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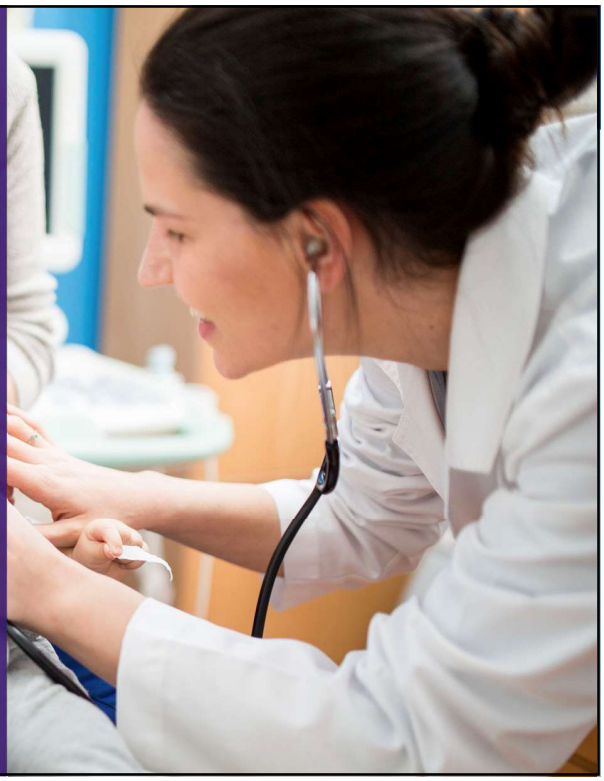
Short Bowel Syndrome: Nutritional Management during the Intestinal Rehabilitation Journey



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February 2nd, 2022

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Disclosures

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- Speakers Bureau
  - Nutricia
- Clinical Advisory board
  - Global Enteral Device Supplier Association (GEDSA)
- ***None pose any conflict of interest for this presentation***

The views & opinions reflected in this presentation are those of the speaker and independent of Nutricia North America

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Learning Objectives

- Participants in this activity will:
- Define short bowel syndrome (SBS)
- Explain the nutritional requirements of infants and children with SBS
- Summarize the role enteral nutrition plays in the intestinal rehabilitation process
- Describe the latest research in the dietary management of SBS

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What is Short Bowel Syndrome?

- **Malabsorption** resulting from anatomical or functional loss of a significant length of the small intestine
  - bowel length, mucosal integrity, motility, perfusion
- **Anatomic**
  - a residual jejunoileal segment of <75 cm secondary to a surgical resection or congenital malformation
  - residual bowel that is 25% of predicted length for gestational age
- **Functional**
  - Total parenteral nutrition (TPN) dependence greater than 6 weeks

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Normal Length of Small Bowel

- **Adult:** 300- 850 cm
- **Full term newborn:** 200- 250 cm
- **Preterm:** 100- 125 cm

Postconception age	Average (cm)
36-38 weeks	142.6
39-40 weeks	157.4
0-6 months	239.2
7-12 months	283.9
13-18 months	271.8
19-24 months	345.5
25-36 months	339.6

Struijs et al. *J Pediatr Surg* 2009;44:933-938.

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What causes intestinal failure?

- Small bowel length is lost
- Small bowel motility is abnormal (neuromuscular, neuropathy, myopathy)
- Small bowel mucosal integrity and absorptive function is abnormal
- Small bowel perfusion is compromised

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What causes intestinal failure?

- **Prenatal**
  - Atresia, gastroschisis
- **Postnatal**
  - NEC, midgut volvulus, vascular thrombosis
- **Congenital enteropathy**
  - Congenital Microvillus Inclusion, Tufting enteropathy, congenital disorders of glycosylation
- **Older children**
  - Crohn's, radiation enteritis, autoimmune enteropathy, SCID, hypogamma, trauma
  - Neuronal Intestinal Dysplasia, Megacystis-Microcolon-Hypoperistalsis
- **Any age**
  - Tumor, major abdominal trauma, mesenteric infarct

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What are the consequences of SBS?

- **Fluid electrolyte** disturbances, diarrhea, dehydration
- **Malnutrition**, micronutrient deficiencies
- **Poor growth**, development
- **Parenteral** nutrition-related complications
  - CLABSI / CRBSI
  - DVT, long-term anticoagulation
- **Parenteral** nutrition-related **organ disease**
  - PNALD (cholestasis), steatosis, cholelithiasis
  - Metabolic bone disease, kidney stones, D-lactic acidosis
- Poor **quality** of life
- High **morbidity**
- **Poor survival** probability

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Anatomic Risk Factors

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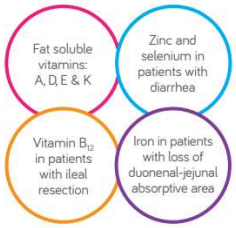
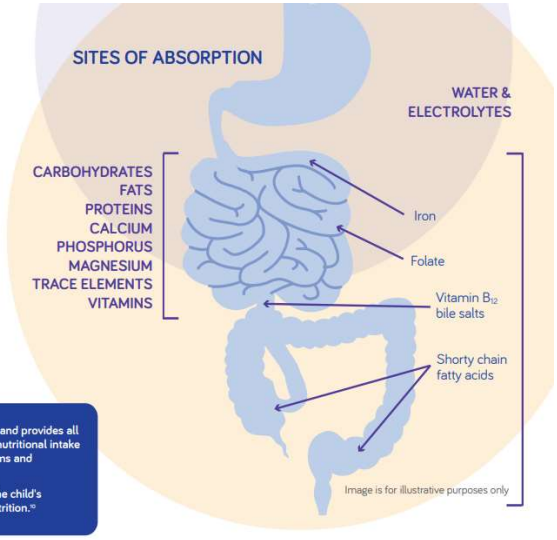
POTENTIAL NUTRIENT DEFICIENCIES IN SBS DURING AND AFTER TRANSITION TO ENTERAL AUTONOMY[1,6-8]



- Conduct regular monitoring to ensure the diet is adequate and provides all essential nutrients. Monitoring should include a review of nutritional intake and requirements, anthropometry, assessment of symptoms and micronutrient status.[9]
- Micronutrient supplementation needs will vary based on the child's intestinal anatomy, degree of malabsorption & route of nutrition.[10]

SITES OF ABSORPTION



Nutrients are absorbed at numerous anatomical locations along the gastrointestinal tract[5]

- Location of the bowel resection in infants and children with short bowel syndrome may determine the frequency and severity of potential micronutrient deficiencies[5]

- DUODENUM
  - Iron and folate absorption
- JEJUNUM
  - Less specific absorptive capacity
  - High output intestinal losses
- ILEUM
  - Bile acids, B12, ileal brake
- COLON
  - Magnesium absorption
  - Water/electrolyte/SCFA absorption
  - Glucagon-like peptide 2 (GLP2) production

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Intestinal Adaptation

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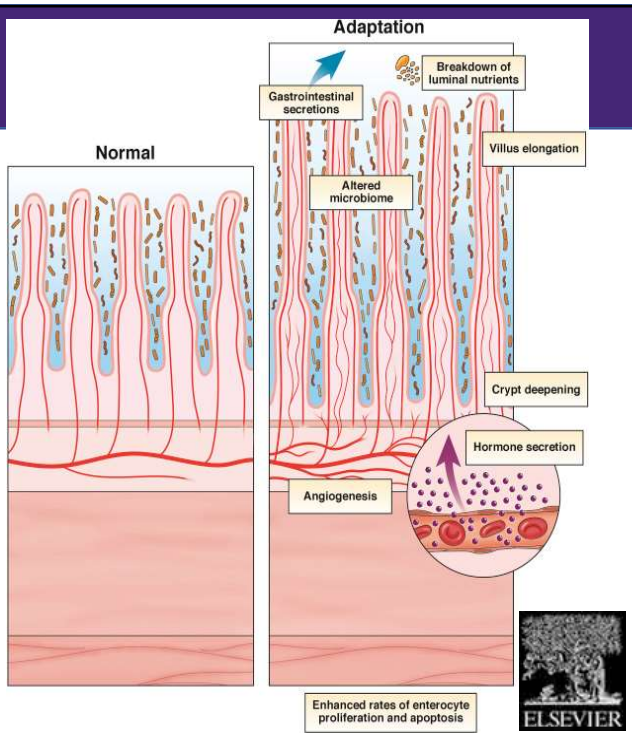

Cellular and Molecular Gastroenterology and Hepatology 2016 2429-438DOI: (10.1016/j.jcmgh.2016.05.001)
https://www.cmghjournal.org/article/S2352-345X(16)30041-8/fulltext

- Mucosal hyperplasia
- Gut hypertrophy
- Remaining small bowel anatomy
- Accelerated crypt cell differentiation
- Deepening of crypts
- Lengthening of villi
- Angiogenesis

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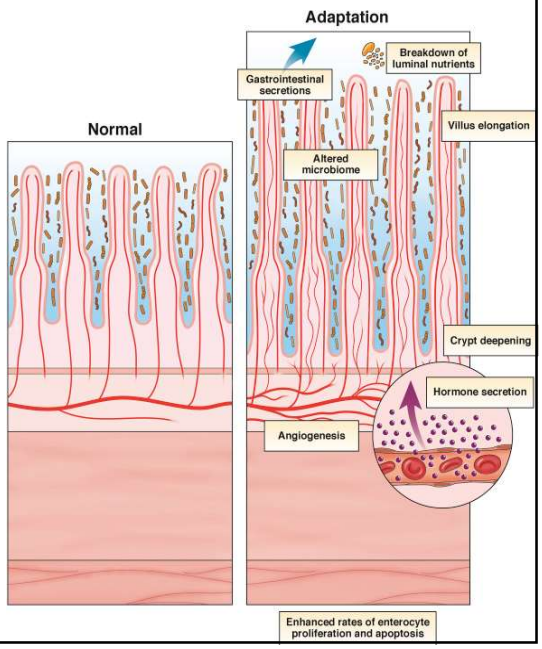
Primary Goals of Nutrition Management

- Facilitate intestinal autonomy
- Promote intestinal adaptation
  - Wean off parenteral nutrition
- Enhance enterohepatic circulation
- Promote an adapted absorptive surface
  - Promote healthy bowel mucosa
  - Improve motility
  - Healthier microbiome



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General Guidance

- Advance enteral feeding **gradually** and carefully
- Do not exceed the intestinal **absorptive capacity**
- **Continuous** feeding pattern versus bolus feeding
- If unable to advance feeds, consider **changing** the formula

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Protein, Fat, Carbohydrates, Fiber

- No significant difference in absorption between hydrolyzed and non-hydrolyzed formulas.
  - N=10 infants randomized crossover study
- No difference in nitrogen balance or intestinal permeability
- **Short bowel syndrome**
  - Hydrolyzed and amino acid-based formulas
    - Non-IgE-mediated milk protein allergy in patients with SBS
  - Shorter duration of TPN dependence
    - Amino acid-based formulas (AAFs)
    - Breast milk

Ksiazyk et al JPGN 2002; Andorsky et al. *J Pediatr* 2001; 139:27-33, Bines et al. *JPGN* 1998; 27(5):614-616, Degreef et al Journal of Nutrition and Metabolism 2010, Kaufman et al *J Pediatr* 1997;131:356-61

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Protein, Fat, Carbohydrates, Fiber

- Long-chain triglycerides (LCTs)
  - Require bile acids to absorb
  - Enhance bowel adaptation
  - LCTs stimulate the secretion of PYY and GLP-2
  - Mediates ileal and jejunal brake
  - LCTs contain n-3 long chain polyunsaturated fatty acids (n-3 LCPs) beneficial effects in SBS
  - Anti-inflammatory effects and improve the splanchnic circulation
  - n-3 LCPs improve cholestasis

Vanderhoof, J. A.; Grandjean, C. J.; Kaufman, S. S.; Burkley, K. T.; Antonson, D. L. Effect of high percentage medium-chain triglyceride diet on mucosal adaptation following massive bowel resection in rats. *J. Parenter. Enter. Nutr.* **1984**, *8*, 685–689.
Grey, V. L.; Garofalo, C.; Greenberg, G. R.; Morin, C. L. The adaptation of the small intestine after resection in response to free fatty acids. *Am. J. Clin. Nutr.* **1984**, *40*, 1235–1242.
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Miller, M.; Burjonrappa, S. A review of enteral strategies in infant short bowel syndrome: Evidence-based or nicu culture? *J. Pediatr. Surg.* **2013**, *48*, 1099–1112.
Pscheidl, E.; Schywalsky, M.; Tschaikowsky, K.; Boke-Prols, T. Fish oil-supplemented parenteral diets normalize splanchnic blood flow and improve killing of translocated bacteria in a low-dose endotoxin rat model. *Crit. Care Med.* **2000**, *28*, 1489–1496.

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Protein, **Fat (MCT)**, Carbohydrates, Fiber

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- Medium Chain Triglycerides (MCTs) are directly absorbed across enterocytes into portal circulation
- Rapid hydrolysis of MCTs in patients with jejuno- or ileostomy can cause osmotic diarrhea
- In patients with intact colon MCTs can improve fat absorption
- Beneficial in patients with bile acid or pancreatic insufficiency
- MCTs are saturated fats and do not contain essential fatty acids

- Amino acid-based and casein hydrolysate formulas
  - High in MCTs
  - More calories from fat even in setting of malabsorption, intestinal resection

Jeppesen, P.B.; Mortensen, P.B. The influence of a preserved colon on the absorption of medium chain fat in patients with small bowel resection. *Gut* **1998**, *43*, 478–483.
Jeppesen, P.B.; Mortensen, P.B. Colonic digestion and absorption of energy from carbohydrates and medium-chain fat in small bowel failure. *J. Parenter. Enter. Nutr.* **1999**, *23*, S101–S105.

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Protein, Fat, **Carbohydrates**, Fiber

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- Lactose may promote production of short chain fatty acids (SFCAs)
- Standard infant formulas: 19-20 kcal/oz
- May dilute to 10 or 15 kcal/oz
  - Decreasing the osmotic load to reduce diarrhea
- Avoid fruit juices, fruits, syrup medications (HFCS)
  - Worsen D-lactic acidosis
  - Diarrhea
- If volume-sensitive
  - May consider 22 kcal/oz or 24 kcal/oz
- The higher the osmolarity the higher the chance of osmotic diarrhea

Goulet, O.; Olieman, J.; Ksiazyk, J.; Spolidoro, J.; Tibboe, D.; Kohler, H.; Yagci, R.V.; Falconer, J.; Grimble G.; Beattie, R.M. Neonatal short bowel syndrome as a model of intestinal failure: Physiological background for enteral feeding. *Clin. Nutr.* **2013**, *32*, 162–171.

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Protein, Fat, Carbohydrates, **Fiber**

- Insoluble fibers
  - Bind to water and cause bulking and softening of the stool
- Soluble fibers
  - Slow gastric emptying and transit time
  - Pass undigested into colon, are fermented into SFCAs
    - Colonocyte fuel/health
    - Enterocyte proliferation
    - Water and sodium reabsorption
- Butyrate (SCFA) has trophic effects on the jejunal and ileal cells when delivered in the colon
- The suggested underlying mechanism of this trophic effect may be the stimulated release of GLP-2
- Animal studies showed that pectin enhanced bowel adaptation

DiBaise, J.K.; Young, R.J.; Vanderhoof, J.A. Intestinal rehabilitation and the short bowel syndrome: Part 2. *Am. J. Gastroenterol.* **2004**, *99*, 1823–1832
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Enteral Nutrition (EN)

- Early Stage: Human milk is best!
- Best formula choice for infants
  - Amino acid-based formula
  - Protein hydrolysate formula

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Choosing a Formula

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Extensively Hydrolyzed (eHF)

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- Extensively Hydrolyzed, whey protein dominant
- > 50% of fat calories as MCT
- For oral or tube feeding
- Nutritionally complete in 1000 ml
- Lactose- and gluten-free (may vary by brand)
- Available at WIC* with prescription

*WIC is a registered service mark of the U.S. Department of Agriculture for USDA's Special Supplemental Nutrition Program for Women, Infants and Children.

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Amino Acid-Based Formulas (AAF)

- 100% free amino acids as protein source
- > 30% of fat calories as MCT
- For oral or tube feeding
- Nutritionally complete
- Dairy- & soy-oil free, no gluten added (varies by brand)
- With or without prebiotic fiber
- Available at WIC* with prescription
- AAFs ***are not all the same***

*WIC is a registered service mark of the U.S. Department of Agriculture for USDA's Special Supplemental Nutrition Program for Women, Infants and Children.

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Role of AAFs in SBS

- ↑ Tolerance to feeds
- ↑ Advancement of feeds
- ↑ Ability to wean down parenteral nutrition

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Supplements

- Powdered carbohydrate & fat
  - Hydrolyzed cornstarch 73%, Fat supplement 22% (35% MCT)
  - Added to formulas to increase the caloric density
  - 42 kcal/Tablespoon
- 100% LCT
  - Safflower oil
  - 67.5 kcal/tbsp
- Emulsified MCT
  - 67.5 kcal/tbsp
- Vegetable Oil/Olive Oil/Coconut Oil
  - 120 kcal/tbsp
  - Doesn't mix as well, give like a medication

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Prebiotics

- Food product that is not hydrolyzed in the upper GI tract
  - Short chain carbohydrates (oligosaccharides)
  - Inulin
  - Dietary fiber
- Alter the balance of bacteria in favor of *Bifidobacteria* and *Lactobacilli*
- Serves as an energy source for colonic bacteria
  - SCFAs: butyrate, propionate, and acetate
  - ↑ epithelial cell proliferation
  - ↓ epithelial cell apoptosis
- Cow's milk-based, extensively hydrolyzed, amino acid-based, soy-based pediatric and infant formulas commercially available

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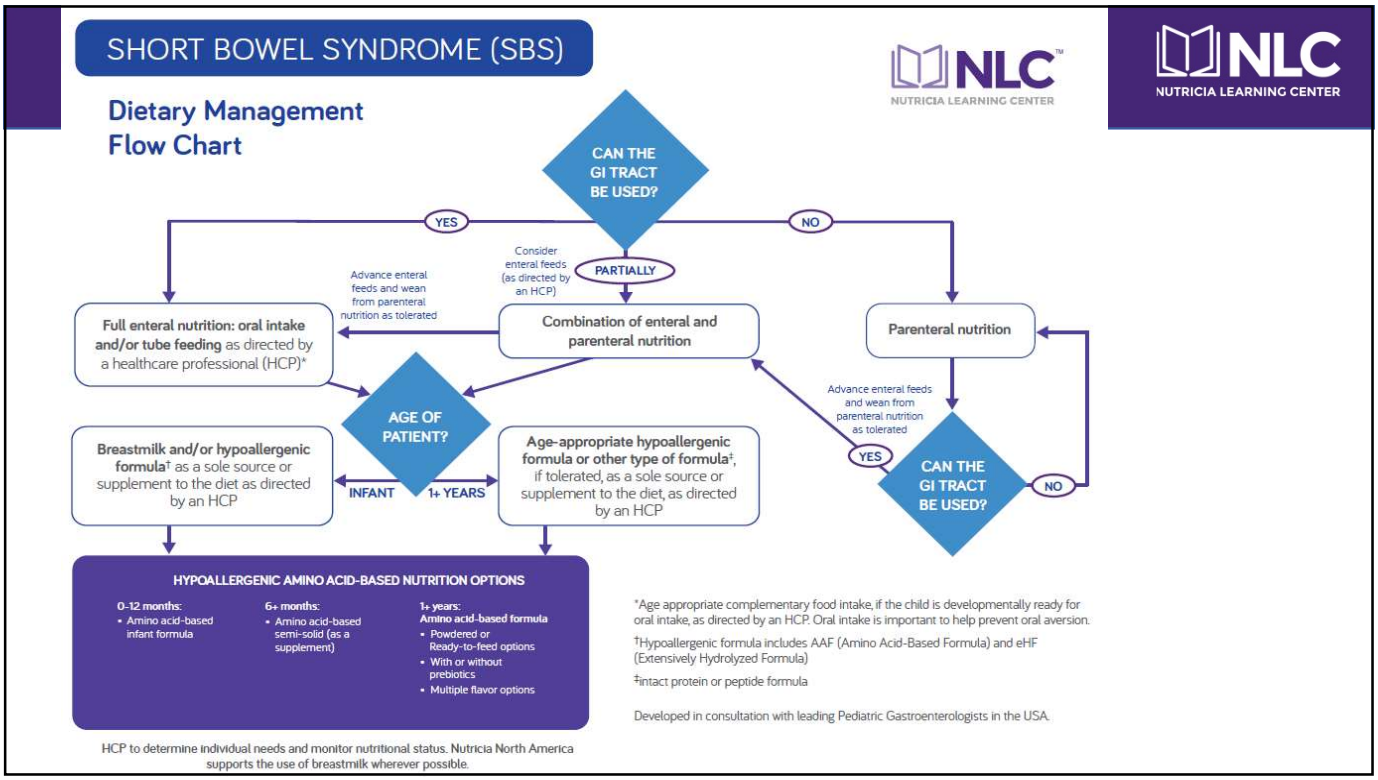

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Practice Surveys

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- 2017 - Pediatric Intestinal Failure Section of the American Society for Parenteral and Enteral Nutrition (ASPEN)
- 2021 - European Reference Network on Rare Inherited and Congenital Anomalies (ERNICA)

Nucci AM, Ellsworth K, Michalski A, et al. Survey of Nutrition Management Practices in Centers for Pediatric Intestinal Rehabilitation. Nutr Clin Pract. 2017:884533617719670.

Verlato G, Hill S, Jonkers C, et al. Results of an International Survey on Feeding Management in Infants with Short Bowel Syndrome-Associated Intestinal Failure (SBS-IF). Journal of Pediatric Gastroenterology and Nutrition. 2021;Published ahead of print.

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Practice Survey ASPEN Pediatric IF Section

- Open-ended questions related to PN and EN feeding strategies, nutrition management of PNALD and laboratory monitoring
  - Fat minimization
  - Trace element modification
  - Avoiding PN overfeeding
  - Providing EN

Nucci AM, Ellsworth K, Michalski A, et al. Survey of Nutrition Management Practices in Centers for Pediatric Intestinal Rehabilitation. Nutr Clin Pract. 2017:884533617719670.

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Summary: Survey of Nutrition Management Practices in Centers for Pediatric Intestinal Rehabilitation

Purpose

To summarize current practices in the nutrition management of children with intestinal failure (IF)/short bowel syndrome (SBS)

Design

Qualitative nutrition practice survey.

23 questions related to enteral & parenteral feeding strategies & laboratory monitoring.

Outcome

RDs from 14 US centers responded to the survey

Nucci AM, Ellsworth K, Michalski A, et al. Survey of Nutrition Management Practices in Centers for Pediatric Intestinal Rehabilitation. Nutr Clin Pract. 2017:884533617719670.

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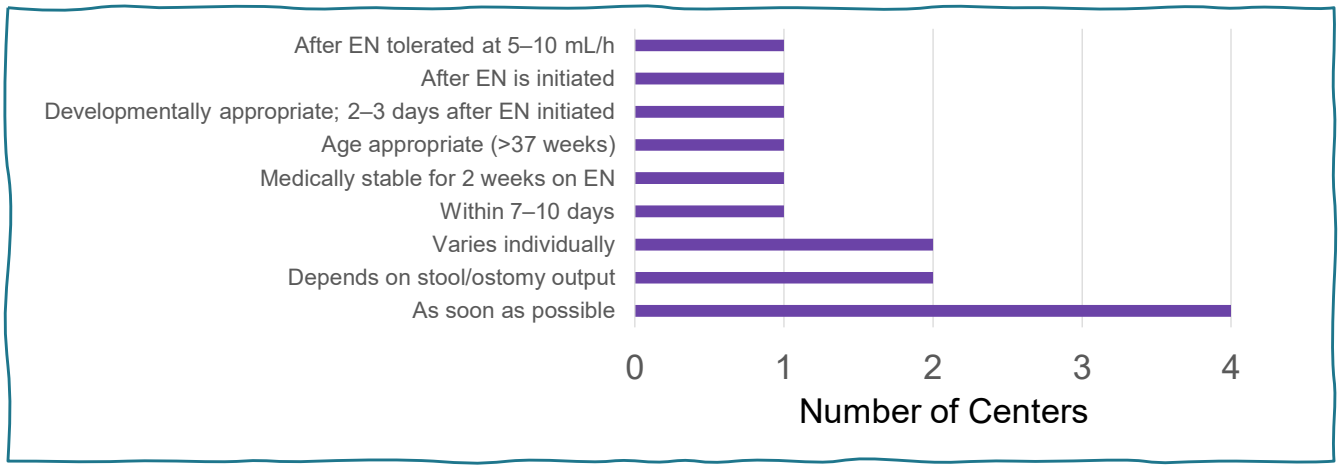
Survey Question: How soon are oral feedings initiated in children with SBS/intestinal failure at your center?

14 out of 14 responses



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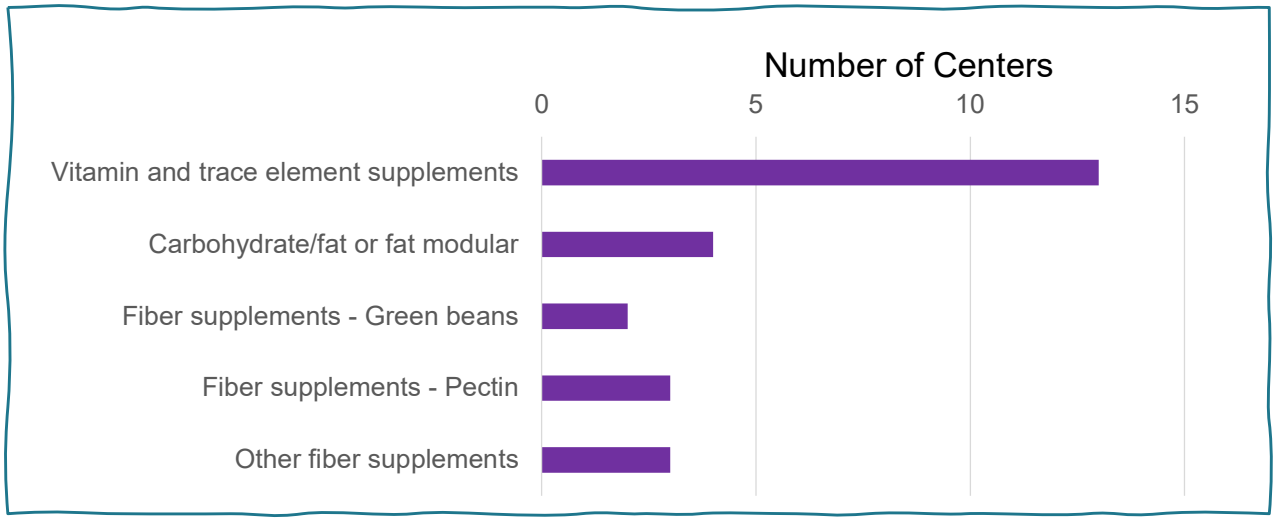
What oral supplements do you typically recommend for patients with SBS/IF?

14 out of 14 responses



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Practice Survey ASPEN Pediatric IF Section

- Majority prescribe a continuous infusion of breast milk or elemental formula 1–2 weeks after resection, remainder determine formula type by the extent of resection
- *Conclusion:* EN and PN management strategies are relatively consistent among U.S. centers

Nucci AM, Ellsworth K, Michalski A, et al. Survey of Nutrition Management Practices in Centers for Pediatric Intestinal Rehabilitation. Nutr Clin Pract. 2017:884533617719670.

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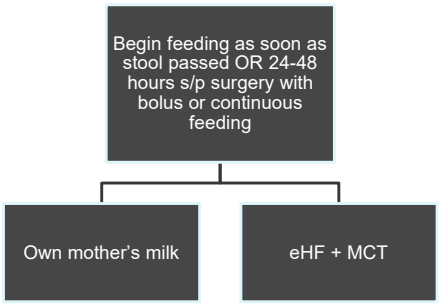
European Reference Network on Rare Inherited and Congenital Anomalies (ERNICA)

- EN was introduced as soon as possible ideally within 24-48 hours post-small intestinal surgical resection
- Majority used mothers' own milk as the first choice of feed
  - eHF
  - AAF
  - donor human milk
- **Conclusions:** There is diversity in post-surgical enteral feeding strategies among centers in Europe
- Respondents favored early post-surgical enteral feed introduction and early age of introducing complementary food/solids



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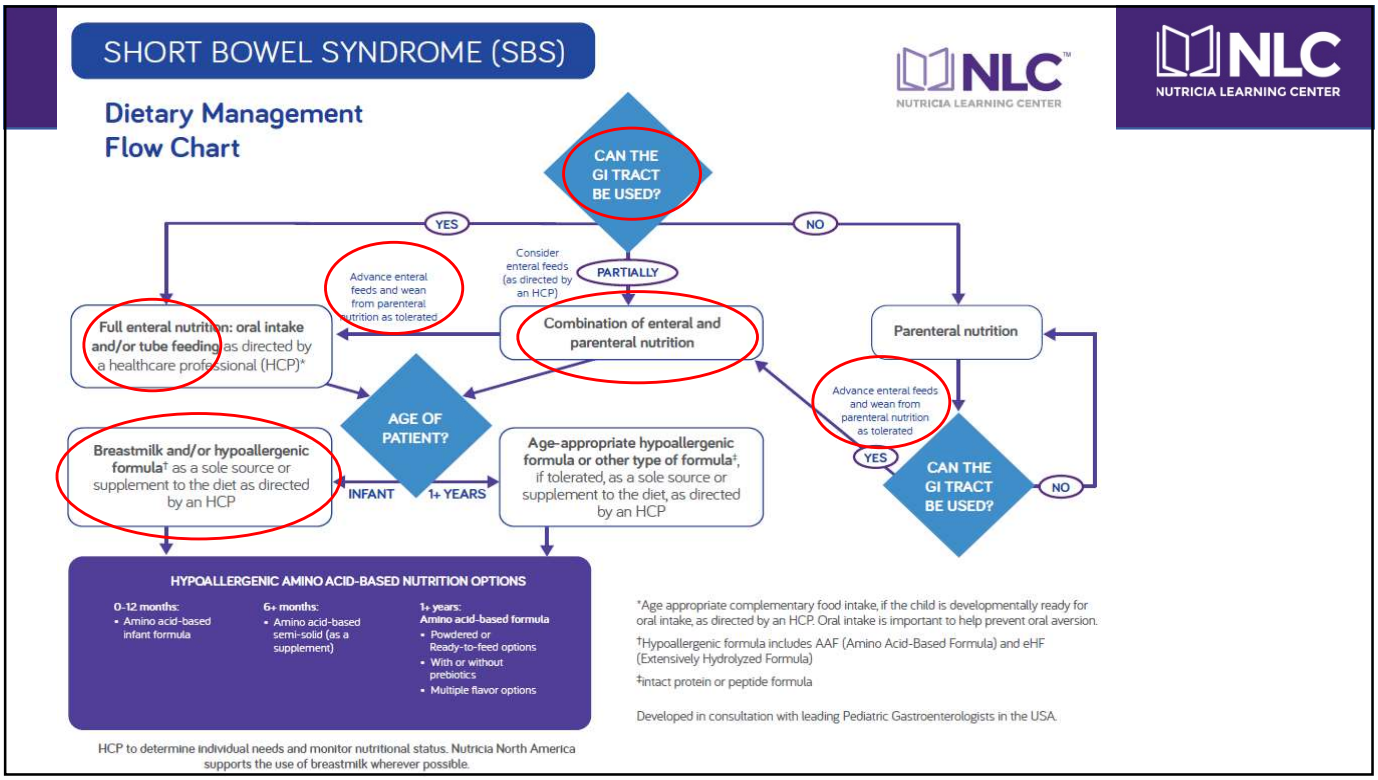

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Thank You!

Q&A

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