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Antibiotic Resistance and Biofilm Formation of *Pseudomonas aeruginosa*, a therapeutic challenge: Narrative Review

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Abstract

Background: In this modern era, medicine is facing many alarming challenges. Among different challenges, antibiotics are gaining importance. *Pseudomonas aeruginosa* is a gram-negative bacterium that causes many diseases in other body parts. It is the most important causeof nosocomial infections in patients. *P. aeruginosa* is also recognized as an important cause of chronic infections due to its ability to form biofilms.

Methods: Studies were collected using different keyword combinations: Biofilm, Antibiotic Resistance, *Pseudomonas aeruginosa*, and nosocomial infections. The literature search strategy in this paper included searching PubMed, PMC, Science Direct, Springer open, Google scholar, and BioMed Central databases.

Results: Significant changes were found in the resistance of *P. aeruginosa* toward certain antibiotics of the β-lactam class. There was an increasing trend in the occurrence of resistance genes in β-lactamase-producing *P. aeruginosa*.

Conclusions: Prior use of antibiotics and prior hospital or ICU stay was the most significant risk factors for acquiring resistant *P. aeruginosa*. These findings guide in identifying patients at an elevated risk for a resistant infection and emphasize the importance of antimicrobial stewardship and infection control in hospitals.

Introduction

Pseudomonas aeruginosa is a ubiquitous Gram-negative bacterium belonging to the family Pseudomonadaceae that can survive in a wide range of environments **[1]**. *Pseudomonas aeruginosa* has been recognized as an opportunistic pathogen that is the most common bacterium associated with nosocomial infections and ventilator-associated pneumonia **[2]**. It rarely affects healthy individuals but causes high morbidity and mortality in cystic fibrosis (CF) patients and immunocompromised individuals **[3]**. Nowadays, it is well-recognized that biofilms play an ecological role and significantly impact medicine by developing healthcare-associated infections. The National Institutes of Health (NIH) estimated that bacterial biofilms involve 65 % of microbial diseases and more than 80 % of chronic conditions **[4]**.

Pseudomonas Biofilm:

Biofilm formation by *P. aeruginosa* occurs with the production of several extracellular matrix components such as type IV pili, Cup fimbria, exopolysaccharides, CdrA adhesin (24), extracellular DNA, LecA/LecB lectins and Fap amyloids **[5]**. Selection during chronic infection of P. aeruginosa variants that overproduce some biofilm matrix components is strong evidence of biofilm involvement in chronic disease **[6]**. P. aeruginosa can synthesize three different exopolysaccharides called Pel, Psl, and alginate, although some strains produce only a subset of these exopolysaccharides **[7]**. Overproduction of alginate allows mucus P. aeruginosa to form persistent infections in the lungs of patients with cystic fibrosis (CF) **[5]**. In addition, minor crude colony variants of P. aeruginosa over-producing exopolysaccharides Psl and Pel showed longer persistence in CF lungs **[8]** and chronic wounds **[9]**. Evidence has been presented that Psl protects P. aeruginosa from host defense during the early stages of CF lung infection **[10]**. Thus, the Psl-dominated extracellular biofilm matrix may be necessary for the early stages of chronic lung infection before bacteria mutate to produce an alginate-dominated biofilm matrix **[5]**.

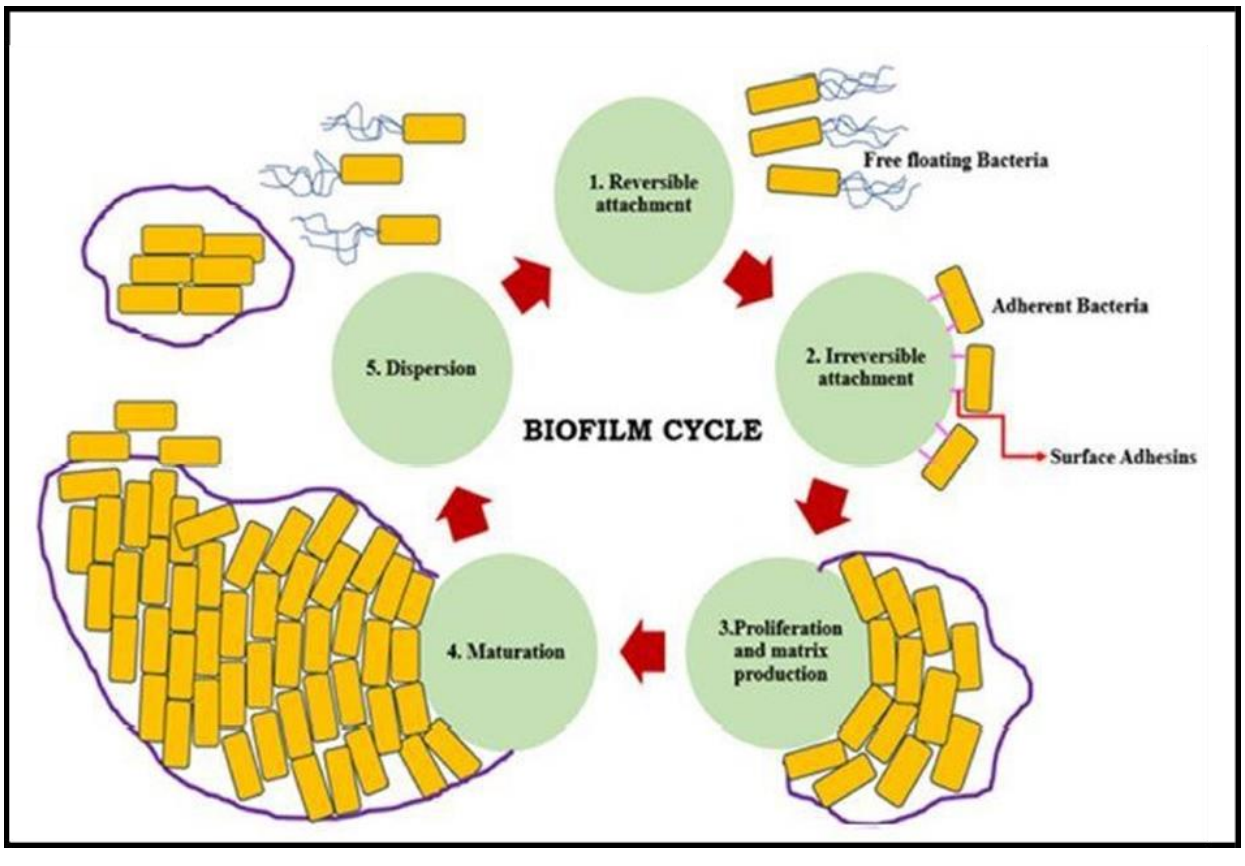

Figure 1: Cyclic process of biofilm formation in *P. aeruginosa*.

Pseudomonas aeruginosa Biofilm Challenge to Antimicrobial Agents

The biofilm structure of *P. aeruginosa* exhibits higher antibiotic resistance for various reasons, such as moderate or insufficient penetration of antibiotics, changes in the chemical environment in the biofilm, and cell differentiation in biofilms **[11]**. These mechanisms occur due to their multicellular nature, leading to antibiotic resistance of biofilm structures and failure of therapeutic strategies **[12,13]**. *P. aeruginosa* possesses antibiotic resistance by various mechanisms, namely, intrinsic, acquired, and adaptive resistance mechanisms **[11]**. The intrinsic resistance includes decreased permeability to the outer membrane; efflux pumps expression, and synthesis of enzymes that inactivate antibiotics. In contrast, the acquired type of resistance includes mutational changes or horizontal transfer of genes responsible for resistance. The final adaptive resistance is implicated in biofilm formation in the lungs of infected patients, which can act as a diffusion barrier to lower antibiotics from reaching the bacterial cells **[14]**. Recently, World Health Organization (WHO) mentioned *P. aeruginosa* as a life-threatening species for which newantibiotics must be developed to prevent its infections **[15]**. To date, empirical antibiotic therapy is used to treat cases of *P.aeruginosa* infections, but more antibiotics for treatment may develop multidrug-resistant strains of *P. aeruginosa* and can cause the failure of empirical antibiotic therapy against this microbe **[16]**.

Discussion and Conclusion:

Antibiotic resistance implies mutations in resistance genetic determinants resulting in accumulated antibiotic bottom restrictive concentrations for microorganism cells noncontinuous from biofilm, and it's accepted as a side-effect of prolonged maintenance antibiotic therapy. There are wide regional and interregional variations in the reported prevalence of MDR P. aeruginosa from general clinical samples with the highest prevalence **[18]**. The increasing rates of MDR or XDR, or resistant *P. aeruginosa*, are a worldwide public health problem. Resistant strains of P. aeruginosa are related to high mortality and augmented resource utilization **[17]**.

Embers of maximum Pseudomonas species effectively shape biofilms and stay as a causative organism for biofilm-mediated illnesses central to improving recurrent infections and continual infectious diseases. In connection to this, the opportunistic pathogen *P. aeruginosa* in its mucoid kingdom grabs interest withinside the study's location due to its affiliation with biofilm formation. One of the essential drawbacks withinside the remedy of those biofilm-associated infections is its extensive spectrum resistance to antibiotic therapies that already exist. Hence, in this review, we've summarized the technique and mechanisms intricated in biofilm formation via way of means of *P. aeruginosa* and the diverse opportunities recognized to deal with those biofilms effectively. In current years, numerous investigations and techniques have been demonstrated to examine the underlying mechanism of biofilm formation and govern its pathogenesis. However, considerably greater choicest strategies making use of superior methods are nevertheless had to discover a more excellent green antibiofilm agent to deal with *P. aeruginosa*-related infections, as they may be complicated and hard to deal with ease.

References

1. Silby MW, Winstanley C, Godfrey SA, Levy SB, Jackson RW (2011) Pseudomonas genomes: diverse and adaptable. FEMS Microbiol Rev. 35(4): 652–680.
2. Barbier F, Andremont A, Wolff M, Bouadma L (2013) Hospital-acquired pneumonia and ventilator-associated pneumonia: recent advances in epidemiology and management.Curr Opin Pulm Med. 19(3): 216–228.
3. Sadikot RT, Blackwell TS, Christman JW, Prince AS (2005) Pathogen-host interactions in Pseudomonas aeruginosa pneumonia. Am J Respir Crit Care Med. 171(11): 1209–1223.
4. Olivares E, Badel-Berchoux S, Provot C, Prévost G, Bernardi T, et al. (2020) Clinical Impact of Antibiotics for the Treatment of Pseudomonas aeruginosa Biofilm Infections. Front. Microbiol. 10: 2894.
5. Moser C, Jensen PØ, Thomsen K, Kolpen M, Rybtke M, et al. (2021) Immune Responses to Pseudomonas aeruginosa Biofilm Infections. Front. Immunol. 12: 625597.
6. Starkey M, Hickman JH, Ma L, Zhang N, De Long S, et al. (2009) Pseudomonas aeruginosa rugose small-colony variants have adaptations that likely promote persistence in the cystic fibrosis lung. J Bacteriol. 191(11): 3492–503.
7. Harmsen M, Yang L, Pamp SJ, Tolker-Nielsen T (2010) An update on Pseudomonas aeruginosa biofilm formation, tolerance,and dispersal. FEMS Immunol Med Microbiol. 59(3): 253–68.
8. Evans TJ (2015) Small colony variants of Pseudomonas aeruginosa in chronic bacterial infection of the lung in cystic fibrosis. Future Microbiol 10(2): 231–9.
9. Gloag ES, Marshall CW, Snyder D, Lewin GR, Harris JS, et al. (2019) Pseudomonas aeruginosa Interstrain Dynamics and Selection of Hyperbiofilm Mutants during a Chronic Infection. mBio. 10(4): e01698-19.
10. Mishra M, Byrd MS, Sergeant S, Azad AK, Parsek MR, et al. (2012) Pseudomonas aeruginosa Psl polysaccharide reduces neutrophil phagocytosis and the oxidative response by limiting complement-mediated opsonization. Cell Microbiol. 14(1): 95–106.
11. Vetrivel A, Ramasamy M, Vetrivel P, Natchimuthu S, Arunachalam S, et al. (2021) *Pseudomonas aeruginosa* Biofilm Formation and Its Control. Biologics. 1(3): 312-336.
12. Kragh KN, Hutchison JB, Melaugh G, Rodesney C, Roberts AE, et al. (2016) Role of multicellular aggregates in biofilm formation.mBio. 7(2): e00237.
13. Sugimoto S, Okuda K, Miyakawa R, Sato M, Arita-Morioka K, et al. (2016) Imaging of bacterial multicellular behaviour in biofilmsin liquid by atmospheric scanning electron microscopy. Sci. Rep.6: 25889.
14. Breidenstein EB, de la Fuente-Núñez C, Hancock RE (2011) Pseudomonas aeruginosa: All roads lead to resistance. Trends Microbiol. 19(8): 419–426.
15. Tacconelli E, Carrara E, Savoldi A, Harbarth S, Mendelson M, et al. (2018) Discovery, research, and development of new antibiotics: The WHO priority list of antibiotic resistant bacteria and tuberculosis. Lancet Infect. Dis. 18: 318–327
16. Park SY, Park HJ, Moon SM, Park KH, Chong YP, et al. (2012) Impact of adequate empirical combination therapy on mortality from bacteremic *Pseudomonas aeruginosa* pneumonia. BMC Infect. Dis. 12: 308.
17. Nicasio AM, Kuti JL, Nicolau DP (2008) The current state of multidrug-resistant gramnegative bacilli in North America. Pharmacotherapy. 28(2): 235–49.
18. Al-Orphaly M, Hadi HA, Eltayeb FK, Al- Hail H, Samuel BG, etal. (2021) Epidemiology of multidrug-resistant Pseudomonas aeruginosa in the Middle East and North Africa region. mSphere. 6(3): e00202-21.

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