VIRUS AS POTENTIAL PATHOGENS

Some of the diseases that are caused by viral pathogens include smallpox, influenza, mumps, measles, chickenpox, ebola, and rubella.Viruses typically range between 20-300 nanometers in length.

A **viral disease** occurs when an organism's body is invaded by pathogenic viruses, and infectious virus particles (virions) attach to and enter susceptible cells.

Structural characteristics

Basic structural characteristics, such as genome type, virion shape and replication site, generally share the same features among virus species within the same family.

There are five double-stranded DNA families: three are non enveloped (Adenoviridae, Papillomaviridae and Polyomaviridae) and two are enveloped (Herpesviridae and Poxviridae). All of the non-enveloped families have icosahedral capsids.

There is one family of partly double-stranded DNA viruses: Hepadnaviridae. These viruses are enveloped.

There is one family of single-stranded DNA viruses that infect humans: Parvoviridae. These viruses are non-enveloped.

There is one family with a double-stranded RNA genome: Reoviridae.

There is one additional virus (Hepatitis D virus) which has not yet been assigned to a family but is clearly distinct from the other families infecting humans.

There is one family and one genus of viruses known to infect humans that have not been associated with disease: the family *Anelloviridae* and the genus *Dependovirus*. Both of these taxa are non-enveloped single-stranded DNA viruses.

Mechanism of pathogenecity

Pathogenesis is the process by which virus infection leads to disease. Pathogenic mechanisms include implantation of the virus at a body site (the portal of entry), replication at that site, and then spread to and multiplication within sites (target organs) where disease or shedding of virus into the environment occurs.

Many factors affect pathogenic mechanisms. An early determinant is the extent to which body tissues and organs are accessible to the virus. Accessibility is influenced by physical barriers (such as mucus and tissue barriers), by the distance to be traversed within the body, and by natural defense mechanisms. If the virus reaches an organ, infection occurs only if cells capable of supporting virus replication are present.

Other factors that determine whether infection and disease occur are the many virulence characteristics of the infecting virus. To cause disease, the infecting virus must be able to overcome the inhibitory effects of physical barriers, distance, host defenses, and differing cellular susceptibilities to infection. The inhibitory effects are genetically controlled and therefore may vary among individuals and races. Virulence characteristics enable the virus to initiate infection, spread in the body, and replicate to large enough numbers to impair the target organ. Extremely virulent strains often occur within virus populations.

The occurrence of spontaneous or induced mutations in viral genetic material may alter the pathogenesis of the induced disease, e.g. HIV. These mutations can be of particular importance with the development of drug resistant strains of virus.

Cellular Pathogenesis

Direct cell damage and death may result from disruption of cellular macromolecular synthesis by the infecting virus.

Pathogenesis at the cellular level can be viewed as a process that occurs in progressive stages leading to cellular disease. Viral pathogenesis at the cellular level is the competition between the synthetic needs of the virus and those of the host cell. Since viruses must use the cell's machinery to synthesize their own nucleic acids and proteins, they have evolved various mechanisms to subvert the cell's normal functions to those required for production of viral macromolecules and eventually viral progeny. The function of some of the viral genetic elements associated with virulence may be related to providing conditions in which the synthetic needs of the virus compete effectively for a limited supply of cellular macromolecule components and synthetic machinery, such as ribosomes.

Tissue Tropism

Most viruses have an affinity for specific tissues; that is, they display tissue specificity or tropism. This specificity is determined by selective susceptibility of cells, physical barriers, local temperature and pH, and host defenses.

Polioviruses selectively infect and destroy certain nerve cells, which have a higher concentration of surface receptors for polioviruses than do virus-resistant cells.

Rhinoviruses multiply exclusively in the upper respiratory tract because they are adapted to multiply best at low temperature and pH and high oxygen tension.

Enteroviruses can multiply in the intestine, partly because they resist inactivation by digestive enzymes, bile, and acid.

Rabies virus uses the acetylcholine receptor present on neurons as a receptor, and hepatitis B virus binds to polymerized albumin receptors found on liver cells.

Similarly, Epstein-Barr virus uses complement CD21 receptors on B lymphocytes, and human immunodeficiency virus uses the CD4 molecules present on T lymphocytes as specific receptors.

Sequence of Virus Spread in the Host

Implantation at Portal of Entry

Viruses are carried to the body by all possible routes (air, food, bites, and any contaminated object). The frequency of implantation is greatest where virus contacts living cells directly (in the respiratory tract, in the alimentary tract, in the genital tract, and subcutaneously).

Even at the earliest stage of pathogenesis (implantation), certain variables may influence the final outcome of the infection.

Local Replication and Local Spread

Successful implantation may be followed by local replication and local spread of virus. Virus that replicates within the initially infected cell may spread to adjacent cells extracellularly or intracellularly.

Extracellular spread occurs by release of virus into the extracellular fluid and subsequent infection of the adjacent cell.

Intracellular spread occurs by fusion of infected cells with adjacent, uninfected cells or by way of cytoplasmic bridges between cells.

Most viruses spread extracellularly, but herpesviruses, paramyxoviruses, and poxviruses may spread through both intracellular and extra cellular routes. Intracellular spread provides virus with a partially protected environment because the antibody defense does not penetrate cell membranes.

A third category of viruses may cause both local and disseminated disease, as in herpes simplex and measles.

Incubation Period

During most virus infections, no signs or symptoms of disease occur through the stage of virus dissemination. Thus, the incubation period extends from the time of implantation through the phase of dissemination, ending when virus replication in the target organs causes disease.

The incubation period tends to be brief (1 to 3 days) in infections in which virus travels only a short distance to reach the target organ. Conversely, incubation periods in generalized infections are longer because of the stepwise fashion by which the virus moves through the body before reaching the target organs. Other factors also may influence the incubation period. Generalized infections produced by toga viruses may have an unexpectedly short incubation period because of direct intravascular injection (insect bite) of a rapidly multiplying virus.

Multiplication in Target Organs

Virus replication in the target organ resembles replication at other body sites except that

(1) The target organ in systemic infections is usually reached late during the stepwise progression of virus through the body, and

(2) Clinical disease originates there. At each step of virus progression through the body, the local recovery mechanisms

Depending on the balance between virus and host defenses, virus multiplication in the target organ may be sufficient to produce dysfunction manifested by disease or death. Additional constitutional disease such as fever and malaise may result from diffusion of toxic products of virus replication and cell necrosis, as well as from release of lymphokines and other inflammatory mediators. Release of leukotriene C4 during respiratory infection may cause bronchospasm. Viral antigens also may participate in immune reactions, leading to disease manifestations.

Shedding of Virus

The most frequent sites are the respiratory and alimentary tracts. Blood and lymph are sites of shedding for the arboviruses, since biting insects become infected by this route. HIV is shed in blood and semen. Milk is a site of shedding for viruses such as some RNA tumor viruses (retroviruses) and cytomegalovirus (a herpesvirus). Several viruses (e.g., cytomegaloviruses) are shed simultaneously from the urinary tract and other sites more commonly associated with shedding. The genital tract is a common site of shedding for herpesvirus type 2 and may be the route through which the virus is transmitted to sexual partners or the fetus. Saliva is the primary source of shedding for rabies virus. Cytomegalovirus is also shed from these last two sites. Finally, viruses such as tumor viruses that are integrated into the DNA of host cells can be shed through germ cells.

Congenital Infections

Infection of the fetus is a special case of infection in a target organ. The factors that determine whether a target organ is infected also apply to the fetus, but the fetus presents additional variables. The immune and interferon systems of the very young fetus are immature. This immaturity, coupled with the partial placental barrier to transfer of maternal immunity and interferon, deprive the very young fetus of important defense mechanisms.

Mechanisms of Antibiotic Resistance

Resistance to antibiotics can be caused by four general mechanisms

- The inactivation or modification of the antibiotic;
- An alteration in the target site of the antibiotic that reduces its binding capacity;
- The modification of metabolic pathways to circumvent the antibiotic effect;
- The reduced intracellular antibiotic accumulation by decreasing permeability and/or increasing active efflux of the antibiotic.

Bacteria can develop resistance to antibiotics by mutating existing genes or by acquiring new genes from other strains or species by gene transfer.

Detection of Antibiotic Resistance

Antibiotic resistance is a highly selectable phenotype and can be detected using growth inhibition assays performed in broth or by agar disc diffusion. In a dilution-based growth inhibition assay, the MIC of an antibiotic can be calculated for each bacterial isolate and the organism is typically interpreted as being susceptible or resistant to the antibiotic. Of course, there is a gradation of resistance and some classification schemes include one or more intermediate levels.

Antibiotic Resistance in Microbial Communities

Antibiotics are widely used in the clinical setting to treat a range of diseases, and recent studies are directed at understanding the impacts of those treatments on the human microbiota.

Antibiotic Resistance in Human-associated Microbes

It is estimated that there are ten-times as many microbes in and on any given human as there are human cells in that person's body and 100-times as many unique genes than in our own genome.The majority of these microbes reside in the gut, with an estimated 800–1000 different bacterial species in the gut community. Those microbes are crucial for human life. However, approximately 80% of the gut microbiota has not yet been cultured.

Humans have directly exposed their bodies to antibiotics in medicines and indirectly through agriculture and cleaning or beauty products. Antibiotics prescribed during clinical visits may have long-term consequences on the human microbiota; community level studies demonstrated that the gut microbiota recovery is incomplete after repeated antibiotic perturbation and that treatment might cause a shift to a different, but stable community.

Antibiotic-resistant strains persist in the human host environment in the absence of selective pressure.

Similar to the human gut microbiata, an important attribute of the oral microbiota is its ability to act as a reservoir of antibiotic resistant organisms. Oral bacteria can easily reach other body sites by swallowing or via the bloodstream and spread to other individuals by, for example, coughing and kissing. Therefore, resistant oral bacteria have the opportunity for rapid dissemination.

Our oral and fecal microbiota are distinctly different, both in the organisms present and the resistance mechanisms found in those organisms.

The fate of antibiotics used in human medicine is largely unknown. After secretion from the human, some antibiotics are broken down by resistance, some are light, or temperature labile, while others may exist for a long time in the environment. As we shall see later, antibiotics in the environment may promote the development of novel mechanisms of antibiotic resistance.

Protozoan diseases

Protozoa are one of the three main classes of parasites that cause diseases in humans. They are single-celled organism, and can only be seen under a microscope. When they invade a human they are able to multiply easily, which causes them to be at a great advantage and puts humans at a disadvantage. This helps them survive in the human body and causes a serious infection even with the arrival of a single protozoon.

1. Amoebiasis

This disease is caused by the sarcodina group of protozoa. They secrete enzymes that are then absorbed by the tissue of the host. Amoebiasis is transmitted through contact with infected feces. Food and water contaminated by feces is the most common route of transmission, however, oral contact with fecal matter can also cause infection. Sometimes there are no visible symptoms but some common ones include loose stools with varying amounts of blood and an inflamed colon.

2. Giardiasis

This disease is also transmitted through oral contact of feces as the parasite is found in fecal matter. If hands are not properly washed after using the bathroom or changing a diaper, it is easy to come into contact with this parasite. Drinking water which has been contaminated by this parasite or even ingesting contaminated swimming water can cause giardiasis. Symptoms include mucusy stools, diarrhea, nausea, abdominal pain and upset stomach.

3. African Sleeping Sickness

African sleeping sickness is a disease caused by the protozoa, which are carried by the tsetse fly and are transmitted to humans through tsetse fly bites. This disease is fairly damaging to the human body and can cause serious illness. Symptoms of this disease include confusion, seizures, insomnia, personality changes, weight loss, slurred speech and trouble talking or walking.

4. Leishmaniasis

This disease is caused by the Leishmania parasite. These parasites are found mainly in southern Europe, the tropics and subtropics. The most common form of this disease being spread is through the bite of a sand fly, which carries the parasite. External leishmaniasis will affect the skin and internal leshmaniasis affects the inner organs such as the spleen and liver. Those parasites that affect the skin cause sores, which will enlarge and become deeper as the disease progresses without treatment. Internal infection will cause weight loss, organ enlargement, fever and extremely high or low blood levels.

5. Toxoplasmosis

Toxoplasmosis is caused by one of the most common parasites in the world, according to the Mayo Clinic. Many of the people infected by this disease do not have any symptoms. However, for those who have weak immune systems such as infants and people suffering from chronic illnesses, this parasite can cause serious illness. Infants who are born to mothers who carry the infection can experience complications at birth. Other symptoms include body aches, fatigue, fever, sore throat and swollen lymph nodes. Symptoms are very similar to flu like symptoms and this disease can sometimes be mistaken for the flu.

6. Malaria

Malaria is a very common disease in some countries and is spread through mosquito bites of mosquitoes that have been infected by one of the many different malaria-causing parasites. In the United States, there are more than 1300 cases of malaria reported. This is mainly reported by individuals travelling to or coming from the South Asian subcontinent or the sub-Saharan Africa who may be carrying the parasite. Malaria symptoms include headache, chills, tremors, aches and shaking.

7. Babesiosis

This disease is caused by the Babesia parasite that is transmitted through ticks. It can also be transmitted through blood transfusions of donors who carry the Babesia parasite. This parasite is common throughout the United States, in cities such as New England, New Jersey, New York, Wisconsin and Minnesota. Those individuals infected with the Babesia parasite may not experience any symptoms. However, common signs and symptoms include nausea, body aches, fatigue, fever, chills, weight loss and a decreased appetite. For those who are already suffering from health problems and those who have a compromised immune system, this disease can be life threatening and cause serious health problems.

8. Trichomoniasis

This disease is caused by the protozoan parasite, Trichomonas vaginalis. This disease is most commonly transmitted sexually. It is a dangerous parasite as it can also help along HIV transmission. Symptoms of this disease differ per gender. In woman, vaginitis may occur which will cause white discharge. Men may experience a burning while urinating. This disease is treatable with an antibiotic such as metronidazole.

HELMINTH DISEASES

Helminths are parasitic worms that feed on a living host to gain nourishment and protection, while causing poor nutrient absorption, weakness and disease in the host. These worms and larvae live in the small bowel and are referred to as intestinal parasites.

The following groups of worms are classed as helminths:

- Nematodes or roundworms
- Trematodes, which includes flukes or flatworms
- Cestodes or tapeworms
- Monogenans, also members of the flatworm phylum

Characteristics of helminths

Helminths share a similar morphology and are multicellular organisms that are visible to the naked eye. The worms are usually caught through treading on contaminated soil in warm, humid countries that have poor sanitation and hygiene.

If an infected person or animal has defecated on soil, helminth eggs present in their feces contaminate the soil. These eggs mature and hatch to produce larvae that grow into adult worms of up to 13 mm in length. These adult worms can penetrate human skin, which can happen if a person walks on contaminated soil. The worms then enter the bloodstream and migrate towards the lungs and also the throat where they are swallowed and transported to the gut.

Some of the features of the different groups of the helminths include:

- The trematodes or flatworms are flat, leaf-shaped and unsegmented. They are hermaphroditic, meaning they have the reproductive organs associated with both males and females.
- Nematodes are cylindrical and have lips, teeth and dentary plates. The worms are either male or female.
- The cestodes or tapeworm is segmented and hermaphroditic. They have a sucker and a projecting, hooked rostellum.

Diseases

Some of the diseases caused by helminths are described below.

- Hookworm disease is a common worm infestation in the developing world caused by *Ancylostoma duodenale* or *Necator americanus*. The illness leads to anemia and malnutrition.
- Dracunculiasis is caused by the guinea worm or *Dracunculus medinensis, which is transmitted through contaminated water. It lies burrowed within the skin and causes severe inflammatory reactions.*
- Loiasis or African eye worm disease is caused by the filaria *Loa loa* worm, which is contracted through Deer fly or Mango fly bites. The adult worms move through subcutaneous tissue towards the subconjunctiva of the eye. The illness causes red, itchy swellings in the skin referred to as Calabar swellings.
- Cysticercosis is caused by the pork tapeworm or *Taenia solium*. Symptoms often do not present for years, but eventually painless bumps develop in the skin and muscles or cause neurological problems.
- Echinococcosis is caused by *Echinococcus tapeworms.*The liver is usually affected first, followed by the lungs and brain. Liver disease may cause abdominal pain and jaundice while lung disease leads to breathlessness and coughing.