Bacterial infections and diseases

Bacterial Diseases of the Skin

Two genera of bacteria, *Staphylococcus* and *Streptococcus*, are frequent causes of skin-related diseases. Both genera also may produce invasive enzymes and damaging toxins.

Pathogenic *S. aureus* can produce enterotoxins, leukocidins, and exfoliative toxin. Localized infections (sties, pimples, and carbuncles) result from entry of *S. aureus* through openings in the skin.

Streptococci are classified according to their hemolytic enzymes and cell wall antigens. Group A beta-hemolytic streptococci produce a number of virulence factors: M protein, deoxyribonuclease, streptokinases, and hyaluronidase.

Pseudomonas aeruginosa produces an endotoxin and several exotoxins. *P. aeruginosa* infections have a characteristic blue-green pus caused by the pigment pyocyanin.

Bacterial Diseases of the Eye

The bacterial microorganisms most commonly associated with the eye usually originate from the skin and upper respiratory tract.

Ophthalmia Neonatorum

Ophthalmia neonatorum is a serious form of conjunctivitis caused by *Neisseria gonorrhoeae*, the cause of gonorrhea. Large amounts of pus are formed; if treatment is delayed, ulceration of the cornea will usually result. The disease is acquired as the infant passes through the birth canal, and infection carries a high risk of blindness. Early in the twentieth century, legislation required that the eyes of all newborn infants be treated with a 1% solution of silver nitrate, which proved to be a very effective treatment in preventing this eye infection, Silver nitrate has been almost entirely replaced by antibiotics because of frequent coinfections by gonococci and sexually transmitted chlamydias, which silver nitrate is not effective against.

Trachoma

A serious eye infection, and probably the greatest single cause of blindness by an infectious disease. T**rachoma** is caused by certain serotypes of *Chlamydia trachomatis*, but not the same ones that cause genital infections

Bacterial Diseases of the Nervous System

An inflammation of the meninges is called **meningitis**. An inflammation of the brain itself is called **encephalitis**. If both the brain and the meninges are affected, the inflammation is called **meningoencephalitis**.

Historically, only three bacterial species have been responsible for most of the meningitis cases and their resulting deaths. Meningitis caused by *Haemophilus influenzae* type B (Hib), once responsible for a majority of cases, has been nearly eliminated in the United States since introduction of an effective vaccine.

In adult patients, that is, older than 16 years, about 80% of meningitis cases are now caused by *Neisseria meningitidis* and *Streptococcus pneumoniae*.
All three of these pathogens possess a capsule that protects them from phagocytosis as they replicate rapidly in the bloodstream, from which they might enter the cerebrospinal fluid. Death from bacterial meningitis often occurs very quickly, probably from shock and inflammation caused by the release of endotoxins of the gram-negative pathogens or the release of cell wall fragments (peptidoglycans and teichoic acids) from gram-positive bacteria. Nearly 50 other species of bacteria have been reported to be opportunistic pathogens that occasionally cause meningitis. Especially important are *Listeria monocytogenes*, group B streptococci, staphylococci, and certain gram-negative bacteria.
Bacterial meningitis is life-threatening and develops rapidly. Therefore, prompt treatment of any type of bacterial meningitis is essential, and chemotherapy of suspected cases is usually initiated before identification of the pathogen is complete. Broad-spectrum third-generation cephalosporins are usually the first choice of antibiotics; some experts recommend including vancomycin.

Tetanus

The causative agent of **tetanus**, *Clostridium tetani*, The symptoms of tetanus are caused by an extremely potent neurotoxin**, *tetanospasmin***, that is released upon death and lysis of the growing bacteria.
The toxin initially binds to receptors on the presynaptic membranes of motor neurons. It then migrates by the retrograde axonal transport system to the cell bodies of these neurons to the spinal cord and brainstem. The toxin diffuses to terminals of inhibitory cells, including both glycinergic interneurons and γ-aminobutyric acid (GABA)-secreting neurons from the brainstem. The toxin degrades synaptobrevin, a protein required for docking of neurotransmitter vesicles on the presynaptic membrane. Release of the inhibitory glycine and GABA is blocked, and the motor neurons are not inhibited. Spastic paralysis results.
A physician's decision for treatment depends largely on the extent of the deep injuries and the immunization history of the patient, who may not be conscious. For extensive wounds in patients with unknown or low immunity, (*tetanus immune globulin*) TIG would be given to provide temporary protection. In addition, the first of a toxoid series would be administered to provide more permanent immunity.

Botulism

Botulism, a form of food poisoning, is caused by *Clostridium botulinum*, Botulinum toxin is absorbed from the gut and binds to receptors of presynaptic membranes of motor neurons of the peripheral nervous system and cranial nerves. Proteolysis, by the light chain of botulinum toxin, of target proteins in the neurons inhibits the release of acetylcholine at the synapse, resulting in lack of muscle contraction and flaccid paralysis.

Leprosy

Mycobacterium leprae was considered to be the only bacterium that grows in the peripheral nervous system.

Bacterial Infections of the Heart

The wall of the heart consists of three layers. The inner layer, called the *endocardium*, lines the heart muscle itself and covers the valves. An inflammation of the endocardium is called **endocarditis**.

One type of bacterial endocarditis, **subacute bacterial endocarditis** (so named because it develops slowly, is characterized by fever, general weakness, and a heart murmur. It is usually caused by alpha-hemolytic streptococci (most often, *Streptococcus viridans*), which are common in the oral cavity,

although enterococci or staphylococci may also be involved. The condition probably arises from a focus of infection elsewhere in the body, such as in the teeth or tonsils. Microorganisms are released by tooth extractions or tonsillectomies, enter the blood, and find their way to the heart. Normally, such bacteria would be quickly cleared from the blood by the body's defensive mechanisms. However, in people whose heart valves are abnormal, because of either congenital heart defects or such diseases as rheumatic fever and syphilis, the bacteria lodge in the preexisting lesions. Within the lesions, the bacteria multiply and become entrapped in blood clots that protect them from phagocytes and antibodies. As multiplication progresses and the clot gets larger, pieces of the clot break off and can block blood vessels or lodge in the kidneys. In time, the function of the heart valves is impaired. Left untreated by appropriate antibiotics, subacute bacterial endocarditis is fatal within a few months. Streptococci can also cause **pericarditis**, inflammation of the sac around the heart (the *pericardium*).

Rheumatic Fever

Rheumatic fever is an autoimmune complication of streptococcal infections. Rheumatic fever is expressed as arthritis or inflammation of the heart. It can result in permanent heart damage. Antibodies against group A beta-hemolytic streptococci react with streptococcal antigens deposited in joints or heart valves or cross-react with the heart muscle.

Rheumatic fever can follow a streptococcal infection, such as streptococcal sore throat. Streptococci might not be present at the time of rheumatic fever.

Bacterial Diseases of the Upper Respiratory System

Streptococcal Pharyngitis (Strep Throat)

Streptococcal pharyngitis (strep throat) is an upper respiratory infection caused by *group A streptococci (GAS)*. This gram-positive bacterial group consists solely of *Streptococcus pyogenes.* Pharyngitis is characterized by local inflammation and a fever . Frequently, tonsillitis occurs, and the lymph nodes in the neck become enlarged and tender. Another frequent complication is otitis media.

The pathogenicity of GAS is enhanced by their resistance to phagocytosis. They are also able to produce special enzymes, called *streptokinases*, which lyse fibrin clots, and *streptolysins*, which are cytotoxic to tissue cells, red blood cells, and protective leukocytes.

Scarlet Fever

When the *Streptococcus pyogenes* strain causing streptococcal pharyngitis produces an *erythrogenic* (reddening) *toxin*, the resulting infection is called **scarlet fever**. When the strain produces this toxin, it has been lysogenized by a bacteriophage.

Diphtheria

Another bacterial infection of the upper respiratory system is **diphtheria**. The organism responsible is *Corynebacterium diphtheriae.* Part of the normal immunization program for children in the United States is the **DTaP vaccine**, which protects against diphtheria, tetanus, and pertussis.

Bacterial Diseases of the Lower Respiratory System

Pertussis (Whooping Cough)

Infection by the bacterium *Bordetella pertussis* results in **pertussis**, or **whooping cough**. The virulent strains possess a capsule. The bacteria attach specifically to ciliated cells in the trachea, first impeding their ciliary action and then progressively destroying the cells. This prevents the ciliary escalator system from moving mucus. *B. pertussis* produces several toxins. *Tracheal cytotoxin*, a fixed cell wall fraction of the bacterium, is responsible for damage to the ciliated cells, and *pertussis toxin* enters the bloodstream and is associated with systemic symptoms of the disease.

Tuberculosis

Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

Pneumococcal Pneumonia

Pneumonia caused by *S. pneumoniae* is called **pneumococcal pneumonia**. The cell pairs are surrounded by a dense capsule that makes the pathogen resistant to phagocytosis.

***Haemophilus influenzae* Pneumonia**

Diagnostic identification of the pathogen uses special media that determine requirements for X and V factors . Third-generation cephalosporins are resistant to the b-lactamases produced by many *H. influenzae* strains and are therefore usually the drugs of choice.

Mycoplasmal Pneumonia

The mycoplasmas, which do not have cell walls, do not grow under the conditions normally used to recover most bacterial pathogens. Because of this characteristic, pneumonias caused by mycoplasmas are often confused with viral pneumonias.

Bacterial Diseases of the Mouth

Dental Caries (Tooth Decay)

The accumulations of masses of microorganisms and their products on the tooth surface called **dental plaque**, are a type of biofilm and are intimately involved in the formation of **dental caries**, or tooth decay.

Oral bacteria convert sucrose and other carbohydrates into lactic acid, which in turn attacks the tooth enamel. Probably the most important *cariogenic* (caries-causing) bacterium is *Streptococcus mutans*. *S. mutans* is capable of metabolizing a wide range of carbohydrates, tolerates a high level of acidity, and synthesizes *dextran*, a gummy polysaccharide of glucose molecules that is an important factor in the formation of dental plaque.

Bacterial Diseases of the Lower Digestive System

Diseases of the digestive system are essentially of two types:
infections and intoxications.

An **infection** occurs when a pathogen enters the GI tract and multiplies. Microorganisms can penetrate into the intestinal mucosa and grow there, or they can pass through to other systemic organs.

Some pathogens cause disease by forming toxins that affect the GI tract. An **intoxication** is caused by the ingestion of such a preformed toxin. Most intoxications, such as that caused by *Staphylococcus aureus*, are characterized by a very sudden appearance (usually in only a few hours). Diarrhea and vomiting are both defensive mechanisms designed to rid the body of harmful material.

Staphylococcal Food Poisoning (Staphylococcal Enterotoxicosis)

A leading cause of gastroenteritis is **staphylococcal food poisoning**, an intoxication caused by ingesting an enterotoxin produced by *S. aureus*.

Shigellosis (Bacillary Dysentery) and Salmonellosis (Salmonella Gastroenteritis)

Bacterial infections, such as salmonellosis and shigellosis, usually have longer incubation periods (12 hours to 2 weeks) than bacterial intoxications, reflecting the time needed for the microorganism to grow in the host.

Typhoid Fever

The most virulent serotype of *Salmonella, S*. Typhi, causes the bacterial disease **typhoid fever**. Unlike the salmonellae that cause salmonellosis, this pathogen is not found in animals; it's spread only in the feces of other humans.

Cholera

The causative agent of **cholera**, one of the most serious gastrointestinal diseases, is *Vibrio cholerae*.

Cholera bacilli grow in the small intestine and produce an exotoxin, *cholera toxin* that causes host cells to secrete water and electrolytes, especially potassium. The result is watery stools containing masses of intestinal mucus and epithelial cells-called "rice water stools" from their appearance.

Escherichia coli Gastroenteritis

One of the most prolific microorganisms in the human intestinal tract is *Escherichia coli*.
Five pathogenic varieties (pathotypes) of *E. coli* have been well characterized.
Enteropathogenic *E. coli* (EPEC) is a major cause of diarrhea in developing countries and is potentially fatal in infants.
Enteroinvasive *E. coli* (EIEC) EIEC gain access to the submucosa of the intestinal tract through M cells in the same manner as *Shigella*. This invasion results in inflammation, fever, and a *Shigella*-like dysentery.
Enteroaggregative *E. coli* (EAEC) is a group of coliforms found only in humans. They are named for their growth habit, in which the bacteria cause a "stacked-brick" configuration when grown with epithelial cells.
In recent years, strains of **enterohemorrhagic *E. coli* (EHEC)**. The primary virulence factor in these bacteria is a Shigalike toxin. Shiga toxins are a family of toxins that are closely related. Some *E. coli* strains that produce Shiga-like toxins are termed **Shiga-toxin-producing *E. coli* (STEC)**. True Shiga toxin is produced only by *Shigella dysenteriae*. Most outbreaks are due to EHEC serotype O157:H7. A pathogenic group of *E. coli* called **enterotoxigenic *E. coli* (ETEC)** secretes enterotoxins that cause diarrhea.

Helicobacter Peptic Ulcer Disease

Helicobacter pylori, it is accepted that this microbe is responsible for most cases of **peptic ulcer disease**. This syndrome includes gastric and duodenal ulcers. *H. pylori* is also designated as a carcinogenic bacterium. Gastric cancer develops in about 3% of people infected with these bacteria.

Bacterial Diseases of the Urinary System

Urinary system infections are most frequently initiated by an inflammation of the urethra, or ***urethritis***. Infection of the urinary bladder is called ***cystitis***, and infection of the ureters is ***ureteritis***. The most significant danger from lower urinary tract infections is that they may move up the ureters and affect the kidneys, causing *pyelonephritis*. Occasionally the kidneys are affected by systemic bacterial diseases, such as *leptospirosis*.
Bacterial infections of the urinary system are usually caused by microbes that enter the system from external sources. Most infections of the urinary tract are caused by *Escherichia coli*. Infections by *Pseudomonas*, because of their natural resistance to antibiotics, are especially troublesome.

Bacterial Diseases of the Reproductive Systems

Gonorrhea

One of the most common reportable, or notifiable, communicable diseases in the United States is **gonorrhea**, an STI caused by the gram-negative diplococcus *Neisseria gonorrhoeae*. In both men and women, untreated gonorrhea can disseminate and become a serious, systemic infection. Complications of

gonorrhea can involve the joints, heart (*gonorrheal endocarditis*), meninges (*gonorrheal meningitis*), eyes, pharynx, or other parts of the body.

Nongonococcal Urethritis (NGU)

Nongonococcal urethritis (NGU), also known as **nonspecific urethritis (NSU)**, refers to any inflammation of the urethra not caused by *Neisseria gonorrhoeae.* Symptoms include painful urination and a watery discharge.
The most common pathogen associated with NGU is *Chlamydia trachomatis.*

Syphilis

The causative agent of **syphilis** is a gram-negative spirochete, *Treponema pallidum*. *T. pallidum* lacks the enzymes necessary to build many complex molecules; therefore, it relies on the host for many of the compounds necessary for life. Outside the mammalian host, the organism loses infectiveness within a short time. For research purposes the bacteria are usually propagated in rabbits, but they grow slowly, with a generation time of 30 hours or more. They can be grown in cell culture, at low oxygen concentrations, but only for a few generations.
T. pallidum has no obvious virulence factors such as toxins, but it produces several lipoproteins that induce an inflammatory immune response. This is what apparently causes the tissue destruction of the disease.