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Nanotechnology-Based Strategies To Combat Against Infectious Diseases

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ABSTRACT

Infectious diseases are caused by various smart pathogens like bacteria, fungi, viruses, and parasites, claiming more than 17M lives globally (1). Currently, we are in the middle of a pandemic that originated from an infectious disease

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The Infectious diseases are caused by various smart pathogens like bacteria, fungi, viruses, and parasites, claiming more than 17M lives globally (1). Currently, we are in the middle of a pandemic that originated from an infectious disease. The available therapies, medical facilities, and research–development teams of each country were exploited, and yet the novel coronavirus claimed ~4,065,876 lives to date. These smart pathogens keep tweaking themselves, posing challenges to treatment therapy such as antibiotic/antiviral drugs resistance, tolerance, and newer strategies to survive inside host cells.

For instance, emergence and spread of the Methicillin-resistant Staphylococcus aureus (MRSA) bacterial resistance constitute a toll on human and animal health, food security, environmental sustainability, and socioeconomic development, triggering the tripartite organizations (Food and Agriculture Organization of the United Nations, FAO; World Organization for Animal Health; and World Health Organization, WHO) to layout a blueprint for tackling such resistance threats the coming five to ten years. Moreover, the novel coronavirus and drug-resistant species of influenza viruses highlighted the urgent need for new antiviral therapies (2). Most of the antibiotics and antiviral agents exhibit low stability, less solubility, extraordinary potential of drug-drug interaction, high occurrence of toxicity or adverse effects, short-half life, and low concentration at the site of infection (3). Thus, there is a desperate need for ground-breaking treatment approaches to combat these evolving infectious diseases.

Nanocarriers come under the umbrella of nanotechnology. The advancement of nano-delivery systems has resolved most of the shortcomings of traditional dosage forms. As compared to conventional drug delivery systems, nanocarriers provide many benefits viz. delivery of low solubility compounds, high drug loading or encapsulation capacity, targeted delivery, and modulated surface charge. Additionally, they are biocompatible and biodegradable. Some nanocarriers, like silver nanoparticles, dendrimers, and carbon nanotubes demonstrate inherent antiviral properties. The nanocarriers can be modified by anchoring ligands to target intracellular infections resulting in more drug concentration at the infection site. Recently, nanocarriers have gained significant attention from researchers. Several nanomedicines (AmBisome®, Abelcet, Amphotec®, etc.) were successfully. marketed for the management or treatment of infectious diseases. Many nanocarriers are at various stages of clinical trials for delivery of biologics (deoxyribonucleic acid, ribonucleic acid), antibiotics, vaccine, vaccine adjuvants, and clustered regularly interspaced short palindromic repeats (CRISPR) components (4).

Thus, to win the battle against these deadly infectious diseases, the future entails the continuous progress of novel theranostics, therapeutics, and nano-formulations. Furthermore, elementary research with computer-aided drug discovery to discover new molecules and computational simulation to investigate the interaction between nanoparticles and pathogens has also expanded research horizons. Currently, development of various nano-technological strategies in the form of nanovaccines, and therapeutics to deal with the SARS-CoV-2 virus are under investigation. Moreover, nano-technological interventions have been explored for the development of PPE kits, masks, and diagnostics against covid-19. Some novel strategies discussed in a reviews related to nanotraps, nanoherbal formulations, nanodiamonds, nanofibers, and nanorobots are also under examination against influenza and HIV (5). These may be explored for other infectious diseases. Nevertheless, there are certain hurdles in the progression of these nanocarriers related to the manufacturing processes, large-scale production, complicated characterization, and the absence of regulatory guidelines. Furthermore, relevant toxicity study of these nanocarriers is a paramount prerequisite to proving safety.

However, the continual emergence of these infectious diseases requires prompt progress to manage and control deadly infections more efficiently, where the consortia of industry and academia are a must to make nanotechnology prosperous. Therefore, the keynote message is that there should be an emphasis on enhancing research on this topic to advance the current remedy, knowledge and circumvent resistance of these pathogens.

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