Nutricia Learning Center

Specialized Nutrition Education – Helping You Help Your Patients

Short Bowel Syndrome: An Update on Nutrition Intervention

Valeria Cohran M.D.,M.S.

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NUTRICIA Advanced Medical Nutrition

Objectives

- Learn about the nutritional deficiencies an infant with Short Bowel Syndrome (SBS) faces
- Review the role enteral nutrition plays in the intestinal rehabilitation process
- Discuss the ways diet modifications can reduce the complications of long-term TPN

Short bowel syndrome

- Occurs in the setting of intestinal loss after abdominal catastrophe
- Results in inadequate digestion and absorption to sustain fluid, electrolyte, and nutritional needs
- Duration of TPN dependence is directly related to the intestinal length
- Anatomic vs Functional

Quiros-Tejeira et al. *J Pediatr* 2005:145:157-63

Etiologies of pediatric SBS

- Surgical SBS
  - Necrotizing Enterocolitis
  - Gastroschisis
  - Intestinal Atresias
  - Volvulus
  - Long segment Hirschsprung's Disease
- Motility disorders
  - Neuronal intestinal dysplasia
  - Chronic intestinal pseudo-obstruction
- Mucosal lesions
  - Microvillus inclusion disease
  - Tufting enteropathy

Intestinal Adaptation

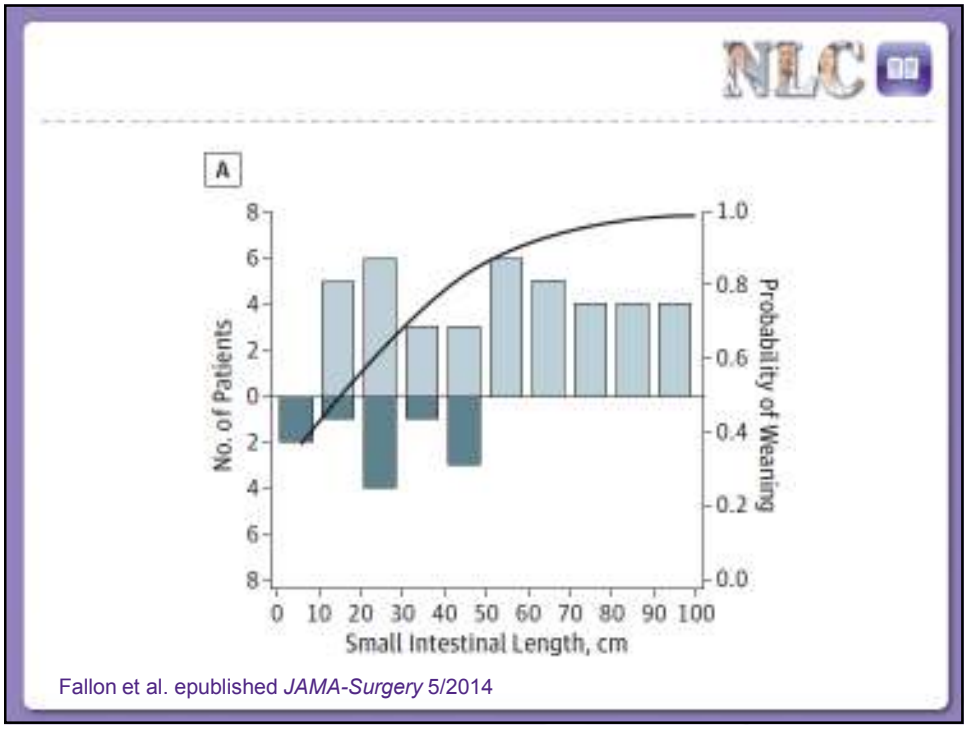
- Process
  - Residual intestinal mass and surface area increase
  - Absorptive capacity of the individual enterocytes
  - Remnant bowel compensates for the loss of intestine leading to enteral autonomy
- Stimulated by enteral nutrition
- Growth factors i.e. Glucagon like peptide-2 (GLP-2)

Kocoshis. *Seminars in Peds Surgery*. 2010 19:20-26

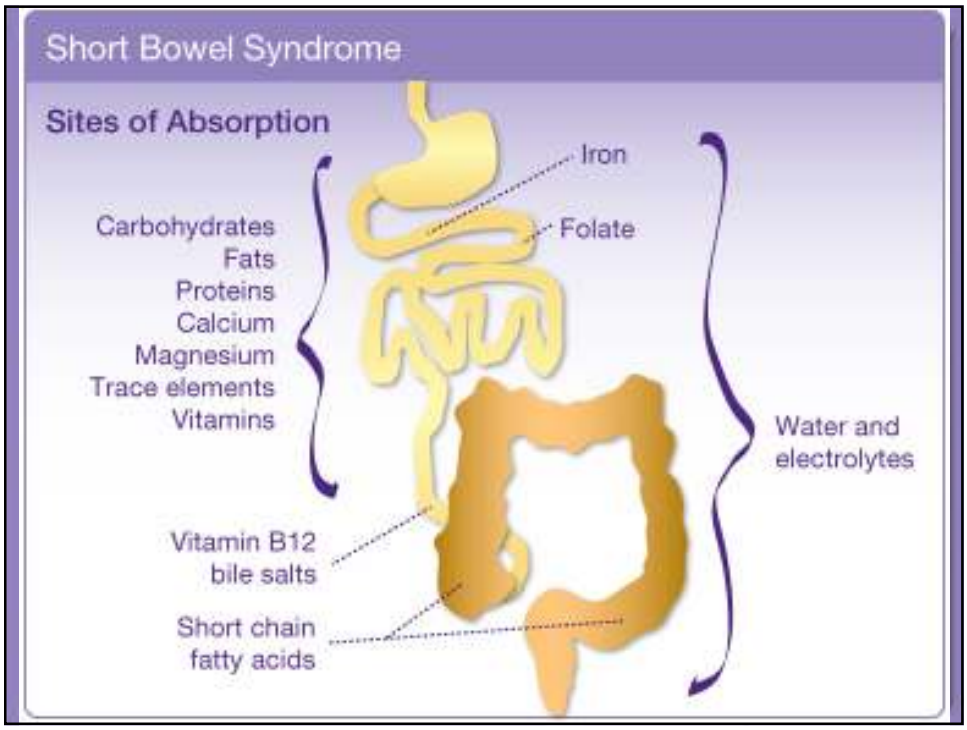
Predictors of Adaptation

- Remnant intestinal length
- Percent daily energy intake
  - 6 weeks
  - 3 months
- Presence or absence of Ileocecal Valve
- Small bowel bacterial overgrowth
- Colonic resection

Sondheimer et al. *J Pediatr* 1998;132:80-4
Andorsky et al. *J Pediatr* 2001: 139:27-33
Quiros-Tejeira et al. *J Pediatr* 2005:145:157-63
Kaufman et al. *J Pediatr* 1997 Sep;131(3):356-61.



Fallon et al. epublished *JAMA-Surgery* 5/2014



Total Parenteral Nutrition

- Fluids
- Electrolytes
- Vitamins
  - B_{12}
  - Vitamin D
- Minerals
  - Copper
  - Zinc
  - Selenium

Must compensate for GI losses in terms of volume and electrolyte needs

Pediatric GI Electrolyte Losses

	Sodium (mEq/L)	Potassium (mEq/L)	Chloride (mEq/L)	Bicarbonate (mEq/L)
Gastric	140	15	155	-
Ileostomy	80-140	15	115	40
Colostomy	50-80	10-30	40	20-25
Secretory	60-120			
Diarrhea	30-40	10-80	10-110	30
Normal Stool	5	10	10	0

Wessel and Kocoshis, *Semin Perinatol* 2007; Apr;31(2):104-11.

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Electrolytes

- Urinary electrolytes
  - Na
  - K
  - Cl
- Use to assess electrolyte status and demonstrate changes before serum levels
- Unable to interpret in the setting of diuretic use

Wessel and Kocoshis, *Semin Perinatol* 2007; Apr;31(2):104-11.

Copper

- Often removed from TPN in setting of cholestasis
- Refractory anemia
  - Thrombocytopenia
  - Neutropenia
  - Pancytopenia
- Copper based enzymes are required for heme synthesis and transport
- Serum copper levels to assess status

Youssef et al. *Curr Gastro Rep* 2012:14:243-252

Zinc

- Commonly seen in malabsorption
- Deficiency
  - Impaired wound healing
  - Dermatitis
  - Diarrhea
- Serum zinc levels to assess status
- High enteral zinc can compete with copper absorption

Mziray-Andrew and Sentongo. *Peds Clin N Am* 2009 56:1185-1200

Selenium

- Nationwide shortage for > 2 years
- Deficiency
  - Muscle weakness
  - Cardiomyopathy
  - Loss of hair and skin pigmentation
- Serum selenium levels to assess status

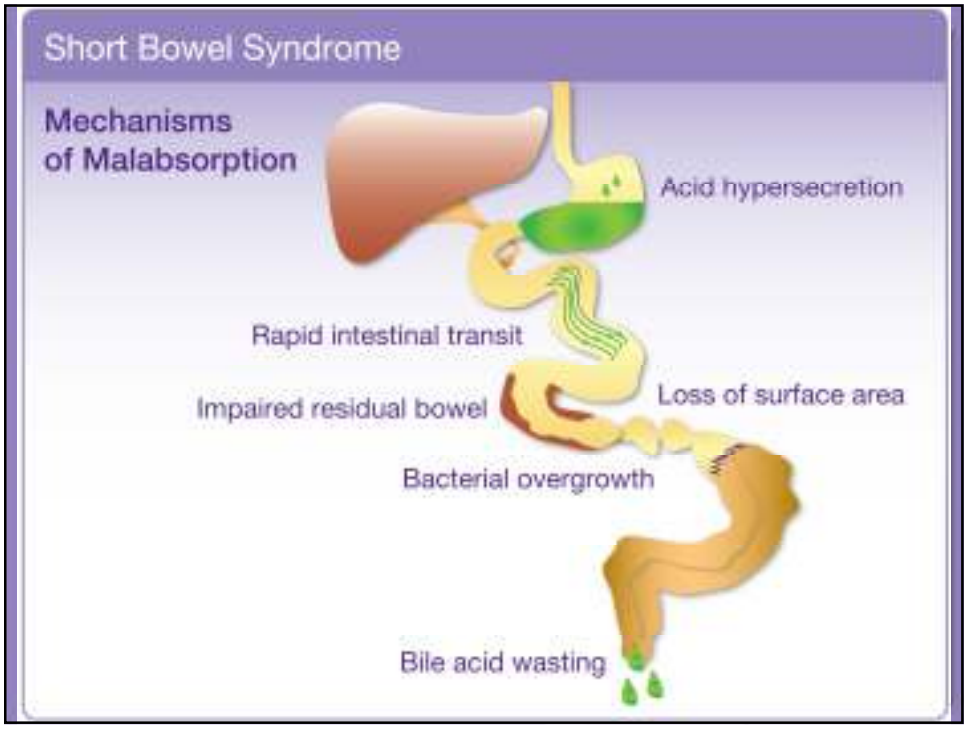
Mziray-Andrew and Sentongo. *Peds Clin N Am* 2009 56:1185-1200

Current Daily Parenteral Recommendations For Infants and Children

Trace Elements	Infants	Children
Copper	20 mcg/kg/d (no max stated)[b]	20 mcg/kg/d (500 mcg/d max[c,d])[b]
Chromium	0.2 mcg/kg/d (max 5 mcg/d)[e]	0.2 mcg/kg/d (max 5 mcg/d[c])[e]
Floride	No recommendations	No recommendations
Iodine	1 mcg/d[f]	1 mcg/d[f]
Iron	Premature: 200 mcg/kg/d[f] Infant: 50-100 mcg/kg/d[f]	50-100 mcg/kg/d[f]
Manganese	1 mcg/kg/d (max 50 mcg/d[c])	1 mcg/kg/d (max 50 mcg/d[c])
Molybdemun	Premature: 1 mag/kg/d Infant: 0.25 mcg/kg/d (max 5 mcg/d[c])	0.25 mcg/kg/d (max 5 mcg/d[c])
Selenium	Premature: 2-3 mag/kg/d Infant: 1-3 mcg/kg/d (no max stated)	1-3 mcg/kg/d (100 mcg/d max[c,d])
Zinc	Premature: 450-500 mcg/kg/d Infants <3 mo: 250 mcg/kg/d Infants <3 mo: 50 mcg/kg/d (max 5000 mcg/d)	50 mcg/kg/d (max 5000 mcg/d[c])

Vanek et al. *Nutr Clin Prac*. 2012:4:440-491.

Enteral Therapy



Goals for Nutrition Therapy

- Achieve intestinal adaptation
- Optimize growth
- Enhance intestinal adaptation during the transition from TPN to solely enteral nutrition
- Stabilize fluid and electrolytes
  - Sodium, bicarbonate supplements
  - Oral rehydration solutions

Enteral Route

- Continuous feedings are beneficial!
- Shorter the remnant bowel, the less likely to tolerate bolus or oral feedings
  - Diarrhea
  - Malabsorption
- 600-700 Kcal/day in adult IF patients receiving tube feedings vs patients taking only oral feedings
- Small amounts of oral feedings to prevent oral aversion if tolerated
- GER or motility disorders are common
  - Nasojejunal
  - Gastrojejunal

Joly et al. *Gastro* 2009;136:824–831

Breast Milk

- **Breast milk always been encouraged**
  - 19% of Pediatric Intestinal Failure Consortium (PIFCON) cohort, n=272
  - 20 different infant formulas
- **Growth Factors**
  - Glucagon like peptide-2
  - Epidermal growth factor
  - Secretory immunoglobulins
  - Lysozyme
  - Interferon
- **Improved outcomes with enteral autonomy**

Squires et al. *J Pediatr* 2012;161:723-8,
Andorsky et al. *J Pediatr* 2001: 139:27-33,

Amino Acid-Based Formulas

Standard dilution = 0.67 kcal/mL
Osmolality=340mOsm/kg
Energy distribution:
- Protein 11.2%
- Carbohydrate 43.1%
- Fat (MCT 33% / LCT 67%) 45.7%

Standard dilution = 1 kcal/mL
Osmolality:
- Unflavored 550 mOsm/kg

Energy Distribution
- Protein 13%
- Carbohydrate 42%
- Fat (MCT 35% / LCT 65%) 45%

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Amino Acid-Based Formulas, cont'd

Standard dilution = 0.67 or 1 kcal/mL
Osmolality:
- 20 kcal/oz = 350 mOsm/kg
- 30 kcal/oz = 560 mOsm/kg

Energy Distribution
- Protein 15%
- Carbohydrate 43%
- Fat (MCT 33% / LCT 67%) 42%

Amino Acid-Based Formulas, cont'd

Standard dilution = 0.67
Osmolality:
- 20 kcal/oz = 350 mOsm/kg

Energy Distribution
- Protein 11%
- Carbohydrate 41%
- Fat 48%

SBS outcomes

30 children with SBS studied retrospectively

Results:

- Shorter duration of TPN associated with:
  - Longer bowel length
  - Higher percentage of calories enterally at 6 weeks
  - Mean duration of TPN 290 vs 720 days in non-breast milk infants
  - Feeding with breast milk or amino acid based milk.
- Early enteral feeding after surgery is associated both with reduced duration of TPN and less cholestasis.

Andorsky et al. *J Pediatr* 2001; 139: 27-33

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Enteral autonomy

Case series of 4 patients with SBS and persistent feeding intolerance

Results:

- Change to amino acid-based formula (Neocate®) enabled discontinuation of PN within 15 months
- Reduction in hospital time (mean: 198 versus 98 days/patient/year),
- Reduction in sepsis
- Histological and functional measures of small bowel were improved

Bines, et al *J Pediatr Gastroenterol Nutr.* 1998 Feb;26(2):123-8.

Impact of Amino Acid formula

- A retrospective case report of four patients with SBS who were weaned from PN after introduction of an amino acid-based formula (Neocate).
- Intestinal length 9, 20, 40, and 50 cm of small bowel
- The weaning period from PN was shortened (< 13 months) on Neocate® in four patients (two of which were preterm infants).

DeGreef et al. *J Nutrition and Metabolism* 2010; article ID 297575

Protein

- Amino Acid-based formulas have been found to be beneficial in SBS patients
  - Shorter duration of TPN dependence
  - Tapering from TPN
- Milk protein allergy is common in these patients

Andorsky et al. *J Pediatr* 2001: 139:27-33

Mazon et al. *Pediatr Allergy Immunol* 2008;19: 180–183

Carbohydrates

- Fructose
- Sorbitol
  - Less rapidly absorbed simple sugars that may cause osmotic diarrhea
  - Avoided in SBS patients
- Complex carbohydrates, i.e. fiber promote water reabsorption

Mziray-Andrew and Sentongo. *Peds Clin N Am* 2009 56:1185-1200

Fat

- High caloric density 9 kcal/gm
- Long Chain Triglycerides (LCT): source of essential fatty acids; promotes intestinal adaptation
- Absorption is dependent on bile acids and mixed micelles
  - Enterohepatic circulation of bile acids affected by ileal resection
- Medium Chain Triglycerides (MCT) can be directly absorbed into the circulation
  - Formulas high in MCT commonly employed in treating patients with SBS

Energy Modules

Duocal®

- Soluble powdered supplement
- Hydrolyzed cornstarch
- Carbohydrate 59%, Fat 41% (35% MCT)
- Added to formulas to increase the caloric density
- 42 kcal/Tablespoon
- Well-tolerated

Microlipid®

- 67.5 kcal/Tbsp
- 100% Fat LCT
  - Safflower oil
- Added to tube feedings

Liquigen®

- 67.5 kcal /Tbsp
- 50% MCT/50% water
- Emulsified for better mixing

Randomized Controlled Trial of Early Enteral Fat Supplement and Fish Oil to Promote Intestinal Adaptation in Premature Infants with an Enterostomy

Table II. Nutritional and clinical outcomes after randomization and before bowel reanastomosi

Infants	All		High ostomy	
	Control (n = 18)	Treatment† (n = 18)	Control (n = 6)	Treatment (n = 8)
Nutritional outcomes				
Feeding, d	47 ± 21	55 ± 22	39 ± 14	45 ± 26
Hyperalimentation, d	37 ± 17	32 ± 18	37 ± 13	36 ± 18
Intravenous lipid, d	33 ± 16	11 ± 6‡	37 ± 13	13 ± 5‡
Feeding volume, mL/kg/d	67 ± 32	89 ± 31‡	35 ± 13	63 ± 25‡
Feeding calorie, % of total calories	44 ± 24	65 ± 21‡	20 ± 9	48 ± 17‡
Total calorie, cal/kg/d	110 ± 6	121 ± 7‡	108 ± 8	117 ± 7‡
Ostomy output, mL/kg/d	17 ± 5	17 ± 11	21 ± 4	20 ± 16
Clinical outcomes				
Conjugated bilirubin before closure, mg/dL	2.9 ± 2.1	1.7 ± 1.5‡	3.4 ± 0.8	2.3 ± 1.6
Number of sepsis evaluations, per infant	1.6 ± 1.9	0.6 ± 0.7‡	0.7 ± 0.8	0.6 ± 0.5
Mean days of antibiotics, per infant	10.5 ± 14.4	3.5 ± 4.5‡	8.3 ± 15.8	3.8 ± 3.9
% of feeding days with central venous catheter§	90.0 ± 23.3	72.8 ± 31.3‡	100.0 ± 0.0	91.4 ± 22.6

*Mean ± SD.
†Treatment group received early enteral fat supplement and fish oil.
‡$P < .05$ treatment vs control.
§Central venous catheter days were defined as the percent of feeding days when PN and intravenous lipids were infused through the catheter.

Yang et al *J Peds* 2014;165:274-9

Randomized Controlled Trial of Early Enteral Fat Supplement and Fish Oil to Promote Intestinal Adaptation in Premature Infants with an Enterostomy

Table III. Nutritional outcomes after bowel reanastomosis*

Infants	All		High ostomy	
	Control (n = 17)	Treatment† (n = 18)	Control (n = 6)	Treatment (n = 8)
Hyperalimentation, d	13 ± 17	10 ± 13	27 ± 23	16 ± 18
Intravenous lipid, d	11 ± 13	6 ± 5‡	21 ± 18	7 ± 7‡
Total calorie, cal/kg/d	115 ± 10	114 ± 12	112 ± 14	117 ± 13
Weight gain, g/d	20 ± 9	27 ± 11‡	14 ± 4	23 ± 5‡
Length gain, cm/wk	0.9 ± 1.3	2.1 ± 1.5‡	0.6 ± 0.8	2.2 ± 1.6
Head circumference gain, cm/wk	.1 ± 0.7	1.4 ± 1.0	0.8 ± 0.9	1.2 ± 0.8

*Mean ± SD in the interval between resumption of enteral feedings and attainment of 150 mL/kg/day of enteral feedings.
†Treatment group received early enteral fat supplement and fish oil.
‡$P < .05$ treatment vs control.

Yang et al *J Peds* 2014;165:274-9

Oral Hydration Solutions

- Premade hydration fluid
  - Contents
    - 250 mOsm/kg
    - Na 45 mEq/L
    - K 20 mEq/L
    - Cl 35 mEq/L
- Oral hydration solutions
  - Ceralyte®, etc…

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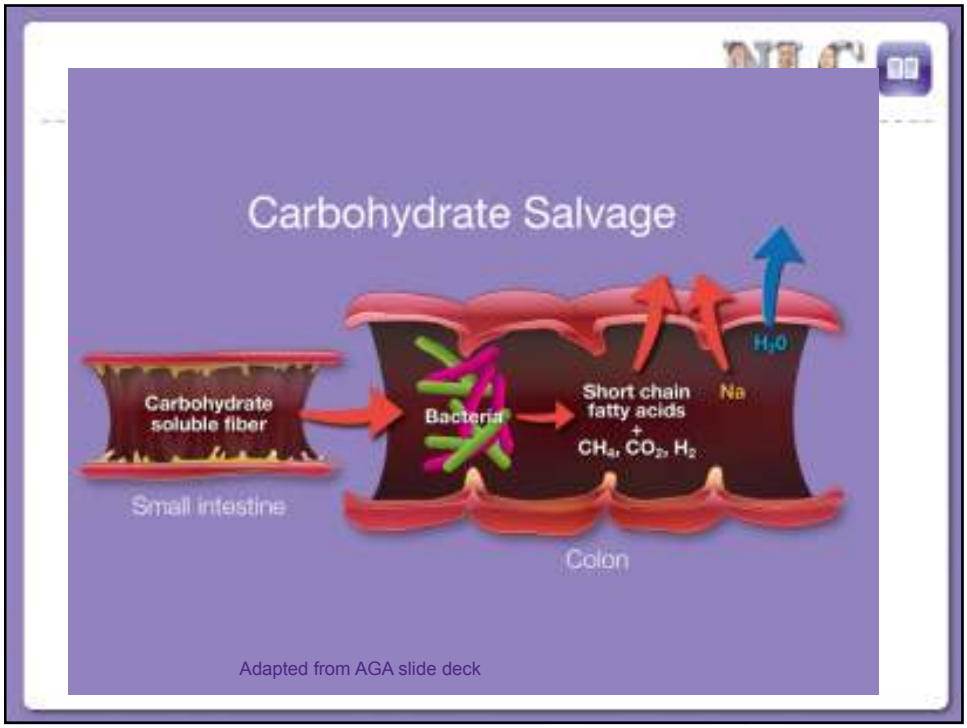
Soluble Dietary Fiber

- Slows gastric emptying
- Enhances water and sodium reabsorption
  - Pectin (1-3%)
  - Benefiber® 1 tablespoon and advance as
  - tolerated
- Butyrate
  - Primary short chain fatty acid (SCFA)
  - Energy source for colonocytes
  - Regulates colonocyte proliferation
- Beneficial in the presence of a colon



Fiber supplementation

- Retrospective of 18 patients with IF or SBS
- Stage 2 green beans to every 8 ounces of 30 kcal/oz formula
- Stool pattern

Green Beans	Before	After
Liquid	12	
Loose	6	
Mushy/Soft		10
Formed		8

- 4 patients had no colon

Drenckpohl, D et al. *ICAN* 2013;58-13

Prebiotics

- Short chain carbohydrates (oligosaccharides)
- Alter the balance of bacteria
  - Increases in bifidobacteria and lactobacilli
- Serves as an energy source for colonic bacteria
  - Short chain fatty acids: butyrate, propionate and acetate
    - Increase epithelial cell proliferation
    - Decrease epithelial cell apoptosis
    - Excretion of pancreatic enzymes

Stoiodis et al. *Nutrition Research Reviews* 2011:24:2130

Prebiotics

Prebiotics/fiber

- 6 week double blind cross over study
- Investigating the tolerance of a peptide based formula with fructo-oligosaccharide and insoluble fiber
- N=14
  - Only two with short bowel syndrome
- Frequency of stools remained the same
- More watery stools with control formula
- Extremes of stool consistency was normalized with the fiber intake

Khoshoo et al. *J Am Diet Assoc*. 2010;110:1728-1733.

Table 1. Diet and Fluid Suggestions in Older Children and Adults with Short Bowel Syndrome (24, 32)

	Colon Present	Colon Absent
Carbohydrate	50–60% of caloric intake Complex carbohydrates	40–50% of caloric intake Complex carbohydrates
Fat	20–30% of caloric intake Ensure adequate essential fats MCT/LCT	30–40% of caloric intake Ensure adequate essential fats LCT
Protein	20–30% of caloric intake High biologic value	20–30% of caloric intake High biologic value
Fiber	Net secretors Soluble	Net secretors Soluble
Oxalate	Restrict	–
Fluids	ORS and/or hypotonic	ORS

MCT, medium-chain triglycerides; LCT, long-chain triglycerides; ORS, oral rehydration solution.

DiBaise et al. *Am J of Gastro* 2004;99;1823-1832

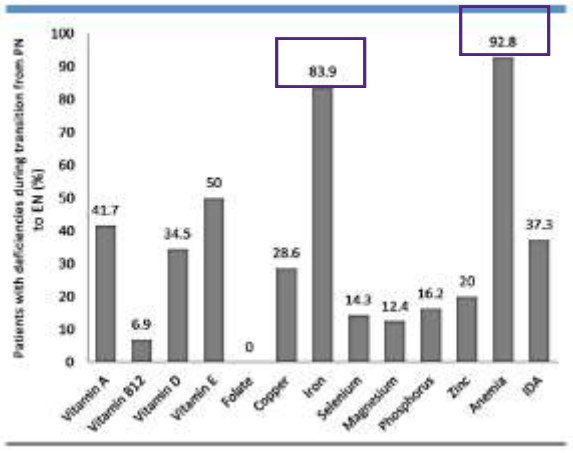
Nutritional Deficiencies

30 patients (mean age, 5 years; range, 2 to 9 years)

- **Transition**: **33**% of patients had at least one vitamin deficiency and **77%** at least one mineral deficiency
- **Full EN :** 70% had at least one vitamin deficiency and 77% had at least one mineral deficiency
  - Most common deficiencies being **vitamin D** (68%), **zinc** (67%), and **iron** deficiency (37%)
- **Protective against development of vitamin deficiencies**
  - Multivitamin supplement (P=.004)
  - Intact ileocecal valve (P=.02)

Yang et al *J Pediatr* 2011 Jul;159(1):39-44

Deficiencies during Transition from TPN



J Pediatr 2013;163:1692-6

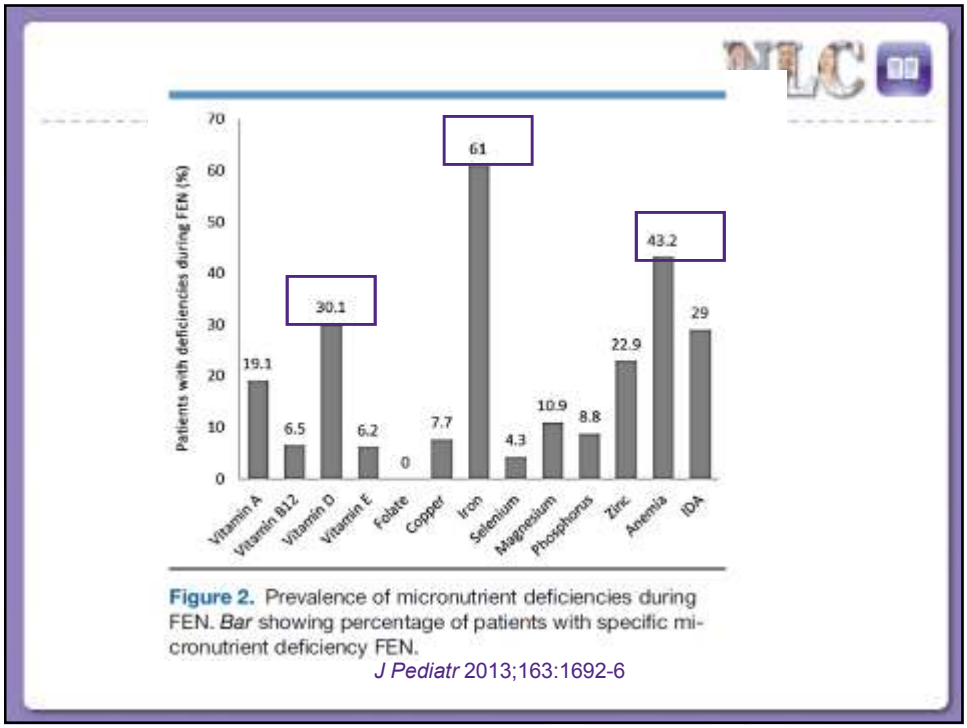
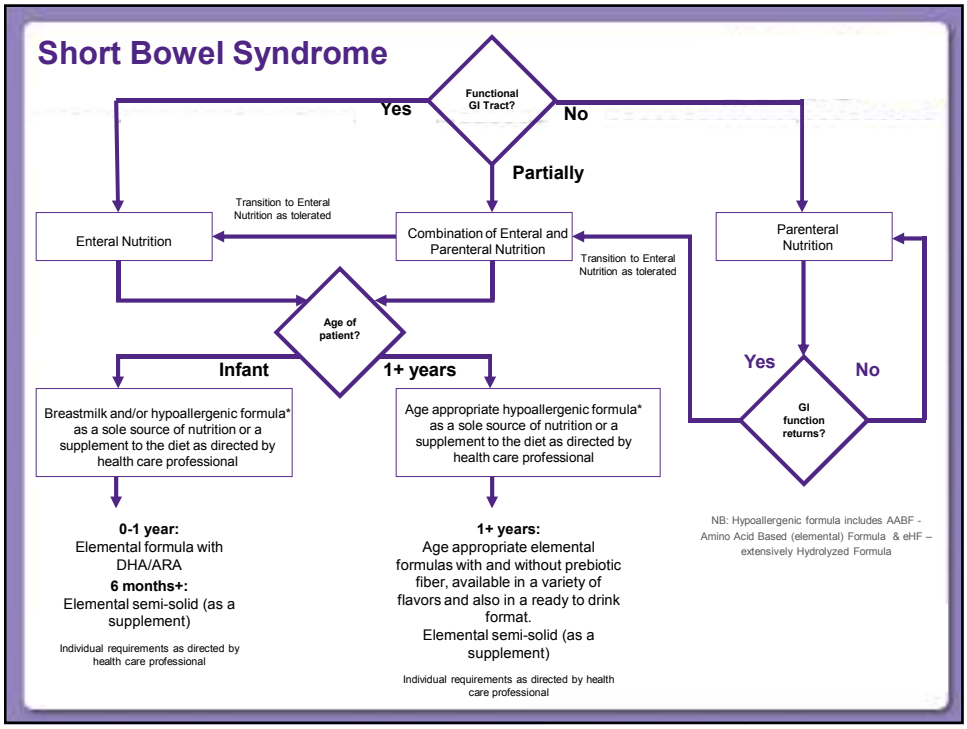
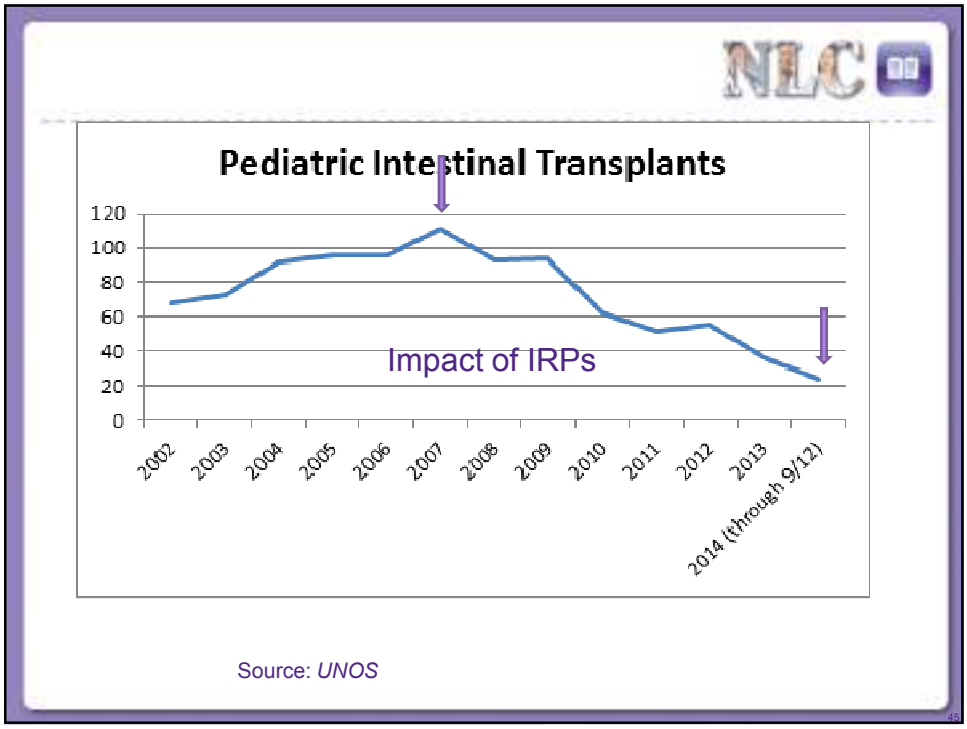


Figure 2. Prevalence of micronutrient deficiencies during FEN. *Bar* showing percentage of patients with specific micronutrient deficiency FEN.

J Pediatr 2013;163:1692-6





Source: *UNOS*

Summary

- Adaptation is dependent on a number of factors including remnant length including type and presence of a colon
- TPN delivery is associated with numerous complications including vitamin and mineral deficiency
- Use of breast milk and amino acid formulas have been shown to shorten TPN duration, albeit retrospectively
- Use of fiber and prebiotics have been shown in to be helpful in the adaptive process.