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Review article

The relationship between Staphylococcus and wound infection

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Abstract

Gram-positive, catalase-positive cocci from the genus Staphylococcus in the family Staphylococcaceae are known as *Staphylococcus aureus*. Regardless of the patient's age, location, or environment, *Staphylococcus aureus* is the most prevalent bacterium causing skin infections globally. A few toxins generated by the bacteria are responsible for the majority of skin clinical manifestations, which result in a wide range of clinical symptoms. The primary toxins responsible for the majority of S. aureus-related dermatological symptoms include Panton Valentine leucocidin, exfoliatins, enterotoxins, and toxin shock syndrome toxin. Endocarditis and bacteremia might cause other, less common cutaneous symptoms. The most significant development at the moment is the global spread of community-acquired S. aureus resistant to methicillin (CAMRSA), which mostly causes skin infections.

Keyword: Staphylococcus Aureus, MRSA, skin infections, Pathogenesis, and Virulence Factors

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1. Introduction

One prevalent issue is wound infection [1]. The germs entered the incision through a skin break, causing infection. These bacteria cause symptoms and hinder recovery. Scientists have been battling illness since the dawn of civilization. It is clear that doctors have difficulties when dealing with wound infections [2].

One to two percent of individuals worldwide suffer from chronic leg ulcers, or CLUs. With a high recurrence rate and frequent healing delays, they are a significant contributor to protracted morbidity [3]. CLUs are common, particularly in older people (over 65), and they raise the expense. The most prevalent kind of CLUs (70% of cases) is chronic venous ulcers (CVUs). An further 5–10% are arterial ulcers. About 60% of diabetic ulcers contain an ischemic component, whereas the remainder have a neuropathic base. Fifteen to thirty percent of CVUs have mixed venous and arterial ulcers [4].

The most frequently identified agents from CLUs are S. aureus and P. aeruginosa, which frequently form biofilms that are resistant to antimicrobial treatment. S. aureus is often found in the top layer of wounds [5]. S. aureus and P. aeruginosa, which colonize around 93 and 52.5% of patients with CLUs, respectively, are important players in chronic wounds. Expression of virulence factors causes serious infections and antibiotic resistance in this situation. The capacity of these organisms to

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generate the Panton–Valentine leukocidin (PVL) toxin, which induces leukocyte lysis or death, has been specifically linked to the pathogenesis of community-acquired MRSA [6].

Recently hampered pharmacological therapy, S. aureus is a frequent opportunistic bacterium that is extremely responsive to various medicines (methicillin sensitive). Treatment of P. aeruginosa is difficult due to its high intrinsic and acquired antibiotic resistance [7].

Bacterial cells' ability to adapt to changes in their environment is crucial to their growth and survival. S. aureus has evolved a variety of defenses against these changes, particularly in the presence [8].

2. Review Literatures

2.1. Description: *Staphylococcus aureus*, sometimes referred to as "golden staph," is a gram-positive coccus that is a member of the genus Staphylococcus, family Staphylococcaceae, order Bacillales, and class Bacilli. It is a facultative anaerobe that is frequently positive for nitrate reduction and catalase. It is also coagulase variable, meaning that it may be positive or negative for coagulase. Under a microscope, the bacteria look like a bunch of grapes and are not motile or spore-forming. Large, spherical [9].

2.2. Nomenclature and Classification

In 1925, the genus Staphylococcus underwent its first differentiation when two distinct groups were introduced: CoPS (formerly known as the "S. aureus group") and CoNS. A different categorization of CoNS was later developed, based on whether they were susceptible or resistant to novobiocin. CoNS species that were susceptible to novobiocin were placed in the "S. epidermidis group," while those that were resistant to it were placed in the "S. saprophyticus group" [10].

2.3. Epidemiology

MRSA is a major infectious disease burden in Asia and is found in almost all healthcare settings. The incidence has fluctuated over time and differs greatly between nations [11]. The majority of HA-MRSA strains from many nations share the same genotype, according to molecular epidemiology research, which suggests that a small number of clones linked to healthcare have spread internationally in this area. Nonetheless, the majority of reports have come from a few relatively wealthy nations, such as Taiwan, Japan, Korea, the Hong Kong Special Administrative Region, and Singapore.

Four distinct kinds of microbes were found in a research on wound infection conducted in Dhaka, Bangladesh. Escherichia coli had the highest proportion (54.9%), followed by Pseudomonas species (51.9%), Proteus species (38.4%), and S. aureus (17.6%). MRSA13 accounted for 83.3% of the six S. aureus isolates. Research conducted in Mymensingh on the [12].

2.4. Skin & infected ulcers

With a surface area of about 1.75m and a weight of 5kg, the skin may be the largest organ. It is colonized by a number of microorganisms, including infection, and is an essential part of innate immunity [13].

Despite these many defense mechanisms, skin is extremely vulnerable to numerous diseases brought on by a few persistent or transitory germs, particularly when there are lesions that reveal underlying tissue. Similar to how P. aeruginosa expresses virulence factors like rhamnolipid that are removed by leukocytes, S. aureus produces a number of virulence factors in acute ulcers, such as enterotoxins, toxins, and hemolysins, which are quickly destroyed by neutrophils and inactivated by the immune system [14].

2.5. Morphology and Growth Characteristics

Occurred nearly simultaneously with the commercialization of methicillin for clinical use in 1960. Across the 1960s, there was a significant MRSA outbreak across Europe and Britain. Jevons found one resistant strain out of 5000 isolates in London in 1961. Isolates sent to the Central Public

Health Laboratory in the United Kingdom rose from 3/5440 (0.06%) in 1960 to 293/7153 (4.1%) in 1969. 8.0% of isolates were methicillin-resistant, according to screening conducted at eight teaching hospitals in London [15].

Many more commercially accessible methods are available for biochemical characterization of strains. *Staphylococcus aureus* is unique due to its ability to coagulate plasma (coagulase). A wound infection can be identified by a number of signs. In order to restore tissue homeostasis and neutralize and eliminate any harmful substances at the site of an injury [16].

2.6. Culture and Isolation

2.6.1. Staphylococci are also non-motile, non-photosynthetic, highly catalase-positive, and do not produce spores. The diameter of the cocci is typically between 0.8 and 1.0 f.L, while it can infrequently reach 2 f.L. Many strains create a yellow or orange · color, especially when exposed to high salt chloride medium. The majority of strains ferment a range of carbohydrates (generating acid but no gas), convert nitrates (to nitrite), and produce acetoin from glucose and ammonia from arginine. No indole is produced. Litmus milk may coagulate due to the organism's ability to acidify it [17]. 37 C is the ideal temperature for S. aureus growth.

2.6.2 Catalase Test:

Microorganisms with catalase enzymes can be identified using the catalase test. The catalase enzymes produced by these bacteria will neutralize the hydrogen peroxide [$\underline{H_2O_2}$] and produce nascent oxygen, which will result in bubbles and a positive test result. The catalase enzyme is mostly produced by obligatory aerobes and facultative anaerobic bacteria. A few drops of 3% H2 O2 are added to a bacterial colony on a slide or in a test tube, and the colony is watched for the development of bubbles within 10 seconds [18]. Because catalase aids in the neutralization of oxidizing free radicals, the majority of bacteria are catalase-positive.

2.6.3. Coagulase Test

One or two forms of coagulase—free and bound coagulase—are produced by the majority of *Staphylococcus aureus* strains. An extracellular enzyme called free coagulase interacts with prothrombin and its byproducts. Located on the cell wall's surface, bound coagulase combines with the α and β chains of plasma fibrinogens to create coagulate. Free coagulase is an extracellularly released enzyme, while bound coagulase is a protein associated with the cell wall. The tube coagulase test can identify free coagulase, while the slide coagulase test may identify bound coagulase [19].

2.6.4. Antimicrobial Susceptibility Test

After being suspended, the bacterial isolates were adjusted to the 0.5 McFarland standard, or 1.5 × 108 CFU/mL. After a 24-hour incubation period at 37°C, the inhibitory zone was measured using a caliper and evaluated in accordance with CLSI (2017) criteria [20].

2.7. Virulence factors

2.7.1. Toxins: STRUCTURE AND PROPERTIES OF ALPHA-TOXIN

Kehoe and associates cloned and sequenced the alpha-toxin gene. The toxin monomer's molecular weight, as determined by the amino acid sequence, was 33,400, which is in perfect agreement with the physicochemical data. Tweten et al. [14] found a precursor that can be explained by a signal sequence. A cell-bound, presumed precursor molecule was also found by Lee and Birbeck [21] following phenethyl alcohol's suppression of toxin release. There is no cysteine in the protein. At pH 8.5 to 8.6, it is isoelectric.

Alpha-toxin generated by various bacterial strains may show notable molecular variability, according to a number of previous publications. Southern studies of DNA from 20 S, however, have not supported this claim in the more recent literature. Restriction segments from aureus isolates showed no heterogeneity [22]. Additionally, no structurally or genetically similar microbial products have been found by DNA hybridization or immunological testing. Alpha-toxin and other pore formers, such as complement and lymphocytolysins, are not similar.

2.7.2. Enzymes

Numerous S. aureus secreted enzymes break down host molecules or disrupt host signaling or metabolic processes. A number of those are proteases. Although they may also have a more targeted effect, relatively non-specific proteases break down host proteins in a broad way, causing tissue death. Many proteins, including insulin B, are cleaved by the protease aureolysin (S. aureus neutral proteinase), which prefers to cleave after hydrophobic residues [23].

2.7.3. Surface Protein A

A sorting signal at the C-terminus of cell wall-anchored (CWA) proteins is what allows the protein to be covalently coupled to peptidoglycan. Up to 24 CWA proteins adorn the surface of Staphylococcus aureus. The strain and growing circumstances determine the exact quantity. S. aureus expresses a small repertoire of CWA proteins, several of which have evolved to carry out crucial host interactions [24]. They fall into several functional and structural groups. Some proteins are multifunctional because they have separate domains that recognize different ligands, whereas others have a single domain that can bind different ligands using different methods [25].

2.7.4. Wound pathogens and their mechanisms of infection

Pathogens are found even in wounds that are not infectious, according to the description of acute and chronic wound microbiota. Resistance to antibiotics, the capacity to create protective biofilms, immune evasion tactics, and the generation of virulence factors are all common characteristics of successful wound infections that allow them to endure and proliferate in wound tissue. In this part, we go over how some of these behaviors relate to diseases that have been researched traditionally, including Pseudomonas aeruginosa and S. aureus. In the context of wound infections, we will provide an overview of the most recent findings from mechanistic research on these species.

S. aureus may live in the nares and on healthy, undamaged skin in an apparently harmless way, but when given the chance, particularly when the skin barrier is compromised, it becomes a serious skin and soft tissue pathogen45. S. aureus correlates with extended healing durations and worse patient outcomes in a variety of wound types. Additionally, S. aureus can influence pathology and patient outcomes in diabetic wounds and other skin diseases in a strain-specific way [26].

2.7.5. Biofilm

Particularly when linked to indwelling medical devices, chronic biofilm-associated infections caused by Staphylococcus aureus can result in considerable increases in morbidity and mortality. Much study has been conducted in an effort to determine the molecular mechanisms governing the production of S. aureus biofilms and the reasons behind these multicellular structures' resistance to antibiotic treatment. This article aims to provide an overview of what we now know about the formation of S. aureus biofilms. It does this by describing a recently developed five-step model of biofilm development and the mechanisms necessary for each stage.

One crucial tactic used by bacteria to colonize and infect skin tissues is the development of biofilms. Bacteria are more frequently seen to form polymicrobial communities in the biofilm matrix, even if they can be seen in planktonic form in chronic wounds. Biofilms have a major role in both overcoming host immunity and impeding the efficacy of antimicrobial medicines in non-healing wounds. It has been demonstrated that bioactive substances from Pseudomonas aeruginosa and S. aureus biofilm communities hinder keratinocyte migration and proliferation in persistent tympanic membrane perforations and skin wounds [27].

2.8. Infections

Life-threatening staphylococcal infections are the only topic covered in the discussion that follows. Most of these illnesses happen to people who have several infection risk factors. A number of recent papers provide more thorough explanations of the clinical signs and symptoms of staphylococcal infections [28]

2.9. Pathogenesis

A wide range of substances and products produced by S. aureus aid in the pathophysiology of infection. These products and components can act alone or in concert, and their duties overlap. The role that these bacterial components play in the development of infection is well understood [29]. Much less is known about their relative relevance in infection and how they interact with host variables and one another.

Given that S. aureus is a commensal that colonizes the nares, axillae, vagina, throat, or injured skin surfaces, its pathogenicity is astounding. When the skin or mucosal barrier is compromised, staphylococci can enter the bloodstream or adjacent tissues, starting an infection. The intricate interaction between host defense mechanisms and S. aureus virulence factors determines whether an infection is controlled or spreads. There is still much to learn about the biology of staphylococci colonization in the nares, which is their main reservoir. In a mechanism involving interactions between staphylococcal protein and mucin carbohydrate, mucin seems to be the crucial host surface that is colonized [30]. It is unknown what part secretory IgA, other commensals, or particular staphylococcal adhesins play.

The presence of foreign material increases the chance of infection. The heightened vulnerability to infection is caused by a number of factors. When foreign material is present, phagocytic function is severely compromised. Serum components like fibrinogen or fibronectin quickly coat devices like intravenous catheters, allowing staphylococci to adhere via MSCRAMM-mediated processes and form glycocalices that aid in colonization. Nosocomial endocarditis is often linked to intravenous catheters. Cases of nosocomial endocarditis that mimic the animal form of endocarditis have been reported since the introduction of long-term indwelling catheters. By injuring the valvular surface, the catheter forms a nonbacterial thrombus on the heart valve, which makes it easier for bacteria to adhere later [31].

2.10. Treatment

The quick emergence of antibiotic resistance is a major issue with S. aureus infections in general. An rise in antibiotic minimum inhibitory concentrations (MIC) relative to planktonic isogenic bacteria, which shows antibiotic tolerance, may exacerbate S. aureus biofilm infections. Furthermore, the possible emergence of antibiotic resistance is linked to the exposure of a biofilm's elevated S. aureus population to antibiotic selection pressure. The most often used medication for infections linked to S. aureus biofilms is vancomycin. However, because S. aureus is prone to developing resistance, physicians are wary of administering this medication.

Acute wound infection: When pathogens infiltrate viable host tissue, the host's inflammatory response is triggered, making it impossible for the host to fend off an attack under pre-existing clinical conditions. The human immune system will be able to restore control over microbial invasion with the use of guided systemic antibiotics. To maximize the healing potential, all possible risk factors must be taken into account when diagnosing acute wound infection. Since the risk of infection is directly correlated with microbial load, a combination strategy involving systemic antibiotics and proper local wound bed preparation—which includes removing any undesirable materials (such as devitalized host tissue) and maintaining an ideal moist environment for wound healing—will probably result in the most effective control [32].

Treatment recommendations usually rely on the kind of infection and, in the case of S. aureus, antibiotic susceptibility [33]. These are clinical practice guidelines that are frequently discussed in the clinical community and are based on randomized controlled clinical trials comparing new and existing treatments to establish the best antibiotic regimens.

2.11. Antimicrobial Resistance

Before antibiotics were used in clinical practice, S. aureus developed drug resistance. The death rate from invasive S. aureus infections was extremely high before penicillin was developed. However, it wasn't until 1942 that a penicillin-resistant strain of S. aureus was discovered, first in a hospital and later in the community, that penicillin significantly decreased the rate of mortality due to S. aureus infection. Up until the mid-1950s, when the number of S. aureus strains resistant to penicillin dramatically rose, penicillin was the preferred medication for treating S. aureus infections. As a result, penicillin's therapeutic value decreased. Resistance to penicillin was acquired via acquisition of plasmids coding for β-lactam resistance [34].

One of the most significant public health issues of our day is antimicrobial resistance (AMR), which kills at least 700,000 people annually globally and is predicted to cause 10 million deaths by 2050, costing the world economy US$100 trillion. Up to 50% of antibiotic prescriptions in the US are inappropriate or ineffective, according to the US Centers for Disease Control and Prevention (CDC), and a Norwegian survey found that 53% of patients with difficult-to-heal wounds received systemic antibiotic treatment before being referred to a specialized wound care facility [35].

3. Conclusions

Skin regeneration and wound healing are frequently and seriously threatened by infections and their associated consequences. Numerous stages of the wound healing process can be impacted by the microbiota that first colonizes injured tissue. Skin and soft tissue pathogens possess unique mechanisms that enable adhesion, invasion, and evasion of host defense. When given the right conditions, commensal and opportunistic microbes can potentially cause infections and damage to skin tissue. There is an urgent need for novel methods to detect, prevent, and treat wound infections due to the rise of antibiotic resistance and the growing public health risk of chronic wounds.

Staphylococcus aureus strains can spread from people to cattle in both directions. A major and expanding worldwide health concern is the rise in diseases brought on by drug-resistant bacteria. Thus, research on *Staphylococcus aureus* infection and transmission should be conducted, and considerable efforts should be made to create novel antibacterial agents with enhanced efficacy.

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Reference

1- Giacometti A, Cirioni O, Schimizzi A, Del Prete M, Barchiesi F, D'errico M, et al. Epidemiology and microbiology of surgical wound infections. Journal of Clinical Microbiology. 2000;38(2):918-22

2- Greif R, Akça O, Horn E-P, Kurz A, Sessler DI. Supplemental perioperative oxygen to reduce the incidence of surgical-wound infection. New England Journal of Medicine. 2000;342(3):161-7

3- Gjødsbøl K, Christensen JJ, Karlsmark T, et al. Multiple bacterial species reside in chronic wounds: a longitudinal study. Int Wound J 2006;3(3):225-31

4- Skerritt L, Moore Z. The prevalence, aetiology, and management of wounds in a community care area in Ireland. Br J Community Nurs 2014(Suppl):S11-17

5- Fazli M, Bjarnsholt T, Kirketerp-Møller K, et al. Nonrandom distribution of Pseudomonas aeruginosa and Staphylococcus aureus in chronic wounds. J Clin Microbiol 2009;47(12):4084-9

6- Amin AN, Cerceo EA, Deitelzweig SB, et al. Hospitalist perspective on the treatment of skin and soft tissue infections. Mayo Clin Proc 2014;89(10):1436-51

7- Forster AJ, Oake N, Roth V, et al. Patient-level factors associated with methicillin-resistant Staphylococcus aureus carriage at hospital admission: a systematic review. Am J Infect Control 2013;41(3): 214-20

8- Harris, L. G., Foster, S. J., & Richards, R. G. (2002). An introduction to Staphylococcus aureus, and techniques for identifying and quantifying S. aureus adhesins in relation to adhesion to biomaterials: review. *Eur Cell Mater*, *4*(3), 100-20.

9- Masalha, M., Borovok, I., Schreiber, R., Aharonowitz, Y., & Cohen, G. (2001). Analysis of transcription of the Staphylococcus aureus aerobic class Ib and anaerobic class III ribonucleotide reductase genes in response to oxygen. *Journal of bacteriology*, *183*(24), 7260-7272.

10- Mahoudeau, I., Delabranche, X., Prevost, G., Monteil, H., & Piemont, Y. (1997). Frequency of isolation of Staphylococcus intermedius from humans. *Journal of Clinical Microbiology*, *35*(8), 2153-2154.

11- Pereira, L. A., & Fisher, D. A. (2008). Methicillin-resistant Staphylococcus aureus control in Singapore: moving forward. *Ann Acad Med Singapore*, *37*(10), 891-896

12- Hanifah YA. Post-operative surgical wound infection. Med J Malaysia. 1990;45(4):293-7

13- Hannigan GD, Grice EA. Microbial ecology of the skin in the era of metagenomics and molecular microbiology. Cold Spring Harb Perspect Med 2013;3(12):a015362

14- Jensen PØ, Bjarnsholt T, Phipps R, et al. Rapid necrotic killing of polymorphonuclear leukocytes is caused by quorum sensing controlled production of rhamnolipid by Pseudomonas aeruginosa. Microbiology 2007;153:1329-38

15- Weinstein MA, McCabe JP, Cammisa Jr FP. Postoperative spinal wound infection: a review of 2,391 consecutive index procedures. Journal of Spinal Disorders & Techniques. 2000;13(5):422-6

16- Guo S, DiPietro LA. Factors affecting wound healing. Journal of dental research 2010;89(3):219-229

17- Minor, T. E., & Marth, E. H. (1971). Staphylococcus aureus and staphylococcal food intoxications. A review: i. The Staphylococci: characteristics, isolation, and behavior in artificial media. *Journal of Food Protection*, *34*(11), 557-564.

18- Facklam, R., & Elliott, J. A. (1995). Identification, classification, and clinical relevance of catalase-negative, gram-positive cocci, excluding the streptococci and enterococci. *Clinical microbiology reviews*, *8*(4), 479-495.

19- Tong, S. Y., Davis, J. S., Eichenberger, E., Holland, T. L., & Fowler Jr, V. G. (2015). Staphylococcus aureus infections: epidemiology, pathophysiology, clinical manifestations, and management. *Clinical microbiology reviews*, *28*(3), 603-661

20- Indrayudha, P. (2021). Antibacterial activity of combination of ethanol extract of peppermint leaves (Mentha piperita L.) and amikacin against Klebsiella pneumonia, Staphylococcus aureus, and Escherichia coli. *Journal of Nutraceuticals and Herbal Medicine*, *4*(1), 12-29.

21- Lee, K. Y., & Birkbeck, T. H. (1985). Effect of phenethyl alcohol on Staphylococcus aureus alpha-lysin production. *Infection and immunity*, *47*(1), 112-117.

22- Patel, A. H., Nowlan, P., Weavers, E. D., & Foster, T. (1987). Virulence of protein A-deficient and alpha-toxin-deficient mutants of Staphylococcus aureus isolated by allele replacement. *Infection and immunity*, *55*(12), 3103-3110.

23- Otto, M. (2014). Staphylococcus aureus toxins. *Current opinion in microbiology*, *17*, 32-37.

24- Patti, J. M., Allen, B. L., McGavin, M. J., & Hook, M. (1994). MSCRAMM-mediated adherence of microorganisms to host tissues. *Annual review of microbiology*, *48*, 585-618.

25- Djahmi N, Messad N, Nedjai S et al (2013) Molecular epidemiology of *Staphylococcus aureus* strains isolated from inpatients with infected diabetic foot ulcers in an Algerian University Hospital. Clin Microbiol Infect 19:E398–E404

26- Uberoi, A., McCready-Vangi, A., & Grice, E. A. (2024). The wound microbiota: microbial mechanisms of impaired wound healing and infection. *Nature Reviews Microbiology*, *22*(8), 507-521.

27- CooperRA, BjarnsholtT, Alhede M (2014) Biofilms in wounds: a review of present knowledge. J Wound Care 23:570–282

28- Waldvogel, F. A. (1990). Staphylococcus aureus (including toxin shock syndrome). *Principles and practice of infectious diseases*, 1489-1510.

29- Marrack, P., & Kappler, J. (1990). The staphylococcal enterotoxins and their relatives. *Science*, *248*(4956), 705-711.

30- Sanford, B. A., & Ramsay, M. A. (1989). In vivo localization of Staphylococcus aureus in nasal tissues of healthy and influenza A virus-infected ferrets. *Proceedings of the Society for Experimental Biology and Medicine*, *191*(2), 163-169.

31- Tsao, M. M., & Katz, D. (1984). Central venous catheter-induced endocarditis: human correlate of the animal experimental model of endocarditis. *Reviews of infectious diseases*, 783-790.

32- Leaper DJ, Schultz G, Carville K et al. Extending the TIME concept: what have we learned in the past 10 years? Int Wound J 2012; 9(Suppl 2):1–19. https://doi.org/10.1111/j.1742-481X.2012.01097.x

33- Berendt, A. (2021). Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. *Clinical Infectious Diseases*.

34- Deurenberg, R. H., Vink, C., Kalenic, S., Friedrich, A. W., Bruggeman, C. A., & Stobberingh, E. E. (2007). The molecular evolution of methicillin-resistant Staphylococcus aureus. *Clinical Microbiology and Infection*, *13*(3), 222-235.

35- Gürgen M. Excess use of antibiotics in patients with non-healing ulcers. EWMA J 2014; 14:17–22