An Overview of Bacterial Diarrheas

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ABSTRACT

Diarrhea is a major public health problem in developing countries resulting in heavy economic burden. Various pathogenic bacteria affect the gastrointestinal tract and produce abdominal cramps, nausea, vomiting and diarrhea. These bacteria are mainly acquired through contaminated water and food. The important ones among them are *Vibrios, Escherichia coli, Staphylococcus, Salmonella, Shigella, Bacillus cereus, Campylobacter, Clostridia, Yersinia, Klebsiella* and *Aeromonas*. Proper sewage disposal and other sanitary hygiene such as proper hand washing must be maintained in the community in order to prevent diarrhea, as ingestion of fecal contaminated water is the primary route of transmission of the pathogens. Safe drinking water is another requisite to fight against the problem of diarrhea. Adequate chlorination of water easily kills organisms such as that of cholera and safeguards against bacterial diarrhea. Salads prepared from materials washed in contaminated water or handled by unhygienic hands are also important vehicles of transmission of pathogenic bacteria. Reheating of refrigerated food kept at room temperature for a very long time also perpetuates spores and may lead to food poisoning. All these preventive measures when taken into account can help to reduce the burden of diarrheal episodes. However despite preventive measures if diarrhea occurs, restoration of fluid and electrolyte balance in the form of oral rehydration therapy is of paramount importance in the management of the illness.

INTRODUCTION

Diarrhea may be defined as deviation from established bowel rhythm characterized by an increase in frequency and fluidity of the stools. In other words, if passage of stool occurs three or more times a day, the patient can be termed as having diarrhea. Diarrhea may manifest itself due to various causes and may be acute or chronic in nature. According to the World Health Organization, a diarrheal attack of sudden onset ranging from 3 to 7 days can be labeled as acute diarrhea. Chronic diarrhea lasts for 3 or more weeks. It has been estimated that about 1.3 billion episodes of diarrhea occur annually and 3.2 million diarrheal death occurs in children below 5 years of age. The median diarrheal incidence per child is 1.5 to 4.7 episodes in the urban areas, whereas in the rural areas it is about 10.5 episodes per child. Thus diarrhea is a major public health problem in developing countries like India and results in heavy economic burden both to the individual as well as the country. Infectious diarrhea may be caused by bacteria, viruses, fungi and parasites. This overview will deal with bacterial diarrheas.

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Bacterial causes of diarrhea

There are various pathogenic bacteria which affect the gastrointestinal tract and produce diarrheal diseases in both industrialized and developing countries. These bacteria are mainly acquired through water and food. The important ones among them are *Vibrios, Escherichia coli, Staphylococcus, Salmonella, Shigella, Bacillus cereus, Campylobacter, Clostridia, Yersinia, Klebsiella* and *Aeromonas.*

1. Diarrhea due to Vibrios

(a) *Vibrio cholera: V. cholerae* is the causative organism of cholera, an acute diarrheal disease. This is characterized by evacuation of copious 'rice water' stools and may be accompanied by agonizing cramps and sometimes severe collapse.

Epidemiology: Cholera is a disease of antiquity and its history is very interesting. The disease could have originated in the regions of Ganga and Brahmaputra rivers, where it is still endemic. Robert Koch's in 1884 isolated the causative agent from the intestinal contents of victims who died of cholera and thus revealed the important role of water in the transmission of the disease. The disease was almost exclusively confined to Bengal residency and surrounding regions before 1817. After that the endemic disease began to gain pandemic proportions when it spread to different countries of the world including Russia, Middle East and North Africa. Up to 1923, six pandemics occurred due to the classical type of *Vibrio cholerae.* The spread of the disease was thought to be due to the mass migration of religious pilgrims, the movements of troops and the busy sea trade around the endemic home of the disease. Between 1923 and 1961 the disease remained confined almost entirely to Bengal after which the 7th pandemic occurred due to another type of the organism named as *V. El Tor*. All these cholera organisms hitherto causing disease belonged to strains of 01 serogroup.

However, in October 1992, a large outbreak of cholera-like infection caused by a strain not belonging to 01 serogroup was reported from Madras (now Chennai). Soon the infection spread to Vellore, Madurai and Calcutta (now Kolkata). Analysis of the organism was done and this new strain became known as *V. cholera* 0139. Remarkably, most patients in the outbreaks have been adults, suggesting that previous exposure to *V. cholerae* 01 affords minimal protection against the new strain. The disease has been reported from Bangladesh, Thailand, Nepal, Pakistan, Malaysia and China.

Environmental aspects

V. cholera is a comma shaped bacillus. The organisms live in natural water and require salt for their multiplication. The organisms which are susceptible to pH > 5.0 are killed when exposed to normal gastric juices. They are also killed by heating at 55ºC for 15 mins. They are sensitive to disinfectants and are killed by drying. In soil, the organisms can live for 6-10 days at 20º-28ºC, if kept moist. Survival time in drinking water depends upon the salinity of potable water where a minimum salinity of 0.01% is required for survival beyond 24 h. Survival times from a few hours up to 30 days have been reported in drinking water, whereas in sea water it may survive for months.

Pathogenesis

Cholera organisms are usually ingested from contaminated water or food. Contaminated food, particularly inadequately cooked or raw sea-food like fish, shell fish, prawns and crabs, is commonly the vehicle of infection. Acidity of the stomach is a barrier to the establishment of infection. Therefore people with absence of free hydrochloric acid in the stomach (such as in pernicious anemia and gastric cancer) might be predisposed to this infection. However, malnutrition is also a very important factor, particularly in endemic regions like India.

The organisms that reach the small bowel may become attached to the intestinal wall and multiply there. However, throughout the course of the infection the vibrios remain on the intestinal wall but do not damage or traverse this barrier. Instead they produce molecules of toxins that get transported to the intestinal cells and toxins bring about an irreversible secretion and loss of chloride, bicarbonate and water which is characteristic of the disease.

About a million bacteria are required to be ingested with food for the development of clinical cholera with copious purging. In endemic regions the disease most commonly affects children below the age of 5 years. Clinical cholera confers immunity to the disease which persists for at least 3 years.

Clinical presentation

Cholera may be mild to life-threatening, depending upon the volume of stool. The patient and the disease are described as pulseless, waterless (urine output decreases resulting in anuria) painless, effortless and odorless purging. But only one out of 10 cases require medical attention. In extreme cases, diarrhea continues for up to 6 days, during which period the victim can lose up to twice his body weight in liquid stools. Normally, diarrhea is painless and of varying severity. However, abdominal discomfort and loss of appetite may be present at times.

Flecks of intestinal mucus are responsible for the characteristic rice water stool appearance. The passage of large volumes of fluid stools is effortless and provides

a feeling of relief. However, continued loss of body fluid results in thirst, legs cramps and weakness which if left untreated leads to death of the victim.

Prevention of diseases

An ingestion of fecal contaminated water is the primary route of transmission of this disease. Preventive measures include careful attention to personal hygiene, use of supposedly 'safe' water supplies and appropriate disposal of contaminated clothing or stools. The existence of chronic human carriers who might excrete the organisms over long period of time is though unlikely. The disease may be maintained by continuous transmission of inapparent infection until climatic conditions become favorable for a new outbreak based on a seasonal pattern. It is now accepted that there may be many symptomless carriers in areas lacking a single recognized case of cholera, so the disease could well be maintained in the human reservoir. Thus, there is a cyclic transmission of the organisms between human beings and the environment.

Prompt medical attention is advocated in every case of cholera as fluid losses may exceed one lit/h. In such cases, when left untreated, the victim will soon die of circulatory collapse. It must be remembered that restoration of fluid and electrolyte balance in the form of oral rehydration therapy is of paramount importance. Only unmanageable cases should be treated with tetracycline, the antibiotic of choice, as overuse of antibiotics might lead to emergence of tetracycline resistant organisms. Oral vaccines that are currently available are Dukoral and mORC-VAX. Dukoral provides protection against *V. cholerae* 01 and mORC-VAX protects against both 01 and 0139 serogroup.

(b) *Vibro parahemolyticus:* This organism is largely acquired through contaminated fish and sea food and is an important cause of diarrheal illness, particularly in Japan. The diarrheagenic factor produced by the organism is a thermostable hemolysin active against human blood cells (Kanagawa phenomenon). This hemolysin is enterotoxic, cytotoxic and cardiotoxic. *V. parahemolyticus* has an incubation period of 2-48 h resulting in profuse diarrhea often leading to dehydration, abdominal pain, vomiting and fever. *V. parahemolyticus* is widely distributed in shallow coastal waters worldwide, contaminating the coastal fish and shell fish. Even though deep sea-fish do not carry the organisms, but may get contaminated in the market.

2. Diarrhea due to *Escherichia coli*

At present, five distinct categories of diarrhea causing Escherichia coli groups are recognized. These are enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC) enteroinvasive *E. coli* (EIEC), enterohemorrhagic *E. coli* (EHEC) and enteroaggregative *E. coli* (EAEC). All these organisms carry a characteristic set of virulence factors.

Environmental aspects

E. coli is a widespread intestinal parasite of mammals and birds. It is not known to have an independent existence outside the animal body.

(a) *Enteropathogenic E. coli:* EPEC is a common cause of diarrhea in children less than one year of age, particularly in developing countries, but is rarely associated with diarrheal illnesses in older children and adults. EPEC causes a distinctive histopathologic lesion in the human intestine, which involves destruction of microvilli and close adherence of the bacteria to the membrane of the enterocyte with cup like pedestals upon which each bacterium rests. Although EPEC strains have not been previously recognized to produce any toxin, a newly recognized EspB protein may account for the rapid onset of diarrhea. An inflammatory response may also contribute to the pathogenesis of EPEC diarrheal disease.

(b) *Enterotoxigenic E.coli:* ETEC is one of the most common etiological agent of traveler's diarrhea in adults and may account for about 50% of cases. Infants in third world countries are also prone to acquire ETEC infections as sporadic cases or as outbreaks. ETEC strains are also responsible for a large proportion of death in malnourished children under 5 years of age in developing countries. ETEC, are rarely seen in geographical regions with good hygiene and nutrition. However, outbreaks do occur in such regions among babies in the hospital and subjects of any age in the general community. When persons from these regions travel to countries with poor hygiene, they contract the traveler's diarrhea. Person to person spread or by simultaneous infection from a common source usually results in an increased incidence. Even in developed

countries, people with relatively poor standard of hygiene may suffer from repeated episodes of infection by ETEC. The most severe manifestation of ETEC infection is a cholera-like disease that is difficult to distinguish clinically from infection with *V. Cholerae* 01; particularly so in areas where cholera is endemic. The illness begins with a rapid onset of diarrhea accompanied by nausea, vomiting and abdominal cramps. ETEC produces two types of enterotoxins (a) heat labile and (b) heat stable. The heat labile toxin induces overstimulation of normal secretory function, whereas the heat stable toxins cause an inhibition of sodium and chloride absorption and result in histologic damage to intestinal epithelium, probably responsible for impaired absorption of fluids.

(c) Enteroinvasive *E. coli:* EIEC are responsible for causing watery diarrhea, though they also cause dysentery occasionally, due to their ability to invade cells. The pathogenesis of watery diarrhea has remained unexplained hitherto, except for a report of EIEC culture strains that stimulate moderate secretion without histologic damage in 18 h ligated rabbit ileal segments. The role of a specific cytotoxin produced by EIEC is not yet delineated.

(d) Enterohemorrhagic *E. coli:* EHEC are also known as Shiga-like toxin producing *E. coli* or verocytotoxin producing *E. coli*. They produce a variety of clinical syndromes that include bloody to non-bloody diarrhea, hemorrhagic colitis and hemolytic uremic syndrome. EHEC produces primary effects on the human colon. They produce several highly potent cytotoxins which are thought to account for the unique clinical features of EHEC disease, partly through local and systemic absorption of toxins resulting in damaged vascular endothelium. Although Shiga like toxins produced by these strains are detectable in the stools of infected patients, the exact location of their production in the bowel is not known. Thus the difference in the clinical symptoms of watery or bloody diarrhea may relate to regional differences in the intestine in response to these toxins. EHEC also includes *E.coli* 0157:H7 which are isolated from bloody stools and is the causative agent for hemorrhagic colitis and hemolytic uremic syndrome.

(e) Enteroaggregative *E. coli:* EAEC strains are associated with persistent diarrhea in young children, particularly so in the developing world. They produce three toxins that are potentially able to stimulate intestinal secretion. EAEC may secrete yet another toxin capable of stimulating a severe acute inflammatory response in the intestine. However, the intestinal pathophysiology due to the production of these toxins is largely unclear.

3. *Staphylococcal d*iarrhea

Environmental aspect: *Staphylococci* are normally found on the skin and mucus membranes of man, e.g. the anterior nares, arm pits, hands and pubic region. In the environment they may be present in fomites, sewage, soil and water and in animal products like cheese, milk, eggs and meat.

Warning signals: Staphylococcal infection results in a wide range of biological activities like vomiting, fever and diarrhea. In fact it is a leading cause of food borne illnesses characterized by the onset of vomiting within 6 h of ingestion of one or more preformed heat stable enterotoxins.

Pathogenesis: *Staphylococci* produce 7 antigenically distinct enterotoxin types A, B, C_1, C_2, C_3, D and E. Types A, B, D and E show different major antigens, whereas type C is further subgrouped on the basis of minor antigenic differences. Another exotoxin, enterotoxin F, which is identical with toxic shock syndrome toxin (TSST), also causes diarrhea as part of the syndrome, but is not incriminated as a cause of food poisoning. Staphylococcal enterotoxins have their action on the nervous system. The site of emetic action is the abdominal viscera and the stimulus travels to the vomiting centre by the vagus nerve. As little as 1µg of enterotoxin is sufficient to produce illness in man. Clinical signs develop 2-6 h after ingestion of contaminated food and depend on the amount of toxin consumed and sensitivity of the person. Recovery is rapid and usually occurs within 24 hours. Strains of *S. aureus* that produce type A and/or type D enterotoxin are responsible for about 70% of outbreaks of staphylococcal food poisoning.

4. *Salmonella* diarrhea

Environmental aspects: *Salmonellae* are among the most resourceful and successful of human pathogens. They are primarily intestinal parasites of man and animals, both domestic and wild. They are frequently

found in sewage, river & other waters and soil, where they survive for weeks and years without significant multiplication. They are also associated with many of the foods like vegetables and fruit.

Warning signals: Gastroenteritis is usually caused by *Salmonella enteritidis* and most of its subspecies such as *S. Typhimurium. Salmonella* food poisoning is usually not life threatening. It is characterized by nausea and vomiting which occurs 8-48 hours after bacterial ingestion.

Pathogenesis: The bacterial factors responsible for diarrhea remain poorly characterized. There is much evidence that salmonella from serotypes most commonly encountered in food poisoning produces a cholera-like enterotoxin. Diarrhea caused by *salmonella* may be multifactorial. It is postulated that infection with *S. Typhimurium* results in the onset of fluid secretion preceded by massive influx of inflammatory cells. Fluid secretion occurs whether gross damage to intestinal mucosa is there or not. However, when damage occurs there is shortening of villi and enhanced secretion.

Prevention of disease: The disease may be prevented by attempting to detect and eradicate the sources of infection, blocking its routes of transmission or by vaccination of persons likely to be infected. Other measures are safe disposal of excreta, safe drinking water supply and hygienic handling of food.

5. *Shigella* dysentery

Epidemiology: *Shigella* dysentery is endemic throughout the world. Several million cases occur annually resulting in a high morbidity and mortality. Shigellosis is predominantly a childhood disease and more than half of the cases occur in children under 5 years of age. Fatalities are also most often seen in children.

Environmental aspects: Contaminated food and water sources are considered to be of less importance for transmission than other enteric infections. However, because of the high infectivity and the extremely low infectious doses ($10^2 – 10^3$ bacteria), person-to- person transmission is of prime importance, as seen by the family members being affected one after the other.

Warning signals: Shigellosis is an acute and usually febrile disease presenting initially with a watery diarrhea that may progress to bloody, mucoid dysentery. Abdominal cramps with painful ineffectual straining during defecation are the hallmarks of severe dysentery. Rectal prolapse, especially in young children may result from the repeated number of stool evacuation.

Pathogenesis: The causative agents of *shigella* dysentery are one of four *Shigella* species: *S. dysenteriae, S. flexneri, S. boydii, or S. sonnei*. Infections caused by *S. dysenteriae* type 1 and various serotypes of *S. flexneri* are particularly severe, resulting quite often in conditions such as protein losing enteropathy. In already malnutritioned children, mortality due to this increases.

Shigellosis also presents with a wide range of extraintestinal manifestations, such as bacteremia, leukemoid reaction, hemolytic uremic syndrome, anemia and reactive arthritis. Shigellosis is a mucosal infection. The ability to invade epithelial cells and tissues is an important mechanism to establish infection. Intracellular multiplication is the next step that is a pre-requisite for the virulence of *Shigellae*. Foci are formed in the colonic epithelium by intercellular spread of the organisms. However, the lesions are superficial and only rarely do the Shigellae penetrate beyond the lamina propria. *S. dysenteriae* type 1 strains produce an important, potent exotoxin known as the Shiga toxin. However, its role in the pathogenicity of bacillary dysentery remains unclear.

Prevention of disease: Improvement of sanitary conditions like availability of sufficient quantities of clean water for washing of hands, provision of soap etc. are simple measures required. Other important measures that need to be taken are proper fecal waste disposal and improved environmental hygienic conditions. Vaccines that protect against illness caused by *S. dysenteriae* type 1 and prevalent serotypes of *S. flexneri* are desirable to control shigellosis particularly in rural communities in developing countries where the hygienic standards are yet to be accomplished.

6. *Bacillus cereus* diarrhea

Bacillus cereus is associated with both diarrheal and emetic syndromes due to food poisoning. It accounts for 1-23% of the total number of outbreaks of known bacterial origin reported by countries throughout the world.

Environmental conditions: The distribution of *Bacillus cereus* in a particular environment depends on local ecological conditions and is attributable to their ability to form spores which survive in conditions not favorable to vegetative bacteria. Therefore, it is widely distributed in nature and is commonly found in soil, milk, cereals and a wide variety of other foods.

Warning signals: The diarrheal type of food poisoning due to *B. cereus* has an incubation period ranging from 8-16 hours. Other symptoms are abdominal pain, profuse watery diarrhea, rectal tenesmus and at times nausea and vomiting. The emetic syndrome caused by emetic strains of *B. cereus* has a short incubation period of about 1- 5 hours and is characterized by nausea, vomiting and stomach cramps. Diarrhea occurring later is not uncommon. The illness is usually mild and transient except when there is excessive vomiting which requires hospitalization.

Pathogenesis: Several biological activities have been attributed to the diarrheal toxin, including secretion & necrosis in rabbit ileal segments, cytotoxicity and increased vascular permeability.

Prevention of Diseases: About 95% outbreaks of emetic syndrome are associated with boiled or fried rice held for long periods at room temperature before being reheated. Endospores in rice survive boiling/frying and germinate under favorable conditions. Although some *B. cereus* strains may produce both the emetic and diarrheal toxins, there is no consistent relationship between these two factors.

7. Campylobacter diarrhea

Campylobacters have long been known as pathogens of animals, causing abortion in cattle and sheep and diarrhea in cattle and pigs; but now *C. jejuni* and *C. coli* are among the commonest identified causes of enteritis in man.

Environmental aspects: Campylobacter diarrhea is a zoonosis and man is a minor reservoir of infection. *C. jejuni* is normally found in the intestines of a wide variety of wild and domesticated animals, especially birds.

Epidemiology: The incidence is higher in rural than in urban communities. In developed countries infection rates are higher in young children and falls gradually with advancing age. It is also responsible for travelers' diarrhea. However, in developing countries, the transmission is sufficiently high for many children to suffer several episodes of infection during the first 2 years of life and thereby gain immunity. The organisms later on attain a carrier state.

Clinical disease: The disease has an average incubation period of 3 days. Clinically it is not possible to distinguish from other acute bacterial infections of the intestine. Some patients suffer a prodromal influenza like illness for 2 to 3 days before the onset of diarrhea, which probably represents a bacteremic phase. Abdominal pain may also precede diarrhea. The onset of diarrhea with liquid bile-stained stools is usually abrupt. When the infection is severe, profuse watery or bloody stools may appear. Spontaneous resolution takes place after a few days, but organisms continue to be excreted in the feces for a variable period.

Prevention of disease: Animals/birds are sources of transmission. *C. coli* is particularly associated with pigs. Natural water is probably an important source of infection for domestic stock. Survey of farm animals in several countries have shown carriage rates of up to 70% in sheep, cattle and pigs and up to 100% in chickens including those sold in shops. Direct transmission from animals usually results from occupational exposure to infection, e.g. veterinarians, butchers and poultry processors. Proper personal hygiene should be maintained to prevent infection. Indirect infections are acquired through the consumption of contaminated food, milk and water. However, normal cooking is more than adequate to kill campylobacters.

8. Clostridial diarrhea

Many clostridium species produce enterotoxins which are lethal for both animals and human beings. The important ones among them will be discussed here.

(a) *Clostridium perfringens*

Outbreaks of *C. perfringens* occur when meat and poultry dishes are kept at room temperature for several hours before serving. Meat provides a favorable anaerobic medium for proliferation of organisms from surviving spores. Multiplication occurs in the intestine for a brief period followed by sporulation and enterotoxin production. In some strains enterotoxin

production occurs even in absence of sporulation.

(b) *Clostridium botulinum*

Most strains of *C. botulinum* produce one of 8 extracellular toxin types viz. A, B, C_1,C_2, D, E, F and G. Toxins A and B account for 80-90% of human infections whereas toxins E, F and G are less commonly preserved food, e.g. canned food which if not properly sterilized provides an environment favorable for growth of these organisms. Food cans that are bloated are likely to be contaminated with *C. botulinum*, and must never be used. The toxin is responsible for the neurologic symptoms observed in the disease. The diagnosis is confirmed by identification of toxin in serum, feces or vomitus and/or the isolation of organisms from the feces or food.

In infant botulism, the *C. botulinum* spores germinate in the intestine and produce toxin which can be identified in fecal samples. Most cases are caused by either type A or B. Infants between 1-6 months of age are affected. Clinical symptoms are of severe neurologic disease.

(c) *Clostridium difficile* diarrhea

Diarrhea due to *C. difficile* differs from the rest of the organisms mentioned in that it is generally associated with exposure to antibiotics. The overgrowth of antibiotic-resistant *C. difficile* after suppression of competing gut flora by antimicrobial therapy is the course of events leading to antibiotic associated diarrhea. The spectrum ranges from mild antibiotic associated diarrhea and colitis which may be self-limiting to the potentially fatal pseudomembranous colitis (PMC), the most characteristic feature of advanced disease. It is generally seen during the first week of commencement of antibiotic therapy. The onset may however be delayed for as long as six weeks after the final dose or the disease may also develop after a single dose. It has been established that oral dosing is four fold more responsible in producing the disease than parenteral infections or topical therapy. Clindamycin, lincomycin, ampicillin and cephalosporins have broad antibacterial activity and are the usual offenders. However, almost all antibiotics as well as cancer therapeutics such as methotrexate have been implicated at one time or the other. Occasionally, a patient may have PMC that cannot be ascribed to antibiotic exposure.

Epidemiology

The incidence of this disease is uncertain even though both sporadic cases and outbreaks have been reported world-wide. Children under the age of 2 years are generally carriers and clinical disease is rarely seen among them. Only a few cases of histopathologically and endoscopically proven cases of PMC in children have been recorded. The incidence of *C. difficile* infection rises with increasing age particularly so in the elderly. This is partly because of increased use of antibiotics in older patients, and also due to the presence of predisposing factors such as gastrointestinal malignancy and major surgical procedures.

Clinical spectrum

C. difficile is the only major pathogen commonly identified in patients with antibiotic associated diarrhea or colitis. The frequency of isolation of *C. difficile* is directly correlated with the severity of disease on the basis of both anatomical and clinical parameters. Many patients have mild diarrhea that often include fever, cramps and leucocytosis. The disease pathologically involves only the colon and the terminal part of the ileum. Chronic diarrhea may last for several weeks or months after administration of the implicated drugs is discontinued.

Pathogenesis

C. difficile produces two high molecular weight protein exotoxins A and B. Toxin A is an enterotoxin accounting for all of the changes within the gastrointestinal tract, whereas toxin B is a cytotoxin that exits through the damaged gut mucosa as a result of the action of toxin A. Toxins attack the mucosa of the colon and terminal ileum which becomes necrotic with the formation, in fulminant cases of an exudative membrane may consist of multiple friable plaques, a few centimeters in diameter and attached to the mucosal surface. At times these may coalesce. The consequent illness may be characterized by a watery diarrhea, abdominal pain and fever. Colicky hypogastric pain may also be present and the onset may be quite sudden. When left untreated the disease may either be mild and self-limiting or result in a fatality.

Prevention of disease

As antibiotics are the main precipitating factors for

C.difficile diarrhea, random use of antibiotics should be discouraged.Withdrawal of the offending agent when diarrheal symptoms develop, often leads to early resolution of the symptoms even in some cases of established PMC. Attention to fluid replacement and electrolyte balance is also necessary.

Other bacterial diarrheas

Yersinia: *Y. enterocolitica* is a common human pathogen which causes gastrointestinal syndrome of varying severity, ranging from mild self-limited diarrhea to mesenteric adenitis evoking an appendicitis. Both stable and labile toxins are produced by *Y.enterocolitica.* The stable toxin is responsible for diarrhea in yersiniosis. As enterotoxins are produced only when the organisms are grown at 25ºC, it may suggest that preformed toxin is ingested with contaminated food stored at low temperature. This may explain occurrence of some cases of poisoning from which no causative organism has been isolated.

Klebsiella: Enterotoxigenic strains of *Klebsiella pneumoniae* also produces gastroenteritis in infants and children. Enterotoxigenity of *Klebsiella* strains has been established by fluid accumulation in rabbit ileal loop. A sporadic episode of diarrhea due to *K. pneumoniae* is difficult, however profuse or predominant growth of *Klebsiella* does suggest a casual rather than a casual association.

Aeromonas: Toxigenic strains of *Aeromonas* may cause nosocomial diarrhea. Even though there is disagreement about the enteropathogenicity of *Aeromonas*, numerous reports record significantly higher frequencies in the presence of diarrhea, and a range of potential pathogenicity factors like hemolysin, enterotoxin, enteroinvasive factor etc have been described.

Plesiomonas: *Plesiomonas* have been implicated in a number of outbreaks of diarrhea. P. shigelloides has been isolated from surface water, fish intestines and mammals like dogs, cats, goats, sheep and monkeys. Sporadic episodes have been described worldwide and both heat stable and labile enterotoxins are known to be produced by them.

Conclusion

Diarrhea is spread by F5, i.e. flies, feces, fomites, fingers and fluid. Therefore, proper sewage disposal and other sanitary hygiene must be maintained in the community. Washing of hands after every visit to the toilet is mandatory irrespective of whether defecation has been done or not. It must be remembered that ingestion of fecal contaminated water is the primary route of transmission of diarrhea. Drinking water should be boiled at least 15 minutes before use. Cholera organisms are easily killed in tap water which has been adequately chlorinated i.e. (0.2 parts per million of residual chlorine in water). Salads prepared from vegetables and fruit washed in contaminated water or handled by unhygienic hands are also important vehicles of transmission. Articles of refrigerated food that have been kept at room temperature for a very long time and are reheated also perpetuate spores that do not die during reheating and may result in food poisoning. If we take into account all these preventive measures, the incidence of diarrheal episodes and outbreaks will certainly be diminished.

Recommended reading

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