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Nanomedicine: Breakthroughs in the Fight against Microbial Infections

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Introduction

Despite a variety of challenges, microbes have dominated life on Earth for the past two billion years. Antibiotics and immunisations brought about these changes in the twentieth century. Microorganisms have developed resistance since then, and various infectious diseases have avoided treatment with traditionally developed vaccines. Over the last few decades, antibiotic resistance and pathogenicity have surpassed antibiotic discovery in terms of importance. These shifts have had massive economic and health ramifications for all socioeconomic levels; thus, we need ground-breaking innovations to effectively manage microbial infections and provide long-term solutions. Nanomedicine has radically altered the pharmaceutical and biotechnology industries, and this trend is now spreading to the antibacterial research community. In this segment, we look at the role of nanomedicine in the prevention of microbial infections, covering topics like diagnosis, antimicrobial therapy, pharmaceutical administration, and immunisations, as well as the opportunities and challenges that lie ahead [1].

Description

Antibiotics and vaccines are two of the most significant medical advances. Broad-spectrum medicines and vaccinations significantly reduced infectious disease morbidity and mortality over the previous century. Between 1900 and 1996, infectious disease mortality in the United States fell dramatically, from 797 to 59 deaths per 100,000 people, with the lowest rate of 36 deaths per 100,000 people in 1980. Some concerning patterns have emerged in recent decades that jeopardise such progress. Infectious and parasitic diseases account for 9.7 percent of global deaths, according to the World Health Organization's Global Health Study from 2016. TB (2.3%), diarrheal bacterial infections (2%), meningitis (0.5%), bacterial sexually transmitted disorders (syphilis, chlamydia, and gonorrhoea, 0.2%), and encephalitis (0.2%) are the top five causes of death worldwide [2].

Shigella and enterotoxigenic Escherichia coli are the most common and lethal bacteria that cause infectious diarrhoea, according to the Global Burden of Diseases consortium. Infectious diarrhoea was the eighth leading cause of death among all ages in 2016, and the fifth leading cause of death among children. Because of a lack of universal health systems, public health issues, potable drinking water, and financial resources, these figures in impoverished countries are significantly higher than the global average. Its emergence has been linked to antibiotic overuse. The ineffectiveness of antibiotics as a result of rising drug resistance is a major threat to public health. Some researchers have even predicted that the 21st century will be the "postantibiotic era". Multidrug resistance is a bacterial phenomenon that can occur.

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Some multidrug-resistant infections are resistant to standard treatments. The increasing number of strains of methicillin-resistant Staphylococcus aureus that are also resistant to vancomycin is an alarming example of multidrug resistance, complicating therapy because vancomycin is usually the last line of defence against S. aureus infections. Medication resistance and the development of new antimicrobial drugs are lagging behind the rapid evolution of microbes. Traditional vaccinations, on the other hand, that use live attenuated microorganisms, killed microbes, or microbial components, have proven to be critical to infectious disease control, though some do not provide adequate protection. Furthermore, some live vaccines should not be used by people who are immunocompromised [3].

Nanomedicine, or the use of nanotechnologies in medicine, has transformed the pharmaceutical and biotechnology industries. As of 2020, nearly a hundred different nanomedicine products have received clinical use approval. Medication delivery and imaging are among the products available, as are implantable biomaterials and medical devices. Nanotechnologies can also address nearly every aspect of microbial disease. The unique physicochemical properties of nanomaterials have aided in the rapid, sensitive, and selective detection of microbial diseases. Furthermore, several inorganic and organic nanoparticles have significant intrinsic antibacterial properties that are rarely seen in bulk. More importantly, certain nanomaterials have the potential to reduce antibiotic resistance by weakening resistance pathways. Furthermore, nanoparticles for antimicrobial drug delivery overcome resistance while having fewer side effects than conventional antibiotics.

Antimicrobial nanoparticles used in medical equipment can also prevent bacteria adhesion and infection. Finally, as vaccine adjuvants or delivery vehicles, nanomaterials can boost immune responses to microbial illness. For antigens that would otherwise disintegrate quickly after injection or cause a transient immune response, encapsulation in nanoparticles allows for a more stable delivery of the localised immune response. The possibility of combining multiple antigens on a single particle to protect against multiple illnesses is also being investigated, as is the use of nanoparticles to deliver vaccines via non-traditional routes such as topical, inhalational, or optical delivery. We will concentrate on recent advances in nanotechnology that have been applied to the fight against infectious microbes.

It has been shown that using the host's immune system to identify and kill germs protects the host from microbial infection. Pathogen-associated molecular patterns aid the innate immune system in identifying pathogens that have penetrated the host's physical barriers. Antigen-specific adaptive immune responses against bacterial infections can last for decades after antigen-presenting cells are activated. The protective response may postpone bacteremia and septic shock, allowing antibiotics to work longer. Immunogenicity and safety of microbe vaccines vary. Concerns have been raised about pathogenicity reversion, vector immunity, and immune-compromised safety in live attenuated bacterial vaccines [4,5].

Conclusion

Nanotechnology holds great promise for the treatment of microbial illnesses. Antibiotics with nanomaterials are a more cost-effective option for macrophage persister cells and biofilm infections due to their high adjustability and broad range of adaptation. Because of their nanomaterial design, nano-antibiotic systems can target, penetrate, absorb, and change infectious microenvironments, as well as combine with other treatment techniques. As

a result, nanomaterials have the potential to significantly improve antibiotic efficacy. Clinical translation must first address a number of issues and thoroughly testify about in vivo toxicity and clinical effects. Nano-antibiotics for resistant bacterial infections will require extensive research and testing before they can be widely used. Nanomaterials are still a promising option for combating antibiotic resistance. We believe that nano-antibiotics will soon be able to combat bacterial resistance and save more lives.

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Conflict of Interest

There are no conflicts of interest by author.

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