

Infectious Diarrheal Diseases

Michael Yin, MD MS

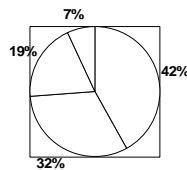
Epidemiology

- Overall burden not well studied in developed world
 - Attack rate: 1-3 illnesses per child per year
 - Food-borne disease in U.S.
 - 76 million illnesses
 - 350,000 hospitalizations
 - 5,000 deaths
 - Waterborne outbreaks

Outline

- Epidemiology
- Pathogenic Mechanisms
- Host Defenses
- Representative Organisms
 - Non-inflammatory diarrhea
 - Inflammatory diarrhea
 - Penetrating
- Approach to the Patient

Epidemiology



□ Campylobacter □ Salmonella
□ Shigella □ E. Coli 0157

- Most cases of acute infectious diarrhea are caused by viruses
- Bacterial pathogens isolated in 1-6% of cases
- Limitation of hospital based survey:
 - 22% examined
 - 5% submitted stool

Epidemiology

- Major cause of morbidity and mortality in children developing world
 - Attack rate: 10-18 illnesses per child per year
 - In Asia, Africa, Latin America there are approximately 1 billion cases/yr resulting in 4-6 million deaths per year (12,600 deaths/day)
 - In some areas >50% of childhood deaths are attributable to acute diarrheal illnesses

Bacterial Pathogens

- Water/Foodborne
 - *Campylobacter*
 - *Salmonella* (nontyphi)
 - Enterohemorrhagic *E. coli* (EHEC) and Enterotoxigenic *E. coli* (ETEC)
 - *Vibrio*
 - *Yersinia*
 - *Clostridium perfringens*
 - *Bacillus cereus*
 - *Staphylococcus aureus*
- Person-to-person
 - *Shigella*
 - *Salmonella typhi*

Pathogenic Mechanisms

- Inoculum size
- Adherence
- Toxin Production
 - Enterotoxin
 - Cytotoxin
 - Neurotoxin
- Invasion

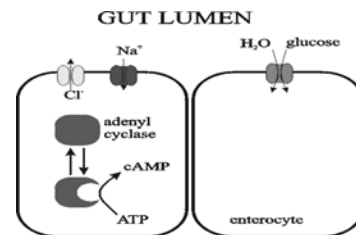
Pathogenic Mechanisms

- Cholera Toxin (enterotoxin)
 - A subunit: enzymatic activity
 - B subunit: binds to enterocyte surface receptor, the ganglioside G_{M1}
 - After binding, the A subunit is
 - translocated across cell membrane
 - catalyzes ADP ribosylation of a GTP-binding protein resulting in persistent activation of adenylate cyclase

Pathogenic Mechanisms

- Inoculum size
 - 10-100 organisms
 - *Shigella*
 - *Enterohemorrhagic E. coli (EHEC)*
 - <1000 organisms
 - *Salmonella typhi*
 - *Campylobacter jejuni*
 - 10^5 to 10^8 organisms
 - *Vibrio cholera*
 - *Salmonella (nontyphoidal)*

Cholera Toxin



Pathogenic Mechanisms

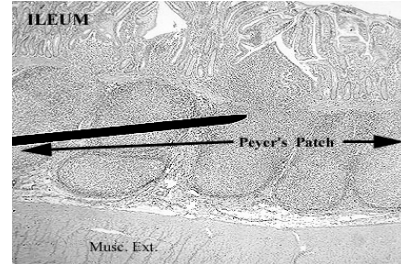
- Toxin Production
 - **Enterotoxin:** cause watery diarrhea by acting directly on secretory mechanisms in the intestinal mucosa
 - *Vibrio cholera*, ETEC, *Clostridium perfringens*
 - **Cytotoxin:** cause destruction of mucosal cells and associated with inflammatory diarrhea
 - *Shigella*, EHEC
 - **Neurotoxin:** act directly on central or peripheral nervous system
 - *Staphylococcus aureus*, *Bacillus cereus*

Pathogenic Mechanisms

- Shigella Toxin (cytotoxin)
 - B subunit binds to host cell glycolipid (Gb3) and facilitates transfer of A subunit
 - A subunit disrupts protein synthesis by preventing binding of aminoacyl-transfer RNA to the 60S ribosomal subunit
 - Results in destruction of intestinal cells and villi, decreasing intestinal absorption

Pathogenic Mechanisms

- **Staphylococcus Aureus enterotoxin (neurotoxin)**
 - Heat-stabile toxin
 - Increases peristalsis by sympathetic activation, resulting in intense vomiting
- **Bacillus Cereus enterotoxin**
 - Two enterotoxins
 - Emetic: incubation period 1-6 hours
 - Diarrheal: Incubation period 10-12 hours



Pathogenic Mechanisms

- **Tissue Invasion**
 - Salmonella Pathogenicity Island-1 and 2 (SPI-1 & SPI-2)
 - Binds to microfold cells (M cell) or enterocytes
 - Introduces salmonella-secreted invasion proteins (Sips or Sps) into M cells resulting in membrane ruffling and phagocytosis
 - Replicates in phagosome (tolerant to acids)
 - Spreads to adjacent epithelial cells and lymphoid tissue.

Clinical approach to Infectious Diarrheas

	Watery Diarrhea	Bloody diarrhea (Dysentery)	Enteric Fever
Mechanism	Non inflammatory (enterotoxin)	Inflammatory (invasion or cytotoxin)	Penetrating systemic infection
Location	Proximal small bowel	Colon or distal small bowel	Distal small bowel
Pathogens	<i>Vibrio cholera</i> ETEC <i>Clostridium Perfringens</i> <i>Bacillus cereus</i> <i>Staphylococcus aureus</i>	<i>Shigella</i> spp. <i>Salmonella</i> (Nontyphoidal) <i>Campylobacter jejuni</i> EHEC/EIEC <i>Clostridium difficile</i>	<i>Salmonella typhi</i> <i>Yersinia enterocolitica</i>

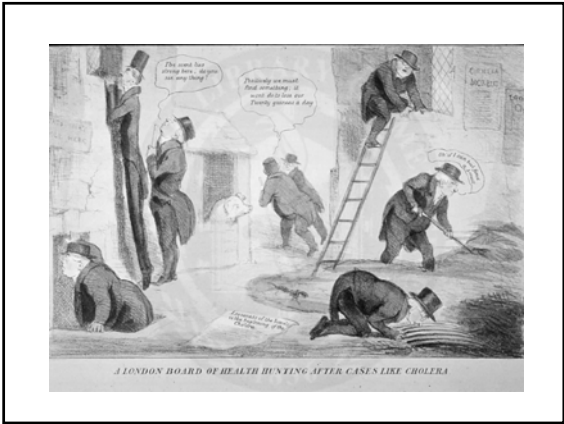
Host Defenses

- **Normal Flora**
 - Anaerobes: acidic pH & fatty acid production prevent colonization by bacterial pathogens
- **Gastric Acid**
 - Increased frequency of Salmonella among patients with gastric bypass
- **Intestinal Motility**
 - Impaired motility allows for bacterial overgrowth
- **Immunity**
 - Secretory IgA, systemic IgG and IgM
 - Cell-mediated immunity
 - Binding of bacterial antigens to the luminal side of M cells in distal small intestines, subsequent presentation of antigen to subepithelial lymphoid tissue

A case of watery diarrhea

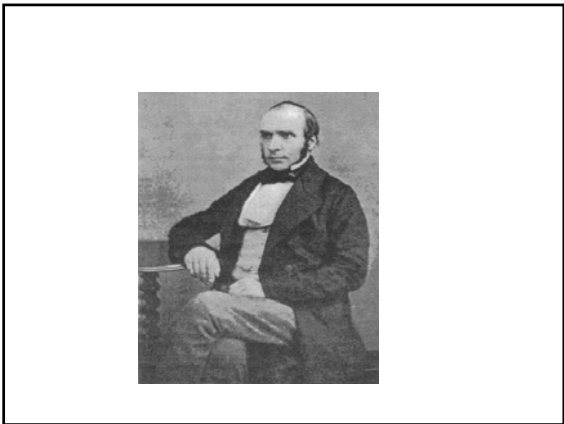
- 1 year old boy with abrupt onset of watery diarrhea and vomiting
- No fever, no bloody stool
- Development of sunken eyes, dry mouth, inability to feed, lack of urination
- Lethargic, unresponsive, death
- Father also with watery diarrhea (1 liter/day), vomiting, cramps





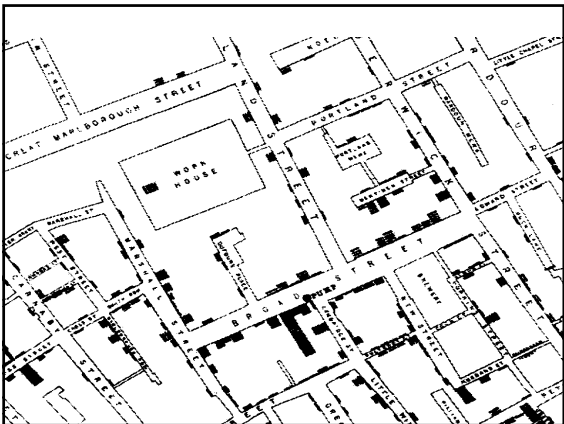
Index case

- “underneath the floorboards of the overcrowded cellars lurked ... a fetid sea of cesspits as old as the houses, many of which had never been drained”
- London had over 200,000 cesspools
- No incentive for maintenance



Vibrio Cholera

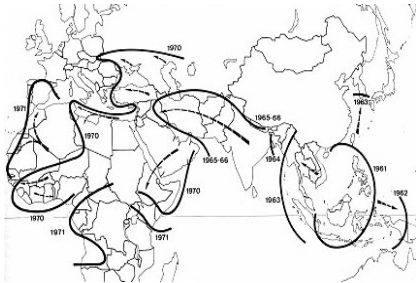
- Microbiology
 - Identified by Filippo Pacini in 1854 and Robert Koch in 1883
 - Curved gram negative bacillus with single polar flagellum
 - Only *V. cholera* carrying O1 and O139 somatic antigens are associated with disease
 - Secretion of enterotoxin



Vibrio cholera

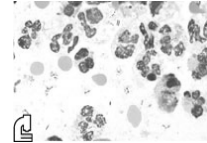
- Epidemiology
 - Lives in aquatic environments attached to algae or crustacean shells
 - Multiplies when temperature, salinity, and nutrients are suitable
 - Both an endemic and epidemic pattern
 - Transmission through contaminated food and water, secondary cases common

The 7th Cholera Pandemic (EL Tor) 1961-1971



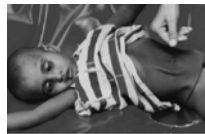
A case of bloody diarrhea

- Laboratory findings
 - Leukocytosis (WBC=13,200, 85% neutrophils)
 - negative blood cultures
 - Stool examination reveals fecal leukocytes, no ova and parasites



Vibrio cholera

- Clinical
 - Variable
 - 75% Asymptomatic
 - 20% Abrupt watery diarrhea
 - 5% Severe watery diarrhea, vomiting, and dehydration
 - No tenesmus, strain or abdominal pain, or fever
 - Dehydration
 - Duration 1-3 days
- Treatment
 - Rehydration: IV followed by Oral Rehydration Solution (glucose and electrolytes)
 - Doxycycline



Shigella

- Microbiology
 - Small gram negative rod, member of Enterobacteriaceae, tribe Escherichieae
 - 40 serotypes. Shigella sonnei (40-80% cases in U.S.), S. dysenteriae, S. flexneri, S. boydii
 - S. dysenteriae 1 produces Shiga toxin

A case of bloody diarrhea

- 4 yr old boy who goes to daycare
- 2 hour history of vomiting, diarrhea, fever, irritability and lethargy
- Physical exam
 - Fever
 - Tachycardia
 - Tachypnea
 - Mild dehydration

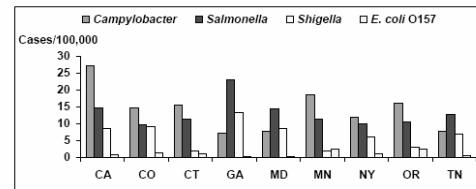
Shigella

- Pathogenesis
 - Low inoculum (<200 organisms)
 - Person-to-person spread, secondary cases common
 - Invasion of intestinal mucosa, moving from small to large intestines, with multiplication and mucosal destruction
 - Cytotoxin elaboration
 - Penetration beyond mucosa is rare

Shigella

- Clinical manifestations
 - 12 hours after ingestion, bacterial multiplication begins in the small intestines resulting in abdominal pain, cramping, watery diarrhea and fever
 - Resolution of fever in a few days
 - Onset of severe lower abdomen pain, accompanied by urgency, tenesmus, and bloody mucoid stools (dysentery)
 - Illness lasts for average of 7 days
 - Colonic shedding for 1-4 weeks
 - *S. dysenteriae* results in more serious diarrhea with risk of Hemolytic Uremic Syndrome (HUS)

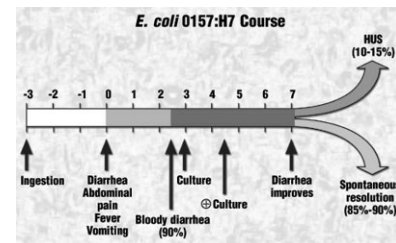
Figure 2. Cases per 100,000 population of foodborne disease caused by specific pathogens, FoodNet sites, 2003



E. coli

- Enterotoxigenic (ETEC): traveler's diarrhea
- Enteropathogenic (EPEC): children's diarrhea
- Enteroinvasive (EIEC): shigella-like dysentery
- Enterohemorrhagic (EHEC): hemorrhagic colitis, associated with HUS in children
- Enteroadherent (EAEC): traveler's diarrhea in Mexico and North Africa

E. Coli 0157:H7



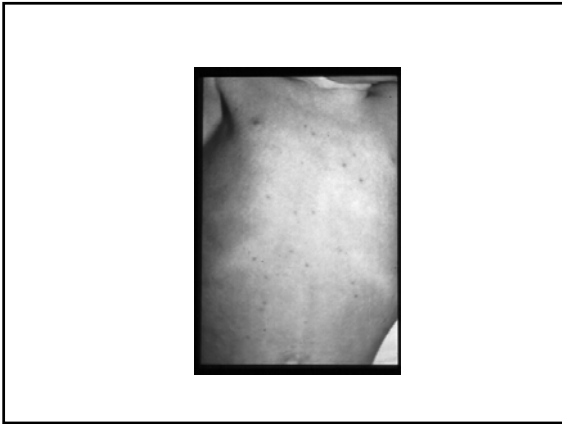
E. Coli 0157:H7



- 1982: ground beef
- 1990: drinking water
- 1991: apple cider
- 1992: hamburger
 - 28 illnesses in 6 states
 - 5 with HUS
 - PFGE analysis links isolates from 18 patients to ground beef from ConAgra & patient's home
 - ConAgra recalls 18.6 million lbs of beef

A case of Enteric Fever

- A 23 year old P&S student develops persistent fevers 2 weeks after returning from Mexico
 - Associated with headache, malaise and anorexia
 - Missed student health appointment prior to departure
 - Had self limited diarrhea while in Mexico
- Physical examination
 - Splenomegaly
 - Salmon pink rash
- Laboratory data
 - Leukopenia
 - Blood culture: gram negative rod



Salmonella

- Clinical Manifestations of Nontyphoidal Salmonella (*S. typhimurium*, *S. enteritidis* etc.)
 - Gastroenteritis
 - Nausea, vomiting, diarrhea 6-48 hours after ingestion
 - Fever, abdominal cramping
 - Self limited (3-7 days)
 - Bacteremia
 - Occurs more rapidly than Typhoid and lacks typical rose spots and leukopenia
 - Often in AIDS patients
 - Tissue invasion/localized infections
 - Arterial infections, cholecystitis, osteomyelitis, septic arthritis

Salmonella

- Microbiology
 - Gram negative, facultative anaerobic rod
 - More than 2500 serotypes
 - *S. typhi* and *S. paratyphi*
 - Nontyphoidal Salmonella (*S. enteritidis*, *S. typhimurium*, *S. virchow*, *S. dublin*, *S. choleraesuis* etc...)
- Epidemiology
 - *S. typhi* and *S. paratyphi* are strict human pathogens
 - Nontyphoidal salmonella colonizes virtually all animals; therefore, causes infection with through contaminated food
 - Up to 0.1% of eggs contain *S. enteritidis*

Salmonella

- Clinical Manifestations of *S. typhi* and *S. paratyphi*
 - Enteric Fever
 - Fever begins 5-21 days after ingestion and persists 4-8 weeks in untreated patients
 - Rose spots (30%), hepatosplenomegaly (50%)
 - Most symptoms resolved by fourth week
 - Complications: death in 1-30%; intestinal perforation, abscesses, endocarditis; relapse in 10%.
 - Asymptomatic carriage
 - 1-4%

Salmonella

- Pathogenesis
 - Ingested Salmonella induce endocytosis by M cells and enterocytes in small intestines
 - Organisms replicate within phagosomes
 - Transcytose to basolateral surface and interact with macrophages and lymphocytes in Peyer's patch
 - Recruitment of additional mononuclear cells and lymphocytes resulting in mucosal necrosis
 - Spread systemically to bone marrow, liver, spleen within macrophages
 - Risk of invasive salmonellosis greater in patients with impaired cell-mediated immunity (AIDS, transplant)



Typhoid Mary



- 1900-1907: Mary Mallon linked to 7 family epidemics
- 1907-1910: confined to Willard Parker Hospital
- 1915: A devastating outbreak linked to Mary
- Confined to North Brother Island until death in 1938

Approach to patient

- History
 - Duration
 - Fever
 - Appearance of stool
 - Abdominal pain
 - Tenesmus
 - Vomiting
 - Common source
 - Antibiotic use
 - Travel

NAME	ADDRESS	CARRIER NO.
Mallon, Mary	Hiverside Hospital	486
AGE 46 yrs. SEX Female COLOR W CREDIT=not given	NO. Bro.	CASE NO. YEAR-1907
<p>HISTORY - IF ANY - Discovered as carrier by Dr. Soper in 1907 as cause of typhoid infection in families where engaged as cook - Sent to Hiverside - later paroled. Upon agreement would report periodically to H. Dr. & not engage in foodhandling - broke her parole and rediscovered at St. Albans Hosp. March 1915. Outbreak of typhoid involving 25 persons Jan. 1915 - traced to pudding prepared by cook Mrs. Brown who proved to be Mary Mallon. Bury. at shore since Oct. 1914. Was apprehended and sent to Hiverside March 1916, where she is 2/15/16. Stools from her periodically are positive. Bacter. ever having typhoid to Dr. Hadden - 11/6 to notify Hadden, to send specimen. Dr. Hadden inf. 12/10/16. Refuse to give stools doctor inf. 1/3/19. Dr. West says he will try again 3/15/17. To B.E. 8/6/22- Chronic Carrier. 8/24/22 Made Chronic Carrier.</p>		
SPECIMENS		
Stools +	Stools +	Stools -
DATE & RESULT	DATE & RESULT	DATE & RESULT
12/11/23 12/14/23	80 positive	4/7/19 no growth
12/18/23 12/20/23	stools from 3/16/20	7/7/20 neg.
12/27/23	to 12/7/23	12/12/20 neg.
		12/6/20 No growth
		neg. 9/12 9/6 too
		obj. 9/28= 9/6 &
		9/11 incomplete
		ins. 8/18/24 over-
		green 8/10 -10/20/24
<p>Comments</p> <p>Board Action 8/24/23 (over)</p> <p>Extra copy for file</p>		

Approach to patient

- Stool evaluations
 - Fecal leukocytes
 - Bacterial culture
 - Clostridium difficile toxin
 - Shiga toxin
 - Ova and parasites

Approach to patient

- Inflammatory or non-inflammatory
 - Epidemiologic context of infection
 - Traveler's diarrhea
 - Food poisoning
 - Hospital acquired diarrhea
- Degree of dehydration
 - Mild: dry mouth, decreased sweat and urine
 - Moderate: orthostasis, skin tenting, sunken eyes
 - Severe: hypotension, tachycardia, confusion, shock

Treatment

- Rehydration
- If non-inflammatory, continue symptomatic therapy
- If inflammatory, consider empiric antibiotic therapy
 - EHEC infection: increase incidence of HUS
 - Salmonella gastroenteritis: does not shorten illness but increases convalescent carriage

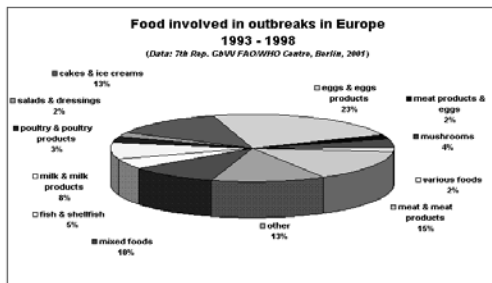
Prevention

- Environmental control
 - Chlorination of water, improved sanitation
 - Improvements in food processing
 - Handwashing
- Vaccines
 - Successful *S. typhi* vaccine to Vi antigen
 - Oral cholera vaccine (Dukoral) composed of killed organism and cholera B subunit

Foodborne Illnesses from Bacterial Infections

Etiology	Incubation	Signs & symptoms	Duration of illness	Associated foods
<i>Listeria monocytogenes</i>	9-48 hrs	Fever, muscle ache, N, D	Variable	Soft cheeses, milk, deli meats
<i>Shigella</i> spp.	24-48 hrs	Cramps, fever, diarrhea	Variable	Person to person, food
<i>Yersinia enterocolytica</i>	24-48 hrs	D, V, abd pain, fever	1-3 weeks	Pork, milk, water
<i>Salmonella</i> spp.	1-3 days	D, Fever, cramps	4-7 days	Poultry, milk, cheese, fruits
EHEC	1-8 days	Severe bloody diarrhea	5-10 days	Beef, milk, raw fruits, veg
<i>Campylobacter jejuni</i>	2-5 days	Diarrhea, cramps, fever	2-10 days	Poultry, milk, water

Foodborne illnesses



Prevention

- Food preparation
 - Wash hands, clean surfaces
 - Refrigerate promptly (within 2 hours)
 - Cook to proper temperatures
 - Beef and pork to 160°F
 - Poultry to 160°F
 - Egg until yolk and white are firm
- If at high risk (immunocompromised, gastric surgery, cirrhosis)
 - Avoid raw shellfish, fish, meat, eggs
 - Avoid unpasteurized milks, cheeses, juice

Foodborne Illnesses from preformed toxins

Etiology	Incubation	Signs & symptoms	Duration of illness	Associated foods
<i>Bacillus cereus</i>	1-6 hrs	Nausea, vomiting	1 day	Rice, meats
<i>Staph aureus</i>	1-6 hrs	Nausea, vomiting	1-2 days	Meat, eggs, potatoes, salads
<i>Bacillus cereus</i>	10-16 hrs	Cramps, diarrhea	1-2 days	Meat, stews
<i>Clostridium perfringens</i>	8-16 hrs	Diarrhea, vomiting, cramps	1-2 days	Meats, poultry gravy
<i>Clostridium botulinum</i>	12-72 hrs	Vomiting, diarrhea, blurred vision, weakness	variable	Canned foods, cheese sauce