***Bacterial Pathogenesis of Pseudomonas***

**CASE STUDY:**

**A 14-year old cystic fibrosis patient was admitted to** **the hospital with symptoms of extreme chest congestion and cough that produces a greenish phlegm. The examination of these symptoms mimicked rhinovirus infection (this infection mimics common respiratory illnesses and can sometimes turn serious if untreated) and phlegm cultures were performed. Within 24 hours, the laboratory reported isolation of the opportunistic bacteria, *Pseudomonas aeruginosa*. Pseudomonas bacteria and its pathogenicity are discussed in this chapter.**

**BACKGROUND:**

**Bacterial pathogenesis** refers to the origination and development of disease from a pathogenic bacteria. Bacteria fall into categories based on their species and characteristics, but also on their impact and role within our own biological ecosystem and ecological community. Bacteria have a place in all things on Earth and play vital roles in our own health and everyday lives.

**OVERVIEW:**

In this chapter, we will discuss the significance of the **Pseudomonas bacteria** as well as what a gram negative bacteria is, it’s biological and virulence characteristics, the **pathogenesis** and immunity specific to this bacteria, **epidemiology**, and a view into what it looks like in a clinical aspect. Over the next few chapters, you should be able to identify what bacteria Pseudomonas is and how important it is in the aspect of the pathogenicity, as well as being able to clinically identify this pathogenic bacteria within cases in the population. After talking about Pseudomonas, we will be getting an overview and insight into the pathogens that are similar to Pseudomonas by characteristics and insight on types of infections and diseases they produce.

***WHAT IS PSEUDOMONAS?***

Pseudomonas is a **gram negative**, **non-fermentative** rod shaped pathogenic bacteria. They are considered an **opportunistic pathogen** and are responsible for infections in hospital settings, open wounds, and patients with compromised immune systems. The main targets of its infections are on the **respiratory system**, and it has devastating consequences if left untreated with antibiotics. This bacteria belongs to the group of bacteria that are known as gram negative bacteria. Gram negative bacteria are classified as bacteria that are tinted red via the chemical process in its visual form. This process is known as Gram staining, which is a chemical process in which bacterial cultures are stained and their ending color determines the group it belongs to based on their membranes. This is because gram negative bacteria are enclosed with a protective layer over their outer membrane creating protection from treatments, such as antibiotics.

Found within the environment, it is known as a non-fermentative, rod shaped bacteria that are usually in pairs when viewed under the **microscope**. This bacteria is mostly found in moisture ridden areas, but can also be found in all areas of hospitals from the sinks to the food. Since this bacteria is considered a pathogen, it is not a bacteria that is commonly found in humans nor is it considered a part of our **natural flora**, which are the communities of good bacteria within our bodies that regulate and provide benefits in humans. The most common findings of it are within patients that are in or have been in the hospital which is the biggest harbored of this bacteria. The different characteristics of this bacteria enhance its **virulence** and thus making it a difficult pathogenic bacteria especially due to its resistance to **antibiotics**. Although this bacteria’s **ubiquitous** presence and strong virulence factors, it is not a common type of infection. This is because these infections are considered primarily opportunistic. **Primary opportunistic infections** are infections that most commonly occur in patients that have weakened immune systems, decrease amounts of the good bacteria within the **microbiome** due to the admission of antibiotics, which is resistant against.

**THE MORPHOLOGY AND CHARACTERISTICS**

Pseudomonas is a rod shaped gram negative bacteria that is motile and known for its pigments such as **pyocyanin** (blue-green), **pyoverdine** (yellow-green/fluorescent), and **pyorubin** (red-brown). This bacteria is known for its utilization of carbohydrates via **aerobic respiration**. Although they utilize aerobic respiration, they are able to grow in **anaerobic conditions** through the utilization **nitrate**. This bacteria is **oxidase** and **catalase** positive; this is what differentiates them from a different species of bacteria known as ***Enterobacteriaceae****,* which are closely related. They have a mucoid appearance due to their **polysaccharide capsule**; this capsule is one of their virulence factors as it is layered over their outer membrane and protects the bacteria from the environment and resistance to some antibiotics. Although there is not a specific name for the smell, there is a common distinct scent that when incubated is noticed from this bacteria. It has the ability to grow around 40-42 degrees Celsius when incubated for clinical laboratory use.

**Virulence factors** are very important when considering the seriousness and severity of infection. Some of these factors are enzymes, toxins, adhesions, and their **specific type III secretion system** used in order to invade and inject their other virulence factors creating a cooperating system that results in disease. Starting with their toxins, Pseudomonas is a possessor of **exotoxins** which are toxins that disrupt **protein synthesis** by blocking the **polypeptide chains** of the cells.

**EPIDEMIOLOGY**

As we know, Pseudomonas is an opportunistic pathogen. It is found mostly in nature and in moist areas within health care facilities. They are able to easily colonize within these conditions and spread via direct contact with **fomites** or ingestion. Due to the nature of this ubiquitous bacteria, it is considered a **nosocomial infection**, which are infections acquired at and associated with health care facilities. This type of infection develops within the admissions and can continue if not found within the time of stay.

**PATHOGENESIS OF PSEUDOMONAS AND TYPES OF INFECTIONS**

Pseudomonas species is a complex bacteria and pathogen. It is invasive and has a strong toxicity in infections. Although every pathway of infection is similar, it is still very relevant and can give insight on how they encounter the environment and with us in relation to infections. Firstly, since Pseudomonas is a primary opportunistic bacteria their main targets and accessible infections are with trauma and **immunocompromised patients** within a hospital due to the environment within and the easily infectable hosts. Once the pathogen comes into contact with a patient, the first step is for the bacteria to attach and begin releasing its virulence factors infecting cells and further colonizing the host. After a good amount of host cells are infected, next comes the formation and primary symptoms of a **localized infection**. These symptoms will begin as mild and not entirely concerning. After some time and more expanded infection, they will travel through the bloodstream and infect and colonize as it travels. This causes diseases, and inhabiting the area it will begin its extreme infection, thus the most serious and life threatening symptoms come into play. It will adhere to the place it is most resourceful in infecting, such as the lungs, and produce **extracellular proteins** and enzymes that aid the organism’s virulence, helping the bacteria invade and cause mass infection to the cells.

After proper infection is conducted by the pathogen, diseases settle in and are able to be identified. Some of the types of infections, clinical disease, are urinary tract, skin, respiratory system, wounds, eyes, **endocarditis**, **pneumonia**, nervous system, ears, and occasionally the musculoskeletal system. Because it primarily infects people who are wounded and immunocompromised, it has a large fatality rate among cases.

**CLINICAL MANIFESTATIONS AND INSIGHT OF CAUSATIONS IN INFECTIONS**

For this bacteria, there are a multitude of clinical infections it is associated with. Specifically, it is an issue for people within a clinical setting due to the nature of the bacteria. For instance, this bacteria has properties of **antimicrobial resistance**, or antibiotic resistance to some categories of antibiotics. Because of this characteristic, it is crucial for finding a treatment for specific infections. Some of the reasons for this resistance is their production of beta-lactamases which are commonly used in creating **beta-lactamase antibiotics**, interfering with effectiveness. Another would be their **efflux pumps**, these are pumps within a bacteria that are able to pump out the enzymes and proteins of the antibiotics, which is not a good thing because the bacteria are able to survive. Lastly, there are cases of mutations within their **porin proteins**. These proteins are within the outer membranes and with this mutation make it impossible for the antibiotics to get through the membranes.

Although infections with this pathogen are limited to their areas, some common causations of infections are due to immunocompromised individuals and contamination. These infections are able to take place within all types of areas within the body, from urinary infections to respiratory infections. Some common recipients of this pathogenic infection are patients with **cystic fibrosis**. Like the case study introduced at the start of this chapter, these patients are very susceptible to this pathogen’s infections. Unfortunately, a lot of patients are exposed to this pathogen and many of these patients with that infection die. There are two different types of infection routes, one is **bacteremia**, and the other is **antibodies**. Bacteremia is not as fatal as the antibodies circulating. This pathogen is able to infect any organ within the body and mortality with this type of infections prove to hold a fatality rate of 50% within the overall documented cases.

The types of clinical manifestations of this pathogen are many, but for this chapter we will look at these most common diagnosed infections. One of the most common and commonly fatal infections are **pulmonary infections**. It can range from any area within the pulmonary region, but is mostly accounted for in the lower respiratory tract. Although pulmonary infections are the most common, this pathogen can infect any area within the body. Some other infections commonly acquired are primary skin and soft tissue infections. These infections include infection of burn wounds in patients, leading to **necrosis**. Other infections include urinary, ear, and eye infections. Within these areas it can cause irreversible trauma to those areas, sometimes proving fatal.

**DIAGNOSIS**

There is an abundance of types of infections this bacteria causes. In this section, we will go over a few that are the most common diagnosis for this pathogen. To start off with, the most common area of infection is the pulmonary tract. These infections include inflammation within the bronchi or lungs. It can cause extreme growth of mucus and lead to a suffocation effect. It can ultimately lead to **necrotizing bronchopneumonia**, which is accompanied by **empyema**, which is fatal. The other infections are within the skin and soft tissue regions, they include **folliculitis** which is when the hair follicles become inflamed. There are also fingernail infections that commonly mimic **fungal infections**. Lastly for this region, there is **osteochondritis**, which is the inflammation of bone and cartilage in a specific area. Next region is the urinary system, specifically the urinary tract, and within this area a common infection is UTI infections. They are inflammation and colonization of bacteria within the urinary tract, causing extreme discomfort. Another is ear and eye infections; these are less common but still clinically important. For the ear, there is external **otitis** which is defined as swimmers’ ear, a common infection from swimming and results in pain, itchiness, and discharge. Another is malignant **external osteitis** which is the more virulent form that is commonly seen in elderly patients, especially those with pre diagnosed immune disease. Next are the eye infections, one specific is **corneal ulcers**, which are rapid in progression and can result in eyesight loss. Some symptoms would be pain and redness. While these infections take place in all areas, it is important to keep an eye out for symptoms in all regions as there is always a possibility of this pathogen infection.

**TREATMENTS AND CONTROL**

The best and primary option for treatment for this infection is antibiotics. Due to the aggressiveness of this pathogen’s infections, it requires direct effective approaches. Some specific antibiotics conjunctions used for treatment are **beta-lactams** and **aminoglycosides** antibiotics. The use of antibiotics is needed for minor and more severe infections to prevent further spread and progression. Another type of treatment would be **monotherapy**, which is a therapy that uses one type of treatment. This is not very effective for select strains of this pathogen and is not a preferred route of treatment.

 In order to control this pathogen’s route of infection, we have to first start at the colonization and common areas of its dwelling. There should be critical decontamination of all areas and medical devices used, sterilizing everything as well as limiting the amount of antibiotics used on all patients when not needed. This alone would provide significant declines of these nosocomial infections of Pseudomonas.

**RELATED PATHOGENIC SPECIES**

There are many gram negative bacteria that have common types of infections in relation to Pseudomonas infections. One bacteria that was once categorized as a Pseudomonas species is now the **Burkholderia species**. There are about 17 different kinds of this species and they contain similar characteristics as Pseudomonas; they live in moist environments and are opportunistic pathogens. This bacterium is considered a saprophyte, which are organisms that obtain their energy from decomposing organic matter. One type of infection common within this species is **melioidosis**, which is an infection that can infect both humans and animals. They can become **cutaneous** and pulmonary infections, similar to Pseudomonas and they commonly cause abscesses within infections. This **bacterium** was separated from Pseudomonas in 1992 and since has been researched.

**SUMMARY**

To conclude this chapter, we have learned about the pathogenic bacteria Pseudomonas. It is considered an opportunistic pathogen and is commonly known for its nosocomial infections. It is a gram negative bacteria that is able to provide antibiotic resistance. It is found naturally in the environment and within clinical settings, targeting patients with compromised immune systems, and it is a common source of death for patients with cystic fibrosis. This pathogen is able to occupy and infect any area in the body, but it commonly infects the pulmonary, cutaneous and soft tissue, and urinary tracts. These infections are serious and able to progress quickly, spreading within the body and easily within contact with other people. Treatments for these infections primarily include combinations of antibiotics and occasionally other types of mono treatments. In order to control the spread and likelihood of infection from this pathogen, it is important to ensure quality sterilization of medical facilities and their equipment. This alone will aid in the prevention of future infections. This pathogen has very similar characteristics of many other gram negative bacteria. One specifically that was considered a part of its species is the Burkholderia species, which was then found to be its own unique pathogen. With all the special characteristics and insights on the disease and specificity of this ubiquitous pathogen, it is special and has its place within the realm of gram negative bacterial pathogens.

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