



A REVIEW ON CURRENT TRENDS IN NANOTHERANOSTICS

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ABSTRACT:

A Nanotheranotic system combines diagnostic and therapeutic capabilities. This combination makes it an ideal tool for personalised medicine. The term comes from thera(py)+ diag(nostics) and it refers to the combination of medical diagnosis and therapy. Nanomedicine is the use of colloidal nanoparticles ranging in size from 1 to 1000nm in size. They are made of macromolecular materials/polymers/carbon nanomaterials/metallic and inorganic nanoparticles that adsorb, bind, trap, and encapsulate diagnostic and therapeutic agents at cellular and molecular levels for diagnosis and treatment. In popular, the precise residences of nanoparticles are used to achieve biomarker identity and drug transport. Nanotheranostics can be implemented to discover and goal imaging biomarkers non-invasively and to develop therapy based on biomarker distribution. This is a large and hopeful position theranostics need to fill. On this evaluate, we've got mentioned how nano materials are designed and customized for nanotheranostics of covid-19,cancer and other sicknesses.

KEYWORDS:

Nanotheranostics, nanomaterials, cancer, neurodegenerative diseases, autoimmune diseases

INTRODUCTION:

Nanotherapeutics is to apply and in addition develop the numerous nanomedicine strategies inclusive of polymer conjugations, dendrimers, micelles, liposomes, metallic and inorganic nanoparticles, carbon nanotubes, nanoparticles of biodegradable polymers for sustained, managed and targeted co-transport of diagnostic and therapeutic agents for higher theranostics consequences and less facet outcomes. The reason is to diagnose and deal with the sicknesses at their earliest stage, when the diseases are most likely curable or atleast treatable. Personalised, or every now and then termed precision medicinal drug (PM), is a brand new fashion in remedy predominantly in most covid -19 & cancers treatment that has promise in improving healthcare before, at some point of and after ailment. This stems from the conclusion that no single remedy has the equal impact on many sufferers with the identical diagnosis. Rather than the most common prescriptions, PMs individualize the fine remedy for each individual (1).

Nanoparticles have specific residences that offer particular imaging and functionalization utilities. Because of their size, nanoparticles are high-quality for localization to disease sites, specifically cancers, in vivo. For example, nanoparticles spend more time circulating inside the blood in vivo than conventional chemotherapeutic agents, depending on their surface functionalization.

Longer stream half lives increase the probability that nanoparticles will leak out of tumor blood vessels and via underdeveloped tumor vasculature into tumor tissue (2). Further, nanoparticles have a excessive surface area-to-volume ratio, which offers high loading capacity for imaging probes, focused on ligands, and therapeutic molecules. Moreover, many nanoparticles have specific imaging properties that can be in addition functionalized to emerge as nanotheranostics. This kind of multifunctional gadget could be of exceptional advantage for PMs to display screen and diagnose unique molecular make-up, optimize therapeutic strategies and delivery, and screen therapeutic efficacy in rather variable illnesses such as covid 19 & cancers. In brief, nanotheranostics can appreciably enhance the first-rate of customized remedy (3).

NANOTHERANOSTICS AND THEIR ROLE IN THE DIAGNOSIS, TREATMENT AND PREVENTION OF COVID-19

They're currently used in the diagnosis and treatment of variety of sicknesses with terrible diagnosis. The use of nanotheranostics has received growing interest during the last 2years, specially as new diagnostic tool for covid-19(1). Remedies for fatal illnesses such as most cancers, neurodegenerative illnesses, cardiovascular sicknesses, genetic diseases, and hemoglobinopathies are limited to specific patients and are selectively given consistent with the unique level of the disease (2-3). The nanomaterials used consist of a brand new technology of various kinds of nanocarriers together with polymer conjugates, metal and non-metal NPs, inorganic NPs, dendrimers, micelles, and liposomes (2,6–11).

The nanotheranostics approach is superior because it monitors the added therapeutics and simultaneously controls the reaction to the treatment in real time. This reduces the possibility of over- and underneath-dosing. Multifunctional nanotheranostics include tumors and lesions obtained by radiolabeling nanomaterials along with gold, silver, silicon NPs, carbon nanotubes (CNTs) with nanosize, delivery, sustained release, and desaturation control includes non-invasive imaging of system (1-4,12).

Nanotheranostics media enable long-time movement of nanomaterials inside the blood, efficient release conduct, tissue targeting, suitable penetration, brilliant sensing competencies, and excessive goal-to-background ratios and low undesirable side outcomes. Must have good imaging. In case of covid-19, the virus entry pathway is initiated by means of the binding of the viral S protein to her ACE2 receptor. After the binding event, mobile entry happens thru protease-activated transmembrane serine protease 2 (TMPRSS2).

Internalization is followed by entry of the virus into the endosomes, where the viral particles release genetic material for protein synthesis, leading to synthesis of new infectious particles and infection of the host. Nanotechnology offers a promising means to combat the current COVID -19 outbreak and future pandemics. Both conventional and advanced biomimetic approaches, including biochemically functionalized NPs, are within the realm of nanotechnology that can be used against COVID -19 (5-8).

Nanotechnology is developing safe, efficient, and targeted drug delivery that culminates in virus-host cell interaction and leads to risk-free and highly efficient immunity that permanently destroys viral particles. Our goal is to produce a nano-vaccine that enables better drug delivery via nanotransporters (9,10).

DELIVERY OF REPURPOSED DRUGS VIA NANOCARRIERS

For SARS-CoV-2, the focus is now on repurposing existing molecules for the development of specific antiviral agents with broad spectrum activity. To this end, nanocarrier delivery systems could be very useful. Minimal water solubility, denaturation, rapid excretion, and low bioavailability significantly hinder the delivery of drugs, including peptides/proteins, DNA/RNA, etc., to target sites. The multiple properties of nanomaterials, such as high surface-to-volume ratio, biofunctionalization, unique physicochemical properties, and multiple routes of administration, are extremely beneficial for overcoming the problems associated with trivial therapeutics. Biocompatible organic/inorganic nanoparticles are emerging as promising candidates for delivering efficient therapeutics with beneficial properties such as controlled release, improved pharmacokinetics, and minimized drug resistance. In addition, small and site-specific nanoparticles have the potential to overcome the biological barriers, thereby penetrating with higher specificity to the protected sites of the body infected by pathogens, while preventing the unwanted release of drugs at non-targeted regions, leading to a reduction in the required dose and systemic toxicity. Nanotechnology also enables the development of personalized therapies (6, 13-15).

Several research groups have demonstrated the potential of nanobased therapeutics or immune system modulation against various viral infections such as SARS-CoV-2, herpes simplex virus (HSV-1 and HSV-2) (treated by embedding aciclovir in chitosan NPs), Venezuelan equine encephalitis virus (VEEV) (treated by using a lipid-coated nanocarrier system of mesoporous silica as a carrier for the antiviral drug ML336), and bleomycin-induced pulmonary fibrosis (treated by introducing liposomes carrying cholesterol-modified hydroxychloroquine). This successful bio-prevention of viruses by nano-platforms could guarantee promising nano-candidates to combat various viral infections, including SARS-CoV-2.

Nanomedicines have potential to overcome site-specific delivery of antiviral drugs. As scientists develop effective drugs against the SARS-CoV-2 virus in the case of COVID-19 disease, an optimized nanomedicine-based targeted drug delivery system will help overcome the challenges of site-specific delivery. Nanomedicine is also useful for controlled release and maintenance of antiviral drugs at specific sites. It plays an important role in the treatment of viral infections (25).

Combinatorial therapies: Loading drug cocktails onto individual nanosystems. Combinatorial therapies enable synergistic mechanisms to suppress overlap, which are currently being investigated to be effective against SARS-CoV-2. Their advantages include minimal drug exposure and negligible side effects [26]. In addition, drug resistance is addressed at a very high level.

In this approach, multiple drugs with different physicochemical properties are loaded onto the same nanocarrier so that both hydrophobic and hydrophilic drugs can be transported within the same nanovehicle, which also ensures their continuous release.

Scientists have recently developed combinatorial nanoparticles containing the endogenous lipid squalene, an adenosine immunomodulator, and α -tocopherol to develop nanotherapy against acute viral inflammation (14).

In addition, lipid-based nanocarriers containing lopinavir, ritonavir, and tenofovir have been produced for the treatment of lymphatic drug insufficiency (16-20). This system has been shown to retain 50-fold higher drug concentrations in lymph nodes than current drug-free oral therapy. This system could also be used against SARS-CoV-2. Common mutations in the SARS-CoV-2 genome continuously alter antigenic proteins.

A67V, H69del-V70del, T95I, G142DV143del-Y144del-Y145del, N211del-L212I, ins214EPE, G339D, S371L, S373P, S375F, K417N, N440K, G446S, S477N, T478K, E484A, Q493R, G496S, Q498R, N501Y, Y505H, T547K, D614G, H655Y, N679K, P681H, N764K, D796Y, N856K, Q954H, N969K, and L981F are 32 mutations in the Omicron spike. In addition, pseudotyped viruses expressing the S protein from other variants of current interest (VOC; alpha, beta, gamma, and delta) and variants of interest (VOI, lambda, and mu) have been tested and reported. (21-27). The introduction of sensitive and specific diagnostic tools is therefore an urgent need to detect viral infections and control viral spread (28), with the aim of developing efficient NP. These nanobased strategies also make antigenic proteins accessible to antigen-presenting cells, leading to improved delivery and therapy [2, 14, 29].

The nanomaterial gold NP administered colorimetric assay for diagnosis of viral infections is efficiently used for timely and specific visual diagnosis of COVID-19 positive patients in a very short time. Capping of SARS-CoV-2 N protein with AuNPs reveals selective aggregation of the antisense RNA strand as reflected by surface plasmon resonance (SPR). Application of RNaseH further cleaved the RNA and formed a precipitate.

Antibody binding graph has the potential for rapid detection of viral target proteins. It can also be used for the development of COVID-19 biosensors. Theranostic NPs have also been proposed to diagnose and neutralize viruses to prevent their survival and spread in the host.

Potential nanobased therapeutics against COVID-19 outbreak include proteolipid nanovehicle-based fusogenic DNA vaccines, mRNA vaccines encapsulated in lipid NP (mRNA-1273) and recombinant protein vaccines NP (NVX-1273, CoV2373), and the development of paper-based colorimetric RNA sensors. The sensor uses a positively charged pyrrolidinyl peptide nucleic acid (acpcPNA) probe that aggregates negatively charged AgNPs. The acpcPNA probe hybridized with viral RNA in the presence of MERS-CoV RNA and formed a negatively charged RNAacpcPNA duplex. The duplex dispersed their AgNPs, resulting in a detectable color change due to electrostatic repulsion [30-31].

Researchers are investigating new mRNA vaccines that directly target the omicron receptor binding domain (RBD). The 'failure' of the ARCoV vaccine to neutralize sera against its Omicron variant highlights the development of mRNAs encoding its RBD and lipid NP formulations of Omicron as potential candidates. Of the 18 proposed mRNA constructs with distinct untranslated regions (UTRs), two, Omicron/1 and Omicron/2, were selected and found to be most suitable for intravenous injection.

Both the LNP-formulated mRNA and ARCoV Omicron are effective in generating Omicron RBD in mouse serum. A final clinical grade mRNA vaccine is currently in production [32-34]. Cancer, Covid-19, and similar pandemics can be successfully targeted with nanotherapeutics in the same manner. Approaches based on 3D nanotechnology have high potential for efficacy detection, prognosis, and mediation. The principles of tissue and cell targeting that apply to cancer and neurodegenerative diseases through nanoparticle delivery may also be effective in antiviral infections and cure infected patients. These theranostic NPs can also kill viruses simultaneously. Nanoparticles can be used to create ultrafine filters for face masks, personal protective equipment (PPE), and surface coatings. These nanotheranostic approaches can help to combat COVID -19 and similar pandemics in a timely and effective manner [14].

Conclusion

Nanobased therapeutics have the potential to diagnose, treat, and even prevent many deadly diseases such as neurodegenerative diseases, cancer, and HIV-AIDS. Today, the COVID -19 outbreak has thrown the world into chaos and forced everyone to stay home. These antiviral pandemic outbreaks can also be incorporated into tracking systems to cure infections and prevent future devastating outbreaks through the integrated approach of nanotheranostics. Various metallic NPs such as AuNPs and AgNPs are discussed in this chapter. In addition, the superparamagnetic and hyperthermic properties of MNPs make them highly potential tools for treating microbial infections. Nanovaccines with the ability to treat various microbial infections are discussed. This book also briefly describes nano-based therapeutics for the ongoing fight against the viral pandemic COVID -19. For example, a lipid NP encapsulating an mRNA vaccine (mRNA-1273) has been developed to serve as a potential DNA vaccine for COVID -19. Other mRNA constructs capable of producing the Omicron RBD in mice, such as Omicron/1 and Omicron/2, are in late-stage clinical trials. These advances in nanotechnology have great potential for the treatment and prevention of microbial outbreaks that lead to epidemics or pandemics.

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