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Bacterial adhesion and proliferation on biomaterials. Techniques to evaluate the adhesion process. The influence of surface chemistry/topography.

M. Katsikogianni , Y. F. Missirlis

Biomedical Engineering Laboratory, University of Patras, Greece

INTRODUCTION: Infection remains a major impediment to the long- term use of many implanted or intravascular devices. Bacterial adhesion to biomaterial surfaces is an essential step in the pathogenesis of these infections, however the molecular and physical interactions that govern it have not been understood in detail. Both specific and non-specific interactions may play an important role in the ability of the cell to attach to (or to resist detachment from) the biomaterial surface. This mini review reports on general aspects of bacterial infection associated with medical devices, factors that influence bacterial adhesion, techniques that are used to evaluate the adhesion process and theoretical models that explain/predict bacterial adhesion on biomaterials.

Factors that influence bacterial adhesion[1]: Bacterial adhesion is a complicated process that is affected by many factors including the bacteria (hydrophobisity, surface charge), the material surface (chemical composition, roughness, configuration, wettability) and environmental factors (serum proteins and antibiotics, temperature, bacterial concentration, time of exposure, flow conditions)

Techniques[2]: two categories of techniques used in calculating bacterial-material interactions are described: those that utilize fluid flowing against the adherent bacteria and counting the percentage of bacteria that remain adhered (parallel-plate flow chambers, radial flow chamber and rotating disc) by a number of methods such as microscopy and viable bacterial counting methods, and those that manipulate single bacteria (atomic force microscope and modified atomic force microscope[3])

Theoretical models[4]: The DLVO theory describes the Van der Waals (generally attractive) and the Coulomb (generally repulsive) interactions. The thermodynamic theory estimates the surface free energy of the bacterial and substratum surfaces and of the suspending solution. The extended DLVO theory estimates not only the Van der Waals and the Coulomb interactions but also the acid–base interactions.

RESULTS: It has been shown that both surface chemical composition and surface topography (roughness, configuration) influence bacterial adhesion. Hydrophilic materials are more resistant to bacterial adhesion than hydrophobic materials. It has been shown that large numbers of bacterial attach to hydrophobic plastics with little or no surface charge, moderate numbers attached to hydrophilic metals with a positive or neutral surface charge and very few attached to hydrophilic, negatively charged substrata. Coating substrata surfaces with proteins, such as bovine serum albumin decreased surface hydrophobisity, leading to an inhibited bacterial adhesion to the surfaces. Modifying surfaces with an antimicrobial peptide coating, Silver, DLC, nonsteroidal anti-inflammatory drug coating or amine-containing organosilicon surfaces discourages bacterial adhesion. As far as surface roughness and configuration is concerned, it has been found that the irregularities of polymeric surfaces promote bacterial adhesion and biofilm deposition. Roughening the surface of certain materials greatly increases bacterial colonisation. Moreover bacteria adhere more to grooved and braided materials compared to flat ones, probably partially due to increased surface area.

DISCUSSION & CONCLUSIONS: This review reveals that both surface chemistry and topography influence bacterial adhesion and biofilm formation. However, the relative importance of these factors has not been clearly understood yet. Refinement of the techniques for measuring bacteria-material interactions with reference materials would improve our knowledge of this important, yet complex phenomenon.

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