Invasive Diarrhea

Some bacteria cause dysentery through direct invasion and destruction of intestinal mucosa rather than through production of a cytotoxin. *Shigella* and enteroinvasive *E. coli* invade and multiply in epithelial cells and spread to adjacent cells. Diarrhea is often accompanied by fever, abdominal cramps, and small amounts of bloody mucoid stools. Other bacteria, such as *Salmonella typhi* and *Yersinia enterocolitica*, penetrate the mucosa before disseminating into the bloodstream to cause a systemic illness.

Bacterial Food Poisoning

Bacterial food poisoning is caused by ingestion of preformed toxins in food; this results in a toxic illness rather than an enteric infection. The toxins may include cytotoxins, enterotoxins, and neurotoxins. Pathogens that produce bacterial food poisoning include *Staphylococcus aureus, Clostridium perfringens*, and *Bacillus cereus*. These organisms grow in food and produce toxins that are ingested directly in the food. Symptoms occur soon after food ingestion, with incubation periods of 1 to 16 hours and high attack rates. The illness is rarely associated with fever, and symptoms usually resolve within 12 to 24 hours after onset.

The staphylococcal and *B. cereus* toxins act on the nervous system to cause vomiting. *S. aureus* causes vomiting and diarrhea within 2 to 7 hours after ingestion of improperly cooked or stored food containing its heat-stable enterotoxin. *C. perfringens* produces secretory and cytotoxin-induced watery diarrhea within 8 to 14 hours after ingestion of contaminated vegetables, meat, or poultry. *B. cereus* often contaminates fried rice, vegetables, or sprouts; it produces one of two toxins which cause disease resembling that of *S. aureus* or *C. perfringens* infection within 1 to 6 hours after ingestion. Ingestion of the bacteria with subsequent in vivo toxin production often results in disease with a longer incubation period (8 to 16 hours).

SPECIFIC PATHOGENS

The epidemiologic and clinical features of common enteric pathogens and the recommended methods for diagnosis and treatment are summarized in Tables 96-1 and 96-2.

Shigella

Diarrhea due to *Shigella* occurs after ingestion of fecally contaminated food or water. The main species include *S. dysenteriae*, *Shigella flexneri*, *Shigella boydii*, and *Shigella sonnei*. Ingestion of as few as 10 to 100 microorganisms can lead to infection because the bacteria are relatively resistant to gastric acid. Person-to-person transmission is common, and the attack rate is highest among infants and young children in child care centers. The incubation period is 6 to 72 hours. Illness may initially manifest as noninflammatory, watery diarrhea caused by enterotoxin production or multiplication of bacteria in the small intestines. Invasion of the colonic epithelium and mucosa often manifests as dysentery. Complications of shigellosis include HUS, which is associated with *S. dysenteriae* type 1, and Reiter's chronic arthritis syndrome, which is associated with *S. flexneri* infection.

Salmonella

Salmonella typhi causes typhoid fever, but not diarrhea. Nontyphoidal salmonellosis results from ingestion of contaminated meat, dairy, or poultry products or from direct contact with animals such as birds, pet turtles, snakes, and other reptiles. An oral inoculum of 10^5 to 10^8 organisms is needed but smaller inocula can cause disease in patients with impaired gastric acidity or compromised immunity. The organisms invade the distal

TABLE 96-1 EPIDEMIOLOGIC AND CLINICAL CHARACTERISTICS OF COMMON ENTERIC PATHOGENS

ORGANISM	EPIDEMIOLOGIC FEATURES	COMMON CLINICAL FEATURES
Campylobacter jejuni	Consumption of undercooked poultry, travel to tropical and semitropical regions	Acute watery diarrhea, fever, abdominal pain, fecal evidence of inflammation (positive fecal leukocytes, lactoferrin, or occult blood)
Vibrio cholerae	Inadequately cooked seafood, travel to endemic regions	Acute dehydrating watery diarrhea; fever is usually absent
Clostridium difficile	Antibiotic use, recent hospitalization, elderly patients with coexisting conditions	Diarrhea with fever, fecal evidence of inflammation, marked leukocytosis
Enterotoxigenic *Escherichia coli*	Travel to tropical and semitropical regions	Watery diarrhea, abdominal cramps, nausea and vomiting; leukocytes absent in stools
Nontyphoidal *Salmonella*	Foodborne outbreaks, exposure to animals	Acute watery diarrhea, fever, abdominal pain, evidence of inflammation
Shigella	Person-to-person transmission, daycare center contact	Severe diarrhea with fever, abdominal pain, bloody diarrhea, fecal evidence of inflammation
Shiga toxin–producing *E. coli*	Foodborne outbreaks, undercooked hamburgers, raw seed sprouts, water and wading pool exposure	Abdominal pain, bloody stools, absence of fever, fecal evidence of inflammation
Noncholeraic *Vibrio*	Ingestion of shellfish and undercooked seafood	Watery diarrhea, abdominal cramps, nausea; fever and vomiting are less frequent
Yersinia enterocolitica	Contaminated food or water, inadequately cooked meats, unpasteurized milk	Acute watery diarrhea, fever, abdominal pain, bloody diarrhea
Norovirus	Winter outbreaks in congregate settings, outbreaks on cruise ships	Watery diarrhea, nausea, vomiting, abdominal pain
Cyclospora	Foodborne outbreaks, travel to tropical and subtropical regions (especially Nepal)	Persistent noninflammatory diarrhea
Cryptosporidium	Waterborne outbreaks, travel to tropical and subtropical regions	Persistent noninflammatory diarrhea
Entamoeba histolytica	Travel to tropical regions, recent immigration from endemic regions	Bloody diarrhea, extraintestinal involvement (liver abscess)
Giardia lamblia	Waterborne outbreaks, travel to mountainous areas of North America, Russia	Abdominal pain, persistent watery diarrhea, flatulence, steatorrhea, nausea and vomiting