Short Bowel Syndrome & Intestinal Transplantation

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Stages of Therapy

- Total parenteral nutrition
- Combination enteral/IV nutrition
- Continuous enteral feeding only
- Weaning to bolus feeding and solid foods
- Dietary modification alone

Parenteral Nutrition Management

Stage 1

- Baseline parenteral nutrition
- Separate infusion to replace excess losses
- Measure electrolyte output to determine replacement fluids

Stage 2

Intraluminal Nutrition

- Enteral-hyperplasia
- Parenteral-no hyperplasia
Benefits of Continuous Enteral Nutrition

- Provides constant mucosal stimulation
- Permits optimal absorption
- Reduces need for parenteral calories
- Decreases risk of TPN liver disease

Predigested Formulas in SBS

- Rapid absorption
- Full use of absorptive surface
- May not be ideal for adaptation
- Adaptation can be maximized by increased rate of infusion
- Osmolality not an issue when given continuously
- Human milk may be an option

Short Bowel Syndrome

Nutritional and other postoperative management of neonates with short bowel syndrome correlates with clinical outcomes

Enteral Nutrition Management

Protein

- Complex proteins are best at inducing adaptation
- Amino acid based formula may avoid allergy in younger infants
- Mixture of amino acids & dipeptides best absorbed

Carbohydrates

- Tend to be osmotic in small children—best to avoid high percentage CHO formulas
- SCFA better absorbed by colon in adults → fiber benefit later in childhood
- Lactose often not a problem except with extensive jejunal resection
- May contribute to D-lactic acidosis in patients with small bowel bacterial overgrowth

Fat

- LCT most trophic to the gut
- MCT - better absorbed in bile & pancreatic deficiencies, however → fewer calories than LCT
  → higher osmotic load than LCT
  → less effective in inducing adaptation
- Mixture MCT & LCT may be beneficial

Glutamine and Growth Hormone

- First attempt at pharmacologic stimulation of adaptation in humans
- Inconclusive benefits in adult studies
- Placebo-controlled pediatric trial showed no clear benefit

Potential Trophic Factors

- Enteroglucagon
- Gastrin
- Neurotensin
- EGF (epidermal growth factor)
- IGF-1 (insulin-like growth factor-1)
- Growth Hormone/Glutamine
- PYY (peptide YY)
- Prostaglandins
- Polyamines
- GLP-II
- Bombesin

Pediatric Growth Hormone Study

- 4 / 12 children had improved oral/enteral nutrition tolerance
  - One patient receiving 37 kcal·kg⁻¹·d⁻¹ parenterally weaned from parenteral nutrition
  - Three patients on enteral nutrition not growing at baseline were doing so by study end
- The other 8 had no improvement in oral/enteral nutrition tolerance
- Nutrient tolerance was not enhanced by GLN supplementation for 3 mo.

EFFECTS OF DIETARY AMINO ACIDS

- Glucose
- Glycine
- Glutamine

DECREASES IN WEEKLY REQUIREMENTS
GLP-II

- Elevated after bowel resection
- Capable of stimulating adaptation
- Produced predominantly in the distal small bowel and colon
- Potentially therapeutically useful in a selected group of patients
  - distal resection
  - no colon

**GLP2 in SBS**

We have observed successful parenteral weaning of several patients with extreme short bowel syndrome despite continued malabsorption. However, cold and exercise intolerance is often a problem in such patients

*This observation has led us to believe that metabolic adaptation, i.e. depressed metabolic rate, may be a key adaptive factor that is allowing these patients to maintain their growth.*

**WEANING FROM PARENTERAL NUTRITION IN SHORT BOWEL SYNDROME: ALL ADAPTATION IS NOT INTESTINAL**

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### WEANING FROM PARENTERAL NUTRITION IN SHORT BOWEL SYNDROME: ALL ADAPTATION IS NOT INTESTINAL

<table>
<thead>
<tr>
<th></th>
<th>Patient A</th>
<th>Patient B</th>
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</thead>
<tbody>
<tr>
<td><strong>Age (yrs)</strong></td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>26.1</td>
<td>21.1</td>
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<tr>
<td><strong>Small Bowel Length (cm)</strong></td>
<td>7</td>
<td>19</td>
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<tr>
<td><strong>Mean VO₂ (mL/kg/min)</strong></td>
<td>3.92</td>
<td>3.07</td>
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<tr>
<td><strong>Mean Kcal/min</strong></td>
<td>0.83</td>
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<tr>
<td><strong>Calculated RER % of Normal</strong></td>
<td>1195</td>
<td>1051</td>
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<td>78</td>
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</tbody>
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### Progressing Enteral Feedings

**Stages 2 and 3**

- Enteral feedings 24 h/day
- Feed solids around NG tube
- Intermittent TPN
- Gradually decrease TPN duration
- May give TPN q.o.d. as needs decrease
- Nighttime enteral infusion helpful
SBS
Solid Foods

- Feed high fat, high protein (meats) in small children
- Avoid carbohydrates (osmotic & bacterial load) in small children
- Use small frequent balanced meals in adults

Chronic Complications
Stage 4

- Nutritional deficiency
- Poor bone mineralization
- PN liver disease
- Loss of venous access
- Bacterial overgrowth

Nutritional Deficiency States

- Vitamin B12
- Fat-soluble vitamins - A, D, E, K
- Trace metals - zinc
- Certain minerals - calcium, magnesium
- Monitor when PN discontinued

Prevention of PN Liver Disease

- Aggressive use of enteral feedings
- Prevention of catheter sepsis
- Prevention of bacterial overgrowth
- Cycle TPN
- Correct use of Lipid

Baseline and follow-up values for direct bilirubin and CRP versus enteral intake (1 cal = 4.184 J) from the start of parenteral fish oil therapy

Small Bowel Bacterial Overgrowth
Major Factor in Many Cases

- Increased bacterial content in small bowel
- Bile salt deconjugation
- Mucosal inflammation
- All exacerbate malabsorption

Complications of Bacterial Overgrowth

- D-lactic acidosis
- Colitis or ileitis
- Arthritis

Possible Pathophysiology of Bacterial Overgrowth

- Increased numbers of organisms
- Predominance of invasive strains
- Immunologic reaction to absorbed bacterial antigens

Bacterial Overgrowth

- Not always bad – SCFA production, etc
- Problem arises from inflammation
- Mucosal injury impairs absorption and adaptation
- Depends on strains present and individual reactions to these strains

Treatment Strategies of Bacterial Overgrowth

- Antibiotics: (intermittent, rotating, continuous, cultures may not help)
  - Goal: change, not eliminate flora
- Gut lavage (PEG with electrolytes)
  - Goal: Reduce number of invasive bugs
- Immune modulation
  - Goal: Reduce inflammation
- Dietary change
  - Goal: Reduce fermentation
Probiotic Potential
Strain Selection
• Non-invasive strain
• Anti-inflammatory properties
• Produce anti-inflammatory SCFA’s
• Down-regulate allergic response
• Clinical experience disappointing

Functions of Ileocecal Valve
• Loss associated with poor prognosis
• Prevents small bowel bacterial overgrowth
• Increases small intestinal transit time
• Multiple attempts have been made to duplicate its function

Effect of Anti-motility Agents
Loperamide, etc.
• Positive : increased absorption
  - greater nutrient contact with mucosa
• Negative : increased transit time
  - bacterial overgrowth

Surgical Options in SBS
• Reduce bacterial overgrowth YES
  - taper or narrow bowel
  - resect tight anastomosis
• Increase length of bowel MAYBE
  - lengthening procedure (Bianchi)
  - serial transverse enteroplasty (STEP)
Bianchi Procedure
Results UNMC

- 12 patients, age 3.5 months - 19 years
- 7 -- reduction in TPN by 30-80%
- 4 -- permanently off TPN
- 1 -- TPN requirements increased

Limitations of Bianchi

- Location (Not duodenum)
- Blood vessel distribution
- Learning curve
- Late dilatation, dysmotility

STEP Procedure
Serial Transverse Enteroplasty


Small Bowel Length Before and After STEP

Percent Enteral Calories Before and After STEP

- The second STEP: the feasibility of repeat serial transverse enteroplasty
  - Hannah Piper, Biren P. Modi, Heung Bae Kim, Dario Fauza, John Glickman and Tom Jaksic

Factors Influencing Prognosis

- Diagnosis of intestinal atresia
- Small bowel length
- Absence of ileocecal valve
- Loss of colon
- Recurrent sepsis

Intestinal Transplantation-Stage 5 Indications

- Liver/small bowel - intestinal failure with: end stage liver disease
- Isolated - intestinal failure with: venous access limitations recurrent sepsis
  - early hepatic dysfunction
  - recurrent sepsis

Survival by Era

Healthier Patients Do Better

Graft-survival rates after intestinal transplantation have significantly improved over time (P < 0.001).

Patient survival rates noted in the time of transplantation show significantly higher survival rates in patients who are waiting at home.
Isolated Liver Transplantation in Short Bowel Syndrome

Long-term Outcome, Growth And Digestive Function In Children 2 To 18 Years After Intestinal Transplantation

Ten Year Review Of Short Bowel Syndrome Data From Pittsburgh

Decision To Perform Liver/small Bowel Transplant

- What is likelihood of 2 year survival without transplant
  - bilirubin
  - prothrombin time
  - liver biopsy
  - rate of progression
- What is prognosis with transplant?

Decision To Perform Isolated Bowel Transplant

- Prognosis without transplant
  - is long-term TPN viable?
- Prognosis with transplant
- Lifestyle considerations No!
- Cost considerations Difficult to assess
### Decision To Perform Isolated Liver Transplant

- Prognosis without transplant
- Gut length and anatomy
- Underlying intestinal disease
- History of adequate trial of aggressive enteral nutrition and appropriate therapy

### Intestinal Transplantation Requirements to Become Standard Therapy

- When compared to home PN
  - better quality of life
  - fewer risks
  - lower costs
- Despite claims otherwise we still are not there