REVIEW ARTICLE

Cancer and its Prevalent Treatment Strategies – A Review

Gauri S Niwal, Rahul G Ingle*

Datta Meghe College of Pharmacy, Datta Meghe Institute of Higher Education & Research (DMIHER), Deemed to be University, Sawangi, Wardha, India.

Received: 27th July, 2024; Revised: 12th August, 2024; Accepted: 19th August, 2024; Available Online: 31st August, 2024

ABSTRACT

One of the main forms of cancer treatment is chemotherapy. Chemotherapy failure is a common occurrence, primarily because of dose-limiting toxicity linked to medication resistance. Effective treatment resistance management is essential for chemotherapy to be successful. Numerous reports in Chinese literature suggest that organic materials can overcome medication resistance in cancer cells, and these findings should be shared with scientific and industrial groups. The reports were condensed into four categories by us: 1. research on cell line models *in-vitro*; 2. serum pharmacokinetics; 3. *in-vivo* research employing animal models; and 4. clinical research. For the first time, antidrug resistance activity was found in 14 single compounds. Drugs have been proven to overcome drug resistance *in-vitro* in a dose-dependent manner by blocking drug transporters, cell detoxification ability, or cell apoptosis sensitivity, even at nontoxic and subtoxic concentrations. Research conducted *in-vivo* revealed that herbal extracts, single components, and formulations all exhibited strong antidrug resistance properties. A significant number of individual chemicals, herbal extracts, and combinations have been applied in clinical settings to treat a range of illnesses, including cancer. Comprehensive information on the utilization of natural compounds in China to combat drug resistance in cancer cells is provided by this review, which could help in the creation of organic substances for the therapeutic treatment of drug resistance in cancer patients.

Keywords: Nanobiopolymer, Nanodrug, Drug delivery, tumor multidrug resistance.

International Journal of Pharmaceutical Quality Assurance (2024); DOI: 10.25258/ijpqa.15.3.101

How to cite this article: Niwal GS, Ingle RG. Cancer and its Prevalent Treatment Strategies – A Review. International Journal of Pharmaceutical Quality Assurance. 2024;15(3):1754-1757.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

A serious health risk is cancer. With 21% (a rate of million) of all deaths occurring from it in developed nations, cancer ranks as the second most common cause of death. Cancer is third among all causes of mortality in developing nations, accounting for 9.5% (4.8 million) of total deaths. Globally, there were about 12.7 million new cases of cancer and 7 million fatalities related to the disease in 2008. The World Health Organization (WHO) projects that there will be 17.5 million annual cancer deaths and 27 million new cancer cases by the year 2050.[1-3]

Despite the significant advancements in cancer prevention, detection, and therapy over the past few decades, cancers still have the potential to develop multidrug resistance or resistance to chemotherapy.

Cancer accounted for nearly 10 million deaths globally in 2020 and remains the second leading cause of death in the United States, behind cardiovascular disease. Laboratory tests, the primary methods of treating cancer have been surgery, radiation therapy, chemotherapy, and immunotherapy. While imaging and biopsies are frequently used to diagnose cancer, the main methods of treatment have been immunotherapy, radiotherapy, and chemotherapy. Over the past three decades, advances in cancer detection and treatment have resulted in a continuous decline in the overall mortality rate among cancer patients in the United States. However, even with the rise in cancer survivorship and a reduction in the mortality rate for many commonly diagnosed cancers (such as lung, prostate, and colorectal cancers), the number of annual deaths from cancer remains high and reached approximately 600,000 in the United States alone in 2020. As a result, there is still an urgent requirement to improve upon electricity screening approaches to achieve earlier detection.

Therapeutic Efficacy

The primary methods of treating cancer have been surgery, radiation therapy, chemotherapy, and immunotherapy. While imaging and biopsies are frequently used to diagnose cancer, the main methods of treatment have been immunotherapy, radiotherapy, and chemotherapy. Over the past three decades, advances in cancer detection and treatment have resulted in a continuous decline in the overall mortality rate for cancer

*Author for Correspondence: rahul.pharmacy@dmiher.edu.in

patients in the United States. However, even with the rise in cancer survivorship and a reduction in the mortality rate for several common cancers (such as the breast, prostate, and colorectal cancers), the number of annual deaths from cancer remains high and reached approximately 600,000 in the United States alone in 2020. As a result, there is still an urgent requirement for upgrades to current evaluation approaches to achieve earlier detection.[4,5]

The best chance of a cure is frequently offered by early cancer diagnosis. The current cancer diagnosis techniques frequently discover the dangerous tissue or tumor once it has progressed and spread.

Cancer Therapy

A number of issues with traditional cancer treatments, such as the drugs' non-specific distribution to good organs and tissues and their ineffective accumulation in tumor tissues, have been addressed by surface-engineered nanoparticles, which have aroused intense interest. Significant advancements in the creation, testing, and use of surface-engineered nanoparticles for cancer treatment have been made in the last few years.

Treatment

The greatest method to address many of the obstacles related to the development of cancer is to combine nanotechnology with innovative, effective pharmaceutical formulations that can selectively target diseased areas and cross biological barriers. First created in the 1960s, doxorubicin, a drug used to treat a variety of malignancies, was enclosed in a liposome.[6]

Physicochemical Parameter

In particular, multifunctional nanoparticles like theranostics which employ nanoparticles to simultaneously diagnose and treat cancer have the potential to completely transform oncology and other medical fields. In order to assemble lipids, carbohydrates, proteins, or artificial polymers like polyethylene glycol (PEG), which is utilized to elude the immune system, multifunctional nanoparticles are complicated in nature.

Cancer Stem Cells (CSCs) and Drug Resistance

The cells that may self-renew and give rise to the diverse lineages observed inside a tumor are referred to as cancer stem cells, which are and are additionally known as tumor starting cells. Research on the limited ability of 1 in 1000 to 1 around 10,000 dollars mouse myeloma cells to form colonies in 1971 provided evidence for the existence of cancer stem cells. Only 1 in 1000–1 in 4000 tumors of the lungs, ovarian cancer, or cells from neuroblastoma produced colonies in soft agar, a finding that was validated six years later in human subjects. Still unanswered was whether only a small number of cancer cells could multiply quickly and develop into tumors or if all cancer cells lacked the capacity to act like stem cells.[7]

Delivery Nanoplatforms that are most Frequently Studied and/or Used in Therapy

An extensive array of nanoparticulate shipping containers has been created using various kinds of biologically compatible and biodegradable materials. Polymers, proteins, lipids, and inorganic substances are among the materials that are most frequently utilized. These days, we present and briefly. Describe these more widely utilized delivery platforms tools for molecule tumor cell recognition and targeting. Targeting pathways, both passive and active, are the two main ways that nanoparticles might accumulate in tumor.[8]

Drug resistance's primary determinants

Cancer therapy can be thought of as a three-tiered system that consists of populations of cancer cells, and therapeutic and particular host environments. The pharmacological properties of the treatment, in addition to intrinsic and adaptive carcinogenic cell chemical and physical parameters and extrinsic conservation factors, all influence the clinical responses. Considerations of intrinsic vs adaptive resistance are a common feature of resistance theories.

Taking on the problem of medication resistance, These factors often overlap in cancer, evolving gradually and in a fashion that is therapy-dependent, even though any biological source of resistance may make treatment refractory. Further sections provide an explanation of four common resistance explanations: initial cancer diagnosis, improved reaction time; therapy observation and adaptive addresses, and the use of cancer dependence. It is also explains how these interpolations may increase the total eliminate probability. Nanotherapeutic approaches to address medication resistance With new possibilities, nano-technological solutions are remarkably perceptive for delivering genetic sequences and chemotherapeutic drugs to the deepest depth of solid tumors after systematic therapy. The pharmaceutical industry uses a variety of viscoelastic nanocomposite vehicles, lipid-based nanostructures like liposomes, solid-lipid vesicles, and nano-emulsions, as well as self-assembling small structures like micelles and dendrimers-based structures for drug delivery.

Prospective

Sadly, a great deal of cancer patients in the greater majority throughout worldwide reach an advanced stage and do not respond well to treatment. About 70% of patients with cancer experience negative effects on their critical organs, often coupled with other symptoms, including bulimia, lips that dry out or thirst, asthenia and malnutrition, constipation, skin issues, anxiety, depressed mood, and disorientation.

Micelles and Nanoparticles Derived from Polymers

Therapeutic payloads can be encapsulated in or covalently attached to by polymeric nanoparticles, polymers that degrade naturally or synthetically are employed. After the medication and polymers are mixed, capsules can form spontaneously or through emulsion procedures as nanosized droplets. These nanospheres are very stable, have a fairly uniform size, have a solid center that is perfect for hydrophobic medicines, and may release medications under controlled conditions. Drugs may constitute covalently linked to water-soluble polymers to lengthen their half-lives in circulation and reduce their toxicity to healthy tissues.

Dendrimers

Dendrimers are established globular geometries of multi-branched polymers with an exterior layer of multifaceted functional groups, a central core, and branches of repeating units. Charged polar molecules can engage electrostatically with these functional groups, while hydrophobic interior cavities can encapsulate non-polar molecules through various interactions.[9] Utilizing targeting molecules like the RGD peptide or mAbs, the exterior functional groups also enable regulated drug delivery by modifying the medication to release only at a particular pH or upon interaction with particular enzymes. Additionally, it is common practice to use covalent bonding of hydrophobic medications like paclitaxel and doxorubicin. Copolymers of poly(glutamic acid)-b-poly(phenylalanine).

Heterogeneity of tumor cells, clonal selection, and growth as possible causes of medication resistance. In the current state of cancer biology, it is acknowledged that tumors with subclonal populations and a comparable diagnostic stage and histopathological status are genetically different. In 160 individuals with chronic lymphocytic leukemia (CLL), a comprehensive whole-exome sequencing analysis identified driver mutations across seven key signaling pathways in 20 mutant genes and five cytogenetic changes. Subclonal mutations were detected in a small percentage of leukemic cells and indicate a later transition, while communal mutations (drivers) were present in most tumor cells and indicate an early occurrence. Significantly more subclonal (in lieu of clonal) mutations were discovered in patients who had received chemotherapy. A variety of nanoparticulate shipping containers have been created using various biodegradable and compatible material types. Fatty acids polymers that are proteins, and inorganic substances are a few examples of materials that are frequently utilized. Here, we provide an overview of these more widely used distribution platforms and highlight some of their features. Strategies for molecularly sensing and targeting tumor cells Both passive and active homing pathways are the two basic ways that nanoparticles might accumulate in malignancies. Natural products overcome different molecular mechanisms to counteract tumor cell drug tolerance on cell line models Traditional Chinese medicine, which uses treatment, moxibustion, and physiotherapy together with natural ingredients, has been used for many years by the Chinese people to cure various ailments. Perhaps because of this history, we are eager to use natural ingredients to overcome treatment resistance in cancer cells. Bowel cancer T24/ADM cells were treated with chemotherapeutics with or without an osthole by Wang and colleagues. It came to light that the half-life of osthole was 76.5 μM, and at concentrations of 17 μM or less, posed no toxicity to the cells. On the other hand, at 17 μM, it managed to reduce the methotrexate IC50 from one to 0.4 μM, leading to a rise in the drug. By reducing the messenger RNA (mRNA) content of MDR1, which is and Bcl-2 as well as the quantity of pIKKα, the scientists' mechanistic research revealed that evodiamine acts on several pathways to defeat drug resistance. Additionally, celastrol exhibits strong antidrug resistance capabilities. It has the ability to significantly raise intracellular levels of drugs and decrease MDR1 protein level in K562/A02 cells while also increasing cell susceptibility toward chemo drug. Drug-resistant K562 cells' susceptibility to daunorubicin was reported to be increased by times by embelin in a different investigation.

To evaluate the antidrug resistance activities of natural compounds, numerous other research use cell line models. While investigating the underlying mechanisms, some studies only look at a compound's antidrug resistance effect. A few more studies investigated the process of drug efflux, the antidrug resistance properties of natural products, and the suppression of apoptotic. Natural products may operate on several molecules to produce their biological activity, as evidenced by their ability to bypass drug resistance and control distinct pathways. Furthermore, the GSH-GST system is known to be targeted by some chemicals. Among these are neferine, flavonoid, emodin has the following sections: arsenic trioxide and polysaccharides from *Ganoderma lucidum*. Medication Efflux Drug toxicity can be avoided by a family of proteins that can drive medications out of cancer cells and lower intracellular drug concentrations. About 48 members of a class of proteins known as ATP-binding cassettes (ABC) that are classified into subgroups ABCA to ABCG 7 are encoded in the human genome; 15 of these members are linked to drug resistance. These proteins are thought to be the main contributors to the chemoresistance of cancer cells. MDR1, multilayer resistance-associated protein (MRPs), the breast tumor resistant protein (BCRP) is the best-characterized ABC protein. The first Aa member linked to drug resistance to be identified is MDR1. It has been discovered that it mediates treatment resistance in numerous malignancies, which include cancers of the breast, colon, stomach, and kidney. It can be detected in almost all tissues.

Property of Nanoparticles

Centering on an exterior layer, with a shell layer, comprises the three layers that makeup NPs. In the surface layer, metal ions, polymers, and surfactants are present. Lipid, polymeric, ceramic, semiconductor, nonmetal, and metallic nanoparticles are among them. Attributes are influenced by the types of materials and sizes that are accessible. Super hard NPs are defined as those with a size lower than 50 nm. Additionally, the ductility and malleability are different. Quantum confinement Q-particles and surface-plasmon resonances are observed in certain magnetic substances, while superparamagnetism is present in others. Particular types of materials display enhanced diffusion at greater temperatures and UV rays in photovoltaic cells because of their huge, broad surface-to-volume ratio. Additionally, near-infrared wavelengths are where NPs initiate localized surface plasmon resonances, which enhances

Nowadays, there is significance placed on the role of nanoparticles in synthetic architectures and their benefits for physical well-being.[10,11]

Prevention of Cancer

Prevention Cancer Types: Primary, secondary, tertiary. Minimizing cancer by avoiding or removing factors that increase risk, seeking treatment and diagnosis as soon as attainable, and eliminating metastasis and recurring The following people are the targets of cancer preventative measures: healthy individuals, pre-symptomatic cancer carriers, and survivors with occult neoplasm lesions.[12]

Non-immunological examples:Tamoxifen in feminine health; Colonoscopy; Supplementation Chemotherapy; Prophylactic The procedure in Family Breast Cancer.

CONCLUSION

Currently, the most challenging issue in cancer treatment is drug resistance to chemotherapy. Since every tumor is unique, its growth and mortality are determined by its characteristics. To prevent medication resistance and improve the lives of cancer patients, chemotherapeutic medicines come in a variety of forms today. Survival statistics from clinical trials, however, don't hold up. The medical community has to put its initial attention toward tackling this major problem.

REFERENCES

1. Ferlay J, Colombet M, Soerjomataram I, Parkin DM, Piñeros M, Znaor A, Bray F. Cancer statistics for the year 2020: An overview. International journal of cancer. 2021;149(4):778-789. https://doi.org/10.1002/ijc.33588.
2. Chenthamara D, Subramaniam S, Ramakrishnan SG, Krishnaswamy S, Essa MM, Lin FH, Qoronfleh MW. Therapeutic efficacy of nanoparticles and routes of administration. Biomaterials research. 2019;23(1):20. DOI: 10.1186/s40824-019-0166-x. PMID: 31832232; PMCID: PMC6869321.
3. Urruticoechea A, Alemany R, Balart J, Villanueva A, Vinals F, Capella G. Recent advances in cancer therapy: an overview. Current pharmaceutical design. 2010;16(1):3-10. DOI: 10.2174/138161210789941847. PMID: 20214614.
4. Longley DB, Johnston PG. Molecular mechanisms of drug resistance. The Journal of Pathology: A Journal of the Pathological Society of Great Britain and Ireland. 2005;205(2):275-292. DOI: 10.1002/path.1706. PMID: 15641020.
5. Huck V, Schneider MF, Gorzelanny C, Schneider SW. The various states of von Willebrand factor and their function in physiology and pathophysiology. Thrombosis and haemostasis. 2014;111(04):598-609. DOI: 10.1160/TH13-09-0800. Epub 2014 Feb 27. PMID: 24573248.
6. Shao J, Zaro J, Shen Y. Advances in exosome-based drug delivery and tumor targeting: from tissue distribution to intracellular fate. International journal of nanomedicine. 2020:9355-9371. DOI: 10.2147/IJN.S281890. PMID: 33262592; PMCID: PMC7700079.
7. McEwen SA, Collignon PJ. Antimicrobial Resistance: A One Health Perspective. MicrobiolSpectr. 2018;6(2). DOI: 10.1128/microbiolspec.ARBA-0009-2017. PMID: 29600770
8. Fillmore CM, Kuperwasser C. Human breast cancer cell lines contain stem-like cells that self-renew, give rise to phenotypically diverse progeny and survive chemotherapy. Breast cancer research. 2008:1-3. DOI: 10.1186/bcr1982. Epub 2008 Mar 26. PMID: 18366788; PMCID: PMC2397524.
9. Mishra V, Singh M, Nayak P, Sriram P, Suttee A. Carbon Nanotubes as Emerging Nanocarriers in Drug Delivery: An Overview. International Journal of Pharmaceutical Quality Assurance. 2020;11(3):373-378. DOI: 10.25258/ijpqa.11.3.11
10. Chauhan R, Singh B, Singh MP, Malik A. Pharmacokinetic Study of Aloin Nanoparticulate: Enhanced Oral Formulation Bioavailability. International Journal of Pharmaceutical Quality Assurance. 2024;15(1):94-100. DOI: 10.25258/ijpqa.15.1.14
11. Nandgude TD, Parakhe PS, Mishra RK. Overview on Solid Lipid Nanoparticle for Topical Delivery and its Inevitable Applications. International Journal of Drug Delivery Technology. 2023;13(2):722-730. DOI: 10.25258/ijddt.13.2.40
12. Nanda N, Tharmaraj C, Haque MA, Swapna S. Polymeric Nanoparticle-Mediated Targeted Drug Delivery System: A Promising Approach for Breast Cancer. International Journal of Drug Delivery Technology. 2024;14(2):1225-1231. DOI: 10.25258/ijddt.14.2.89