Introduction

- Derived from Greek *dia* means “through” and *rhien* “to flow”
Definition

• Sudden onset of increased fluid content of the stool above normal
  • Duration:
    • Acute: < 2 weeks
  • Volume:
    • Infants and toddlers >10 mL/kg/day
    • Older children > 200 mL/day
• From Practical viewpoint:
  • Decrease in consistency (to loose or liquid) and increase in frequency of bowel movements to ≥ 3 per day
Epidemiology

• WHO estimates: Diarrheal disease cause 17% of deaths in children < 5 yrs worldwide

• In United States:
  • Annually 38 million cases,
  • 2 million to 3.7 million physician visits,
  • 320,000 hospitalizations
  • associated with up to 9% of all hospitalizations in children < 5yrs
  • 325 to 425 deaths

• Seasonal peak in the winter

Lancet 2005; 365:1147-1152
J Pediatr 1991; 118:S27-S33
Pathophysiology

- Four processes that either individually or collectively contribute to diarrhea
  - Secretory
  - Cytotoxic
  - Osmotic
  - Inflammatory
Effect of bacterial enterotoxin on mucosal cells of the small intestine

- Enterotoxin stimulates secretion of fluid and electrolytes from mucosal crypt cells
  - Mediated through prostaglandins
  - Affects cAMP, GMP and calcium ion flows
  - Blocks absorption of fluid and electrolye by the villi
Cytotoxic Process

- Destruction of small intestinal mucosal villi by infectious viral agent
  - Villi shorten after cell lysis
  - Decreased small bowel surface area decreases capability of small intestine to absorb fluid and electrolytes
  - Proportional increase in secretion with marked decrease in absorptive function of small bowel mucosa
Osmotic Process

- Commonly seen in malabsorption syndromes
  - Lactose intolerance

- Malabsorbed substance is osmotically active, leading to a net flux of water into the intestinal lumen – resulting in loose diarrheal stools

- Large intestinal flora is inundated with increased CHO, which then is metabolized and produces gas, abdominal pain and decreased stool pH
Inflammatory Process

- Inflammation of mucosa and submucosa of terminal ileum and large bowel

- Invasion by a bacterial agent causes edema along with mucosal bleeding and leukocytic infiltration

- Inflammation causes increased colon motility and frequent stooling with tenesmus

- Alteration in GI motility – often with secretory and cytotoxic processes

- Luminal dilation, delayed gastric emptying (cause nausea and vomiting), rapid intestinal transit time with marked peristaltic rushes
## Cause of Acute Diarrhea: Infectious / Inflammatory

<table>
<thead>
<tr>
<th>Secretory</th>
<th>Cytotoxic</th>
<th>Dysenteric</th>
</tr>
</thead>
<tbody>
<tr>
<td>• E. coli</td>
<td>• Rotavirus</td>
<td>• Campylobacter fetus</td>
</tr>
<tr>
<td>• Vibrio cholerae</td>
<td>• Norwalk agent</td>
<td>• Clostridium difficile</td>
</tr>
<tr>
<td>• Clostridium difficle</td>
<td>• Cryptosporidium</td>
<td>• Salmonella</td>
</tr>
<tr>
<td>• Clostridium perfringes</td>
<td>• Escherichia coli</td>
<td>• Shigella</td>
</tr>
<tr>
<td>• Aeromonas hydrophila</td>
<td>• Giardia lamblia</td>
<td>• Yersinia enterocolitica</td>
</tr>
<tr>
<td>• Staphylococcus aureus</td>
<td>• Yersinia enterocolitica</td>
<td>• Entamoeba histolytica</td>
</tr>
<tr>
<td>• Vibrio parahemolyticus</td>
<td>• Yersinia enterocolitica</td>
<td></td>
</tr>
<tr>
<td>• Bacillus cereus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Shigella</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Salmonella</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Yersinia enterocolitics</td>
<td>• Yersinia enterocolitica</td>
<td></td>
</tr>
<tr>
<td>• Giardia lamblia</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thomas G. DeWitt *Pediatrics in Review* 1989;11;6
Causes of Acute Diarrhea

- **Drug Induced**
  - Antibiotic associated
  - Laxatives
  - Antacids that contain magnesium
  - Opiate withdrawal

- **Surgical conditions**
  - Acute appendicitis
  - Intussusception

- **Heavy metals or toxins**
  - Copper, tin, zinc
  - Chemotherapy or radiation induced enteritis

- **Vitamin Deficiency**
  - Niacin, Folate

- **Vitamin Toxicity**
  - Vitamin B3, C, Niacin

- **Disorders of Malabsorption**
  - Lactase deficiency
  - Sucrase-isomaltase deficiency

- **Food allergies or intolerance**
  - Cow’s milk or soy protein allergy
  - Methylxanthines(caffeine, theobromine, theophylline)
Indications of Moderate to Severe Disease

- Age < 3 months
- Weight <8 kg
- History of premature birth, chronic medical conditions or concurrent illness
- Fever $\geq 38^\circ$ C for infants <3 mo or $\geq 39^\circ$ C for children 3 to 36 months
- Visible blood in the stool
- High output diarrhea
- Persistent emesis
- Signs of dehydration
- Mental status changes
- Inadequate response to or caregiver unable to administer ORT

Adapted from King et al MMWR Recomm Rep 2003
Physical Examination of the Child With Diarrhea

- Growth chart
- Vital signs
- Muscle mass
- Subcutaneous fat
- Pubertal stage
- Psychomotor development
- Skin (perianal)
- ENT region - otitis media

- Abdomen
  - Organomegaly
  - Tenderness

- Rectal exam
- Stool sample
- Color Consistency
- ? Occult blood → Hemoccult
- ? pH → Indicator
- ? Fermentation → Clinitest
# Signs of Dehydration

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Minimal or No Dehydration (&lt; 3% Loss of Body Weight)</th>
<th>Mild to Moderate Dehydration (3–9% Loss of Body Weight)</th>
<th>Severe Dehydration (&gt; 9% Loss of Body Weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental status</td>
<td>Well; alert</td>
<td>Normal, fatigued or restless, irritable Thirsty; eager to drink Normal to increased</td>
<td>Apathetic, lethargic, unconscious Drinks poorly; unable to drink Tachycardia, with bradycardia in most severe cases</td>
</tr>
<tr>
<td>Thirst</td>
<td>Drinks normally; might refuse liquids</td>
<td></td>
<td>Weak, thready, or impalpable Deeply sunken Absent Parched Deep</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Normal</td>
<td></td>
<td>Re coil in &gt; 2 s Prolonged; minimal Cold; mottled; cyanotic Minimal</td>
</tr>
<tr>
<td>Quality of pulses</td>
<td>Normal</td>
<td>Normal to decreased Slightly sunken Decreased Dry Normal; fast Recoil in &lt; 2 s</td>
<td></td>
</tr>
<tr>
<td>Eyes</td>
<td>Normal</td>
<td></td>
<td>Parched</td>
</tr>
<tr>
<td>Tears</td>
<td>Present</td>
<td></td>
<td>Deep</td>
</tr>
<tr>
<td>Mouth and tongue</td>
<td>Moist</td>
<td></td>
<td>Absent</td>
</tr>
<tr>
<td>Breathing</td>
<td>Normal</td>
<td></td>
<td>Prolonged</td>
</tr>
<tr>
<td>Skin fold</td>
<td>Instant recoil</td>
<td></td>
<td>Cool</td>
</tr>
<tr>
<td>Capillary refill</td>
<td>Normal</td>
<td></td>
<td>Decreased</td>
</tr>
<tr>
<td>Extremities</td>
<td>Warm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urine output</td>
<td>Normal to decreased</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Treatment of Dehydration

## TABLE 2: Summary of treatment based on degree of dehydration

<table>
<thead>
<tr>
<th>Degree of dehydration</th>
<th>Rehydration therapy</th>
<th>Replacement of losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal or no dehydration</td>
<td>Not applicable</td>
<td>&lt;10 kg body weight: 60–120 mL oral rehydration solution (ORS) for each diarrheal stool or vomiting episode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10 kg body weight: 120–240 mL ORS for each diarrheal stool or vomiting episode</td>
</tr>
<tr>
<td>Mild to moderate dehydration</td>
<td>ORS, 50–100 mL/kg body weight over 3–4 hours</td>
<td>Same</td>
</tr>
<tr>
<td>Severe dehydration</td>
<td>Lactated Ringer’s solution or normal saline in 20 mL/kg body weight intravenous amounts until perfusion and mental status improve; then administer 100 mL/kg body weight ORS over 4 hours or 5% dextrose ½ normal saline intravenously at twice maintenance fluid rates</td>
<td>Same; if unable to drink, administer through nasogastric tube or administer 5% dextrose ¼ normal saline with 20 mEq/L potassium chloride intravenously</td>
</tr>
</tbody>
</table>
## Composition of Oral Rehydration Solution

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>ESPGHAN-ORS (mmol/L)</th>
<th>WHO –ORS 2002 (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>74-111</td>
<td>75</td>
</tr>
<tr>
<td>Na</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>K</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Base</td>
<td>10 (citrate)</td>
<td>30</td>
</tr>
<tr>
<td>Cl</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>Osmolality</td>
<td>225-260</td>
<td>245</td>
</tr>
</tbody>
</table>
Early Refeeding

• Early refeeding is recommended in managing acute gastroenteritis
  • Luminal contents are known growth factors for enterocytes and help facilitate mucosal repair after injury
  • Almost all infants with acute gastroenteritis can tolerate breastfeeding
  • Diluted formula does not provide any benefit over full-strength formula
  • Infants with the most severe diarrhea may require lactose-free formula until mucosal recovery is complete at around 2 weeks
  • Older children can consume a regular age-appropriate diet
    • BRAT diet not recommended
Other Treatment Options

- Antibiotics
- Zinc
- Immunoglobulin
- Drugs
- Probiotics
Antibiotics

• May prolong illness, increase carrier state & increased morbidity

• **Antibiotic use always indicated**
  - *V. cholera, Shigella* and *Giardia lamblia*

• **Antimicrobial therapy in selected circumstances**
  - Enetropathogenic *E. Coli* when running a prolonged course
  - Enteroinvasive *E. Coli* based on serologic, genetic and pathogenic similarities with *shigella*
  - *Yersinia* infection in subjects with sickle cell disease
  - *Salmonella* infection in very young infants, if febrile or with positive blood culture
Zinc

- Micronutrient deficiency in malnourished children with diarrhea

- Zinc supplementation in acute diarrhea (WHO/UNICEF in 2004)
  - Infants > 6 months of age – 10mg/day
  - Children with 20mg/day
  - Duration 10-14 days

- Any of zinc salts ie, sulphate, gluconate or acetate may be used

- Benefits – can shorten course and severity
Immunoglobulin

• Oral or enteral immunoglobulin in treatment of rotavirus diarrhea (immunocompromised or immunocompetent)

• Current evidence does not support the use of oral immunoglobulin preparations to prevent rotavirus infection in low birth weight infants

Haque KN et al Cochrane Database Syst Rev. 2011 Nov 9;(11)
Probiotics

- Modify the composition of the colonic microflora and act against enteric pathogens, their mechanism of action is yet to be defined
  - May be effective for acute diarrhea, in addition to ORS
  - Proof of efficacy is limited to few strains, *Lactobacillus rhamnosus GG* (LGG) and the yeast *Saccharomyces boulardii*

- For acute diarrhea in developed countries shorten duration of diarrhea by 1 day
  - Effects seen when administered early in course and dose of 1 billion CFU/d

- Efficacy is evident in viral diarrheas of mild to moderate degree, less or absent in invasive bacterial diarrhea

Alfredo Guarino et al. Expert Opin Pharmacother. 2012 Jan;13(1)
Prevention

• Education
• Sanitation
• Hygiene
  • Simple hand washing has decreased incidence by >50%
• Breast feeding
• Food safety
  • Food safety has also been effective in decreasing the incidence by >50%
• Appropriate use of oral rehydration therapy
• Probiotics
• Development of vaccinations
  • Rota virus vaccine – RotaTeq and Rotarix