Objectives

• To understand
  – History
  – Indications
  – Delivery modes
  – Components
  – Monitoring
  – Safety

related to EN for pediatric patients
Program Outline

History

Indications

Delivery Modes/Tubes

Principles of Designing/Monitoring Pediatric EN Support

Age/Medical Condition

Monitoring of Tolerance

Safety
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Disclosures

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- Speaker Disclosure here
# List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>amino acid</td>
</tr>
<tr>
<td>ARA</td>
<td>arachidonic acid</td>
</tr>
<tr>
<td>Ca</td>
<td>calcium</td>
</tr>
<tr>
<td>CHO</td>
<td>carbohydrate</td>
</tr>
<tr>
<td>DHA</td>
<td>docosahexanoic acid</td>
</tr>
<tr>
<td>EN</td>
<td>enteral nutrition</td>
</tr>
<tr>
<td>EFA</td>
<td>essential fatty acid</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>FOS</td>
<td>fructooligosaccharides</td>
</tr>
<tr>
<td>FTT</td>
<td>failure to thrive</td>
</tr>
<tr>
<td>GER(D)</td>
<td>gastroesophageal reflux (disease)</td>
</tr>
<tr>
<td>GI</td>
<td>Gastrointestinal</td>
</tr>
<tr>
<td>G-J</td>
<td>gastro-jejunal</td>
</tr>
<tr>
<td>GRV</td>
<td>gastric residual volume</td>
</tr>
<tr>
<td>GT</td>
<td>gastrostomy tube</td>
</tr>
<tr>
<td>IBD</td>
<td>Inflammatory Bowel Disease</td>
</tr>
<tr>
<td>K</td>
<td>potassium</td>
</tr>
<tr>
<td>MCT</td>
<td>medium chain triglycerides</td>
</tr>
<tr>
<td>Mg</td>
<td>magnesium</td>
</tr>
<tr>
<td>ND</td>
<td>nasoduodenal tube</td>
</tr>
<tr>
<td>NG</td>
<td>nasogastric tube</td>
</tr>
<tr>
<td>NJ</td>
<td>nasojejunal tube</td>
</tr>
<tr>
<td>Phos</td>
<td>phosphorus</td>
</tr>
<tr>
<td>RFS</td>
<td>re-feeding syndrome</td>
</tr>
<tr>
<td>Se</td>
<td>selenium</td>
</tr>
<tr>
<td>Zn</td>
<td>zinc</td>
</tr>
</tbody>
</table>
History
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 indicates 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 \(^1\)
  – 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

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 of infection as compared to parenteral EN, and is cost effective.\(^1\)

- 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

Delivery Modes/Tubes
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).


www.cincinnatichildrens.org/health/n/nasojejunal-kangaroo
What is a G Tube?

• A G tube is a tube placed into the stomach through an opening called a stoma

http://www.adamimages.com
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 for 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
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

Protein
Infant Formulas: Protein Content

• Divided into 4 classes of formulas:
  – Cow’s milk–based formulas
    • Preterm and follow-up preterm formulas as well
    • Partially hydrolyzed whey; not considered hypoallergenic but less allergic diseases
  – Soy formulas
  – Casein hydrolysate formulas
  – Amino acid–based formulas

Review of EN Components

Carbohydrates
Infant Formulas – CHO

• Main types of carbohydrate in formulas\(^1\)
  – Lactose
  – Sucrose
  – Glucose polymers

• Galactosemia: soy formulas, because they do not contain lactose\(^2\)
  – Isomil\(^\circledast\)

• Which formulas contain sucrose?\(^1\)
  – Alimentum\(^\circledast\) and soy formulas, except Prosobee\(^\circledast\)

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1. Perlstein D. *Infant Formulas*. MedicineNet.com
Review of EN Components

Fat
Infant Formulas – Fat Content

• Main types of fats in formulas
  – Long-chain triglycerides
  – MCTs
• When are MCTs beneficial?
  – Impaired fat absorption or lymphatic abnormalities
  – Cystic fibrosis, short gut syndrome, cholestasis, and protracted diarrhea
• Which formulas contain MCTs?
  – Alimentum® (33%), Pregestimil® (55%)
  – Enfacare® (20%)
  – Enfaport® (84%)
  – Elecare Infant® (33%), Neocate Infant® (33%)
  – Premie formulas (50%)
  – 3232A (85%)

DHA and ARA

- Docosahexaenoic acid (DHA) and arachidonic acid (ARA), both long-chain polyunsaturated fatty acids
- Present in breast milk; were not in formulas
- Animal models showed increased visual acuity and neurologic development; some infant studies agree
- No harmful effects found
- Now in most infant formulas
- A recent meta-analysis found no effect of DHA/ARA on cognitive development

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)

Standard Cow Milk–Based

- Widely available
- Cheap
- Unflavored, which lowers osmolarity
- Lactose-free
  - Potential for lactose intolerance
- Fat mixture
  - Mixture of long and medium-chain fats
Di- and Tripeptide Formulas

- Not designed for allergy or malabsorption conditions
- Better gastric emptying $^{2,3}$
- Better tolerated
  - Fats contain a percentage of MCT

Elemental Pediatric Formulas

• AA–based

• Contain MCT

• Use for allergic?

• Short bowel
  – Better emptying
  – Absorption immediately

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
Blenderized 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
## 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) Nasogastric | • 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 |
| 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 |

# 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></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpyloric</td>
<td>• Nasoduodenal</td>
<td>• Congenital upper GI anomalies</td>
<td>• Pneumatosis intestinalis</td>
</tr>
<tr>
<td></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>
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>
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</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></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>Daily Baseline</td>
<td>Daily Monthly</td>
<td>Weekly- monthly Monthly or at clinic</td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intake</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calories, protein, fluid</td>
<td>Daily</td>
<td>Weekly</td>
<td>Monthly</td>
</tr>
<tr>
<td><strong>GI Tolerance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal girth, residuals, emesis</td>
<td>As ordered, reported</td>
<td>As ordered, reported</td>
<td>As reported</td>
</tr>
<tr>
<td><strong>Stool/ Ostomy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume, frequency, consistency</td>
<td>Daily</td>
<td>Daily</td>
<td>Report changes in stool pattern</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>
# Monitoring/ Evaluation - I

<table>
<thead>
<tr>
<th>Problem</th>
<th>Prevention/Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea/ Abdominal Cramping</td>
<td>• Decrease delivery rate</td>
</tr>
<tr>
<td></td>
<td>• Recognize or avoid drugs that result in diarrhea</td>
</tr>
<tr>
<td></td>
<td>• Consider fiber containing products</td>
</tr>
<tr>
<td></td>
<td>• Consider osmolarity and addition of modular additives</td>
</tr>
<tr>
<td></td>
<td>• Semi-elemental or elemental formula if indicated</td>
</tr>
<tr>
<td>Vomiting/ Nausea</td>
<td>• Ensure formula is always at room temperature prior to tube feedings</td>
</tr>
<tr>
<td></td>
<td>• Elevate head of bed</td>
</tr>
<tr>
<td></td>
<td>• Consider postpyloric or continuous feeding</td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>• Reduce flow rate</td>
</tr>
<tr>
<td></td>
<td>• Use formulas with minimal simple sugars</td>
</tr>
<tr>
<td></td>
<td>• Consider insulin if clinically indicated</td>
</tr>
<tr>
<td>Problem</td>
<td>Prevention/Intervention</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</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 malabsorption
    - Unable to tolerate long chain fats related to liver function, pancreatic function or malabsorption

- Volume tolerance
  - Fluid restricted
Outline of Products

• Infant Formulas
  – 0 to 1 year of age

• Pediatric Formulas
  – 1 to 13 years of age

• Specialized formulas/supplements

• Modular Additives
Infant Formulas

Standard and Premie

– Goal
  • simulate human milk (20 kcal/oz), Premie (22 kcal/oz or greater)

– Composed of intact protein, CHO, and fat

– Indications
  • functional gastrointestinal tract

– Intended for less than 1 year old
Specialty Infant Formulas

• Protein allergy/malabsorption
  – Cow milk allergy, multiple food allergies
  – Short bowel syndrome

• Fat malabsorption
  – Liver disease
  – Cystic fibrosis
  – Steatorrhea
  – Short bowel syndrome
  – Persistent diarrhea
Standard Pediatric Formulas

Children 1-10 years, vitamins/minerals

- 30 kcal/oz (1kcal/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 water, liquids and moist foods
- No altered taste
- High kcal (cornstarch + refined vegetable oils + MCT)
- Protein free, lactose free, gluten free
Principles of Designing/Monitoring Pediatric EN Support

Monitoring of Tolerance
Monitoring Tube Position

• NG tube surveillance
  – Mark insertion point\(^1\)
  – Recheck X-ray if change in tube length

• NJ tube surveillance
  – As above
  – Recheck X-ray if change in tube length or change in feeding tolerance

Gastric Residual Volumes (GRV)

• No standard practices on how, when and what is a high value gastric residual volume (GRV)

• Difficult to withdraw well with small tube

• No studies that prove correlation of GRV with intolerance

• GRVs result in holding feedings despite no other signs of intolerance¹

Intolerance Interventions

- Drip feedings-continuous
- Consider trial of promotility agents either to advance tube or enhance emptying/feeding tolerance
  - Several promotility agents have side effects
- Trans-pyloric feedings
  - Previous adult studies show it ends up delaying feeding initiation
  - Consider if aspiration risk or intolerance to gastric

Principles of Designing/Monitoring Pediatric EN Support

Safety
Refeeding Syndrome (RFS)

• RFS is a term used to describe the metabolic and clinical changes that can occur during nutritional support of a malnourished patient
  – Normally occurs within 3-4 days after initiating feeds
  – Signs/symptoms include weakness, muscle pain, ataxia, paresthesia, confusion, arrhythmia, seizures
  – Phos depletion is the hallmark and cause of the majority of symptoms

Serum Abnormalities During Refeeding

Serum abnormalities are often seen in patients during refeeding and may include:

- Hypophosphatemia
- Hypokalemia
- Hypomagnesemia
- Glucose abnormalities
- Thiamine deficiency
- Derangements of sodium, nitrogen, and fluid balance

Management Guidelines for RFS

• Identify patients at risk of RFS
  – Check electrolytes (including K, Ca, Phos, Mg, blood urea nitrogen, and creatinine) prior to start of feeding
  – Start refeeding at 50-75% of goal calories and increase to goal over 3-5 days

• Protein does not need to be restricted

• Rehydrate carefully, being careful not to fluid overload

• Monitor K, Ca, Phos, and Mg levels frequently during first four days and replace appropriately

### Electrolyte/Micronutrient Replacements

<p>| | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>K</td>
<td></td>
<td>2-4 mmol/kg daily</td>
</tr>
<tr>
<td>Phos</td>
<td></td>
<td>0.3-0.6 mmol/kg daily</td>
</tr>
<tr>
<td>Mg</td>
<td></td>
<td>0.2 mmol/kg daily IV or 0.4 mmol/kg daily orally</td>
</tr>
</tbody>
</table>

**Multivitamin and mineral supplementation**

- Thiamine, Zn, and Se
- Fe usually not given during initial phase, as increased risk of infection and oxidative stress

Summary

• Consider EN in patients who cannot take enough nutrition orally or have intolerance to oral feeding

• A variety of enteral tubes, feeding modalities and formulas are available
  – Each should be tailored to the individual patient

• Patients should be monitored to ensure tolerance of EN

• RFS should be anticipated in malnourished patients who are begun on EN and should be prevented / managed