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Pathogenic Bacteria Associated with Urinary Tract Infections

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ABSTRACT:

UTIs, which are also commonly referred to as urinary tract infections, are a common and sometimes reoccurring infection that can range from happening on their own to posing a severe risk to the health of the patient. This condition is characterized by the presence of pathogenic bacteria in the urinary canal or strictures. This is the defining characteristic of the disorder. Not only is this a widespread source of illness and death, but it is also a substantial contributor to the development of antibiotic resistance. It is estimated that Uropathogenic *Escherichia coli* (UPEC), *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Klebsiella pneumoniae* are the most common forms of pathogenic bacteria that are responsible for urinary tract infections. Urinary tract infections are a public health concern that can be caused by so many different types of bacteria that are considered to be harmful. Some individuals are of the opinion that the majority of the financial burden that these diseases generate can be attributed to the high incidence rates and novel drug resistance that have been created by uropathogenic bacteria. This is a hypothesis that has been proposed by someone.

1. INTRODUCTION

An infection of the urinary system, generally referred to as a urinary tract infection (UTI), is one of the most prevalent diseases caused by microorganisms around the world, impacting one hundred million patients on a yearly basis. (Foxman, 2014). At the present time, the public expenses that are linked with chronic disorders account for approximately $3.49 billion annually in the United States. chronic expenses include the costs of medical care as well as the time that is lost from work. In the time leading up to the outbreaks of COVID-19, there were 404.59 million people all over the world who were diagnosed with urinary tract infections (UTIs). As a consequence of this, there were over 201,000 deaths that were known to have taken place before the epidemics. (Codelia-Anjum et al., 2023).

Urinary tract infections provide a significant health risk for male infants, elderly guys, and females of all age groups. Possible consequences of these difficulties include recurring infections, pyelonephritis accompanied by sepsis, kidney impairment in young children, pre-term birth, and complications arising from frequent use of antimicrobial drugs. The risk of UTIs is higher in sexually active women, those with poor hygiene, or those who undergo instrumentation. Although the body's physical and immunological defenses typically eliminate pathogenic bacteria before an infection can take hold, any impairment in these defenses can increase susceptibility to UTIs (Flores-Mireles et al., 2015).

On an annual basis, medical experts in the United States diagnose urinary tract infections (UTIs) at a rate that is higher than ten percent for females and three percent for men. This is the case in the United States particularly. Furthermore, it is anticipated that more than sixty percent of females will, at some time in their lives, become aware that they have a urinary tract infection. This is a fact that is likely to occur at some point in their lives. An individual's susceptibility to infection can be affected by a number of factors, including but not limited to their age, sexual activity, family history, pre-existing medical conditions, and personal history of urinary tract infections (UTIs). Pre-existing medical issues are another aspect that may have an impact on the outcome(Epp et al., 2010). Over thirty percent of women will encounter another infection within a year after the initial symptom resolution, even if they receive proper antibiotic therapy. This is a substantial contributor to the overall incidence and morbidity rates, as recurrent urinary tract infections (UTIs) are a widespread problem. (Klein & Hultgren, 2020).

For example, infections in the urinary tract can be caused by a wide variety of bacterial pathogens, including Gram-positive and Gram-negative bacteria, as well as specific types of medicinal fungi. Any one of a vast variety of bacterial pathogens has the potential to deliver these diseases. Uropathogenic Escherichia coli, more commonly referred to as UPEC, is the urinary tract infection (UTI) causing bacterial pathogen that is the most prevalent. Since the infection is infectious, this holds true regardless of whether or not the urinary tract infections are complicated. Numerous bacterial species, such as *Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumoniae, Staphylococcus saprophyticus, Enterococcus faecalis, and Candida sp.*, are the agents that cause UPEC to varied degrees or to a greater or lesser extent are the agents that cause UPEC. When looking at Figure 1, it is evident that the presence of UPEC is the most common cause of urinary tract infections (UTIs) that are considered to be in the more serious category. Following this, people belonging to the genus Candida, species of Enterococcus, K. pneumoniae, S. aureus, P. mirabilis, and P. aeruginosa, and all of these bacteria are included.

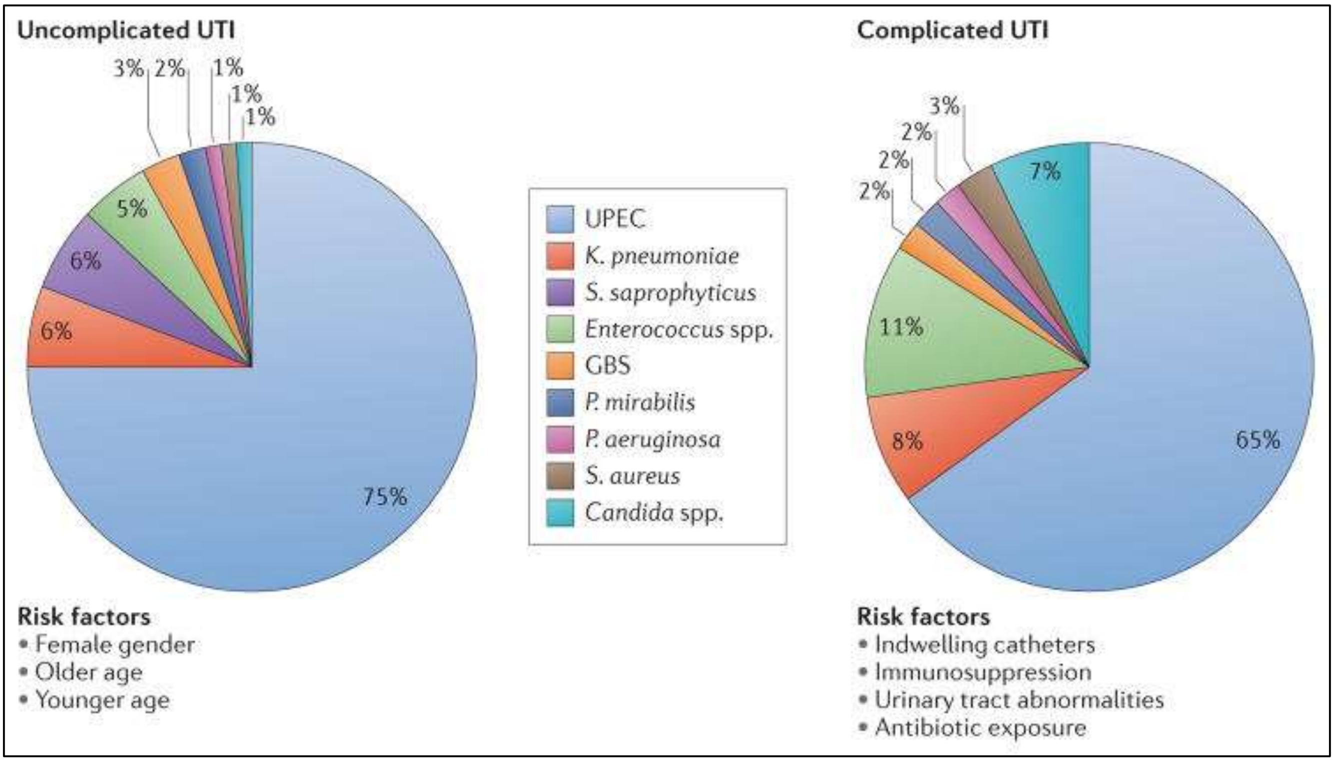

Figure (1): Urinary tract infections: population prevalence and distribution (Flores-Mireles et al., 2015)

UROPATHOGENIC *ESCHERICHIA COLI* (UPEC)

Escherichia coli (UPEC) account for three quarters of uncomplicated urinary tract infections (UTIs) and two thirds of severe UTIs. They are the most common causal agents of urinary tract infections (UTIs) and are responsible for the majority of community and hospital-acquired UTIs (Whelan et al., 2023). A, B1, B2, and D are the four primary genomic UPEC phylogroups that have been found by microbiologists. Each of these phylogroups expresses virulence components to varying degrees, including iron-acquisition systems, surface polysaccharides, poisons, adhesins, and flagella—all of which are examples of virulence factors. A number of these virulence factors are often required for UPEC to establish a urinary tract infection (UTI). (Hannan et al., 2012).

Contracting UPEC can result in discomfort, frequent urination, and elevated body temperature. More severe clinical consequences can include urosepsis, renal impairment, and death. UPEC, or uropathogenic Escherichia coli, is a pathogen that can easily adapt to different conditions. This poses a difficulty for treatment since it has many molecular components that allow it to avoid the body's defense mechanisms, survive in the urinary system, and resist antibiotics (Whelan et al., 2023).

Through the acquisition of a wide variety of virulence factors, UPEC has been able to circumvent the immunological defenses of the host, hence hastening the process of infection and the progression of illness. Proteins that are responsible for the motility of bacterial cells and their attachment to host receptors are included in these components. The probability of developing pyelonephritis is increased when certain sticky surface proteins have a propensity for adhering to kidney cells. Through the use of adhesives, bacteria are able to keep themselves from being expelled through the process of urine. Additionally, the creation of intracellular bacterial communities (IBCs) is triggered when bacteria attach themselves to the uroepithelium at the beginning of the process. Within these communities, bacterial cells have the ability to grow within the uroepithelium, infect cells that are next to them, and avoid being destroyed by TLR-4 antibodies. As a consequence of this, the urinary system will become colonized for an extended period of time. Strains of UPEC that are more persistent and difficult to treat are also more prone to the formation of biofilms. The reason for this is that the biofilm offers the cells a natural defense mechanism, which reduces their susceptibility to antibiotic therapy. (Behzadi et al., 2020)

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PROTEUS MIRABILIS

Proteus mirabilis, belonging to the Enterobacteriaceae family, is characterized by its high motility. P. mirabilis, in contrast to other members of its family, is not typically responsible for the development of urinary tract infections (UTIs) in individuals who are in good health. On the other hand, it is more frequently observed in cases of complicated urinary tract infections, particularly in those who have functional or anatomical abnormalities, such as kidney stones or urinary catheters that have been in place for an extended period of time. P. mirabilis is well-known for its ability to produce urease, an enzyme that causes the formation of ammonia, leading to an elevation in urine pH above 7.2. The formation of calcium and magnesium crystals in alkaline urine blocks the catheter tube, causing sudden inability to urinate and the development of bacterial infection and other illnesses that spread upwards. This sequence of events can advance to pyelonephritis, bacteremia, and shock. (Chen et al., 2012).

Proteus mirabilis is susceptible to nitrofurantoin and tetracycline, despite its susceptibility to β-lactams, aminoglycosides, fluoroquinolones, and trimethoprim/sulfamethoxazole. In recent years, there has been a discernible trend that suggests that Enterobacteriaceae species, such as P. mirabilis, are becoming increasingly resistant to a variety of antimicrobial agents. This surge in resistance has necessitated alterations in antimicrobial treatment strategies and has been associated with unfavorable outcomes and a rise in mortality rates among hospitalized patients. (Lockhart et al., 2007).

Proteus mirabilis is responsible for around 1.1-10.1% of urinary tract infections (UTIs), with the prevalence of this bacterium varies based on the geographic area of the study, the types of samples taken, and the characteristics of the patients. A recent comprehensive investigation that was carried out in North America found that this bacterium was responsible for 3.9% of almost 3,100 cases of urinary tract infections (UTIs). For the purpose of invading and colonizing the urinary system of the host, P. mirabilis makes use of a wide range of virulence factors. The production of stones through the action of urease, the formation of fimbriae and other adhesins, the processes for the acquisition of iron and zinc, the formation of biofilm, toxins, proteases, and the regulation of pathogenesis are some of the elements that contribute to this condition. Urease, which is produced by Proteus, is responsible for catalyzing the hydrolysis of urea into ammonia and carbon dioxide. The ammonia that is produced is a main source of nitrogen for a wide variety of bacterial species. (Karlowsky et al., 2011).

Similar to numerous bacteria, P. mirabilis utilizes flagella for locomotion in fluids and towards chemical cues. In liquid environments, P. mirabilis typically exhibits a short rod shape with a few peritrichous flagella. However, when grown on nutrient-rich solid surfaces, P. mirabilis undergoes differentiation into elongated non-septate polyploid cells, often ranging from 20-80 µm in length, though occasionally exceeding 100 µm, and bearing hundreds to thousands of flagella (Schaffer & Pearson, 2015).

PSEUDOMONAS AERUGINOSA

Pseudomonas aeruginosa is a Gram-negative bacterium that is frequently diagnosed as an opportunistic causative agent of urinary tract infectionsUTIs, which are infections of the urinary tract that are caused by P. aeruginosa, are often defined by higher rates of mortality and morbidity in adult patients. This pathogen has been identified as a pathogen of greatest concern by the World Health Organization (WHO) due to the fact that it is resistant to antibiotics. In many cases, the antibiotic resistance of these strains that have been identified from urinary tract infections (UTIs) is higher than that of Escherichia coli, which is the major agent that causes UTIs. (Newman et al., 2022).

Pseudomonas aeruginosa is the third most prevalent type of bacterium that has been connected with catheter-related urinary tract infections (UTIs) as a result of their acquisition in healthcare facilities. To put it another way, the virulence of P. aeruginosa is influenced by a variety of different properties, each of which makes a contribution to the overall picture in some way. Exotoxin A, phospholipase, elastase, protease, pyocyanin, exoenzyme S, hemolysins (rhamnolipids), and siderophores are all examples of exoenzymes or secretory virulence factors. Other examples include siderophores. Pyocyanin is also included in this category. The following adhesins are also included in this description: alginate, lipopolysaccharide (LPS), flagellum, pilus, and adhesins that are not pilus. Each of these substances contributes to the virulence of P. aeruginosa. Through the process of opportunistic entry, pathogens such as P. aeruginosa are able to enter the host, and their capability to cause infection is intimately associated with their ability to create biofilms. Because P. aeruginosa has a natural propensity for clinging to catheter surfaces and forming biofilms, it is able to increase the risk of urinary tract infections (UTIs), particularly in patients who have been catheterized for an extended period of time. (Mittal et al., 2009).

The emergence of antimicrobial resistance plays a crucial role in infections stemming from Pseudomonas aeruginosa biofilms, such as those affecting the urinary and pulmonary tracts. Resistance develops via intrinsic and extrinsic mechanisms. Resistance to specific antibiotics is on the rise in pseudomicrobial infections, and it may develop during treatment. In cases where there is a high likelihood of antibiotic resistance (e.g., severe sepsis, inpatient neutropenia, and septicemia), it is advisable to combine two agents from distinct classes. A combination of an aminoglycoside and an antipseudomonal beta-lactam (e.g., cephalosporin, penicillin) is frequently employed to treat Pseudomonas infection. Alongside antipseudomonal quinolones and an aminoglycoside, carbapenems (e.g., imipenem, meropenem) may also be implemented. (Narten et al., 2012)

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KLEBSIELLA PNEUMONIAE

K. pneumoniae is the major causative agent of hospital-acquired infections globally, resulting in septicemia, pneumonia, and urinary tract infections. *K. pneumoniae* is member of the bacterial causative agents for nosocomial UTIs. Most cases recorded for *K. pneumoniae* are hospital-acquired and cause high risky infections, that may lead to morbidity of 50% of the documented cases. New antimicrobial options for the management of UTIs caused by carbapenem-resistant *K. pneumoniae* have been identified, including : cefiderocol, ceftazidime, tazobactam, ceftolozane, avibactam, or meropenem-vaborbactam or (Chapelle et al., 2021).

With a range that goes from 5% to 53%, the likelihood of urinary tract infections (UTIs) being brought on by K. pneumoniae is quite fluid. In examinations carried out across Europe and Asia on individuals belonging to this demographic, K. pneumoniae was identified as the second most prevalent bacteria responsible for urinary tract infections (UTIs), trailing behind Escherichia coli. (Shimizu et al., 2021).

There are numerous factors that contribute to the virulence of K. pneumoniae bacteria, which allows it to circumvent the host's natural immune responses. Encapsulations, lipopolysaccharides (LPSs), adhesins, exopolysaccharides that contribute to mucoviscosity, and mechanisms for iron acquisition are among these. Factors exacerbating K. pneumoniae infections include its resistance to multiple antibiotics and its capability to induce nosocomial infections in humans (Riwu et al., 2022).

Klebsiella pneumoniae is capable of producing a wide range of virulence factors, including as capsules, endotoxin, siderophores, iron acquisition systems, and adhesins. The progression of the disease is dependent on them, in addition to other virulence factors, which are crucial for the progression of the disease. For the purpose of providing more clarification, the capsule is a crucial component of the virulence of the organism, and it is involved in at least two distinct biological pathways. There are a few of these methods, some of which include keeping the bacteria from being phagocytosed and directly blocking the immunological response of the host by the bacterium. (Wei` et al., 2016).

ENTEROCOCCUS FAECALIS

Enterococcus faecalis, also known as *E. faecalis*, is a Gram-positive, facultative anaerobic commensal organism that is a member of the enterococci bacterial group. In most cases, they are found in the gastrointestinal (GI) tract; however, they may also occasionally be found in the oral cavity and the vaginal tract. Even while E. faecalis is normally harmless within the human body, it has the potential to transform into an opportunistic pathogen, which means that it can cause illness when the immune system is compromised. Furthermore, E. faecalis is classified as an opportunistic pathogen because of this. It is the most common cause of urinary tract infections among all of the different types of enterococci known to exist. (Hashem et al., 2021).

Urinary tract infections resulted from Enterococcal species are responsible for more than 30.0% of all infections in patients attending hospitals (Lin et al., 2012). Anyhow, many researchers observed that Enterococcal species are account for a tiny ratio of public infections. In a previous study by Malmartel & Ghasarossian (2016), about 1120 patients have been investigated for urine samples, the results indicate dthat 7% diagnosed with *Enterococcus* spp. Another study by Laupland et al. (2007) reported that 5.29% of the patients diagnosed with UTIs had *Enterococcus* spp.

Enterococcus faecium is equipped with a number of methods that boost its capacity to cause disease. These techniques include the production of biofilms as well as components of pathogenicity. For close to forty years, researchers have been looking at the process by which enterococci produce biofilm. There are four stages involved in the process: attachment, which is the act of sticking to a surface; microcolony formation, which is the formation of small clusters of cells; biofilm maturation, which is the development and growth of a biofilm community; and dispersal, which is the spreading or release of cells from a biofilm. There is a wide variety of virulence factors that are present in the urine isolates of Enterococcus species. These factors include gelatinase, collagen-binding protein, TcpF, pilin gene clusters (PGCs), enterococcal surface proteins, and aggregation chemicals. (Codelia-Anjum et al., 2023).

CONCLUSIONS

There are a variety of bacteria that are thought to be hazardous, and they are the ones that are responsible for these infections of the urinary system. These habitats are home to a wide variety of bacteria, the most prevalent of which are Uropathogenic Escherichia coli (UPEC), Proteus mirabilis, Pseudomonas aeruginosa, Enterococcus faecalis, and Klebsiella pneumoniae. As a consequence of the high incidence rates and the new antibiotic resistance that uropathogenic bacteria have evolved, it is anticipated that the financial strain that is caused by these diseases has greatly increased. This is due to the fact that the occurrence rates have increased. This is due to the fact that these bacteria have developed such resistance to that particular substance. The urinary system is susceptible to infections caused by a wide variety of bacteria, the most common of which are pathogenic bacteria. Urinary tract infections can be caused by a number of different types of bacteria. Urinary tract infections are caused by groups of bacteria that are among the most common. These bacteria are responsible for the infection.

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