

Anbar University

Medicine College

Microbiology department

Enteric bacteria are bacteria of the intestines, and may refer to:

- 1-Gut flora, which is always present and usually harmless
- 2-Pathogenic bacteria of bacterial gastroenteritis
- 3-The taxonomic family Enterobacteriaceae

Enterobacter is a genus of common Gram-negative, facultative anaerobic, rod-shaped, non-spore-forming bacteria of the family Enterobacteriaceae. Several strains of these bacteria are pathogenic and cause opportunistic infections in immunocompromised (usually hospitalized) hosts and in those who are on mechanical ventilation. The urinary and respiratory tracts are the most common sites of infection. The genus *Enterobacter* is a member of the coliform group of bacteria. It does not belong to the fecal coliforms (or thermotolerant coliforms) group of bacteria, unlike *Escherichia coli*, because it is incapable of growth at 44.5 °C in the presence of bile salts. Some of them showed quorum sensing properties as reported before.

Escherichia coli

Escherichia coli is a Gram-negative, facultative anaerobic, rod-shaped bacterium of the genus *Escherichia* that is commonly found in the lower intestine. Most *E. coli* strains are harmless, but some serotypes can cause serious food poisoning in their hosts, and are occasionally responsible for product recalls due to food contamination. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K₂, and preventing colonization of the intestine with pathogenic bacteria.

Serotypes

Pathogenic *E.coli* strains can be categorized based on elements that can elicit an immune response namely:

1. O antigen: part of lipopolysaccharide layer

2. K antigen: capsule
3. H antigen: flagellin

For example *E.coli* strain EDL933 is of the O157:H7 group.

Enteric *E. coli* (EC) are classified on the basis of serological characteristics and virulence properties serotypes includes:

1-Enterotoxogenic E.coli (ETEC): is a type of *Escherichia coli* and the leading bacterial cause of diarrhea, as well as the most common cause of travelers' diarrhea and cause diarrhea in children. Causes fimbria adhesions (projections from the bacterial cell surface) to bind enterocyte cells in the small intestine. ETEC can produce enterotoxins.

2- Enteropathogenic E. coli (EPEC): EPEC cause either a watery or bloody diarrhea, the former associated with the attachment to, intestine. Bloody diarrhea and an acute tissue-destructive process, caused by a toxin similar to that of *Shigella dysenteriae*, also called verotoxin. In most of these strains the shiga-like toxin. EPEC are highly infectious for infants is prolonged infection causes dehydration and electrolyte imbalance.

3-Enteroinvasive E.coli(EIEC): EIEC infection causes a syndrome that is same to shigellosis, with profuse diarrhea and high fever.

4-Enterohemorrhagic E.coli (EHEC): The most infamous member of this serotype is strain which causes bloody diarrhea and no fever. EHEC can cause hemolytic-uremic syndrome and sudden kidney failure. It uses bacterial fimbriae for attachment (*E. coli* common pilus, ECP), and shiga toxin production that can elicit an intense inflammatory response.

5-Enteraggregative E.coli(EAEC): So named because they have fimbriae which bind to the intestinal mucosa to cause watery diarrhea without fever. EAEC are noninvasive. They produce a hemolysin and an enterotoxin similar to that of ETEC.

Pathogenesis:

E. coli are bacteria that normally live in the intestines of humans. Many strains of *E. coli* are harmless or beneficial. pathogenic *E. coli* cause illness, either diarrhea or illness outside of the intestinal tract. The types of *E. coli* that can cause diarrhea and transmitted through contaminated

water or food or through contact with other persons and some strains associated with Shiga toxin-producing *E. coli*.

Shiga toxin-producing *E. coli* (STEC)

Escherichia coli are bacteria that normally live in the intestines of humans. Most strains of the *E. coli* bacteria do not cause illness. However, Shiga toxin-producing *E. coli* (STEC) can cause serious illness in humans as Enteropathogenic *E. coli*. It is more common in children than in adult.

The following steps show how pathogenic *E. coli* of each pathotype cause disease:

1-Pathogenic *E.coli* causes infection due to eating or drinking of contaminated food or water of and enter the intestinal tract.

2- *E.coli* has fimbrial adhesins which mediate adherence to specific receptors on the intestinal epithelial cells.

3- Enterotoxins production which stimulate water and electrolyte loss into the intestinal lumen and causes dehydration and possibly death, and a decreased weight.

Diseases of *Escherichia coli*:

Escherichia coli is one of the most frequent causes of many common bacterial infections, including cholecystitis, bacteremia, cholangitis, urinary tract infection (UTI), and traveler's diarrhea, and other clinical infections such as neonatal meningitis and pneumonia.

Other miscellaneous *E coli* infections include septic arthritis, endophthalmitis, suppurative thyroiditis, sinusitis, osteomyelitis, endocarditis, and skin and soft-tissue infections (especially in patients with diabetes).

Symptoms of Intestinal Infection of *E. Coli*

Symptoms of intestinal infection generally begin between one and five days after you have been infected with *E. coli*. Symptoms can include:

1-abdominal cramping 2-sudden, severe watery diarrhea that may change to bloody stools 3-gas 4-loss of appetite/nausea 5-Nausea and vomiting,

in some people 6-fatigue 7-fever .Symptoms can last anywhere from a few days to more than a week.

Symptoms of a severe *E. coli* infection may include:

1-bloody urine 2-decreased urine output 3-pale skin 5-dehydration

Complication

Most healthy adults recover from *E. coli* illness within a week. Some people particularly young children and older adults may develop a life-threatening form of kidney failure called hemolytic uremic syndrome.

Way of transmission :

1-Eating or drinking contaminated food:You get an *E. coli* infection by coming into contact with the feces, or stool, of humans or animals. This can happen when you drink water or eat food that has been contaminated by feces.

2-Eating of Uncooked meat .

3-Drinking of unpasteurized milk.

4-Eating Raw fruits and vegetables, unpasteurized fruit or vegetable that have come in contact with infected animal feces.

5-Human or animal feces infected with *E. coli contaminated*, pools, and water supplies.

6-The bacteria can also spread from one person to another, usually when an infected person does not wash his or her hands well after a bowel movement. *E. coli* can spread from an infected person's hands to other people .

Laboratory diagnosis

1-Specimen collection:Stool,CSF,

2-Culture: MacConkey agar or EMB agar inoculated on MacConkey agar, deep red colonies are produced, and it is lactose fermental.

3-Gram Stain : gram-negative rods

4-Biochemical test: IMViC for *E. coli*; as it is indole-positive (red ring) and methyl red-positive (bright red), but VP-negative (no change-colourless) and citrate-negative (no change-green colour).

5-Serological test:ELISA

6-Molecular test:PCR

Klebsiella species

Klebsiella is a genus of nonmotile, Gram-negative, oxidase-negative, rod-shaped bacteria with a prominent polysaccharide-based capsule. It naturally occurs in the soil.

Klebsiella pneumoniae is a gram-negative, non-motile, lactose fermenting, rod-shape organism. *K. pneumoniae* is able to grow either with or without free oxygen, deeming it a facultative anerobe. This organism is also surrounded by a capsule, which increases its virulence by acting as a physical barrier against the host's immune response. *K. pneumoniae* is a home-grown microorganism in that it resides in the microbiota found in the mouth, skin, and intestinal tract, where it initially does not cause disease. *K. pneumoniae* causes pneumonia, bloodstream infections, wound infections, urinary tract infections, and meningitis. Patients who require equipment such as catheters or ventilators are at high risk for infections. Also, a patient administered a course of broad-spectrum antibiotic treatment is at an even high risk due to the disruption of the normal flora of the bacteria in the body, deeming it more susceptible to pathogens.

Serotypes

Members of the *Klebsiella* genus typically express two types of antigens on their cell surfaces. The first, O antigen, is a component of the lipopolysaccharide (LPS). The second is K antigen, a capsular polysaccharide. Both contribute to pathogenicity and form the basis for serogrouping.

Virulence factors

Lipopolysaccharide (LPS) and capsular polysaccharide (CPS) are two of the most important virulence factors of *K. pneumoniae* in causing sepsis. To resist complement-mediated killing, LPS contains lipid A, core, and O-polysaccharide antigen. CPS is essentially the outer layer of the

pathogen containing polymorphonuclear cells, which resistance against phagocytosis.

Klebsiella diseases.

Klebsiella pneumoniae is a bacterium that normally lives inside human intestines, where it doesn't cause disease.

However, if *K. pneumoniae* gets into other areas of the body, it can cause a range of different illnesses. These include:

1-Pneumonia (lung infection)

2-Bloodstream infections

3-Wound infections

4-Surgical site infections

5-Meningitis (an inflammation or infection of the meninges, the membranes covering the spinal cord and brain)

6-Urinary tract infections (UTI)

7- *Klebsiella* bacteria have developed antimicrobial resistance, most recently to the class of antibiotics known as carbapenems.

How Klebsiella Pneumoniae Spreads

1- Patients whose care requires devices like ventilators (breathing machines) or intravenous (vein) catheters and causes pneumonia, or bloodstream infection.

2- *Klebsiella pneumoniae* transmitted from person-to-person by the contaminated hands.

4-*K. pneumoniae* infections is "nosocomial" infections and transmitted in a hospital in patients with weakened immune systems.

5- Taking long courses of certain antibiotics are most at risk for *Klebsiella* infections .

Symptoms of *K. Pneumoniae* Infections

The symptoms of a *K. pneumoniae* infection differ depending on where the infection is located, and are similar to symptoms of the same diseases caused by other microbes.

For instance, meningitis from *K. pneumoniae* produces the hallmark symptoms of bacterial meningitis, including fever, confusion, neck stiffness, and sensitivity to bright lights.

Bloodstream infections (bacteremia and sepsis) from *K. pneumoniae* cause fever, chills, rash, light-headedness, and altered mental states.

Pneumonia from *K. pneumoniae* can result in:

- 1-Fevers and chills
- 2-Flu-like symptoms
- 3-Cough, which may produce mucus that's yellow, green, or bloody
- 4-Breathing issues

Pathogenesis of *K. pneumoniae*

Infection of *K. pneumoniae* occur in the lungs, where they cause necrosis, inflammation, and hemorrhage within the lung tissue. That sometimes produces thick, bloody, mucoid sputum (currant jelly sputum) caused by aspirating oropharyngeal microorganisms into the lower respiratory tract.

As a general rule, *Klebsiella* infections are seen mostly in people with a weakened immune system. Most often, illness affects middle-aged and older men with debilitating diseases. This patient population is believed to have weakened respiratory host defenses, including persons with diabetes, alcoholism, malignancy, liver disease, chronic obstructive pulmonary diseases (COPD), glucocorticoid therapy, renal failure, and certain occupational exposures (such as paper mill workers). Many of these infections are obtained when a person is in the hospital for some other reason (a nosocomial infection). Feces are the most significant source of patient infection, followed by contact with contaminated instruments.

Diagnosis

1-Specimen collections'. pneumonia may be isolated from blood, urine, pleural fluid, and wounds. urinary catheters

2- Gram stain :By simply gram staining a sputum sample obtained from a patient could lead one to diagnosing *K. pneumoniae*.

3- Cultures : Colonies are large high convex and mucoid .On MacConkey agar the colony give pink colonies due to lactose fermentation.

4-Biochemical test: IMViC for *K. pneumoniae* as it is indole- negative and methyl red negative but VP- positive and citrate-positive .

5-Serological test:ELISA

6-Molecular test:PCR

Pseudomonas aeruginosa

Pseudomonas aeruginosa is a common Gram negative bacterium aerobic, coccobacillus bacterium with unipolar motility. That can cause disease in humans (An opportunistic human pathogen). It is citrate, catalase, and oxidase positive. It is found in soil, water, skin flora, and most man-made environments throughout the world. The symptoms of such infections are generalized inflammation and sepsis. If such colonizations occur in different organs, such as the lungs, the urinary tract, and kidneys, the results can be fatal.

In certain conditions, *P. aeruginosa* can secrete a variety of pigments, including pyocyanin (blue-green), pyoverdine (yellow-green and fluorescent), and pyorubin (red-brown). These can be used to identify the organisms.

Pathogenesis

P. aeruginosa is an opportunistic, nosocomial pathogen of immunocompromised individuals, *P. aeruginosa* typically infects the airway, urinary tract, burns, wounds, and also causes other blood infections. It is the most common cause of infections of burn injuries and of the outer ear (otitis externa), and is the most frequent colonizer of medical devices (e.g., catheters). *Pseudomonas* can be spread by equipment that gets contaminated and is not properly cleaned or on the hands of healthcare workers. *Pseudomonas* can, in rare circumstances,

because community-acquired pneumonias, as well as ventilator-associated pneumonias, being one of the most common agents isolated in several studies

The pathogenesis of pseudomonal infections is multifactorial and complex. *Pseudomonas* species are both invasive and toxigenic. The 3 stages, are:

- (1) Bacterial attachment and colonization,
- (2) Local infection,
- (3) Bloodstream dissemination and systemic disease.

The importance of colonization and adherence is most evident when studied in the context of respiratory tract infection in patients with cystic fibrosis and in those that complicate mechanical ventilation. Production of extracellular proteases adds to the organism's virulence by assisting in bacterial adherence and invasion.

Diseases

Pseudomonas aeruginosa has become an important cause of infection, especially in patients with compromised host defense mechanisms. It is the most common pathogen isolated from patients who have been hospitalized longer than 1 week, and it is a frequent cause of nosocomial infections. Pseudomonal infections are complicated and can be life-threatening.

Pseudomonal infections can involve the following parts of the body, with corresponding symptoms and signs:

- 1-Respiratory tract (eg, pneumonia)
- 2-Bloodstream (bacteremia)
- 3-Heart (endocarditis)
- 4-CNS (eg, meningitis, brain abscess)
- 5-Ear (eg, otitis externa and media)
- 6-Eye (eg, bacterial keratitis, endophthalmitis)

7-Bones and joints (eg, osteomyelitis)

8-Gastrointestinal tract (eg, diarrhea, enteritis, enterocolitis)

9-Urinary tract infection

10-Skin (eg, ecthyma gangrenosum)

Who gets this infection (Way of transmission)

1-The bacteria can be spread in hospitals by the hands of healthcare workers or by hospital equipment.

2-Pseudomonas is one of the main causes of pneumonia in patients who are on breathing machines as ventilator.

3- Burn wound may get dangerous pseudomonas infections of the blood, bone, or urinary tract.

4- Pseudomonas infection by using IV needles or catheters.

5- The infection might occur after swimming in the pools and causes skin rash or swimmer's ear.”

6- Eye infections can occur due to infected contact lens solution in people who wear contacts lens.

Symptoms

Symptoms depend on where the infection is. If it's in a wound, there may be green-blue pus in or around the area. If you have swimmer's ear, your ear aches. If the infection causes pneumonia, you may get a cough. Pseudomonas infection fever and feel tired. But all pseudomonas infections can make you very sick if they spread through the bloodstream (septicemia). A serious infection can cause symptoms of high fever, chills, confusion, and shock.

The Risk for Pseudomonas Infections

Pseudomonas infections are considered opportunistic infections. This means that the organism only causes disease when a person's immune system is already impaired.

Conditions that may increase the risk of infection include:

- burn wounds
- cancer patients receiving chemotherapy
- cystic fibrosis
- HIV or AIDS
- presence of a foreign body, like a mechanical ventilator or catheter
- patients undergoing an invasive procedure, like a surgery

Infections can be severe in patients whose immune systems are already compromised.

Very mild illnesses like skin rashes and ear infections have been reported in healthy individuals.

Diagnosis

1-Specimen collection: A diagnosis is made by sending a sample of pus, blood, or tissue and sputum .

2- Gram stain: is Gram-negative rod or (coccobacillus).

3-Culture: *P. aeruginosa* produces colonies with a characteristic "grape-like" or odor on bacteriological media. it can be isolated as clear colonies on MacConkey agar and it does not ferment lactose.

4-Biochemical test: oxidase test positive.

5- Confirmatory tests include production of the blue-green pigment pyocyanin on cetrimide agar and growth at 42 °C.

6- A TSI slant is often used to distinguish nonfermenting *Pseudomonas* species from enteric pathogens in faecal specimens.

Proteus species

Proteus is a genus of Gram-negative bacteria. *Proteus* bacilli are widely distributed in nature as saprophytes, being found in decomposing animal matter, sewage, manure soil, and human and animal feces. They are opportunistic pathogens, commonly responsible for urinary and septic infections, often nosocomial. *Proteus* species are part of the Enterobacteriaceae family of gram-negative bacilli causes of infections in humans. *Proteus* species are most commonly found in the human intestinal tract as part of normal human intestinal flora.

Proteus species

1-Proteus mirabilis

2-Proteus vulgaris

3- Proteus penneri

Proteus mirabilis causes 90% of *Proteus* infections is and can be considered a community-acquired infection.

Proteus vulgaris and *Proteus penneri* are easily isolated from individuals in long-term care facilities and hospitals and from patients with underlying diseases or compromised immune systems.

Proteus vulgaris is a rod-shaped, nitrate-reducing, indole and catalase-positive, hydrogen sulfide-producing, Gram-negative bacterium that inhabits the intestinal tracts of humans. It can be found in soil, water, and fecal matter. It is grouped with the Enterobacteriaceae and is an opportunistic pathogen of humans. It is known to cause urinary tract infections and wound infections.

Proteus mirabilis is a Gram-negative, facultatively anaerobic, rod-shaped bacterium. It shows swarming motility and urease activity. *P. mirabilis* causes 90% of all *Proteus* infections in humans. It is widely distributed in soil and water.

Disease

This rod-shaped bacterium has the ability to produce high levels of urease, which hydrolyzes urea to ammonia (NH₃), so makes the urine more alkaline. If left untreated, the increased alkalinity can lead to the formation of crystals, calcium carbonate. The bacteria can be found throughout the stones, and these bacteria lurking in the kidney stones can reinitiate infection after antibiotic treatment. Once the stones develop, over time they may grow large enough to cause obstruction and renal failure. *Proteus* species can also cause wound infections, septicemia, and pneumonia, mostly in hospitalized patients.

Pathogenesis

Three species of *P. vulgaris*, *P. mirabilis*, and *P. penneri* are opportunistic human pathogens. *Proteus* includes pathogens responsible for many human urinary tract infections. *P. mirabilis* causes wound and

urinary tract infections. Most strains of *P. mirabilis* are sensitive to ampicillin and cephalosporins. *P. vulgaris* is not sensitive to these antibiotics. However, this organism is isolated less often in the laboratory and usually only targets immunosuppressed individuals. *P. vulgaris* occurs naturally in the intestines of humans and in soil, and polluted waters. *P. mirabilis*, once attached to the urinary tract, infects the kidney more commonly than *E. coli*. *P. mirabilis* is often found as a free-living organism in soil and water.

About 10–15% of kidney stones are struvite stones, caused by alkalinization of the urine by the action of the urease enzyme (which splits urea into ammonia and carbon dioxide) of *Proteus* (and other) bacterial species.

Proteus infections

- Nosocomial infections
- *P. mirabilis* causes 90% of *Proteus* infections.
- *P. vulgaris* and *P. penneri* are easily isolated from individuals in long-term care facilities and hospitals and from patients with underlying diseases or compromised immune systems.
- Patients with recurrent infections, those with structural abnormalities of the urinary tract, those who have had urethral instrumentation, and those whose infections were acquired in the hospital have an increased frequency of infection caused by *Proteus* and other organisms (e.g., *Klebsiella*, *Enterobacter*, *Pseudomonas*, enterococci, and staphylococci)