Transactions on Materials, Biotechnology and Life Sciences
ISSN: 2960-1932, eISSN: 2960-2319 | Volume 2
BBBS 2023

Application and prospect of novel nanomedicine in cancer therapy

Lijie Qiao
The Australian National University, Australian

Abstract. With the rapid development of nanotechnology, the application of new nanodrugs in cancer treatment has gradually become a research hotspot. In this paper, we explore the design principles, preparation methods and their anticancer effects in vitro and in vivo, and explore potential clinical applications. The results show that nanomedicine improve the therapeutic effect and reduce the side effects by achieving accurate delivery and controlled release of drugs, providing a new solution for cancer treatment. In terms of design principles, nanomdrugs mainly make use of unique properties such as small size effects, surface effects and quantum size effects of nanomaterials to combine drug molecules with nanocarriers to achieve precise delivery and controlled release of drugs. In terms of preparation methods, physical, chemical and biological methods are used to prepare nanoscale drugs with different morphology and structures. In vitro and in vivo experiments showed that nanomedicines can significantly increase the concentration of the drug in the tumor cells, enhance the therapeutic efficacy, and reduce the toxicity to normal tissues. However, nanomedicine still face many challenges in the field of cancer therapy. Looking ahead, with the continuous advances in nanotechnology, it is reasonable to believe that nanomedicine will play a greater role in the field of cancer therapy. Through in-depth study of the mechanism of action of nanomedicine, optimizing the preparation process, improving the precision of the controlled drug release system, and focusing on the biological safety issues, we are expected to bring safer and more effective treatment methods for cancer patients. At the same time, the combined application of nanomedicine and other therapeutic means such as immunotherapy and gene therapy will also become a research hotspot in the future, providing more comprehensive and personalized treatment options for cancer treatment.

Keywords: nanodrugs; cancer; gene therapy.

1. Foreword

Cancer, as a major health problem affecting the world, has long plagued the medical community and patients. Although the traditional chemotherapy methods have achieved some effects in inhibiting tumor growth, they have obvious side effects, such as drug resistance, toxicity and so on, which bring great pain to patients. Moreover, normal tissues are often also damaged due to the non-specific distribution of drugs, which limits the use dose of chemotherapeutic drugs and therapeutic efficacy. Therefore, the development of new and highly efficient anticancer drugs has become an urgent demand.

In recent years, the rapid development of nanotechnology has provided new ideas for the research and development of anticancer drugs. As an emerging anti-cancer means, nanomedicine realizes the precise delivery and controlled release of drugs through nanotechnology, which is expected to solve the existing problems of traditional chemotherapeutic drugs. Nanodrugs have unique physicochemical properties, such as small size effects, surface effects, and quantum size effects, which give them significant advantages in drug delivery, targeted therapy, and controlled drug release.

First, the small size of nanopedicine enables them to penetrate the vascular wall of tumor tissue and enter the interior of tumor cells to achieve accurate drug delivery. Secondly, the surface of the nanomedicine can be functionalized to have an active targeting function, further increasing the concentration of the drug in the tumor cells. In addition, nanodrugs can also achieve slow drug release through a controlled release system, prolong the half-life of the drug in the body, and improve the therapeutic effect.

Therefore, nanomedicine is promising in cancer treatment. This paper aims to explore the application and prospect of new nanomedicine in cancer treatment, and provide new solutions for cancer treatment by deeply studying the design principle, preparation method, in vitro and in vivo anti-cancer effects and potential clinical applications. At the same time, we will also analyze the challenges and nanomedaceuticals' future directions to provide reference for future research.

one. Design principle and preparation method of nanomedicine

(1) Design principle

The design principle of nanomedicines is based on the unique physical ochemical properties of nanomaterials, which confer significant advantages in drug delivery and controlled release. First, the small size effect of nanopedicine enables them to penetrate the vascular wall of tumor tissue and enter the tumor cells to achieve accurate drug delivery. This penetration ability overcomes the difficulty of the traditional drugs to enter the tumor tissue, thus improving the concentration and therapeutic effect of the drugs in the tumor cells.

Second, the surface and quantum size effects of nanomedines offer the possibility of drug binding with nanocarriers. By selecting a suitable nanocarrier, such as liposomes, polymer nanoparticles, and inorganic nanoparticles, the drug molecules and the nanocarrier can be tightly combined to form a stable drug delivery system. These nanocarriers can protect drug molecules from the in vivo environment and improve drug stability and bioavailability.

Moreover, active targeting function can be conferred by functionalizing nanodrug surfaces. For example, attaching specific ligands or antibodies on the surface of a nanomedicine enables them to specifically bind the receptor to the surface of tumor cells, thus enabling active targeted delivery of the drug. This active targeting function could further increase the concentration of drug in tumor cells, reduce the distribution in normal tissues and reduce side effects.

In conclusion, the design principle of nanomedicine is based on the unique properties of nanomaterials, and through the selection of appropriate nanocarrier and surface modification, to achieve precise delivery and controlled release of drugs, improve the therapeutic effect and reduce side effects. This provides new solutions for cancer treatment and provides new ideas for future drug development.

(2) Preparation method

The preparation method of nanomedicine is varied, including physical, chemical, and biological methods. The choice of these methods depends on the nature of the drug, the type of nanocarriers, and the requirements of the preparation process.

Physical method mainly uses physical means to combine drug molecules with nano carrier, such as grinding, crushing, etc. These methods are suitable for the preparation of large-scale nanodrugs, but they may cause damage to the drug molecules and affect the activity and stability of the drug. Chemical method combines drug molecules with nanocarrier through chemical reaction, such as precipitation method, sol-gel method, etc. These methods can prepare nanodrugs with specific morphology and structure, but require strict control of reaction conditions to avoid producing toxic substances or affecting the activity of the drug. Biological laws use biomaterials or biological processes to prepare nano-drugs, such as microbial synthesis, plant extraction, etc. These methods have the advantages of being environmental-friendly and sustainable, but have longer preparation cycles and low yields. The stability and controllability of the nanomedicine should also be considered when preparing them. Stability is the key to ensure the stability and efficacy of nanomedicines in the body, while controllability refers to the ability to accurately control the release rate and release location of the drug.

In conclusion, the preparation methods of nanomedicine are diverse, which need to be selected according to the properties of the drug, the type of nanocarrier, and the requirements of the preparation process. Meanwhile, the stability and controllability of nanodrugs need to be considered to ensure their efficacy and safety in vivo.

2. Application and effectiveness of nanomedicine in cancer therapy

(1) Chemotherapeutic nanoscale drugs

Chemotherapeutic nanomedicines are a great application of nanotechnology in cancer therapy. Delivery of chemotherapeutic drugs to the interior of the tumor cells by nanocarrier can significantly increase the concentration of the drugs in the tumor cells, thus enhancing the effect of chemotherapy and reducing the side effects. For example, paclitaxel nanoparticles wrap paclitaxel drugs inside the nanoparticles by nanotechnology to deliver the drug to the tumor cells through passive or active targeting. Due to the small size and special surface properties of nanoparticles, precise positioning and drug release to tumor tissues can be realized, thus increasing the concentration of paclitaxel in tumor cells, enhancing the effect of chemotherapy, and reducing the distribution of drugs in normal tissues and reducing side effects.

In addition to paclitaxel nanoparticles, there are many other chemotherapeutic nanodrugs, such as doxorubicin liposomes, cisplatin nanoparticles, etc. Doxorubicin liposomes act through the wrapping of the liposome, and deliver the drug to the interior of the tumor cells through the targeting of the liposome. This drug delivery method can reduce the distribution of doxorubicin in normal tissues and reduce its toxicity to normal tissues, while increasing the concentration of drugs in tumor cells and enhancing the effect of chemotherapy.

(2) Nanomedicine of radiotherapy

Radiotherapy nanomedicine is another application of nanotechnology in cancer therapy. Delivery of the radiotherapy sensitizer to the interior of the tumor cells by nanocarriers can enhance the radiotherapy effect and reduce the damage to the normal tissue. For example, gold nanoparticles can absorb X-rays and convert them into high-energy electrons and photons, thus increasing the sensitivity of tumor cells to radiotherapy. When the gold nanoparticles are delivered to the interior of the tumor cells, the sensitivity of the tumor cells to radiotherapy is enhanced, making the radiotherapy effect better. In addition, the magnetic nanoparticles can achieve the precise positioning of the tumor tissue and improve the accuracy of radiation therapy under the action of the external magnetic field. This precise positioning can reduce the damage to normal tissue and improve the safety of radiotherapy.

(3) Photodynamic therapeutic nanopedicine

Photodynamic therapeutic nanomedicine is an emerging cancer therapy. The photosensitizer is delivered to the tumor cells by nanocarrier, producing reactive oxygen species under light conditions and thereby killing the tumor cells. This method has the advantages of no trauma and no drug resistance, providing new options for cancer therapy. For example, certain photosensitizer nanoparticles can deliver drugs to the internal tumor cells through active or passive targeting. Under light conditions, photosensitizers absorb light energy and produce reactive oxygen species, which can destroy the structure and function of tumor cells, thus killing tumor cells. Due to the high selectivity and precision of photodynamic therapy, it is possible to reduce the damage to normal tissue and improve the safety of the treatment.

In conclusion, significant progress has been made in the application of nanodrugs in cancer therapy. Different types of nanomedicine, such as chemotherapy, radiotherapy and photodynamic therapy, offer new options and solutions for cancer treatment. However, the application of nanomedicine in cancer treatment still faces some challenges and problems, such as the safety, stability, and preparation process of nanomedicine, which require further research and improvement.

3. Clinical applications and challenges of nanomedicines

(1) Clinical application

In recent years, with the rapid development of nanotechnology, more and more nanodrugs have entered the clinical trials and achieved remarkable results in some cancer treatments. The success of these clinical trials provides strong support for the clinical application of nanomedicines.

Some cutting-edge nano-drugs, such as paclitaxel nanoparticles and doxorubicin liposomes, have shown significant therapeutic results in clinical trials. Through precise delivery and controlled release, these nanodrugs increase the concentration of drugs in tumor cells, enhance the effect of chemotherapy, and reduce the toxicity to normal tissues. Moreover, some radiotherapy nanomedicine and photodynamic therapeutic nanomedicine have also achieved good results in clinical trials, providing new options for cancer treatment.

However, despite their certain achievements in clinical trials, nanoscale drugs still face many challenges and problems in their clinical application.

(2) Challenges

Stability of preparation process: At present, the instability of nanomedicine preparation process still exists, which leads to it difficult to guarantee the quality and safety of drugs. Therefore, how to further improve the stability of the preparation process and ensure the quality and safety of nanomedicine is an important challenge for the clinical application of nanomedicine.

Precision of controlled release system: controlled release system of nano drugs is the key to realize accurate drug delivery and controlled release. However, the current drug controlled release system still has the problem of insufficient precision to achieve the precise release of drugs in tumor cells. Therefore, how to strengthen the precision of controlled drug release system and improve the concentration and therapeutic effect of drugs in tumor cells are the key problems to be solved in the clinical application of nanomedicine.

Biological safety problem: As a new type of drug delivery system, the biological safety problem of nanodrugs has attracted much attention. Although some nanomedicine show a good safety profile in clinical trials, their potential biological toxicity needs to be thoroughly studied and evaluated. This includes aspects of its distribution, metabolism, excretion, and potential effects on normal tissues. Only the biological safety of nanomedicine can be fully evaluated to ensure its safety and efficacy in clinical applications.

Clinical application feasibility: Although some achievements have been made in clinical trials, the feasibility of their clinical application still needs to be further studied and verified. This includes problems regarding the therapeutic effect, applicable population, administration mode, and dose optimization of nanodrugs in different types of cancer. Only after the full study and validation can determine the feasibility and advantages of nanomedicine in clinical application.

In conclusion, the application of nanodrugs in cancer therapy is promising, but they still face many challenges and problems. In order to further promote the clinical application and development of nanomedicine, it is necessary to continuously strengthen the research and innovation, and improve the stability of the preparation process, the precision of the drug controlled release system, and the level of biological safety. At the same time, more international cooperation and exchanges are needed to jointly promote the development and application of nanomedicine in the field of cancer therapy.

4. Conclusions and outlook

With the rapid development of nanotechnology, the application prospect of new nanometer drugs in the field of cancer therapy is increasingly broad. Through unique design principles and preparation methods, these nanodrugs show incomparable therapeutic advantages of traditional drugs. They can not only improve the concentration of drugs in tumor cells, achieve accurate delivery and controlled release of drugs, but also reduce side effects to a certain extent and improve the therapeutic effect.

However, we must also recognize that nanomedicine still faces many challenges and problems in the field of cancer therapy. First, although we have achieved some encouraging clinical trial results, the mechanism of action of nanomedicine still needs more intensive research to better understand their therapeutic effects and possible risks. Secondly, the precision of the preparation process and the controlled release system remains to be improved to ensure the quality and safety of drugs. In addition, the biological safety of nanoscale drugs in vivo is also something that we must be highly concerned about.

Looking ahead, we look forward to addressing the challenges and problems facing nanomedicines in the field of cancer therapy through continuous research and innovation. We look forward to developing safer and more efficient nanodrugs that provide better treatment options for cancer patients. At the same time, we also expect that nanomedicine can be combined with other treatments such as immunotherapy and gene therapy to form a more comprehensive and personalized treatment plan, and further improve the effect and survival rate of cancer treatment.

In conclusion, the application prospect of new nanomedicine in the field of cancer therapy is promising, but it still requires our continuous efforts and innovation. We expect that in the near future, nano-drugs can become an important weapon in cancer treatment, bringing hope and recovery to more cancer patients.

References

[1] High bell pick. Application and prospect of novel drug delivery system technology in drug research and development [J]. Journal of China Pharmaceutical University, 2023,54 (01): 1-4.

[2] Zhou Shijie, Zhao Ying, Niu Rui and so on. Novel degradable nanodrugs ZnO_2@Fe~ (3 +) -TA @ PVP for the chemokinetic treatment of tumors [J]. Journal of Chemistry of Higher Education, 2022,43 (12): 315-323.

[3] Zhang Siqi, Li Ke, Jia Xiaoyan and so on. Construction of self-assembled novel nanomedicine and evaluation of its targeted therapeutic effects in preeclampsia [J]. Journal of the Army Military Medical University, 2022,44 (12): 1187-1198. DOI:10.16016/j.2097-0927.202201174.

[4] Zhang Hongyuan, Sun Shengnan, Wang Chen, et al. Progress in the use of novel nano-drug delivery systems for thrombosis diagnosis and treatment [J]. Journal of Shenyang Pharmaceutical University, 2022,39 (06): 760-772. DOI:10.14066/j.cnki.cn21-1349/r.2021.0996.

[5] Huang Jing, Zou Junna, Ren Huanhuan, etc. Novel strategies to promote tumor penetration of anticancer nanodrugs [J]. Journal of Pharmacy, 2022,57 (06): 1758-1770. DOI:10.16438/j.0513-4870.2021-1330.

[6] Chen Jie, Cao Ye, Li Shuangshuang, etc., et al. Progress in developing novel nanomedicine delivery systems for tumors [J]. Chinese Journal of Pharmacy, 2020,55 (21): 1749-1756.