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Nanomaterials for alternative antibacterial therapy

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Abstract

Despite an array of cogent antibiotics, bacterial infections, notably those produced by nosocomial pathogens still remain a leading factor of morbidity and mortality around the globe. They target the severely ill, hospitalized and immunocompromised patients with incapacitated immune system, who are prone to infections. The choice for antimicrobial therapy is largely empirical and is not devoid of toxicity, hypersensitivity, teratogenicity and/or mutagenicity. The emergence of multi-drug resistant bacteria further intensifies the clinical predicament as it directly impacts public health due to the diminished potency of current antibiotics. In addition, there is an escalating concern with respect to biofilm-associated infections that are refractory to the presently available antimicrobial armory, leaving almost no therapeutic option. Hence, there is a dire need to develop alternate antibacterial agents. The past decade has witnessed a substantial upsurge in the global use of nanomedicines as innovative tools for combating the high rates of antimicrobial resistance. Antibacterial activity of several metal and metal oxide nanoparticles has been reported. The microbes are eliminated either by microbicidal effects of the nanoparticles such as release of free metal ions culminating in cell membrane damage, DNA interactions, free radical generation, or by the microbistatic effects coupled with killing potentiated by the host's immune system. The diverse annihilative effects of conventional and green nanomaterials on the bacteria are discussed in this review. Combinatorial therapy with metallic nanoparticles as adjunct to the existing antibiotics, may aid to restrain the mounting menace of bacterial resistance and nosocomial threat.

Introduction

Hospital-acquired bacterial infections, mainly caused by the nosocomial pathogens such as Acinetobacter baumannii, Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae and so on, pose the foremost challenge to the well-being of a patient. The bacteria counteracts the host’s innate immune defense machinery which becomes the prime cause of death in patients confined to the intensive care unit (ICU), with weakened immune system, culminating in invasive bloodstream infections. The widespread use of broad-spectrum antibiotics4 has led to the appearance of multidrug-resistant (MDR) isolates that further intricate the clinical problem as the bacteria spread epidemically among the patients. With the compromising efficacy of the available chemotherapeutics due to mounting drug resistance and the biofilm recalcitrance towards antibiotics, there is a pressing need to identify alternate drugs. In this respect, nanomaterials have shown promise owing to their unique physical and chemical attributes. Their large surface area relative to volume enables intimate interactions with microbial membranes, as well as surface functionalization, which help in developing more effective antibacterial agents. Over the last decade, there has been a remarkable global focus on conventional as well as biogenic metallic nanoparticles (NPs) as innovative tools for combating the high rates of antimicrobial resistance. Chemotherapeutic drugs when given in combination with metallic NPs may result in a cumulative effect due to the antibiotic as well as the metal ions released from NPs. Moreover, the antibacterial agent may be used at a much lower dose than when administered alone, hence overcoming the problem of resistance and diminishing other undesirable side effects to some extent. There has also been a paradigm shift in management of biofilms and MDR bacteria with polymeric nanocomposites and antibiotic-loaded polymeric NPs. Improved therapeutic efficacy with concomitant decline in side effects of antimicrobial drugs has also been achieved by surface modification of metallic NPs with ligands or antibodies for targeted delivery.

Biography

Hassan A Hemeg is an Associate Professor at Taibah University, Saudi Arabia. He published several papers in Medical Microbiology. He lead several committees in health organizations related to the health care accreditation His new area of
interest is the Nano-Material and the Implementation in the Antimicrobial Therapy.

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