids provide essential fatty acids (EFA—linoleic and linolenic acids) and/or DHA which are necessary for cell metabolism and particularly brain and retinal development	Early and adequate proteins lead to better nitrogen retention, better postnatal growth, better head growth and lesser incidence of bronchopulmonary dysplasia (provides 10% of energy)
Starts on day 1	Starts on day 1	Starts on day 1
Dose calculated on the basis of glucose infusion rate (GIR)	Minimum dose of 1 g/kg/day (desirable up to 3 g/kg/day)	Preterm: Minimum of 2 g/kg/day on day 1 (desirable 2.5 to 3 g/kg/day). Amino acids are graded up on consecutive days to a maximum of 3.5 g/kg/day)
	Tolerance of lipids: Serum triglyceride estimation (maintain below 200 mg/dL). In the past, there were concerns regarding the use of lipids in neonatal jaundice, sepsis and thrombocytopenia. Recent studies have shown lipids to be safe in these conditions if proper dosage and administration guidelines are followed. Dose of 1 g/kg/day are sufficient to prevent EFA deficiency	The calorie-nitrogen ratio (CNR) ensures adequate calories for the amount of proteins being given. It is calculated as follows: Calorie-nitrogen ratio = Non-protein calories (Dextrose + Lipids) / 0.16 × proteins (g)

(DHA: docosahexaenoic acid; EFA: essential fatty acid; PN: parenteral nutrition)

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Table 3: Doses of minerals used in PN.

Sodium	0–3 mEq/kg/day (0 on day 1 and then 2–3 mEq/kg/day)
Potassium	0–2 mEq/kg/day (0 on day 1 and then 2–3 mEq/kg/day)
Chloride	0–5 mEq/kg/day (0 on day 1 and then 4–5 mEq/kg/day)
Calcium	42–120 mg/kg/day (preterm), 32 mg/kg/day (term)
Phosphorus	28–64 mg/kg/day (preterm), 14 mg/kg/day (term)
Magnesium	5 mg/kg/day

(PN: parenteral nutrition)

available and adult MVI is used as a substitute. Being water-soluble, adult MVI cannot be mixed in lipid solution and has to be mixed in dextrose, electrolyte containing solution. Limitations—higher vitamin A content (undesirable), no vitamin K, and is alcohol based. It also has benzoic acid as a stabilizer, which is not suitable for neonatal use.

- *Minerals:* Minerals are required in doses as described in **Table 3**.
- *Trace elements:* If the neonate needs to be on total parenteral nutrition (TPN) for more than 15 days, trace elements are started after 10 days of life. Presently T-pres/Celcel 5 (Trace element injection 5) is used in TPN solution which includes zinc, copper, chromium, manganese, and selenium.

CALCULATION OF PARENTERAL NUTRITION NEEDS (TABLE 4)

Nutritional requirements of premature babies have to be calculated very accurately to facilitate growth and to avoid complications.

Manual calculation is difficult, time consuming, needs training and validation before execution of order. Prescription errors up to 27.9% have been reported.

The process of writing repetitive tasks and tedious calculations thus leading to errors can be prevented by use of a dedicated software, thus improving the safety of PN administration.

Software Calculations

There are softwares for PN calculations which are accurate, validated, and reduce errors of calculation and compounding. It is used to keep track of patient's nutritional status on a serial basis. At neonatal intensive care unit (NICU) of KEM Hospital, Pune, we have developed user-friendly software named "Kimaya NICU software", which is in regular use.

COMPOUNDING OF TOTAL PARENTERAL NUTRITION (TABLE 5)

Compounding means preparing the PN solutions for administration once the calculations are done. There are two methods of compounding (manual and automated). Manual compounding implies preparation of PN solution by the nutritionist/nurse/doctor under a system called Laminar Flow system. Dextrose, amino acids, electrolytes, vitamins, and trace elements are compounded in one bottle, whereas the lipids are administered separately through a syringe.

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Table 4: Total parenteral nutrition (TPN) calculation sheet.

Name: _____

Registration number: _____ Date: _____

Day of life: _____ Birth weight _____

Weight for calculation: _____

1. **Total fluid** (mL/kg) = _____ mL × wt =
2. **Lipids** = ___ g/kg = ___ g = ___ × 5 mL of 20% lipid solution = ___ mL ___ Rate = ___ mL/hr infusion over 24 hrs
3. **Additives** = (a + b + c + d) mL as below:
   a. Antibiotics ___ mL
   b. Feeds ___ mL
   c. Hep-lock solution ___ mL
   d. Others ___ mL
4. (Net fluid will contain amino acids + dextrose + electrolytes), etc.
   Net fluid remaining = Total fluids – (lipids + additives) = ___ mL ___ Rate = ___ mL/hr infusion over 24 hrs
   A. Amino acids = ___ g/kg = ___ g = ___ × 10 mL of 10% amino acid solution
   B. Na = ___ mEq/kg = ___ mEq = ___ × 2 mL of 3% NaCl = ___ mL
   C. K = ___ mEq/kg = ___ mEq = ___ × 0.5 mL of KCL = ___ mL
   D. Ca gluconate = ___ mL/kg = ___ mL
   E. MVI = ___ mL
   F. Remaining volume for **Dextrose** (Dex volume) = Net fluid volume – (A + B + C + D + E) = _____ mL

$$\text{Dextrose concentration required} = \frac{\text{Weight} \times \text{Glucose infusion rate} \times 144}{\text{Dextrose volume}} = _____\%$$

To calculate required dextrose concentration, we can use 50% and 5% dextrose

$$\text{Volume of low conc solution} = \frac{\text{High conc} - \text{desired conc}}{\text{High conc} - \text{low conc}} \times \text{Dextrose volume}$$

i. $$\text{Here volume of 5\% D} = \frac{50 - \text{desired conc}}{50 - 5} \times \text{Dextrose volume} = _____ \text{ mL}$$

ii. Volume of 50% D = Dextrose volume – volume of 5% D = _____ mL

TPN calculation sheet example 2 kg neonate needing 150 mL/kg fluid

Weight for calculation _____

1. **Total fluid** (mL/kg) = 150 mL × wt = 300 mL
2. **Lipids** = 2 g/kg = 4 g = 4 × 5 mL of 20% lipid solution = 20 mL Rate = 0.8 mL/hr infusion over 24 hrs
3. **Additives** = (e + f + g + h) mL as below
   e. Antibiotic = 5 mL
   f. Feed = 25 mL
   g. Hep-lock solution = 10 mL
   h. Others = 0 mL
4. (Net fluid will contain amino acids + dextrose + electrolytes), etc.
   Net fluid remaining = Total fluids – (lipids + additives) = 300 – (20 + 40) mL = 240 mL Rate = 10 mL/hr infusion over 24 hrs
   G. Amino acids = 3 g/kg = 6 g = 6 × 10 mL of 10% amino acid solution = 60 mL
   H. Na = 3 mEq/kg = 6 mEq = 6 × 2 mL of 3% NaCl = 12 mL
   I. K = 2 mEq/kg = 4 mEq = 4 × 0.5 mL of KCL = 2 mL
   J. Ca gluconate = 8 mL/kg = 16 mL
   K. MVI = 1 mL
   L. Remaining volume for **Dextrose** (Dex volume)
   = Net fluid volume – (A + B + C + D + E) = 240 – (60 + 12 + 2 + 16 + 1) = 240 – 91 = 149 mL

Contd…

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Contd…

- Dextrose concentration required = $\frac{\text{Weight} \times \text{Glucose infusion rate} \times 144}{\text{Dextrose volume}} = \frac{2 \times 6 \times 144}{149} = 11.6\%$

To calculate required dextrose concentration, we can use 50% and 5% dextrose

$$\text{Volume of low conc solution} = \frac{\text{High conc} - \text{desired conc}}{\text{High conc} - \text{low conc}} \times \text{Dextrose volume}$$

iii. Here volume of 5% D = $\frac{50 - 11.6}{50 - 5} \times 149 = \frac{38.4}{45} \times 149 = 127$ mL

iv. Volume of 50% D = Dextrose volume – volume of 5% D = 149 – 127 = 22 mL

(MVI: multivitamin infusion; KCL: potassium chloride)

Table 5: Compounding of parenteral nutrition.

Bottle	*Syringe*
Dextrose	Lipids
Amino acids	
Electrolytes—sodium, potassium, calcium, magnesium, chloride	
Minerals—zinc, manganese, copper, chromium, selenium	
Vitamins	

COMPATIBILITY AND STABILITY

The PN formulation is a complex mixture containing different chemical components that may cause problems with stability and compatibility.

Factors on which stability of the nutrients primarily depends on are:

- Amino acid constitution and pH of the solution
- *pH of the formulation*: Maintaining a final pH of 5.0 or above
- *Dextrose concentration*: Keeping the final dextrose concentration at 3.3% or greater
- Concentration of the electrolytes
- Order of mixing
- *Ca:PO_4 ratio*: Calcium and phosphorus are common essential electrolytes in PN solutions. If mixed in too high a concentration, calcium and phosphorus may form an insoluble precipitate of calcium phosphate. Pulmonary emboli secondary to calcium phosphate precipitates have been reported to be fatal.
- *Osmolarity*: The osmolarity of the final PN formulation dictates the administration route. Osmolarity is primarily dependent on the dextrose, amino acid, and electrolyte content.

Photoprotection of Parenteral Nutrition

Peroxide formation in PN is now considered as an important issue that needs attention. Sources of peroxide in PN are many, viz. amino acids (tryptophan, tyrosine, methionine, cysteine, and phenylalanine), multivitamins (riboflavin), trace elements, lipid emulsion (polyunsaturated fatty acid), and additives used for stabilization of PN.

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Effects: Hypertriglyceridemia and impairs glucose uptake in muscle and fat; disrupts cell membrane integrity; mediates tissue injury; and changes quality of PN and causes loss of potency of PN by reducing levels of some vitamins and amino acids.

QUALITY CONTROL OF PARENTERAL NUTRITION PREPARATION

- Visual check for precipitation or particulate matters.
- *Biological integrity of the product:* On periodic basis, random samples of 5–10 mL are aseptically drawn from prepared TPN solutions. They are sent to microbiology laboratories for sterility testing.
- *High-efficiency particulate air (HEPA) filter hood environmental samples:* Periodically swabs for culture must be taken from working surface of the HEPA hood.
- *High-efficiency particulate air filter hood certification:* HEPA filter hoods must be tested for its efficiency once every 6 months.

SETTING UP

- Total parenteral nutrition solutions must be administered using an IV-infusion set with filter.
- Never add anything to a TPN solution. Never piggy back a TPN solution with any other preparations due to physical, chemical, and biological incompatibility.
- Use of Y connectors or triple lumen connectors for administrating amino acid solution and lipid together from same line. Alternatively, some units infuse amino acid-dextrose-electrolyte solution and lipids through separate infusion lines at different sites.
- Infusion sets need to be changed daily. Bacterial filters are changed every 3 days.

ROUTES AND TECHNIQUES OF PARENTERAL NUTRITION ADMINISTRATION

Total parenteral nutrition can be administered through peripheral or central lines (umbilical or central venous route). Use of peripheral line is safer when PN is needed for less than 10 days.

Percutaneous inserted central catheter (PICC) is inserted to avoid phlebitis when:

- Concentrations of >12.5% glucose are needed.
- Osmolarity of solution is >900 mOsm/L.
- Prolonged period of TPN is anticipated.

The position of the tip of the catheter needs to be in a large vessel preferably the superior or inferior vena cava outside the heart with position confirmed by X-ray prior to use. Single lumen central lines are preferred over multiple lumen catheters due to less risk of sepsis. PN lines should be handled minimally and with all aseptic techniques.

KEY POINTS

- Parenteral nutrition can be provided by peripheral or central route.
- Both amino acids and lipids should be started on day 1 of life.
- Starting dose of amino acids and lipids is 1 g/kg/day. Lipids need to be increased daily keeping check on triglyceride concentrations.
- Parenteral nutrition calculation software is a good alternative to manual calculation.

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SELF ASSESSMENT

1. **Maximum osmolality which can be tolerated while giving parenteral nutrition through peripheral route is**
   a. 800 mOsm/L
   b. 1,200 mOsm/L
   c. 900 mOsm/L
2. **Trace elements need to be added to parenteral nutrition if it is given for more than:**
   a. 5 days
   b. 10 days
   c. 15 days
3. **How many calories are needed per gram of protein for best accretion of protein?**
   a. 20 calories
   b. 30 calories
   c. 40 calories

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