Review Article

INTERVENTION AND TREATMENT OF HIV/AIDS THOROUGH NANOTECHNOLOGY

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Human Immunodeficiency Virus (HIV) infection and its advanced stage, Acquired Immuno-deficiency Syndrome (AIDS), continue to represent a major global public health challenge despite significant progress in therapeutic interventions. Since the introduction of antiretroviral therapy (ART), particularly Highly Active Antiretroviral Therapy (HAART), the morbidity and mortality associated with HIV/AIDS have been substantially reduced. However, these conventional therapeutic strategies are not curative and are associated with several limitations, including drug resistance, systemic toxicity, poor bioavailability, limited penetration into viral reservoirs, and the requirement for lifelong adherence. These challenges necessitate the exploration of innovative and more effective treatment approaches. In this context, nanotechnology has emerged as a promising and transformative tool in the field of HIV/AIDS intervention and treatment.
Nanotechnology involves the design, development, and application of materials at the nanoscale, typically ranging from 1 to 100 nanometers, where unique physicochemical properties such as enhanced surface area, improved reactivity, and tunable surface functionalities can be exploited for biomedical applications. In HIV therapeutics, nanotechnology offers novel strategies for targeted drug delivery, improved pharmacokinetics, reduced toxicity, and enhanced therapeutic efficacy. Nanocarriers can be engineered to deliver antiretroviral drugs directly to infected cells and tissues, thereby minimizing off-target effects and maximizing drug concentration at the site of infection.A variety of nanocarrier systems have been investigated for HIV treatment, including liposomes, polymeric nanoparticles, dendrimers, solid lipid nanoparticles, nanomicelles, and inorganic nanoparticles such as gold and silver nanoparticles. These nanosystems differ in their composition, structure, and functional capabilities, allowing for flexi sebility in drug encapsulation and delivery. Liposomes, for instance, are biocompatible vesicles capable of carrying both hydrophilic and hydrophobic drugs, while polymeric nanoparticles offer controlled and sustained drug release. Dendrimers, with their highly branched architecture, provide high drug-loading capacity and can also function as antiviral agents. Lipid-based nanoparticles, particularly lipid nanoparticle systems, have gained considerable attention for their ability to deliver nucleic acids, including RNA-based therapeutics One of the most significant advantages of nanotechnology in HIV treatment is its ability to overcome biological barriers and target viral reservoirs. HIV persists in latent reservoirs such as macrophages, lymphoid tissues, and the central nervous system, which are often inaccessible to conventional drugs. Nanoparticles can be designed to cross physiological barriers, including the blood-brain barrier, enabling drug delivery to these hidden sites of infection. Furthermore, surface modification of nanoparticles with ligands or antibodies allows for active targeting of specific cell types, such as CD4+ T cells and macrophages, thereby enhancing treatment specificity.

Keywords: Nanoformulated antiretrovials, nanogels for PrEP , antiretroviral,HIV/AIDS,Targeted drugs.

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