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Significance of Particulate Drug Delivery System in Anti-microbial Therapy

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Introduction

Antimicrobial agents are the substances, used to kills or inhibit the growth of pathogenic microorganisms in living things. Several antimicrobial therapeutic agents have been exploited to treat infectious diseases caused by pathogenic microbes such as bacteria, fungi and viruses. These agents differ in their physicochemical, pharmacological properties and in their mechanisms of action. Typically, antimicrobials agents kill or inhibit the growth of bacteria by binding to some significant components of bacterial metabolism, and thereby alter the functional bimolecular synthesis or normal cellular activities. The successful antibacterial therapies necessitate presence of antibacterial agent at its target site and interfere with bacterial functions with an adequate effective concentration to achieve a desired result without producing the toxic effects [1].

Drug resistance

Some microorganisms develop natural resistance to certain antimicrobials. This resistance is usually occurs through mutation, adaptation, or gene transfer either by one or more mechanisms. The vital reasons for development of drug resistance have been identified due to insufficient concentration of drug at its target site, drug inactivity, or drug target alteration [2]. Permeability nature of microbial cell wall is selective in allowing transport of certain antibacterial molecules across; effectively reduce the drug concentration at the target site. Many bacteria also have efflux pumps on their membrane that can transport drugs out of the cell. Secondly, drug inactivation is general mechanism of bacterial drug resistance. Failure of bacterial cell to activate a pro-drug in the body may leads to develop drug resistance. Alteration in drug target may occur due to natural target mutation, modification of target, or acquisition of a resistance form of the native, and susceptible target [3]. The irrational use of antibiotics during animal breeding has enhanced the drug resistance and made the treatment of infections even more complicated [4]. The clinical judgment and thorough knowledge of pharmacological and microbiological factors helps in rational selection and judicious use of antimicrobials for the therapy of infectious diseases.

Nanostructured anti-bacterial drug delivery approaches

In spite of our current effort in bringing awareness about the rational use antibiotics and scientific knowledge about these life saving drugs, antibiotics are the most misused drug among all leading to the world's major public healthcare problems. However, the process of invention of newer anti-bacterial drugs is not in the required speed. Along with microbial resistance, intracellular infectious diseases remained difficult to treat due to their poor transport through cell membranes and low activity inside the cells. Moreover, toxicity and unwanted side effects to healthy tissues limiting their use. Hence, to address these issues, there is a urgent need to look at the development of alternative novel drug delivery approaches in order to achieve safe and effective use of antimicrobial therapy [5]. The recent studies revealed that nanostructure formulation of antibacterial agents could be best alternative drug delivery devices for highly effective antimicrobial therapy. Nanostructure drug delivery device would solve the increasing drug resistance problem and reduce the complications associated with treatment of infectious disease. Utilization of novel nanotechnological approach in developing nanostructured pharmaceutical drug delivery carriers has been posing bright anticipation both in pharmaceutical research and clinical setting. To achieve the delivery of adequate amount of drug at the site of action, nanostructures prepared through nanotechnology are assumed to be most potential. The drug-loaded nanostructured devices can enter host cells through endocytosis and then release drug payloads at the site of intracellular infections [6]. Moreover, surface modification of pharmaceutical nanocarriers leads to regulate their biological characteristics in a desirable pattern and make them to perform various therapeutically important functions including increased stability and half-life and required biodistribution. To address the issue related with, acquired microbial drug resistance which present major challenge for infection treatment, is to incorporate multiple antimicrobial agents in a single nanoparticle and then concurrently deliver the drugs to the same microbes. The combinatorial drug therapy is expected to have higher potency as multiple drugs can achieve synergistic effects. Recent nanostructured drug delivery devices are said to be able to distinguish microbes or infectious cells from healthy cells due to the lack of the specific targeting ability, although targeted drug delivery has been extensively studied for other disease treatment such as cancers and cardiovascular diseases.

Conclusion

In summary, the major disadvantages associated with conventional antibacterial therapy can be successfully overcome by drug loaded nanostructured delivery systems. Extensive studies have demonstrated that varieties of drug loaded nanostructured carriers are able to overcome these issues and facilitate antimicrobial delivery to microbial infection sites. While most of these nanostructured devices are currently in preclinical development, several have been approved for clinical use. The interdisciplinary effort in nanostructured drug delivery research may help to improve treatment of bacterial infections and life-threatening diseases. In order to rectify the problems associated with antibacterial therapy, it is essential to proceed with multidisciplinary approaches by sharing knowledge of pharmaceutical scientists, physicians, nanoengineers and biotechnologists in developing nanostructured antibacterial drug delivery devices.

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