Gastroenteritis disorders in Children

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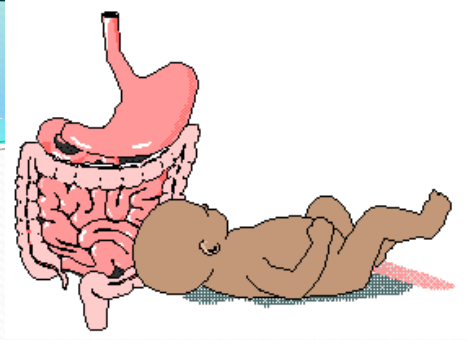
دكتوراة طب الاطفال وحديثي الولادة
ماجستير علم الطفيليات
باحث علمي في الربو والحساسية
عضو المجلس الطبي الكندي
بكلوريوس طب وجراحة عامة /جامعة بغداد

MBChB, CABP ,MSc., MCC

Diarrhea



- Definition:

  An increase in the fluidity, volume and frequency of stools.

- Acute diarrhea:

  Short in duration (less than 2 weeks).

- Chronic diarrhea:

  more than 2 weeks

Mechanisms of Diarrhea

- Osmotic
- Secretory
- Exudative
- Motility disorders

Mechanisms of Diarrhea

- **Osmotic**

  Defect present:

  Digestive enzyme deficiencies

  Ingestion of unabsorbable solute

  Examples:

  Viral infection

  Lactase deficiency

  Sorbitol/magnesium sulfate

  Infections

  Comments:

  Stop with fasting

  No stool WBCs

Mechanisms of Diarrhea

- **Secretory:**

Defect:

Increased secretion
Decreased absorption

Examples:

Cholera
Toxinogenic E.coli

Comments:

Persists during fasting
No stool leukocytes

Mechanisms of Diarrhea

- **Exudative Diarrhea:**

  Defects:

  Inflammation
  Decreased colonic reabsorption
  Increased motility

  Examples:

  Bacterial enteritis

  Comments:

  Blood, mucus and WBCs in stool

Mechanisms of Diarrhea

- **Increased motility:**

  Defect:

  Decreased transit time

  Example:

  Irritable bowel syndrome

Causes of acute diarrhoea in infancy and childhood

- Non-enteric causes: otitis media. Meningitis, sepsis generally
- Non-infectious causes: milk/food allergies, drug side effects, malabsorption
- Infections of the gastrointestinal tract

Infantile gastroenteritis: principal causes

- *Escherichia coli*
  - -enteropathogenic
  - -enterotoxigenic
  - -enteroinvasive

- Viruses
  - -rotavirus
  - -Noroviruses (Norwalk like)

Enteropathogenic *Esch coli* (EPEC)

- Small intestine affected
- Local destruction of intestinal epithelial cells
- Causes infantile diarrhoea
- Fever, nausea, vomiting, non-bloody stools
- Self-limiting
- Supportive care, no specific antibiotic treatment

EPEC Cont'd

- More than 20 (O) serotypes have been identified in outbreaks of infantile diarrhoea
- May affect maternity or neonatal units
- Adherence and colonizing factors appear important in pathogenesis (no toxin)

Enterotoxigenic *Esch coli*

- Infant diarrhoea, Travelers' diarrhoea
- Cause low grade fever, nausea, watery diarrhoea, cramps
- Small bowel affected
- Heat labile enterotoxin with cholera like effect
- Heat stable toxin
- Fluid and electrolyte loss

Enteroinvasive *Esch coli* (EIEC)

- Fever, watery diarrhoea, cramps
- Develops to (bacillary) dysentery, bloody stools
- Large bowel affected, by invasion and local destruction of epithelial cells
- Not enteropathogenic serotypes or enterotoxin producers

Viral gastroenteritis

- Frequent cause of infantile gastroenteritis
- Up to 50% of cases caused by rotaviruses in under 3 year olds
- Short incubation of 2-4 days
- Presents as acute diarrhoea of mild to moderate severity, may be vomiting
- More common in winter months
- Diagnosed by detection of rotavirus antigen in stool
- Supportive care

Other viruses causing infantile gastroenteritis

- Noroviruses ('Norwalk like viruses') and Sapoviruses are 2 genera of the family Caliciviridae
- (Small round structured viruses (SRSV))
- Astroviruses
- Adenoviruses

Management of infantile gastroenteritis

- Replacement of fluid and electrolytes
- Antibiotics don't alter course of the infection
- May be prevented by breast feeding babies
- A vaccine under development

Infantile gastroenteritis: other infectious causes

- *Salmonella* spp: usually food poisoning species, can cause outbreaks on units

  Note: enteric fever species also can cause this presentation
- Shigella spp: cause bacillary dysentery
- *Campylobacter jejuni*
- *Giardia lamblia*

Enterohaemorrhagic *Esch coli*

- Haemorrhagic colitis with severe abdominal cramps, watery then bloody diarrhoea
- Cause Haemolytic Uraemic Syndrome (HUS)
- Often caused by *E coli* 0157
- Children more affected with renal failure
- Antibiotics don't alter course

Haemolytic uraemic syndrome

- May follow 'uncomplicated' diarrhoeal illness
- Haemolytic anaemia, acute renal failure, thrombocytopenia
- Caused by verocytoxin (VTEC) same as S dysenteriae type 1 toxin
- Identified in microbiology lab as sorbitol non fermenting strains

HUS

- Most outbreaks due to strain O157:H7
- A large outbreak occurred in Scotland 1996 associated with consumption of meat contaminated by organism
- Many deaths in elderly people
- Source was cattle
- Control by good hygiene practices

Cryptosporidiosis

- A self limiting diarrhoeal illness in children
- Accompanied by nausea and vomiting
- Acquired by drinking contaminated water containing cysts of *Crypto parvum*
- Its very resistant to chlorination
- Source is infected cattle
- A more severe illness occurs in immunocompromised (AIDS)
- Diagnosed by finding cysts in stool (acid 'fast')
- No specific treatment

Gastrointestinal infections associated with travel (common)

- Enterotoxigenic *Esch coli* (Travellers' diarrhoea)
- *Salmonella* and *Campylobacter* spp (food poisoning)
- *Shigella* spp (Bacillary dysentery)
- Giardia lamblia (giardiasis)

Travellers' diarrhoea

- Commonly associated with travel especially to South America, Far East, Middle East etc.
- Diarrhoea with 'constitutional' upset
- Ideally diagnosis made by microbiological tests
- Severe diarrhoea with 6 or more stools per day consider therapy
- Selective prophylaxis

Giardiasis

- Caused by *Giardia lamblia*
- Protozoon pathogen
- Cosmopolitan
- Acquired by ingestion of cysts in contaminated food or water (resists chlorination)
- These develop into trophozoites in duodenum
- Symptoms of cramping abdo pain, flatulence, diarrhoea

Giardiasis: Diagnosis and management

- Find cysts or rarely trophozoites in stool
- Need to perform a stool 'concentration'
- Look at several samples
- Occasionally need duodenal aspirate or small bowel biopsy
- Metronidazole is antimicrobial of choice

Bacillary dysentery (SHIGELLOSIS)

- *Shigella sonnei* is the most common species in developed countries
- Causes a mild intestinal illness, with fever, malaise, self-limiting diarrhoea
- Requires low infecting dose acquired by direct contact
- Short incubation period
- Is locally invasive in large bowel
- Isolate organism on selective culture media

Shigellosis cont'd

- Other 3 species *S flexneri, S boydii, S dysenteriae* usually acquired abroad
- S dysenteriae causes severe illness which in developing countries can be fatal
- Produces an enterotoxin
- For this form of disease antibiotic therapy necessary

Uncommon causes

- Amoebic dysentery
- Causative organism: *Entamoeba histolytica*
- Mainly found in Indian sub Continent, Africa (but Worldwide distribution)
- Acquired from eating food contaminated with cysts
- Causes ulceration of the colon
- Variation in severity of symptoms but can be severe diarrhoea with blood and mucus in stool

Amoebic dysentery

- Can progress to cause perforation of large bowel and peritonitis
- Also, liver involvement with hepatitis or liver abscess
- Diagnosis made by finding amoebic trophozoites in ‘warm’ stool
- Serology positive in liver infection (immunofluorescence test for antibody)
- Treatment with metronidazole (emetine in non responders)

Cholera

- A severe diarrhoeal illness with production of ‘rice water’ stools
- Vomiting and nausea may accompany
- Leads to dehydration, prostration, electrolyte loss, circulatory and renal failure
- Due to toxigenic V cholerae of 3 types, classic, El Tor, and O139

Cholera

- Typically water borne
- Short incubation period
- Vibrio attaches to small intestinal epithelium and produces an enterotoxin which causes increased cyclic AMP production with outpouring of fluid and electrolytes
- Treat by rehydration and antibiotics
- Prevent by good sanitation, heat drinking water, oral vaccine

Other infections of intestinal tract

- Enteric fever (typhoid and paratyphoid) caused by *Salmonella enterica* serotypes *Typhi/paratyphi*
- *Yersinia enterocolitica* gastroenteritis
- *Aeromonas hydrophila* (aqautic organism)
- *Plesiomonas shigelloides* colitis
- Pseudomembranous colitis (*C difficile*)

Complications of Diarrhea

- Dehydration
- Metabolic Acidosis
- Gastrointestinal complications
- Nutritional complications

Complications of Diarrhea

Metabolic Acidosis

- Reduced serum bicarbonate
- Reduced arterial PH
- Compensating respiratory alkalosis

Complications of Diarrhea

Gastrointestinal complications

- Secondary carbohydrate malabsorption
- Protein intolerance
- Persistent diarrhea

Management

- Non-specific

- Oral Rehydration Solution (ORS):
  - Effective in all types & all degrees of dehydration.
  - Can prevent dehydration if given early in the disease.
  - Cheap, easy to administer; can be given by mother at home.
  - No chance of overhydration or electrolyte overdose.

- Methods of administration: spoon, cup, dropper, syringe, naso-gastric tube

ORS Composition

- Sodium Chloride
- Tri-Sodium Citrate (bicarbonate)
- Potassium Chloride
- Glucose

Notes:

- Gastroenteritis is acute self-limited illness.
- Diarrhea and vomiting in infancy and childhood is usually due to viral gastroenteritis.
- Fluid replacement with ORS is the mainstay of management.
- Breast feeding should be continued.
- Antibiotics and antiemetics agents are contraindicated.

Pediatric Fluid Therapy

Conditions

Gastroenteritis

Fever

Deprivation

Diabetes (Insipidus, mellitus - DKA)

Burns

Coma

Diuretics

Intestinal Drainage

Cystic fibrosis

Pediatric Fluid Therapy

Principles

Maintenance H_2O needs:

Weight in Kg	*H_2O fluid needs*
1-10	100cc /kg /day
11-20	1000 + 50cc/kg/day
> 20	1500 + 20cc/kg/day

Add 12 % for every ^{o}C

Na^+ & K^+ Daily Needs

Na^+ = 2-3 meq / kg / day

K^+ = 1-2 meq / kg / day

Serum Osmolality

Defined as the number of particles per liter.

May be approximated by:

2(Na) + Glucose (mg/dl)/18 + BUN(mg/dl)/2.8

Normal range: 275-295 mOsm/L

Insensible Fluid Losses

300-500 cc/M2/day

Less in patients on the ventillator

Composition of Body Fluids

Fluid	Na (mEq/L)	K (mEq/L)
Gastric	20-80	5-20
Small bowel	100-140	5-15
Bile	120-140	5-15
Diarrhea	10-90	10-80
Burns	140	5
Normal Sweat	10-30	3-10
Cystic fibrosis sweat	50-130	5-25

IV fluids

D5W (5 g sugar/100 ml)

D10W (10 g sugar/100 ml)

NS (0.9% NaCl) 154 mEq Na/L

1/2 NS (0.45% NaCl) 77 mEq Na/L

D5 1/3 NS 51 mEq Na/L

3% NaCl 513 mEq Na/L

8.4% $NaHCO_3$ (1 meq/cc Na & HCO_3)

IV fluids

Lactated Ringer's

- **Na 130 mEq/L**
- **$NaHCO_3$ 28 mEq/L as lactate**
- **K 4 mEq/L**
- **273 mOsm/L**

IV fluids

Amino acid 8.5 %

8.5 gm protein/100 cc

Albumin 25% (salt poor)

25 gm protein/100 cc

Na 100-160 mEq/L

Intralipid

2.25 gm lipid/100cc

Pediatric Fluid Therapy

Principles

Assess water deficit by:

1. weight:

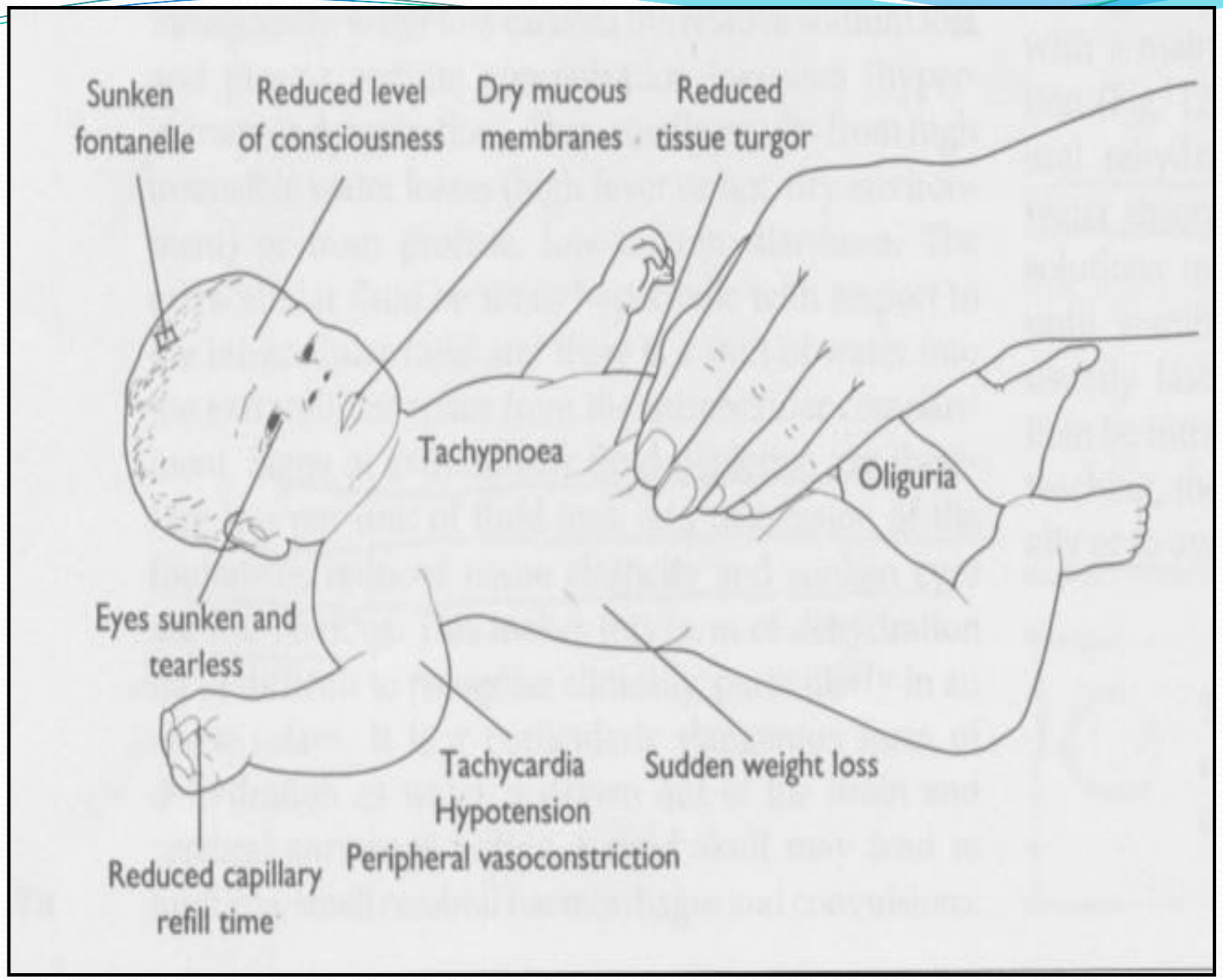
   weight loss (Kg) = water loss (L)

OR

2. Estimation of water deficit by physical exam:

Physical Signs of Dehydration

Signs & sympt.	MILD	Moderate	Severe
General	Thirsty, allert, restless	Thirsty, irritable, or drowsy	Drowsy – limp, skin cold / sweaty
Radial pulse	Normal rate	Rapid, weak	Rapid, feeble
Respiration	Normal	Deep	Deep & rapid
Anterior font.	Normal	Sunken	Very sunken
Skin turgor	Pinch retracts immediately	Retracts slowly	Poor
Eyes	Normal	Sunken	Grossly sunken
Tears	Present	Absent	Absent
Mucous memb.	Moist	Dry	Very dry
Urine flow	Normal	Dark & decreased	Oliguria / anuria


Sunken fontanelle
Reduced level of consciousness
Dry mucous membranes
Reduced tissue turgor
Tachypnoea
Oliguria
Eyes sunken and tearless
Tachycardia
Hypotension
Peripheral vasoconstriction
Sudden weight loss
Reduced capillary refill time

Pediatric Fluid Therapy

Principles

- *Moderate to severe dehydration:*

  IV push

  10-20 cc / Kg

  Normal saline or ringer lactate

  May repeat till sign and symptom improved.
- Half deficit over 8 hours, and half over 16 hours.
- If hypernatremic dehydration, replace deficit over 48 hours (evenly distributed).

Correction of Dehydration

- Estimate Fluid Deficit
  (% :- Mild, Moderate, Severe).
- Find Type of Dehydration
  (Isonatremic, Hyponatremic, Hypernatremic).
- Give daily Maintenance.
- Give Deficit as follows:
  Half volume over 8 hours, half volume over 16 hours
  (Exception: in Hypernatremic Dehydration, replace deficit over 48 hours).

Isonatremic Dehydration

Normal serum Na^+, Decreased total body Na^+.

Estimated deficit of Na^+ =

Mild 2-4 meq/ kg body weight

Moderate 6-8 meq/ kg body weight

Severe 8-12 meq/ kg body weight

Example:

In a 10 kg infant, with moderate-severe dehydration (10% dehydration)

Maintenance = (10)(100) = 1000cc
Deficit = (10)(100) = 1000cc
Total = 2 L

Na^+ maintenance = (3)(10) = 30 meq
Na^+ deficit = (10)(8) = 80 meq
Total = 110 meq

110 meq Na^+ in 2L = 55 meq Na^+ / L
= 0.3 saline

Hyponatremic Dehydration

$$\text{Total } Na^+ \text{ Deficit} =$$

$$(\text{Desired } Na^+) - (\text{Actual } Na^+) \times \text{Body Wt Kg} \times 0.6$$

$$+$$

Deficit similar to Isonatremic Dehydration

Symptomatic Hyponatremia

Convulsions

Rapid Intravenous administration of Na^+

3% saline infusion (1-2cc/kg body weight)

Hypernatremic Dehydration

Doughy skin

Significant morbidity & high mortality

Dehydration / Salt intoxication

Risk:

- Hypocalcemia
- Hypo / hyperglycemia
- Acidosis
- Cerebral hemorrhage
- Cerebral venous thrombosis

Hypernatremic Dehydration

- Serum Na+ > 150 meq/L (up to 213)
- Deficit replacement over 48 hours

  0.18% – 0.3% saline
- Regular daily maintenance
- Fluid evenly distributed over time
- Dialysis option in severe hypernatremia

Potassium

- Daily requirement: 1-2 meq / kg body weight.
- Usually add 10-20 meq KCl / L of IV fluid.
- Added only once the urine output is established.
- In Hypokalemia, add: 30 meq / L of IV fluid
  40 meq / L of IV fluid
  50 meq / L of IV fluid
  60 meq / L of IV fluid
  70 meq / L of IV fluid

ECG monitoring

Frequent testing

Acidosis

Usually Resolves with Hydration

In severe acidosis:

Alkali therapy ($NaHCO_3$) IV

Calculation:

(Desired HCO_3^- – Actual HCO_3^-) × wt Kg ×0.3

Oral Rehydration

Principle

Glucose absorption (enterocytes) facilitates water and electrolyte absorption.

Composition of Oral Rehydration Solution (O.R.S)

	Glucose	Na^+	K^+	Cl^-	Base
	gram %	mmol/L	mmol/L	mmol/L	mmol/L
W.H.O solution	2.0	90	20	80	30
Pedialyte	2.5	45	20	35	30

CHRONIC DIARRHEA

- ❑ diarrhea lasting > 14 days

Investigations for Chronic Diarrhea of Unknown Etiology

- ❑ serial heights, weights, growth percentiles
- ❑ if child is growing well and thriving, minimal workup is required
- ❑ if chronic diarrhea with FTT (the diagnosis can usually be made with history and physical exam),

but the following investigations depending on suspected diagnosis:

- **stool: consistency, pH, reducing substances, microscopy, occult blood, O&P, C&S, C. *difficile toxin, 3-day fecal fat***
- **urinalysis**
- **CBC, differential, ESR, smear, electrolytes, total protein, immunoglobulins**

- absorptive and nutritional status: albumin, carotene, Ca2+, PO4, Mg, Zn, Fe, ferritin, folate, fat-soluble vitamins, PT, PTT
- sweat chloride
- α-antitrypsin level, thyroid function tests, urine VMA and HVA, HIV test, lead levels
- CXR, upper GI series + follow-through
- specialized tests: small bowel biopsy, endoscopy and biopsy

A. CHRONIC DIARRHEA WITHOUT FAILURE TO THRIVE

Infectious

- **bacterial: e.g. *Campylobacter, Salmonella***
- **antibiotic-induced: C. *difficile colitis***
- **parasitic: *Giardia lamblia***
- **post-infectious: secondary lactase deficiency**

Toddler's Diarrhea

- ❑ most common cause of chronic diarrhea during infancy
- ❑ diagnosis of exclusion in thriving child (no weight loss, no fluid or electrolyte abnormalities, no FTT)
- ❑ onset between 6-36 months of age, ceases spontaneously between 2-4 years
- ❑ diet history: too much juice overwhelms small bowel resulting in disaccharide malabsorption

- ❑ stool may contain undigested food particles, 4-6 bowel movements (BM's) per day
- ❑ excoriated diaper rash
- ❑ management
  - reassurance, self-limiting
  - four F's (adequate fiber, normal fluid intake, 35-40% fat, discourage excess fruit juice)

Lactase Deficiency (Lactose Intolerance)

❑ **clinical features**

- **chronic, watery diarrhea**
- **abdominal pain, bloating, borborygmi**

❑ **two scenarios**

- **primary lactose intolerance: crampy abdominal pain with loose stool**
- **secondary lactose intolerance: older infant, persistent diarrhea (post viral/bacterial infection, celiac disease, or IBD)**

❑ **diagnosis**

- **clinical trial off milk or lactose free milk**
- **watery stool, acid pH, positive reducing sugars**
- **positive breath hydrogen test if > 6 years**

❑ **management**

- **lactose-free diet, soy formula**
- **Lacteeze, Lactaid tabs/drops**

B. CHRONIC DIARRHEA WITH FAILURE TO THRIVE

1. INTESTINAL CAUSES

Celiac Disease

- ❑ also known as "gluten-sensitive enteropathy"
- ❑ defect at the mucosal level
- ● toxic or immunologic reaction to gluten in "BROW"

(Barley, Rye, Oats, Wheat)

Celiac disease

- Autoimmune disorder with a prevalence of approximately 0.5 to 1 percent in the United States. (1 in every 100-200 persons)
- Inappropriate immune response to the dietary protein gluten, which is found in rye, wheat, and barley.
- Manifestations range from no symptoms to overt malabsorption with involvement of multiple organ systems and an increased risk of some malignancies.

- Most all patients with celiac disease express human leukocyte antigen (HLA)-DQ2 or HLA-DQ8, which facilitate the immune response against gluten proteins

- Concordance rates of 70 to 75 % among monozygotic twins and 5 to 22 % among first-degree relatives.

Risk Factors for Celiac Disease

Risk factor	*Prevalence among those with risk factor (%)*
Dermatitis herpetiformis	100
First-degree relative with celiac disease	5 to 22
Autoimmune thyroid disease	1.5 to 14
Down syndrome	5 to 12
Turner's syndrome	2 to 10
Type 1 diabetes mellitus	
Children	3 to 8
Adults	2 to 5

Dermatitis Herpetiformis

Signs and Symptoms

- Common
  - Diarrhea
  - Fatigue
  - Borborygmus
  - Abdominal pain
  - Weight loss
  - Abdominal distention
  - Flatulence
- Uncommon
  - Osteopenia/ osteoporosis
  - Abnormal liver function
  - Vomiting
  - Iron-deficiency anemia
  - Neurologic dysfunction
  - Constipation
  - Nausea

Recommendations for Celiac Disease Screening

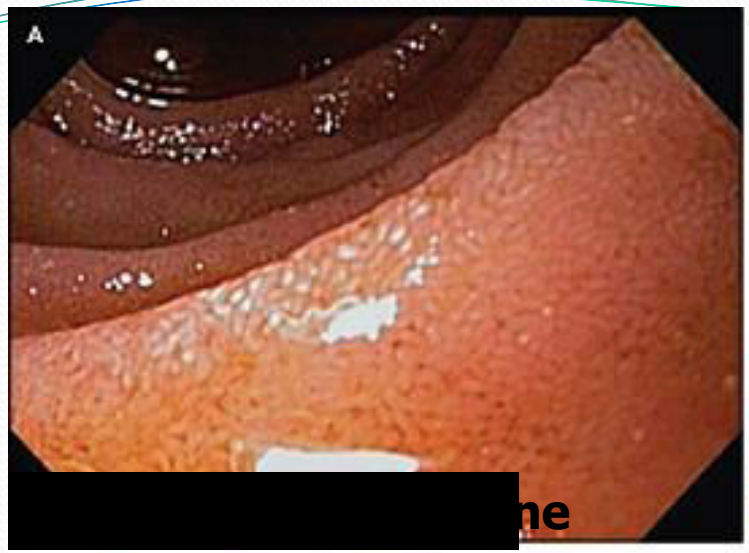
- **Consider testing in symptomatic patients at high risk for celiac disease with any of the following conditions:**
  - Autoimmune hepatitis
  - Down syndrome
  - Premature onset of osteoporosis
  - Primary biliary cirrhosis
  - Unexplained elevations in liver transaminase levels
  - Unexplained iron deficiency anemia

SEROLOGY

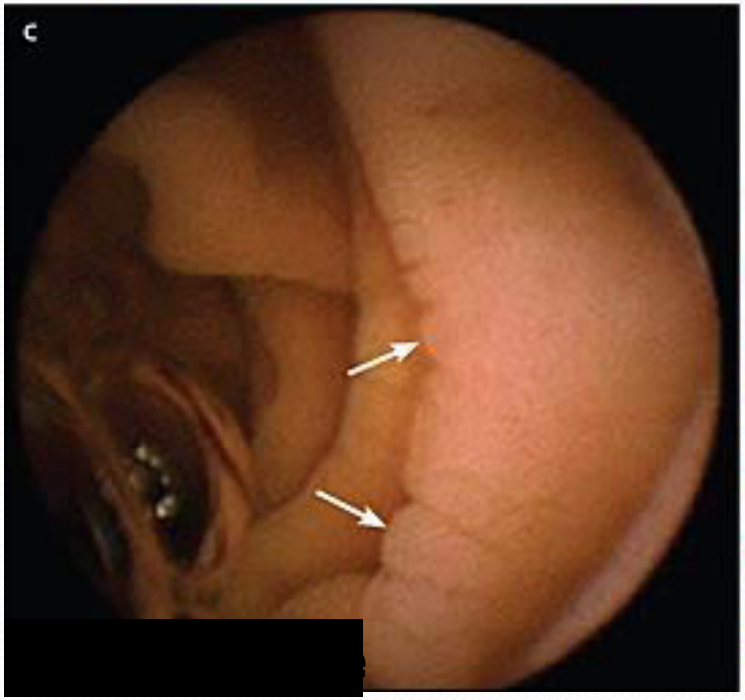
- Serum immunoglobulin A (IgA) endomysial antibodies and IgA tissue transglutaminase (tTG) antibodies. Sensitivity and specificity > 95%.
- Testing for gliadin antibodies is no longer recommended because of the low sensitivity and specificity for celiac disease.
- The tTG antibody test is less costly because it uses an enzyme-linked immunosorbent assay; it is the recommended single serologic test for celiac disease screening in the primary care setting.
- When the prevalence is low, as in the general U.S. population, the risk of a false-positive result is high even with an accurate test . PPV 49.7%, NPV 99.9%
- Confirmatory testing, including small bowel biopsy, is advised.

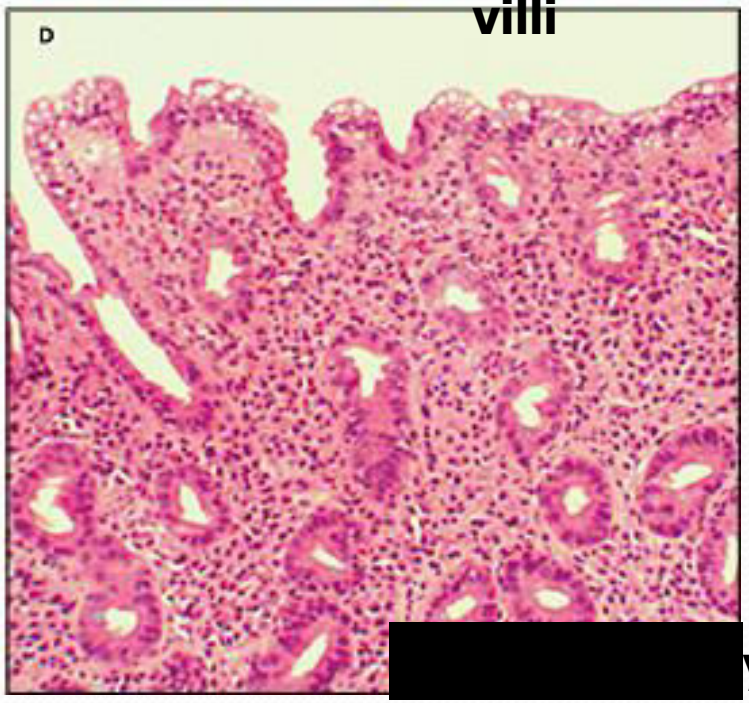
SMALL BOWEL BIOPSY

- Required to confirm the diagnosis of celiac disease for most patients.
- Should also be considered in patients with negative serologic test results who are at high risk or in whom the physician strongly suspects celiac disease.
- Mucosal changes may vary from partial to total villous atrophy, or may be characterized by subtle crypt lengthening or increased epithelial lymphocytes.
- To avoid false-negative results on endoscopic biopsy, most authorities recommend obtaining at least four tissue samples, which increases the sensitivity of the test.



villi





COMORBIDITIES

- Osteoporosis
- Thyroid dysfunction
- Deficiencies in folic acid, vitamin B12, fat-soluble vitamins, and iron
- Increased mortality due to increased risk of malignancy
  - Non-Hodgkin's lymphoma (3-6x more likely)
  - Oropharyngeal, esophageal, and small intestinal adenocarcinoma.

Cow milk intolerance

immune-mediated mucosal injury

❑ can be associated with anemia, hypoalbuminemia, edema

❑ up to 50% of children intolerant to cow's milk may be intolerant to soy protein

❑ often in atopic individuals

❑ 2 scenarios

• enterocolitis – vomiting, diarrhea, anemia, hematochezia

• enteropathy – chronic diarrhea, hypoalbuminemia

❑ treatment: casein hydrosylate formula

- **Inflammatory Bowel Disease (IBD)**

Other

- **specific enzyme deficiencies**
- **liver disease, biliary atresia**
- **a-ß-lipoproteinemia**
- **short gut toxic or immunologic reaction**
- **blind loop syndrome**
- ***Giardia lamblia***

2. PANCREATIC INSUFFICIENCY

- **Cystic Fibrosis (CF)**
- **Schwachman-Diamond Syndrome**