بسم الله الرحمن الرحيم

Parenteral Nutrition in Neonates

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What are we going to discuss?

- Parenteral Nutrition: Definition & Goals.
- Types of PN Admixtures.
- Routes of Administration of PN.
- Nutritional Components of PN Formula.
- Macronutrients : Daily requirements, Regimen, Special consideration.
- Micronutrients : Daily requirements, Regimen, Special consideration.
- Complications of PN.
- Monitoring of PN.
- Weaning of PN.

Parenteral Nutrition

PN is the administration of intravenous nutrition in patients with a

Non- functioning or Inaccessible GIT in which it is anticipated that the patient will be unable to be fed enteral for at least 3 days in Neonates.

(Roberton's A Manual of Neonatal Intensive Care, 5th ed., 2013)

Parenteral Nutrition Goals

(1) Weight maintenance or promoting growth.

(2) Preservation of lean body mass& visceral proteins.

(3) Correct or prevent nutritional deficiencies.

(4) Avoidance of vitamins & trace elements abnormalities.

(5) Avoidance of fluid& electrolyte abnormalities.

Types of PN Admixtures

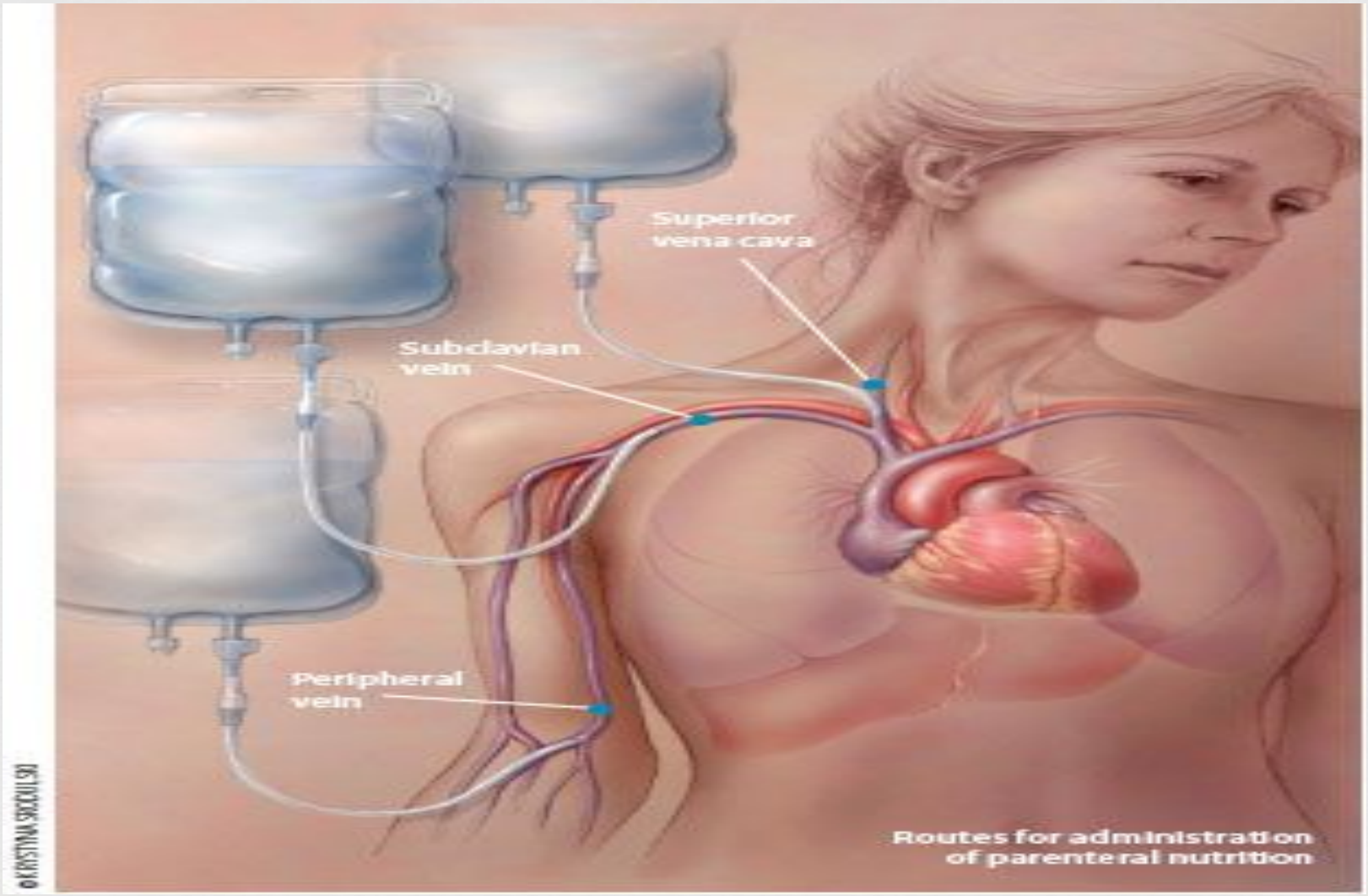
2 in 1

- all nutrients are mixed in the same IV bag, except for lipids.

3 in 1

- all nutrients are mixed in the same IV bag to form a lipid emulsion.

Routes of Administration of PN



Central Access

- **Advantages :**
  - ***No restrictions on the osmolarity*** of central PN, so **Hypertonic solutions** can be given safely.
- **Disadvantages :**
  - Skilled procedure.
  - risk associated with catheter insertion, use, and care.
  - life risking complications.

Peripheral Access

- **Advantages :**
  - Basic skill level.
  - Low potential for serious complications.
- **Disadvantages :**
  - Short life span.
  - **Hypertonic solutions** cannot be supplied via a peripheral vein.

Central Access

- **Indications:**

For patients who

- require long-term nutritional support.
- have large nutrient requirements , poor peripheral venous access.

Peripheral Access

- **Indications:**
  - For partial or supplemental PN or for short-term TPN.
  - When central intravenous access is unavailable.

Criteria for Peripheral Administration

1. **Osmolarity must not exceed 900 mOsm/L.**
2. **Final dextrose concentration should be <10% (Don't exceed 12.5%)**
3. **Final AA concentration should be 2.5%–4%**
4. **Ca^{2+} concentration should be < 5 mEq/L**
5. **K^{+} concentration should be <40–60 mEq/L**

Based on these **macronutrient and micronutrient concentration restrictions, probably Peripheral Parenteral Nutrition will not meet nutritional needs.**

Nutritional Components of PN Formulation

PN should provide a balanced nutritional intake of

1) Macronutrients including (amino acids, dextrose , Fat emulsions)

- They are important sources of structural & energy yielding substrates.

2)Electrolytes & micronutrients (including vitamins & trace elements)

- Are required to support essential biochemical reactions, metabolic activities , maintain physiologic serum concentrations.

Estimating the Osmolarity of Parenteral nutrients

Nutrient	Estimated Osmolarity
Amino acids	10 mOsm/L
Dextrose	5 mOsm/L
Lipid emulsion 20%	1.3- 1.5 mOsm/L
Sodium(acetate,chloride,phosphate)	2 mOsm/mEq
Potassium(acetate , chloride , phosphate)	2 mOsm/mEq
Calcium gluconate	1.4 mOsm/mEq
Magnesium sulfate	1 mOsm/mEq

- **Peripheral TPN: <900 mOsm/L**
- **Central TPN: 1500 - 2800 mOsm/L**

Calculating the Osmolarity of a Parenteral Nutrition Solution

1. Multiply the grams of dextrose per liter by 5.
2. Multiply the grams of protein per liter by 10.
3. Multiply the (mEq per L sodium + potassium + calcium + magnesium) X 2

[glucose (g/L) × 5] +[amino acids (g/L)×10]+ [cations (mEq/L)× 2]

Source: K&M and PN Nutrition in ADA, Nutrition in Clinical Practice. P 626

http://www.ncbi.nlm.nih.gov/pubmed/14763792

Developing a Regimen for PN Administration

Through Central Line

I. Evaluation of patient case

PN components should be adjusted individually to each patient according to:

Clinical status
Nutritional status
Nutritional requirements
Underlying disease state
Level of metabolic stress
Organ functions

I. Evaluation of patient case

First of all Review:

1. Patient Age, weight (Kg).
2. Make sure that patient is good candidate for PN.
3. Investigate patient lab values :

- Electrolytes: serum level of Na^+, K^+, Ca^{2+}, etc.
- Evaluate Kidney function through Cr level & BUN.
- Evaluate Liver function through ALT & AST level.
- Lipid profile
- Serum Albumin, Pre-albumin , Transferrin
- C- reactive protein & Complete Blood Count (CBC)

Evaluation of patient case continue

4. Assessment of degree of hydration.

Signs of dehydration:

- Reduced urine output
- BUN : Cr > 10 : 1
- Decreased skin turgor
- Dry mucous membrane

II. Start Calculating Components of PN Formula

Steps of Calculation

- **Fluid need/tolerated**
  (Subtract drugs, Blood, O.R.S, milk from TFR)
- **Patient's energy needs (Kcal/day)**
- **Protein need/day**
- **Fat emulsion need/tolerated**
- **Dextrose need/concentration**
- **Electrolytes /trace elements /vitamins need**
- **Osmolality**
- **Route**
- **TPN soln: 2 in 1, 3 in 1**

1.Determine Fluid Requirements

Daily maintenance of fluids intake on body weight basis

Weight	Daily maintenance fluid requirements
< 1.5 kg	130 - 150 ml/kg/day.
1.5 – 2 Kg	110 -130 ml/kg/day.
2 - 10 kg	100 ml/kg/day.

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The Neonatal adaptation processes after birth may be divided into three major phases:

Phase I: transition. (first 3–6 days after birth)

- The immediate postnatal phase is characterised by a relative oliguria followed by a diuretic phase
- Phase I usually ends when maximum weight loss has occurred.
- The generally accepted water loss is up to 10% of body weight.

A gradual increase of fluid volume is recommended.

Phase II: stabilisation

- the intermediate phase is characterized by diminished insensible water loss, a fall in urine volume to less than 1–2 ml/kg per hour, and a low sodium excretion.
- This phase may vary in duration from about 5–15 days and is completed when birth weight is regained and the kidneys produce more concentrated urine.
- Expected weight gain is 10–20 g/kg /day.

Phase III: established stable growth

- stable growth is characterized by continuous weight gain with a positive net balance for water and sodium.
- Expected weight gain is 10–20 g/kg body weight per day

Recommended Parenteral fluid intake (ml/kg /day)

During the first postnatal week

Days after birth	1st day	2nd day	3rd day	4th day	5th day	6th day
Term neonate	60–120	80–120	100–130	120–150	140–160	140–180
Preterm neonate >1500 g	60–80	80–100	100–120	120–150	140–160	140–160
Preterm neonate <1500 g	80–90	100–110	120 –130	130–150	140–160	160–180

During the intermediate phase prior to the establishment of stable growth

Birth weight	(ml/kg per day)
Term neonate	140–170
Preterm neonate >1500 g	140–160
Preterm neonate <1500 g	140–180

During the first month of life with stable growth

Birth weight	(ml/kg per day)
Term neonate	140–160
Preterm neonate	140–160

Variations in Fluid Requirements

- Do not use PN for fluid replacement but for maintenance fluid only.
- **Patients with the following conditions may have increased fluid requirements**:

fever, burn, diabetes insipidus , diarrhea, ileostomy or biliary drainage, and hyperbilirubinemia.

- **Patients with the following conditions may have decreased fluid requirements**:

hypothermia, syndrome of inappropriate antidiuretic hormone, oliguric renal failure, or patent ductus arteriosus, other Kidney or Cardiac dysfunction.

Suggested initial adjustment in specific situations

- Fever…..+12% for each degree >37 c.
- High humidity…..0.7 × maintenance.
- Radiant heat…..1.5 × maintenance.
- Photo Therapy… 10% × number of photo units× maintenance
- Congestive HF…..0.5 ×maintenance.
- Brain injury…….0.5-0.7 × maintenance.
- Renal failure……0.3 ×maintenance + urine output.
- Mechanical ventilation….(using humidifiers)0.7×maintenance

Adjustment of Fluid Requirements in case of Kidney Dysfunction

TFR= I.W.L + U.O.P

- **Insensible water loss (IWL):**

Used if urine output <1 ml/kg/hour

Birth weight (g)	IWL (ml/kg/day)
750-1000	82
1001-1250	56
1251-1500	46
>1500	28

2. Determine Caloric Requirements

Parenteral energy needs may be roughly estimated using the following ranges

Age	(Kcal /kg /day)
Preterm Neonate	**110-120**
0 – 1 year	**90-100**

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Factors affecting variations in caloric requirements

Further aspects need to be taken into account according to clinical parameters:

- **Weight gain** in regard to the target growth and required catch-up growth.
- **Recommended intake** of the different macronutrients
- **Tolerance to PN** administration (i.e. hyperglycaemia, hypertriglyceridaemia, liver enzyme abnormalities, cholestasis).
- **Nutritional status**, **underlying diseases**, **energy intake**, **energy losses**, **age**.

Variations in Caloric Requirements

- **Patient require increased caloric needs in case of** fever, inflammation, sepsis, burn, cardiac or pulmonary disease, **major complicated surgery**, and patients requiring "catch up" growth.

- **Patients require decreased caloric needs in case of** sedation, pentobarbital coma, mechanical ventilation, or paralysis.

Factors that increase caloric requirements

FACTOR	INCREASE IN CALORIC NEED
Fever	10 - 12 % (for each degree > 37^{o} C)
Cardiac failure	15 - 25 %
Major surgery	20 - 30 %
Burns	up to 100 %
Severe sepsis	40 - 50 %
Long term growth failure	50 - 100 %

The Caloric balance of PN Formula

- Caloric needs are met by a proper balance of carbohydrates, proteins, and fats, **A balanced PN formula of total daily calories should include:**

According to ASPEN Recommendations

1) 10-20 % amino acid.
2) 50-60 % dextrose.
3) 20-30 % Fat emulsion.

According to ESPEN Recommendations

- energy needs can be calculated based on non protein calories as protein needs are calculated only for new tissue deposition, as well as for tissue renewal and not as an energy source.
- Glucose should cover 60–75% of non-protein calories.
- Lipid should provide 25–40% of non-protein calories.

3.Determine Protein Requirements

- Proteins are the major structural and functional components of all cells in the body.
- Amino acid supply should start on the first postnatal day.

Protein requirements of neonates and children depend on age and weight

Age	Protein Requirements (g/kg / day)
Preterm neonate	Min 1.5 - Max 4
Term neonate	Min 1.5 – Max 3

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Regimen of Protein Administration

- Start with 1.5 gm/kg/d and then increase by 1 gm/kg/d to maximum of 3.5 - 4 gm/kg/d.
- Advance or wean of protein dose , depend on the serum BUN level and protein goals.

Protein requirements Variations

Increased amount of amino acids are required in case of patients with

- short bowel syndrome, Stress (trauma, infection, Burn, surgery), wound healing.

Patients with kidney dysfunction may need a protein restriction .

- Kidney dysfunction without dialysis, 0.5–1 g/kg/day
- Kidney failure with intermittent haemodialysis, 1.2–1.5 g/kg/day (1.5–2.5 g/kg/day if continuous renal replacement)

Potential complications and risks of providing IV amino acids

1- Acidosis

2- Elevated BUN

3- Hyper- ammonaemia

4- Cholestasis (with prolonged administration)

Caloric Value of Proteins

- **<u>Calories from protein (4 kcal/g)</u>**
  Inadequate supplementation of energy from carbohydrates and lipids results in protein breakdown for energy instead of growth, Therefore
- Protein calorie/non protein calorie ratio should be kept in range of 1:8-1:10
- Values less than 1:6 are likely to result in hyperaminocidemia & aminoaciduria.

4.Determine Lipid Requirements

Providing fat is essential to

- Achieve adequate caloric intake in TPN
- Utilize amino acid effectively.
- Prevent or treat essential fatty acid deficiency

The lipid requirements of neonates and children depending on age

Age	Lipid Requirements g/kg/ day
Preterm	Min 0.25 – Max 4
Term	Min 0.1 – Max 3

Essential fatty acid deficiency can be prevented by supplying 2%–4% of total calories as lipid (can administer lipid emulsion once every 1–2 weeks).

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Regimen of Lipid Administration

- Starting dose of 1 g/kg/day
- Titrate toward the goal as tolerated by serum triglyceride levels to 3 g/kg/day by day 4.
- If lipid infusion is increased in increments of 0.5 to 1 g/kg per day, it may be possible to monitor for hypertriglyceridaemia.

Caloric Value of Lipids

- **Calories from Lipid (10 kcal/g)**
- Maximum fat oxidation occurs when intravenous lipid emulsions provide 40% of the non-protein PN calories in newborns .
- A higher percentage of calories from lipid (up to 50%–60% of the non-protein PN calories) ,can be provided for a short time in certain cases **(e.g., hyperglycaemia, hypercapnia).**
- Do not allow lipids to exceed 60% of total caloric intake.

Bresson JL, Bader B, Rocchiccioli F, et al. Protein-metabolism kinetics and energy-substrate utilization in infants fed parenteral solutions with different glucose-fat ratios. Am J Clin Nutr 1991; 54:370–6.

Precautions For Neonates

- Restrict the dose of lipids in minimum amounts that will provide only the essential fatty acids following acute episodes of:

1) Thrombocytopenia
2) Sepsis
3) Respiratory distress

Lipids when given as a slow infusion over 24 hours are not associated with worsening of respiratory distress.

4) Severe hyperbilirubinemia who are on phototherapy .

In this case, lipids may need to be limited to 0.5 - 1.5 g/kg/day.

Potential complications and risks of providing IV Lipids

- Hyperlipidemia.
- Potential increased risk or exacerbation of chronic lung disease.
- Potential exacerbation of Persistent Pulmonary Hypertension (PPHN).
- Lipid overload syndrome with coagulopathy and liver fail.
- Cholestasis.

(In patients with marked progressive cholestasis associated with PN, unrelated to acute infection, a decrease or even a transient interruption in intravenous lipid supply should be considered.)

- potentially kernicterus in premature infants.

Monitoring

- Plasma clearance of infused triglycerides can be assessed by measurement of plasma triglyceride concentrations. Checking serum triglyceride levels should be considered with each increase of 1.0 g/kg per day of intravenous lipids and weekly after the maximum dose is achieved to prevent or provide early identification of these complications.
- When triglyceride levels become Elevated (200 mg/dl or 1.8 mmol/L), consider decreasing the daily dose & if it is severely elevated (300 mg/dl or 3 mmol/L), omit lipids until levels return to normal.
- Serum triglyceride levels in serum should be monitored closely in patients receiving lipid emulsions, particularly in cases with a marked risk for hyperlipidaemia (e.g. patients with high lipid dosage, sepsis, catabolism, extremely low birthweight infants).

patients receiving lipid emulsions	Recommendation
Critical Illness and Infection	• more frequent monitoring of plasma triglyceride concentration and • dose adjustment in case of hyperlipidaemia
Respiratory Failure	• avoid the high dosages, but continued at least in amounts supplying the minimal essential fatty acids requirements.
Premature and Newborn Infants	• IV lipid emulsions should be started no later than on the third day of life, but may be started on the first day of life. • Early administration of IV lipids in the first days of life does not increase the incidence of chronic lung disease or death in premature infants when compared to late administration of intravenous lipids . • However there are concerns about potential adverse effects of early administration of lipid emulsions in VLBW (very low birth-weight) infants weighing less than 800 g.
Thrombocytopenia	• In severe thrombocytopenia or coagulopathy (e.g. sepsis, DIC) serum triglyceride concentrations should be monitored and a reduction of parenteral lipid dosage be considered. • Lipids in amounts supplying at least the minimal essential fatty acids requirements should always be given to maintain normal platelet function.

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5. Determine Carbohydrates Requirements

- Dextrose is major immediate energy source . Several body tissues depend mainly on dextrose for energy including CNS, RBCS & the renal medulla.
- Dextrose is the main source of calories in PN, and usually represent most of the osmolality of the solution.

Estimation of carbohydrates requirements

- Recommended parenteral glucose supply (g/kg/day)

	Day 1	Day 2	Day 3	Day 4
Up to 3 kg	10	14	16	18
3–10 kg	8	12	14	16 - 18

- It is important, especially when prescribing PN for infants, to accurately evaluate the carbohydrate load provided by concurrent infusion therapy.
- In critically ill and unstable patients, it is reasonable to start with lower amounts of carbohydrates and increase the amounts according to the patient's condition.
- Very preterm infants may not tolerate that much dextrose and may even need insulin as an infusion to achieve adequate caloric intake without hyperglycemia.

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Variations in Carbohydrates Requirements

- **Carbohydrates Requirements need to be adapted according to**
  - Age and clinical situation (e.g. malnutrition, acute illness, drug administration, refeeding syndrome in severe malnutrition)
  - oral and/or enteral energy intake
  - the required weight gain for normal or catch up growth.

- Glucose intake should be adapted in case of simultaneous administration of drugs known to impair glucose metabolism such as steroids, somatostatin analogs, tacrolimus.

Regimen of Carbohydrate Administration

For neonates: Begin with GIR

- ✔ 4-8 mg/kg/min in preterm
- ✔ 4-6 mg/kg/min in full term
- ✔ 4-6 mg/kg/minute for those weighing < 500 g

- ❖ In critically ill children limit GIR to 5 mg/kg/minute (7.2 g/kg /day).
- ❖ Advance with daily increment of 1-2 mg/kg/min to a goal of 10-12 mg/kg/minute as tolerated.

Caloric Value of Dextrose

- Dextrose yields 3.4 kcal/ g

D 5%	D 10%	D 25%
5 gm. / 100 ml	10 gm. / 100 ml	25 gm. / 100 ml
0.17 Kcal /ml	0.34 Kcal /ml	0.76 Kcal /ml

- Peripheral line: maximum dextrose concentration 12.5%.
- Central line: maximum concentration 25- 30 %.

Potential complications

1) Hyperglycemia or hypoglycemia.
2) Glycosuria and potential osmotic diuresis.
3) Cholestasis and/or hepatic steatosis (usually from long-term high concentration infusion).
4) increased CO2 production.

Monitoring parameters:

blood glucose (<150), CO2 (from blood gas).

Managing Hyperglycemia in Neonates

If hyperglycemia develops:

↓GIR

insulin may improve glucose tolerance .

Do not provide glucose at a rate <3mg/kg/min.

6. Estimate a Daily Maintenance amount of Electrolytes Vitamins & Trace elements

A) Electrolytes

- Initial PN solutions may be started without added electrolytes.
- Add electrolytes gradually as the patient becomes more stable.
- Electrolyte abnormalities should be addressed and corrected before PN is initiated.
- Avoid replacing electrolyte deficiencies using PN in acutely ill patients.

Electrolytes Requirements

	Preterm mEq / Kg / day	Infants mEq / Kg / day
Sodium	2 – 5	2 – 5
Potassium	2 – 4	2 – 4
Calcium	2 – 4	0.5 – 4
Phosphorus	1 – 2 mmol/ kg/ d	0.5 – 2 mmol/kg/d
Magnesium	0.3 – 0.5	0.3 – 0.5

- *If Magnesium Sulfate was administered prior to delivery then leave Mg out of PN until patient serum level returns to WNL.*
- *Do not start magnesium until the serum level is <2.5mg/d L.*

Recommended Parenteral electrolyte intake

		*Na^+ (mmol/kg /day)	**K^+ (mmol/kg /day)
First postnatal week		0–3	0–2
Intermediate phase prior to the establishment of stable growth	Term neonate Preterm neonate >1500g Preterm neonate <1500 g	2–5 3–5 2–3	1–3 1–3 1–2
During the first month of life with stable growth	Term neonate Preterm neonate	2–3 3–5	1.5–3 2–5

*Careful adjustment of water and electrolyte administration is needed in ELBW infants at onset of diuresis and in polyuric patients.

**K+ supplementation should usually start after onset of diuresis.

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Phosphate Normal Ranges by Age

- Normal values of Phosphate are age related as a result of differences in the maturation of the renal system and the rate of bone growth and turnover.

Age	Normal Values (mg / dL)
Newborns	4.2 - 9
6 week to 19 month	3.8 - 6.7
19 month to 3 years	2.9 - 5.9
3-15 years	3.6 - 5.6
15 years	2.5 - 5

B) Trace Elements

- Standard trace elements contain *selenium, chromium, copper , manganese , and zinc.*
- Neonates on long term TPN may develop trace element deficiencies and it is recommended that their levels should be checked.
- In general we use only short term TPN and hence do not add trace elements.

Trace Elements Requirements

	Preterm Neonate < 3 kg (mcg/kg/d)	Term Neonate > 3 kg (mcg/kg/)
Zinc	400	50-250
Copper	20	20
Manganese	1	1
Chromium	0.05-0.2	0.2
Selenium	1.5-2	2

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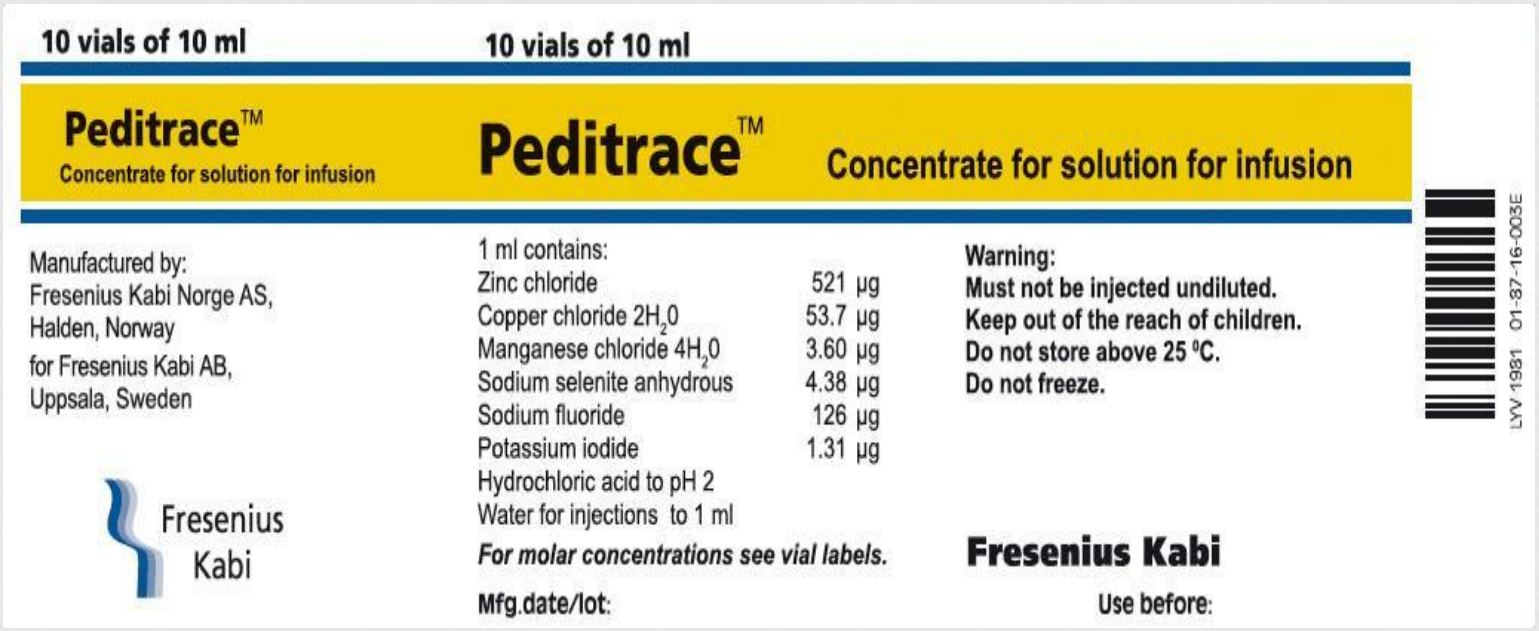

Dose:

1 ml/ kg/ day for Premature, Infant & Children with a weight < 15 Kg

C) Vitamins Requirements

- Similar to trace elements, multivitamins are often standard in PN unless requested otherwise.
- Vitamins included in PN include:

both fat-soluble vitamins (A, D, E, K) and

water-soluble vitamins (C, B 1,2,3,6,7,9,12)..

- Dose

1 ml/kg/day if weight less than 10 kg,

if weight more than 10 kg 1 vial every day.

Medication Additives in PN

Generally, medications should not be added to PN if it can be avoided.

- **Do not add the following to PN:**

ceftriaxone (precipitates with Ca),

phenytoin (can change the pH of PN),

medications containing propylene glycol or ethanol as diluents (e.g., furosemide, diazepam, lorazepam , digoxin, phenytoin, etoposide), iron dextran (trivalent cations destabilize the lipid emulsion in 3-in-1 PN).

- **Incompatible drugs** should be administered through a separate intravenous catheter or a separate lumen of a central venous catheter, if possible.
- **Only regular insulin is compatible with PN**.

PN Complications

Short term Complications

1- Catheter-related infections

2- Catheter insertion complications

3-Peripheral Thrombophlebitis

4-Gut atrophy

5- Fluid or, Acid- base imbalance

6- Hyperglycemia

5-Overfeeding can cause hepatic steatosis , hypercapnia hyperglycemia, and azotemia.

6-Essential fatty acid deficiency

Short term Complications Continue

7. **Refeeding syndrome**

can occur in acutely or chronically malnourished patients by initiating EN or PN.

- **Characterized by hypophosphatemia, hypokalemia , hypomagnesemia**
- **Can cause cardiac dysfunction, respiratory dysfunction, and death**

Prevention of refeeding syndrome

1. **Identify patients at risk**
2. **Initially, provide less than 50% of caloric requirements; then advance over several days to desired goal.**
3. **Supplement vitamins as well as potassium, phosphate, magnesium (if needed) before initiating PN .**
4. **Monitor daily for at least 1 week; and replace electrolytes as needed**

Long term Complications

1-Hepatobiliary Disorders

(includes steatosis, cholestasis, and gallbladder stones)

2-Osteoporosis & osteomalacia associated with higher protein doses (causes increasedCa^{2+} excretion) &

chronic metabolic acidosis (because of insufficient acetate).

Monitoring PN Administration

1- Infection: Temperature ,WBC , IV access site

2- Peripheral vein thrombophlebitis (if peripheral access)

3- Fluid status: (weight , edema , vital signs, input and output, temperature).

4- Monitor nutritional status

Prealbumin

- Useful in monitoring in patients not critically ill.
- Goal : increase at least 3-5mg/dl/week until normal
- Value

  Normal : 16-40 mg/dl

  Moderate malnutrition: 11-16mg/dl

  Severe malnutrition: Less than 11 mg/dl

Monitoring Continue

5-Glycemic control(Hyperglycemia and hypoglycemia.)

Goal : 150 mg/dl or less

6- Monitor for electrolyte and acid-base imbalances

7- Monitor Triglyceride level

TG more than 400 mg/dl stop lipid

8- Monitor hepatic function.

9- Monitor for patient readiness for oral or EN support.

Monitoring Laboratory measurement

Frequency	Parameter
3-4 times / week initially, then weekly	Serum electrolytes
3 times / week initially, then weekly	Blood urea
3 times / week initially, then weekly	Calcium, magnesium, phosphorus
-1st week: every 6 hrs the 1st 2 days , then every 12 hrs -After the 1st week: daily	Glucose
Daily	Urine glucose
Weekly	Protein
Weekly	Liver function tests
Weekly	Hematocrit
4 hours after a dose increase initially, then weekly	Serum triglycerides
Daily until stable , then twice weekly	Blood gases

Transition to Oral or Enteral Nutrition

- When initiating enteral or oral nutrition , monitor for glucose, fluid , and electrolyte abnormalities.
- Parenteral nutrition, should be continued till the patient is tolerating >50 % of total estimated daily calories & protein requirements via the oral or enteral route , wean PN gradually.
- **PN should be reduced by similar amounts or slightly more than the increase in EN.**

When should you stop PN?

- once patient is tolerating at least 75 % of total daily calories & protein requirements via the oral or enteral route.


Thank
you!

A- Patient data:

Age: 2year, weight: 10 kg, Phase: acute

B- Calculations:

1- Total fluid intake = 10×100=1000 ml/d.

2-Amino acids:

- 2gm/kg/d
- Volume = 2×10×(100/10) = 200 ml/day.
- Calories = [20gm A.A×4KCal/gm]/10 weight(kg) = 8 Kcal/kg/d.

3- Lipids:

- Dose 1.0 gm/kg/day.
- Volume =10×1×(100/20)=50 ml/d
- Calories= [10gm lipids×10kcal/gm]/10(weight)=10 Kcal/kg/d.

4- Electrolytes:

- Na (0.9%) Saline = 200 ml/d.
- P(Glycophos) = 10 ml/d.
- K = 5 ml/d.

5- Trace elements: Addamel = 1 ml/d

6- Vitamins: soluvit N = 10 ml/d.

7- Calculation of glucose %

- Total fluid intake 1000 ml/d.
- Volume of glucose = TF- (2+3+4+5+6)= 514 ml.
- GIR= 9 mg/kg/min
- Amount of glucose = (10×9×60×24)/1000 = 130gm glucose.
- Glucose concentration = (130/514) × 100 = 25%.
- Calories = [130 gm × 3.4 kcal/gm]/10 weight = 44.2 kcal/kg/d.

8- Total caloric intake= 44.2+10+8 = 62.2 Kcal/kg/d.

9- Non protein calories/nitrogen = (44.2+10) ×wt / A.A (gm) × 0.15 = 184.

10- Rate of lipid infusion (24 hr/day) = 50ml/24hr = 2.1 ml/hr.

11- Rate of other components = 950 ml /24 = 39.6 ml/hr.

Recommendations

- **Preterm and Term Infants During the Transition Phase**

Sodium, chloride and potassium should be supplemented in the first 3–6 days after birth, i.e. in phase I (transition) when contraction of extracellular fluid compartment occurs.

Na1 supplementation may start after the first 2 days under monitoring of serum electrolytes levels has shown in Table 1.

- **Preterm and Term Infants During the Stabilisation Phase**

Phase II (stabilisation) when extracellular fluid compartment contraction is completed may vary in duration from about 5–15 days and is completed when birth weight is regained and the kidneys produce more concentrated urine. Expected weight gain is 10–20 g/kg body weight per day (Table 2).

- **Preterm and Term Infants During the Phase of Established Growth**

Chloride supplementation follows sodium and potassium. Expected weight gain is 10–20 g/kg body weight per day (Table 3).

Electrolytes Function

Electrolyte	Importance
Sodium	is vital to fluid and electrolyte balance and homeostasis of the body.
Potassium	required for neuromuscular function, metabolic activity, protein synthesis, and resting membrane potential.
Calcium	important for normal blood clotting, cell membrane permeability, secretory behaviour, and neuromuscular excitability.
Magnesium	activates coenzymes needed for carbohydrate and protein metabolism. required to achieve calcium and potassium homeostasis. Important in skeletal development and in the maintenance of electrical potential in nerves and muscle membranes.
Phosphate	the major intracellular anion and is required for cell function and integrity.

Trace Elements Function

Trace Element	Importance
Zinc	zinc is a cofactor in many enzymes, is critical for normal growth and immune functions, and maintains the integrity of skin and gastrointestinal tract mucosa. Zinc (Zn) is involved in the metabolism of energy, proteins, carbohydrates, lipids and nucleic acids and is an essential element for tissue accretion.
Copper	Copper is important for transferrin and leukocyte production, as well as bone formation. Copper (Cu) is a component of several enzymes
Manganese	Manganese is a cofactor in the production of many enzymes
Chromium	Chromium mediates insulin reactions and is important for peripheral nerve function. essential micronutrient required for carbohydrate and lipid metabolism
Selenium	Selenium acts as an antioxidant helps prevent oxidative tissue damage and is important in thyroid metabolism.

Special consideration

Trace Element	consider
Zinc	• Additional zinc supplementation required in case of: high-output fistulas, diarrhea , burns, or large open wounds. • Zinc is recommended from day one of PN; the other trace elements are generally provided after 2 weeks.
Selenium	• Additional selenium supplementation required in case of: chronic diarrhea, malabsorption, or short-gut syndrome or patients with critical illness. • Excretion are impaired with renal disease and impaired renal function, renal dialysis and should be removed from PN until renal function is improved. • Added early in the administration of PN (within the first week of life).

Trace Element	Consider
Copper & Manganese	• **Discontinue** for patients with severe cholestasis to prevent accumulation and toxicity because both are excreted via bile. • Serum levels should be obtained in patients with liver dysfunction. • Elimination impairment (indicated by direct bilirubin >2 mg/dl) these should be removed from PN until the direct bilirubin <2 mg/dl . and give: *Zinc 400 mcg/kg/d TOTAL (preterm infants)* *300 mcg/kg/d TOTAL (term infants)* *Chromium 0.2 mcg/kg/d* *Selenium 2 mcg/kg/d*
Molybdenum	is only indicated for patients on long-term PN who are NPO > 30 days. Dose: 0.25 ug/kg. essential for several enzymes involved in the metabolism of DNA

Medication Additives Continue

:Heparin

- may be added to the TPN solutions in (0.5 - 1 unit/mL of final PN volume) is added to all central & peripheral lines and to running at < 2ml/ hr in order to
  1. *Maintain catheter patency*
  2. *Decrease the risk of thrombophlebitis, especially with PPN.*
  3. *Enhance lipid particle clearance by acting as cofactor for lipoprotein lipase enzyme.*

Concerns about Stability& compatibility of IV lipid with heparin added at concentrations >1 unit / ml .

In Neonates Use of heparin

- Recommended where small lumen central lines are used.
- Contraindicated in neonates with evidence of coagulopathy.
- The final concentration decreased to *0.5 units/mL* in small neonates receiving larger TPN volumes in order to avoid approaching therapeutic amounts.

- There is no proven benefit of heparin for the prevention of thrombotic occlusion of CVC's under regular use in children. Therefore its routine use is not recommended
- Routine use of heparin has not been shown to be useful in prevention of complications related to peripherally placed percutaneous CVCs in neonates.
- Heparin does not improve utilisation of intravenous lipids and should not be given with lipid infusion on a routine basis, unless indicated for other reasons.

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Medication Additives Continue

Carnitine

- Should be added if a patient continues to require PN after 10 days and where PN constitutes more than 50% of a patient's nutrition:
- Generally recommended to add within the first week of life , to Premature infants of < 34 weeks gestation receiving PN,
- Carnitine is essential for optimum oxidation of fatty acids (for energy) in the mitochondria.

Dose: 10-20 mg/kg.

- Decreased levels of carnitine occur during prolonged PN without carnitine supplementation. LOE 1
- There is no documented benefit of parenteral carnitine supplementation on lipid tolerance, ketogenesis or weight gain of neonates requiring PN. LOE 1
- Carnitine supplementation should be considered on an individual basis in patients receiving PN for more than 4 weeks.

Medication Additives Continue

H2 antagonist

such as famotidine or ranitidine, may be added to the daily PN when indicated.

H2 antagonist may indicated to prevent stress related mucosal damage.

This provide continuous acid suppression & reduce nursing time by avoiding intermittent scheduled infusions.

Illustrative case

A 5-day-old neonate,

with gestational age of 28 weeks and birth weight of 900 g with respiratory distress on a ventilator, on TPN since day one.

Answer

Step I: Total fluids 150 mL/kg = 135 mL

Step II: Amino acid (10%) 1 g/kg/day = 9 ml

Step III: Lipids (20%) 1g/kg/day = 4.5 mL

Step IV: Supplementation:

(1) Sodium 3 meq/kg/day = 18 ml (NaCl 0.9 %)

(2) Potassium 1 meq/kg/day = 0.45 mL

(3) Calcium 2 meq/kg/day = 1.8 meq Calcium gluconate 10% = 4 mL

(4) MVI 1 mL/kg/day MVI solution = 0.9 mL

Step V: Dextrose Infusion: GIR 4 mg / kg/ min

Volume of glucose = TFR – (AA + lipid + Electrolytes)

= 135 – (9+ 4.5 + 18 + 0.45 + 4+ 0.9) = 98 ml

Required concentration of glucose =(0.9× 4 × 60 × 24 × 100)÷ (98 × 1000) = 5.2 %

Example for Calculation of Osmolarity

[glucose (g/L) × 5] +[amino acids (g/L)×10]+ [cations (mEq/L)× 2]

100 g of dextrose x 5 = 500 mOsm/L

30 g of protein x 10 = 300 mOsm/L

80 mEq of (sodium + potassium + calcium + magnesium) X 2 = 160

Total osmolarity = 500 + 300 + 160 = 1020 mOsm/L