Review

The bacterial biofilm and importance to human health

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Accepted 09 July, 2014

ABSTRACT

Biofilms are a population of cells that grown attached to a surface involved in exopolysaccharide matrix which protects them from attack by antibiotics or immune system. Over 60% of all microbial infections are caused by biofilms which increasing the resistance to antimicrobials through of several mechanisms including: synthesis of extracellular polymers (physical barrier effect), enzymatic modification of antimicrobials, decrease of bacterial growth rate, phenotypic changes in bacterial cells as a result of the acquisition of resistance genes within the biofilm, and the persistence of a small group of cells in the bacterial community. Biofilm is usually associated with the infectious processes, however it is clear that some of them may have a protective role as is the normal flora.

Keywords: Biofilms, Bacterium, Antimicrobial, Exopolysaccharydes, Matrix.

INTRODUCTION

Contrary to popular belief, few are the bacteria capable to produce diseases in humans (Diemond and Miranda, 2007). These microorganisms are of great interest to the area of health and especially those that have been adapted to harsh environments, developing mechanisms against the bactericidal agents (Costerton et al., 1999; Donlan, 2002; Donlan and Costerton, 2002; Rendueles and Ghigo, 2012). One such mechanism corresponds to the formation of biofilm, which confer protection against several bacterial lethal factors, for example make them more resistant to the action of various antibiotics (Costerton et al., 1999; Costerton, 2001; Donlan, 2002a; Kostakioti et al., 2013; Mah and O’Toole, 2001; Rao et al., 2005; Stewart and Costerton, 2001).

The bacteria forming biofilms are associated in communities of organisms which are strongly attached to different surfaces (such as objects, human tissues or human organs) (Costerton et al., 1999; Chauhan et al., 2012; Donlan et al., 2002; Kostakioti et al., 2013). Bacteria in biofilms possess a complex network or matrix of exopolysaccharide and other molecules of excretion like proteins, nucleic acids, bacterial lysates, water, etc, which facilitate the adherence to a contact surface (Betancourt et al., 2004; Decho, 2013; Flemming and Wingender, 2010; Mohammed et al., 2013). Among the exopolysaccharides which have been found in the biofilms can summon the alginates, cellulose, N-acetylglucosamine, glucosamine, levans, etc. This matrix confers resistance to extreme changes in temperature, pH, reducing or oxidizing agents, including antibiotics and to certain components of the immune response of the host (Flores et al., 2009; Lasa et al., 2005; Riera et al., 2012).
Formation of biofilm

The biofilm formation occurs at different stages. First, the cells are in a free state which is called planktonic. These lifestyles are able to move through the medium in which they are immersed. Many of these forms have flagella or cilia that let you scroll through chemoattractants and/or stimuli (Donlan, 2002; Romanova and Gintsburg, 2011). Once these cells detect the site where they can adhere, they are deposited on surface and form clusters. This cell types are known as "sessile biofilm forms". This is the phenomenon of adhesion. Subsequently, colonize and begin to excrete carbohydrates to the periphery (array of exopolysaccharides). Once formed the array of exopolysaccharides, cells begin to multiply and to excrete signalling molecules to form a homogeneous system (Costerton et al., 1999; Donlan, 2002a; Donlan, 2002b). Nutrients pass freely between the spaces that leaves the array of exopolysaccharides, providing an environment conducive to their development. The biofilm when moving to a mature stage, is able to release cells from the periphery, which are passed from sessile to planktonic stage, repeating this cycle over times (Figure 1) (Donlan, 2002b; Krom and Oskam, 2014; O'Toole et al., 2000; Romanova and Gintsburg, 2011).

The bacterial biofilm

The study of biofilms has gained great importance in recent years, the biofilms that already having a significant impact on public health (Costerton et al., 1999; Pratten et al., 2003; Rao et al., 2005). Many cases have been reported in bacterial infections have become chronic and even repeat, because the treatment becomes more difficult when microorganisms are able to form biofilms (Diemond and Miranda, 2007; Costerton et al., 1999; Ferrières et al., 2007; Van Loosdrecht et al., 2002). Among the microorganisms which have been most studied and possess the ability to form biofilms are: *Pseudomonas aeruginosa* - an opportunistic, nosocomial pathogen, typically infects the pulmonary tract, urinary tract, burns, wounds, and also causes other blood infections especially in patients with compromised host defense mechanisms; *Escherichia coli-* are bacteria found in the environment, foods, and intestines of people and animals. Some *E. coli* are pathogenic, can cause diarrhea, urinary tract infections, respiratory illness, bloodstream infections, and other illnesses. *Staphylococcus aureus* is responsible for many infections but it may also occur as a commensals. It is a common cause of skin infections and respiratory disease, is extremely prevalent in persons with atopic dermatitis. This can lead to many different types of infections including furuncles and carbuncles. *Streptococcus mutans-* commonly found in the human oral cavity and is a significant contributor to tooth decay. *Salmonella* is actually a group of bacteria that can cause diarrheal illness in humans; salmonellosis, this disease is found worldwide. *Porphyromonas gingivalis-* it is found in the oral cavity, where it is implicated in certain forms of periodontal disease, as well as the upper gastrointestinal
Table 1. The bacteria form biofilm in diverse infectious processes.

<table>
<thead>
<tr>
<th>Bacterial species</th>
<th>Associated to</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Streptococcus species</em></td>
<td>Dental caries</td>
<td>(25,39,41,50)</td>
</tr>
<tr>
<td>Group A <em>Streptococci</em></td>
<td>Necrotizing fasciitis</td>
<td>(25,39,30)</td>
</tr>
<tr>
<td><em>Viridans group Streptococci</em></td>
<td>Endocarditis of the native valve</td>
<td>(25,39)</td>
</tr>
<tr>
<td><em>Staphylococcus species</em></td>
<td>Infections of skeletal muscle</td>
<td>(19,22,20,25)</td>
</tr>
<tr>
<td><em>Staphylococcus epidermidis</em></td>
<td>Sutures, vents, way arteriovenous</td>
<td>(22,37)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>Hickman catheters, central venous</td>
<td>(12,22,36)</td>
</tr>
<tr>
<td></td>
<td>catheters, mechanical heart valves, devices</td>
<td></td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>Bacterial prostatitis, cystitis by urinary</td>
<td>(6,39,49)</td>
</tr>
<tr>
<td></td>
<td>recurrent urinary tract infections</td>
<td></td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>Pneumonia in cystic fibrosis, meliodosis</td>
<td>(25,39)</td>
</tr>
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<td></td>
<td>contact lenses</td>
<td></td>
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<tr>
<td><em>Haemophilus influenzae</em></td>
<td>Otitis media</td>
<td>(32,43)</td>
</tr>
<tr>
<td><em>Actinomyces israelii</em></td>
<td>Intrauterine devices</td>
<td>(25,28,39,41)</td>
</tr>
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</table>

Biological and human health

In the developed countries it has been reported that cardiovascular and infectious diseases are the first and second leading causes of death. This information is relevant for public health. More than half of infections affecting immunocompromised patients are produced by bacteria species can produce chronic infections, that respond poorly to antibiotics treatment and cannot be prevented by immunization (Bjarnsholt; 2013; Bridier et al., 2011; Mah and O’Toole, 2001). Examples of bacteria infections associated with biofilms have otitis media, native valve endocarditis, chronic urinary tract infections, infections of the prostate, osteomyelitis and implant-related infections, to name a few. To directly examine the implants and tissues in those infections was in evidence that in the majority of cases the bacteria responsible for the infection grow attached on the tissues or implants forming biofilms. Table 1 shows examples of infections that involved different biofilm forming bacteria (Bjarnsholt; 2013; Costerton et al., 1999; Lasa et al., 2005). The list includes Gram positive and negative bacteria, aerobic and anaerobic bacteria, some actinomycetes. Among the bacterial genera are streptococci associated with bacterial endocarditis, dental caries; staphylococci are associated with musculoskeletal infections, heart valve, prosthesis, catheters, etc (Flores et al., 2009; Marsh, 2004; Nishihara and Koseki, 2000).

The prosthesis are target for microbial colonization due to bad handling of the same or the presence of exposed lesions which permit the passage of pathogens. In this case it could complicate the situation with bacteremia (Welliver et al., 2014) This can be avoided with chemoprophylaxis and adequate equipment for operating.
The biofilm increases the resistance to antibiotics

At present diverse studies have been realized on the antimicrobial resistance. It has been proposed that the biofilms promote the survival of these microorganisms, since they increase: 1. Traffic nutrient through the matrix; 2. Activation of mechanism of response to chemical stress; 3. Antagonist to antimicrobial action (Bridier et al., 2011; Bjarnsholt, 2013; Flores et al., 2009; Mah and O´Toole, 2001). It is known that bacteria growing in protected environments (as is the case of the biofilms), show greater antimicrobial resistance in comparison to those which are grown in culture media. The biofilm forming bacteria are more resistant to the action of antibiotics (hundreds to thousands of times more resistant). This could be attributed to the physical disability due to the barrier effect (by matrix exopolysaccharide) to traverse this complex network and reach the target of action of the antibiotic (Cha et al., 2013; Hoiby et al., 2010; Mah and O´Toole, 2001; Meissner et al., 2013). In addition, biofilms block the action of the phagocytes and the antibodies, since the pore size of the network is very small and only allows the traffic from smaller molecules (Mah and O´Toole, 2001; Diemon and Miranda, 2007; Gotz, 2002; O’Toole et al., 2000; Peters et al., 1981; Rupp et al., 2001; Von Rosenvinge et al., 2013).

However, some studies show that the antimicrobials are able to penetrate the biofilm and that the exopolysaccharides only decreases the rate at which the drug is introduced, eg fluoroquinolones penetrate more easily the biofilm compared with aminoglycosides. In the biofilm, the time to attain a bactericidal concentration is variable (depending on the drug) (Chen et al., 2013; Donlan and Costerton, 2002; Mah and O’Toole, 2001; Stewart and Costerton, 2001).

CONCLUSION

The biofilm is a natural state of development of the bacteria, which enables them to stay together, establish communication, and above all gives them a protective environment. On the other hand, the formation of biofilms in the bacteria represents a serious problem to the Public Health, because bacteria that produce are associated with difficult-to-treat infections: require longer treatment and high costs and are difficult to eradicate. In other cases, biofilms that form the normal flora protect to human from infectious agents on the skin, oral cavity, vagina, digestive tract, etc.

ACKNOWLEDGEMENTS

Thank to L.I. Sonia Guadalupe Pérez Hernández for the valuable technical collaboration for the development of this work. Also at the Facultad de Medicina-BUAP and VIEP-BUAP for the facilities provied for the development of this work.

REFERENCES


