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Application of Nanotechnology in Drug and Gene Delivery

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Editorial Note

Despite recent advances in clinical research, the major problem faced by clinics is the lack of effective therapeutic approaches to treat various diseases. Most of the current therapeutic agents are water-insoluble leading to poor bioavailability, the least effect at the disease site, and severe therapy-associated side effects. Scientists from diverse parts of the globe are working hard in day and night to resolve these issues and improve the therapeutic benefits of the treatment. Recent years have witnessed unexpected growth in research in the area of nanotechnology [1]. The application of nanotechnology in drug and gene delivery has become attractive over the past few decades in health care and other fields [2]. There is increasing confidence that nanotechnology applied to medicine will significantly advance cancer diagnosis, treatment, and prevention. The growing interest in nanotechnology's future medical applications leads to the emergence of a new field called nanomedicine, aiming to maximize the therapeutic index, vastly expand the human lifespan, and minimize undesirable side effects [3]. However, to realize that potential, it needs to overcome several major hurdles, including improving circulation stability and disease site targeting efficacy.

Countless nanomedicines have been established using various organic and inorganic materials like lipids, polymers, metals, or their combinations with the desired physicochemical properties and biological functions to treat various diseases, such as cancer, diabetes, and neurodegenerative disorders [4]. Physicochemical parameters such as particle size, shape, surface charge, and surface ligand distribution are needed to be optimized using improved chemical methods to overcome biological barriers via the enhanced permeability and retention (EPR) effect. Compared to free drugs, nano formulated drugs exhibit improved pharmacokinetics, such as extended half-life time in the circulation, increased drug concentration at the disease site, and reduced normal tissue toxicity [5].

However, since the mid-nineties, only a few nano formulated drugs have been approved by the FDA [6], such as Doxil (a liposomal formulation of doxorubicin), the first nanomedicine approved in 1995 for cancer treatment. In 2005 Abraxane, the albumin-bound paclitaxel formulation) was approved, mainly for its reduced side effects in the treatment of solid tumors. Recently, the FDA approved ONIVYDE™ (Irinotecan liposome injection) to treat metastatic pancreatic adenocarcinoma in combination with other chemotherapy after gemcitabine treatment. Despite significant progress in the nanotechnology field, not many approved nano-formulated drugs are on the market [7]. Indepth characterization is often represented as a translational bridge over which every candidate nanomedicine must cross [8]. The most perilous step in nanomedicine evaluation is a comprehensive and well-documented classification of each material. Without a comprehensive understanding of the nanoformulations, its biological investigation can be easily misinterpreted. The physical, chemical, and biological features of each preparation must be rigorously assessed to avoid delays in reaching clinical testing [8]. Based on our experiences, there is a gap in understanding the complexity of nanotechnology-based therapeutics' development. Many different physical and chemical characteristics, including nanoparticle size, charge, surface chemistry, and hydrophobicity, must be fine-tuned for each application, and this tuning process requires a suite of skills and technologies that often must be developed iteratively. For example, the formula of "One size does not fit all" has to be considered in the field of nanomedicine [9]. Therefore, in the application of nanotechnology to drug delivery, nanocarriers design must be taken into consideration in the pharmacology of the delivered drugs, that is, to deliver the drugs to the right site at the right time at the right levels [10]. The ultimate goal of drug delivery systems' clinical use is to enhance drug efficacy while reducing unwanted side effects. Only by resolving these issues we can hope that nanotechnology-based nanomedicine will reach its full potential for improving healthcare when it can replace all the existing therapies and be part and parcel of newly invented therapies in the future.

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