INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

A Complete and Compressive Review on Anticancer Drugs

Tapade Saurabh S., Jamadar Amrata A.*, Kamshette Arati D., Devshatwar Radhika S., Suvase Mohini S., Akuch Sandhya P.

Godavari Institue Of Pharmacy Kolpa, Latur- 413512 Maharashtra, India.

ARTICLE INFO

Published: 03 April. 2025
Keywords:
Drug stability, Prodrugs, vesicular systems, Nanoparticles, Trastuzumab, Cancer therapy.
DOI:
10.5281/zenodo.15131119

ABSTRACT

In past decades, anticancer research has led to remarkable results despite many of the approved drugs still being characterized by high systemic toxicity mainly due to the lack of tumor selectivity and present pharmacokinetic drawbacks, including low water solubility, that negatively affect the drug circulation time and bioavailability. The stability studies, performed in mild conditions during their development or under stressing exposure to high temperature, hydrolytic medium or light source, have demonstrated the sensitivity of anticancer drugs to many parameters. For this reason, the formation of degradation products is assessed both in pharmaceutical formulations and in the environment as hospital waste. To date, numerous formulations have been developed for achieving tissue-specific drug targeting and reducing toxic side effects, as well as for improving drug stability. The development of prodrugs represents a promising strategy in targeted cancer therapy for improving the selectivity, efficacy and stability of active compounds. Recent studies show that the incorporation of anticancer drugs into vesicular systems, such as polymeric micelles or cyclodextrins, or the use of nanocarriers containing chemotherapeutics that conjugate to monoclonal antibodies can improve solubility, pharmacokinetics, cellular absorption and stability. In this study, we summarize the latest advances in knowledge regarding the development of effective highly stable anticancer drugs formulated as stable prodrugs or entrapped in nanosystems.

INTRODUCTION

Antineoplastic agents are used to treat the cancer. Cancer is a group of disease involving an abnormal and uncontrolled cell division im most of the normal body cells. This new cell growth invades the surrounding structures. The cancer may be benigs and malignant. Benigs tumors do not metastaise [spread of cancer to other locations in the body] but malignant do metastaise. Cancer is

***Corresponding Author:** Jamadar Amrata A.
Address: Godavari Institue Of Pharmacy Kolpa, Latur- 413512 Maharashtra, India.
Email ✉: amratajamadar487@gmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

classified according to the type of cell in which new growth occurs as.

1. Carcinoma:- This type of cancer derived from epithelial cells. This group represents nearly all those in breast ,lungs, prostate, colon, and pancreas cancer.
2. Sarcoma:- This type of malignant tumor arises from transformed cells of connective tissues.This tumor is made of cartilage, fat, vascular ,cancellous bone and hematopoistic tissues.
3. Leukemia and Lymphoma:-These two malignant tumors derived from haematopoietics [blood cell forming].This tumor mature in lymps nodes and blood respectively. Lymphoma are Hodgkin Lymphoma and the non-Hodgkin Lymphomas. The enlarged Lymphomas. The enlarged Lymph nodes are usually painless.
4. Germ cell tumor:- It is derived from germ cells. It may be malignant or benigs. Germ cells normally found in the ovary and testis.
5. Blastoma:- It is common in children.It is a tumor that resembles an immature or embryonic tissue . Examples are neproblastoma, medulloblastoma and retinobltoma.

- Antineoplastic agents have different mode of actions and their effect depends upon crytotoxic action which is selective for benigs cell i.e.rapidly dividing cells. Cancer can be treated by many ways including chemotherapy ,surgery, radiation therapy and neoplasting agents. The antineoplastic agents are the specialised drugs used primilarily to treat cancer. The first antineoplastic agents were used in 1940s, which were made naturally or synthetically. Antineoplastic agents can be used alone or in combination with other antineoplastic drugs. These drugs destroy the cancer cells but have some side effects like nausea, hair loss, mouth ulcer and lowering of the blood cells

Classification: -

- **Alkylating agent**
- **Antibiotics**
- **Antimetabolites**
- **Plant product`**
- **miscellaneous**

Alkylating agents

Alkylating agents act directly on cell DNA. They damage DNA to prevent cells from multiplying.

Some examples include:

- Altretamine,
- Bendamustine,
- Busulfan,
- Carmustine,
- chlorambucil
- cyclophosphamide
- dacarbazine
- ifosfamide
- lomustine

Antibiotics

Antibiotics are a class of drugs used to treat bacterial infections. They work by either killing bacteria (bactericidal) or inhibiting their growth (bacteriostatic). Antibiotics are effective against bacterial infections but do not work against viral infections like the common cold, flu, or COVID-19. The development of antibiotics revolutionized medicine, saving countless lives from infections that were once fatal.

Key Points About Antibiotics:

1. Selective Toxicity: Antibiotics are designed to target and kill bacteria or inhibit their growth without causing harm to the host (human or animal). This is achieved by targeting bacterial structures or processes that are absent or different from human cells, such as bacterial cell walls, protein synthesis, and DNA replication.

2. Spectrum of Activity: Antibiotics can be classified based on their spectrum of activity, meaning how many types of bacteria they can treat:

- Broad-spectrum antibiotics: Effective against a wide range of bacteria (both Gram-positive and Gram-negative).

- Narrow-spectrum antibiotics: Target specific groups of bacteria.

3. Resistance: Overuse or misuse of antibiotics can lead to antibiotic resistance, where bacteria evolve mechanisms to evade the effects of the drug, making infections harder to treat. This is a growing global health concern.

Antimetabolites

Antimetabolites are drugs that interfere with DNA and RNA synthesis by inhibiting essential enzyme production, disrupting cell division and tumor growth. They are often used in cancer treatment due to their ability to target rapidly dividing cells.

Antimetabolites include three main types of drugs:

- **Antifolates**: These drugs, such as methotrexate, pemetrexed, and pralatrexate, inhibit folic acid metabolism, which is crucial for DNA synthesis.
- **Purine Analogs**: Drugs like azathioprine, cladribine, and fludarabine mimic purine nucleotides, disrupting DNA and RNA synthesis.
- **Pyrimidine Analogs**: Including cytarabine, decitabine, and 5-fluorouracil (5-FU), these analogs disrupt the synthesis of pyrimidine, a building block of DNA.

Plant alkaloids

Plant Alkaloids are naturally derived compounds that interfere with cell division, making them effective in cancer treatment. They primarily inhibit mitosis, which is essential for cell replication, and are therefore particularly useful for targeting rapidly dividing cancer cells.

Plant alkaloids include four main types of drugs:

- **Vinca Alkaloids**: These drugs, such as vincristine, vinblastine, and vinorelbine, prevent the formation of microtubules, inhibiting mitosis in dividing cells.
- **Taxanes**: Including paclitaxel and docetaxel, taxanes stabilize microtubules and prevent them from breaking down, which is necessary for cell division.
- **Podophyllotoxins**: Such as etoposide and teniposide, these drugs inhibit enzymes involved in DNA replication, specifically targeting cancer cell DNA.
- **Camptothecins**: Including irinotecan and topotecan, these drugs inhibit topoisomerase I, an enzyme critical for DNA replication and repair.

Miscellaneous

Miscellaneous Anticancer Agents are drugs that don’t fit neatly into traditional classes (like antimetabolites, alkaloids, or antibiotics) but have unique mechanisms for targeting cancer cells.

These drugs work in various ways to inhibit cancer cell growth and proliferation.

Miscellaneous anticancer agents include:

- **Platinum Compounds**: Drugs like cisplatin, carboplatin, and oxaliplatin create DNA cross-links, interfering with DNA synthesis and function, leading to cell death.
- **Anthracenediones**: Mitoxantrone is an example that intercalates with DNA, disrupting its structure and inhibiting enzymes like topoisomerase II, which are essential for DNA repair.
- **Enzymes**: Asparaginase, for instance, targets acute lymphoblastic leukemia by depleting asparagine, an amino acid essential for cancer cell survival.
- **Proteasome Inhibitors**: Such as bortezomib, these drugs block proteasomes (structures that break down proteins) in cancer cells, leading to protein buildup and cell death.

Risk: -

- Risks to patients
- Antineoplastic agents can cause a number of short-term and long-term effects, including:
- Liver and kidney damage
- Bone marrow damage
- Lung and heart damage
- Infertility
- Effects on reproduction and the developing fetus in pregnant women
- Hearing impairment
- Risks to healthcare workers Healthcare workers who prepare, administer, or handle antineoplastic agents are at risk of exposure. Exposure can cause long-term organ damage, fertility issues, and even cancer.
- Risks to the environment Exposure to antineoplastic drugs can occur through contact, aerosols, ingestion, and inhalation.

Side effects

- Side effects can include bone marrow suppression, bruising easily, anemia, hair loss, nausea and vomiting, loss of appetite, diarrhea and constipation, changes in mood, dry mouth, and more.
- Hepatotoxicity
- Almost all antineoplastic agents have some degree of hepatotoxicity, but it's usually dose related and self-limiting.
- Protective measures
- Occupational exposure to antineoplastic drugs should be minimized through the use of protective measures and good work practices.

Sign and symptomes

The signs and symptoms associated with anticancer drugs (chemotherapy agents) vary depending on the type of drug, the dose, the type of cancer being treated, and the individual patient's response. Chemotherapy drugs can target rapidly dividing cancer cells, but they can also affect healthy cells that divide quickly, such as those in the bone marrow, gastrointestinal tract, and hair follicles. This can lead to a variety of side effects.

Common Signs and Symptoms of Anticancer Drugs (Chemotherapy)

1. Myelosuppression (Bone Marrow]

- Symptoms:
- Fatigue or weakness (due to low red blood cell count, causing anemia)
- Increased susceptibility to infections (due to low white blood cell count, especially neutropenia)
- Easy bruising or bleeding (due to low platelet count)
- Signs:
- Blood tests showing low levels of red blood cells, white blood cells, or platelets (anemia, neutropenia, thrombocytopenia)

2. Nausea and Vomiting

- Symptoms:
- Severe nausea and vomiting, sometimes occurring shortly after treatment (acute nausea) or up to several days after (delayed nausea).
- Loss of appetite and general discomfort.
- Signs: Weight loss, dehydration (dry mouth, reduced urination), and changes in electrolyte balance.

3. Hair Loss (Alopecia)

- Symptoms:
- Hair thinning or complete hair loss (can affect scalp, eyebrows, eyelashes, and body hair).
- Signs: Noticeable shedding of hair, bald patches, or complete baldness. This is generally reversible after treatment ends.

4. Mucositis (Mouth Sores)

- Symptoms:
- Painful mouth sores, ulcers, and swelling inside the mouth, tongue, and throat.
- Dry mouth, difficulty swallowing, or hoarseness.
- Increased risk of oral infections.
- Signs: Visible sores, redness, and swelling inside the mouth or throat.

5. Fatigue

- Symptoms:
- Persistent, overwhelming tiredness or lack of energy that doesn't improve with rest.
- Difficulty performing daily activities or even getting out of bed.
- Signs: General weakness, decreased physical activity, and reduced alertness.

6. Gastrointestinal Effects

- Symptoms:
- Diarrhea or constipation, often due to chemotherapy's impact on the lining of the gastrointestinal tract.
- Stomach cramps, bloating, and discomfort.
- Signs: Abnormal bowel movements, abdominal distension or pain.

Cancer Therapy: -

Surgery

- When used to treat cancer, surgery is a procedure in which a surgeon removes cancer from your body. Learn the different ways that surgery is used against cancer and what you can expect before, during, and after surgery.

Targeted Therapy

- Targeted therapy is a type of cancer treatment that targets the changes in cancer cells that help them grow, divide, and spread. Learn how targeted therapy works against cancer and about common side effects that may occur.

Biomarker Testing for Cancer Treatment

- Biomarker testing is a way to look for genes, proteins, and other substances (called biomarkers or tumor markers) that can provide information about cancer. Biomarker testing can help you and your doctor choose a cancer treatment.

Chemotherapy

- Chemotherapy is a type of cancer treatment that uses drugs to kill cancer cells. Learn how chemotherapy works against cancer, why it causes side effects, and how it is used with other cancer treatments.

Hormone Therapy

- Hormone therapy is a treatment that slows or stops the growth of breast and prostate cancers that use hormones to grow. Learn about the types of hormone therapy and side effects that may happen.

Hyperthermia

- Hyperthermia is a type of treatment in which body tissue is heated to as high as 113 °F to help damage and kill cancer cells with little or no harm to normal tissue. Learn about the types of cancer and precancers that hyperthermia is used to treat, how it is given, and the benefits and drawbacks of using hyperthermia.

Immunotherapy

- Immunotherapy is a type of cancer treatment that helps your immune system fight cancer. This page covers the types of immunotherapy, how it is used against cancer, and what you can expect during treatment.

Photodynamic Therapy

- Photodynamic therapy uses a drug activated by light to kill cancer and other abnormal cells. Learn how photodynamic therapy works, about the types of cancer and precancers it is used to treat, and the benefits and drawbacks of this treatment.

Radiation Therapy

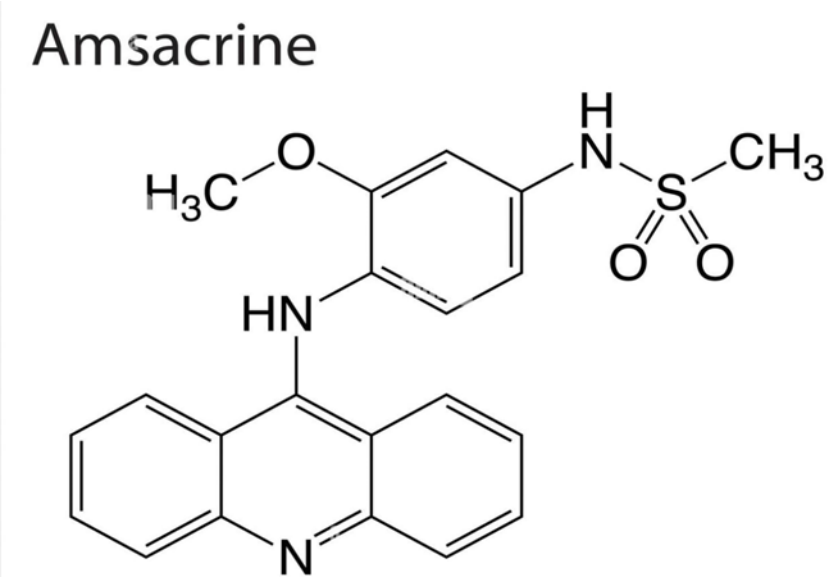
Radiation therapy is a type of cancer treatment that uses high doses of radiation to kill cancer cells and shrink tumors. Learn about the types of radiation, why side effects happen, which side effects you might have, and more.

Stem Cell Transplant

Stem cell transplants are procedures that restore stem cells that grow into blood cells in people who have had theirs destroyed by high doses of chemotherapy or radiation therapy. Learn about the types of transplants, side effects that may occur, and how stem cell transplants are used in cancer treatment.

Structures: -

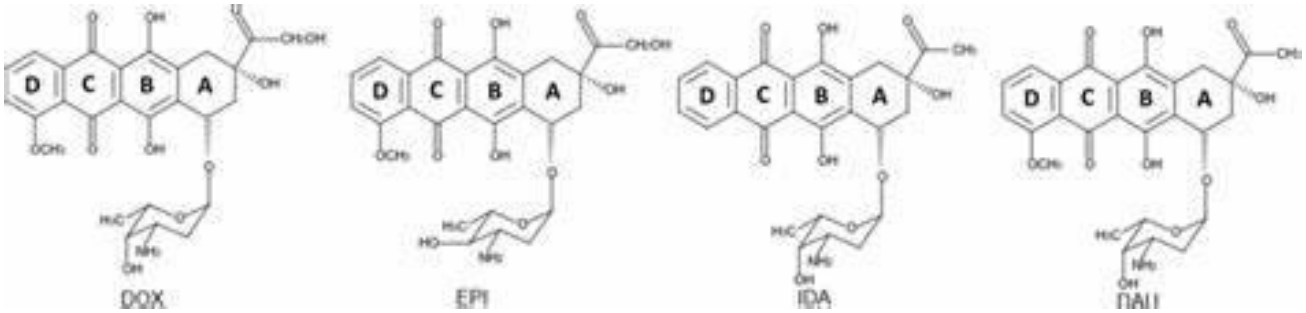
1. Amsacrine and Its Class: Acridine Derivatives



- **IUPAC NAME-**

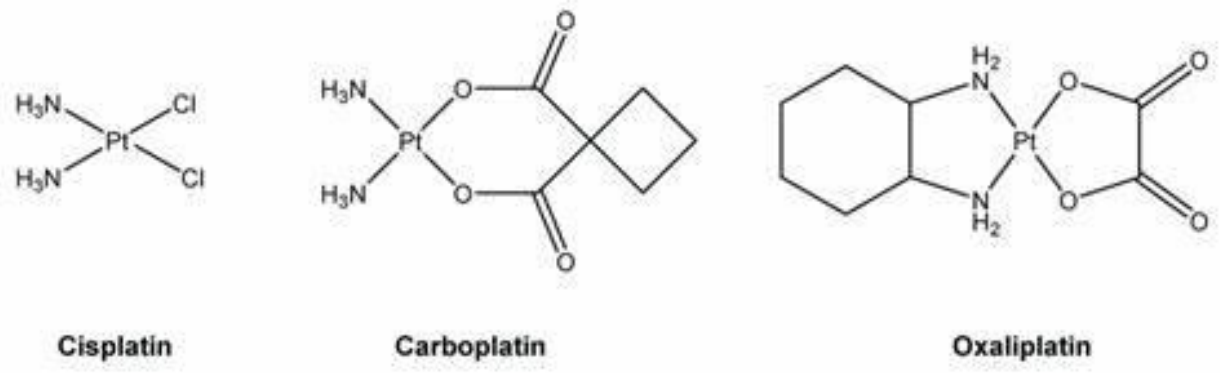
Amsacrine is an intercalating agent that inserts itself between DNA strands, disrupting DNA synthesis and repair. Structurally, it contains an acridine ring which intercalates with DNA, and a methanesulfonanilide group that inhibits topoisomerase II, an enzyme critical for DNA replication.

2. Anthracyclines (e.g., Doxorubicin, Daunorubicin)



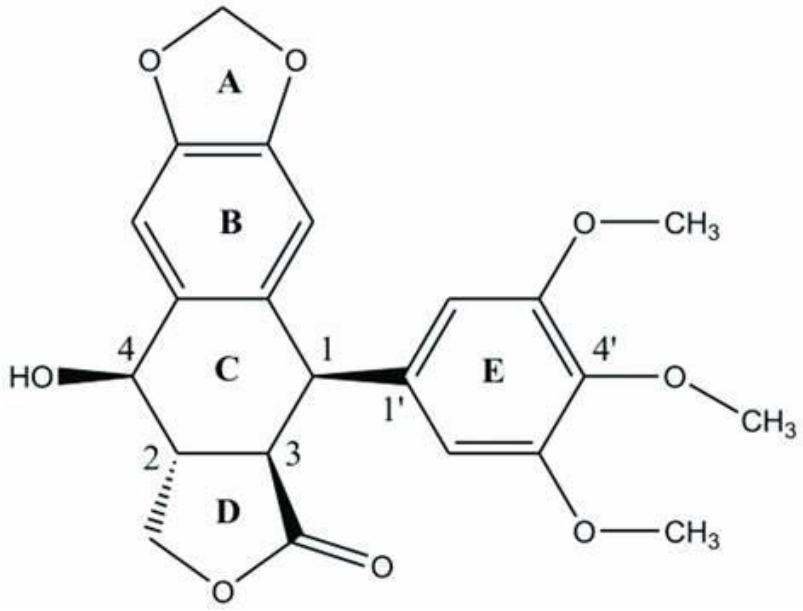
- These drugs are known for their four-ring anthraquinone structure that allows intercalation into DNA, interfering with DNA and RNA synthesis. Additionally, they generate free radicals that damage cellular components, especially in cancer cells with less efficient repair systems.
- Key Structure: Tetracyclic rings with an amino sugar (daunosamine) attached, contributing to DNA intercalation and topoisomerase II inhibition.

3. Platinum-Based Compounds (e.g., Cisplatin, Carboplatin)



- These compounds contain a central platinum atom coordinated with ammonia and chloride or carboxylate groups. When they enter cells, they lose their chloride ions and form strong covalent bonds with DNA bases, creating in trastrand cross-links that halt DNA replication.
- Key Structure: Platinum-centered coordination complex with ligands that can be exchanged in the cellular environment to bind DNA.

4. Podophyllotoxins (e.g., Etoposide, Teniposide)



- Derived from the podophyllum plant, these compounds have a lactone ring and a four-ring structure that inhibit topoisomerase II by stabilizing DNA-enzyme complexes, preventing DNA unwinding necessary for replication.
- Key Structure: Multiple rings with a lactone moiety and a sugar group, contributing to DNA-topoisomease II binding.

1. Mechanisms of Drug Resistance in Cancer Cells

- **Overview**: Cancer cells can develop resistance to chemotherapy and targeted drugs, leading to reduced efficacy.
- **Types of Drug Resistance**:
  - **Primary Resistance**: Cancer cells initially resistant due to genetic mutations or other innate mechanisms.

- **Acquired Resistance**: Cancer cells develop resistance over time, often due to exposure to anticancer drugs.
- **Mechanisms of Resistance**:
- **Efflux Pumps**: Proteins like P-glycoprotein (P-gp) pump drugs out of cells, reducing their effectiveness.
- **Drug Inactivation**: Cancer cells can metabolize drugs, neutralizing their effects.
- **Target Alteration**: Changes in the drug's target protein reduce drug binding (e.g., mutations in EGFR affecting TKI binding).
- **Cell Cycle Alterations**: Cancer cells evade drug effects by modifying their cell cycle checkpoints.

2. Advances in Nanotechnology for Cancer Drug Delivery

- **Nanoparticles and Drug Carriers**:
- How nanoparticles, liposomes, and micelles are engineered to deliver anticancer drugs with higher specificity and reduced toxicity.
- **Key Types of Nanocarriers**:
- **Lipid-based Nanoparticles**:
- Liposomes and solid lipid nanoparticles enhance drug solubility and control release.
- **Polymeric Nanoparticles**:
- Use polymers like PLGA for sustained drug release.
- **Inorganic Nanoparticles**:
- Metallic nanoparticles (e.g., gold, iron oxide) provide diagnostic and therapeutic benefits.
- **Benefits**:
- Improved drug stability, enhanced cellular uptake, reduced off-target effects, and potential for crossing biological barriers (e.g., blood-brain barrier).
- **Clinical Applications and Challenges**:
- Recent clinical trials of nanoparticle-based therapies and challenges such as regulatory approval and scalability.

3. Role of Tumor Microenvironment in Drug Efficacy

- **Introduction to Tumor Microenvironment (TME)**:
- Explains the unique cellular environment of tumors, including stromal cells, immune cells, and extracellular matrix.
- **Impact on Drug Efficacy**:
- **Hypoxia**:
- Hypoxic conditions in tumors reduce the effectiveness of drugs that require oxygen for activation.
- **Acidic pH**:
- Alters drug solubility and distribution within tumors.
- **Immune Suppression**: TME often includes cells that suppress immune response, reducing the effectiveness of immunotherapies.
- **Strategies to Target TME**:
- Drug formulations targeting TME components like angiogenesis inhibitors.
- Combination therapies involving TME-modifying agents to improve drug response.

4. Immunotherapy and Cancer Vaccines

- **Overview of Immunotherapy**: Overview of how the immune system can be harnessed to attack cancer cells.
- **Checkpoint Inhibitors**: Drugs like nivolumab and pembrolizumab that block immune checkpoints (e.g., PD-1/PD-L1) to boost immune response.
- **CAR T-Cell Therapy**: Engineering patients' T cells to recognize and kill cancer cells.
- **Cancer Vaccines**: Emerging vaccines aimed at preventing and treating specific cancers by priming the immune system.
- **Challenges**: Managing immune-related side effects, high costs, and limited efficacy in certain cancers.

Drug Stability and Development

Drug stability is critical for effective anticancer therapies. Factors affecting stability include temperature, pH, light, and moisture. Stability studies guide formulation strategies to minimize degradation. The incorporation of excipients can enhance stability, while prodrug strategies can improve the pharmacokinetic properties and reduce toxicity.

Prodrugs: These inactive derivatives convert to active drugs in the body, enhancing solubility and absorption. For instance, the use of prodrugs like Capecitabine, which converts to 5-Fluorouracil, exemplifies this strategy.

Vesicular Systems and Nanocarriers:

- **Polymeric Micelles:** Improve drug solubility and bioavailability, enhancing delivery to tumor sites.
- **Liposomes:** Encapsulate hydrophilic drugs, enhancing stability and reducing systemic toxicity.
- **Cyclodextrins:** Increase solubility and can modify release profiles of drugs.

Clinical Applications:

Recent clinical trials have demonstrated the efficacy of nanoparticle-based therapies in delivering anticancer agents more effectively while reducing off-target effects. However, challenges remain in regulatory approval and large-scale production.

Role of the Tumor Microenvironment (TME)

The TME consists of non-cancerous cells and extracellular matrix that influence cancer progression and response to therapies.

- **Hypoxia:** Many tumors are hypoxic, which can reduce the efficacy of oxygen-dependent therapies.
- **Acidic pH:** The TME often has a lower pH, affecting drug solubility and efficacy.
- **Immune Suppression:** Various TME components can suppress immune activity, presenting challenges for immunotherapies.

Targeting the TME: Developing drugs that modify the TME can enhance the efficacy of existing therapies, such as angiogenesis inhibitors and immune checkpoint inhibitors.

Immunotherapy and Cancer Vaccines

Immunotherapy represents a paradigm shift in cancer treatment, harnessing the body's immune system to combat cancer.

- **Checkpoint Inhibitors:** These drugs inhibit proteins that suppress the immune response (e.g., PD-1/PD-L1 inhibitors), allowing for stronger immune attacks on tumors.
- **CAR T-Cell Therapy:** Involves modifying T cells to recognize and kill cancer cells more effectively.

- **Cancer Vaccines:**

Vaccines can be designed to provoke a targeted immune response against specific cancer antigens.

Challenges: While immunotherapy offers promise, challenges include managing immune-related side effects and varying effectiveness across different cancer types.

Epigenetic Modulators in Cancer Treatment

Epigenetics plays a crucial role in cancer biology, with alterations in DNA methylation and histone modification affecting gene expression.

Types of Epigenetic Drugs:

- **DNA Methyltransferase Inhibitors:** Drugs like Azacitidine and Decitabine help reverse abnormal methylation patterns.
- **Histone Deacetylase Inhibitors:** Agents like Vorinostat restore normal gene expression and can be used in combination with other therapies.

Pharmacokinetics and Pharmacodynamics of Anticancer Drugs

Understanding pharmacokinetics (PK) and pharmacodynamics (PD) is essential for optimizing anticancer treatments.

- **PK Parameters:** Absorption, distribution, metabolism, and excretion (ADME) influence drug effectiveness.
- **PD Mechanisms:** Understanding how drugs interact with targets in cancer cells informs treatment strategies.

PK/PD Modeling: These models help predict drug efficacy and optimize dosing regimens for improved patient outcomes.

Biomarker-Guided Therapy in Oncology

Biomarkers play a significant role in personalizing cancer treatment, allowing for more effective and targeted therapies.

- **Identifying Biomarkers:** Genetic, protein, or metabolic markers can indicate potential responses to specific therapies.
- **Advancements in Testing:** Techniques like liquid biopsy and companion diagnostics enable timely and precise treatment choices.

Combination Therapies for Enhanced Efficacy

Combination therapies have become a cornerstone of cancer treatment strategies.

- **Rationale for Combination:** Using multiple agents can target diverse cancer pathways, reducing the likelihood of resistance.
- **Common Regimens:** Combining chemotherapy with targeted agents or immunotherapies has shown enhanced outcomes.

Clinical Trials and Approval Process for New Anticancer Drugs

Understanding the clinical trial process is essential for developing new therapies.

- **Phases of Trials:** Involves preclinical studies followed by Phase I-IV trials to assess safety, efficacy, and optimal dosing.
- **Regulatory Considerations:** Regulatory bodies like the FDA evaluate drugs for approval, focusing on safety and therapeutic benefits.

Patient Management and Quality of Life

Effective cancer treatment also involves managing patient quality of life.

- **Supportive Care:** Addressing side effects such as pain, nausea, and fatigue is crucial for maintaining patient quality of life.
- **Psychosocial Support:** Psychological and emotional support can significantly improve patient outcomes and adherence to treatment regimens.

Diagnosis

The diagnosis of side effects from anticancer drugs (chemotherapy) involves a combination of clinical

evaluation, patient-reported symptoms, and diagnostic tests. Oncologists closely monitor patients undergoing chemotherapy to detect, manage, and mitigate potential adverse effects. Below is an overview of how diagnosis and monitoring typically occur for chemotherapy side effects:

1. Myelosuppression (Bone Marrow Suppression)

- Clinical Evaluation:

- Symptoms of fatigue, increased infections, and easy bruising or bleeding suggest myelosuppression.

- Signs: Pallor (due to anemia), fever, or signs of infection may be observed.

- Diagnostic Tests:

- Complete Blood Count (CBC): This is the primary test for assessing myelosuppression. A low RBC count (anemia), low white blood cell count (neutropenia), or low platelet count (thrombocytopenia) confirms bone marrow suppression.

- Reticulocyte count: This helps evaluate bone marrow function and the body's response to anemia.

2. Nausea and Vomiting

- Clinical Evaluation:

- The onset of nausea or vomiting after chemotherapy suggests the possibility of this side effect.

- Diagnostic Tests:

- Diagnosis is typically based on patient symptoms. Lab tests are generally not required unless dehydration or electrolyte imbalances are suspected.

- Electrolyte panel: To check for imbalances due to excessive vomiting (e.g., low potassium or sodium).

3. Hair Loss (Alopecia)

- Clinical Evaluation:

- Alopecia is a common and distinguishable side effect of chemotherapy.

- Patients will typically report noticeable thinning or complete loss of hair within 2–3 weeks after chemotherapy.

- Diagnostic Tests:

- Scalp examination to determine the extent of hair loss.

- Trichoscopy (a specialized microscope) may be used to assess hair follicle health.

4. Mucositis (Mouth Sores)

- Clinical Evaluation:

- Painful sores or ulcers in the mouth and throat, difficulty swallowing, and dry mouth are indicative of mucositis.

- Diagnostic Tests:

- Oral examination: The oncologist will inspect the mouth, gums, and tongue for ulcers, redness, or swelling.

- Swab cultures: If infection is suspected (especially fungal or viral infections), a sample may be taken for culture.

5. Fatigue

- Clinical Evaluation:

- Persistent, unexplained fatigue is a common side effect of chemotherapy, and its intensity is usually correlated with the degree of myelosuppression and the specific drug used.

- Diagnostic Tests:

- CBC: To assess for anemia (a common cause of fatigue).

- Thyroid function tests: To rule out hypothyroidism, which can contribute to fatigue.

- Liver and kidney function tests: To ensure organ function is not contributing to the symptoms.

6. Gastrointestinal Effects (Diarrhea/Constipation)

- Clinical Evaluation:

- Diarrhea or constipation that begins during or after chemotherapy may suggest gastrointestinal toxicity.

- Diagnostic Tests:

- Stool sample: To rule out infections (especially if diarrhea is severe or associated with fever).

- Abdominal X-ray or ultrasound: In cases of severe abdominal pain or bloating, these imaging tests may help identify blockages or distension in the intestines.

7. Skin and Nail Changes

- Clinical Evaluation:

- Symptoms such as rashes, dryness, or changes in nail color or texture should raise suspicion for skin toxicity from chemotherapy.

- Diagnostic Tests:

- Skin biopsy: In rare cases, a biopsy may be performed to confirm the diagnosis of a skin reaction.

Conclusion on Anticancer Drugs

The fight against cancer has seen remarkable advancements over the past few decades, primarily due to the development of various anticancer drugs. These medications have transformed cancer treatment, leading to improved survival rates and enhanced quality of life for many patients. The complexity of cancer as a disease necessitates a multifaceted approach, and anticancer drugs play a pivotal role in this strategy.

Evolution of Anticancer Therapies

The journey of anticancer drug development began with traditional chemotherapy, which targets rapidly dividing cancer cells. While effective for many cancers, chemotherapy often comes with significant side effects due to its impact on healthy cells. This has led to the exploration of targeted therapies, which are designed to attack specific molecular targets associated with cancer, minimizing damage to normal cells. Drugs like imatinib for chronic myeloid leukemia exemplify how targeted therapies can revolutionize treatment by offering more precise and effective options. In recent years, immunotherapy has emerged as a groundbreaking approach, harnessing the body’s immune system to fight cancer. Immune checkpoint inhibitors, such as pembrolizumab and nivolumab, have shown promise in treating various malignancies by blocking proteins that prevent T-cells from attacking cancer cells. This shift towards immunotherapy reflects a broader understanding of cancer biology and the immune system's role in tumor surveillance and eradication.

Personalized Medicine and Treatment Approaches

One of the most significant advancements in cancer treatment is the movement towards personalized medicine. Genetic profiling of tumors allows for tailored treatment plans that consider the unique characteristics of a patient's cancer. This individualized approach helps in selecting the most effective therapies while reducing unnecessary side effects. Biomarkers play a crucial role in this process, guiding clinicians in making informed decisions about which drugs will be most effective for specific patient populations.

Challenges and Limitations

Despite these advancements, the use of anticancer drugs is not without challenges. One of the most pressing issues is drug resistance. Many cancers eventually develop resistance to the drugs that initially seemed effective, leading to treatment failure. Understanding the mechanisms of resistance is critical for developing new strategies and improving existing therapies. Ongoing research into combination therapies, which use multiple drugs to target different pathways simultaneously, may help overcome resistance and enhance treatment efficacy. Moreover, the side effects associated with many anticancer drugs can significantly impact patients' quality of life. Chemotherapy, in particular, is notorious for causing nausea, fatigue, and immune suppression, among other side effects. Newer drugs and treatment regimens aim to mitigate these adverse effects, but the quest for more tolerable and effective treatments continues.

REFERENCES

1. Kumar, S., & Sharma, A. (2021). "Targeted Cancer Therapy: An Overview." *Journal of Cancer Research and Therapeutics*, 17(2), 195-202. doi:10.4103/jcrt.JCRT_18_20.
2. Pardoll, D. M. (2012). "The blockade of immune checkpoints in cancer immunotherapy." *Nature Reviews Cancer*, 12(4), 252-264. doi:10.1038/nrc3239.
3. Gordon, M. S., & Goh, B. C. (2015). "Emerging role of immunotherapy in the treatment of breast cancer." *Breast Cancer Research and Treatment*, 154(3), 579-589. doi:10.1007/s10549-015-3651-1.
4. Kris, M. G., et al. (2014). "Molecular Testing for the Selection of Lung Cancer Patients for Targeted Therapies." *Journal of Clinical Oncology*, 32(24), 2777-2792. doi:10.1200/JCO.2013.54.5160.
5. Wagner, S. D., & Pan, H. (2020). "Chemotherapy-induced changes in the immune system: Implications for immunotherapy." *Current Opinion in Oncology*, 32(5), 479-487. doi:10.1097/CCO.0000000000000622.
6. Jiang, Y., & Liu, H. (2021). "New advances in cancer immunotherapy: The role of nanomedicine." *Journal of Nanobiotechnology*, 19(1), 1-14. doi:10.1186/s12951-021-01033-7.
7. Yuan, Y., & Yang, Y. (2019). "Challenges in the Development of Anticancer Drugs: Resistance and Efficacy." *Expert Opinion on Drug Metabolism & Toxicology*, 15(3), 187-203. doi:10.1080/17425255.2019.1583695.
8. Cohen, J. (2019). "The development of cancer immunotherapy: A review of the key breakthroughs." *Nature Reviews Clinical Oncology*, 16(8), 485-498. doi:10.1038/s41571-019-0205-1.
9. Zhou, J., & Zhang, H. (2020). "Precision medicine in cancer therapy: Recent advances and future challenges." *Journal of Hematology & Oncology*, 13(1), 1-11. doi:10.1186/s13045-020-00829-1.

10. Schreiber, R. D., et al. (2011). "Cancer immunoediting: integrating immunity's role in cancer evolution." *Immunity*, 35(1), 1-2. doi:10.1016/j.immuni.2011.06.001.

HOW TO CITE: Tapade Saurabh S., Jamadar Amrata A.*, Kamshette Arati D., Devshatwar Radhika S., Suvase Mohini S., Akuch Sandhya P., A Complete and Compressive Review on Anticancer Drugs, Int. J. of Pharm. Sci., 2025, Vol 3, Issue 4, 402-416 https://doi.org/10.5281/zenodo.15131119