Journal of Bacteriology and Infectious diseases

Editorial

2020
Vol. 4, Iss. 2

Review on Drug Delivery Systems Targeted Against Infectious Diseases

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Infectious diseases are of utmost concern and threat to the entire world currently. They are caused primarily by bacterial, fungal, parasitic and viral infections. According to world health organization (WHO) millions of deaths may occur due to infectious diseases by 2050 which shows a growing need to develop appropriate drugs or drug delivery systems. With a view overcoming manifold infectious diseases, they are treated with an array of drugs which act on a few specific targets and accomplish some amelioration in disease symptoms. However, a few drugs show adverse effects such as gastrointestinal inflammation, non-targeted delivery and short systemic circulation etc. Nanotechnology based drug delivery systems are currently in use to overcome these challenges. The current study focuses on multifarious drug delivery systems such as polymeric nanomaterials, hydrogels, dendrimers etc which considerably enhance the efficacy of encapsulated therapeutics such as drugs or bioactive molecules. Drug resistance has been a major biological riddle in the treatment of infectious diseases. Dendrimers play a pivotal role in overcoming this issue. Control release mechanisms, reducing toxicity and averting reticuloendothelial systems are the vital characteristics offered by delivery systems against fungal, bacterial and viral infectious diseases. Systemic antibiotics such as tetracycline, beta-lactam antibiotics, nitroimidazoles are extensively used in the treatment of periodontal diseases and peri-implantitis. However, systemic antibiotic use results in a few problems such as drug resistance, dysbacteriosis and toxic effects. The antibacterial effect is also significantly low due to the low amount of the drug reaches the oral lesion after systemic circulation. Moreover, low bioavailability and infiltration in the infection site and increase of drug-resistant bacteria impede the success of conventional drugs. Oral stimuli-responsive DDS have been designed which are smart DDS that accurately release the therapeutic in oral cavity. DDS improved therapeutic efficacy and curtailed toxic effects remarkably. Numerous molecular polymers have been synthesized and used as drug carriers. Antibiotics or antibacterial compounds such as chlorhexidine were entrapped and local biofilm attenuation was achieved. In addition, remineralizing compounds such as fluoride were also loaded in varnish or gels to circumvent caries and have been currently used in clinics. Introduction of nanotechnology lead to the discovery of micro/nano-scaled carriers to treat several oral diseases. Manifold hitherto designed nanocarriers can successfully load anti-bacterial agents, anti-inflammatory drugs and biomolecules such as proteins, genes and growth factors and can also be used to treat oral diseases. Surprisingly, nano-scaled DDS linked to dental materials like dental restoration systems and dental implants offered anti-bacterial effect without controlling the basic properties. Plethora of copolymers used in DDS are poly(lactic-co-glycolic acid) (PLGA), poly(D, L-lactide) (PDLLA), poly(ethylene glycol)(PEG) and other biopolymers such as lipid, chitosan, pectin, and alginate which are biodegradable, biocompatible and can undergo modification easily. Moreover, liposomes, micelles and other copolymer NPs were used for targeting the antibacterial agents such as peptides, triclosan and chlorhexidine. Fluoride loaded NPs based on the biopolymers like chitosan, pectin and alginate and with a 4-hour steady fluoride release was observed. Silica nanoparticles, microspheres, polymeric carriers, fullerenes, dendrimers and nanoplexes have been extensively used to load number of antibiotics. Antimicrobial hybrid designed by chemo-photothermal therapy which is dependent on polydopamine (PDA)-coated gold nanorods (GNRs) exhibited increased silver ion encapsulation efficiency and protective efficacy against drug-resistant Gram-positive methicillin- resistant Staphylococcus aureus (MRSA) or Gram-negative Escherichia coli. Hydrogels with high water withholding capacity, high biocompatibility, high drug loading rate play a vital role in the treatment of oral diseases. Currently, hydrogels were used on tooth surface and oral mucosa as bio-adhesive materials for controlled drug release. Injectable hydrogel based DDS have been widely used in the treatment of periodontitis and peri-implantitis. The liquid form of hydrogel is introduced into the periodontal tissue and after introduction into tissue, gel is formed due to sol-gel transition and controlled drug release has been achieved. The stimuli sensitive systems were developed for the first time in 1970 in the form of thermosensitive liposomes for the controlled release of drugs. Smart materials are sensitive to pH, temperature and enzymes of oral cavity and release therapeutics correctly. Photothermally sensitive DDS was developed using polyelectrolyte shell made by layer by layer positioning of negatively charged poly(-sodium 4-styrenesulfonate) and positively charged poly(allylamine hydrochloride) into which lysozyme crystal and Au NPs were incorporated. Irradiation of these capsules with a 10 ns pulsed laser (λ = 1064 nm) at 50 mJ cm-2 for 5 min at a frequency of 10 Hz before mixing with a suspension of Micrococcus lysodeikticus stimulated lysozyme release followed by bacterial digestion. Wealth of studies has shown the substantial therapeutic efficacy of smart materials in the treatment of infectious diseases. In addition, Surface functionalization with target moieties on nanoparticle surface enhances the localization of therapeutics in the target tissues and ameliorates. Numerous ligands have been discovered and which can span biological barriers such as blood brain barrier etc and deliver the therapeutic appropriately. The ligands tethered on the surface of the DDS not only carry the therapeutic loaded nanoparticles to the target tissue but also ensure their localization into the cell and eventually accomplish the enhanced therapeutic efficacy. The drug delivery systems currently in use provide enhanced therapeutic efficacy and lower side effects. However, a few shortcomings still exist which needs to be addressed by amalgamating the expertise from various scientific fields such as medicine, biochemistry, material science and chemistry. Eventually, it can be concluded that expertise from various subjects such as becomes a holy grail in the treatment of infectious diseases.