Care Guidelines: Neonatal Short Bowel Syndrome and Intestinal Failure

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Introduction

Aim Statement

This guideline provides evidenced based education, resources, and guidelines aimed to improve outcomes and decrease morbidity and mortality in neonatal and pediatric patients with short bowel syndrome and intestinal failure (1). A structured multi-disciplinary collaboration providing continuity of care, close follow-up, family education, early treatment of complications and quality improvement initiatives provides a continuum of care bridging these complex infants from the NICU into outpatient care (2).

Goals

- Achieve optimal growth, body composition, and neurodevelopment
- Maximize the process of intestinal adaptation
- Mitigate inflammation, infection, and intestinal failure associated liver disease
- Optimize oral feeding skills and mitigate oral aversion
- Optimize family/caregiver readiness for discharge and decrease hospital readmissions

Definitions

Pediatric intestinal failure (PIF): "Pediatric intestinal failure is the reduction of functional intestinal mass below that which can sustain life, resulting in dependence on supplemental parenteral support for a minimum of 60 days within a 74 consecutive day interval" (3).

Short Bowel Syndrome (SBS): Most common cause of intestinal failure (IF). It is characterized by the development of IF following surgical bowel resection or the congenital loss of bowel (3).

Ultra-Short Bowel Syndrome: "The development of IF following significant small-bowel resection resulting in a residual small-bowel length that is <10% of expected" (3).

Enteral autonomy (EA): "Enteral autonomy is the maintenance of normal growth and hydration status by means of enteral support without the use of parenteral support for a period of >3 consecutive months" (3).

Intestinal failure associated liver disease (IFALD): "Liver injury, as manifested by cholestasis, steatosis, and fibrosis, in patients with intestinal failure that is independent of, or in addition to, other potential etiologies. The development of IFALD is multifactorial, typically as a consequence of metabolic abnormalities in intestinal failure and the medical and surgical management strategies of intestinal failure themselves. It can be stabilized or reversed with appropriate early modification of management strategies and promotion of intestinal adaptation, or it can progress to hepatic dysfunction and end-stage liver disease" (3).

Biochemical IFALD may be defined as conjugated bilirubin of ≥ 2 mg/dl (34 µmol/L) for > 2 weeks with a minimum PN exposure of 2 weeks, without concurrent sepsis. Other causes of liver disease must be ruled out, including infectious, hepatitis, metabolic diseases, cystic fibrosis, and anatomical abnormalities (biliary atresia).

Parenteral nutrition associated liver disease/cholestasis (PNALD/PNAC): Also known as IFALD; current recommendations are to utilize the term IFALD as it better encapsulates the complex pathogenesis of liver disease in this population (3).

Hypergastrinemia: Often related to proximal and/or massive bowel resection; likely results from decreased secretion of inhibitory hormones or inadequate breakdown of gastrin leading to high levels in the gut lumen. This results in hyperacidity, which decreases the pH of the intestine leading to malabsorption and increased ostomy/stool output (4).

Small intestine bacterial overgrowth (SIBO): Objectively defined as an excess of bacteria in a duodenal jejunal aspirate that are typically found in the colon (gram negatives, enterococci, anaerobes) or a via a glucose or lactose hydrogen breathe test. However, these methods are impractical in the NICU setting. Thus, in the absence of objective data, SIBO may be diagnosed by otherwise unexplained increase in direct bilirubin, abdominal pain or distention, emesis, bloating, diarrhea, or flatulence that respond to a course of enteral empiric antibiotic therapy (3) (5).

Rationale:

Normal physiology eliminates bacteria from the small intestine through peristalsis and mucosal immune factors. The number of bacteria passing through the stomach into the small bowel is normally decreased by the presence of gastric acid (19). However, in SBS/IF patients dysmotility, absence of an ileocecal valve (ICV) (allows retrograde of bacteria from the colon into the small bowel), presence of an ostomy, and the use of H2-blockers or proton pump inhibitors (decreases the amount of gastric acid) place these patients at risk for SIBO (4)*. SIBO can create major problems in the bowel, such as: deconjugation of bile salts, utilization of enteral nutrients, bacterial translocation or Gram-negative sepsis, competition for metabolites, and acidosis* (5)*.*

Etiology

The most common cause of IF is SBS (2). Rarer are motility disorders such as Hirschsprung's disease involving the small bowel or congenital diarrheas and enteropathies (CODES). CODEs (e.g microvillous inclusion disease) are rare genetic disorders that affect the intestinal epithelium, or the immune system impairing epithelial function and can lead to IF (6).

In the NICU, necrotizing enterocolitis (NEC) is the most common cause of SBS (35%), followed by gastroschisis (18%) (2) (7). Additional causes of SBS includes volvulus or other congenital malformations (e.g., intestinal atresia, complicated meconium ileus, aganglionosis, congenital SBS).

Length and Region of Remaining/Resected Bowel

Feasibility and timeframe for attaining EA is influenced by the length, region, and function of remaining and/or resected bowel. See Table: Predictors of Enteral Autonomy

Reference values for small bowel length are preferentially based on the infant's length at the time of surgery; weight and age reference values are also available and may be used in conjunction to calculate estimated small bowel length (8). See Table: Estimating Bowel Length

Identifying the remaining and resected bowel helps to anticipate and guide nutrition prescription. See: Sites of Gastrointestinal Secretion, Absorption and Care Implications

Rationale:

Loss of intestinal length can limit digestion by reducing nutrient exposure to the brush border enzymes. However, even with adequate intestinal length, outcomes vary based on the region and quality of the remaining intestine (5)*. For example, with the loss of the jejunum, the ileum can adapt and compensate for the lost absorptive surface area* (5)*. In contrast, with ileal resection, the jejunum is limited in its absorption of fluid and electrolytes, bile acids and vitamin B12* (5)*. The ICV helps slow intestinal transit time and prevents reflux of colonic bacteria and thus bacterial overgrowth in the small intestine (SIBO). The ICV also remains a proxy for the terminal ileum which functions to absorb bile acids and vitamin B12 and secrete GLP-2, a peptide involved in intestinal growth and adaptation* (9)*.*

Guidelines of Care

Pre-Operative Considerations

- ☐ Orders:
  - Refer to perioperative checklist (Labs, antibiotics, pain management, IV fluids)
  - Radiologic Studies (Reference clinical guidelines for specific diagnosis on PAWS insert web link)
  - Genetic work-up as indicated
  - Central Line (PICC, Broviac)
  - NPO
  - MOP (Milk Oral Pharyngeal)

    Rationale:

    Surgical infants are at risk for altered immunity, increased risk of infection, and oral aversion. Maternal colostrum helps to stimulate the development and response of the neonatal immune system as it is exposed to the lymphoid tissue in the oropharynx and gut. When infants are not able to feed orally, maternal colostrum or human milk placed in the mouth allows immunologic factors to be absorbed systemically through the oral mucosa providing antimicrobial, anti-inflammatory, and immunomodulatory functions (10). *Because human milk changes in the response to antigens mothers/parents are exposed to, when a mother/parent holds her infant, they can provide specific protection for their infant. Furthermore, utilizing colostrum early empowers and motivates moms/parents to maintain a pumping regimen through stressful situations and provides positive oral stimuli for the infant* (10).

Intra-Operative Findings and Documentation

- ☐ Surgeon to document surgical findings, including but not limited to:
  - Condition of the bowel/organs
  - Length and location of resected and remaining bowel
  - Presence/absence of ICV and colon
  - Location of ostomy and mucous fistula (if placed)
  - Photos and/or diagrams of remaining bowel configuration
  - Gastrostomy, NGT/OGT, Salem sump (SS)*, Repogle tube** or drain placement
  - Line placement (as applicable)
  - Estimated timeline for re-anastomosis, additional studies, or surgeries
- ☐ Document % small bowel remaining; See Table: Estimating Small Bowel Length

Acute Post-Operative Management

- ☐ Orders:
  - Refer to peri-operative checklist (Labs, antibiotics, pain management)
  - NPO
  - MOP
    - Gastric decompression
    - SS to low-intermittent suction (LIS) at 40-60 mmHg (max 80 mmHg)
    - Place G-tube to gravity (as applicable), it may not be placed to suction for decompression
    - Replace SS output exceeding 15-20 mL/kg/shift, especially with signs of fluid volume deficit (decreased UOP, electrolyte derangement, signs of dehydration)
      - 1/2 NS +/- KCl 10 mEq/L, 1 mL/mL IV for output volume exceeding 15-20 mL/kg/shift, to run over 4-6 hours
- ☐ Fluids and Electrolytes
  - Increased fluid needs in infants with:
    - Abdominal wall defects with additional insensible losses (gastroschisis)
    - High out-put renal failure

- Decreased fluid needs in infants with:
  - Syndrome of inappropriate antidiuretic hormone secretion (SIADH)
  - Patent ductus arteriosus (PDA)
  - Oliguric renal failure or acute kidney injury (AKI)
- Monitor ongoing fluid losses and electrolyte imbalances
  - Chest tubes, ostomies, gastric drainage, wounds
- Lab frequency per operative course and clinical status
  - Electrolytes (BMP or CMP) and CBC
- Monitor and adjust for metabolic needs and complications
  - Decreased energy needs and increased protein needs as catabolism takes place. See Table: Enteral and Parenteral Nutrient Requirements
  - Lower metabolic demand in ventilated, sedated, and/or paralyzed infants
  - Tissue injury (e.g., surgery, sepsis, or trauma) results in alterations in carbohydrate, protein, and fat utilization; substrates and energy normally utilized for growth are shunted to the production of acute phase proteins (e.g., C-reactive protein [CRP]) (11).
- Metabolic complications from stress and injury
  - Excessive carbohydrate and/or use of dexamethasone may result in hyperglycemia (11).
  - Stress related hypertriglyceridemia
  - Renal injury/failure
- Fluid management
  - SIADH, compartment syndrome

Chronic Post-Operative Management

Nutrition Management

Goal is to provide well-conceived TPN regimens and individualized enteral support to optimize growth, neurodevelopment, and nutrient balance while mitigating over-feeding, risk of infection, and IFALD.

Total Parenteral Nutrition (TPN)

See: Enteral and Parenteral Nutrient Requirements

See: TPN Guideline and Algorithm

Lipid Management

Intravenous Lipid Emulsion (IVFE) Management			
Lipid Type	Indication	Dosing	Considerations
SMOFlipid® 20% *30% Soybean, 30% Coconut, 25% Olive, 15% Fish Oil* *2 Calories/mL*	Standard IVFE for surgical neonate/infant	*Standard:* 3 g/kg/d	Minimum dose to prevent EFAD: < 2.5 g/kg/d (9)
Intralipid® 20% *30% Soybean* *2 Calories/mL*	Utilize for compatibility issues (dopamine, epinephrine, PGE)	*Standard*: 3 g/kg/d *IFALD/Anticipated PN days > 60 days:* 1 g/kg/d	Minimum dose to prevent EFAD: 0.5-1.5 g/kg/d min (Greatest risk in ELBW infant)
Omegaven® 10% *100% Fish Oil* *1.12 Calories/mL*	Biochemical IFALD/cholestasis (Direct bilirubin >2mg/dL) for 2 consecutive measures with anticipated TPN for some time	*Standard:* 1 g/kg/d *EFAD, malnutrition, BW < 1500 g with caloric deficit:* 1.5 g/kg/d	Discontinue with resolution of biochemical IFALD (x 2 weeks) IF patients who require long-term PN (>6 months) may continue/benefit despite resolution of cholestasis (12)

Rationale:

SMOFlipid® 20%: *In 2022, the FDA approved the use of SMOFlipid® (an IVFE 4-oil blend that contains soybean, medium chain triglycerides [MCT], olive and fish oils) in neonatal and pediatric populations. Due to the lower concentration of phytosterols and omega-6 fatty acids with the addition of omega-3 fatty acids, this IVFE has the theoretic benefit of improving neurodevelopmental outcomes, lipid tolerance, and lowering systemic inflammation implicated in the multiple comorbidities that plague the preterm or surgical neonate* (13). *Studies suggest SMOFlipid® is protective but not completely preventative of PNALD in infants with IF* (14).

Intralipid® Restriction: *Historically, due to limited choices of IVFE, IL restriction was used to slow the progression of IFALD in infants requiring long term TPN (> 4 weeks). There is inadequate research to demonstrate safety and long-term growth outcomes with this practice, so should only be considered when other IVFE (e.g. SMOFLipid® or Omegaven®) are contraindicated* (14). *This practice may necessitate glucose infusion rates (GIRs) higher than standard recommendations (GIR 14-18 mg/kg/min)1 to meet Calorie goals.*

Omegaven®: *The first 100% fish oil IVFE to be approved by the FDA as a source of Calories and fatty acids for TPN dependent infants and children with IFALD* (15). *Multiple studies have shown significant improvement in biochemical cholestasis and decreased rates of morbidity and mortality when compared to those receiving soy IVFE. Omegaven is not intended for use in transient cholestasis, IFALD prevention, or to treat other etiologies of cholestasis, such as exposure to hepatotoxic medications, infection/sepsis, thyroid and/or endocrine disorders, or hepatic obstruction* (12) (15).

Cyclic TPN

- ☐ Indications and Considerations:
  - Minimum weight of 2.5-3 kg
  - Tolerating current TPN prescription with adequate growth
  - Anticipate long-term/home TPN with cholestasis or risk of cholestasis
  - Current GIR < 14 mg/kg/min on 24-hr TPN; if GIR > 14-18 mg/kg/min, cyclic TPNs not safe to initiate as it would further increase GIR above recommended range
  - Time frame of cyclic TPN is dependent on age, tolerance, and amount of enteral feeding.
  - While inpatient PICC lines and Broviac catheters may not be heparin-locked
  - Refer to: Cycling TPN in the NICU: Step-by Step Worksheet

Rationale:

For infants who are clinically stable with adequate growth and tolerance of their goal nutrition prescription, cycling off TPN for 2 to 4 hours per day may decrease the incidence of or delay the onset of IFALD (16) (17). *Additionally, tapering TPN over 30-60 minutes prior to discontinuation may help counteract rebound hypoglycemia* (17).

Micronutrients

Provide standard daily dosing of trace element packets (Multry's) and vitamins per pharmacy protocol. Careful attention should be paid during shortages to preferentially provide vitamins and trace elements to patients with SBS/IF as deficiencies can lead to significant clinical symptoms.

- ☐ Do not alternate trace elements for prevention/treatment of cholestasis due to risk of copper deficiency.
- ☐ Consider dosing individual trace elements with persistent cholestasis and/or deficiency/toxicity of micronutrients; pharmacy approval and persistent need for TPN required for consideration.
- ☐ Micronutrients should be routinely monitored, and abnormal blood levels should be monitored ~monthly. See Table: Laboratory Monitoring
- ☐ Obtain a CRP immediately prior to or in conjunction with micronutrient levels; inflammation can result in significant changes to plasma concentrations of micronutrients (18)

Enteral Nutrition (EN)

EN is the primary treatment for SBS and is essential to mitigating cholestasis, promoting bowel adaptation, and ultimately achieving EA.

See: Enteral and Parenteral Nutrient Requirements

Pre-Feeding Considerations:

MOP: Continue while NPO

SHAM Feeding

SHAM feeding is oral feeding provided by breast or bottle in which the human milk/formula are immediately removed via a repogle (esophageal obstruction) or SS (bowel obstruction). SHAM feeding may benefit infants with bowel obstruction in which a delayed/prolonged surgical repair delays oral feeding opportunity. Primary surgeon and medical team approval required for initiation.

Rationale:

Build suck/swallow motor skills and motor mapping in infants who experience extended periods without positive oral experiences thus increasing their risk of delayed feeding skills and long-term oral aversion. SHAM feeding provides positive feeding experiences to decrease risk of long-term oral aversions and provide opportunity for family/caregiver nurturing and bonding experiences.

SHAM Feeding Process:

Equipment:

- Salem sump
- Mucous trap
- Suction canister (intermittent and continuous settings)

Procedure: Volume and frequency to be determined by medical team (based on age, oral skills, anatomy, and tolerance)

- Mode of delivery: Taste trials, breast, bottle
  - Breastfeeding: Initiate non-nutritive breast feeding with volume presented as tastes around breast, once tolerance is notable with larger volumes, initiate volume-transfer breast feeding
- Frequency: 1x/shift, or 2x/d
  - Parent involvement should be prioritized, and SHAM feeding schedule should optimize parent opportunities for bonding
  - Feeds should last < 20 minutes (goal for positive experience, muscle exercise, motor mapping and exposure to bioactivity in human milk; it is not nutritional)
  - Increase frequency of sham feeding; monitor for a minimum of 2 days before advancing
  - Increase frequency before volume
- Volume: Initial max volume of 5 ml
  - Monitor for minimum of 3 days prior to advancing
- Feeding composition: Human milk (maternal/parent or donor)
- Monitor clinical signs of intolerance
  - Oral feeding leads to physiologic changes such as increased oral/gastrointestinal secretions and/or gastric/bowel motility
  - Adjust SHAM feeding order PRN:
    - Excessive gastric output (above baseline) leading to fluid and electrolyte derangements
    - Bearing down leading to significant discomfort
- Gastric decompression
  - Change LIS to LCS during the SHAM feeding and up to 5 minutes following feed
  - Empty mucous trap prior to SHAM feeding and use to measure oral intake (mucous trap should collect roughly the same amount as oral intake)
- Document PO into I/O's (indicate sham feed) and document BF occurrence as applicable

Return of Bowel Function

☐ Defined:

- Ability to remove gastric decompression (SS) and clamp G tube without emesis or significant abdominal distention

- Positive bowel sounds, reassuring abdominal exam
- Passed stool/ostomy output

Feeding Composition

Human milk

Human milk, preferentially maternal/parent's milk (EHM) is recommended; donor human milk (DHM) may be used in early feeds to supplement EHM or in the absence of EHM. Emerging evidence suggesting its use results in a shorter duration of TPN, earlier attainment of full enteral feeds, and protection against IFALD as compared to infants who received formula (19) (20).

Rationale:

Human milk contains complex proteins, disaccharides, and long-chain fatty acids, which have been associated with improved intestinal adaptation (5). *Human milk contains nucleotides, immunoglobulins, and leucocytes which support the immune system of the neonate and growth factors (e.g., glutamine, growth hormone and epidermal growth factor) which promote bowel adaptation* (21). *Oligosaccharides (non-digestible carbohydrates) present in human milk are fermented by bacteria in the colon and converted to short-chain fatty acids (SCFAs), improving adaptation of the small bowel and colon. Long chain fatty acids (LCFAs) in human milk promote brain development. The n-3 fatty acids have anti-inflammatory effects, improve splanchnic circulation, and increase intestinal adaptation. Long chain fatty acids have also been associated with slowed proximal intestinal transit and the secretion of GI hormones important in intestinal adaptation* (22). *Probiotic supplementation in SBS appears promising, though adequate safety and efficacy has yet to be established. However, bacteria from the maternal/parent gut translocate through the entero-mammary pathway into human milk, safely supplying the infant gut with commensal bacteria* (23).

Formula

When EHM is unavailable/insufficient appropriate transition to formula may be indicated (see SBS/IF Enteral Feeding Guideline and Feeding Intolerance Algorithm for indications/timeframe). Amino acid–based formulas may be advantageous to mitigate the increased risk of non-IgE-mediated intestinal allergic disease risk, provide easily digested glucose polymers, and provide a dual source of fats (16) (4). However, ideal feeding composition has not yet been determined (5) (24).

Rationale:

Amino acid-based infant formulas contain amino acids, glucose polymers (no lactose), and a ratio of 70% LCT (long-chain triglyceride) to 30% MCT (medium-chain triglycerides).

MCTs are absorbed directly into the stomach and across the enterocyte to the liver and thus are beneficial for rapid energy uptake and intraluminal bile salt deficiency with evidence of steatorrhea (patients with ileal resection and an intact colon) (16). *Due to its high osmotic load, additional MCT supplementation should be started at a low dose and gradually increased as tolerated.*

LCFAs are a major trophic factor for bowel adaptation and help slow motility by serving as an "ileal break." However, they require bile for emulsification and chylomicrons for absorption into the lymphatic system (25). *LCTs and supplementation of LCT's may be most beneficial in infants without a colon* (24).

Feeding Administration and Advancement

☐ Mode of Delivery

- Start feeds via oral/bolus feeding; encourage early controlled/limited non-nutritive or nutritive breastfeeding to support long-term milk supply, positive oral and bonding experiences, and the transfer of biologic components in EHM (26) (27).
- Continuous feeding may be utilized in conjunction with oral/bolus feeding as a strategy to improve feeding tolerance.

Rationale:

Bolus feeding stimulates gastrointestinal hormones, growth factors, and trophic factors that assist in bowel adaptation and allows for periods of fasting to promote bacterial clearance and prevent hyperinsulinemia (16) (28). *Continuous feeding by oro/nasogastric (short-term) or gastrostomy (long-term) has been shown to improve absorption and weight gain in SBS patients. In circumstances of significant SBS/IF, a combined approach (daytime bolus with continuous drip feeds at night) may provide physiologic benefit while minimizing feeding aversion and optimizing quality of life* (4) (28).

☐ Volume Initiation and Advancement

- See How to Choose a Feeding Guideline to choose from SBS/IF Enteral Feeding Guideline, Surgical NICU Feeding Guideline 1, or Surgical NICU Feeding Guideline 2
- Low probability of LBW infants with ostomy achieving EA prior to reanastomosis (29).
- TPN should not be reduced isocalorically; calories from EN do not equal calories PN due to inherent malabsorption in SBS/IF. Advancement should be based on growth, nutrient adequacy, and fluid status.
- See SBS/IF Feeding Intolerance Algorithm for potential nutrition, medical and surgical etiologies, and/or treatments to address feeding intolerance and/or inability to advance EN feeds.
- Minimal progress on EN advancements, despite nutritional and medical interventions, may suggest pathway for home TPN.

Enteral Supplementation

A multi-nutrient supplement is required in most cases to maintain nutrient sufficiency once patient has been weaned off PN. Additional supplementation of specific nutrients (vitamin D, zinc, sodium chloride or sodium bicarbonate) may be indicated based on laboratory values and growth.

Supplement (1 ml)	Indication(s)	Nutrient/ml							
		Vit A (IU)	Vit D (IU)	Vit E (IU)	Vit K (mcg)	Vit C (mg)	Zinc (mg)	Se (mcg)	Fe (mg)
Poly-vi-sol (Fe)		830	400	7.5	_	50	_	_	0 (11)
DEKAs Plus	Cholestasis Malabsorption Exclusive EHM	5751	750	50	500	45	5	5	0

Growth

Weight gain/velocity is the most common method of monitoring growth in the NICU. However, suboptimal linear growth (stunting) and altered body composition (e.g., increased fat mass and decreased muscle mass, bone mineralization, and brain mass), have been observed in neonates with SBS and should be a focus of concern (30). These findings may be attributed to the extended periods of inflammation and illness, inadequate protein accretion, metabolic consequences of nutrient administration from TPN, medications, and lack of appropriate physical movement (30).

Monitor Anthropometrics:

☐ Preterm infants: Utilize Fenton Growth Charts→ WHO Growth Charts for preterm infants (>40 weeks CGA)

☐ Term infants: WHO Growth Charts

Monitoring Growth			
Obtain	Goal 23-36 wks CGA	Goal > 36 wks	Considerations
Daily weight, percentile, z-score	15-20 g/kg/d	20-30 g/d	Risk of excessive wt gain: excessive fluid, energy/nutrient intake; overfeeding in setting of TPN → risk of IFALD

Weekly length, percentile, z-score	1 cm/wk	0.7 cm/wk	Risk of poor linear growth: systemic steroids, genetic conditions, congenital anamolies
Weekly head circumference, percentile, z-score	1 cm/wk	0.7 cm/wk	OFC increases > 1.25 cm/wk→ risk of macrocephaly and/or hydrocephalus
Z-scores: View in Cerner growth charts (select table view); also available on Peditools (http://peditools.org/)			

(31)

Medical and Surgical Management

A multidisciplinary team approach lends itself to orchestrating and strategizing the appropriate introduction of nutrition, medical, and surgical interventions to enhance bowel adaptation and feeding tolerance in infants with SBS/IF. When used strategically, a combination of these therapies can help reduce complications associated with the altered anatomy, medical and surgical complications, and subsequent feeding intolerance these infants endure.

Medications

Several medications can be utilized in conjunction with nutrition interventions to combat the common complications of neonatal SBS/IF. Thoughtful initiation and discontinuation of these medications is essential in weighing the risks and benefits of these medications in this high-risk population.

See Table: Common Medications for Patients with SBS/IF

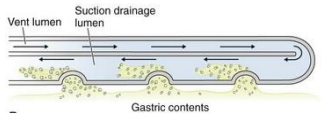
Surgical

- Surgical interventions due to failed nutrition and medical therapies may be indicated (3) (30) (32).
  - Stoma closure: in the presence of growth failure, inability to attain meaningful EN feeding and/or progressive IFALD
  - Stricture repair: unexplained vomiting and abdominal distention with radiologic evidence of obstruction
  - Serial transverse enteroplasty (STEP) and longitudinal intestinal lengthening and tailoring (LILT): Severe bowel dilation inherent to bowel adaptation leading to significant dysmotility, recurrent sepsis, SIBO and subsequent IFALD progression
  - Small bowel or multivisceral organ transplant: life threatening comorbidities, such as recurrent infections, loss of central venous catheter sites, or cholestasis unresponsive to lipid therapy

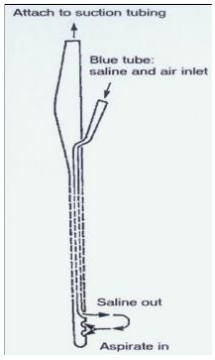
Appendix

Salem Sump vs Repogle Tube

*Salem Sump: Gastric decompression



**Repogle Tube: Esophageal flush/suction



Estimating Small Bowel Length

At time of Surgery

Post conception age	*Mean (cm)*	*Standard Error (SE)**
24-26 wk	70.0	6.3
27-29 wk	100.0	6.5
30-32 wk	117.3	6.9
33-35 wk	120.8	8.8
36-38 wk	142.6	12.0
39-40 wk	157.4	11.2
0-6 mo	239.2	18.3
7-12 mo	283.9	20.9
13-18 mo	271.8	25.1
19-24 mo	345.5	18.2
25-36 mo	339.6	16.9
37-48 mo	366.7	37.0
49-60 mo	423.9	5.9
Weight at surgery (g)	*Mean (g)*	*SE*
500-999	83.1	9.2
1000-1499	109.9	6.6
1500-1999	120.1	4.6
2000-2999	143.6	8.0
3000-4999	236.5	23.8
5000-7999	260.3	14.1
8000-9999	300.1	22.0
10,000-12,999	319.6	16.4
13,000-15,999	355.0	19.2
16,000-19,999	407.0	13.2
Length/Height (cm)	*Mean (cm)*	*SE*
30-39	97.4	6.0
40-49	129.0	5.6
50-59	205.9	21.6
60-74	272.0	11.1
75-89	308.5	16.5
90-99	382.5	15.2
100-120	396.4	15.3

SE: Estimates the variability across samples of a population (8)

Enteral & Parenteral Nutrient Requirements			
	Calories (kcal/kg/d)	Protein (g/kg/d)	IV Lipids (g/kg/d)
*Acute PN (*Catabolism)*	55-70 kcal/kg/d	3-4 g/kg/d (↓ with AKI)	1-2 g/kg/d
*Chronic PN *(Anabolism)*	90-115 kcal/kg/d	3-4 g/kg/d	3 g/kg/d
Preterm			
EN	110-140	3.5-4.5	–
Combined PN/EN	110-130	3.5-4.5	–
Term			
EN	108-120	2.5-4	–
Combined PN/EN	110-120	2.5-4	–
As CRP normalizes, energy requirements will transition from catabolism to anabolism			

Predictors of Enteral Autonomy	
Positive Predictors (9)	Negative Predictors (9)
Prematurity SBS etiology Diagnosis of NEC & intestinal atresia Residual small bowel length > 50% Presence of the ICV and/or colon Achieve > 50% Goal EN feeds 6 months post-operatively	Diagnosis complicated by dysmotility (e.g, Gastroschisis) Ileal resection LBW infant with ostomy (29)

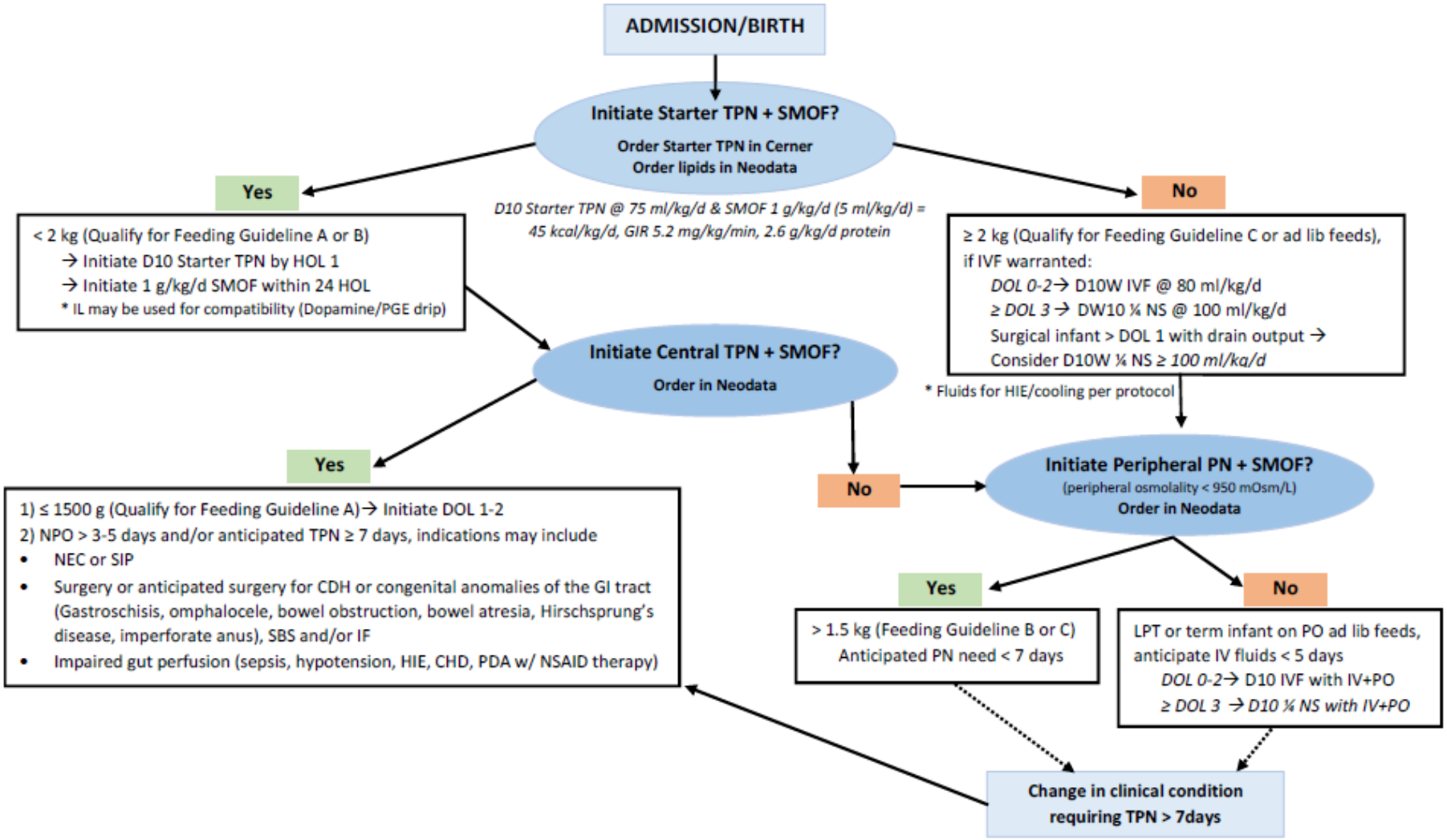
NICU Fact Sheet: TPN and Lipid Guidelines/Algorithm

1. Identify fluid goal and IV access (central line position to be confirmed on Xray; peripheral osmolality < 950 mOsm/L)
2. Custom TPN/Lipids written in Neodata, printed, and **faxed to pharmacy 12 pm**; CAPs to deliver by 7 pm; hangtime 9-10 pm

INITIATION, ADVANCEMENT & GOALS					
TPN and Lipids should be **advanced daily** per tolerance until goal has been reached and growth is adequate					
Nutrient	**Initiation**	**Daily Advance**	**Goal**	**Considerations & Monitoring**	
Dextrose (mg/kg/min) 3.4 kcal/g Glucose infusion rate (GIR= mg/kg/min) *Max: peripheral 12.5%, central 30%*	4-6 (min 4 for brain)	1-2 (with POC WNL)	10-14 (max 14-18)	Advance GIR by 1-2 mg/kg/min HOLD GIR Decrease by 1-2 mg/kg/min Glucose > 300 mg/dL with a GIR ≤ 4 mg/kg/min, consider insulin	Glucose ≤ 180 mg/dL Glucose 180-200 mg/dL ≥ 200 mg/dL
Amino Acids (Trophamine®) (g/kg/d) 4 kcal/g	3.5-4 (preterm) 3-3.5 (term)	0.5-1 0.5-1	3.5-4 3-3.5	May limit w/ impaired renal function	
SMOFLipid® (g/kg/d) 10 kcal/g (2kcal/ml) Additional Lipid Options: *Intralipid (IL)®* per clinical indication and/or on dopamine or PGE drip *Omegaven®* per protocol See Lexicomp® for lipid/med compatibility	1 (< 1.5 kg) 2 (> 1.5 kg)	1	3 (max 0.15 g/kg/h)	Prevent EFAD High risk: ELBW/prolonged NPO Check TG after on goal of 3 g/kg/d TG < 350 mg/dL TG 350-500 mg/dL TG > 500 mg/dL If on ≤ 1 g/kg/d SMOF after 3 days (VLBW), change to 20% IL to prevent EFAD	SMOF > 2.5 g/kg/d Intralipid 0.5-1.5 g/kg/d No change and/or advance as appropriate; recheck weekly until TG < 250 mg/dL Decrease and/or stay at 1 g/kg/d, check daily until TG <350, resume standard advance, recheck on 3 g/kg/d Discontinue, recheck after 24 hrs, if <350, resume standard advance, recheck on 3 g/kg/d
Kcal (kcal/kg/d)	–	–	100-115 Term 90-115	Increased needs with surgery, wound healing, CLD, cardiac	
Sodium (mEq/kg/d)	0-3	0.5-2	2-5	May be withheld in first 48 hrs of life to allow for diuresis	
Potassium (mEq/kg/d)	0-2	0.5-1	2-4	Caution in renal dysfunction	
Chloride/Acetate	As needed to maintain acid/base balance			1 g/kg/d AA provides 1 mEq/kg/d acetate; compounded with Na/K	
Calcium (mEq/kg/d) *Max: peripheral 2 mg/ml*	2	0.5-1	2-4	Higher Ca/Phos needs < 1500 g (Goal: 4 mEq Ca/2 mmol Phos) *Central* Ca:Phos Ratio (2 mEq:1 mmol ratio) *Peripheral* Ca:Phos Ratio ([Max]2 mg/ml: 0.5 mmol)	
Phosphorus (mmol/kg/d)	1	0.1-0.5	1-2		
Magnesium	0-0.4	0.1-0.3	0.2-0.5	Do not give for 1-3 days if mom received Mg prior to delivery	

	Goal (mcg/kg/d)	Multrys (mcg/kg/d) in 0.3 ml/kg/d	Standard additional dosing	Dosing considerations	
Zinc	400-500 (PT) 250-400 (Term)	300	100 (< 36wks CGA)	High output renal failure: up to 600 mcg/kg/d Excessive stool/ostomy losses: 400-800 mcg/kg/d Wounds: Consider additional dosing	
Copper	20	18	–	Reduce only with elevated Cu level	
Manganese	≤ 1	0.9	–	–	
Chromium	0.05-0.3	0	–	Prolonged PN: Glucose intolerance/insulin resistance → deficiency	
Selenium	2-4	1.8	2	Renal failure, may reduce or remove	
L-Carnitine	20 mg/kg/d	–	20 mg/kg/d		
Cysteine	20-40 mg/g amino acid	–	–	Do not add in the 1st 2 weeks of life	
MVI	–	–	≤2 kg: 2.5 ml/kg		> 2 kg: 5 ml/day

NICU Fact Sheet: TPN and Lipid Guidelines/Algorithm



Lab Monitoring	Initial	Steady State
BMP (CMP per clinical condition)	Daily until stable	CMP, Phos, Mag (Monday) BMP +/- Phos & Mag (Thursday)
Triglycerides	3g/kg/d lipids	Weekly until TG <250mg/dL, then PRN
Trace Elements	Do not reduce prophylactically in cholestasis or renal insufficiency, only with altered micronutrient levels- See SBS Guideline	

5.25.2022

Cycling TPN in the NICU: Step-by-Step Worksheet

- ☐ Collaborate with parent/caregiver to determine ideal time to cycle off TPN
- ☐ Gradually increase time off TPN as tolerated (normal blood glucose levels); maintain GIR < 14-18 mg/kg/min
  - Start: 2 hours off TPN + 1 hr taper ↑ & 1 hr taper ↓; taper may be weaned off when assured of glucose stability prior to d/c
  - Infants may not tolerate daily changes in TPN cycling and may require changes 2-3 times per week
  - Keep lipids x 24 hrs until at goal cycle TPN; then rate may be changed to mirror TPN cycle (max infusion rate 0.15 g/kg/hour)
- ☐ TPN written in Neodata; rate/volume/time must be handwritten on the TPN Sheet prior to faxing to pharmacy (see below)
- ☐ New bag will hang on current ordering day (~9 pm), but the cycle will occur the following day (~9 am)
- ☐ PICC/Broviac catheters can't be heparin locked in NICU (per policy); TPN rate to run at 1ml/hr while "off" (see below)

Calculating Cyclic TPN Rates (Ex: 3 kg infant)

Standard 24 hr TPN/Lipids

TPN Rate: 300 ml/d ÷ 24 hr = 12.5 ml/hr

SMOFLipid Rate (3 g/kg/d): 45 ml/d ÷ 24 hrs = 1.87 ml/hr

Wean #1: Cyclic TPN x 22 hours (1 hr taper x 2)

TPN at full rate x 20 hrs + 1 hr taper down & 1 hr taper up at ½ rate

Example calculation:

Total volume 300 ml/d ÷ 21 hr (accounts for full rate + taper rates) = 14 ml/hr

- → 14 ml/hr x 20 hrs
- → 7 ml/hr x 2 hrs (½ rate taper up/taper down = 1 hr full rate)

Wean #2: Cyclic TPN x 20 hours (1 hr taper x 2)

TPN at full rate x 18 hrs + 1 hr taper down & 1 hr taper up at ½ rate

Example calculation:

Total volume 300 ml/d ÷ 19 hr (accounts for full rate + taper rates) = 16 ml/hr

- → 16 ml/hr x 18 hrs
- → 8 ml/hr x 2 hrs (½ rate taper up/taper down = 1 hr full rate)

Wean #3: Cyclic TPN x 19 hours (30 min taper x 2)

TPN at full rate x 18 hrs + 30 min taper down & 30 min taper up at ½ rate

Example calculation:

Total volume 300 ml/d ÷ 18 hr (accounts for full rate + taper rates) = ~16 ml/hr

- → 16 ml/hr x 18 hrs
- → 8 ml/hr x 1 hr (½ rate taper up/taper down = ~30 min full rate)

Wean #4: Cyclic TPN & Lipids x 18 hours (no taper)

TPN & Lipid rate x 18 hrs:

Example calculation:

TPN Total volume: 300 ml/d ÷ 18 hrs = 16.5 ml/hr

SMOFLipid Rate (3 g/kg/d): 45 ml/d ÷ 18 hrs = 2.5 ml/hr (0.16 g/kg/hr = MAX)

Wean #5: Cyclic TPN & Lipids x 17 hours (no taper)

TPN & Lipid rate x 17 hrs:

Example calculation:

TPN Total volume: 300 ml/d ÷ 17 hrs = 17.5 ml/hr

*SMOFLipid Rate (2.5 g/kg/d): 32 ml/d ÷ 17 hrs = 1.9 ml/hr (0.12 g/kg/hr)

Wean #6: Cyclic TPN & Lipids x 16 hours (no taper)

TPN & Lipid rate x 16 hrs:

Example calculation:

TPN Total volume: 300 ml/d ÷ 16 hrs = 19 ml/hr

*SMOFLipid Rate (2 g/kg/d): 30 ml/d ÷ 16 hrs = 1.9 ml/hr (0.13 g/kg/hr)

** Adjust lipid dose to account for MAX infusion rate; ensure EFA/Calorie sufficient prior to weaning dose*

EXAMPLE: Template to write on bottom of TPN Sheet

Day 1: TPN x 20 hrs (+ 2 hr taper) = total 22 hrs
___ mL/hr when this bag hangs (~9pm-9am)
___ mL x ___ hr down (9-10am)
_1_ mL/hr "off" (10am-12pm); Blood sugar at 11 am
___ mL x ___ hr up (12pm-1pm)
___ mL/hr until new bag hangs (1pm-9pm)

Day 2: TPN x 18 hrs (+ 2 hr taper) = total 20 hrs
___ mL/hr when this bag hangs (~9pm-9am)
___ mL x ___ hr down (9-10am)
_1_ mL/hr "off" (10am-2pm); Blood sugar at 12 pm
___ mL x ___ hr up (2pm-3pm)
___ mL/hr until new bag hangs (1pm-9pm)

Day 3: TPN x 18 hrs (+ 2-30 min taper) = total 19 hrs
___ mL/hr when this bag hangs (~9pm-9:30am)
___ mL x ___ hr down (9:30-10am)
_1_ mL/hr "off" (10am-4pm); Blood sugar at 2 pm
___ mL x ___ hr up (4pm-4:30pm)
___ mL/hr until new bag hangs (4:30pm-9pm)

Day 4: TPN x 18 hrs (+ NO taper) = total 18 hrs
___ mL/hr when this bag hangs (~9pm-10am)
_1_ mL/hr "off" (10am-4pm); Blood sugar at 2 pm
___ mL/hr until new bag hangs (4pm-9pm)
Lipids x 18 hrs
___ mL/hr when this bag hangs (~9pm-10am)
_0_ mL/hr "off" (10am-4pm)
___ mL/hr until new bag hangs (4pm-9pm)

Day 5: TPN x 17 hrs (+ NO taper) = total 17 hrs
___ mL/hr when this bag hangs (~9pm-10am)
_1_ mL/hr "off" (10am-5pm); Blood sugar at 2 pm
___ mL/hr until new bag hangs (5pm-9pm)
Lipids x 18 hrs
___ mL/hr when this bag hangs (~9pm-10am)
_0_ mL/hr "off" (10am-5pm)
___ mL/hr until new bag hangs (5pm-9pm)

Day 6: TPN x 16 hrs (+ NO taper) = total 16 hrs
___ mL/hr when this bag hangs (~9pm-9am)
_1_ mL/hr "off" (9am-5pm); Blood sugar at 2 pm
___ mL/hr until new bag hangs (5pm-9pm)
Lipids x 18 hrs
___ mL/hr when this bag hangs (~9pm-9am)
_0_ mL/hr "off" (9am-5pm)
___ mL/hr until new bag hangs (5pm-9pm)

CHOC

Laboratory Monitoring

Nutrient or Condition	Laboratory Value	Indication to Monitor	Frequency of Monitoring	Additional Considerations
Electrolytes (Na)	BMP/CMP (pending need for liver function) Serum & urine Na CO2 (stool losses) Cl (gastric losses; hydration status)	Jejunostomy Ileostomy Colostomy/Partial colon Growth failure Dehydration	*Inpatient:* PN: Weekly EN+PN: Weekly EN: Weekly, then per MD discretion *Outpatient:* PN: At each visit EN+PN: At each visit EN (Acute): At each visit EN (Chronic): Per MD discretion	Urine Na < 30 mmol/L, consider additional supplementation Diuretic use can increase urinary Na excretion (interpret lab value/adjust supplementation accordingly)
Metabolic Bone Disease	Serum Ca*; ionized Ca (most accurate) Serum Mg Serum Phos Serum ALP *See sections below for monitoring frequency:* 25 OH Vitamin D PTH, TSH, T4	Prematurity Chronic TPN Renal Disease Hypothyroid Vitamin D Deficiency	*Inpatient:* PN: Every 1-2 weeks PN+EN: Weekly EN: 2 weeks *Outpatient:* PN: At each visit PN+EN: At each visit EN (Acute): At each visit EN (Chronic): Per MD discretion	With routine X-Rays monitor bone demineralization Consider DEXA (Dual-energy X-ray absorptiometry) scan
Liver Function	AST, ALT, GGT, ALP TGs (monthly) *See sections below for monitoring frequency:* INR, PT, PTT, platelets	Jaundice Cholestasis Synthetic liver dysfunction (coagulation/ thrombocytopenia)	*Inpatient:* 1-2 weeks *Outpatient:* PN: At each visit/PRN PN+EN: At each visit/PRN EN: Per MD discretion	
Iron	CBC with differential, ferritin* INR, PT, PTT (coagulation factors)	Microcytic anemia Thrombocytopenia	*Inpatient:* Monthly; Ferritin 3 months *Outpatient:* PN: Monthly, Ferritin 3 months PN+EN: 3 months EN (Acute): 3 months EN (Chronic): 6-12 months	Dose for deficiency: 4-6 mg/kg/day Fe IV iron only for extreme cases of SBS/feeding intolerance; on PN/minimal EN

Fat-Soluble Vitamins		Cholestasis Fat malabsorption Ileal resection	*Inpatient:* PN: 3 months PN+EN: 6 months EN: 3-6 months	Consider water-miscible vitamin supplementation (DEKA's plus) Cholestyramine may reduce absorption Consider intramuscular delivery of Vitamin K
Vitamin A	Retinol-binding protein*	Impaired immune response		
Vitamin D	25-OH Vitamin D*	Rickets		
Vitamin E	Serum α-tocopherol; α-tocopherol: cholesterol ratio	Hemolytic anemia	*Outpatient:* PN: 3 months PN+EN: 6 months EN (Acute): 3 months EN (Chronic): 12 months	
Vitamin K	PTT, INR, PT	Prolonged bleeding		
Copper*	Serum copper	Cholestasis Persistent neutropenia Anemia Prematurity	*Inpatient/Outpatient:* PN: Every 3 months EN+ PN: 3 months/PRN EN: PRN	*Dose for:* Toxicity: 10 µg/kg/day Deficiency: 30-40 µg/kg/day Prematurity: 20-40 µg/kg/day
Zinc**†	Serum Zn Serum ALP Indicates zinc stores *Low ALP*: Zn deficiency *High ALP*: liver disease or osteopenia	Chronic diarrhea/high ostomy output Delayed wound healing Skin rash Prematurity	*Inpatient:* PN: 3 months PN+EN: 3-6 months EN: 3 months *Outpatient:* PN: 3 months PN+EN: 3 months EN (Acute): 3 months EN (Chronic): Yearly	Dose for preterm infants, high ostomy/stool output, wound healing, deficiency: > 400 µg/kg/day *Stool Zn content: 12-17 mg/L*
Selenium*†	Serum selenium	Chronic diarrhea, high ostomy output Prematurity	*Inpatient:* PN: 2-3 months PN+EN: 3-6 months EN: 6 months/PRN *Outpatient:* PN/PN+EN: 3 months EN: 6-12 months	Dose for deficiency: 5-7 µg/kg/day Increase by 1-2 µg/kg/day, recheck 2-4 weeks
Vitamin B12†	Serum methyl-malonic acid	Ileal resection Hemorrhagic manifestations Macrocytic anemia	*Inpatient/Outpatient:* PN: 3 months PN+EN: 6 months	Consider intramuscular delivery

			EN: Every 3-12 months	
Manganese	Whole blood (toxicity) Serum manganese (deficiency)	Cholestasis Concern for toxicity	*Inpatient/Outpatient:* PRN based on clinical presentation	Remove completely, or dose not to exceed 1µg/kg/day
Iodine[†]	Urinary iodine (UI) concentration (preferred over TSH, T4); low UI may have variable effect on thyroid function TSH, T4	Lack of iodinated antiseptics Exclusive PN or minimal EN	*Inpatient/Outpatient:* PN: 6 months PN+EN: 6 months/PRN	Dose for deficiency: 1 µg/kg/day (Moderate deficiency: UI < 50 µg/L) (Severe deficiency: UI < 100 µg/L)
Chromium	Serum chromium (may not reflect body stores; resolution of glucose intolerance after supplementation is the best indicator)	Glucose intolerance Insulin resistance	*Inpatient/Outpatient:* PRN based on clinical presentation	Contaminant in TPN; deficiency is rare Assumed deficiency, supplement 0.2 µg/kg/d Avoid with renal insufficiency
EFAD	EFAD Panel	IL or Omegaven < 1g/kg/d SMOFlipid < 2-2.5 g/kg/d Growth failure, thrombocytopenia, poor wound healing, infection susceptibility	*Inpatient/Outpatient:* PRN with PN dependence and prolonged lipid restriction	

If laboratory result abnormal (deficiency or excess), more frequent lab monitoring may be indicated

* Micronutrient levels are affected by acute phase reactants and/or hypoalbuminemia; obtain c-reactive protein (CRP) as normal serum value needed for interpretation of micronutrient values.

[†] Potential for intravenous (IV) trace mineral preparation shortages, additional monitoring may be required.

PN: If receiving > 70% energy from TPN

EN Acute: < 3 months after TPN discontinued (prior to or at the time of EA establishment)

EN Chronic: > 3 months since TPN discontinued (after EA established)

Abbreviations: ALP (alkaline phosphatase); ALT (Alanine aminotransferase); AST (aspartate aminotransferase); Ca (calcium); CO2 (carbon dioxide); Cl (chloride); EFAD (essential fatty acid deficiency); GGT (gamma-glutamyl transferase); INR (international normalized ratio); Mg (magnesium); Phos (phosphorus); PT (prothrombin time); PTH (parathyroid hormone); PTT (partial thromboplastin time); Na (sodium); T4 (thyroxine); TGs (triglycerides); TSH (thyroid stimulating hormone); Zn (zinc)

(16) (30) (33) (34) (19) (35) (4) (28) (36) (37) (38) (39) (40) (41) (42) (43) (44) (12)

How to Choose a Feeding Guideline			
	SBS/IF Enteral Feeding Guideline	*Surgical NICU Feeding Guideline 1*	*Surgical NICU Feeding Guideline 2*
Suggested Indication(s)	< 50% expected small bowel Including but not limited to jejunostomy or proximal ileostomy (4,6)	Gastroschisis with prematurity and/or complications (ex: intestinal atresia) Moderate bowel resection (> 50% expected SB remaining) Delay in return of bowel function post-op (> 3-4 weeks)	Gastroschisis (term, uncomplicated) Minimal bowel resection Rapid/expected return of bowel function (<1-2 weeks)
Initiation	Trophic volumes based on weight/disease process; trophic volumes for 2-3 days	10 ml/kg/d	20 ml/kg/d
Advancement	See algorithm	10 ml/kg/d	20 ml/kg/d
Considerations	See algorithm	BID advancement options at 80 ml/kg/d Recommended fortification trial at 80 ml/kg/d: Prematurity Conditions requiring fluid restriction and/or increased energy expenditure (CHD, CLD, growth restriction, etc…)	
Notes	Initiate oral feeds per CGA, developmental recommendations, and tolerance BF or NNBF encouraged as first PO feed per maternal/parent preference (all above guidelines) Do not utilize IV+PO order; calculate TPN rate based on feeding guideline volumes		

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Surgical NICU Feeding Guideline 1

Date	Line Day	Weight (kg)	Wt. X ml/kg/d ÷ 8	= ml/fdg q 3 hr	Fortification, Supplements	Care Practices
	1		x 10 ÷ 8			
	2		x 20 ÷ 8			Non-nutritive BF
	3		x 30 ÷ 8			
	4		x 40 ÷ 8			* Initial Nutritive BF with IBCLC or Developmental team
	5		x 50 ÷ 8			** 1x daily BF
	6		x 60 ÷ 8			** 2x daily BF
	7		x 70 ÷ 8			
	8		x 80 ÷ 8		≤ 2.5 kg and/or ≤ 34 weeks consider fortification If donor milk, consider formula transition	*BID line advancement optional*
	9		x 90 ÷ 8			
	10		x 100 ÷ 8		Change to oral meds	** 3x daily BF
	11		x 110 ÷ 8			
	12		x 120 ÷ 8			
	13		x 130 ÷ 8			Discuss central line removal
	14		x 140 ÷ 8		Start vitamins & iron	
	15		x 150 ÷ 8		Discuss readiness for ad lib volumes	IBCLC to determine BF plan for home
	16		x 160 ÷ 8			

- **Use birth weight until regained and then use daily weight**
- **Feeding initiation should be discussed with surgical team**
- **Initiated with breast milk – maternal or banked per policy (after consent obtained)**
- **Advance occurs with ongoing assessment and clinical judgment**
- **Feedings are increased before shift change by night nurse (First feed delivered ~10AM)**
- **Round up/down feeding volume to the nearest 10th**
- *** IBCLC or developmental team to assess and utilize scale to guide timeframe for subsequent BF**
- **** Utilize time to attempt BF volume to match q 3 hr feeding volume after initial BF**

CHOC Children's

M Powell & G O'Toole Rev 7/2021

NOT A PERMANENT PART OF THE CHART

Surgical NICU Feeding Guideline 2

Date	Line Day	Weight (kg)	Wt. X ml/kg/d ÷ 8	= ml/fdg q 3 hr	Fortification, Supplements	Care Practices
	1		x 20 ÷ 8			Non-nutritive BF
	2		x 40 ÷ 8			* Initial Nutritive BF with IBCLC or Developmental team
	3		x 60 ÷ 8			** 1x daily BF
	4		x 80 ÷ 8		≤ 2.5 kg and/or ≤ 34 weeks consider fortification If donor milk, consider formula transition	** 2x daily BF *BID advancement optional*
	5		x 100 ÷ 8		Change to oral meds	* 3x daily BF
	6		x 120 ÷ 8			Discuss central line removal
	7		x 140 ÷ 8		Start vitamins & iron Discuss readiness for ad lib volumes	IBCLC to determine BF plan for home
	8		x 160 ÷ 8			

- **Use birth weight until regained and then use daily weight**
- **Feeding initiation should be discussed with surgical team**
- **Initiated with breast milk – maternal or banked per policy (after consent obtained)**
- **Advance occurs with ongoing assessment and clinical judgment**
- **Feedings are increased before shift change by night nurse (First feed delivered ~10AM)**
- **Round up/down feeding volume to the nearest whole number**
- *** IBCLC or developmental team to assess and utilize scale to guide timeframe for subsequent BF**
- **** Utilize time to attempt BF volume to match q 3 hr feeding volume after initial BF**

CHOC Children's

M Powell & G O'Toole Rev 7/17

SBS/IF Enteral Feeding Guideline: Infants ≤ 50% Estimated Small Bowel length

Term & Late Preterm Infants

Initiate: EHM/DHM via PO q 3 hours (gavage → development skill)
Start trophic feeds: 5-10 ml/kg/d x 2-3 days
Advance by: 5-10 ml/kg/d ml 2-4x/wk as tolerated

As needed based on tolerance/anatomy:
Daytime feeds (x 3-4 feeds)
Nighttime Feeds at 1ml/hr x 10-14 hrs
*Transition to elemental formula if no EHM

Advance at least 2-3x/wk by
~2-5 ml/feed for daytime PO feeds
~ 1-2 ml/hr for nighttime drip feeds
May increase day and night feeds or alternate pending feeding tolerance/anatomy

Unable to advance 2-3 x/wk and/or reach ~ 100 ml/kg/d

Team to discuss/assess EA Potential:
1. Consider Cyclic TPN (see worksheet)
2. Dependence on IV fluids, TPN macro/micronutrients
3. Potential for enteral supplementation
4. Social barriers for Home TPN

EA attainable in NICU

EA not attainable in NICU

Checklist: HOME *without* TPN

Adequate growth & labs WNL off TPN for > 3-5 days
Family education complete
(GTube, pumps, ostomy/wound care)
Arrange: Feeding/medical supplies, home health
Follow-Up: TPN Team, Surgery, Bridge, Developmental

Checklist: HOME TPN

TPN/Feeding Rx tolerated with weekly lab adjustments
Family education complete
(GTube, central line, pumps, ostomy/wound care)
Family to meet with home TPN team and home health
Arrange: Home TPN, central line/and feeding supplies
Follow-Up: TPN Team, Surgery, +/- Bridge, Developmental

Important Note:
Time and enteral feeding are essential elements of bowel adaptation.

Refer to the ***Feeding Intolerance Algorithm*** *to define intolerance/provide interventions*

ELBW infant +/- Ostomy

Initiate: EHM/DHM via NGT/OGT/GTube q 3 hours
Start trophic feeds: 5-10 ml/kg/d x 2-3 days
Advance by 5-10 ml/kg/d 2-4x/wk as tolerated

Feeding Administration

As needed based on tolerance/anatomy and/or presence of proximal ileostomy/jejunostomy:
- After trophic feeds may transition to intermittent or continuous drip feeds
- Incorporate PO feeds per developmental readiness despite progress of EA→
- Offer PO tastes/feeds 1x/shift, advance frequency prior to volume

EBM/DHM Fortification

EHM/DHM Fortification:
- Trial outside of volume advancement; monitor for ≥ 1-2 days prior to volume/calorie change
- HMF 22 cal/oz at 60-80 ml/kg/d
- HMF 24 cal/oz at 90-110 ml/kg/d
- Remove central line once tolerating full fortified feeds (Consider growth, labs)

Considerations

CGA > 34 weeks with no anticipated surgical intervention prior to discharge:
- Failed progression of feeds, and suboptimal tolerance/anatomy

Expressed human milk (EHM) = maternal/parent milk; Donor human milk (DHM); Enteral autonomy (EA)

3.30.23

SBS/IF Feeding Intolerance Algorithm

Important Note:
Time & enteral feeding are the most important elements of bowel adaptation.

Trial 1 intervention at a time and give 3-5 days to evaluate response prior to initiating additional interventions

Dumping
Stool/Ostomy > 30-40 mL/kg/d
and/or clinical signs:
- Suboptimal growth
- Electrolyte Abnormalities (↓Na/BiCarb)
- Stool reducing substances >1%
- Stool pH > 5.5 (infants with intact colon)
- Excessive skin breakdown around ostomy/anus

Non-Obstructive Dysmotility
Confirmed by radiologic studies with clinical signs:
- Bilious &/or excessive emesis
- Worsening abdominal distention
- Inconsistent stooling needing routine suppository

Medical Management
- Pro- Motility Medications

Nutrition Interventions

Replace Fluid & Electrolytes
For output > 15-20 mL/kg/12hrs
and/or clinical signs:
- Decreased fluid volume
- Electrolyte abnormalities
- Dehydration (↓ UOP, weight loss)

Acute
½ NS +/- KCl
1 mL/mL IV
for output
> 15-20 mL/kg
per shift,
run over 4 hrs

Chronic
Account for fluid/electrolyte losses in TPN

Determine Etiology for Appropriate Intervention

Hypergastrinemia
- H2 Blocker
- Maximize H2 Blocker Dose
- Consider PPI

SIBO (I)
- Cycle antibiotics 1 week on/ 3 weeks off
- Cycle antibiotic 2 weeks on/ 2 weeks off
- Alternative antibiotic
- ID consult for persistent SIBO

** Acid suppression:*
Use with caution in patients at risk of SIBO

Inadequate Bowel Length/Function

Feeding Administration
Prioritize oral feeds as appropriate
- *Daytime:* 3-4 PO/bolus q 3 hrs
- *Nighttime:* Continuous drip x 10-14 hrs
- Interrupted Continuous (6hrs on/ 2hrs off)
- Continuous Feeds *(Consider with no ability to PO feed)*
- Mucous fistula refeeding (see policy)

Feeding Composition
- If on DHM→ elemental formula (> ~1800 g)
- If on EHM with adequate/excess EHM, consider hindmilk
- Inadequate EHM → elemental formula to supplement
- Consider 25-50% elemental formula
- *Full EHM supply, consider modular/medications prior to EHM displacement*

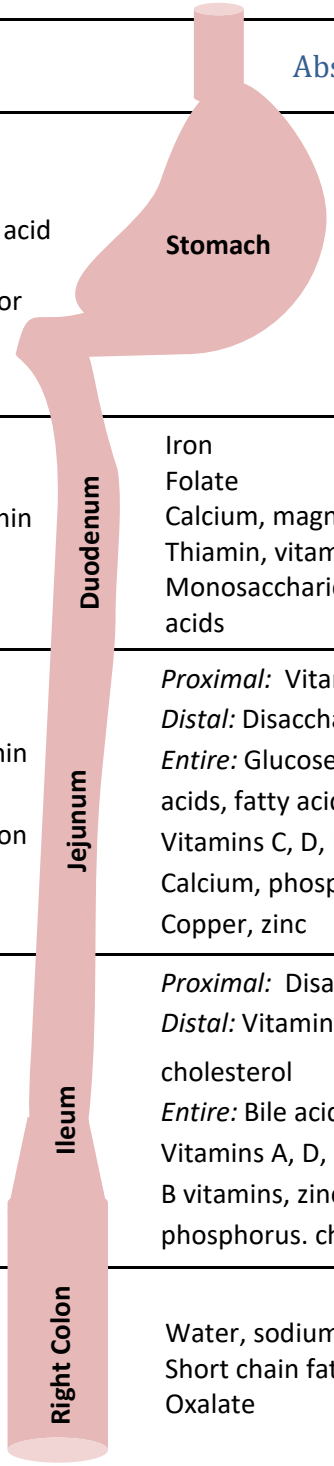
Modulars and/or Medications
- Long-chain EN fat supplementation (ideal in patient's w/ ostomy)
- Pectin's, e.g, Nana Flakes (intact colon)
- Loperamide
- CGA > 4-6 months consider pureed solids (bananas, green beans, sweet potatoes)

Expressed human milk (EHM) = maternal/parent milk; Donor human milk (DHM)

3.30.23

+Common Medications for Patients with SBS/IF		
Medication	Indication (Clinical Presentation)	Considerations
H2 blocker, Proton pump inhibitor (PPI)	Gastric acid hypersecretion (Diarrhea, peri-anal/stoma skin breakdown) Gastroesophageal reflux disease (Significant emesis)	*Potential side effects:* Increased risk of NEC and infections in preterm infants Increased risk of fractures
Loperamide	Slow intestinal transit Decrease stool output (Diarrhea)	
Antibiotics (metronidazole, ciprofloxacin, rifaximin, bactrim, and gentamicin)	Bacterial overgrowth (Unexplained rise in direct bilirubin, diarrhea, D-Lactic acidosis)	ID
Ursodiol[11,34]	Cholestasis	May initiate when tolerating feeds > 40-60 ml/kg/d
Bile acid sequestrants (Cholestyramine)	Bile salt malabsorption after terminal ileum resection (Choleretic diarrhea)	
Prokinetic/gastric promotility agents (Erythromycin, amoxicillin-clavulanic acid)	Non-obstructed dysmotility Gastroesophageal reflux disease (Significant emesis)	Radiographic studies may be indicated to r/o obstruction prior to use
GLP-2 analog (Teduglutide); approved for pediatric patients > 1 year of age	Increase absorption → increase villous height, inhibit gastric acid secretion, increase portal and intestinal blood flow and decrease motility	
		(45) (4) (46) (47)

Sites of Gastrointestinal Secretion, Absorption, and Care Implications



Secretion	Absorption	Alterations with Resection
Hydrochloric acid Pepsin Intrinsic Factor		Hypergastrinemia → hyperacidity → impaired digestion of amino acids and starch with increased osmotic load → fluid electrolytes losses, inactive pancreatic enzymes and inhibition micelle formation
Cholecystokinin Secretin	Iron Folate Calcium, magnesium Thiamin, vitamin C Monosaccharides, lactose, amino acids	Hypergastrinemia (see above) Anemia and osteopenia Impaired fat/fat soluble vitamin digestion
Cholecystokinin Secretin Enteroglucagon	*Proximal:* Vitamin A, iron, lactose *Distal:* Disaccharides, dipeptides *Entire:* Glucose, galactose, amino acids, fatty acids Vitamins C, D, E, B vitamins, folic acid Calcium, phosphorus, magnesium Copper, zinc	Hypergastrinemia (see above) Major substrate nutrient deficiencies, steatorrhea, cholestasis Bacterial overgrowth and lactic acidosis from undigested disaccharides
Distal: GLP-2	*Proximal:* Disaccharides, potassium *Distal:* Vitamin B_{12}, intrinsic factor, cholesterol *Entire:* Bile acids/salts Vitamins A, D, E, K, B vitamins, zinc, iodine, magnesium, phosphorus. chloride	Watery diarrhea, steatorrhea and cholelithiasis *ICV resection*: Diarrhea, bacterial overgrowth→ Lactic acidosis, bile acid deconjugation, worsening cholestasis
Sodium Potassium Bicarbonate GLP-2	Water, sodium Short chain fatty acids Oxalate	Watery diarrhea→ dehydration Oxalate renal stones

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