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BACTERIAL INFECTIONS

Advanced acuity in microbial biofilm genesis, development, associated clinical infections and control

Actualités sur la formation des biofilms, leur développement, les infections associées et leur contrôle

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KEYWORDS
Biofilms;
Antibiotic resistance;
Clinical infection;
Microbes

Summary Equipped with many distinctive features, developments of biofilm through many complex processes in microorganisms are proven as a boon for their survival. Ability to secrete extracellular polymeric substance (EPS) matrix with surface attachment, decreased growth, demarcated structural design and, last but not the least, modification in some crucial genes have aided in their existence. A well-established communication medium via quorum sensing facilitated by up and down guidelines of some genes, passing of genetic material among cells has direct impact on biofilm formation and its disengagement. Different prevailing growth forms are blamed for infection in humans and animals. Being extremely resistant to antimicrobial compounds and immune counterattack, microbial biofilms have marked their global strong presence in clinical infections and medical devices related failures that directly or indirectly affect public health. Therefore, different approaches like anti-quorum agents with biofilm dispersal ability, sensible application of available antibiotics combined with improving and analyzing their effective outcome should be included in the strategies against biofilm for improving patient management.

MOTS CLÉS
Biofilm ;
Résistance aux antibiotiques ;
Infection clinique ;
Bactéries

Résumé Le développement de biofilms par de nombreuses espèces de microorganismes a été montré comme étant un avantage pour leur survie, grâce à l'acquisition de propriétés spécifiques. La capacité de secréter une matrice composée d'une substance polymérique extracellulaire, une croissance ralentie et des modifications dans certains gènes cruciaux ont permis la formation des biofilms. Une communication intercellulaire via le *quorum sensing* a été bien établie, sous la régulation de plusieurs gènes, permettant la formation et la régulation du biofilm. Différentes formes de biofilm ont été décrites dans des infections humaines et animales.

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Les biofilms sont très résistants aux antibiotiques et à la réponse immune, leur permettant d'être à l'origine d'infections cliniques sur matériel étranger et d'échecs thérapeutiques, posant des problèmes de santé publique. En conséquence, différentes approches comme les agents anti-*quorum sensing* en association avec des antibiotiques devraient être incluses dans les stratégies de lutte contre les biofilms pour améliorer la prise en charge des patients.

Introduction

In the late 1960s, Robert Whittaker proposed 5-kingdom classification, which remains popular even today. He classified single cell organism either in Monera (Prokaryotes) or in Protista (Eukaryotes). Bacteria hold a major portion of kingdom Monera and are seeded in the entire planet. Since the formation of Earth, bacteria are the species which have faced all the catastrophism and yet, they stand still to the test of time.

There are many special characteristics that aided bacteria to survive and succeed. One of the special characteristics is the formation of biofilm. Biofilm is the collection of the microorganisms in which they adhere to a surface (non-hygienic and non-exfoliating) or stick together. They greatly differ in construction and configuration in different environmental conditions. Ranging from biotic system to abiotic system, they can be easily seen in surrounding environment. Though single species can form biofilms but in real natural constraints these biofilms gather a diversity enriched colony of different species of Monerens (fungi, algae, yeasts and other microorganisms' products). Microbial parts, properties, functions and survival behaviors in a biofilms are totally different and far better than the free-floating cells of the same microbe. Free-floating cells consume the nutrient but lack ample ability to drain substrate from surrounding cells. The overall metabolic exercises of cells in biofilms target the confined microchemical activity and thus lead to the gradient in substrate concentration. This limited metabolic exercise offer far low sensitivity to antimicrobial agents.

Biofilm formation is triggered either by the cellular ability to recognize the precise or non-precise attachment points of nutritional hints on the surface or by exposing free-floating cells to sub avoiding antibiotic concentration. Free-floating cells are loaded with the genetic guidelines to counteract various stress conditions. However, they are easily crushed by strong antimicrobial test. Cells die before genetically activated stress response comes into action. In comparison, cells in biofilm are effective in stress management at the liability of other cells which are killed. Free-floating cells can neutralize the antimicrobial substance but they are incapable to decrease antimicrobial concentration in surrounding cells. In comparison, the overall nullifying effect of cells tend to target the nonfunctioning of antimicrobial in biofilm.

Cells of biofilms are continuously fixed within autonomous produced matrix of Extracellular Polymeric Substance (EPS). EPS is usually composed of extracellular DNA, proteins, non-cellular components and polysaccharides packed in a compact mass. When a planktonic cell transforms into biofilm growth mode, large number of genes are distinctly operated. These biofilms are very quick to respond and adapt in constantly changing surrounding parameters. Free-floating cells parent the persister cells but under bearable growth constraints in planktonic culture, persister cells go back to the liable condition. In comparison, persister cells hoard in biofilm just because they are substantially saved in matrix and are not easily converted back. Biofilms are present on common aquatic habitat (natural and industrial), inherited medical devices and living tissues and can produce dangerous chemical products, which are mostly toxins within their matrix. Biofilms are not interface restricted by any permutation of any states of matter (solid, liquid, gas). Surface coatings are biodegraded by many airborne pathogens at solid—air interface. Likewise, biofilms present on liquid—liquid interfaces are held responsible in hydrocarbon biodeterioration comprising oils and fuels.

Biofilm formation stages

There are various steps involved in formation of biofilm.

Surface habituation layer

Surface profile happens to be the determining factor in the biofilm formation and the surface roughness, aided by minute surface flaws, is directly proportional to bacterial attachment to counter the surface shearing forces. Rough surface also increases the mass transfer coefficient, and the free energy change during attachment is negative. In addition, physiochemical characteristics of surface also contribute to the adhesion as bacterial cells attach more easily to non-polar hydrophobic surfaces than the hydrophilic surfaces because the hydrophobicity is inversely related to the repulsion between the bacteria and the matrix [1].

In the natural environment, microorganisms attach to the conditioning film and not directly to the surface. Surface is chemically modified by the conditioning film and thus, it influences the rate and extent at which microbial attachment takes place. The composition of conditioning film is complex consisting of polysaccharides, glycoproteins and dependent on surface [2]. It modifies the physiochemical characteristics of surface, provide nutrients and other important small elements. Table 1 shows the list of microorganisms forming biofilms and their disadvantages.

Connection passage machinery

Attachment in the dynamic condition of fluid transport pipes is governed by the simple principles of physics, i.e. laminar and turbulent flow. In blood vessels and urinary vessels, laminar flow is observed. Fluid moves forward in a series of concentric lamina and slide over each other. Central lamina is fastest and the outer layer may be stationary

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