

# Short Bowel Syndrome



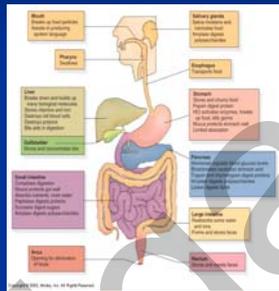
นพ. วีระชาติ ลิ้มจิตสมบุรณ์  
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## Outlines

- Anatomy
- Function of bowel segment
- Short bowel syndrome
  - Etiology
  - Clinical manifestation
  - Bowel adaptation
  - Management
  - Complication

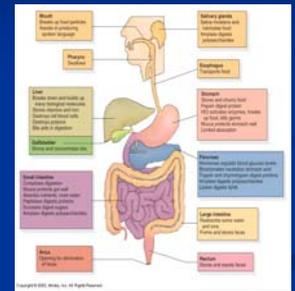
## Gastrointestinal System

- Oral cavity
- Major glands
  - Salivary gland
  - Pancrease
  - Liver
  - Gall bladder
- Alimentary canal
  - Esophagus
  - Stomach
  - Small intestine : Duodenum, jejunum, ileum
  - Large intestine : colon, caecum, rectum, anal canal

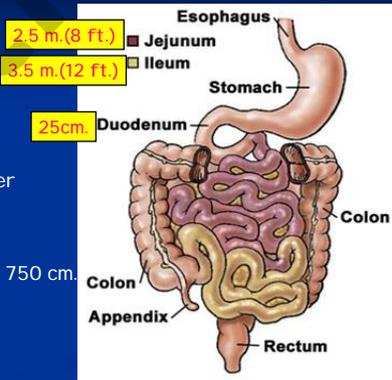


## Gastrointestinal System

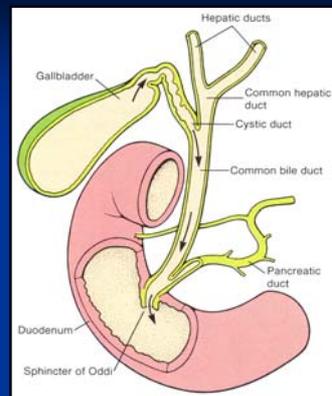
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## Small Intestine : Gross Anatomy

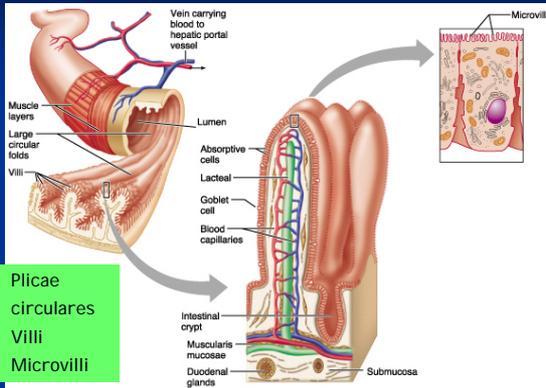


- From pyloric sphincter to the ileocecal valve
- Neonate ~ 250 cm.
- Adulthood : grows to 750 cm.



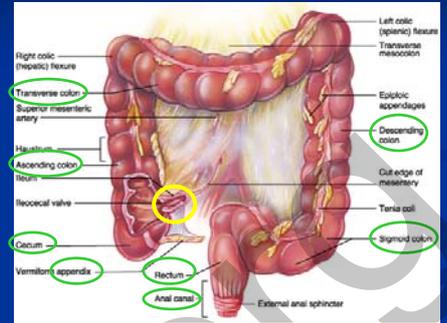
## Duodenum

## Small Intestine : Microscopic Anatomy

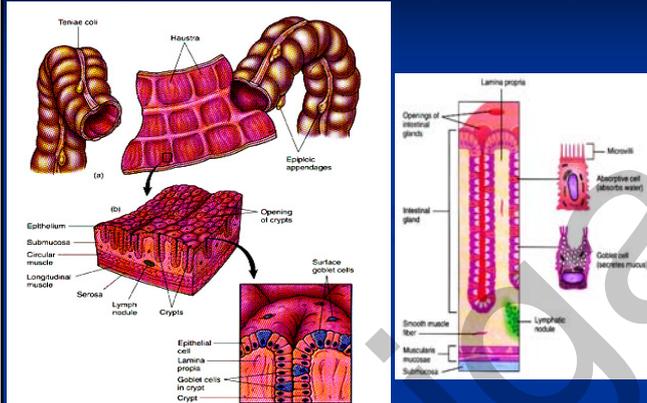


## Large Intestine : Gross Anatomy

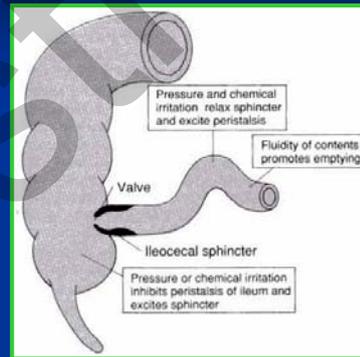
- 1.5 m. (5ft.)
- cecum
- appendix
- colon
  - ascending
  - transverse
  - descending
  - sigmoid
- rectum
- anal canal



## Large Intestine : Microscopic Anatomy



## Function of the ileocecal valve



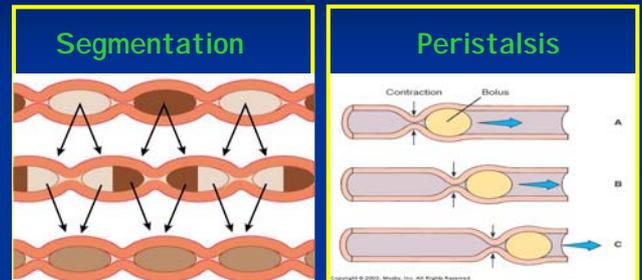
To prevent backflow of fecal contents from the colon → small intestine

## Function of the bowel segment

### 4 basic digestive processes

- Motility
- Secretion
- Digestion
- Absorption

## Motility



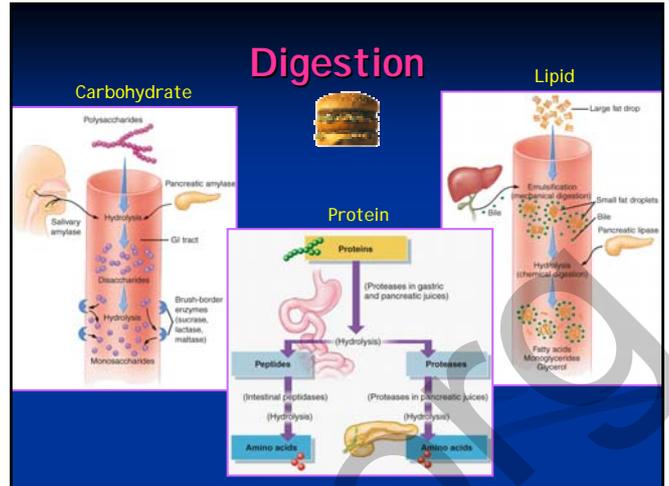
Pylorus → I CV 3-5 hr.  
I CV → T. colon 8-15 hr.  
T. Colon → sigmoid 2-3/day

## Secretion

### Crypts of Lieberkuhn

1. Water, Na, Cl, HCO<sub>3</sub>
- Enzyme : 1800 mL/day, pH7.5-8.0
    - Peptidase
    - Sucrase, maltase, isomaltase, lactase
    - Intestinal lipase

Brunner's gland : mucous

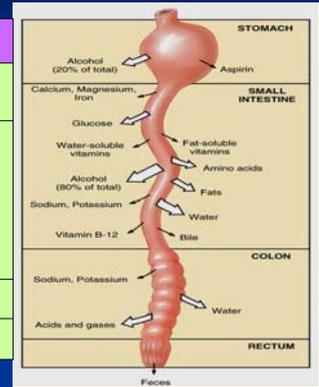


## Digestion : Large intestine

- much mucus, no enzymes are secreted
- some digestion of chyme by bacteria in colon
  - bacteria produce some vitB complex and K

## Absorption

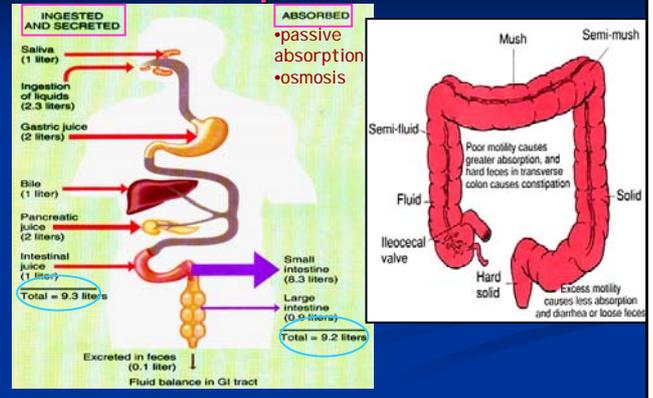
Site	Nutrients
Duodenum	Calcium, magnesium, iron, zinc
Jejunum	<ul style="list-style-type: none"> <li>Mono, disaccharide</li> <li>Protein</li> <li>Fat-soluble vitamin A and D</li> <li>Water-soluble vitamin : B1, B2, B6, C, folic acid</li> </ul>
Ileum	Fat, B12, bile salts
Colon	Fluid, electrolyte



## Absorption

Absorption of	Small intestine			Colon
	upper	mid	lower	
Carbohydrate	++	+++	++	0
Amino acids	++	+++	++	0
Fatty acids	+++	++	+	0
Bile salts	+	+	+++	0
Water soluble vitamins	+++	++	0	0
Vitamin B12	0	+	+++	0
Na	+++	++	+++	+++
K	+	+	+	0
Ca	+++	++	+	0
Fe	+++	++	+	0
Cl	+++	++	+	0

## Absorption : Water



## Electrolyte composition of enteral fluids

Fluid	Na <sup>+</sup> mEq/L	Cl <sup>-</sup> mEq/L	K <sup>+</sup> mEq/L	HCO <sub>3</sub> <sup>-</sup> mEq/L	H <sup>+</sup> mEq/L
Saliva	30-60	15-40	20	15-50	N/A
Gastric	20-80	100-150	5-20	N/A	30-100
Duodenal	100-140	90-130	5-15	50	N/A
Bile	120-140	80-120	5-15	40-50	N/A
Pancreatic	120-140	90-120	5-15	90	N/A
Jejunal	100	100	5-10	10-20	N/A
Ileal	140	20-110	3-15	30	N/A
Colonic	60	40	30	20	N/A

## Short Bowel syndrome

- Etiology
- Clinical related to site of resection
- Intestinal adaptation
- Application of adaptive process

## Background

- The short bowel syndrome is a malabsorptive state that may follow massive resection of the small intestine.
- The small intestine of the neonate is about 250 cm in length ,750 cm in adult.
- Loss of at less 50% of small bowel cause short bowel syndrome.

## Background

- Degree and extent of malabsorption and metabolic complications depend on the site of resection.
- Factor that influence the length of time until child independent of TPN
  - Remaining small bowel >40 cm
  - Absence of an ileocecal valve double time to complete adaptation.

## Background

- Better outcome association with
  - Breast milk
  - Aminoacid base formula
  - Percentage of kilocalories taken enterally by 6wk of life
  - Residual small bowel length at the time of surgery.

## Etiology

- Normal GI anatomy :
  - Resection of bowel from NEC ,Crohn's dz ,volvulus,tumor ,radiation enteritis, Hirschsprung's dz, ischemic injury
- Congenital anomalies :
  - Atresia in anywhere of the intestine.
  - Multiple atresia due to anomalies in the superior mesenteric artery.
  - gastroschisis

## Clinical relate to site of resection

- Jejunal resection
- Ileal resection
- Loss of the ileocecal valve

## Jejunal resection

- Transient malabsorption is related to the compensatory process of ileal adaptation.
- Following jejunal resection, ileum adapts rapidly and assumes jejunal function.

## Ileal resection

- Major ileal resection with jejunostomy: osmotic diarrhea associated with high carbohydrate feeding.
- Site-specific receptors for B12 and bile acid are not replaced in the jejunum or the colon.
- Thus, resection of >100 cm of ileum in adults impairs vitamin B12 and bile acid absorption but in infants is poorly defined.

## Ileal resection

- Leads to vitamin B12 deficiency and impaired absorption of fat and fat soluble vitamin.
- Secretory diarrhea (choleraic enteropathy): unabsorbed bile acids to the colon.
- Kidney stone: hyperoxaluria secondary to steatorrhea.

## Ileal resection

- Hypergastinemia (PU, esophagitis): loss of negative feedback for gastrin.
- Impair regulation of gut motility by nutrient (especially fat)
  - impair the ileal brake phenomenon which is controlled by peptide YY and perhaps other local hormones.

## Loss of the ileocecal valve

- Bacterial overgrowth
- Rapid transit time that exacerbate malabsorption and increase sensitivity to osmotic load in the small bowel.

## Intestinal adaptation

- **Change in morphorogy** to increase its absorptive surface area.
  - This process is **hyperplasia not hypertrophy**.
- **Change in functional capacity** to meet body's metabolic needs.

## Change in morphorogy

- **Macroscopic**
  - Dilatation
  - Thickening
  - Increase in length
- **Protein content**
  - Increase in DNA and RNA content
- **Microscopic**
  - Villus: increase height and diameter
  - Crypt: elongation
  - Epithelial cell life cycle: increase proliferation decrease apoptosis

## Change in functional capacity

- **Functional adaptation per unit length**
  - **Carbohydrate**: increase absorption per unit length
  - **Protein**: increase absorption per unit length
  - **Electrolytes**: upregulation of sodium-glucose transporter

## Change in functional capacity

- **Functional adaptation independent of morphologic adaptation occur rapidly.**
- **The nutrient** may act directly upon intestinal cell to **induce the synthesis or suppress** the degradation of **transport protein**.

## Change in functional capacity

- **High diet carbohydrate** stimulate:
  - enhance glucose transport within 1-3 days.
  - morphologic change in 1-3 wks.

## Intestinal adaptation

- The **absorption** following adaptation is **impaired and less magnitude than increase in mucosal mass**.
- Older animals are able to increase their intestinal mass greater than smaller animals.
- **Neonatal** bowel resection may reach their **full adaptive potential beyond the fifth of life**.

## Role of enteral nutrition in adaptation

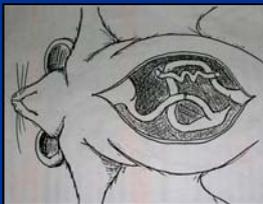
- Nutrient effects 3 major categories.
  1. Direct stimulation of hyperplasia through contact of the epithelial cell with intraluminal nutrient.
  2. Stimulation of secretion of trophic GI hormone.
  3. Stimulation of production of upper GI secretion.



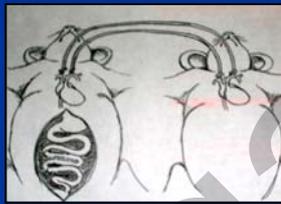
## Direct stimulation of hyperplasia epithelial cell

- It can improve intestinal adaptation.
- Stimulate regeneration of mucosa following injury.
- Maintain mucosal mass and normal glucose transport.
- Nutrient –sensitive epithelial proliferation.
  - Functional work load
  - Release of trophic factor

## Stimulation of secretion of trophic GI hormone



Thiry-Vella fistula



Concept of parabiosis



## Hormonal regulation

Hormone	source	function	note
<ul style="list-style-type: none"> <li>■ Glucagon like peptide 2</li> <li>■ Enteregucagon</li> </ul>	Ileum & proximal colon	Villi hyperplasia	Deficit : ↓ transit time
<ul style="list-style-type: none"> <li>■ Gastrin</li> </ul>	G cells of antrum	1. Stimulates secretion of HCl, pepsinogen 2. Stimulates gastric motility	- Inh by Secretin - Gastric pH < 1.5

## Hormonal regulation

Hormone	source	function	note
<ul style="list-style-type: none"> <li>■ secretin</li> </ul>	S cells of duodenum	1. Stimulates pancreatic HCO <sub>3</sub> secretion 2. Inhibits gastric acid secretion	- Prevent mucosal hypoplasia - nature antacid - Deficit : ↓ transit time
<ul style="list-style-type: none"> <li>■ Epidermal growth factor</li> </ul>	Breast milk	Stimulate gut epithelium in stomach	Maintain normal gut mass

## Hormonal regulation

Hormone	source	function	note
<ul style="list-style-type: none"> <li>■ Cholecysto kinin (CCK)</li> </ul>	I cells of duodenum and jejunum	1. Stimulates Gallbladder contraction 2. Inhibits gastric emptying 3. Stimulates secretion of HCl, pepsinogen	Deficit : in cholelithiasis, pain worsens after eating fatty foods due to CCK release

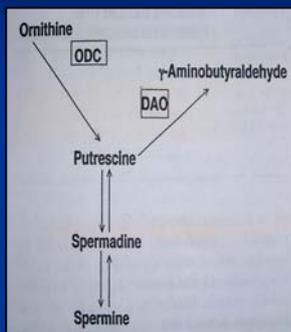
## Hormonal regulation

Hormone	source	function	note
■ IGF1		Regulate intestinal mass	
■ Peptide YY	Ileum & proximal colon Increase by add menhaden oil	Decrease GI motility Increase transit time	If deficit = delay transit time

## Prostaglandins

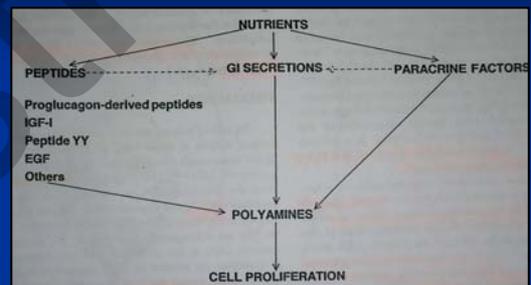
- Regulate epithelial cell proliferation.
- Using aspirin adversely affects intestinal adaptation of ileum not proximal small bowel.

## Polyamine



- Essential for normal cell growth and cell differentiation
- Induce maturation of sucrase isomaltase synthesis and Na/glucose transport

## Polyamines



Polyamine is final common pathway, which trophic factors stimulate intestinal adaptation

## Application of adaptive process

- Nutrients which may stimulate adaptation more than others
  - Long chain fats
  - 3-omega fatty acid
  - Short chain fatty acid
  - Fiber
  - Glutamine?

## Application of adaptive process

- Complex diet tends to induce more adaptation than elemental diet.
- Hydrolyzed casein > whole protein
- Long chain TG > medium chain TG
- High long chain TG, but deficit in essential fatty acid < adequate essential fatty acid.

## Application of adaptive process

- **Menhaden oil** :highly unsaturate fish oil,omega3 > oil with high essential fatty acid high saturate fat.
  - Increase in peptide YY level
- Mucosal atrophy associated with TPN can reverse by parenteral short chain fatty acid.

## Application of adaptive process

- Use of continuous enteral or small bolus feedings reduces the osmotic load in the small bowel.
- Diets higher in fat decrease the osmotic load to the small bowel and help stimulate gut adaptation.
- Aggressive use of enteral feeding stimulates gut adaptation, reducing the dependence on parenteral nutrition over time.

## Application of adaptive process

- Provision of extra vitamins and minerals based on the segment of small bowel resected is essential to prevent of nutritional deficiency states.
- The absence of the ileocecal valve and poor gut motility create bacterial overgrowth which must be carefully evaluated and managed.

## Management in short bowel syndrome

## Early postoperative stage

1. Large gastric or small bowel fluid losses  
Fluid and electrolyte management
2. Stomal and fecal losses  
Replaced every 2 hours
3. Gastric hypersecretion  
H<sub>2</sub> blockers/PPI in first 6 months
4. diarrhea  
Control with
  - a. anti-motility agent, loperamide
  - b. opiate
  - c. octreotide

## Early postoperative stage

- TPN for the first 7-10 days S/P enterectomy
- TPN should be supplied 30 kcal/kg/day
- Enteral feeding when hemodynamic stable and fluid management stable
- Electrolyte replacement and monitoring
- Blood glucose and triglycerides monitoring

## The goals of nutritional therapy

1. Maintain adequate nutrition
2. Promote intestinal adaptation
3. Avoid complications

## ENTERAL FEEDING

- Continuous enteral feeding via a nasogastric or gastrostomy tube initially
- Volume: small frequent feedings are preferable to infrequent large feedings
- Concentration: rapid increased up (0.67 kcal/ml in infants or 1 kcal/ml in children)
- Oral electrolyte solutions may be useful adjuncts especially in children with feeding tubes and high output fluid loss

## Composition

- Protein hydrolysate or elemental diets
- Complex carbohydrate is better than simple carbohydrate (Carbohydrates create a much higher osmotic load)
- Oxalate restriction in patient with an intact colon and fat malabsorption to avoid stone formation

## Composition

- Lipid
  - Medium-chain triglycerides  
water soluble, better absorbed in the presence of bile acid or pancreatic insufficiency.
  - Long-chain triglycerides: more effective in stimulating intestinal adaptation

## Composition

- Fiber supplementation: enhance intestinal adaptation and decrease the watery stools
- Solid feeding:
  - Infant and small children: start with meat (high-fat, protein and low carbohydrate)
  - Older children: high-fat and low carbohydrate balanced diet with small frequent feeding

- Stop enteral feeding when: stool losses increase by more than 50% (more than 40-50 ml/kg/day)

## Micronutrients supplementation

- Vitamin A 10000-50000 UNITS DAILY
- Vitamin B12 2300 µg subcutaneously monthly for terminal ileal resection
- Vitamin C 200-500 mg
- Vitamin D1 600 units DHT daily
- Vitamin E 30 IU daily
- Vitamin K 100 mg weekly

- Calcium
- Magnesium
- Iron As needed
- Selenium 60-100 µg daily
- Zinc 220-440 µg daily(sulfate)
- Bicarbonate As needed

## Nutrients that may stimulate adaptation

- Long-chain fats
- Omega-3 fatty acids
- Short-chain fatty acids
- Fiber
- Glutamine ??

## Limited ileal resection

- Secretory diarrhea from bile salt malabsorption, fat and vit.B12 malabsorption
- Cholestyramine : improve diarrhea
- Life-long vitamin B12 supplementation: monthly intramuscular injections

## Extensive small bowel resection

- Risk for nutrient, mineral, and vitamin deficiencies because of the loss of absorptive surface.
- Monitor serum level of "calcium, magnesium, zinc, selenium, and fat-soluble vitamins (A, D, E, K)" every 3 months.

## Indications for continued parental nutrition

- Poor weight gain or loss of maintenance weight.
- Extensive stomal fluid and electrolyte losses which cannot be replaced orally.

## Pharmacologic therapy

DRUG	MECHANISMS
H <sub>2</sub> blockers Proton pump inhibitors	Suppress gastric hypersecretion
octreotide	↑Small bowel transit time
Growth factors growth hormone Glucagon-like peptide 2(GLP-2) Hepatocyte growth factors IL-11 Epidermal growth factor	↑Enhance mucosal growth, Intestinal epithelial cell function

## Indication for Small bowel transplantation

- Impending or overt liver failure
- Thrombosis of major central venous channels
- Frequent central line related sepsis
- Frequent severe dehydration

## Nontransplantation procedures

- To improve the surface area or to slow transit emptying time.
- **Bianchi procedure** (intestinal tapering or lengthening)
- Contraindicated in small children and patients with small bowel bacterial overgrowth ,dilated bowel.

## CHRONIC COMPLICATIONS

- Complications of parenteral nutrition catheter-related problems  
sepsis  
TPN liver disease
- Unrelated to the parenteral nutrition  
small bowel bacterial overgrowth  
micronutrient deficiency ( stop parenteral )

## BACTERIAL OVERGROWTH

- Defined as increased bacterial content in the small intestine
- Normal small bowel bacterial counts vary from 10<sup>3</sup> proximally to greater concentration in the ileum
- A high concentration of gastric acid normally limits the number of bacteria

## BACTERIAL OVERGROWTH

- Eliminated from the small intestine through the combination of normal antegrade peristalsis and mucosal immune factors
- Short-bowel syndrome, many of these factors are disrupted
- When motility is slowed, the bowel is dilated, ileocecal valve is absent, bacterial overgrowth is almost universally present

## BACTERIAL OVERGROWTH

- Reduction in gut-associated lymphoid tissue following resection might also impair the immune
- Mainly facultative bacteria and anaerobes
- Bacteria deconjugate bile salts, resulting in rapid reabsorption of bile acids, depleting the bile salt pool→impairs micellar solubilization and results in steatorrhea and malabsorption of fat soluble vitamin

## BACTERIAL OVERGROWTH

- Also causes mucosal inflammation which further nutrient malabsorption
- Compete with the host for vitamin B<sub>12</sub>
- Should be considered when a patient experiences bloating, cramps, diarrhea, or GI blood loss
- Also common cause of clinical deterioration in a previously stable patient with short-bowel syndrome

## BACTERIAL OVERGROWTH

- Diagnosis→increased bacterial content by small intestine aspiration and culture of the fluid, not practical, unnecessary
- screening→breath hydrogen determination
- Markedly elevated fasting breath hydrogen levels, or a rapid rise in breath hydrogen following oral administration of glucose is suggestive

## BACTERIAL OVERGROWTH

- Screening → urine indican, indicator for bacterial overgrowth
- Small intestine biopsies→inflammatory changes, suggest bacterial overgrowth, esp. dilated, motility is poor, or a partial obstruction exists.
- D-lactic acidosis results because bacteria produce both D-and L-lactate, but only L-lactate is well metabolized by most humans

## BACTERIAL OVERGROWTH

- Consequently, broken down to lactic acid by the bacteria.
- D-lactate then accumulates in the blood stream, resulting in neurologic symptoms
- Small bowel colitis, another complication of bacterial overgrowth
- Occasionally responds to antimicrobial, sulfasalazine and immunosuppressive drugs are often efficacious

## BACTERIAL OVERGROWTH

- Short course of steroids → improvement in pt. with small bowel bacterial overgrowth-induced enterocolitis
- Arthritis and other rheumatologic symptoms suggest the possibility that the disorder may be immune complex related, possibly due to absorbed bacterial antigens

## BACTERIAL OVERGROWTH

- Broad spectrum antibiotics given intermittently, usually the first five days of each month
- Oral metronidazole 10-20 MKD , either alone or in combination with trimethoprim sulfamethoxazole
- Oral gentamicin, minimally absorbed

## BACTERIAL OVERGROWTH

- Refractory to therapy , antibiotics must be given continuously
- Absence of an IC valve results in severe overgrowth in the distal small intestine
- Encouraging frequent voluntary defecation may result in clinical improvement
- Daily saline enemas ,or occasionally enteral lavage with polyethylene glycol reduce bacterial content

## BACTERIAL OVERGROWTH

- Antimotility,loperamide may exacerbate bacterial overgrowth, contraindicated in pt. whose GI motility is already delayed.

## TREATMENT FOR BACTERIAL OVERGROWTH

- Antibiotics      intermittent  
                                 continuous cyclical
- Surgery            tapering  
                                 lengthening
- Prevention of colonic stasis  
                                 frequent bowel movements  
                                 saline enemas  
                                 enteral lavage

## WATERY DIARRHEA

- Occurs in many pts. With short-bowel syndrome
- Result of excessive osmotic load in small intestine when large quantities of carbohydrates are fed
- Elevated serum gastrin levels are often present, maybe enhanced fluid secretion
- Rarely, responds to H<sub>2</sub> antagonist

## WATERY DIARRHEA

- Somatostatin analogs have been used ,with varying results.
- Improve initially, but the favorable response is often transient, and exacerbation of fat malabsorption may negate the benefits of the drugs
- Cholestyramine, binds bile acids,esp. following ileal resection,where increased conc. of bile acids may cause watery diarrhea

## WATERY DIARRHEA

- Massive ileal resection, pt. may have bile acid insufficiency, and cholestyramine may exacerbate steatorrhea by further reducing effective bile acid conc.

## EFFECTS OF BILE SALT MALABSORPTION

- Mild = secretory diarrhea
- Severe = fat malabsorption  
loss of calories  
loss of fat soluble vitamins

## NUTRITIONAL DEFICIENCY STATES

- Once, off of parenteral nutrition, no longer control the pt.'s nutritional status
- Compromised small intestinal function becomes a major problem in ensuring adequate nutrient stores
- Macronutrients (protein, CBH, fat) can be absorbed in adequate quantities, but micronutrients frequently deficient.

## NUTRITIONAL DEFICIENCY STATES

- Malabsorption of fat-soluble vitamins, esp. A, D, and E is common
- Trace metal deficiencies, with iron and zinc being most common.
- Low serum zinc level esp. in association with a low serum alkaline phosphatase, suggest zinc deficiency

## NUTRITIONAL DEFICIENCY STATES

- Zn. def. result in poor growth as well as impaired intestinal adaptation and administration of exogenous zinc is important
- Selenium absorption may also be impaired.
- Deficiencies of minerals esp. calcium and magnesium also may exist

## NUTRITIONAL DEFICIENCY STATES

- Extra vitamin D and calcium may correct calcium def.
- Magnesium def. is more difficult to manage, administer Mg of results in osmotic diarrhea
- Other micronutrients, such as carnitine, choline, and taurine may also be important

## NUTRITIONAL DEFICIENCY STATES

- Ileum is solely responsible for bile acid and vitamin B<sub>12</sub> malabsorption
- Ileal resection, pt. should be periodically monitored for vitamin B<sub>12</sub> deficiency
- vitamin B12 deficiency may take years to develop, and periodic attention to this possibility is advisable

## PARENTERAL NUTRITION-INDUCED LIVER DISEASE

- Major cause of death in children with short-bowel syndrome
- Common in children receiving long-term parenteral nutrition
- Mechanism is unknown.
- May be from toxicity of amino acids, competition of amino acid with bile acid for transport across the canalicular membrane

## PARENTERAL NUTRITION-INDUCED LIVER DISEASE

- product of toxins in the unused bowel
- Excess nutrient administration
- Toxic substances in parenteral nutrition
- Nonstimulation gastrointestinal hormones that normally control biliary secretions

## PARENTERAL NUTRITION-INDUCED LIVER DISEASE

- Aggressive administration of enteral feedings, hopefully to ensure at least 20 or 30 % of total daily caloric intake through the enteral route
- Prevention of bacterial overgrowth, reduction of catheter-related sepsis, important in protecting pt. from parenteral nutrition-induced liver disease

## PARENTERAL NUTRITION-INDUCED LIVER DISEASE

- Biliary disease may also occur in children who depend on parenteral nutrition
- 20% of infants receiving parenteral nutrition may develop cholelithiasis
- Malabsorption of bile acid, altered bilirubin metabolism, and gall-bladder stasis are likely to be important factors in cholelithiasis

## PARENTERAL NUTRITION-INDUCED LIVER DISEASE

- Early cholecystectomy is advocated in patients on long-term parenteral nutrition

## PREVENTION OF TOTAL PARENTERAL NUTRITION LIVER DISEASE

- Aggressive use of enteral feedings
- Prevention of catheter sepsis
- Prevention of bacterial overgrowth

## CATHETER-RELATED COMPLICATIONS

- Complications relating to chronic indwelling central venous catheters are common
- Septic episodes typically occurring more frequently than once per year
- Highest in infants under one year of age
- Catheter thrombosis is also common

## CATHETER-RELATED COMPLICATIONS

- Infections may result either from poor catheter care technique, or from bacterial overgrowth with subsequent seeding of the blood stream with bacteria from the small intestine
- The former appears more common
- Catheter care techniques should be the first step in pt. with frequent central venous catheter infections

