

Neonatal Nutrition Survival Guide for Residents: Parenteral Nutrition

NICU Dietitians

Rebecca Vander Veer (Orange Team) – Cisco 7989, Ext. 4513, Pager 0644
 Sasha Nunes (Yellow Team) – Cisco 7988, Ext. 7812, Pager 0310
 Victoria Catalano (Green Team) – Cisco 4911, Ext. 4911, Pager 3225
 On-call Dietitian (after hours and weekends) – Pager 58688

Risks of Parenteral Nutrition

- Liver damage
- Intestinal atrophy → NEC
- Sepsis/line infection
- Infiltrates

Term infants do not require PN until ~DOL 3.
Preterm infants should be started on PN as soon as possible.

Glucose Infusion Rate (GIR) = amount of glucose the liver metabolizes per minute

- Everything that contains dextrose contributes to GIR – TPN, IVF cocktails, carrier fluids, and medications running in dextrose-containing IVF
- Always know the total GIR
- Increase/decrease by **1-2 mg/kg/min**. Avoid making rapid changes
- Provide **minimum of 4 mg/kg/min** to prevent hypoglycemia and maintain brain function
- Keep GIR stable if blood glucose >120-150 mg/dL. Reduce GIR if blood glucose >150-180 mg/dL. Insulin may be used if blood glucose >180-200 mg/dL.

To calculate GIR:

Total fluid volume per kg x % dextrose ÷ 1.44 (there are 1,440 minutes in 24 hours)

E.g.: D10% running at 100 ml/kg/day → **100** (ml/kg/day) x **0.1** (dextrose %) ÷ **1.44** = **6.9 mg/kg/min**

Starter PN

- All infants <1800 g at birth should receive Starter PN immediately on admission
- Order through Cerner (“Neonatal Starter PN”)
 - Should always run at **60 ml/kg/day**, via central or peripheral line
 - If the baby is hyper/hypoglycemic, make changes to the IVF and not Starter PN
- Pharmacy keeps a total of 3 bags on hand at all times
- Provides:
 - 3 g/kg protein (helps avoid negative nitrogen balance)
 - GIR of 3.1 mg/kg/min ←
 - 30 mg/kg elemental calcium
- Can be used as a bridge until full TPN can be initiated

You will need to run additional D10 to bring the GIR up to the minimum 4 mg/kg/min.

Labs

Daily, until stable (~3-5 days)	BMP, Mg, Phos, triglycerides
Mondays (Cerner: Large TPN set)	CMP, Mg, Phos, direct bili, triglycerides, ionized calcium
Thursdays (Cerner: Small TPN set)	BMP, Mg, Phos

Starting NICU TPNs

Preterm

	Initiate	Advance	Goal
Dextrose	4-6 mg/kg/min (or 1-2 mg/kg/min above current GIR)	1-2 mg/kg/min	11-12 mg/kg/min (or to meet kcal goals)
Lipid	0.5-1 g/kg	0.5-1 g/kg	3 g/kg
Protein	3-4 g/kg	1 g/kg	3.5-4 g/kg

*Note: lipids are run over 24 hours, with few exceptions (usually only if IR is consulting).

Term

	Initiate	Advance	Goal
Dextrose	6-8 mg/kg/min (or 1-2 mg/kg/min above current GIR)	1-2 mg/kg/min	10 mg/kg/min (or to meet kcal goals)
Lipid	1-2 g/kg	1 g/kg	3 g/kg
Protein	2.5-3 g/kg	--	2.5-3 g/kg

Preterm infants should start PN ASAP. Term infants can be NPO x 3 days.

Max GIR for infants:
15-17 mg/kg/min.

Electrolytes

	Initiate	Adjust	Needs
Sodium	0-3 mEq/kg	1-2 mEq/kg	1-6 mEq/kg
Potassium	0-2 mEq/kg	0.5-1 mEq/kg	1-6 mEq/kg
Magnesium	0-0.3* mEq/kg	0.05-0.1 mEq/kg	0.2-0.3 mEq/kg

*Magnesium: If lab ≤ 1.7 , start at 0.2-0.3 mEq/kg. Otherwise, put no Mg in PN.

Src	Substance	Value	Numer	Denom
U	Volume	60	ml	/day
T	Duration	24	hour	/-
T	Period	24	hour	/-
T	Overfill	100	ml	/day
U	Dextrose 70%	7.5	gm%	/-
U	Intralipid 20%	1	gram	/PatKg
U	Premasol 10%	4	gram	/PatKg
U	Sodium	2	mEq	/PatKg
U	Potassium	1	mEq	/PatKg
T	Acetate	3.76	mEq	/PatKg
U	Phosphate	1	mM	/PatKg
U	Calcium	50	mg	/PatKg
U	Magnesium	0.2	mEq	/PatKg
T	Chloride	1.66	mEq	/PatKg
T	MVI-Pediatric	2	ml	/PatKg
T	Heparin	1	Unit	/mlAV
T	Zinc Chloride 1	200	mcg	/PatKg
U	L-CARNITINE	20	mg	/PatKg
U	M.T.E.-4 Ped.	0.2	ml	/PatKg
U	Selenium	2	mcg	/PatKg

Sample TPN for preterm infant.

← TPN volume in **ml/day**.

TPN volume = (Total fluid goal x weight) - (lipids + continuous infusions + 24 hour feeding volume)

} Per charts above

} Na and K per team. Infants on day of life 0-2 may not require any Na or K.

} Usually start Ca at 40-50 mg/kg and Phos at 0.8-1 mM/kg (may be less during Na/K Phos shortage)

← Check lab. See note above for details.

← Max Cl unless indicated otherwise by labs or team. See TPN Survival Guide for more information.

← Add 10-20 mg/kg/day L-carnitine for preemies

} OK to leave M.T.E.-4 Ped and Se out on first few days of PN. Zn starts at 200; if leaving out M.T.E.-4 Ped and Se, increase Zn to 400 for <2.5 kg and 250 for >2.5 kg.

Updated 5/17



Please write in Label Notes:



TFG: ___ ml/kg/day = ___ ml/day

Feeds: ___ ml; Lipids: ___ ml; Drips: ___ ml

Calcium and Phosphorus

Calcium/Phos Ratio

- Providing calcium and phos in ratio helps achieve maximal mineral retention and bone accretion
- Recommended Ca:Phos ratio for premature infants:

							
Calcium (mg)	40	50	60	70	80	90	100
Phos (mmol)	1	1.25	1.5	1.75	2	2.25	2.5

L-cysteine


U	L-Cysteine	160	mg /PatKg
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- Increases solubility of calcium and phos
- Order L-cysteine if Ca/Phos graph is in the red zone
- Dosage: 40 mg per gram protein. **Multiply the TPN protein (in g/kg) by 40**
 - Patient receiving 3.5 g/kg of Premasol (protein) → L-cysteine 140 mg/kg

Ionized calcium

- Monitor every 24-48 hours for first 1-2 weeks of TPN
- Goal is 1.2-1.4 mmol/L
 - **If <1.2**, increase calcium by 10-20 mg/kg/day
 - **If >1.4**, increase phosphorus by ~0.5 mmol/kg/day; consider decreasing calcium by 10-20 mg/kg

Peripheral lines

- If a line is/becomes peripheral, change in Baxa under "Patient Information" → "IV Site"
- Maximize fluid – additives are limited; most likely will not be able to meet nutrition goals
- Decrease additives until osmolality is <900 mOsm/kg, otherwise you will not be able to sign the order
 - Biggest contributors to osmolality are **dextrose, protein, sodium, potassium, and calcium**
- Maximum dextrose concentration is 12.5%
- **No more than 50 mg Ca and 4 mEq K per 100 ml TPN volume** to minimize the risk of phlebitis 
 - You must calculate this – Baxa will not give you an error if you have too much Ca or K
 - Divide the total TPN volume (not including lipids, feeds, or continuous infusions) by 2 to find the maximum. If the number is >50, do not exceed 50 mg/kg Ca.

H₂ Blocker Dosing (per Pharmacy)

ZANTAC (in TPN)

-Preterm/renal = 0.5 mg/kg/day

-Term = 1 mg/kg/day

FAMOTIDINE (in TPN)

-Preterm = 0.25 mg/kg/day

-Term = 0.5 mg/kg/day

Only use when indicated and use with caution!

Can increase risk of NEC!

Common Errors

- "Maximum MVI peds" (weight > 2.5kg)
 - Change MVI-Pediatric dose to 5 mL/day
- "Insufficient volume requested"
 - Increase fluid goal or decrease additives
 - If feeds >90-100 mL/kg/day, no need to write for TPN.
- "Calculated Ingredient Volume is too small. Sodium Chloride 23.4%"
 - Increase sodium until error goes away

Monitoring TPN

Blood glucose:

- Monitor at least 4x/day in the first 24 hours, and at least 2x/day as dextrose is advanced. Once WNL, can monitor daily.
- High risk: SGA, LGA, <1000 g, <24 weeks, indomethacin/steroids, sepsis, surgery, stress

Triglycerides:

- Monitor triglycerides daily when initiating and advancing lipids (x ~3-5 days after TPN started)
- High risk for hypertriglyceridemia: SGA/IUGR, <1000 g, <24 weeks, on steroids, sepsis
- If triglycerides >200 mg/dL, **decrease lipids by 0.5-1 g/kg. Recheck level in 24 hours**
- If triglycerides >300 mg/dL, **d/c lipids for 12-24 hours, and recheck level in 24 hours**
- Do not withhold lipids for >48-72 hours due to risk for essential fatty acid deficiency
- **L-carnitine** is required for the transport of fatty acids into the mitochondria
 - Add to PN at 10-20 mg/kg/day for infants <34 weeks gestation and infants expected to be on exclusive PN for >7-14 days
 - If <750 g at birth, add L-carnitine immediately at 20 mg/kg/day

Direct Hyperbilirubinemia:

- When D bili is >2mg/dL:
 - ★ Decrease lipids to 1 g/kg/day and adjust for the change in lipid volume in the total volume
 - Increase GIR if blood glucose is stable to make up for the decrease in lipid kcal
 - ★ Delete MTE-4-Ped (d/t risk for manganese toxicity)
 - Increase zinc → total 400 mcg/kg for infants <2.5 kg and 250 mcg/kg for infants ≥2.5 kg
 - Add copper → 10-20 mcg/kg
 - Continue selenium → 2 mcg/kg

Weaning TPN as feedings are advanced

- Subtract feeding volume from the total fluid goal once feeds >20 ml/kg/day (trophics)
 - If feeds are advancing q 12 hours at noon and midnight, **multiply volume at midnight by 8** to obtain 24-hour feeding volume

TPN volume = (Total fluid goal x weight) -- (lipids + continuous infusions + 24 hour feeding volume)

- Decrease protein by ~0.25 g/kg/day
- Decrease lipids by ~0.5-1 g/kg/day
- Decreased PN volume automatically decreases GIR/dextrose kcal
- Goal kcal from TPN + feeds = 100-110 kcal/kg/day

Stopping TPN

- Discontinue TPN when feeds reach 100-120 ml/kg/day
- When TPN is discontinued, provide D10% to meet maintenance fluid needs (up to ~130-150 ml/kg/day) until feeds are close to goal
- Fluid cocktail not usually needed unless specifically discussed during rounds

Determining 24-hour Lipid Volume

- Click Lipids tab
- Click Special Lipid Duration; note volume
- Unclick check box and return to order

Adding Ingredients

- Select ingredient from list and click OK
 - Press Ctrl key to select more than 1
- Input units first, then the dose

- Lipids + Continuous Infusions + Enteral feeds should be subtracted from total fluid goal in **ml/day**
- Do not subtract replacement fluids, blood products, or trophic feeds (<20-24 ml/kg/day)

If red or blue, click here to adjust calcium and phos until in the yellow or green zone

Deleting Ingredients

- Select ingredient in TPN order
- Click "delete ingredient"

Ion	Value	Numer	Denom
Sodium		3 mEq	/PatKg
Potassium		1.5 mEq	/PatKg
Acetate		3.29 mEq	/PatKg
Phosphate		1.75 mM	/PatKg
Calcium		30 mg	/PatKg
Magnesium		0.4 mEq	/PatKg
Chloride		2.16 mEq	/PatKg

Acid-Base Balancing

- Max Chloride can be selected for most patients
- To increase acetate (patient has metabolic acidosis):
 - Select "Chloride Float". Increase acetate by 1-2 mEq/kg; max recommended is 5 mEq/kg (if acidosis persists and you need >5, please speak to TPN Pharmacy)
- To decrease acetate (patient has metabolic alkalosis):
 - Select "Max Chloride" **OR** select "Acetate Float" and enter Cl amount manually
 - Acetate is present in IV protein (Premasol), so there will still be acetate in the TPN if Max Chloride is selected

Appendix: Other useful information

Estimated nutrient needs for parenteral nutrition

	Preterm Infant	Term
Fluid	130-150 ml/kg	120-140 ml/kg
Kcals	85-95 kcal/kg	80-90 kcal/kg
Protein	3-4 g/kg	2.5-3 g/kg

Guidelines for fluid provision (ml/kg/day)

	<750 g	750-1000 g	1000-1500 g	1500-2500 g	>2500 g
DOL 0-1	110-140	90-100	80-100	70-90	60-80
DOL 1-2	120-150	100-130	110-120	90-100	80-100
DOL 2-3	130-160	130-150	120-140	110-140	100-120

Omegaven

- Alternative lipid source approved for compassionate use only
 - Omega-6 fatty acids in Intralipid likely play a role in development of parenteral nutrition-associated liver disease (PNALD)
 - Omega-3 fatty acids in Omegaven can help repair liver damage
- Qualification criteria:
 - Direct bilirubin >3 on two consecutive measurements
 - Expected to remain on TPN for >3 weeks
- Dr. Scavo and Dr. Revenis can obtain consent from parents
- Orders signed by neonatologists and put in Cerner by Investigational Drug Services PharmDs

Ordering a fluid cocktail

Electrolytes need to be added in excess to account for the volume that the baby will not receive in 24 hours.

Example:

You are writing a fluid cocktail for a 2.5 kg baby at 100 ml/kg/day with 5 mEq/kg of Na and 3 mEq/kg of K.

First, figure out what the total volume and rate/hr will be:

$$100 \text{ ml/kg/day} \times 2.5 \text{ kg} = 250 \text{ ml/day} \text{ (10.4 ml/hr)}$$

$$250 \text{ ml} \div 500 \text{ ml} = 0.5 \text{ or } 50\% \text{ of the bag in one day}$$

Since the baby will only receive 50% of the 500 ml bag, you must figure out how much of the additional electrolytes to add to account for this:

$$\text{NaCl: } 5 \text{ mEq} \times 2.5 \text{ kg} = 12.5 \text{ mEq}$$

$$12.5 \text{ mEq Na} \div 0.50 = 25 \text{ mEq}$$

$$\text{KCl: } 3 \text{ mEq} \times 2.5 \text{ kg} = 7.5 \text{ mEq}$$

$$7.5 \text{ mEq} \div 0.50 = 15 \text{ mEq}$$

So your fluid cocktail would be:

D10% at 10.4 ml/hr with 25 mEq NaCl, 15 mEq KCl, and 200 mg Elemental Ca

This will provide 100 ml/kg/day, a GIR of 6.9 mg/kg/min, 5 mEq of NaCl and 3 mEq of KCl.

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