NOVEL APPROACHES IN BIOFILMS. ELECTRICAL FIELDS AND BIOFILMS: COULD THE BIOELECTRIC EFFECT BE A NEW STRATEGY FOR TREATING BIOFILM-RELATED INFECTIONS?

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The pathogenesis of a wide variety of human infections, including device-related infections, as well as infections not associated with devices, is now recognized to relate to the presence of bacteria in biofilms. It has been estimated that two thirds of human bacterial infections involve biofilms. Biofilm growing microorganisms are protected, to a large extent, from killing by innate host defenses and the bactericidal activity of antimicrobial agents, a type of resistance unique to biofilm-associated bacteria and distinct from conventional antimicrobial resistance. The antibacterial activity of electric current has been previously demonstrated against several microorganisms. The mechanism of the antibacterial activity of electric current has been variously suggested to result from toxic substances produced as a result of electrolysis, oxidation of enzymes and coenzymes, membrane damage leading to leakage of essential cytoplasmic constituents, and/or decreased bacterial respiratory rate. In vitro experiments have shown that electric current and electromagnetic fields can enhance the activity of some antimicrobial agents and biocides against certain bacteria in biofilms; this has been termed the ‘bioelectric effect’. Much has been hypothesized to explain the mechanism of action of the bioelectric effect; however a satisfactory explanation remains. Some of the hypothetical mechanisms that have been suggested include reduction of biofilm capacity for binding the antimicrobial agent, increased membrane permeabilization, electrophoretic augmentation of antimicrobial transport, increased bacterial growth due to electrolytic generation of oxygen, electrochemical generation of potentiating oxidants, increased convective transport due to contraction and expansion of the biofilms, increased transport through electroosmosis, physical removal of the biofilm with electrolytically generated bubbles and enhanced susceptibility due to a temperature increase inside the biofilm.

Direct electrical current has already been safely used in humans for fracture healing. Application of direct electric current with antimicrobial chemotherapy in humans could theoretically abrogate the need to remove the device in device-related infections, a procedure associated with substantial morbidity and cost. Furthermore, implantable devices could be accessed to produce effective electric fields to enhance the perioperative use of antimicrobials to kill developing bacterial biofilms preventing device related infections.