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Nanomaterials for alternative antibacterial therapy

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Despite an array of cogent antibiotics, bacterial infections, notably those produced by nosocomial pathogens, still remain a number one factor of morbidity and mortality round the globe. they aim the severely ill, hospitalized and immunocompromised patients with incapacitated system , who are susceptible to infections. the selection of antimicrobial therapy is essentially empirical and not barren of toxicity, hypersensitivity, teratogenicity and/or mutagenicity. The emergence of multidrug-resistant bacteria further intensifies the clinical predicament because it directly impacts public health thanks to diminished potency of current antibiotics. additionally , there's an escalating concern with reference to biofilm-associated infections that are refractory to the presently available antimicrobial armory, leaving almost no therapeutic option. Hence, there's a dire got to develop alternate antibacterial agents. The past decade has witnessed a considerable upsurge within the global use of nanomedicines as innovative tools for combating the high rates of antimicrobial resistance. Antibacterial activity of metal and metal oxide nanoparticles (NPs) has been extensively reported. The microbes are eliminated either by microbicidal effects of the NPs, like release of free metal ions culminating in cell wall damage, DNA interactions or radical generation, or by microbiostatic effects including killing potentiated by the host's system . This review encompasses the magnitude of multidrug resistance in nosocomial infections, bacterial evasion of the host system , mechanisms employed by bacteria to develop drug resistance and therefore the use of nanomaterials supported metals to beat these challenges. the various annihilative effects of conventional and biogenic metal NPs for antibacterial activity also are discussed. the utilization of polymer-based nanomaterials and nanocomposites, alone or functionalized with ligands, antibodies or antibiotics, as alternative antimicrobial agents for treating severe bacterial infections is additionally discussed. Combinatorial therapy with metallic NPs, as adjunct to the prevailing 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 like Acinetobacter baumannii, Pseudomonas aeruginosa, Escherichia coli , Staphylococcus aureus, Klebsiella pneumoniae then on, pose the foremost challenge to the well-being of a patient.1 The bacteria counteracts the host's innate immune defense machinery,2,3 which becomes the prime explanation for death in patients confined to the medical care unit (ICU), with weakened system , culminating in invasive bloodstream infections. The widespread use of broad-spectrum antibiotics4 has led to the looks of multidrug-resistant (MDR) isolates that further intricate the clinical problem because the bacteria spread epidemically among the patients. With the compromising efficacy of the available chemotherapeutics thanks to mounting drug resistance and therefore the biofilm recalcitrance towards antibiotics, there's a pressing got to identify alternate drugs. during this respect, nanomaterials have shown promise due to their unique physical and chemical attributes.5–7 Their large area relative to volume enables intimate interactions with microbial membranes, also as surface functionalization, which help in developing simpler antibacterial agents. Over the last decade, there has been an interesting global specialise in conventional also as biogenic metallic nanoparticles (NPs) as innovative tools for combating the high rates of antimicrobial resistance. Chemotherapeutic drugs when given together with metallic NPs may end in a cumulative effect thanks to the antibiotic also because the metal ions released from NPs. Moreover, the antibacterial agent could also be used at a way lower dose than when administered alone, hence overcoming the matter of resistance and diminishing other undesirable side effects to some extent.6,8 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.

This review summarizes the immune evasion strategies and antibiotic resistance mechanisms employed by bacteria to survive in the host and the probable metallic nanomaterials-based bactericidal effects to fight against nosocomial pathogens. The antibacterial activities of biologically synthesized metallic NPs as well as polymeric nanocomposites and surface-modified NPs are also highlighted. The metal-based nanomaterials alone or functionalized with antibiotics when translated to clinics may show promise as next-generation nanotherapeutics against bacterial menace

Gravity of the problem

Bacterial infections have emerged as the leading cause of the formidable rates of deaths in hospitalized and immunosuppressed patients, especially those in ICUs and those undergoing invasive operations, worldwide as well as in parts of Saudi Arabia where the prevalence

has been reported to be 31.7%.12 The hospital-acquired infections manifest in a wide gamut of severe clinical ramifications, such as bacteremia, septic shock, ventilator-related pneumonia and massive soft tissue necrosis, and rapidly progress to systemic infections that eventually culminate in multiorgan failure and death.13 The control measures including implementation of hygiene, patient isolation and environmental decontamination have proved ineffective in keeping the infection at bay. Improper use of antibiotics has favored an upward trend in the development of resistance to almost all the available drugs, further compounding the clinical problem.9,14 The challenge to control these infections is augmented in MDR bacteria such as those producing extended-spectrum β-lactamases and carbapenemases (*K. pneumoniae* carbapenase) and in methicillin-resistant *S. aureus* (MRSA). Drug combination regimens have also proved ineffective due to formation of biofilms, agglomerates of bacterial colonies that adhere to a surface and resist traditional means of killing by avoiding contact with the antibiotics.15 The bacteria survive in the biofilms for extended periods of time and are likely to be transmitted within the health care settings. The quandary of mechanisms of antibiotic resistance has retrogressed the clinical outcome and inflated the economic burden of infectious diseases, leaving the medical practitioners with few therapeutic options to address the emerging threat.14 Furthermore, an arsenal of strategies has been employed by bacteria to subvert the host immune system, adversely impacting the surrogate markers of clinical course such as the length of hospitalization and hospital-related deaths.

Biography

Dr. Hassan A. Hemeg pursued Masters in Pathological Science from Sheffield University, UK and received his Ph.D. from King Abdulaziz University, Saudi Arabia. He also completed Diploma in National Association of Safety Professionals from USA.

He has earned several honors such as Fellow of the Institute of Biomedical Science, UK and Certified Canadian Accreditation Specialist for Health Care Facilities. He also acquired training in Microbiology from Sheffield University and Bristol University, UK and, U.S Department of Labor Occupational Safety and Health Administration. He has also worked as Educational Instructor and Supervisor in Clinical Molecular Microbiology Laboratories at King Abdulaziz University Hospital, Jeddah and as Head of Environmental Health and Safety Unit at King Abdulaziz University Hospital. He has served as a member, Secretary and Chairman of several Committees and is a permanent representative of Ministry of Higher Education in Safety Traffic Committee. Presently, he is also the Vice Dean of Medical Applied Science College at Taibah University. His research interest is antimicrobial. He has published several papers in Journals of International repute

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