Perspective

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American Journal of Computer Science and Information Technology
ISSN 2349-3917

2023
Vol.11 No.1:005

Applications of AI-Enabled Nanomedicines in Cancer Management and their Application in Diagnosis, Monitoring and Therapy

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Received date: December 26, 2022, Manuscript No. IPACSIT-23-15956; **Editor assigned date**: December 28, 2022, PreQC No. IPACSIT-23-15956 (PQ); **Reviewed date:** January 11, 2023, QC No. IPACSIT-23-15956; **Revised date:** January 18, 2023, Manuscript No. IPACSIT-23-15956 (R); **Published date:** January 26, 2023, DOI: 10.36648/ 2349-3917.11.1.5

Citation: Li F (2023) Applications of AI-Enabled Nanomedicines in Cancer Management and their Application in Diagnosis, Monitoring and Therapy. Am J Compt Sci Inform Technol Vol. 11 No.1:005.

Description

The diagnosis and treatment of diseases in nanomedicine have advanced at a rate never before seen. The clinical transition of nanotechnology-modified medicines from the bench to the bedside has been demonstrated by the approval of several nanomedicines for clinical use. By enabling the acquisition and analysis of large datasets and the customization of precision nanomedicines for the management of cancer, the application of Artificial Intelligence (AI) in the production of products based on nanotechnology has the potential to revolutionize the healthcare industry. By tuning the properties of nanomedicines, achieving effective drug synergy, and reducing nanotoxicity, AI-enabled nanotechnology could enhance the targetability, personalized dosing, and treatment potency of nanomedicines, as well as improve the accuracy of molecular profiling and early patient diagnosis. Cancer is still the leading cause of death worldwide, and the cost of treating it is high. After decades of research, significant advancements in the treatment of cancer patients have been made, including target therapy, immunotherapy, and combinational therapy, despite the disease's high mortality rate. However, the abnormal Extracellular Matrix (ECM) in solid tumors prevents the penetration of therapeutic components or immune cells, and the current treatments for cancer have their own side effects. To address these limitations, recent efforts have been made to develop anticancer nanomedicines. For diagnosing, monitoring, and treating diseases, nanomedicines combine nanotechnology and medicine. They can be administered to patients in a clinical setting or incorporated into biological machines, nanobiosensors, and medical biodevices. The fields of engineering, physics, chemistry, life science, and clinical practice all intersect in the field of cancer nanomedicine. By (i) combining multiple therapeutic molecules to exert a synergistic anti-tumor effect, (ii) realizing multiple modalities with different mechanisms of action (for example, combining chemotherapy with photodynamic therapy), (iii) maximizing the antitumor efficacy while reducing drug doses and toxicity, (iv) improving drug targeting and tissue permeability, overcoming various biological barriers, and controlling drug release at a specific site and biodistribution throughout the body

Potential of Nanomedicines in the Healthcare System

At the moment, a lot of research has been done on using nanomaterials to diagnose, monitor, control, prevent, and treat diseases. For instance, a number of nanomedical products have entered the global market and have been utilized to treat a variety of cancers, such as ovarian cancer, breast cancer, lung cancer, pancreatic cancer, acute myeloid leukemia, and others. The European Medicines Agency (EMA) and the U.S. Food and Drug Administration (FDA) have granted marketing approval to approximately 80 nanomedicines since 1989. The immense potential of nanomedicines in the healthcare system is exemplified by the extensive pipeline of drugs currently in various stages of development. In addition, nanomedicine-derived biodevices and biosensors have been used for early disease detection, patient profiling, and treatment-related monitoring. Nanopore sequencing and single-molecule real-time sequencing, for instance, enable the direct imaging and detection of single DNA molecules without the need for amplification, significantly increasing the accuracy of DNA analysis. In comparison to conventional biosensors, nanosensors made from nanomedicines have lower detection limits and a higher sensitivity. Cancer treatment has become increasingly data-intensive and personalized in tandem with advances in biology, medicine, and nanotechnology. To accomplish better restorative impact and lower poisonousness, the qualities of people should be explicitly thought of, and the improvement of helpful medications or mix treatment ought to be around the world upgraded toward the start of plan. In order to achieve precision medicine treatment, Artificial Intelligence (AI) and related technologies have been widely used to analyze data from multiple sources and dimensions. The goal of Artificial Intelligence (AI), a subfield of computer science, is to use computers or machines controlled by computers to carry out intricate tasks that call for "human intelligence." Artificial general intelligence, artificial narrow intelligence, and artificial super intelligence are the three broad categories of AI. Machine Learning (ML), Artificial Neural Networks (ANN), and Deep Learning (DL) are examples of AI subfields.

Interactions between Nanocarriers and their Incorporated Drugs

According to reports, AI-enabled methods are frequently utilized in the fields of medicine and life science. Some examples include the early detection of pandemic disease outbreaks, radiological and histological diagnosis, muti-omics analysis for establishing molecular profiles, and detecting minute variations in the concentration of biological species or chemical compounds from the baseline. By taking into account the integration of multimodal mechanisms of action and the realization of their synchronous therapeutic effects, the design of nanomedicines typically entails a great deal of complexity. The characteristics of nano-carriers and their corresponding nanomedicines, in addition to the evaluation of physical and chemical properties, cytocompatibility and hemocompatibility, pharmacokinetics, and potential interactions of loaded drugs, are required. To ensure that nanomedicines are as safe and effective as possible, it is necessary to take into account their interactions with tumor cells, including their internalization, response to the tumor microenvironment, intracellular distribution, and therapeutic actions. Despite the fact that the integration of AI and nanomedicines is still in its infancy, AI has the potential to play a crucial role in these processes. AI algorithms can help optimize nanopharmaceutical formulations to improve the transport and targeting of nanomedicines by predicting interactions between nanocarriers and their incorporated drugs, biological mediators, or cell membranes, estimating drug encapsulation efficiency, and modeling drug release kinetics from nanocarriers. Additionally, AI-enabled strategies enable the selection of drug combinations and the global optimization of combination therapy in order to achieve drug synergy while lowering toxicity and ultimately enhancing clinical outcomes. ML algorithms and nano-scale biosensors can also be used to predict disease outbreak or recurrence, distinguish patients with diseases from healthy volunteers, and discover novel biomarkers and therapeutic targets. We describe how AI algorithms are used in these nanomedical approaches and provide an overview of how nanotechnologies are used at all stages of the development of precision cancer medicine, including molecular profiles, diagnostics, and treatment.