

Lecture-7:

Food-associated infections:

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The study of microorganisms in food environments , includes types and activities of these organisms and other factors that affecting on them. This science is large field of microbiology and it is called food microbiology.

Foods are important source of pathogenic microorganisms that infect human . Transmission of organisms from food to human during feeding or food handling.

Food-borne infection associated with consumption of contaminated food. Generally, Food poisoning occurs after consumption of food containing toxins, which may be chemical or bacterial in origin. The bacteria multiply and produce toxin within contaminated food. The organisms may be destroyed during food preparation, but the toxin is unaffected, consumed and act within hours. In food-associated infection, the food may simply act as a vehicle for pathogen or provide conditions in which the pathogen can multiply to produce numbers large enough to cause disease.

Food poisoning(intoxication); presence of pathogenic microorganism or their products in food .It is the toxin alone that produce symptoms such as botulism.

Food-infection; presence of microorganisms in food is essential for cause disease such as salmonellosis.

Gastroenteritis; a syndrome is related to inflammation of stomach and small intestine which characterized by gastrointestinal symptoms including nausea ,vomiting , diarrhea, and abdominal discomfort.

Enterocolitis; inflammation involving the mucous of both the small and large intestine.

Diarrhea; abnormal fecal discharge characterized by frequent and/or fluid stool; usually resulting from disease of small intestine and involving increased fluid and electrolyte loss.

Dysentery ; inflammatory disorder of GIT often associated with blood and pus in feces and accompanied by symptoms of pain ,fever, abdominal cramps, usually resulting from disease of large intestine.

Food-poisoning caused by *Staphylococcus aureus* :

- *S.aureus* is gram-positive cocci usually arranged in grape-like irregular clusters.
- The bacteria grow facultative anaerobic on ordinary media .
- catalase and coagulase are positive.
- mannitol fermentation
- The organism produces golden yellow colonies.
- The organism produces beta hemolysis.

Habitat and transmission :

S.aureus is part of normal flora of skin and URT(nose, throat). Approximately 30-40% of adult populations are carriers of *S.aureus*, and the nares probably are most important carriage site. Staphylococci are capable of extended survival on environmental surfaces and in air. The contaminated food is most means in food-poisoning.

Pathogenicity and clinical features;

- Most (not all) coagulase positive strains of *Staphylococcus aureus* are enterotoxigenic. It produces Enterotoxin which consist of two polypeptide chains linked together by disulfide bridge to form cystein loop that is toxic part of molecule. The enterotoxin has (MW:32,000-40,000 Dalton), it is heat stable, and resistant to destruction by enzymes in stomach and small intestine. The enterotoxin divided at least 8 serologically distinct antigenic types A-F. Type A is most common ,while others are rare.

Optimum temperature range for toxin production is 4-46C and pH 4.8-8. The toxin is very resistant to heating at 100C or more for 30 minutes whereas the bacteria can be destroy at 66C for 12 minutes or at 60C for 80 minutes. Therefore normal cooking or pasteurization(72C/15 minutes) are not enough for destruction of toxin. Some investigators suggested greater inactivation of toxin at low temperature. Number of cells (dose) that required for cause poisoning is less than 10^6 cells. Lethal dose (LD50)of toxin is 0.134-0.183 µg/kg of body weight.

- Mechanism of action : Enterotoxin is superantigen and acts on specific receptors in gut that transmit impulse to modularly center that control on vomiting and diarrhea. It acts locally on lymphoid cells lining the small intestine. The toxin binds to MHC-II molecules on APC (macrophage or monocyte) and this complex form bridge with β -chain (V β component) of TCR, resulting non-specific T-cell stimulation of large number of T-cells and production of massive amounts of cytokines(IL-1,IL-2

and TNF- α) from macrophage and Th-cells , that mediate shock and tissue injury. The emetic effect of toxin is probably the result of CNS stimulation(stimulate vomiting center in brain during neural receptor) in the gut.

- Food poisoning is due to enterotoxin , which characterized by short incubation period 1-6 hours after taking contaminated food (meat, fish ,milk). Violent nausea, intensive vomiting , never fever are most clinical signs. The vomiting occurs within 3-6 hrs of consumption. The prominent vomiting caused by cytokines released ,which stimulate enteric nervous system to activate the vomiting center in brain. Diarrhea is not main feature , but in some cases may cause watery ,non-bloody diarrhea, and recovery within 1-2 days(duration period) is usual

Epidemiology:

S.aureus is most common type that causes food poisoning. Staphylococcal food poisoning occurs world-wide and is not a communicable disease. Types of food that serve as growth media for staphylococci include meat, poultry, fish, milk ,cream ,custard, other processed food.

True problem with staphylococcal food poisoning are not associated with food processing, but instead are related to mishandling of food in food service and in home.

Complications or death associated with this disease are rare. Mortality rate is low 1-10%.

Control:

- No treatment with antibiotics, but give fluid and electrolytes for infected patients .
- The food must be kept at low temperature in refrigerator or in freezing.

Food-poisoning caused by *Clostridium botulinum* :

It is cause botulism, which generally is severe food poisoning.

- Gram positive rod, obligate anaerobic.
- spore-former ,the spore is wider than bacillary body. It is located in terminal or subterminal of cell.
- It is non-capsulated .
- It is motile by peritrichous flagella.
- Ferment many sugars with production of acid and gas.

Transmission and epidemiology;

Spores are widespread in soil, and the organism is found in microhabitats in gut of man and animals. Infection may be endogenous or exogenous.

Food poisoning result from ingestion of toxin-contaminated food. The contaminate vegetables and meat when these food are canned or vacuum-packed without adequate sterilization. Spore survive and germinate in anaerobic conditions ,and produce exotoxin in contaminated food. The spore is highly resistant at 100C for several hours, but destroy at acid pH and high salt concentration. While the toxin is heat labile and destroy by boiling at 100C for 10 minutes or at 80C for 30 minutes , but not destroyed by digestive enzymes.

Botulism is derived from Latin botulus, meaning sausage. Outbreak of botulism is associated with variety of food products including prepared homed-food, and commercial products . Botulism occur mainly in birds and mammals, rare in humans due to the toxin is encoded by genes carried in viruses and it easy destroyed by boiling. The organism is very sensitive to oxygen, and its spores are sensitive to stomach acidity. Mortality rate is high 60-70% of cases.

Pathogenesis and clinical features;

Clostridium botulinum is produces botulinum toxin which encoded under genetic control of lysogenic phage. Therefore certain strains of the organism capable of causing disease in human .The toxin is consist of two polypeptide chains ; light chain-A(active part) has enzymatic activity and cause lytic effect, and heavy chain-B (binding part)bind to receptor on surface of target nerve cell. The toxin has molecular weight 150,000 Dalton(A-chain: 50,000 ; B:100,000). The light chain and heavy chain linked together by disulfide bond. There are eight serological types of toxin A-F. The type A, B and E are most common in human illness.

The toxin is called neurotoxin because it has specific cytotoxic activity(attack only nerve cells), it attached to endings of efferent nerves. There it block release of acetylcholine at synapse and cause flaccid paralysis.

The toxin affecting nerve cells (neurons) and interfering with impulse transduction. The heavy chain binds to ganglioside receptor on membrane of target nerve cells(presynaptic nerve). Uptake of the toxin into nerve terminals by endocytosis within endosome. Because changes in pH inside endosome result in cleavage of toxin and release the active subunit.

Normally, the release of acetylcholine (excitatory neurotransmitter) from acetylcholine vesicle(synaptic vesicle)depends on many proteins that collectively called SNARE proteins that facilitate the exocytosis of Acetylcholine into synaptic cleft and then bind to its receptor on surface of muscle to achieve its work(muscle contraction).

Botulinum toxin(acts as inhibitory neurotransmitter) cause inhibition of neurotransmitter exocytosis from presynaptic terminal by cleavage of specific SNARE proteins. The blocks release of neurotransmitter at

peripheral nerve terminals of neuromuscular junction(no contraction) and lead to flaccid paralysis(muscle relaxation).

Neurotoxin is one most important and dangerous toxin. Approximately 1µg is lethal for humans(1g of this toxin is enough to kill several millions of people). There is regarding its potential use as agent of biowarfare.

The bacteria are non-invasive and produce toxin within canned and preserved foods especially alkaline vegetable and, cheeses ,smoked fish.

There are three forms of botulism :

- a. Food-poisoning.
- b. Infant botulism .
- c. Wound botulism.

Food poisoning is caused by ingestion of neurotoxin in food or after ingestion of organism and then produce toxin in gut. This toxin absorbed from intestine into bloodstream and then reach their action at nerve synapses . The action of toxin is to block neurotransmission . After incubation period (12-36 hr.) is start signs of poisoning with vomiting, thirst(mouth and throat dryness), difficult in swallowing , difficult in speaking and in breathing , dysurea, constipation , double vision, coma and paralysis of motor muscles which spreading to respiratory and heart muscles. Death during 1-7 days may occurs because stopped of heart action and breathing.

Infant botulism is associated with ingestion of spore-contaminated honey. Affected infants develop weakness or flaccid paralysis and may need respiratory support but usually recover spontaneously .While wound botulism is associated with drugs abuse, especially skin-popping with black tar heroin, and tattoo.

Control:

- Antitoxin should be promptly administered if botulism is suspected.
- Antibiotic are generally used for treatment of secondary infection.
- Supportive care such mechanical ventilation and intravenous and nasogastric nutritional support.
- Canned food must be preserving at acid pH or storing food at less than 4C.
- Destroying the toxin in food by heating at 80C for 30 minutes.
- Avoid taking the swelling canned food.

Food-poisoning caused by *Clostridium perfringens* :

It is cause gas gangrene and food poisoning.

- Gram positive rod, obligate anaerobic.
- spore-former ,the spore is wider than bacillary body. It is located in center or sub-terminal of cell.
- It is capsulated .
- only species of genus is non-motile.
- Ferment many sugars with production of acid and gas. Therefore produces stormy fermentation in litmus milk medium.

Habitat and transmission

It is widely distributed in environment. The spore is found in soil, water and sewage .The organism is a normal inhabitant of large intestine of man and animals. The spore is resistant to heating and can be survive in cooking and germinate in large numbers in reheated foods. Infection may be endogenous. Food serve as sources of infection are meat, chicken and fish. The infection occurs after the consumption of contaminated meat or when the meat is kept warm for many hours(e,g, reheated meat).

Pathogenicity and clinical findings :

It is produces enterotoxin , heat-labile, which acts as superantigen. Mode of action is similar to action of toxin of *V.cholerae* and *E.coli*. Huge numbers of organism is required to cause disease. After incubation period (8-24 hours) the clinical symptoms which appear as abdominal pain ,watery diarrhea with little vomiting and no fever , then recovery within 12-24 hours.

Control :

1. Antimicrobial treatment is rarely required.
2. Preferable avoiding cooking food too long before consumption.

Food-poisoning caused by *Bacillus cereus* :**Specified properties:**

- *Bacillus* is large gram-positive rod .
- *Bacillus* have square ends and arranged in long chains.
- Spore-former bacteria, the spore is located in center and it not result in swelling the mother cell.
- Aerobic bacteria.

It is similar in morphology to *B. anthracis* except that it usually is active motile (produce swarming) , non capsulated, and beta-hemolytic.

Habitat and Transmission :

The organisms and their spore are found in soil. The spore germinates when rice is kept warm for many hours(e,g, reheated fried rice). The

portal of entry is gastrointestinal tract ,and transmission by ingestion of contaminated food(meat, vegetables, rice, custard).

Pathogenesis and clinical features :

The organisms produce two enterotoxins ,

1. Heat-labile enterotoxin (diarrhogenic toxin) is associated with contaminated meat, poultry and vegetables.
2. Heat-stable enterotoxin(emetic toxin) is associated with contaminated fried rice.

The mode of action of one is same as that of cholera toxin and L.T toxin of *E.coli* ,ie , it adds adenosine diphosphate-ribose, a process called ADP-ribosylation, to G-protein, which stimulate adenylate cyclase and leads to increased concentration of cAMP within enterocytes. The mode of action of other enterotoxin resemble that of staphylococcal enterotoxin, ie, it is superantigen.

B.cereus causes food poisoning (gastroenteritis)which characterized by abdominal pain , vomiting during 1-5 hour, or diarrhea during 6-18 hour after eating the food, never fever. There are two syndromes of gastroenteritis

1. One has short incubation period ,4 hours, and consists of nausea, and vomiting, similar to staphylococcal food poisoning. Vomiting due to ingestion of enterotoxin in food.
2. Other has long incubation period, 18 hours, and features watery, non-bloody diarrhea, resembling clostridial food poisoning. Diarrhea resulting from production of enterotoxin in gut.

Control :

Treatment; it is treated with fluid replacement, and antibiotics.

Prevention ; good food-handling practice such as refrigerating foods and cooking and heating food above 56C before eating. Rice should not be kept warm for long period.

Food-poisoning caused by *Salmonella enterica* serotype enteritidis (formerly; *Sal. enteritidis*):

- Gram-negative rods , catalase positive, oxidase negative.
- Non-lactose ferment, but do produce H₂S and gas from fermentation of carbohydrates.
- Non-Capsulated, motile by peritrichate flagella.
- Aerobic or facultative anaerobic,

Habitat and Transmission ;

Natural habitat is enteric tract of animals and humans. There are large animal reservoirs of infection. The organism is transmitted to man via contaminated food; especially poultry ,meat ,eggs, and dairy products. Water-borne is less frequent. Salmonella infection is also transmitted

from person to person via fecal contamination of food and water. Carriers are important sources of infection.

Pathogenesis and clinical findings;

Salmonella enteritidis produce enterotoxin (endotoxin) and cause food poisoning (enterocolitis). The ingestion of large number of organism is needed to cause disease. Infectious dose is at least 10^5 cells. Infectious dose is high because organisms are inactivated by stomach acid.

Invasion of epithelial and subepithelial tissues of the mucosa of small and large intestines then penetrate it and migrate to lamina propria of ileocecal region. The organism multiply in lymphoid follicles causing reticuloendothelial hyperplasia and hypertrophy. The inflammatory response mediated by PMN leucocytes and release prostaglandins which stimulate cAMP and activate fluid secretion. The organism can enter the blood, and causing sepsis.

Predisposing factors include lowered stomach acidity from either antacids or gastrectomy.

Incubation period (12-48 hours) after ingested contaminated food, enterocolitis begins with nausea and vomiting and fever then progress to abdominal pain and watery diarrhea which can vary from mild to severe, with or without blood, may persist for 2-7 days.

Control:

1. Treatment;

- The fluid and electrolytes replacement may be required.
- Antibiotics usually not recommended for uncomplicated enterocolitis. But Ceftriaxone and other drugs are used for sepsis.

2. Prevention;

- public health measures, eg. Do not eat raw eggs or meat, Sewage disposal, chlorination of drinking water supply.
- No vaccine is available.

Table 7–5. Bacterial diseases transmitted by foods.

Bacterium	Typical Food	Main Reservoir	Disease
I. Diarrheal diseases			
Gram-positive cocci			
<i>Staphylococcus aureus</i>	Custard-filled pastries; potato, egg, or tuna fish salad	Humans	Food poisoning, especially vomiting
Gram-positive rods			
<i>Bacillus cereus</i>	Reheated rice	Soil	Diarrhea
<i>Clostridium perfringens</i>	Cooked meat, stew, and gravy	Soil, animals, or humans	Diarrhea
<i>Listeria monocytogenes</i>	Unpasteurized milk products	Soil, animals, or plants	Diarrhea
Gram-negative rods			
<i>Escherichia coli</i>	Various foods and water	Humans	Diarrhea
<i>E. coli</i> O157:H7 strain	Undercooked meat	Cattle	Hemorrhagic colitis
<i>Salmonella enteritidis</i>	Poultry, meats, and eggs	Domestic animals, especially poultry	Diarrhea
<i>Shigella</i> species	Various foods and water	Humans	Diarrhea (dysentery)
<i>Vibrio cholerae</i>	Various foods, eg, seafood, and water	Humans	Diarrhea
<i>Vibrio parahaemolyticus</i>	Seafood	Warm salt water	Diarrhea
<i>Campylobacter jejuni</i>	Various foods	Domestic animals	Diarrhea
<i>Yersinia enterocolitica</i>	Various foods	Domestic animals	Diarrhea
II. Nondiarrheal diseases			
Gram-positive rods			
<i>Clostridium botulinum</i>	Improperly canned vegetables, smoked fish	Soil	Botulism
<i>Listeria monocytogenes</i>	Unpasteurized milk products	Cows	Sepsis in neonate or mother
Gram-negative rods			
<i>Vibrio vulnificus</i>	Seafood	Warm salt water	Sepsis
<i>Brucella</i> species	Meat, milk	Domestic animals	Brucellosis
<i>Francisella tularensis</i>	Meat	Rabbits	Tularemia
Mycobacteria			
<i>Mycobacterium bovis</i>	Milk	Cows	Intestinal tuberculosis