Pediatric Enteral Nutrition

A Comprehensive Review

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Disclosure: Support for this educational activity was provided by Nestlé HealthCare Nutrition, Inc.
Objectives

- History
- Indications
- Modes of delivery/tubes
- Principles of designing and monitoring enteral support
- Special populations:
  - Short bowel syndrome
  - Cerebral palsy
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Disclosures

• Educational Support for the NASPghan Foundation & NASPghan Pediatric Enteral Nutrition: A Comprehensive Review Slide Set was provided by Nestlé HealthCare Nutrition, Inc.

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No disclosures
List of Abbreviations

AA - amino acid
Ca – calcium
CARS - compensatory anti-inflammatory response syndrome
CHO - carbohydrate
CF - cystic fibrosis
CP - cerebral palsy
DXA - dual x-ray absorptiometry
EGF - epidermal growth factor
ELBW - extra low birth weight
ENT- Otolaryngologist
EPO - erythropoietin
EN - enteral nutrition
FFA - free fatty acid
FTT - failure to thrive
GI – Gastrointestinal
G-J - gastro-jejunal
GRV - gastric residual volume
GT – gastrostomy tube
HMF - Human milk fortifier
ICU - Intensive Care Unit
K - potassium
LBW - low birth weight
MCT - medium chain triglycerides
Mg - magnesium
Na - sodium
NEC – necrotizing enterocolitis
NG - nasogastric tube
NNH - number needed to harm
NNT - number needed to treat
PEG - percutaneous endoscopic gastrostomy
PICU - pediatric intensive care unit
Phos - phosphorus
PN - parenteral nutrition
QoL - quality of life
RFS - re-feeding syndrome
RTF - ready to feed
SBS - short bowel syndrome
Se - selenium
SIRS - systemic inflammation syndrome
SLP - Speech Language Pathologist
TEF - transpyloric enteral feeding
Zn - zinc
VLBW – very low birth weight
History of EN

18th Century
- John Hunter designed orogastric probe
- Whalebone encased in eel skin
- Jellies, eggs with milk, water with sugar beaten in

1930s:
- Protein hydrolysate formulations fed to surgical patients

1940s:
- First infant formula created: protein hydrolysate, corn oil, dextrimaltose, vitamins and minerals

1950s:
- Plastic tubing and pumps invented
- Formulations of blended infant foods

1960s:
- Advanced understanding of nutrient needs and design of liquid formulas
Indications
Indications for Nutrition Intervention

• There is no Grade A level evidence that indicate that EN will shorten stay or improve outcomes
  – Logically nutrition is needed for healing and metabolic processes
  – Adult studies indicate that the malnourished benefit from nutritional intervention
  – Can be used as exclusive or partial support

Pediatric Enteral Nutrition

- Enteral nutrition is the provision of nutrients via the gastrointestinal tract.

- Enteral nutrition maintains the integrity of the GI tract and is associated with fewer infections than parenteral nutrition\(^1\)

- Children who require EN support are those that
  - Eat less than 80% of needs by mouth
  - Require an extended period of time to eat

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Progressive Intervention

- Attempt oral feeding first. If the gut works, use it
  - There are no trials comparing enteral versus parenteral nutrition
  - EN is physiologic, has reduced, or less severe, incidence infection as compared to parenteral EN, and is cost effective.

- If the patient cannot take enough nutrition orally or has intolerance, then begin NG feedings
  - Bolus usually first
  - Drip next

- If intolerant of NG feedings then transpyloric
  - Must be continuous feedings

EN Considerations

• Fluid
  – Cardiac and renal patients often have fluid volume limits
  – Requires adjustment of nutrition plan

• Electrolytes
  – K most common problem

• Protein
  – Used to worry more in renal patients
  – Restrictions have eased in recent years
Nasogastric (NG), Nasoduodenal (ND) and Nasojejunal (NJ) Tubes

NG tubes are temporary feeding tubes placed manually via the nose and esophagus into the stomach.

When feedings are not tolerated in the stomach, the tube may be placed into the duodenum (ND) or jejunum (NJ).

[Image: Inserting a nasogastric (NG) tube]


www.cincinnatichildrens.org/health/n/nasojejunal-kangaroo
# Enteral Feeding Methods

## Gastric Vs. Post-pyloric - I

<table>
<thead>
<tr>
<th>Site</th>
<th>Delivery Route</th>
<th>Indications</th>
<th>Potential Complications</th>
</tr>
</thead>
</table>
| Stomach       | Orogastric (infants)    | • Short-term nutrition support (6-8 wks)  
• Inadequate oral intake due to increased needs or anorexia of chronic disease  
• Refusal to eat  
• Nocturnal feeds  
• Inability to suck or swallow | • Aspiration  
• Nasal mucosal ulceration  
• Tube occlusion  
• Pneumothorax  
• Bleeding  
• Epistaxis  
• Sinusitis  
• Otitis Media |
|               | Nasogastric             |                                                                                                        |                                                 |
| Gastrostomy   |                         | • Long term tube feeding  
• Congenital anomalies, such as tracheoesophageal fistula, esophageal atresia  
• Esophageal injury/obstruction  
• Failure to thrive | • Dislodgement  
• Aspiration  
• Tube deterioration  
• Bleeding  
• Tube occlusion  
• Pneumoperitoneum  
• Wound infection  
• Stoma leakage |

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## Enteral Feeding Methods

### Gastric Vs. Post-pyloric - II

<table>
<thead>
<tr>
<th>Site</th>
<th>Delivery Route</th>
<th>Indications</th>
<th>Potential Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transpyloric</td>
<td>Nasoduodenal</td>
<td>Congenital upper GI anomalies</td>
<td>Pneumatosis intestinalis</td>
</tr>
<tr>
<td>Postpyloric</td>
<td>Nasojejunal</td>
<td>Inadequate gastric motility</td>
<td>Bleeding</td>
</tr>
<tr>
<td></td>
<td>Gastrojejunal</td>
<td>High aspiration risk</td>
<td>Dislodgement</td>
</tr>
<tr>
<td></td>
<td>Jejunostomy</td>
<td>Severe GER</td>
<td>Tube deterioration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Functioning intestinal tract with obstruction above it</td>
<td>Tube occlusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bowel obstruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stomal leakage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wound infection</td>
</tr>
</tbody>
</table>
What is a G Tube?

- A G tube is a tube placed into the stomach through an opening called a stoma.
Tube goes through the abdominal wall.
Methods for inserting a GT

- By Surgery:
  - Open surgical gastrostomy
  - Laparoscopic gastrostomy placement

- By Endoscopy:
  - Percutaneous endoscopic gastrostomy

- By Radiology:
  - Interventional Radiology placement
‘PEG’

- Percutaneous endoscopic gastrostomy
- Ponsky Pull
- Inserted under anesthesia
- Stay for a few days in hospital afterwards

http://vimeo.com/32507507
PEG tubes

- Tubes are changed after 3 months to smaller button G tubes
A G-J tube is a tube that is placed via the opening into the stomach (stoma) and passes through the pylorus into the mid section of the small intestine (the jejunum). It has a G port which can be used for gastric decompression with jejunal feeds, gastric med delivery or bolus feeds. The j port can be used for continuous feeds.
Why Use a G or J Tube?

• A G tube allows need to EN to be met by feeding into the stomach

• A J tube can be used when needs for EN may not be met by feeding into the stomach, allowing EN feeding to occur past the stomach, i.e. in the jejunum
  – Cannot use bolus feeding technique beyond the pylorus due to dumping syndrome
Replacement Gastrostomy Tubes

These tubes have a balloon at the end that goes into the stomach. Replacement tubes are used after the initial tract has healed.
Balloon Devices

- Button
- AMT balloon button
- Mickey balloon button

Catheter tubes
- Mic Tube (high profile)
- Foley Catheters
Replacement Gastrostomy Tubes

This is a low profile G tube that is held in place by a mushroom shaped dome inside of the stomach. There is no balloon port.
Bard Button

No balloon port
G-J tube

- Goes in through stomach and has 3 ports: one ends in stomach; one ends in jejunum and one is the balloon port. Can be low profile or long version

- Medications given through G tube have a risk for clogging of the J tube limb
Name That Tube!

Cor-Pak feeding tube with stylet

Bard button

High-profile gastrostomy

High-profile GJ
Basic Care of Tubes I

- Daily washing of site with soap and water as needed. Dry skin well. Do not use hydrogen peroxide. Do not apply occlusive dressings.
- Inspect site for infection, leakage or skin irritation/breakdown. If leakage present, always protect the peristomal skin with a skin barrier.
- Check water in balloon if having leakage from stoma or tube appears too tight or too loose.
- Every patient with G tube should have access to a replacement tube (via their homecare company).
Basic Care of Tubes II

- Consider measuring Low Profile G tubes for proper fit at least once a year or at any time the tube appears too tight or loose or with significant weight fluctuation.

- Rotate the gastrostomy hub position to minimize pressure.

- Prevent clogged tubes by flushing the tube with sterile water before and after each medication and feedings. Post pyloric tubes (G-J, ND, NJ or surgical jejunostomies) clog easily and often require more frequent flushing. Avoid clogging J tubes by using liquid medications when possible, diluting viscous meds with sterile water, and not mixing meds directly into formula.
Bolus vs. Continuous Feedings

**Bolus**
- Can mimic or supplement meals
- More physiologic
- May not require a pump
- Freedom of movement between feedings
- Only GT feeding
- Can promote osmotic diarrhea

**Continuous**
- Slow infusion may improve tolerance and absorption
- Can be given overnight to avoid disruption of daytime schedule and oral intake
- Encourages intestinal adaption by constant mucosal stimulation
- Reduces need for parenteral calories

Review of EN Components

Additives
Immune Input

- Probiotics
  - Evidence of decreased infectious illnesses, especially diarrheal illnesses
  - Now present in some infant formulas

- Prebiotics
  - Growth factors that foster the growth of “good bacteria” in the gut e.g., inulin, fructooligosaccharides (FOS)
Enteral Feeding Questions

- Fiber? Helps with stooling issues
  - Soluble versus insoluble
- Transpyloric feeds - Elemental?
  - Tolerance okay
  - Animal studies; absorption better
- When are adult EN formulas suitable?
  - Adolescent? Ca and Phos needs to be higher
  - Do contain higher protein content
Blended Formula

- One commercially available
  - Compleat® Pediatric

- Parents perceive as better
  - Potential to be nutritionally incomplete without guidance
  - Resources available with carefully worked out recipes
  - Labor intensive for the family
Principles of Designing/Monitoring Pediatric EN Support

Age / Medical Condition
Administration

• The route of and duration (bolus vs. continuous) of enteral administration depends on:
  - Indication for EN, the duration of need
  - Anatomical integrity of the GI tract
  - Functional integrity of the GI tract
  - Risk of aspiration
Bolus vs. Continuous Feeds

- Enteral feeds may be given as bolus (intermittent), continuous, or a combination

- **Bolus Feedings**

<table>
<thead>
<tr>
<th>Age</th>
<th>Initiation</th>
<th>Advance</th>
<th>Suggested Tolerance Volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 12 months</td>
<td>10 – 15 mL/kg every 2 to 3 hours</td>
<td>10 to 30 mL per feed</td>
<td>20 to 30 mL/kg every 4 to 5 hours</td>
</tr>
<tr>
<td>1 - 6 years</td>
<td>5 – 10 mL/kg every 2 to 3 hours</td>
<td>30 to 45 mL per feed</td>
<td>15 to 20 mL/kg every 4 to 5 hours</td>
</tr>
<tr>
<td>&gt; 7 years</td>
<td>90 to 120 mL every 3 to 4 hours</td>
<td>60 to 90 mL per feed</td>
<td>330 to 480 mL every 4 to 5 hours</td>
</tr>
</tbody>
</table>

- **Continuous Feedings**

<table>
<thead>
<tr>
<th>Age</th>
<th>Initiation</th>
<th>Advance</th>
<th>Suggested Tolerance Volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 12 months</td>
<td>1 to 2 mL/kg/hour</td>
<td>1 to 2 mL/kg every 2 to 8 hours</td>
<td>6 mL/kg/hour</td>
</tr>
<tr>
<td>1 - 6 years</td>
<td>1 mL/kg/hour</td>
<td>1 mL/kg every 2 to 8 hours</td>
<td>1 to 5 mL/kg/hour</td>
</tr>
<tr>
<td>&gt; 7 years</td>
<td>25 mL/hour</td>
<td>25 mL every 2 to 8 hours</td>
<td>100 to 150 mL/hour</td>
</tr>
</tbody>
</table>
## Monitoring / Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
<th>Hospital</th>
<th>Outpatient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometrics</strong></td>
<td>Weight Height</td>
<td>Daily Baseline</td>
<td>Daily Monthly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weekly- monthly Monthly or at clinic</td>
</tr>
<tr>
<td><strong>Intake</strong></td>
<td>Calories, protein, fluid</td>
<td>Daily</td>
<td>Weekly</td>
</tr>
<tr>
<td><strong>GI Tolerance</strong></td>
<td>Abdominal girth, residuals, emesis</td>
<td>As ordered, reported</td>
<td>As ordered, reported</td>
</tr>
<tr>
<td><strong>Stool/ Ostomy</strong></td>
<td>Volume, frequency, consistency</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td><strong>Tube Placement</strong></td>
<td>Prior to each feeding</td>
<td>Prior to each feeding</td>
<td>Prior to each feeding</td>
</tr>
<tr>
<td><strong>Tube Site</strong></td>
<td>Daily</td>
<td>Daily</td>
<td>Daily</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Problem</th>
<th>Prevention/Intervention</th>
</tr>
</thead>
</table>
| Diarrhea/ Abdominal Cramping | • Decrease delivery rate  
                               • Recognize or avoid drugs that result in diarrhea  
                               • Consider fiber containing products  
                               • Consider osmolarity and addition of modular additives  
                               • Semi-elemental or elemental formula if indicated |
| Vomiting/ Nausea         | • Ensure formula is always at room temperature prior to tube feedings  
                               • Elevate head of bed  
                               • Consider postpyloric or continuous feeding |
| Hyperglycemia            | • Reduce flow rate  
                               • Use formulas with minimal simple sugars  
                               • Consider insulin if clinically indicated |
<table>
<thead>
<tr>
<th>Problem</th>
<th>Prevention/Intervention</th>
</tr>
</thead>
</table>
| Constipation                           | • Ensure optimal fluid intake  
• Increase free water intake  
• Change to a product containing fiber                                              |
| Gastric Retention of Formula           | • Monitor for correct tube placement  
• If residuals are high (>2 hour volume of feeds), hold feeds; recheck residuals in 1 hour  
• Consider continuous or postpyloric feeding  
• Position patient on right side                                                      |
| Clogged Feeding Tube                   | • Ensure tube is flushed after checking residuals, boluses and every 4 – 8 hours with continuous feeds  
• Check tubing size for appropriateness for some formulas  
• Infuse formula past pylorus  
• Consider continuous infusion                                                       |
Selecting the Right Formula

- Select formula based on gut function and volume tolerance
  - Normal function
    - Able to tolerate intact protein and long chain fats
  - Abnormal function
    - Unable to tolerate intact protein related to allergy or malabosorption
    - Unable to tolerate long chain fats related to liver function, pancreatic function or malabsorption
  - Volume tolerance
    - Fluid restricted
<table>
<thead>
<tr>
<th>Standard</th>
<th>Protein</th>
<th>Fat</th>
<th>CHO</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal bowel function</td>
<td>Oral Tube</td>
<td>Whole protein</td>
<td>Long-chain fats</td>
<td>Lactose-free</td>
</tr>
<tr>
<td>Normal fluids requirements</td>
<td></td>
<td></td>
<td></td>
<td>• Nutren® Junior (1-10 yr)</td>
</tr>
<tr>
<td></td>
<td>Tube</td>
<td>Whole protein</td>
<td>long-chain fats</td>
<td>• Pediasure® (1-10 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Ensure® (11yr-adult), Nutren® 1.0</td>
</tr>
<tr>
<td>Volume Intolerance</td>
<td>Concentrated</td>
<td>Whole protein</td>
<td>Varies</td>
<td>Lactose-free</td>
</tr>
<tr>
<td>Normal/ Abnormal bowel function</td>
<td></td>
<td></td>
<td></td>
<td>• Compleat® Pediatric (1-10 yr)</td>
</tr>
<tr>
<td>Increased calorie and protein</td>
<td></td>
<td></td>
<td></td>
<td>• Jevity® 1 cal (11yr-adult)</td>
</tr>
<tr>
<td>needs</td>
<td></td>
<td></td>
<td></td>
<td>• Osmolite® (11yr-adult)</td>
</tr>
<tr>
<td>Fluid restricted</td>
<td></td>
<td></td>
<td></td>
<td>• Jevity® (fiber) (11yr-adult)</td>
</tr>
<tr>
<td>Impaired Digestion/Allergy</td>
<td>Peptide</td>
<td>Hydrolyzed</td>
<td>Mix of MCT and LCT fat</td>
<td>Varies: corn syrup solids</td>
</tr>
<tr>
<td>Abnormal bowel function</td>
<td>Based</td>
<td>whey-protein 3-5 peptide chains</td>
<td></td>
<td>• Peptamen® Junior</td>
</tr>
<tr>
<td>Unable to digest fully</td>
<td></td>
<td></td>
<td></td>
<td>• Pediasure® Peptide (1-13 yr)</td>
</tr>
<tr>
<td>intact protein,</td>
<td></td>
<td></td>
<td></td>
<td>• Nutramigen®, Pregestimil®</td>
</tr>
<tr>
<td>carbohydrate or fat.</td>
<td></td>
<td></td>
<td></td>
<td>• Peptamen® 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Vital® HN</td>
</tr>
</tbody>
</table>
## Formula - II

<table>
<thead>
<tr>
<th>Condition</th>
<th>Protein</th>
<th>Fat</th>
<th>CHO</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Abnormal bowel function                  | Amino acid Based  | Free amino acids         | Mix of MCT and LCT fat | • Elecare® infant, Elecare® Jr,  
• Neocate®, Neocate® Jr  
• Nutramigen® AA  
• Tolerex® (Free amino acids) |
| Related to allergy, malabsorption, short gut |                   |                          | Corn syrup solids |                                              |
| Fat malabsorption                        | Fat Mal-         | Intact whole protein / casein | Contain 55% or greater MCT oil, DHA, ARA | • Portagen®  
• Enfaport®  
• Pregestimil®  
• Tolerex® (Free amino acids)  
• Vital® HN |
| Related to chylothorax Pancreatitis      |                   |                          |                |                                              |
| Disease Specific                         | Varies           |                          |                | • Nutren Glytol (diabetic)  
• Optisource® (bariatric surgery)  
• Pulmocare®  
• Suplena® (renal) |
Outline of Products

• Infant Formulas
  - 0 to 1 year of age

• Pediatric Formulas
  - 1 to 13 years of age

• Specialized formulas/supplements

• Modular Additives
Children 1-10 years, vitamins/minerals

- 30 kcal/oz (1 kcal/ml)
- Milk based (whey, casein)
- With or without fiber
- Usually gluten-free, lactose-free
Specialty Pediatric Formulas

Semi Elemental

- Partially hydrolyzed protein (casein or whey)
- Indications:
  - Malabsorption/GI impairment
    - Short bowel syndrome, IBD
  - Protein allergy
    - Most children will outgrow their protein allergies
- Costly: $
Specialty Pediatric Formulas

Elemental

• Broken down even more = Free AA
• Decreased palatability
• Indications:
  – Severe multiple food protein allergy/intolerance
  – Eosinophilic esophagitis
  – Gastrointestinal tract impairment/malabsorption
  – Severe GERD
• Costly: $$$
Modular Additives - Protein

- Modular additives are used to increase kcals and/or protein
- Protein
  - Beneprotein®
    - Whey and soy protein isolates
    - NOT for milk protein allergy!!
  - Amino acid module
Modular Additives - CHO

Carbohydrate

- **Polycose® powder**
  - Low osmolality, minimal sweetness

- **Cornstarch**
  - Slow release CHO – helpful to treat hypoglycemia/dumping
  - **NOT** for 24 hour batch/continuous feeds. Thickens over time
  - Add at time of feeding

- **Corn syrup, dextrose, fructose, sucrose**
  - Not used often
Modular Additives - Fat

- **Corn oil (8.4 kcal/mL)**
  - Over the counter, inexpensive
  - Oleic/linoleic unsaturated. Fatty acids
  - Boluses acceptable
- **MCT Oil® (7.7 kcal/mL)**
  - Absorbed directly into portal system (bile salts & lipase not needed)
  - Does not contain EFA
  - Expensive
  - Good for patients with cholestatic liver disease
- **Microlipid® (4.5 kcal/mL)**
  - Safflower oil
  - 50% fat emulsion – mixes well with formulas/foods
- **MCT Procal**
  - 97% MCT per 16g sachet – powder form
  - Contains milk protein and lactose
Modular Additives - Combination

DuoCal®

- Used mostly in outpatient clinic
- Dissolves in waters, liquids and moist foods
- No altered taste
- High kcal (cornstarch + refined vegetable oils + MCT)
- Protein free, lactose free, gluten free
Overview of EN Support in Special Populations

Short Bowel Syndrome/
Intestinal Failure
Short Bowel Syndrome (SBS)/Intestinal Failure

- Functional definition (not dependent on length alone)
  - Malabsorptive state occurring as a result of the loss of a significant portion of the intestine
  - Characterized by the inability to maintain protein-energy, fluid, electrolyte or micronutrient balances when on a conventionally accepted, normal diet.

- Results from surgical resection, congenital defect or disease-associated loss of absorption
  - Most frequent cause is surgical resection due to NEC
  - Other causes of include intestinal atresia, gastroschisis, midgut volvulus, or later in childhood from trauma or Crohn's disease

Factors Affecting Patient Outcomes

- PN has dramatically improved the historically dismal prognosis of SBS.
  - Prior to PN, severe SBS was invariably fatal from dehydration, electrolyte deficiencies and malnutrition.

- Today, factors associated with the prognosis of SBS-associated intestinal failure are:
  - Underlying disease and age of patient
  - Length of residual small intestine and functional bowel
  - Presence/absence of the colon and of the ileocecal valve
  - Status of enteral dependence or independence.

Principles of Nutritional Care of SBS

- EN key to intestinal adaptation and reduction of dependence on PN
- Goals in nutrition management
  - Keep the infant/child well nourished and growing
  - Keep fluid and electrolyte status stable
  - Maximize the process of bowel adaptation
- Successful transition to EN feeding depends upon
  - Length of remaining bowel & percentage of daily energy intake enterally
  - Remaining segments of small bowel and intestinal continuity
  - Presence of the colon and an intact ileocecal valve
  - Intestinal adaptation

Sites Of Absorption

- Carbohydrates
- Fats
- Proteins
- Calcium
- Magnesium
- Trace elements
- Vitamins

Iron and Folate

Water and Electrolytes

Short chain Fatty acids

Vitamin B12 and bile salts
Nutritional Consideration with Bowel Loss

**Jejunum**
- Primary site for digestion and absorption of most nutrients
- Loss does not result in severe malabsorption because ileum has a large capacity to compensate for increased absorption

**Ileum**
- Ileal loss can predispose to malnutrition, excessive fluid losses and electrolyte deficiencies because the jejunum is more porous and has limited capacity to enhance absorption

**Ileocecal Value**
- Slows down transit time
- Prevents reflux of colonic contents into Small Bowel
- Reduce absorption of vitamin B 12
- Deconjugate bile salts
- Reduce bile salt absorption

**Colon**
- Loss of “colonic brake”
- Loss of water and electrolyte resorptive capacity
- Loss of ability to salvage calories from malabsorbed carbohydrates.
Nutrition Therapy

- TPN – ensure adequate nutrition and hydration
- Enteral feeding
  - Formula type
  - Route: oral, NG, GT
  - Bolus vs. continuous
  - Progression to solids

Total Parenteral Nutrition

• Essential for survival in SBS, but may contribute to the mortality of this condition

• Allows adequate macro and micronutrient intake in individuals with intestinal failure

• Clinical Disadvantages
  
  – Does not promote intestinal adaptation

  – PN-associated cholestasis (PNALD) / Intestinal failure-associated liver disease (IFALD)

  – Metabolic complexity

  – Requires central line – nidus for infection and clot formation

Benefit of Feeding Type in SBS

- Breast-milk
  - Immune benefits, contains growth factors, encourages healthy microbiome

- Standard Formula
  - Increased possibility of malabsorption with intact protein, CHO (lactose) and fat source, allergic reaction to cow or soy protein common

- Protein Hydrolysate Formula
  - Lower antigenicity, contains medium chain triglycerides (does not require bile acids or micelles for absorption)

- Amino Acid Formula
  - Shorter duration of TPN
  - Reduced intestinal allergy
  - Higher content of long chain triglycerides which can be trophic to the intestines

SBS Conclusion

• Maintain proper nutrition and growth
• Enteral feeding is the most important stimulus for bowel adaptation
• Continuous enteral feeds results in more nutrient absorption
• Transition to enteral can be a slow and steady process
Overview of EN Support in Special Populations

Cerebral Palsy
Nutrition & Cerebral Palsy

- Under-nutrition, growth failure & overweight may be present
- Micronutrient deficiencies include:
  - Vitamins: C, D & E
  - Trace elements: Se, Zn
  - Essential fatty acids
  - Minerals: Fe, Ca, Phos
- Osteopenia: more prevalent in non ambulatory children and may be related to anti-convulsant therapy & reduced physical activity
- Nutritional monitoring is very important including consultation with RD

Goals & Benefits

• Goals of nutritional therapy
  – Consistent and adequate weight gain
  – Linear growth commensurate with underlying neurological disorder since neurological disease may adversely affect linear growth even in the absence of under-nutrition
  – Optimize functional status and quality of life

• Benefits of nutrition
  – Restore linear growth & normalize weight
  – Improve health and QoL
  – Reduce hospitalization rate and missed fewer days of social activity
  – Decrease irritability and spasticity
  – Increase alertness and enhance development
  – Improve wound healing and peripheral circulation
  – Ameliorate GER

Factors Resulting in Nutritional Deficits

• Nutritional factors
  – Inappropriate dietary intake
  – Oral motor dysfunction, dependency on caretaker, longer mealtimes
  – Increased nutrition losses (spillage, reflux, emesis from gastroparesis)
  – Abnormal energy expenditure

• Non- nutritional factors
  – Type & severity of neurological disability
  – Mechanical forces and ambulatory status: scoliosis, contractures
  – Cognitive ability
  – Genetic factors
  – Endocrine dysfunction: GH
  – Environment: home vs. chronic care facility

Nutrition Assessment - I

• History
  – Medical, nutritional assessment, growth, and social (caretakers)

• Anthropometry
  – Weight, length/height, head circumference, mid arm measurements
  – Alternative measurements of linear growth
  – Always need to use the same method for monitoring
  – Appropriate measuring equipment needed: wheelchair scales, bed scale, anthropometer

Nutrition Assessment - II

• Growth charts
  - Normal or Traditional growth charts may not always be appropriate
  - Many CP specific are available which may be descriptive rather than prescriptive
  - New growth charts stratified for gender and gross motor function classification system level may be useful in prognosis and determining level of intervention
  - If using the CDC or WHO charts, look for trends rather than the absolute percentile, see if the patient is tracking parallel to the 3rd percentile. Remember that not everyone belongs on the 50th percentile

Nutrition Assessment - III

• Physical examination
  – Evaluate for under-nutrition, stunting, overweight
  – Micronutrient deficiencies
    • pallor, skin rash, smooth tongue, gum bleeds, petechiae, bony deformities, edema
  – Other
    • muscle tone, activity, athetosis, contractures, scoliosis, signs of aspiration, abdominal distension, decubitus ulcers

• Meal observation
  – Important to observe
    • portion size offered, spillage, parent child interactions, eating efficiency, oral motor function

Nutrition Assessment -IV

- Laboratory testing
  - CBC, Fe studies, serum electrolytes, Ca, Phos, 25OH vitamin D, albumin and pre-albumin, Zn, Se, vitamin E, linoleic acid and triene:tetraene ratio

- Other testing
  - DXA (lumbar, distal femur, forearm)
  - REE measurements
  - Additional gastrointestinal evaluation as warranted (radiology, ultrasound, endoscopy)

Determining the Nutritional Plan - I

- Individualized plan based on nutritional status, feeding abilities, and medical condition
- Determine a target weight/target skinfold thickness (weight at which the TSF is between the 10-15\textsuperscript{th} percentile)
- Annual nutritional assessments at a minimum and increased frequency in younger children
- EN is preferred vs. PN
- Oral diets are preferable. May need to use thickened fluids in patients with dysphagia and aspiration.
- Positioning of the patient is important for oral feeding along with the use of an oromotor therapist.
- Behavior modification and feeding therapy will help with food acceptance

Determining the Nutritional Plan - II

- Tube feeds if patients cannot orally meet nutritional needs
- Formula is preferable to blenderized diets due to risks of infection, inappropriate composition, and clogging of tubes
- Ethical considerations
  - tube placement is sensitive issues for some families
  - thoughtful discussions and consideration of parental wishes is key
- Energy intake
  - WHO equation is easy requiring only weight, age, and activity/stress factor but may overestimate calories.
  - In general would use lower number, response to therapy, and subsequent weight measurements to adjust caloric intake
- Fluid
  - Often patients do not receive maintenance fluids

Determining the Nutritional Plan - III

- All regiments need to be assessed to provide enough protein, vitamins, and minerals
- Protein
  - Insufficient data; but often low intake documented
- Micronutrients
  - Deficiencies exist; supplementation may be required
- Route of administration of feeds
  - Short-term (NG, NJ tubes); long-term (G, G-J, J tubes)
- Method of administration or tube feeds:
  - Bolus feeds are more physiological, flexible, and convenient in ambulatory children
  - Continuous feeds (day or night) used with feeding intolerance or with JT

Picking a Formula

- No one formula meets needs of all children with CP
- Often need to manipulate formula to provide adequate protein in the face of low calories and use modular formulas, vitamins and electrolyte solutions, or combine two formulas
- Calorie needs may be very low; monitor for sufficiency of intake of Na, Phos, K, Ca, Fe, vitamin D, and protein
- Can use standard age appropriate formulas
- Adult formulas may provide more protein but may not meet Fe, vitamin D, Ca, and Phos needs
- Whey based may be better tolerated to enhance gastric emptying
- Fiber can be helpful but may cause bloating if advanced too fast
- If use 1.5 or 2 cal/mL formulas but warrants monitoring of fluid, protein, and micronutrient intake
Feeding Intolerance

• Symptoms
  – Vomiting, reflux, bloating, constipation or diarrhea and nausea

• Treatment
  – Exclude progression of neurological disease, infection, intestinal obstruction
  – Consider
    • change from bolus to continuous feeds
    • decrease rate of infusion
    • concentrate formula to decrease volume
    • alternative formula: whey based formulas are associated with improved gastric emptying
    • treat reflux, gastroparesis, constipation

Summary

• Nutrition plays an important role in the care of patients with CP
• Nutritional status affects prognosis and QoL
• Growth assessment and monitoring is important
• Nutritional regimens need to be individualized and monitored for fluid, calorie, protein and micronutrient adequacy
Are we having fun yet?

Questions?