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Pathogenic Species of Staphylococcus: A Review Article

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ABSTRACT: The genus Staphylococcus includes a wide range of species that are well-known for their saprophytic habit making them very important in clinical practice. The most common species of Staphylococcus are : S. aureus and S. epidermidis, which are well studied for their large contribution in health-cate associated infections. Many staphylococcal species have been commonly identified for their pathogenic action. The high attention that has been paid on these pathogenic bacteria is because of the increasing number of clinical studies that focused on their roles in different types of series infections, which have progressively increased human and financial cost to countries and societies.

1. INTRODUCTION

Bacterial species in the genus Staphylococcus are pathogenic opportunistic bacteria that infect of man as well as other mammals. Staphylococcal bacteria are Gram-positive spherical cells with a diameter of approximately 0.5 to 1.0 µm. They typically arrange in clusters, double-cells, and sometimes in few-cells chains. The clustering occurs due to that Staphylococcus divide along two planes. This arrangement distinguishes micrococci and Staphylococcus from streptococci, which generally form chains. Streptococci that are grown on solid media may exhibit clusters, which is why it is crucial to observe these characteristics in cultures that are grown in broth. A comprehensive examination of numerous fields is necessary to accurately identify the presence of clusters or chains (Götz et ak., 2006).

Staphylococcus has generally been divided into two categories according to their coagulase activity: coagulase-positive and coagulase-negative. S. aureus is a highly pathogenic species that lies within the coagulase-positive group. Moreover, Staphylococcus epidermidis has emerged as a significant pathogen in both humans and animals in recent years. This species is the most substantial coagulase-negative staphylococcus (CNS) and is the primary cause of infections associated with catheters and prosthetic devices. 2012 (Rahman et al.). In contrast, it has been reported that approximately 89 species and subspecies of Staphylococcus have been identified (Cho et al., 2022).

Staphylococcal species other than S aureus can lead to infections in human. These bacteria might cause many types of infections, including: endocarditis, pneumonia, food poisoning, skin infections, bacteremia, infections of bones, toxic shock syndrome (TSS). These species do not commonly cause nosocomial infections. Other species that are coagulase-negative include: S haemolyticus, S warneri, S hominis, S capitis, S intermedius, S schleiferi and S simulans are infrequent pathogenic bacteria (Becker et al., 2014). This review article cast a bit light on the most important pathogenic species of the genus Staphylococcus.

STAPHYLOCOCCUS AUREUS

Spherical in shape, Staphylococcus aureus are Gram-positive bacteria that are positive for catalase reactions. They are facultative anaerobic, typically cluster together, and lack flagella, which prevents them from forming spores. Their diameter ranges from 0.5 to 1.5 µm. Uniquely, these bacteria are capable of withstanding osmotic stress and elevated salt concentrations. In both humans and animals, this species is frequently encountered as a component of the natural flora of the epidermis. It is widespread (Ahmad-Mansour et al., 2021).

In humans, strains of S. aureus are significant contributors to wound infections, burns, and other skin conditions. Additionally, they are among the most prevalent sources of food poisoning. Urinary tract infections, pneumonia, meningitis, and mastitis, which affect the breast in women or the mammary in domestic animals, are also caused by S. aureus. In addition, toxic shock syndrome, a severe condition that is linked to the release of a toxin into the circulation from the infection site, can result from localized staphylococcal infections (Britannica et al., 2014).

Potential virulence factors are produced by Staphylococcus aureus in the form of a diverse array of extracellular and cell surface-associated proteins. Identifying the precise function of any individual factor is challenging due to the multifactorial nature of the development of the majority of diseases induced by this bacterium. The deficiencies of numerous animal models employed to investigate infections caused by staphylococci are also emphasized by this complexity (Zhu et al. 2023).

The surfaces of Staphylococcus aureus cells include proteins that make it easier for the bacteria to attach themselves to the proteins of the host. These proteins include laminin and fibronectin, both of which are components of the extracellular matrix. Not only is fibronectin a component of blood thrombus, but it can also be found on the surface of epithelial and endothelial cells simultaneously. In addition, the majority of strains are capable of producing the clumping factor, which is a fibrinogen/fibrin-binding protein. The ability of the organism to cling to blood clots and injured tissues is due to the presence of this protein. The vast majority of S. aureus strains are capable of expressing both fibronectin and fibrinogen-binding proteins during their growth (Liang et al., 1993).

The surface polysaccharide of the majority of clinical isolates of S. aureus is typically classified as either serotype 5 or 8. A microcapsule is the term used to describe this polysaccharide, as it is only visible under electron microscopy after antibody labeling, in contrast to the numerous capsules of other bacteria that are visible under light microscopy. The polysaccharide is typically present in elevated levels in S. aureus obtained from infections; however, it rapidly diminishes upon laboratory subculture. Although it may impede phagocytosis, the precise function of the capsule is still uncertain. (Visansirikul et al., 2020).

Protein toxins are most likely the cause of symptoms during infections, as Staphylococcus aureus has the capacity to generate a variety of them. Although its relevance in vivo is uncertain, certain toxins cause injury to erythrocyte membranes, which is the cause of hemolysis. Hemolysis is not induced by leukocidin, which damages leukocyte membranes. Enterotoxins and TSST-1 induce toxic shock, while the systemic release of α-toxin results in septic shocks (Zhu et al. 2023).

Staphylothrombin is a complex that is formed by the interaction of an extracellular protein (coagulase) with prothrombin in the host's plasma. The protease activity, which is analogous to thrombin, becomes active in this complex, resulting in the conversion of fibrinogen to fibrin. The tube coagulase test is based on this mechanism, in which plasma solidifies after incubation with the supernatant from S. aureus broth cultures. Coagulase is a standardized indicator that is employed to identify S. aureus in clinical microbiology laboratories (Pickering et al., 2021).

Staphylococcus aureus can produce proteolytic enzymes, a lipolytic enzymes, a fatty acid modifying enzyme (FAME) and a deoxyribonuclease (DNase). The lipase, protease and DNase may supply nutritional materials for the bacterium, and it just has a secondary role in pathogenic activity. Nevertheless, the FAME enzyme might play a significant role in abscesses by altering anti-bacterial lipids, thereby extending bacterial survival. The thermostable DNase is a crucial diagnostic test for identifying S. aureus (Ahmad-Mansour et al., 2021).

STAPHYLOCOCCUS EPIDERMIDIS

A persistent component of the typical human microbiota, Staphylococcus epidermidis is typically found on the mucous membranes and the integument. It is also often found on the skin. By sticking to the tissue surfaces of the male by adhesins that are particular to him, S. epidermidis forms a lifetime commensal relationship with the host during his entire life. This association begins at an early age. One theory proposes that S. epidermidis, which is a commensal microbe, confers benefits upon the human host by engaging in competition with more powerful pathogens. Since S. epidermidis is able to form biofilms on implanted foreign bodies, it has become a significant opportunistic infection in people who use medical devices. This is due to the fact that it is able to establish itself on these foreign bodies. Around twenty percent of all orthopedic device-related infections (ODRIs) are caused by it, and the rate increases to fifty percent in infections that arise later in the process (Sabaté Brescó et al., 2017).

STAPHYLOCOCCUS HAEMOLYTICUS

Staphylococcus haemolyticus (S. haemolyticus) is a significant component of the human cutaneous microbiota. It has become a significant cause of nosocomial infections, and it is prevalent in hospitals and among medical personnel. In comparison to other coagulase-negative Staphylococcus species, S. haemolyticus isolates, particularly those responsible for hospital-acquired infections, exhibit a higher level of antibiotic resistance. Substantial evidence suggests that S. haemolyticus has the capacity to transmit resistance genes to other Staphylococcus species. It is particularly prevalent in immunocompromised individuals and is linked to severe infections,

including meningitis, endocarditis, prosthetic joint infections, bacteremia, septicemia, peritonitis, and otitis. Additionally, S. haemolyticus has been detected in livestock, breeding kennels, and canines. The capacity to establish biofilms is a distinguishing characteristic of pathogenic S. haemolyticus isolates, which are responsible for catheter-associated and other hospital-acquired infections. S. haemolyticus secretes a variety of factors that facilitate bacterial adherence and invasion, in addition to biofilm formation, such as enterotoxins, hemolysins, and fibronectin-binding proteins (Eltwisy et al., 2022).

STAPHYLOCOCCUS WARNERI

Staphylococcus warneri is an opportunistic pathogenic bacteria that is coagulase-negative and is known to cause a variety of infections, particularly in patients with indwelling medical devices.. The global challenge of treating infections caused by Staphylococcus is one of antimicrobial resistance. The capacity to generate biofilms is the most significant virulence factor of CoNS. S. warneri is a natural component of the skin flora, with a particular concentration in the head, nares, arms, and thighs. The importance of S. warneri as a contemporary pathogen is on the rise, as it has evolved into a flourishing nosocomial pathogen. The majority of S. warneri isolates from these infections exhibit resistance to beta-lactam antimicrobial agents. Adhesins, enzymes, extracellular toxins, a capsule, iron uptake systems, virulence regulators, and the capacity to form biofilms, invade, and damage epithelial cells are all believed to contribute to the virulence of S. warneri which is multifactorial. It has not yet been possible to completely eradicate the pathogenetic mechanisms, which include the methods by which these bacteria elude the host's immune system and persist (Karam et al., 2022).

STAPHYLOCOCCUS CAPITIS

Staphylococcus capitis was first isolated from human skin in 1975 (Heath et al., 2023). By incubating S. capitis isolates on MRSA Brilliance 2 agar (Oxoid®, Basingstoke, UK) in moist conditions for 5 days at 37°C, they can be distinguished from other coagulase-negative Staphylococcus (CoNS) due to their large colony size and distinctive appearance. The mauve colonies of S. capitis NRCS-A isolates are surrounded by a cream-colored halo, whereas blue colonies are formed by MRSA isolates and tiny white colonies are developed by other CoNS (Butin et al., 2018).

It is believed that proteins found in specific strains of S. capitis are crucial for the formation of biofilms, adherence, and virulence. A study observed that the S. capitis TE8 strain contains 14 adhesins that facilitate adherence, thereby facilitating its colonization of human skin. S. capitis isolates exhibited the most potent urease activity among all non-H. pylori bacteria isolated from patients' stomachs, according to an additional study. Their capacity to establish biofilms is the primary pathogenicity factor for S. capitis species. Variations in the proportion of S. capitis strains capable of biofilm production were observed in various investigations. According to reports, biofilm-forming capabilities were exhibited by 87.49% of S. capitis strains. Specific environmental stimuli and experimental conditions, such as growth in high-osmolarity media, have been associated with the ability of S. capitis to form biofilms (Heath et al., 2023).

STAPHYLOCOCCUS HOMINIS

Neonatal and immunosuppressed patients are susceptible to infections such as bacteremia, septicemia, endophthalmitis, and endocarditis caused by Staphylococcus hominis, the third most prevalent opportunistic pathogen. Documentation has been made of the emergence of methicillin-resistant Staphylococcus hominis (MRSHo), which is becoming more alarming. (Meriyani et al., 2023).

S. hominis is the third most common pathogen among coagulase-negative Staphylococcus species, and it causes opportunistic infections in the blood of neonates and immunosuppressed adults. In recent years, there has been a significant increase in the number of reported cases of bacteremia, septicemia, endophthalmitis, and endocarditis caused by S. hominis (Pereira et al., 2018).

taphylococcus hominis has shown resistance to various antibacterial agents, posing challenges in treatment strategies. The emergence of MRSHo, attributed to the acquisition of the mecA gene, which alters penicillin-binding proteins with reduced affinity for beta-lactam antibiotics like penicillin, is of particular concern (Oliveira et al., 2016).

Despite its resistance to several antibiotics, Staphylococcus hominis remains susceptible to certain treatments, including ceftaroline, tetracycline, , aminoglycosides, cephalosporins, glycopeptides, and lipoglycopeptides (like vancomycin), as well as other antibacterial agents like daptomycin (Alter et al., 2019)

CONCLUSIONS

The Staphylococcus genus holds significance due to its direct and harmful effects on other organisms. While many Staphylococcus species do not possess the virulence factors found in S. aureus and are less commonly isolated from infectious cases, their role in pathogenesis is often underestimated.

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