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Nanomedicine for Targeted Drug Delivery Systems: A Mini-Review

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Abstract:

Nanomedicine is a recent advance presented via Freitas. When one applies a technology to medicine for molecular diagnosis and cure. Nanoscience should be fused with biology because the parts of a cell exist at a nano-level. It will allow for precise therapeutic approaches. Nanomedicine is very commonly heard these days and hence researchers are constantly engaged to make therapeutic interventions more efficient, safe, and effective. Nanomedicines are made using nanoparticles that are specifically designed for a particular purpose which can help them deliver drugs at the exact site. Recent research helps to quicken neglected diseases like malignancies and excessive concentration of medicines target operation on them. Nanomedicine for cancer therapy reduces unwarranted interactions at many sites in the body while increasing the availability of drugs at the target site. Nanoparticles could deliver drugs to lung granuloma in TB-type ailments not getting killed by the macrophage. Nanoparticles could be engineered with specific features to improve patient outcomes. We are improving our knowledge of nanotechnology which will be done in the clinic regularly. Nanomedicine is getting better with time. We will soon witness precision medicines and prolonged applications so as to get rid of an infectious disease which can be fatal.

INTRODUCTION

Throughout the history of medicine, drug delivery systems have been gradually and significantly developed from ancient medicinal herbs to current sophisticated formulations to treat a wide range of diseases (Panda *et al.,* 2014; Salvati and Poelstra, 2022). However, the conventional dosage forms could not serve successfully those patients requiring long-term therapy, better therapy, early diagnosis, biopsy, and detection and prevention of cancer, etc. (Sahu *et al.,* 2021). Because, the traditional drug delivery systems lost only less than one percent of the total administrated drugs to the desired sites, and the remaining bulk of the administrated dose was dispersed all over the body either in bound or unbound form resulting in serious toxic side effects (Sonamuthu, 2019). People are suffering and even die due to these side effects in long-term usage. To overcome these problems, advanced drug delivery systems for controlled and targeted drug delivery have been developed in recent years (Emeihe *et al.,* 2024). The nanotechnology-based drug delivery systems are regarded as an alternative to conventional drug delivery systems, as they can enhance the transport through various biological barriers, extend the drug blood circulation half-life, minimize the systemic administrations, improve the therapeutic efficacy, bioavailability, reduction in dose, compliance, dispersion, and minimal side effects, especially for anticancer drugs and diagnostic as well as the therapeutic agents for the detection and prevention of the life-threatening diseases (Cheng *et al.,* 2023; Prakash, 2023).

Diseases associated with the central nervous system (CNS) and neurodegenerative disorders are one of the major problems of the healthcare system because of the high mortality and low accurate diagnosis rate with conventional devices (Domingues *et al.,* 2022). Therefore, it's better to have nanodevices that can target the defect tissues directly and provide therapy or real-time diagnosis (Abdel-Mageed *et al.,* 2021). Concerning this, nanotechnology was applied in treating diseases that are obstinate (for example, tumors) through the controlled drug delivery of nanodrugs, even poorly absorbed drugs (Rasool *et al.,* 2022). In the drug delivery fields, 'nanomedicine' denotes the utilization of nano-ranged entities for the therapeutic purpose after functional screening to target therapy that can control the drug release. As a result, these molecular-based treatment options could play a vital role in the field of life science (Wang and Zhang, 2023). Nanomedicine embraces three dimensions in the therapeutic area, which are regenerative medicine, nano-based drug delivery, and nano therapy and molecular imaging. Thus, in the era of modernizing technology, nanoscience and nanotechnology are condensed to address challenges in the modern healthcare system (Gholami *et al.,* 2024). Thus to fulfill the requirements of the modern healthcare system the nano-designed drugs for the needs are consolidated to form 'NANOMEDICINE'. Nowadays, nanotechnology is used as a tool to diagnose the disease in its early stages. It is possible through biosensors and biochips, which in general consist of biological material (Chehelgerdi *et al.,* 2023).

Nanotechnology in Drug Delivery Systems

The imaginative design and exploitation of systems created with precisely defined materials, structures, and shapes at the nanometer scale are the footing of nanotechnology. Nearly all biological mechanisms occur on a molecular level and on the nanometer scale (Sohail *et al.,* 2021). By using this technology, one might imitate natural processes. For pharmacy, this means the possibility to influence fundamental processes like the release of active agents by embedding, for example, drug substances in artificially created nanoparticles (De *et al.,* 2022; Iqbal *et al.,* 2021). For many applications, it is desired to interfere with natural processes by administrating foreign substances or to introduce new effects which do not take place in nature. This is expected to bring a true revolution also in medical treatments (Malik *et al.,* 2023; Zhang *et*

al., 2024). A new chemistry, often behaving differently, is traditionally not possible on the macroscopic or even microscopic scale (Si *et al.,* 2024).

The assumption of new, unique properties arises from the knowledge that material properties and biological activities are determined from an atomic/molecular level, where most entities take place on the nanometer scale (Sonamuthu, 2019). Nanocarriers are systems that wrap up drug substances and can be viewed as reservoirs to release the existing issues at a desired rate (Si *et al.,* 2024). Several different kinds of materials have been employed to obtain nanoparticles (Iqbal *et al.,* 2021; Selim *et al.,* 2017). Still, polymers remain the preferred choice (Sonamuthu, 2019). Nanoparticles with their potential medicinal applications could be used to deal with life-threatening diseases (Ashraf and Iqbal, 2021; Iqbal, 2019, 2020, 2021). Nanoparticles consist of hydrophobic molecules and can either be liquid with a polymer envelope or solid with the polymer/monomer blended in solid form. On the one hand, considering the carrier vector, the particle aspect should be taken into account since the entire pharmacological properties are size-dependent (Li *et al.,* 2024). On the other hand, the packaging effect should be evaluated it is important to analyze how much time the drug remains inside the carrier before its release (Afzal *et al.,* 2022). For poorly (or not at all) water-soluble drugs, the use of carriers in drug delivery is advantageous since it allows the drug to be dissolved in the oil phase and placed into the nanoparticle nucleus. Hence, its stability is increased by decreasing the contact with the outside environment. The packaging effect is greatest, the smaller the carrier is (Li *et al.,* 2024). To ameliorate this effect, the drug can be encapsulated in carriers of different dimensions and with a broad noteworthy distribution. After the encapsulation into polymeric selected systems, drug substances are released more easily and rapidly. Little nanoparticles are also removed from endothelial pores and taken through the macrophagic system (Wang *et al.,* 2024). Once internalized by cells, nanoparticles are accumulated into closed-end packages that do not facilitate the release of the drug. On the other hand, one can obtain carriers which are able to adhere to specific tissues and hence obtain a targeted administration. Decreasing the dimensions of the carriers is likely to enhance the contact with cells' surfaces and can result in increased uptake by its phagocytic apparatus. Ultimately, the size of the carrier system is a crucial factor in its workings. Apart from the size, the surface properties play a crucial role too. Since the particle's surface is the actual broker of the interaction with the body environment. Carriers should be adequately designed to evade recognition and hence the macrophagic uptake (Zhao *et al.,* 2022). However, other kinds of carriers do not display relevant aspects and thus are not ruffed by foreign cells. From this perspective, the uncovered phenomenon can be envisaged only in nanoparticulate systems (Wang *et al.,* 2024). At the same time, this aspect brings about new considerations. One has to be careful about the packaging material used. The surface has to be adequately coated to evade recognition and thus the macrophagic clearance (Li *et al.,* 2024). The carrier's surface has also to be tailored for prolonged circulation in primary fluids. From these perspectives, a general indication of the shape seems impossible. All in all, the specific pharmacological effects have to be evaluated from case to case and adequate considerations have to be drawn (Afzal *et al.,* 2022).

In considering the development and evaluation of new possibilities, the general direction should be the revolution in the definition and testing of risks linked to the nanomedicine field. It is an undeniable fact that one's expectations often face a gap with reality (Sonamuthu, 2019). It is the under-development of concerns about the possible side effects and/or problems arising from the use of nanocarriers and substances for biological applications (Zhang *et al.,* 2024). Regulatory agencies worry because they consider the responsible definition and fulfillment of the related safeguards as impracticable (Sonamuthu, 2019). Hence, a rapid spread does not occur. Promptly increasing knowledge in the

field will bring awareness of the potential problems (Zhang *et al.,* 2024). However, the perception of risks is lower for nanoparticles than for the chemicals used in classical pharmaceutical sciences or other contexts (De *et al.,* 2022). Yet, attention should be placed on advanced technological investigation in order to develop and have appropriate protocols and surrogate materials for safety evaluations (Zhao *et al.,* 2022).

Targeted Drug Delivery Systems

Given the increasing incidence of cancer and intensified living pressures, an increasing number of life-threatening diseases are emerging, laying a more severe burden on human health. Therefore, it is very important to design and fabricate highly efficient and biocompatible nanocarriers for targeted drug delivery (Singh *et al.,* 2023). Recently, many designs and approaches have been proposed to fabricate hierarchical nanostructures with inorganic materials for drug delivery (Xue *et al.,* 2021). On one hand, it can improve the loading and protection efficiency of drugs; on the other hand, it can realize accurate treatments (Iqbal *et al.,* 2021; Hu *et al.,* 2022). However, there are still some technical challenges, including toxic and immunogenic, difficult degradation, and removal of inorganic nanomaterials in our bodies (Iqbal *et al.,* 2021; Al-Thani *et al.,* 2024). With the rapid development of nanotechnology, small-sized inorganic nanoparticles (NPs) that can biodegrade into small molecules or ions are urgently needed (Varzi *et al.,* 2021; Sargazi *et al.,* 2022). Furthermore, it is very vital to optimize the internal design with high efficiency, large capacity, and green routes (Sargazi *et al.,* 2022; Tian *et al.,* 2022). It is crucial to reasonably choose the cavity sizes for constructing doxorubicin (DOX) delivery systems to improve the drug-loading capacity, biological stability, and anti-cancer effect on MCF-7/ADR (Zhang *et al.,* 2021; Ansari *et al.,* 2022). Safe therapy necessitates the design and preparation of therapeutic agents with extremely targeted performance to enhance the therapeutic index and protect cells (Li *et al.,* 2023).

Development of a drug designed to moderate disease is tough due to the multifaceted nature of the disorder (Shah *et al.,* 2021). Nanocarrier-mediated targeted drug distribution is a major challenge to moderate illnesses and has numerous advantages compared with traditional drugs (Taliyan *et al.,* 2022). For instance, selective targeting of nanocarriers decreases the consumption of high doses of medicines, improves safety to normal human tissues, reduces the liver first-pass clearance of drugs during systemic administration, and enhances the dose of drug uptake and effectiveness at the target site (Wang *et al.,* 2021). Nanocarrier owns the better safety and efficacy to penetrate the BBB and aim at particular tissues or cells (Liu *et al.,* 2024). In addressing potential inadequacies in the RB and improving frequency management, it is crucial to explore recent advancements in the targeted distribution of encapsulated drug nano-carriers (Qu *et al.,* 2022). This research aims at defining key drafting issues so that the submitted works are chosen for publication. Moreover, established and refined experimental analysis is provided to address these issues. Given the complexity of AEs, disease-induced biological barriers are also briefly addressed (Addissouky, 2024). The proposed approaches and strategies for targeting drug delivery are introduced (Adetuyi and Vega, 2024).

CONCLUSION

Nanomedicine is an emerging multi-disciplinary field covering medical, pharmaceutical, and materials sciences, as well as research at the interface between biology and physics, chemistry, and engineering. Outstanding developments in nanotechnology and nanoscience have cascaded a lot of attention in various scientific and technological fields and have led to the formation of numerous nanotechnology and nanoscience-based companies. With this current rate of expansion, nanotechnology and especially innovative applications in medicine could transform drug

development and therapy, diagnostics, and other areas of patient care. Besides conventional uses of nano-related materials (such as nanoparticles, nanocapsules, liposomes, nanoscaled polymer, or micelles) some novel approaches have also emerged. Nanotechnology has become an interesting area for engineers and physicists who are exploring the interactions between biological molecules and inorganic surfaces and are developing analytical tools useful for life science research. In 2004, the global market for nanomedicine had a value of US$6.8 billion, a sum forecast to grow considerably to $150 billion by 2015. This paper describes how the application of nanomedical strategies in the developing field of drug delivery systems can significantly increase drug efficacy through improved pharmacokinetics and biodistribution within the organism, and decrease the side effects of the administered drug. However, despite the great progress achieved recently, multiple challenges remain to be addressed. Special emphasis should be put on enhancing the biocompatibility and safety of the nanostructures along with elucidating their potential risk to human health. Engaging multidisciplinary collaboration in the field, among for example pharmacists, toxicologists, health care specialists, material scientists, and physicists, may help to achieve success.

CONFLICT OF INTEREST

Author of this article wish to declares no conflict of interest.

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