

# Pediatric Enteral Nutrition

## *A Comprehensive Review*

**NASPGHAN**

NORTH AMERICAN SOCIETY FOR  
PEDIATRIC GASTROENTEROLOGY,  
HEPATOLOGY AND NUTRITION



**NASPGHAN**

FOUNDATION  
For Children's Digestive Health & Nutrition

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Disclosure: Support for this educational activity was provided  
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# 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

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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

**IBD** - Inflammatory Bowel Disease

**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

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# History of EN

## 18<sup>TH</sup> 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 <sup>1</sup>
  - Can be used as exclusive or partial support

Gramlich et al. *Nutrition*. 2004;20(10):843-8.

Kleinman et al. *J Pediatr Gastroenterol Nutr*. 2004;39:15–27.



# 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<sup>1</sup>
- Children who require EN support are those that
  - Eat less than 80% of needs by mouth
  - Require an extended period of time to eat

1. Gramlich et al. *Nutrition*. 2004;20(10):843-8.

# 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 <sup>1</sup>



- 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

1. Kawagoe et al. *Am J Infect Control*. 2001;29(2):109-14.

# EN Considerations

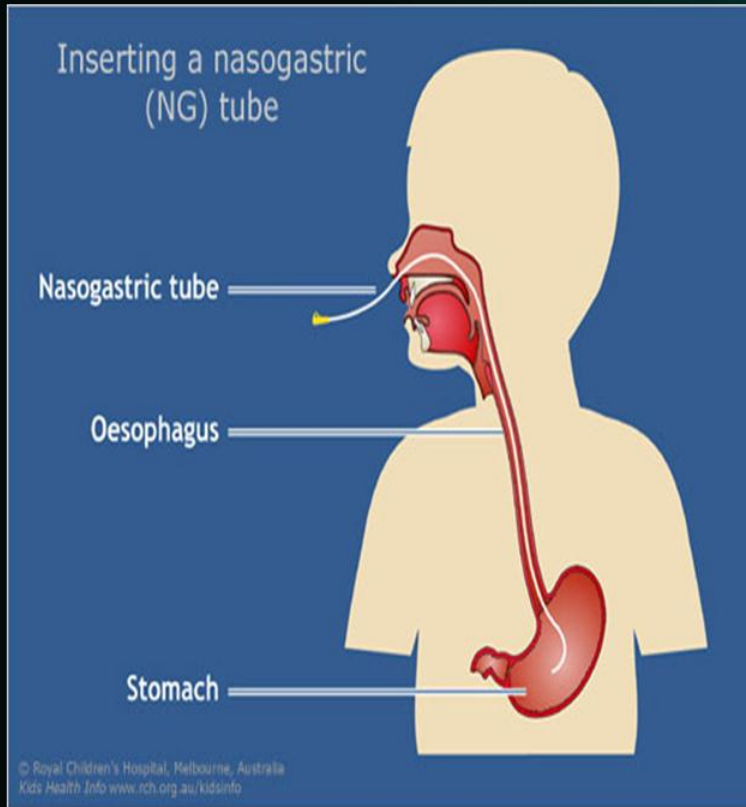
- Fluid
  - Cardiac and renal patients often have fluid volume limits
  - Requires adjustment of nutrition plan
- Electrolytes
  - K most common problem
- Protein
  - Used to worry more in renal patients
  - Restrictions have eased in recent years



# Delivery Modes/Tubes

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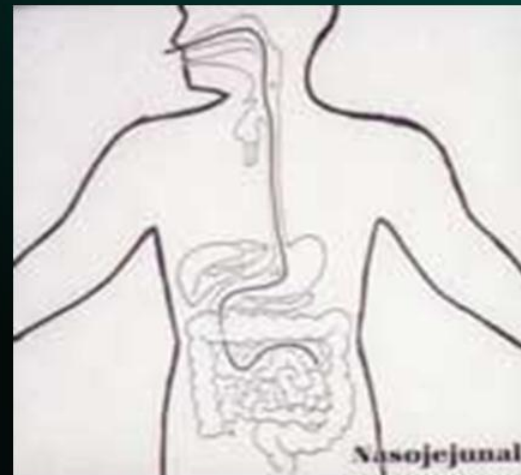
# Nasogastric (NG), Nasoduodenal (ND) and Nasojejunal (NJ) Tubes



[www.rch.org.au/kidsinfo/factsheets.cfm?doc\\_id=9766](http://www.rch.org.au/kidsinfo/factsheets.cfm?doc_id=9766)

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](http://www.cincinnatichildrens.org/health/n/nasojejunal-kangaroo)

# Enteral Feeding Methods

## Gastric Vs. Post-pyloric - I

Site	Delivery Route	Indications	Potential Complications
Stomach	Orogastric (infants) Nasogastric	<ul style="list-style-type: none"> <li>• Short-term nutrition support (6-8 wks)</li> <li>• Inadequate oral intake due to increased needs or anorexia of chronic disease</li> <li>• Refusal to eat</li> <li>• Nocturnal feeds</li> <li>• Inability to suck or swallow</li> </ul>	<ul style="list-style-type: none"> <li>• Aspiration</li> <li>• Nasal mucosal ulceration</li> <li>• Tube occlusion</li> <li>• Pneumothorax</li> <li>• Bleeding</li> <li>• Epistaxis</li> <li>• Sinusitis</li> <li>• Otitis Media</li> </ul>
	Gastrostomy	<ul style="list-style-type: none"> <li>• Long term tube feeding</li> <li>• Congenital anomalies, such as tracheo-esophageal fistula, esophageal atresia</li> <li>• Esophageal injury/obstruction</li> <li>• Failure to thrive</li> </ul>	<ul style="list-style-type: none"> <li>• Dislodgement</li> <li>• Aspiration</li> <li>• Tube deterioration</li> <li>• Bleeding</li> <li>• Tube occlusion</li> <li>• Pneumoperitoneum</li> <li>• Wound infection</li> <li>• Stoma leakage</li> </ul>

# Enteral Feeding Methods

## Gastric Vs. Post-pyloric - II

Site	Delivery Route	Indications	Potential Complications
Transpyloric Postpyloric	<ul style="list-style-type: none"> <li>• Nasoduodenal</li> <li>• Nasojejunal</li> <li>• Gastrojejunal</li> <li>• Jejunostomy</li> </ul>	<ul style="list-style-type: none"> <li>• Congenital upper GI anomalies</li> <li>• Inadequate gastric motility</li> <li>• High aspiration risk</li> <li>• Severe GER</li> <li>• Functioning intestinal tract with obstruction above it</li> </ul>	<ul style="list-style-type: none"> <li>• Pneumatosis intestinalis</li> <li>• Bleeding</li> <li>• Dislodgement</li> <li>• Tube deterioration</li> <li>• Tube occlusion</li> <li>• Bowel obstruction</li> <li>• Stomal leakage</li> <li>• Wound infection</li> </ul>



# What is a G Tube?

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



High profile



Low profile "button"

# Tube goes through the abdominal wall

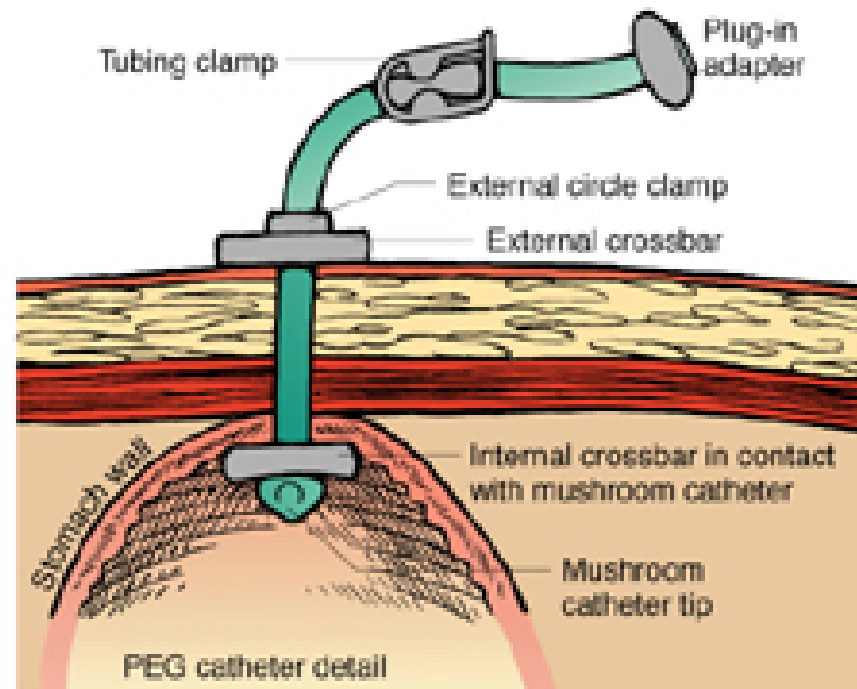


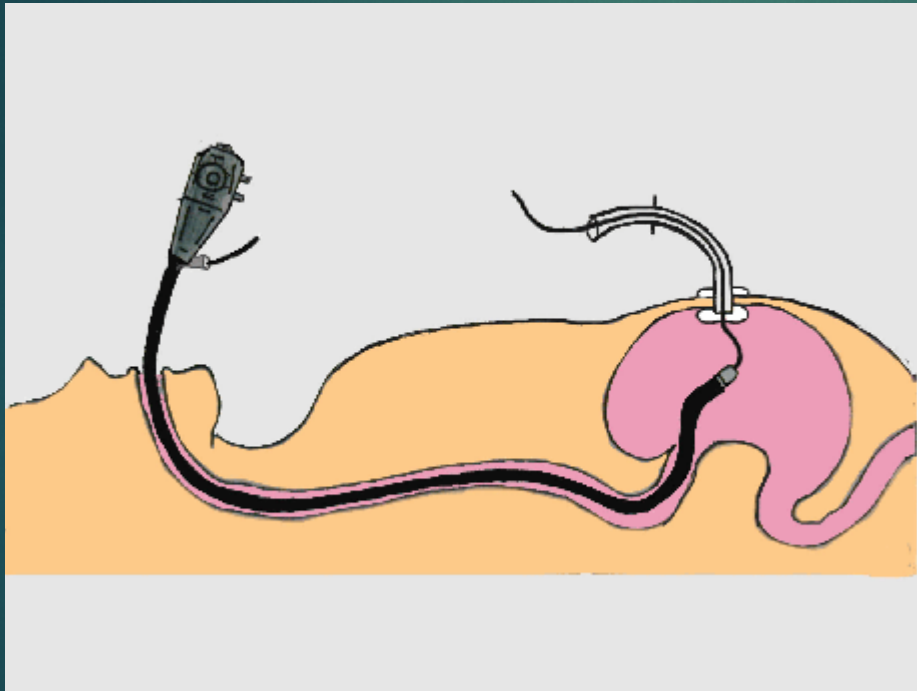
Figure 42-7 Percutaneous endoscopic gastrostomy tube in place in the stomach. (Smeltzer, S. C., & Bare, B. G. [2004]. *Brunner and Seidel's textbook of medical surgical nursing* [10th ed., p. 998]. Philadelphia: Lippincott Williams & Wilkins.)

# Methods for inserting a GT

- ▶ By Surgery:
  - ▶ Open surgical gastrostomy
  - ▶ Laparoscopic gastrostomy placement
- ▶ By Endoscopy:
  - ▶ Percutaneous endoscopic gastrostomy
- ▶ By Radiology:
  - ▶ Interventional Radiology placement



# ‘PEG’

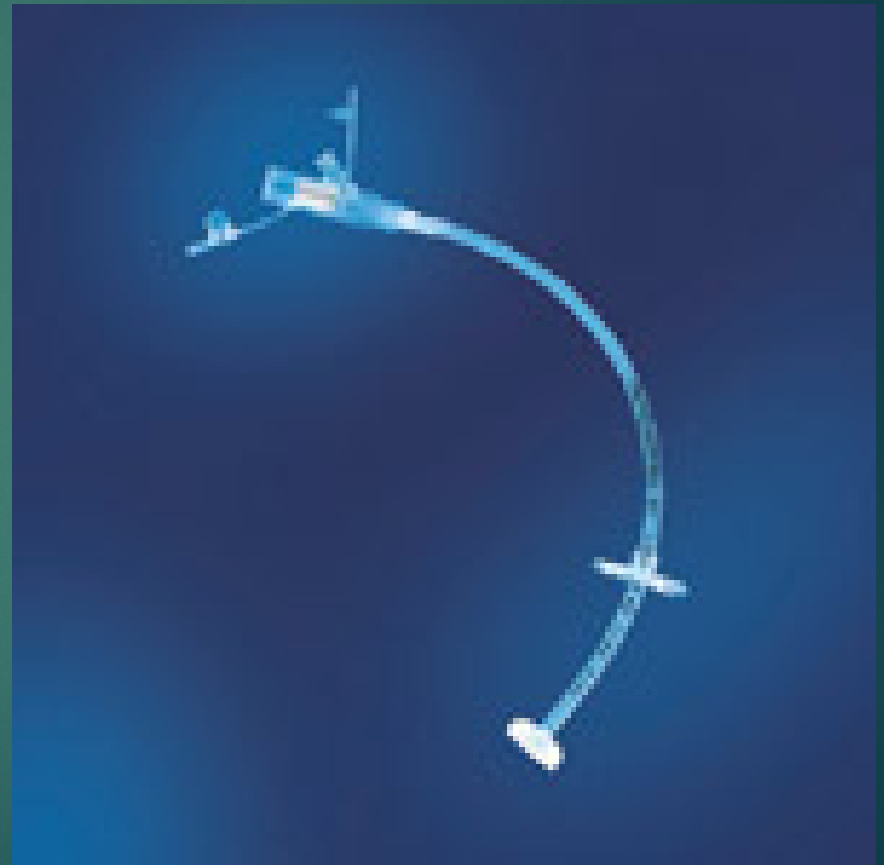
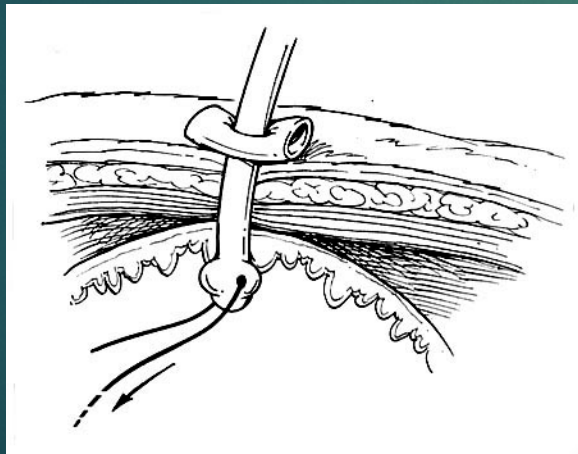


- ▶ Percutaneous endoscopic gastrostomy
- ▶ Ponsky Pull
- ▶ Inserted under anesthesia
- ▶ Stay for a few days in hospital afterwards

<http://vimeo.com/32507507>

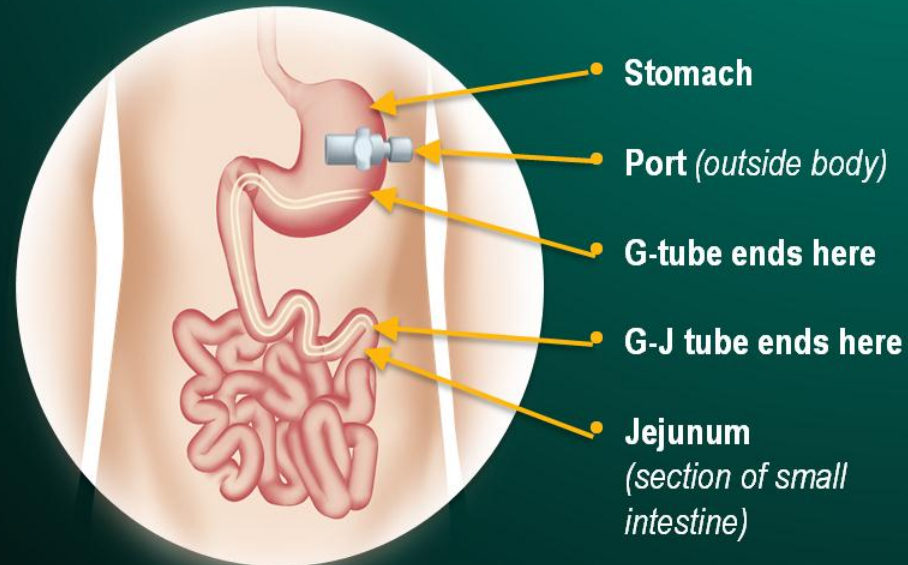
# PEG tubes

- ▶ Tubes are changed after 3 months to smaller button G tubes



# Gastrojejunostomy Tube (G-J Tube)

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.



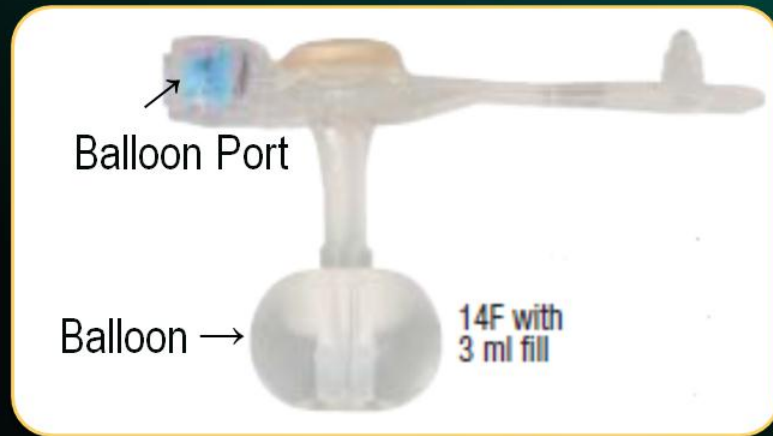
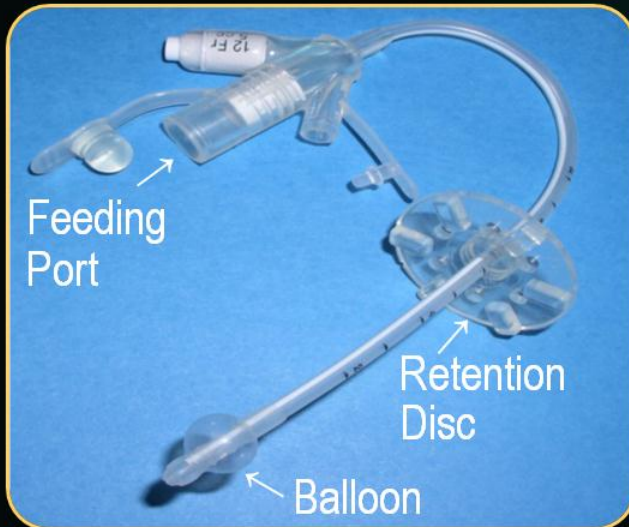


# Why Use a G or J Tube?

- 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

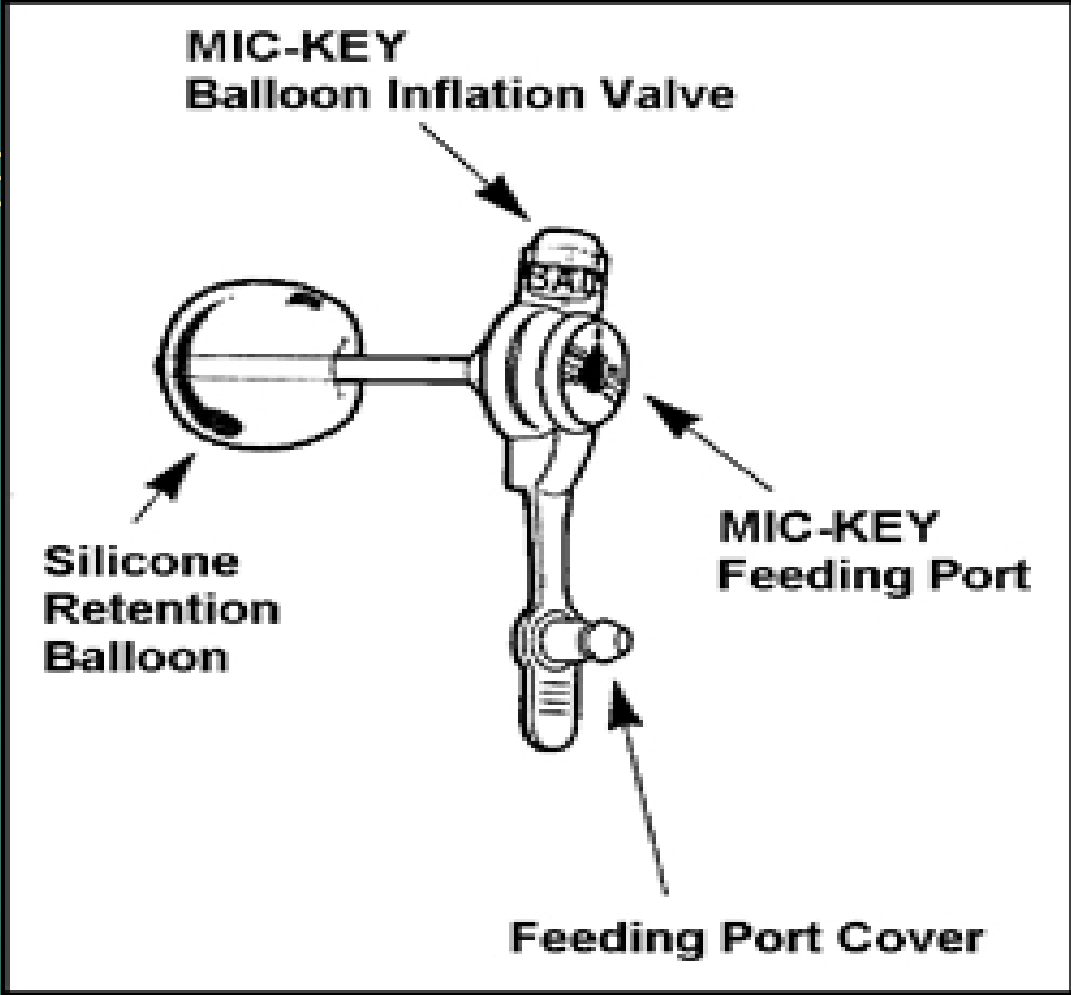
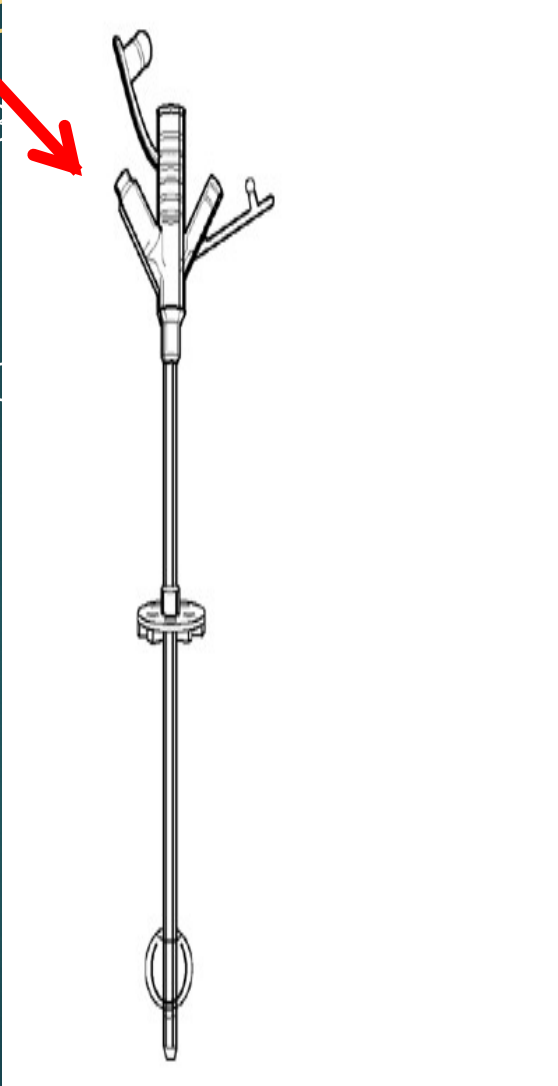
These tubes have a balloon at the end that goes into the stomach. Replacement tubes are used after the initial tract has healed.



# Balloon Device

▶ B

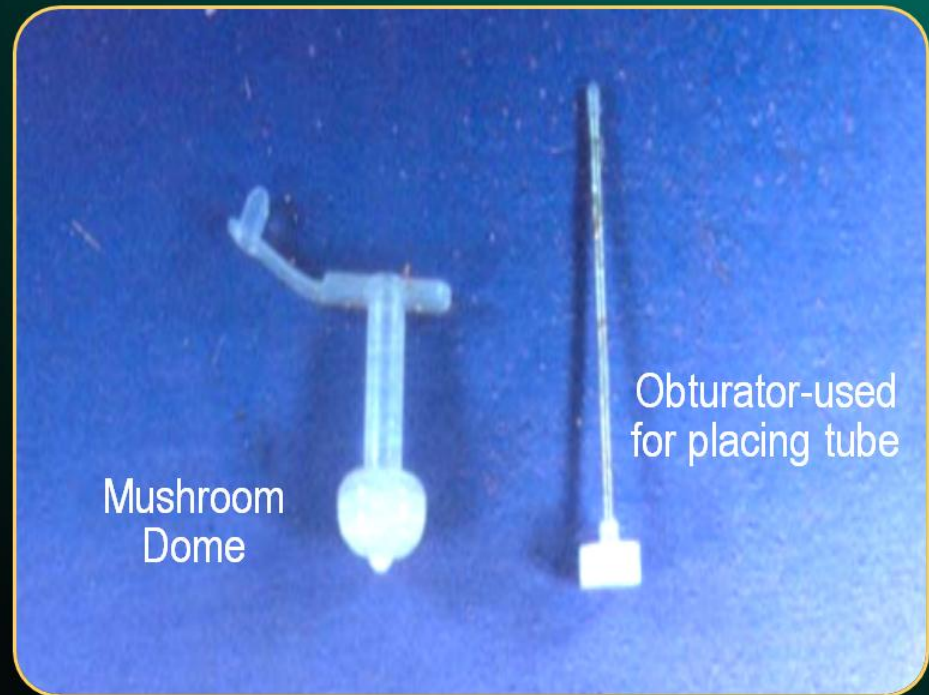
▶ C





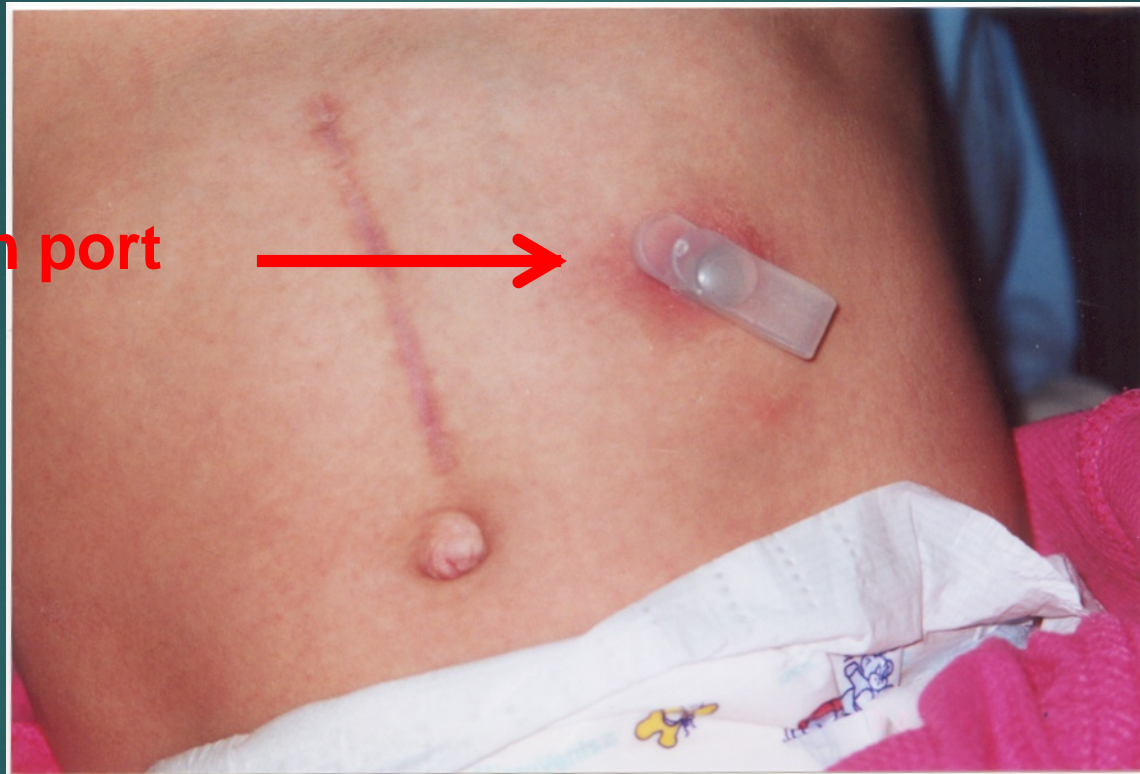
# Replacement Gastrostomy Tubes

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.



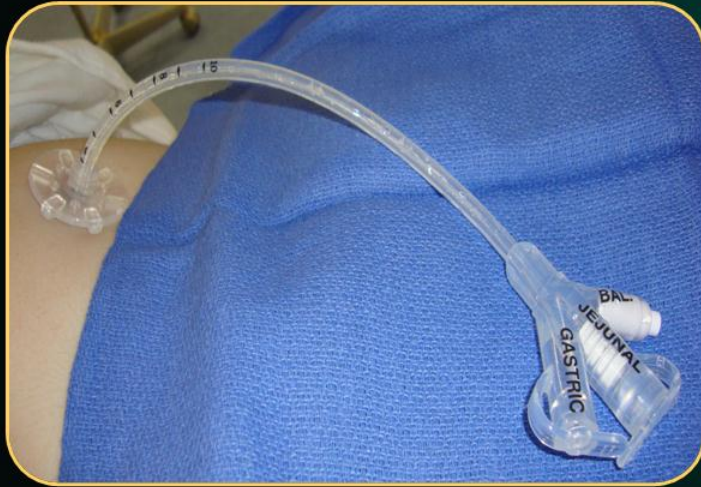
# Bard Button

No balloon port



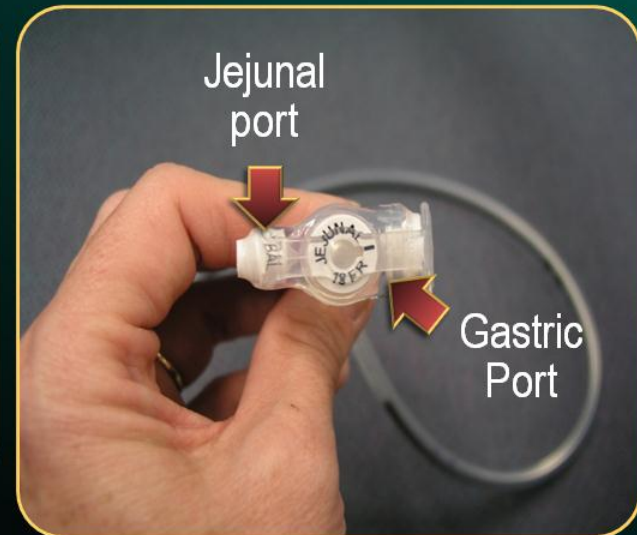


# Balloon G-J Tubes



## 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

# 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

# Bolus vs. Continuous Feeds

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

Age	Initiation	Advance	Suggested Tolerance Volumes
0 - 12 months	10 – 15 mL/kg every 2 to 3 hours	10 to 30 mL per feed	20 to 30 mL/kg every 4 to 5 hours
1 - 6 years	5 – 10 mL/kg every 2 to 3 hours	30 to 45 mL per feed	15 to 20 mL/kg every 4 to 5 hours
> 7 years	90 to 120 mL every 3 to 4 hours	60 to 90 mL per feed	330 to 480 mL every 4 to 5 hours

- Continuous Feedings

Age	Initiation	Advance	Suggested Tolerance Volumes
0 - 12 months	1 to 2 mL/kg/hour	1 to 2 mL/kg every 2 to 8 hours	6 mL/kg/hour
1 - 6 years	1 mL/kg/hour	1 mL/kg every 2 to 8 hours	1 to 5 mL/kg/hour
> 7 years	25 mL/hour	25 mL every 2 to 8 hours	100 to 150 mL/hour

# Monitoring /Evaluation

		Initial	Hospital	Outpatient
Anthropometrics	Weight Height	Daily Baseline	Daily Monthly	Weekly- monthly Monthly or at clinic
Intake	Calories, protein, fluid	Daily	Weekly	Monthly
GI Tolerance	Abdominal girth, residuals , emesis	As ordered, reported	As ordered, reported	As reported
Stool/ Ostomy	Volume , frequency, consistency	Daily	Daily	Report changes in stool pattern
Tube Placement	Prior to each feeding	Prior to each feeding	Prior to each feeding	Prior to each feeding
Tube Site	Daily	Daily	Daily	Daily

Green et al. In Corkins M, Ed. *The ASPEN Pediatric Nutrition Core Curriculum*.  
ASPEN; 2010.



# Monitoring/ Evaluation - I

Problem	Prevention/Intervention
Diarrhea/ Abdominal Cramping	<ul style="list-style-type: none"><li>• Decrease delivery rate</li><li>• Recognize or avoid drugs that result in diarrhea</li><li>• Consider fiber containing products</li><li>• Consider osmolarity and addition of modular additives</li><li>• Semi-elemental or elemental formula if indicated</li></ul>
Vomiting/ Nausea	<ul style="list-style-type: none"><li>• Ensure formula is always at room temperature prior to tube feedings</li><li>• Elevate head of bed</li><li>• Consider postpyloric or continuous feeding</li></ul>
Hyperglycemia	<ul style="list-style-type: none"><li>• Reduce flow rate</li><li>• Use formulas with minimal simple sugars</li><li>• Consider insulin if clinically indicated</li></ul>

# Monitoring/ Evaluation - II

Problem	Prevention/Intervention
Constipation	<ul style="list-style-type: none"> <li>• Ensure optimal fluid intake</li> <li>• Increase free water intake</li> <li>• Change to a product containing fiber</li> </ul>
Gastric Retention of Formula	<ul style="list-style-type: none"> <li>• Monitor for correct tube placement</li> <li>• If residuals are high (&gt;2 hour volume of feeds), hold feeds; recheck residuals in 1 hour</li> <li>• Consider continuous or postpyloric feeding</li> <li>• Position patient on right side</li> </ul>
Clogged Feeding Tube	<ul style="list-style-type: none"> <li>• Ensure tube is flushed after checking residuals, boluses and every 4 – 8 hours with continuous feeds</li> <li>• Check tubing size for appropriateness for some formulas</li> <li>• Infuse formula past pylorus</li> <li>• Consider continuous infusion</li> </ul>

# 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

# Formula - I

		Protein	Fat	CHO	Examples
<b>Standard</b> -Normal bowel function -Normal fluids requirements	Oral Tube	Whole protein	Long-chain fats	Lactose-free	<ul style="list-style-type: none"> <li>• Nutren® Junior (1-10 yr)</li> <li>• Pediasure® (1-10 yr)</li> <li>• Ensure® (11yr-adult), Nutren® 1.0</li> </ul>
	Tube	Whole protein	long-chain fats	Lactose-free	<ul style="list-style-type: none"> <li>• Compleat® Pediatric (1-10 yr)</li> <li>• Jevity® 1 cal (11yr-adult)</li> <li>• Osmolite® (11yr-adult)</li> <li>• Jevity® ( fiber) (11yr-adult)</li> </ul>
<b>Volume Intolerance</b> -Normal/ Abnormal bowel function -Increased calorie and protein needs -Fluid restricted	Concentrated	Whole protein	Varies	Lactose-free	<ul style="list-style-type: none"> <li>• Pediasure® 1.5, Nutren® 1.5</li> <li>• Nutren® 2.0</li> <li>• Twocal® HN</li> <li>• Ensure® Plus</li> </ul>
<b>Impaired Digestion/ Allergy</b> -Abnormal bowel function -Unable to digest fully intact protein, carbohydrate or fat.	Peptide Based	Hydrolyzed whey-protein 3-5 peptide chains	Mix of MCT and LCT fat	Varies: corn syrup solids	<ul style="list-style-type: none"> <li>• Peptamen® Junior</li> <li>• Pediasure® Peptide (1-13 yr)</li> <li>• Nutramigen®, Pregestimil®</li> <li>• Peptamen® 1.5</li> <li>• Vital® HN</li> </ul>



# Formula - II

		Protein	Fat	CHO	Examples
<b>Abnormal bowel function</b> -Related to allergy, malabsorption, short gut	Amino acid Based	Free amino acids	Mix of MCT and LCT fat	Corn syrup solids	<ul style="list-style-type: none"> <li>• Elecare<sup>®</sup> infant, Elecare<sup>®</sup> Jr,</li> <li>• Neocate<sup>®</sup>, Neocate<sup>®</sup> Jr</li> <li>• Nutramigen<sup>®</sup> AA</li> <li>• Tolorex<sup>®</sup> (Free amino acids)</li> </ul>
<b>Fat malabsorption</b> -Related to chylothorax Pancreatitis	Fat Mal-absorption	Intact whole protein / casein	Contain 55% or greater MCT oil, DHA, ARA	Corn syrup solids	<ul style="list-style-type: none"> <li>• Portagen<sup>®</sup></li> <li>• Enfaport<sup>®</sup></li> <li>• Pregestimil<sup>®</sup></li> <li>• Tolorex<sup>®</sup> (Free amino acids)</li> <li>• Vital<sup>®</sup> HN</li> </ul>
<b>Disease Specific</b>		Varies			<ul style="list-style-type: none"> <li>• Nutren Glytol (diabetic)</li> <li>• Optisource<sup>®</sup> (bariatric surgery)</li> <li>• Pulmocare<sup>®</sup></li> <li>• Suplena<sup>®</sup> (renal)</li> </ul>

# Outline of Products

- Infant Formulas
  - 0 to 1 year of age
- Pediatric Formulas
  - 1 to 13 years of age
- Specialized formulas/supplements
- Modular Additives

# 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<sup>®</sup> 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<sup>®</sup> (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<sup>®</sup> (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

Cole et al. *Pediatrics*. 2008;122(3):e573-82.

O'Keefe et al. *Clin Gastroenterol Hepatol*. 2006;4(1):6-10.

Goulet et al. *Eur J Ped Surg*. 2005;15(2):95-101.

# 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.

Goulet et al. *Gastroenterology*. 2006;130(2 Suppl 1):S16-28.

Jeejeebhoy et al. *Gastroenterology*. 2006;130(2 Suppl 1):S60–66.

Sondheimer. *J Pediatr*. 1998;132:80–84.



# 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

Wessel et al. *Semin Perinatol.* 2007;31(2):104-111.

Sondheimer et al. *J Pediatr.* 1998;132:80.



# Sites Of Absorption

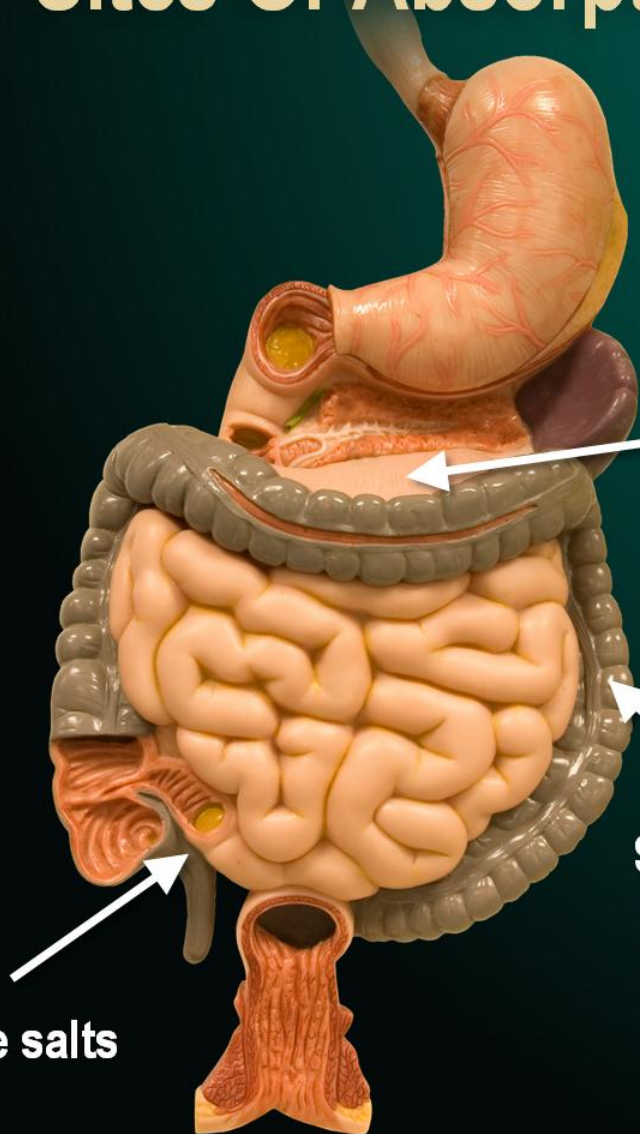
Carbohydrates  
Fats  
Proteins  
Calcium  
Magnesium  
Trace elements  
vitamins

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 Valve

- 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

Goday PS. *Clinical Perinat.* 2009(36):101-10.

Joly et al. *Gastroenterology.* 2009(136):824-31.



# 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

Forchielli et al. *Adv Pediatr*. 2003;50;245–67.

Sondheimer et al. *J Pediatr Gastroenterol Nutr*. 1998;27(2):131-7.



# 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

Andorsky et al. *J Pediatr.* 2001;139(1):27–33.

Vanderhoof et al. *J Parenter Enteral Nutr.* 1984;8(6):685-89.

# 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

Kuperminc et al. *Dev Disabil Res Rev.* 2008;14(2):137-46.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

Hendersen et al. *Pediatr.* 2002;141(5):644-51.

Jones et al. *J Pediatr Gastroenterol Nutr.* 2001;33(5):602-5.



# 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

**Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.**

**Stevenson et al. *Pediatr.* 2006;118(3):1010-18.**

**Sampson-Fang et al. *J Pediatr.* 2002;141(5):637-43.**

# 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

Kuperminc et al. *Dev Disabil Res Rev.* 2008;14(2):137-46.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

# 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: wheel chair scales, bed scale, anthropometer

Oeffinger et al. *Dev Med Child Neurol.* 2010;5(9):e195-201.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

Stevenson et al. *Pediatrics.* 2006;118(3):1010-18.

Gauld et al. *Dev Med Child Neurol.* 2004;46(7):475-80.



# 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 3<sup>rd</sup> percentile. Remember that not everyone belongs on the 50<sup>th</sup> percentile

Stevensen et al. *Pediatrics*. 2011;128(2):e436-7.

Brooks et al. *Pediatr*. 2011;128(2):e299-307.

Day et al. *Dev Med Child Neurol*. 2007;49(3):167-71.

Marchand et al. *J Pediatr Gastroenterol Nutr*. 2006;43(1):123-35.

# 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

Stevensen et al. *Pediatrics*. 2011;128(2):e436-7.

Brooks et al. *Pediatr*. 2011;128(2):e299-307.

Day et al. *Dev Med Child Neurol*. 2007;49(3):167-71.

Marchand et al. *J Pediatr Gastroenterol Nutr*. 2006;43(1):123-35.

# 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)

Stevensen et al. *Pediatrics*. 2011;128(2):e436-7.

Brooks et al. *Pediatr*. 2011;128(2):e299-307.

Day et al. *Dev Med Child Neurol*. 2007;49(3):167-71.

Marchand et al. *J Pediatr Gastroenterol Nutr*. 2006;43(1):123-35.



# 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<sup>th</sup> 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

Dahlseng et al. *Acta Paediatr.* 2012;101(1):92-8.

Kuperminc et al. *Dev Disabil Res Rev.* 2008;14(2):137-46.

Mahant et al. *Arch Dis Child.* 2009;94(9):668-73.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

# 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

Dahlseng et al. *Acta Paediatr.* 2012;101(1):92-8.

Kuperminc et al. *Dev Disabil Res Rev.* 2008;14(2):137-46.

Mahant et al. *Arch Dis Child.* 2009;94(9):668-73.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

# Determining the Nutritional Plan - III

- All regimens 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

Arowsmith et al. *Dev Med Child Neurol.* 2012;54(2):170-5.

Schoendorfer et al. *Br J Nutr.* 2012;107(10):1476-81.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.



# 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

Savage et al. *J Parenter Enteral Nutr.* 2012;36(1 Suppl):118S-123S.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

# 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

Savage et al. *J Parenter Enteral Nutr.* 2012;36(1 Suppl):118S-123S.

Marchand et al. *J Pediatr Gastroenterol Nutr.* 2006;43(1):123-35.

# 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?