Exploring the Tall Tales of Nutrition in the ICU

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Financial Disclosures

▪ None related to this topic

Objectives

▪ Explain the relationship between nutrition and improved outcomes in the critically ill patient
▪ Understand terminology of relevant gastroenterology disease processes
▪ Recognize situations in which nutrition should be utilized in the critically ill patient

#1 Myth: Starvation or Under-nutrition is Ok!

▪ Nutrition is essential for survival:
▪ Supports anabolism
▪ Ameliorates uncontrolled catabolism
▪ Maintains a competent immune system
▪ Bottom line … nutrition if given at the right time by the right route, will improve patient outcomes

Indirect calorimetry and predictive equations:

▪ 2349 publications retried, with 18 studies included
▪ Predictive equations underestimated and overestimated energy expenditure in 13-60% and 0-88%, respectively
▪ 43% below and 66% above indirect calorimetry values observed

Caloric Intake of Parenteral Nutrition and Clinical Outcomes in Acute Critically Ill Patients: A Meta-Analysis of Randomized Controlled Trials

Eun Young Choi, MB; Dong Ah Park, MD; Beulah and HoHyung Park, MD

Calorie intake to meet the needs of ICU patients remains unclear
Meta analysis including 4 studies showed:
▪ No significant difference in mortality between under- and full fed group
▪ Subgroup analysis showed underfed group significantly lower mortality when fed >33.3% of standard requirement in comparison to the full fed group
▪ No difference in mortality between underfed group fed ≤33.3% of standard caloric requirements
▪ LOS and LOICUS did not differ

The Prevalence of Underprescription or Overprescription of Energy Needs in Critically Ill Mechanically Ventilated Adults as Determined by Indirect Calorimetry: A Systematic Literature Review

Chuns K. Lamartinet, LIP; Enyu Kim; Emma J. Röller, APN, MPH; and Andrea C. Barnes, MD, PhD

Indirect calorimetry and predictive equations:

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▪ Predictive equations underestimated and overestimated energy expenditure in 13-60% and 0-88%, respectively
▪ 43% below and 66% above indirect calorimetry values observed
The Latin phrase primum non nocere, translated to "first, do no harm" serves as a reminder to clinicians that good intentions may have harmful consequences.

- Use of inaccurate predictive estimates for support of the critically ill patient combined with aggressive therapy to achieve target nutrition intakes without consideration of potential consequences of this therapy may have harmful consequences.
- Each patient needs to be evaluated closely for signs and symptoms of overfeeding and feeding intolerance.

**Consensus**

- Generalized belief that optimal calorie and protein intake are associated with improved patient outcomes.
- Severity of illness is a variable = less sick patients tolerate EN.
- Despite these limitations, the Society of Critical Care Medicine, American Society of Parenteral and Enteral Nutrition guidelines, and Canadian and European guidelines all recommend
  - EN be initiated within 48 hours in the critically ill patient who is unable to maintain volitional intake.
- There is no known illness or disease that benefits from starvation.

**Bowel rest**

- Popular in the 1970s for Crohn's, colitis, acute and chronic pancreatitis, diverticulitis and a number of other GI disorders.
- Why?
  - Enteral nutrition (EN) enhances inflammation.
  - Removal the stimulus of luminal antigens and bowel function.
- Contrary:
  - Starvation does not inhibit bowel function.
  - Starvation decreases splanchnic blood flow resulting in profound structural and functional changes to the GI tract.

**Characteristics of Splanchnic blood flow**

- Regulates circulating blood volume and systemic blood pressure.
- In acute hypovolemia, such as hemorrhage, splanchnic circulation is reduced to supply blood and oxygen to vital or essential organs = brain and heart.
- A key source of inflammatory mediators.

**Regulators**

**Intrinsic**
- Local metabolic & myogenic control
  - Blood flow: Vasoconstrictors/vasodilators
  - Local reflexes
  - Locally produced vasoactive substances

**Extrinsic**
- Sympathetic innervations
  - Increases vascular resistance to decrease blood flow
  - Circulatory vasoactive substances
  - Systemic hemodynamic changes

#2 Myth: Parenteral Nutrition is Safe!

- If the gut works, use it!
- Parenteral nutrition (PN) prevents progressive malnutrition in patients unable to feed enterally
- Widely accepted to use the GI tract as a preferred route in delivering nutritional support.
- Strongly recommended in critically ill and postoperative patients
- Although widely accepted, parenteral nutrition is still used in patients who can feed enterally

Adverse effects of Parenteral Nutrition

- Double hit if you are not feeding the gut and using PN
- Metabolic, immunologic, endocrine, and infective complications associated with high glucose concentration and fat globules via the systemic venous system.
- PN bypasses the GI tract and liver
- EN stimulates enterohormones which are crucial in regulating gut function and metabolic pathways
- EN supplies the portal system supplying the liver with a rich source of nutrients and hormones
- Increased risk for GI mucosal atrophy, bacterial overgrowth and translocation, increased intestinal permeability
- PN is associated with impaired leukocyte chemotaxis, impaired phagocytosis, impaired bacterial and fungal killing and an attenuated inflammatory response

#3 Myth: EN is Contraindicated with Vasopressors!

- Hemodynamically unstable and/or require vasopressors = common in the ICU
- Vasopressors improve hemodynamics as they shunt blood from the gut to the central circulation
- Feeding during these times?
- No, if limited oxygen delivery to the gut, why would you increase oxygen demand by feeding?
- Will cause bowel ischemia

Clinical Controversies

Feeding the Hemodynamically Unstable Patient: A Critical Evaluation of the Evidence

Gary F. Talley, M.D., Patricia B. Roberts, M.D., and Paul Mudd, M.D.

- In animal models, mesenteric and renal blood flows improved with low dose enteral nutrition while receiving low dose vasopressin
- As vasopressin therapy increased, the benefit of enteral nutrition on mesenteric perfusion was not maintained
- To promote splanchic perfusion with use of enteral nutrition, the authors advocate for enteral nutrition ~6 hours post fluid resuscitation
In endotoxic and septic shock models, enteral feeding improved:
- Hepatic artery and portal vein blood flow
- Superior mesenteric artery blood flow
- Intestinal mucosal microcirculatory flow
- Hepatic microcirculatory flow
- Hepatic and intestinal tissue oxygenation, and
- Hepatic energy stores

Prospective study = 886 ICU mechanically ventilated pts
- Optimal nutritional therapy associated with a decrease in 28-day mortality by 50%
- Only reaching energy targets is not associated with a reduction in mortality.

#4 Myth: Early EN is not Important in Patients Receiving Mechanical Ventilation!
- The commencement of enteral nutrition is typically delayed in mechanical ventilated patients
- Likely cause? Not a current priority and may be pushed to the back burner
- Older guidelines support mechanically ventilated patients go 1 week without nutrition.
- Mechanical ventilation is a predictor for failure to provide enteral nutrition

Early EN within 2 days of admission associated with a significant reduction of ICU and hospital mortality

The implementation of an evidenced-based nutritional management protocol significantly shortened the duration of mechanical ventilation
- EN was associated with reduced risk of death
#5 Myth: EN is Contraindicated with High Gastric Residual Volume!

• Many monitor gastric residual volume (GRV)
• Enteral nutrition is stopped with elevated GRVs
• High GRVs do not necessarily predict aspiration
• Low GRVs do not necessarily predict aspiration will not occur
• Interrupting EN with GRV 100-200mls not shown to decrease prevalence of aspiration

Speculation for GRVs

May have arisen from beliefs:
• #1 the stomach is a container of finite size
• #2 when input exceeds output over time, the stomach will “overflow”
• #3 overflow into … the esophagus which equals aspiration
• If we have knowledge of gastric contents at any given time through GRV we will predict risk of overflow and ultimately prevent aspiration

Implications to the theory of High GRVs

• GRVs accurately reflect the total volume in the stomach
• Formula retained in the stomach will alert the clinician to delayed gastric emptying equaling impending intolerance
• Stop the feeding to prevent vomiting or aspiration from occurring

Implications of low GRVs

• Presumed to indicate low intra-gastric volume
• The formula is being emptied appropriately
• Risk for aspiration with a low GRV expected to be minimal, so the patient is tolerating enteral feedings

Flaws to rationale

• Total salivary and gastric secretion = output up to 1500mls salivary and 3000mls gastric secretions
• Aspiration of oropharyngeal secretions
• Some degree of aspiration may occur normally in normal healthy individuals
• Patient populations vary with regard to risk for aspiration pneumonia, specifically risk for aspiration of gastric contents.
• Must consider the specific patient:
  • Communicative patients with functional GI tract = no benefit
  • Uncommunicative patients with potential for impaired GI tract = might benefit
  • Patients with inability to handle oral secretions = no benefit

Do residual volumes impede nutritional support?

• GRVs may lead to clogging of feeding tubes = acid mixed with intact proteins in the tube clotting the formula
• Low GRVs may give clinicians false sense of security
• Institutional threshold values of GRVs guide the clinician to withhold nutrition
Poor validity of residual volumes as a marker for risk of aspiration in critically ill patients.

McClave, et al recommends:

- High-risk patient populations should be identified by their disease process, not solely by GRV
- Trauma, head injury, sedated, altered mental status
- Pertinent physical findings suggesting ileus
- Abdominal distention, nausea, vomiting, or overt aspiration or regurgitation
- Clinicians should not depend on GRVs to distinguish high risk from low risk
- Obvious trend of increasing GRVs should prompt a clinical pathway or algorithm
- Rather than automatic cessation of enteral feeding, consider:
  - Prokinetic agent, depending on age
  - Reducing sedation
  - Sepsis
  - Elevate head of bed

Tests to evaluate for aspiration

- Videofluorographic swallow study = “gold standard” modified barium swallow test looking at 3 phases of swallowing (oral, pharyngeal and esophageal phases)
- Fiberoptic Endoscopic Evaluation of Swallowing (FEES)
- Scintigraphy

#6 Myth: Post-pyloric Feeding Reduces the Risk of Aspiration!

- Many clinicians believe critically ill patients should receive post-pyloric feedings.
- Undoubtedly, some ICU patients would not tolerate early gastric feeding due to delayed gastric emptying
  - Underlying comorbidities
  - Medications
  - Electrolyte disturbances, hyperglycemia
  - Surgery
  - Shock
- No consensus for routine use of post-pyloric feeding and associated decrease aspiration risk
Now what, gastric feeding has failed?

- Gastric feeding intolerance
- Abdominal distension
- Regurgitation
- Timed trial of prokinetics
- Then, place post-pyloric feeding tube
- Known gastric dysmotility and ECMO = post-pyloric feeding

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#7 Myth: EN is Contraindicated in Patients Without Bowel Sounds and/or a Postoperative Ileus!

- 1905, first clinician to suggest the relationship between bowel sounds and bowel function
- Part of the standard physical exam
- After abdominal surgery, the auscultation of bowel sounds leads to feeding

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#8 Myth: EN is Contraindicated Following GI Surgery!

- The period of post-operative ileus is believed to last for 3-5 days
- Treated with nasogastric tube to low intermittent suction, intravenous fluids, parenteral nutrition

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Figure 1: Cumulative deficit as a percentage of daily energy goal.

- EONNT
- Metoclopramide
- Erythromycin

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Gastrointestinal myoelectric and clinical patterns of recovery after laparotomy.

- Bowel sounds require the swallowing of air and gastric emptying
- Small bowel myoelectric activity returned immediately after surgery.
- On average, took 2.4 days for the return of auscultated bowel sounds
Early enteral feeding versus “nil by mouth” after gastrointestinal surgery: systematic review and meta-analysis of controlled trials

- Systematic review and meta-analysis of randomised controlled trials comparing any type of enteral feeding started within 24 hours after surgery with nil by mouth management in elective gastrointestinal surgery
- 837 patients, 11 studies
- No clear advantage to keeping patients nil by mouth after elective gastrointestinal resection

Enteral feeding post surgery

- Aggressive enteral nutrition does not come without risk
- Gastrointestinal intolerance:
  - Abdominal distention
  - Hypotension
  - Shock
  - Small bowel ischemia or necrosis
  - High mortality rate

Clinical Controversies

Feeding the Hypotensive Patient: Does Enteral Feeding Precipitate or Protect Against Ischemic Bowel?
Stephen A. McClenon, MD and Wil Bays Chang, MD, PhD

- Before and after episodes of hypotension, the benefits of enteral nutrition warrant a fairly aggressive approach
- The risk:benefit ratio rises steeply during the period of hypotension
- Feeds may be continued during this period, as long as there is close clinical monitoring and a high index of suspicion is maintained for any signs of GI intolerance and the possibility of early mucosal ischemic injury

#9 Myth: EN is Contraindicated in Patients with an Open Abdomen!

- NPO or PN
- Assumption that enteral nutrition be held due to bowel wall edema and bowel dysfunction

Original Communications

Feeding the Open Abdomen
Bryan Collins, DO; Omar Guillen-Acosta, MD; Bryan Nix, MD; Rob Brandan, RNBP
Andrew Gushard, BS; Russ Schul, BS; Jill Heclo, RN; Todd Young, MD; MPH; Richard Miller, MD, and Jesse Bux, Jr, MD

Retrospective review = 78 patients

Early enteral nutrition in the open abdomen was associated with:
1. earlier primary abdominal closure
2. lower fistula rate
3. lower hospital charges by $50,000

Retrospective study of 37 pts with ACS:

Enteral feeding was never started in 12 patients; 4 died within 48 hours of admission, 7 required vasoactive agents until their death, and 1 developed an enterocutaneous fistula requiring parenteral nutrition. Enteral feeding was initiated in the remaining 25 patients: 13 had feeds started within 24 hours of abdominal closure; 5 were fed with open abdomens; and 7 had a delay because of vasopressors (n = 2), multiple trips to the operating room (n = 2), paralytics (n = 2), and increased intra-abdominal pressures (n = 1). Once advanced, enteral feeding was tolerated in 23 (92%) of the 25 patients with attainment of goal feeds in a mean of 3.1 +/- 1 days.
#10 Myth: EN is Contraindicated in Patients with Pancreatitis!

In 1991, it was believed in acute severe pancreatitis, total parenteral nutrition be initiated to allow rest of the pancreas and provide nutrient deficits and energy caused by the inflammatory process.

What is pancreatitis?

- Acute pancreatitis is sudden inflammation of the pancreas that may be mild or life threatening but usually subsides.
- Gallstones and alcohol abuse are the main causes of acute pancreatitis.
- Heredity
- Medication
- Virus
- Cystic fibrosis diagnosis with increased risk
- Severe abdominal pain is the predominant symptom
- Whether mild or severe, acute pancreatitis usually requires hospitalization
- Gallstones and constant, heavy alcohol abuse account for almost 80% of hospital admissions for acute pancreatitis.
- Women, ~1½ times that of men caused by gallstones.
- Normally, the pancreas secretes pancreatic fluid through the pancreatic duct to the duodenum.
- This pancreatic fluid contains inactive digestive enzymes and inhibitors that inactivate any enzymes that become activated on the way to the duodenum.
- Blockage of the pancreatic duct by a gallstone stuck in the sphincter of Oddi stops the flow of pancreatic fluid.
- Causing activated enzymes to accumulate in the pancreas, overwhelm the inhibitors, which begin to digest the cells of the pancreas, causing severe inflammation.

Six randomized controlled studies with 263 participants

- Enteral nutrition was associated with a significantly lower incidence of infections (relative risk 0.45; 95% confidence interval 0.26 to 0.78; P = 0.004).
- Reduced surgical interventions to control pancreatitis (0.48, 0.22 to 1.0, P = 0.05).
- Reduced length of hospital stay (mean reduction 2.9 days, 1.6 days to 4.3 days, P < 0.001).
- There were no significant differences in mortality (relative risk 0.66, 0.32 to 1.37, P = 0.3) or non-infectious complications (0.61, 0.31 to 1.22, P = 0.16).

Conclusions: Enteral nutrition should be the preferred route of nutritional support in patients with acute pancreatitis.

#11 Patients Must be Fed Semi-recumbent at 45 Degrees!

In 1999, Drakulovic, et al in their randomized controlled study found:

- 39 intubated patients in semi-recumbent
- 47 intubated patients in supine

- Nutritional support should be viewed as an active therapeutic intervention that improves the outcome of patients with acute pancreatitis.
- Enteral nutrition should begin within 24 h after admission following the initial period of volume resuscitation and control of nausea and pain.
- Patients with mild acute pancreatitis should be started on a low-fat oral diet.
- In patients with severe acute pancreatitis, enteral nutrition may be provided by the gastric or jejunal route.

Meta-analysis of parenteral nutrition versus enteral nutrition in patients with acute pancreatitis

By T. Moret, C. P. Loge

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Semirecumbent versus supine or near supine

- van den Nieuwenhoven et al. (2006) randomized 112 intubated patients: 45 degrees was not achieved 80% of the time.
- The supine patients were repositioned more frequently than supine.
- No difference in ventilator-associated pneumonia.
- Grup, et al. (2005) reported a mean backrest elevation of 21.7 degrees without association to pneumonia.

- 45 degrees = recorded in 22.3% of instances
- 38-45 degrees = recorded 22.3% of instances
- Nursing a patient semirecumbent at 45 degrees is not feasible
- Attempts may not reduce ventilator associated pneumonia
- 45 degree positioning = patient slides down, sacral pressure, uncomfortable for patient
- Support at 0 degree probably increases the risk of pneumonia; however, no strong evidence that elevation of the head of the bed to 10-30 degrees will increase the risk for pneumonia.

Conclusion

- Myths delay and limit optimal enteral nutrition
- Few exceptions prohibit enteral nutrition = GI bleed requiring endoscopy, surgical problem that must be repaired or planned extubation where oral feeding is likely to be resumed
- Early EN is feasible and improves outcomes of critically ill patients
- Patients who are about to die or are deceased

References

- The Lancet, 368, 601-608.
Objectives

- To define FIT and determine which children will benefit from nutritional intervention
- To describe the common interventions used in the management of FIT and feeding disorders
- To describe FIT and feeding disorder scenarios where a primary care provider should seek help from specialists

Definitions

1. Weight < 75% of median weight for chronological age (Gomez criterion)
2. Weight < 80% of median weight for length (Waterlow criterion)
3. Body mass index for chronological age < 5th centile
4. Weight for chronological age < 5th centile
5. Length for chronological age < 5th centile
6. Weight deceleration crossing more than two major centile lines from birth until weight within the given age group
7. Conditional weight gain = lowest 5%, adjusted for regression towards the mean from birth until weight within the given age group

• Is 3% of the population below the 3rd percentile?
  – WHO growth charts for children under 24 months
  – Observations falling ≥ 3 SD and ≤ 3 SD of the sample median were excluded

• Is weight alone enough?
  – Proportionately small children are often not failing to thrive
  – Weight-for-length or BMI < 3rd percentile may be a better marker of FTT

• What is stable growth during infancy?
  – 6-39% of full-term infants cross two weight percentiles between birth and 2 years

• Growth curves are averages which are mathematically smoothed out

• 0-2 years: use WHO growth standards
• 2 years +: use CDC growth charts

• Danish birth cohort
  – Significant undernutrition
    • 3% under the age of 1
  – Poor concurrence among all seven criteria
  – None of the FTT children met all the criteria
  – Most met only one criterion
  – Most single criteria
    • Not accurate enough


Olsen et al. Arch Dis Child 2007
### Normal variants masquerading as FIT

**Mid-parental height?**

- To the average of the parents' heights
  - Add 2.5” if male
  - Subtract 2.5” if female

- This is the median height expected for that child
  - 8.5 cm on either side of the median will give 2 SD on either side

**Normal variants masquerading as FIT**

- Genetic short stature
  - Short parents
  - Low percentiles but do not cross percentiles

- Ex-premature infant
  - Normal birth weight if corrected for gestation
  - Low percentiles if uncorrected, but may show catch-up growth

- Preemies under 32 weeks gestation
  - May never catch up if growth during first months of life was poor

- Constitutional delay
  - Initial drop in percentiles, then follow their own line
  - Family history +
  - Bone age assessment

- Catch-down growth
  - Above-expected birth weight
  - Initial fall in percentiles, then follow percentiles
  - This is important in LGA babies
Practical definition

- Weight-for-length < 2nd percentile (WHO growth chart) or BMI < 3rd percentile (CDC growth chart)
- Poor or no weight gain
  - Over a period of time that varies according to the age of the child
- Significant downtrend in weight percentiles
  - 30% of full-term infants cross one percentile and 23% cross two percentiles between birth and 2 years
- These should be done along with
  - Assessment of parental size / growth
  - Correction for prematurity (where applicable)

A simple approach to FTI

- Inadequate intake of calories
- Loss of calories
  - Vomiting
  - Malabsorption
  - Malnutrition
- Increased caloric need
  - Cardiovascular disease
  - Liver disease
  - Renal disease
  - Chronic infections

Inadequate food intake

- Failure of food intake underlies most cases of FTI
  - Lack of available food
  - Lack of knowledge about infant feeding
  - Maternal depression
  - Specific dietary beliefs
- Parent-child interaction
  - Parent not offering food
  - Child refusing to take food
- Specific organic issues in the infant

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Small-for-gestational-age child

- The most common definition of SGA is 2SD below the mean for gestational age (≤ 2SD).
- ~90% of SGA infants exhibit spontaneous catch-up growth.
- Appropriate weight gain ("Goldilocks" amounts) is associated with the best neurological outcomes.
  - ↑↑ weight gain (> 5000 gm in the first 16 weeks of life) is associated with ↓ cognition and ↑ BMI at age 7 years.

Pylipow et al. J Pediatr 2009

Small for gestational age

- If a child is ≤ 2SD below the mean for gestational age, then child is SGA.

**Nutrition history**

- Feeding behavior and environment
- Allergies to foods
- Assessment of intake
  - Qualitative vs quantitative
  - 24-hour food recall
  - 3-day diet record

**Social history**

- Who feeds the child?
- Where and when does the child eat?
- Are there distractions?
- Is there any force feeding?
- Is there any grazing?
- Perception of growth failure as a problem

**Measurements**

- Vital for accurate assessment of growth
- Length
  - Length board until age 2
- Weight
  - < 24 months
    - Nude or in clean, dry diaper
  - 24+ months
    - Light clothing
- Thorough physical exam

**The physical exam**

**Z-scores**
The use of Z-scores

- Z-scores allow more precision in describing anthropometric status

Short stature

- Causes
  - Genetics 50%
  - Constitutional/nutritional 35%
  - Chronic illness >10%
  - Endocrine < 5%
- Children with growth hormone deficiency are not usually malnourished
- In malnutrition, serum IGF-1 will be low

Weight versus height

- Low weight, low height → Malnutrition
- Normal weight, low height → Endocrine
- Normal weight, low height, dysmorphism → Endocrine and Genetics
- SGA patients without catch-up growth by the age of 3 years can be referred to an endocrinologist for possible growth hormone treatment

Labs

- Laboratory tests do not help in the evaluation of FTT
  - 1.4 – 3.2% laboratory tests were helpful in making a diagnosis
  - All positive results suspected clinically

Labs

- Do not perform lab tests unless
  - Child is not responding to standard interventions
  - Child has other symptoms or signs of disease
- Common labs
  - CBC, ESR
  - Metabolic panel, electrolytes
  - Anti-ITG IgA, serum IgA level
  - Fecal elastase
  - Urinalysis
Assessment of Dietary Intake

Assessing intake
- Have parents describe typical day
- Look for red flags
  - Excessive juice intake
  - Excessive milk intake
  - ‘Grazing’

Juice
- 15 calories per ounce, no protein
- Has been shown to be contributing factor to FTT

Got too much milk?
- Excessive milk consumption can cause iron deficiency anemia and constipation
- If milk intake excessive, cut back to promote increase in solid food intake
- Whole milk - until age of 2
- Recommended milk intake
  - 2-3 years: 16-20 ounces
  - 4-12 years: 24-32 ounces

High-calorie beverages
Children < 1 year
- Adding powdered formula to expressed breast milk
- Increasing calories in formula

Children > 1 year
- 30 calorie per ounce beverages
  - Ready-to-feed: Pediasure, Nutren Jr
  - Mix powder with milk: Carnation Instant Breakfast w/ whole milk
  - Milk with heavy cream : 7 oz of whole milk with 1 oz of heavy cream

High-calorie foods
- Use the family’s usual foods
  - Add fat to the child’s foods
  - Suggest fats that are appropriate to the food being served
- Do not commence junk food


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- Increasing calories in formula

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Mealtimes Behaviors

• Meals/snacks
  – At table or in high chair
• Structured meals and snacks
  – No more than 20-30 minutes to eat/drink
  – Feed every 3 hours
• Only water between meals and snacks

Multivitamins

• Ask parents to look for a complete Pediatric multivitamin (not a gummy!)
• Most complete multivitamins
  – ½ tablet for 2 & 3-year-olds
  – Full tablet for 4+ years

Initial Interventions in a Child with FIT

• Establish Meal Time Routine
  – Meals and snacks offered every 3 hourly
  – Limit all feedings to maximum of 30 minutes
  – All meals and should be offered in a high chair/at the table
  – Minimize distractions
  – Avoid force feeding
  – Eliminate grazing between meals and snacks
  – Water between meals and snacks

Initial Interventions in a Child with FIT

• Decrease or eliminate juice
• High-calorie diet
  – Use the family’s regular meals but add fats only to foods presented to the patient
  – Do not switch child over to junk food
  – High-Calorie Beverages

High-Calorie Beverages

• In moderate or severe failure to thrive
• Unmotivated families
  – risk of child worsening if something is not done
• Balance between high-calorie beverage and solid food
• Wean off high-calorie beverage at the first possible opportunity
### Loss of calories

- Investigate and appropriately treat causes of vomiting and diarrhea
- Investigate for malabsorption if child is consuming sufficient calories
- Referral to appropriate subspecialists

### Increased caloric needs

- Eliminate juice
- Eliminate grazing
- Maximally concentrate all solids and liquids
- Consider tube-feeding early
- Referral to appropriate subspecialists

### Feeding Disorders

### Normal Feeding Milestones

- Rapid acquisition of feeding skills during 1st year of life
  - no plateau
- Consistent increase in variety and volume consumed during 1st year of life
- Should transition through purees, finger foods and early table foods by 1st birthday

### Normal Feeding Milestones

- Demonstrate basic chewing skills by age 1
  - continued refinement throughout early childhood
- Age and development should always guide feeding expectations
- Feeding a child should not be stressful

### In any child with a feeding disorder

- Is it organic in origin? Is it a lack of skill?
- Is it a behavioral issue?

In general, the younger the child the less likely that it is a behavioral issue.
Any child with a feeding disorder

- Establish Meal Time Routine
  - Meals and snacks offered every 3 hourly
  - All meals and should be offered in a high chair/at the table
  - Minimize distractions
  - Avoid force feeding
  - Grazing in between meal and snack times should be eliminated

Consider hunger manipulation

- This should only be done when it is fairly certain it is behavioral
- Should not be done in malnourished children
- Should be done correctly up to ½ - 1 whole day
- Should be abandoned if it does not work

Candidates for the Feeding Team

- Have enough neurological abilities to PO feed
- Highly motivated families
- Behavioral feeding problems
- Chronically G-tube-fed children who have the ability to eat by mouth

Summary

- Making a diagnosis of FTT requires a combination of objective and subjective information
- Once a diagnosis of FTT is made, further information is required to guide management
- Most children with FTT do not require laboratory studies
- Most children with FTT and Feeding Disorders can be managed through a series of simple interventions
The New Opportunities for Verification of Enteral Tube Location (NOVEL) Project Update

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Division of Pediatric Gastroenterology and Nutrition, Medical College of Wisconsin

Background

- In 2012, a safety alert was distributed by the Child Health Patient Safety Organization recommending the immediate discontinuation of the auscultation method for NG tube placement verification.
- 1.3-2.4% of NG tube in over 2,000 insertion were located outside of the gastrointestinal tract.
- 20% of those tubes led to pulmonary complications.
- Abdominal film is current gold standard.

Background continued

- Common in hospital and home settings.
- Used for enteral nutrition, fluids and medication administration.
- Broad discrepancies regarding verification of placement = lack of literature.
- Pediatrics more complex than adults: size of patient in relationship to size of tube, goal to minimize exposure to radiation.
- X-ray is the gold standard, followed by pH.
- NG tube misplacement can cause serious neurological harm or death.
- Nurses are primary health care providers who insert NG tubes in the hospital and home settings.

A mother’s story: (GET OUT THE KLEENEX)

- My name is Deahna Visscher and I lost my son to an avoidable medical error. On April 8, 2008 I gave birth to Grant Lars Visscher. He was born with a heart defect that required surgery. He flew through the recovery of his surgery with amazing progress. At 11 days old and within a couple of days of being released from the hospital. The day before he was to go home, I was scheduling his next appointment and our nurse came in and was not comfortable with his current feeding tube placement and wanted to put in a new one.

- As she was placing his new feeding tube I asked her how she would know it was in the right place. She then showed me how fluid was removed from the tube to show that it was in his stomach. I then asked her how she knew that sound was accurately in his abdomen. She then showed me how fluid was removed from the tube to show that it was in the right place. The nurse then showed me that she would put in a burst of air in the tube and listen through a stethoscope to hear the bubble in his abdomen. I asked the nurse how she could be sure that sound was accurately in his abdomen. She then showed me how fluid was removed from the tube to show that it was in the right place. She then showed me how fluid was removed from the tube to show that it was in the right place. She then showed me how fluid was removed from the tube to show that it was in the right place. She then showed me how fluid was removed from the tube to show that it was in the right place.

- I did not know then that my questions would come to haunt me, as the very things that I was shown to absolve my fears were proven false. He died that night because the placement was not correct despite the facts the nurse did to verify placement.

- Grant only lived 11 days. I mourn my loss daily. Mostly, I mourn for the time I did not get to spend with him. Since Grant’s death I have become determined to find a better and safer method for feeding tube placements so that no other parent or person will have to go through the pain and suffering that we did.

- Permission from Deahna to share.

Objectives:

- Discuss NG/OG/post-pyloric tube placement verification in pediatrics.
- Discuss the NOVEL project mission.
- Discuss research findings.
- Discuss future direction.
Ponder these questions

- How many of you have known of or been associated with an adverse outcome?
- Do you think NG tube misplacements is under-reported?
- What role does quality and safety have in relationship to placement?
- Should we be concerned just from this one story?

American Society for Parenteral and Enteral Nutrition (ASPEN)

- A literature review revealed very few pediatric studies to guide our practice
- ASPEN formed a task force to address this issue
- Invited participation from stakeholder organizations
- Named the project NOVEL (the New Opportunities for Verification of Enteral Tube Location)

Why ASPEN?

ASPEN Strategic Goals and the Novel Project

- Foster the discovery of new knowledge and its application to the field of nutritional science (NS) therapy
- Education healthcare professionals to provide optimal care
- Advocate on behalf of the field of NS to improve clinician experience and patient outcomes
- Position ASPEN as the leading organization in NS therapy

NOVEL Project

- Mission:
  - Determine best practices in NG tube placement verification in pediatric patients
  - Work with biomedical engineers and industry to develop non-radiologic methods to verify and re-verify NG tube placement
  - Disseminate knowledge to professionals to improve clinical practice

Study

- Email blasts were sent to members of ASPEN, AACN, SPN and Patient Safety Officers explaining the NOVEL project with directions for IRB and data collection
- 140+ individuals/hospitals requested the protocol and 8 withdrew
- Final count = 63 participating institutions
- 2 conference calls were held in December 2013 to explain the data collection process to local investigators
- Hospitals sent in IRB approval letters and data collection forms
- Data were collected between January – April 2014
Data Collection Tool

- Respondents were asked to fill out:
  - Name of hospital (coded)
  - Project coordinators credentials
  - Census on the day of collection
  - Number of critical care beds
  - Number of NICU beds
  - Verification method for checking placement
    - Ranked in order 1, 2, 3

Example of tool

<table>
<thead>
<tr>
<th>Patient Number</th>
<th>Patient Weight in kg</th>
<th>Patient age (See below)</th>
<th>Patient Location</th>
<th>Patient weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>(PICU, NICU, med/surg floor)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participating Institutions

- 63 Participating Sites
- Total census = 8333
- 39 pediatric facilities
- 8 adult with newborn
- 16 adults with pediatrics and newborn
- Percentage of patients with tube at time of collection = 23.94%

- Total number of NICU beds = 2791
- Total number of PICU beds = 1438
- Location of patients with tubes
  - NICU = 1219
  - PICU = 359
  - Med/Surg beds = 421
  - Unknown = 5

- Mean age = 14.33 months
- Mean tube size = 6.5 French
- Mean weight = 6.83kg
• Prevalence of NG tubes, n=1995
  • NG = ~66% n=1316
  • OG = ~21% n=414
  • Post pyloric = ~13% n=261
  • 4 unknown

• Of the 63 sites:
  • All listed a primary method of checking tube placement verification
  • 55 sites listed a secondary method of checking
  • 39 sites listed a tertiary method of checking

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Verification of Placement

• METHOD 1
  • Aspiration 21/63 = 33%
  • Auscultation 18/63 = 29%
  • Measurement 8/63 = 13%
  • pH 10/63 = 16%
  • X-ray 6/63 = 1%

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Verification of Placement

• METHOD 2
  • Aspiration 5/63 = .08%
  • Auscultation 20/63 = 0.32%
  • Measurement 4/63 = .06%
  • pH 5/63 = .08%
  • X-ray 19/63 = 30%

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Verification of Placement

• METHOD 3
  • Aspiration 12/63 = 19%
  • Auscultation 3/63 = 0.4%
  • Measurement 9/63 = 14%
  • pH 1/63 = 0.1%
  • X-ray 13/63 = 21%
  • Some left blank, one indicated fluoroscopy

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Verification by Type of Institution

• Pediatric Hospitals
  • Method 1 – aspiration
  • Method 2 – X-ray
  • Method 3 – measurement

• Adult hospitals with a NICU
  • Method 1 – auscultation
  • Method 2 – auscultation
  • Method 3 – auscultation

• Adult/Pediatric/Neonatal Hospital
  • Method 1 – aspiration
  • Method 2 – auscultation
  • Method 3 – X-ray
What does this mean?

- This data validates what is in the literature = limited
- Despite current recommendations, there is clearly inconsistencies across the country
- Research is needed
  - Barriers to implementing current recommendations
  - EBP studies for best practice
  - Size/weight of patient affecting verification
  - Negative effects of repeated X-ray exposure

Forward thinking for NOVEL

- Establish best practice
- Evidence based practice studies to evaluate the guidelines
- Potential for Enteral Access Safety Teams
- Dissemination of studies surrounding NG tube safety

From a nurse

“...I placed the NG like I had done hundreds of times in the past, with no complications and checked placement with air bolus and started the feed. The patient ended up coding on the floor and being sent to our PICU where she was intubated and started on ECMO. The moment that the patient went into respiratory distress, my whole life changed. I had not missed a day of work in seven years and went to my nurse manager and told her I needed to leave and could no longer be a nurse, and that I would not be back to work...”

from invited commentary in NCP June, 2014
Short bowel syndrome – A nutrition perspective

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Division of Gastroenterology and Nutrition
Medical College of Wisconsin
Milwaukee, WI

Objectives
- To review the definition and common etiologies of short bowel syndrome
- To discuss the pathophysiology of short bowel syndrome and the physiology of adaptation
- To review the clinical management of short bowel syndrome
- To discuss the complications of short bowel syndrome

Definition

Short-bowel syndrome (SBS) is defined functionally and is considered to exist when the patient has malabsorption in the presence of a shortened small intestine

Major features of SBS
- dehydration secondary to diarrhea
- malabsorption of macro- and micronutrients
- malnutrition
- failure to thrive

Etiology of SBS

- Neonates
  - NEC
  - Midgut volvulus
- Abnormal anatomy
  - Multiple atresias
  - Gastroschisis
  - Hirschsprung disease
- Older children and adults
  - Crohn's disease
  - Malrotation with volvulus
  - Tumors
  - Radiation enteritis
Length needed for TPN-free survival

- In infants with "normal" birth weight
  - at least 15 cm of jejunum or ileum and the ileocecal valve
  - or 40 cm of small bowel without the ileocecal valve
- Gestational age is imperative when reporting residual bowel length
  - 28-week-old neonate has approximately 200 cm of bowel, and this increases to 300 cm at term
- The anticipated increase in bowel length is greatest in premature infants - an important prognostic factor in SBS patients

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Jejuno-ileal length in preemies

<table>
<thead>
<tr>
<th>Weeks Range</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 – 27 weeks</td>
<td>114.8 +/- 21 cm</td>
</tr>
<tr>
<td>27 – 35 weeks</td>
<td>172.1 +/- 29 cm</td>
</tr>
<tr>
<td>&gt; 35 weeks</td>
<td>248.0 +/- 40 cm</td>
</tr>
</tbody>
</table>


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Physiology and pathophysiology

Anatomy of Small Intestine

- Stomach
- Duodenum
- Jejunum
- Ileum
- Ascending colon
- Descending colon
- Rectum
**Jejunum**
- Long villi
- Large absorptive surface
- High concentration of enzymes and carrier proteins
- Top site for nutrient absorption
- Large tight junctions
- Relatively porous
- Large influx of water and electrolytes into the lumen from the vasculature

**Ileum**
- Short villi
- Smaller absorptive surface
- Less important for nutrient absorption
- Important for bile salt and vitamin $B_12$ absorption
- Small tight junctions
- Conserves water and electrolytes

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**Effect of resections**

**Normal physiology**

<table>
<thead>
<tr>
<th>Duodenum</th>
<th>Jejunum</th>
<th>Ileum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrated nutrients delivered</td>
<td>a large influx of fluid and electrolytes into the lumen</td>
<td>Absorption of majority of fluid and electrolytes</td>
</tr>
</tbody>
</table>

**Ileal resection**

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**Jejunal resection**

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**The ileocecal valve**
- Serves as a barrier for reflux of colonic bacteria from the colon into the small intestine
- Resection may result in bacterial overgrowth in the small intestine
- It also regulates the exit of fluid and nutrients from the small intestine
- Rapid transit of nutrients into the colon may worsen malabsorption and increase sensitivity to osmotic loads
The colon

- The adult colon receives and absorbs 1-2 liters of fluid from the small bowel.
- Resection
  - Dehydration and electrolyte problems
  - Loss of energy via SCFA
- Right colon absorbs the majority of water and electrolytes
  - If the right colon is removed, gradual improvement in sodium and water absorption occurs in the left colon.

Adaptation

Adaptation

- Compensatory response that follows an abrupt decrease in mucosal surface area after an extensive small bowel resection.
- Includes anatomic and functional changes that increase the gut's digestive and absorptive capacity.
- Begins within 48 hours of surgery but may require up to 5 years for completion.

Adaptation

Structural alterations

- The remnant small bowel increases in length and caliber, with hyperplasia / hypertrophy of each intestinal layer.
- The magnitude of the response is greater after resection of the proximal small bowel compared with a distal resection.

Adaptation

Structural alterations

- The patient's age at the time of resection affects the extent of bowel lengthening.
  - Neonates are more likely than adults to achieve independence from TPN after extensive resection.

Adaptation

Structural alterations

- The adapting intestine develops an increased caliber and hypertrophy of the longitudinal and circular smooth muscle layers.
- The increased intestinal caliber increases the absorptive surface area.
  - May result in ineffective peristalsis.
  - This dysmotility leads to stasis, bacterial overgrowth, sepsis, and malabsorption.
Adaptation
Structural alterations

- Epithelial hyperplasia is the fundamental change
  - Increases villus height
  - Increases crypt depth
  - The number of villi is also increased

Adaptation
Functional alterations

- The sodium-glucose co-transporter increases its activity up to 2.5-fold
- Disaccharidases and dipeptidases along the brush border of the adapting small bowel show increased activity when measured per villus

Adaptation
Intestinal permeability

- Intestinal epithelium performs an important barrier function to infection
- Septic episodes in SBS may be secondary to a breach of this barrier with translocation of bacteria
- Bacterial overgrowth secondary to gut dysmotility is common in patients with SBS and can lead to bacterial translocation

Mechanisms of adaptation

- Trophic hormones
  - Enterochromaffin
  - Gastrin
  - Secretin
  - Cholecystokinin
  - Epidermal growth factor
  - Insulin-like growth factor 1
  - Peptide YY
  - Glucagon-like peptide 2 (GLP-2)
- Trophic substances
  - Prostaglandins
  - Polyamines
- Nutrients
  - Long-chain fats
  - Omega-3 fatty acids
  - Short-chain fatty acids
  - Fiber
  - ? Glutamine

Pharmacological manipulation

- Glutamine - Unclear
- MCT - Works with an intact colon
- LCT - Unclear
- Soluble fiber - Unclear
- Pancreatic enzymes - Do not work
- Bile acids - Unclear
- Growth hormone - Promising
- GLP-2 - Promising
How to feed?
When to feed?
What to feed?

Malabsorption
- The major consequence of resection of the small intestine is malabsorption
- Due to reduction of the absorptive surface area with loss of digestive enzymes and transport carrier proteins
- Carbohydrates
  - Produce tremendous osmotic diarrhea following resection of the ileum as reabsorption of water is impaired
- Proteins
  - Larger molecules which are ingested in smaller quantities, produce fewer symptoms when malabsorbed
- Fats
  - Large molecules, whose malabsorption creates little additional fluid loss from the small intestine
  - Fat-soluble vitamins may also be malabsorbed in large quantities
  - Following extensive ileal resection, bile salt depletion may occur

Motility changes
- Motility abnormalities following intestinal resection
- Intestinal transit time may increase as the intestine adapts in an attempt to increase nutrient contact time with the small-bowel mucosa
- Mucosal surface area will likewise increase as the small intestine dilates
- Unfortunately, both of these changes result in increased bacterial content in the small bowel

Importance of enteral nutrition
- Atrophy has been observed in the small intestine deprived of nutrient contact either by bypassing the small intestine surgically or by using parenteral nutrition
- Intravenous feeding following small-bowel resection results in slight mucosal atrophy, whereas enteral nutrition stimulates mucosal hyperplasia

Enteral nutrition
- Enteral nutrition is also important for stimulating regeneration of the mucosa
- The combination of parenteral and enteral nutrition is superior to parenteral nutrition in stimulating intestinal regeneration in a group of patients with protracted diarrhea of infancy
- A more rapid resolution of malabsorption and diarrhea following enteral nutrition alone versus parenteral nutrition in the same disorder has also been observed
- Enteral nutrition is also important in maintaining mucosal mass in SBS

Managing a patient with SBS
Initial management
- The immediate postoperative period is characterized by a transient ileus, and all nutrients must be given parenterally to stabilize fluid and electrolyte imbalances
Patients then develop large-volume fluid and electrolyte secretions once the ileus resolves, and gastric fluid and ostomy losses may be high. Because these losses may vary significantly with time, placing the patient on a standard parenteral nutrition solution is optimal. Excessive fluid losses can then be replaced based on the electrolyte content of these secretions as determined in the laboratory. These secretions can be replaced every few hours using a separate fluid and electrolyte solution. Losses tend to be high in sodium and solutions with at least 80 - 100 mEq/L of sodium are needed to maintain fluid and electrolyte homeostasis.

The first stage of therapy is the time to replete any nutritional deficiency states that may have existed at the time of resection.

When fluid and electrolyte losses have decreased, a continuous enteral infusion is initiated. Elemental diets are usually used. Some people use a lower concentration of formula and advance the concentration prior to advancing the rate (this prevents overloading the patient). Others start at optimal concentrations and advance the rate as tolerated.

Continuous enteral infusion is gradually advanced based on the absence of the following:
- A marked increase in stool loss by more than 50%
- Stool losses greater than 40 to 50 mL/kg/day or ostomy output strongly positive for reducing substances
- In patients with an intact colon, a decrease in stool pH below 5.5 is frequently indicative of carbohydrate malabsorption

Further advancement of enteral feedings is likely to result in a significant increase in osmotic diarrhea in such patients.

The use of continuous enteral infusion is advantageous. Feedings are frequently better tolerated. Emesis is reduced. Carrier proteins are continuously saturated and intestinal function is optimized. The increased enteral calories try to increase the functional workload of the small intestine, resulting in additional stimulation of intestinal adaptation. Administration of extra calories through the enteral route reduces the need for parenteral nutrition and its complications.

The appropriate solids to give initially to patients with short-bowel syndrome are a matter of controversy. Tradition has suggested high-carbohydrate diets. These are hyperosmolar and may increase fluid losses. Meat may be the best initial solid. Feeding fats or proteins results in less fluid loss. Fat is also a good trophic agent to the small intestine.
Enteral formulas

- Patients with SBS are given elemental diets
  - These are diets that contain amino acids rather than peptides
  - However, most protein is absorbed in the form of di- and tripeptides, so the concept of an elemental diet is extended in pediatrics to partially elemental formulas - extensive protein hydrolysates
  - Carbohydrates are usually present from one or more sources, including partially hydrolyzed starch and disaccharides such as sucrose
  - A mixture of medium- and long-chain fats is included
  - Adult elemental formulas are usually inappropriate in pediatrics
    - deficient in vitamins, minerals, and essential fatty acids
    - tend to be high in carbohydrate content

Enteral formulas

- Alimentum and Pregestimil
  - relatively high in fat content, reducing the osmotic load in the small intestine
  - Both contain substantial amounts of long-chain fats, important for their trophic effect
  - In older infants and toddlers, fiber-supplemented complex formulas may be instituted
    - as they produce a firmer stool
    - fiber, through its effect on SCFA production, may play a role in adaptation
  - Newer ‘amino-acid’ formulas do not confer any absorption advantage

Managing a patient with SBS

Long-term management

- As parenteral nutrition is decreased and enteral nutrition is increased, intermittent parenteral nutrition can be used.
- The patient is given the parenteral portion of his nutrition over an 8- to 16-hour period each day
- In small infants, parenteral nutrition may be required for the greater part of the 24-hour day, but soon the interval “off” parenteral nutrition can gradually be increased as the patient's tolerance of enteral calories increases

Managing a patient with SBS

Long-term management

- Caloric changes are gradually increased, based on the child's growth needs, to ensure that the child parallels the 50th percentile for both height and weight
- Excessive caloric administration is often a problem at this stage of management as the child is incapable of regulating his/her own nutrient intake
- Careful monitoring of the child's growth to make certain that the patient's weight gain is appropriate for length

Managing a patient with SBS

Long-term management

- Fluid losses are often substantial during early stages of short-bowel syndrome management
  - The enteral diets may be diluted with oral electrolyte solution and the rate of administration increased accordingly to replace these losses and simplify patient management as well as improve absorption
  - In the absence of small bowel bacterial overgrowth, the antimotility agents, such as loperamide, may occasionally be useful in slowing intestinal transit and increasing fluid and nutrient retention

Managing a patient with SBS

Long-term management

- Early in the course of therapy, preparations for home parenteral nutrition should be made
- Home parenteral nutrition
  - reduces the cost of long-term management
  - decreases family stresses and nosocomial infections
  - It has now become the standard of care in patients with short-bowel syndrome
### Chronic complications

#### Bacterial overgrowth
- One of the least-recognized complications
- Also one of the most treatable
- Overgrowth is considered to occur when bacterial content increases in the small intestine above normal levels
- Usually caused by facultative organisms and a variety of anaerobic bacteria

#### Watery diarrhea
- Excessive fluid secretion frequently occurs in SBS
- Often due to excessive carbohydrate administration
- This complication occurs more frequently with bolus than with continuous enteral feeding
- Somatostatin analogs have been used - usually with transient results
- Cholestyramine (bile acid binder) is sometimes helpful in short-bowel syndrome with watery diarrhea
- Cholestyramine may worsen diarrhea in massive ileal resections

#### Nutritional deficiencies
- Once patients are free of parenteral nutrition, they are subject to nutritional deficiency states.
- Usually, macronutrients can be absorbed in adequate quantities
- Trace minerals and vitamins, are often less well absorbed
  - Malabsorption of fat-soluble vitamins, especially A, D, and E, is common
  - Iron and zinc deficiency is common
  - Selenium absorption may also be impaired
  - Low serum levels of calcium and magnesium are also frequently observed
**Chronic complications**

**Nutritional deficiencies**

- Occasionally, the supplemental parenteral vitamins, minerals, micronutrients, and even fluid may be required even if the patient is able to absorb enough calories and protein to meet growth needs.
- Following ileal resection, patients should be monitored carefully for vitamin B12 deficiency.

**Parenteral nutrition liver disease**

- The major cause of death in children with SBS
- Common in children receiving long-term parenteral nutrition
- The incidence increases in inverse proportion to age; therefore, it is more common in small infants
- Many mechanisms have been postulated
- Prevention (?)
  - Aggressive use of enteral feedings – at least 20 - 30% of the total daily caloric intake through the enteral route
  - Prevention / treatment of bacterial overgrowth
  - Reduction in catheter-related sepsis
  - Omegaven

**Surgical techniques in SBS**

- Tapering enteroplasty
- Intestinal plication
- Creation of intestinal valves
Surgical techniques in SBS

Bianchi procedure

STEP procedure

Attempt to wean off PN

Successful
Unsuccessful or incomplete

Participation in investigational studies

Unable to tolerate home PN

Appropriate nontransplant surgery candidate

Tolerating home PN

Monitor for complications

Successful
Unsuccessful or incomplete