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The Study of Bacterial Biofilm formation on Medical Devices, IUDs and Associated Infections

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Abstract: Biofilms are groups of microorganisms that have come together on a surface. Many bacteria commonly exist in the environment in biofilms, so to understand bacteria and their survival, it's vital we understand how biofilms form and how being in a biofilm helps bacteria survive. biofilms can be up to 1000 times more resistant to antibiotic treatment than free-floating bacteria, making them a significant cause of treatment failure for infectious disease. Biofilm is a slimy, protective film of the microorganisms e.g. bacteria, fungi, algae that could stick to each other and a surface which make characteristics complex community cab be embedded in a self-produced matrix of the sticky substances. In simple words biofilms can define as the significant problem in treating the bacterial infections and are one of the main reasons for the persistence of infections. There is the need for the alternative treatments are essential for treating and suppressing biofilm-associated infections. Various bacteria are able to form biofilms e.g. Listeria monocytogenes, Streptococcus mutans, Staphylococcus aureus, Staphylococcus epidermidis, E. coli, Klebsiella pneumoniae and Pseudomonas aeruginosa. The formation of biofilms depends on the various physical factors, mainly the composition of the nutrient media, pH, temperature and the biological factors. The microbes aggregates into the biofilms becomes of the significant virulence factor. In the medical field the biofilm infections are related to the various medical devices like knee replacements, catheters, implants, contact lenses, joints, screws. About 90 % of all the microorganisms are organized in the biofilms and are found in an ecosystem such as lakes, surface water, ground water etc. Bacterial biofilms are complex communities encased in extracellular polymeric substances. This article aims to describe the understanding biofilms and the risks in the formation of biofilm on medical devices and its associated infections.

Keywords: *Biofilms, Infections, Antibiotics, Medical Devices.*

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I. INTRODUCTION

Biofilm has been defined as a community of microorganisms, bacteria, which are capable of living and reproducing as a collective entity known as a colony. Biofilm is an association of the micro-organisms in which cells stick to each other on a surface encased within matrix of extracellular polymeric substance produced by bacteria themselves. A Dutch researcher, Antoni van Leeuwenhoek, was the first time observed 'animalcules' on the surfaces of the tooth by using a simple microscope. This is said to be considered as the microbial biofilm discovery.

Characklis in 1973 was indicated that biofilms shows higher resistant to the disinfectants e.g. chlorine. Costerton, in 1978, was the first to coin the term biofilm and was alerts the world about the biofilm. The human body consists of bacteria, fungi, and viruses. and resides in the gastrointestinal tract, salivary mucosa, and skin, and performs various physiological functions. Biofilms are present everywhere in nature and can be found in industrial places, hotels, waste water channels, bathrooms, labs, hospital settings and commonly occur on hard surfaces submerged in or exposed to an aqueous solution. It can also be formed as floating mats on surface of liquid. Its formation can occur on both living and non-living surfaces Bacteria growing in biofilm are sessile and are responsible for most physiological processes in the biofilm environment [1].

The bacterial biofilm has different growth, gene expression, transcription, and translation rates. The structure of a biofilm is extremely viscoelastic and has a rubbery behaviour [2]. The bacteria that could forms biofilms on the surface of the medical equipment. e.g. Staphylococcus. aureus, S. Staphylococcus epidermidis, Escherichia coli, Pseudomonas . aeruginosa, Klebssiela . pneumoniae, and Enterococcus faecalis.

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There are various microbes which are leads to forms biofilms. The biofilm forming bacteria mainly consists of Escherichia coli, , Proteus mirabilis, Streptococcus viridans, Pseudomonas aeruginosa, Staphylococcus epidermidis Klebsiella pneumoniae Staphylococcus aureus, and Enterococcus faecalis [3}. The diverse group of the gram-positive bacteria like staphylococci are generally found in the skin and mucosa of mammalians. This genus is responsible for nearly 80 % of the infections which are caused by the implantable devices in the humans [4, 5]. Biofilms are the major cause of an infection in an implanted medical device. The formations of the device-related biofilms are closely related to the interactions between bacterial cells. It has been found that about 70 % of all human infections are due to the biofilms e.g. non-healing chronic wounds, cystic rhinosinusitis, fibrosis, meningitis, endocarditis, periodontitis, osteomyelitis kidney infections etc. [6 ,7]

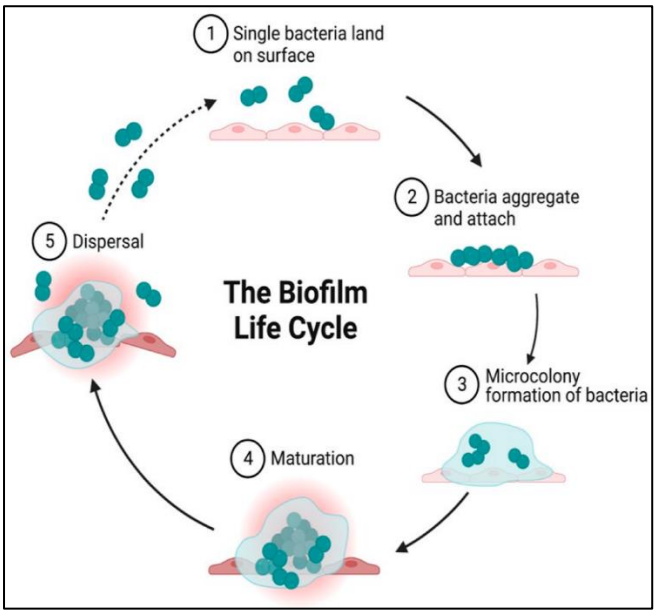

Fig 1 Biofilm Life Cycle

➢ *Biofilm Life Cycle*

- Attachment Single, free-floating bacteria has encountered a surface. They briefly attach using flagella or appendages, this attachment is temporary.
- Irreversible Attachment: Bacteria firmly adhere to the surface and produce EPS (polysaccharides, proteins, DNA), forming a sticky glue. This is permanent attachment.
- Maturation I (Microcolony Formation): Cells multiply and form small clusters (microcolonies) embedded in the EPS matrix. The biofilm develops its characteristic 3D architecture and water channels.
- Maturation II (Mature Biofilm): The biofilm becomes a complex, fully developed 3D structure and microenvironments. It gives protection from antibiotic.
- Dispersion (Detachment): Here the enzymes break down the EPS matrix. Individual cells or small clumps detach, returning to a planktonic state to find new surfaces. This will be restarting the biofilm cycle (See Fig.1).

➢ *Biofilm Infection*

Many bacterial infections with the biofilm and are both device-related and non-device-related like P. aerobicus and Fusobacterium nucleatum is the cause for periodontitis due to inadequate oral cleanliness due to infection of the gingiva [8]. The biofilms formed on the surface of the tooth resulting in the formation of plaques composed of calcium and phosphate ions.

The biofilms that grows in wounds of the diabetic patients causes chronic infections [9, 10]. The biofilm-associated microorganisms will be responsible for the infections like otitis media, chronic prostatitis, native valve endocarditis, cystic fibrosis, and periodontitis [11].

The biofilms could be responsible for diseases in the following routes.

- Detachment of biofilm cells or masses of cells leading to the blood and urine infections,
- Cells interchange resistance plasmids within biofilms,
- decreased susceptibility of the cells to antimicrobial agents,
- Endotoxin production by the biofilm-associated by bacteria, and
- Resistance host immune system.

➢ *Biofilms on Medical Devices*

Biofilms plays a vital job in medicinal contamination, like intravascular catheters, urinary catheters, dental inserts, breast implants, and orthopaedic inserts. A urinary catheter, central catheters, stents, contact lenses, IUDs, and dental chair water lines all are susceptible to bacterial adhesion and leads to biofilm formation. The catheters are inserted in patients for the administration of the liquids, blood and blood products, drugs, nourishment, and hemodynamic monitoring [12, 13]

➢ *Contact Lenses*

Contact lenses are hard or soft and soft contact lenses composed of hydrogel or silicone that allows oxygen diffusion through the lens material to the cornea. Contact lenses are made up of the polymethylmethacrylate that could be allowing oxygen-containing tears to flow underneath the lens through movement. Staphylococcus aureus, Pseudomonas aeruginosa, Staphylococcu. epidermidis, Serratia spp., Escherichia coli, and Candida spp. are the examples of the bacteria that have been reported for the responsible for infections related to contact lenses.

➢ *Intrauterine Devices (IUDs)*

The bacteria that can be found in the IUDs mainly consisting of Staphylococcus aureus, beta-hemolytic Streptococci, Escherichia. coli, that have reported from women with pelvic inflammatory disease. The pathogens like Lactobacillus plantarum, Staphylococcus epidermidis, Corynebacterium spp., Micrococcus spp., Candida albicans, IUDs are made of polyethylene, a nonabsorbable polymer impregnated with the barium sulphate. IUD can be cause pelvic inflammatory disease

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Micro-organisms have the ability to form biofilm on the various surfaces [14]. Microorganisms could be able to bind to a surface and produces an extracellular polymeric substance and form biofilm. Now-a-days the biofilm formation has been posing the threat for human health due to its resistant nature to antibiotics and disease agents [15].

II. CONCLUSIONS

Biofilms are found to be detrimental however it has the beneficial applications in which biofilms can be exploited. Biofilm formation enhances the survival of the micro-organisms Biofilm infections are the major concern in the healthcare.. The Future research on the prevention of the biofilm infection should focus on remedial measures against biofilm colonization of medical devices. This study was aimed to the combat antimicrobial resistance. There in need of research in the medical, dietary, water, and environmental microbiology this was focused on the threats of the biofilms. Now-a-days there is Biofilm-associated infection is a major clinical problem. Biofilms can form on the surface of the devices and non-devices, which leads in increasing the patient deaths. The future research will be exploring the innovative sterilization techniques in nanotechnology and bio-engineering.

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