Mini Review
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Recent advances in the management of cancer

Abstract

Cancer, nowadays, is one of the most lethal diseases spreading across the world. Cancer is a group of diseases where cells grow and divide in a disorderly fashion and destroy body's normal functioning. Cancer is induced by the current living style and can be cured if it is discovered in an early phase. Treatment of cancer relies upon numerous internal and external elements which induce cancer. Cancer is concealed by many distinct health examinations and its treatment is available at present such as precision medicine such as genomic profiling, targeted therapy like Imatinib, immunotherapy such as the full form of Chimeric Antigen Receptor T-cell Therapy, emerging technologies like Clustered Regularly Interspaced Short Palindromic Repeats-CRISPR associated protein 9 gene editing, combination therapies, etc. Nano-theranostics is the next generation medicine which is the inclusion of analysis and interpretation in nano-formulations. Non-invasive methods of diagnosis such as liquid biopsies are a major evolution which can be used for early phase diagnosis of cancer. Hereinafter WHO estimates that cancer caused 9.6 million deaths and around 29.4 million cases of cancer are expected to be diagnosed until 2040.

Keywords: cancer patient, nanoformulations, liquid biopsies, chemotherapy, crispr-cas9

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Introduction to cancer: understanding the disease that affects millions worldwide

Cancer, an ancient malady intricately intertwined with human history, continues to cast a profound shadow across the globe. With a history that dates back to antiquity, cancer's path has been characterized by bafflement, tenacity, and paradigm-changing discoveries. Because it is a sickness that cuts through time and culture, there have been persistent efforts made to understand, treat, and ultimately eradicate it. Cancer's presence was acknowledged, albeit with limited understanding, from the enigmatic growths mentioned in the Edwin Smith Papyrus of ancient Egypt to the Greek term "karkinos" that sounds like a crab and was employed by Hippocrates, the father of medicine.[1]

In the middle ages, cancer was viewed as an elusive foe that was frequently connected to a humoral imbalance. Mystical remedies including herbal mixtures and cautery were used. With Ambroise Paré's novel surgical techniques and Wilhelm Roentgen's discovery of X-rays, which gave rise to radiation therapy, the Renaissance and Enlightenment eras brought to a greater understanding of the anatomy.[2] Scientific progress against cancer accelerated in the 20th century. Chemotherapy changed the course of medical care, as seen by the introduction of medications like Methotrexate. A new era of personalized medicine was ushered in by significant accomplishments including the discovery of relationships between cancer and viruses and the introduction of targeted medicines like Tamoxifen for breast cancer.[3] The advent of the twenty-first century brought with it the promise of genomics and immunotherapy. The human genome's decoding allowed for customized interventions, and immunotherapy used the immune system of the body to fight cancer.

Cancer drug discoveries reveal the way forward, from targeted therapies like Imatinib that are revolutionizing the treatment of chronic myeloid leukemia to checkpoint inhibitors like Pembrolizumab that are redefining immune response modulation.[4] Millions of people impacted by cancer have joined a larger narrative where successes coexist with setbacks in this worldwide search. Across continents, cultures, and socio-economic levels, there is a cancer fight. To develop diagnosis, therapies, and public awareness, organizations like the American Cancer Society, the World Health Organization, and numerous research institutions collaborate. The journey is still one of resiliency, common purpose, and ongoing discovery as cancer's tale continues to change and its complexity is revealed by contemporary research. A testament to human ingenuity, compassion, and a shared global pursuit for a world where cancer's impact is lessened and its grip on lives is loosened, the collective determination to shed light on the shadow cast by cancer is seen in everything from ancient healers' incantations to modern laboratories' meticulous research.

Extent of cancer globally

Millions of people around the world are impacted by cancer, which has a significant global impact. Region, lifestyle, and access to healthcare all affect how common it is. The World Health Organization, better known as the WHO, estimates that cancer caused 9.6 million deaths in 2018[5] and that 29.4 million new cases will be identified through 2040.[6] Cancers of the stomach, lung, breast, colorectal, and other organs are among the most prevalent worldwide. Population increase and ageing are two factors that contribute to the rising cancer burden. Early detection, more advanced treatment options, and awareness efforts are all part of the fight against cancer.

Insight of cancer

The body's aberrant cells multiply and divide out of control, leading to cancer, a difficult and deadly disease. It resists the body's built-in controls, causing the growth of cancerous tumors or aberrant cell masses. Genetic mutations, which can happen for a variety of reasons, such as genetics, exposure to carcinogens like tobacco or ultraviolet radiation, or even just random chance, frequently result in this cellular revolt. The effects of cancer extend beyond the physiological to include social, emotional, and emotional aspects. It takes many forms, each of which is difficult in its own way. Its diversity reflects the complexity of the human body itself, from breast cancer's ubiquitous threat to the subtle growth of lung cancer. The understanding and treatment of cancer have advanced significantly thanks to medical science. Using multidisciplinary methods that combine surgery, chemotherapy, radiation therapy, and more modern targeted therapies, individual patients are being progressively customized. Advances in early detection have allowed for higher survival rates, emphasizing

the importance of timely intervention. But problems still exist. The disease may grow resistant to treatment and recur due to its diversity and adaptability. The research being done in genetics, immunotherapy, and precision medicine offers hope for overcoming these barriers. The huge impact of cancer on the world underscores the necessity of continued research, preventative measures, and a fair distribution of access to high-quality healthcare. To combat cancer, communities, healthcare organizations, government agencies, and individuals must all collaborate.[7]

Tumors and its types

An abnormal growth of cells within the body that is characterized by unchecked proliferation is referred to as a tumor. Malignant and benign tumors (Table 1) have different properties and possible effects on health. Understanding tumor kinds is essential for patient care, diagnosis, and treatment.[8]

Table 1 Tumor and its types

S. No.	Benign tumors (non-cancerous tumors)	Malignant tumors (cancerous tumors)
1	Adenomas	Carcinomas
2	Fibromas	Sarcomas
3	Lipomas	Leukemias
4	Meningiomas	Lymphomas
5	Papillomas	CNS tumors

Benign tumors

Non-cancerous growths known as benign tumors are often localized growths that do not infiltrate neighboring tissues or spread to other sections of the body. They typically grow slowly and frequently have clearly defined boundaries. Benign tumors usually do not present a life-threatening risk, despite the fact that they may produce symptoms depending on their location and size. Examples comprise:

Adenomas: These tumors develop from glandular tissues and can occur in various organs, such as the colon, thyroid, adrenal glands, and pituitary gland. While most adenomas are benign, some may have the potential to become cancerous over time.

Fibromas: Fibromas are tumors that originate from fibrous or connective tissue. They can appear in the uterus, skin, and other locations. Uterine fibroids, for example, can cause pelvic pain and heavy menstrual bleeding.

Lipomas: Lipomas are soft, fatty tumors that often appear under the skin. They are usually painless and moveable. Lipomas can develop anywhere on the body but are most commonly found on the shoulders, neck, back, and arms.

Meningiomas: Meningiomas are usually benign tumors that form in the meninges, the layers of tissue covering the brain and spinal cord. They can cause symptoms depending on their location and size.

Papillomas: Papillomas are wart-like growths that can develop on the skin's surface or within tissues. They often occur in areas like the vocal cords (vocal cords papillomas) and the breast ducts (intra-ductal papillomas).9[22]

Malignant tumors (Cancer)

Malignant tumors are cancerous tumors that have the potential to metastasis (spread) to various regions of the body via the circulatory system or lymphatic system.[10] They can also infect surrounding tissues. They are unable to properly regulate cell division, which can impair normal organ function. Malignant tumor examples include:

Carcinomas: The most prevalent type of cancer, these are the most common type of malignant tumors and originate from epithelial tissues that cover the body's surfaces or line organs and glands. There are several subtypes of carcinomas, including adenocarcinoma, squamous cell carcinoma, squamous cell carcinoma and basal cell carcinoma.

Sarcomas: Though less frequent, sarcomas can be very aggressive cancers that develop from connective tissues like bones, muscles, or cartilage. Their subtypes include osteo-sarcoma (originates from bone cells) and leiomyosarcoma (originates from muscle cells).

Leukemias: These malignancies damage the tissues that produce blood and cause the abnormal creation of blood cells. They are cancers of the blood and bone marrow, where blood cells are produced. They involve abnormal growth of white blood cells and can be acute or chronic. Leukemias affect the body's ability to produce healthy blood cells.

Lymphomas: Lymphomas are cancers of the lymphatic system, which includes the lymph nodes and lymphatic vessels. They can be classified as Hodgkin lymphoma or non-Hodgkin lymphoma. Lymphomas affect the immune system and can spread to different organs.

Central Nervous System (CNS) tumors

These tumors can be primary originating in the CNS (brain & spinal cord) or secondary (arising from metastasis), and it includes gliomas, meningiomas and ependymomas. Glioblastoma multiforme is a particularly aggressive type of brain tumor.

Aetiology of malignancy: unveiling factors influencing oncogenesis

Combating this complex disease requires an understanding of the many causes of cancer. The goal of this paper is to give a clear, well-supported scientific summary of the various elements influencing the development and spread of cancer. They expressed their aim to illuminate the complex interactions that contribute to malignancy through an examination of genetic, environmental, behavioral, and viral factors.[11]

Genetic factors

Numerous malignancies are mostly caused by genetic alterations. Proto-oncogene and tumor suppressor gene alterations throw off cellular control, promoting unchecked growth. Breast and ovarian cancer risk are increased by inherited abnormalities like $BRCA_1$ and $BRCA_2$. Genetic instability is further exacerbated by somatic mutations, which can be brought on by things like exposure to mutagens or mistakes in DNA replication.[12]

Environmental carcinogens

Exposure to the environment plays a significant role. Lung, mouth, and other cancers are caused by carcinogens such polycyclic aromatic hydrocarbons in cigarette smoke. The powerful carcinogen asbestos is linked to mesothelioma. Ionizing radiation increases the incidence of several malignancies, while UV radiation is a proven cause of skin cancer. Leukaemia incidence is increased by occupational exposure to toxins like benzene.[13]

Lifestyle decisions

Cancer risk is substantially influenced by lifestyle choices. Obesity raises the risk of colorectal, breast and other cancers because it is associated with altered hormone levels and adipose tissue inflammation. A diet deficient in fresh produce and rich in processed

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foods can worsen gastrointestinal cancers. Multiple cancer forms are associated with both excessive alcohol consumption and physical inactivity.[9,14]

Agents of infection: Certain malignancies are influenced by infections. Hepatitis B and C viruses increase the risk of developing liver cancer, while the human papillomavirus (HPV) causes cervical and other genital cancers. Due to ongoing inflammation, Helicobacter pylori infection is linked to stomach cancer.[15]

Treatment of cancer

The landscape of cancer treatment has undergone revolutionary changes, revolutionizing the strategy for treating this complex illness. The purpose of this report is to provide insights into the mechanisms, applications, and prospective effects of the cutting-edge treatments that have just become available.[16] The focus is to seek a thorough understanding of the cutting-edge therapeutic modalities influencing the future of cancer care by examining precision medicine, immunotherapy, targeted therapies, and emerging technology (Figure 1).

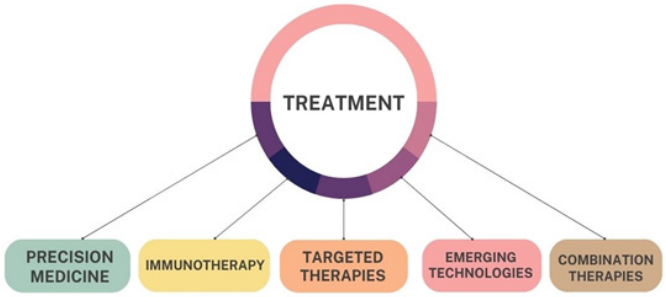

Figure 1 Treatment of Cancer.

Precision medicine

Precision medicine tailors treatment strategies based on individual patient characteristics, including genetic makeup and molecular profile of their tumor. Genomic analysis enables identification of specific mutations, guiding the selection of therapies that target the underlying molecular aberrations. Personalized approaches akin to tyrosine kinase inhibitors (TKIs) used by patients with specific genetic alterations like EGFR mutations in lung cancer, have demonstrated remarkable efficacy, minimizing side effects and optimizing treatment responses. The realm of cancer treatment has experienced a paradigm shift with the advent of precision medicine.[17,18]

Genomic profiling: At the heart of precision medicine lies the comprehensive analysis of a patient's genetic makeup. Genomic profiling involves deciphering alterations in the DNA sequence, identifying mutations, deletions, or amplifications that underlie cancer development. High-throughput sequencing techniques enable the identification of driver mutations, which are pivotal for oncogenesis, while distinguishing them from passenger mutations.

Molecular sub-typing: Precision medicine extends beyond genetic mutations. Molecular sub-typing categorizes tumors based on molecular signatures, leading to more refined disease classification. This approach enables tailored treatment recommendations by accounting for the heterogeneous nature of cancers. For example, breast cancer sub-typing, like HER_2-positive or triple-negative, guides therapy selection and predicts treatment response.

Targeted therapies: Precision medicine's hallmark is the development of targeted therapies. These therapies specifically address the molecular aberrations identified in a patient's tumor. Small molecule inhibitors and monoclonal antibodies are designed to interfere with oncogenic pathways. Examples include EGFR inhibitors in lung cancer and BRAF inhibitors in melanoma, yielding impressive responses while minimizing off-target effects.

Therapeutic resistance and adaptation: Precision medicine's journey is complex, marred by challenges like therapeutic resistance. Tumors exhibit remarkable adaptability, developing resistance mechanisms to targeted therapies. Combating this resistance necessitates continuous monitoring of molecular alterations, allowing for timely therapeutic adjustments or combination strategies to counteract evolving resistance.

Patient stratification: Precision medicine is shifting cancer management from a one-size-fits-all approach to patient-specific care. Biomarker-driven patient stratification enables treatment decisions to be tailored to an individual's genetic makeup and tumor characteristics. This approach optimizes treatment efficacy while minimizing unnecessary toxicity, enhancing patient outcomes.

Immunotherapy

Immunotherapy has emerged as a groundbreaking approach that harnesses the anatomy's immune-competence to apprehend and destroy tumorigenic cells. Immuno checkpoint modulated interventions, like PD-1/PD-L1 inhibitors, block inhibitory signals, enabling immune cells to effectively target cancer. CAR T-cell therapy involves engineering patients', T cells to express receptors that recognize cancer antigens, leading to remarkable responses in hematological malignancies. Immune checkpoint inhibitors have transformed the treatment landscape of various cancers, with durable responses in advanced stages.[19,20]

The immune system and tumor immune evasion: The immune system's role in recognizing and eliminating abnormal cells is pivotal. Yet still, tumors often exploit mechanisms to evade immune surveillance, hindering immune responses. Immunotherapy seeks to reawaken the host defense system's potential to validate and focus neo-plastic cells.

Immune check-point inhibitors: Immune checkpoint inhibitors are at the forefront of immunotherapy. They block inhibitory pathways like PD-1/PD-L1 or CTLA-4, enabling immune cells to recognize and attack cancer cells effectively. This approach has revolutionized the treatment of various cancers, leading to durable responses in conditions where conventional therapies falter.

Engineered T-cell mediated healing interventions: It involves engineering patients' own T cells to target neoplasm. CAR T-cell interventions entails introducing engineered receptors that recognize specific cancer antigens. This approach has demonstrated remarkable efficacy in hematological malignancies, achieving sustained remissions.

Cancer vaccines: Cancer vaccines harness the immune system's memory to recognize and combat cancer cells. Therapeutic vaccines stimulate immune responses against tumor antigens, priming the immune system to target cancer. Prophylactic vaccines, like the HPV vaccine, prevent virus-induced cancers by thwarting infection.

Targeted therapies

Targeted therapies focus on specific molecules or pathways critical for cancer growth and survival. Small molecule inhibitors and monoclonal antibodies are designed to precisely interfere with

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these targets. In chronic myeloid leukemia, tyrosine kinase inhibitors like Imatinib inhibits BCR-ABL fusion protein, leading to impressive responses. HER_2-targeted therapies, including Trastuzumab, have revolutionized. However, resistance mechanisms and tumor heterogeneity present challenges.[21,22] By probing into molecular targeting, tyrosine kinase inhibitors (TKIs), monoclonal antibodies, and challenges, it gives a comprehensive understanding of the role of targeted therapies in reshaping cancer care.

Molecular targeting: Targeted therapies revolve around precision, addressing specific molecular alterations pivotal for cancer development and progression. By capitalizing on these molecular vulnerabilities, these therapies aim to impede tumor growth while minimizing collateral damage to healthy cells.

Tyrosine kinase inhibitors (TKIs): TKIs represent a cornerstone of targeted therapy. These small molecule inhibitors hinder signaling pathways driven by overactive kinases, often resulting from genetic mutations. In chronic myeloid leukemia, Imatinib targets BCR-ABL fusion protein, yielding remarkable responses. TKIs have transformed treatment across cancers like lung (EGFR mutations) and renal cell carcinoma (VEGFR signaling).

Monoclonal antibodies: Monoclonal antibodies bind specifically to cancer cells or their microenvironment, impeding tumor growth. Trastuzumab, targeting HER_2-positive breast cancer, exemplifies this approach. Immune checkpoint inhibitors, a subset of monoclonal antibodies, unleash immune responses against cancer by blocking inhibitory signals, yielding durable responses in various malignancies.

Rational combinations: Combining targeted therapies with other treatments leverage synergistic effects. Dual HER_2 blockade with Trastuzumab and Pertuzumab exemplifies this approach. Combination strategies counteract resistance mechanisms, augmenting treatment efficacy.

Emerging technologies

Advanced technologies are reshaping cancer treatment paradigms. Gene editing tools like CRISPR-Cas9 offer the potential to precisely modify cancer-related genes, opening avenues for therapeutic interventions and understanding drug resistance mechanisms. Nanotechnology allows targeted delivery of therapies to tumor sites, minimizing off-target effects. Liquid biopsies, assessing circulating tumor DNA, aid in monitoring treatment response and detecting early relapse. Artificial intelligence and machine learning analyze vast data sets, aiding in treatment prediction and drug discovery.

Single-cell sequencing: Single-cell sequencing offers unprecedented insights into the heterogeneity within tumors. By analyzing individual cells, researchers uncover diverse cell populations, aiding in understanding tumor evolution, drug resistance, and metastasis. This technology provides granularity that bulk sequencing cannot achieve, revolutionizing our perception of tumor complexity.[23,24]

Liquid biopsies: Liquid biopsies tap into the potential of analyzing cell-free DNA, circulating tumor cells, and other molecules from blood samples. Liquid biopsies are non-invasive medical tests that involve the analysis of various components, such as DNA, RNA, proteins, and other molecules, found in bodily fluids like blood or urine. These tests are used to detect and monitor various diseases, including cancer, without the need for traditional tissue biopsies. Liquid biopsies offer several advantages over traditional tissue biopsies, such as being less invasive, allowing for more frequent monitoring, and providing a broader view of tumor heterogeneity. However, they might not completely replace tissue biopsies but rather complement them, offering a less burdensome and more dynamic approach to cancer diagnosis and management. It enables real-time monitoring of treatment responses, early detection of relapse, and assessment of tumor evolution.[25]

Artificial intelligence (AI): AI is reshaping cancer research and treatment. Machine learning algorithms analyze vast datasets, identifying patterns that guide treatment decisions, predict patient outcomes, and aid drug discovery. AI also enhances medical imaging analysis, enabling earlier and more accurate diagnosis.

Nano-technology: Nano-technology enables precise drug delivery to tumor sites, minimizing off-target effects and enhancing therapeutic efficacy. Nano-particles can encapsulate drugs, releasing them selectively within tumors. This approach reduces systemic toxicity and improves treatment outcomes.[26]

CRISPR-Cas9 gene editing: CRISPR-Cas9 allows precise manipulation of genes, offering unprecedented potential for cancer research and therapy. Researchers can edit cancer-related genes, studying their functions and identifying potential therapeutic targets. CRISPR-based therapies are also being explored for their ability to disable cancer-driving mutations.[27]

Combination therapies

The synergy of multiple treatment modalities is emerging as a promising approach. Immuno-oncology combinations, such as checkpoint inhibitors paired with targeted therapies, exploit complementary mechanisms to enhance treatment efficacy. Neo-adjuvant approaches, where therapies are administered before surgery, aim to shrink tumors, increasing surgical success rates. Concurrent chemo-radiotherapy optimizes local and systemic control, particularly in locally advanced cancers.[28]

Mechanisms and rationale: Combination therapy capitalizes on the synergistic effects of different treatment approaches, often targeting distinct aspects of cancer biology. By leveraging the strengths of individual treatments, combination therapy aims to maximize efficacy while minimizing resistance development. This approach is particularly relevant in cancers with complex genetic profiles and heterogeneous characteristics.

Rational combinations: Rational combinations involve selecting treatments based on complementary mechanisms of action. For instance, combining chemotherapy with targeted therapies can address both rapidly dividing tumor cells and specific molecular aberrations, respectively. This approach reduces the likelihood of resistance and enhances treatment response.

Immunotherapy combinations: Combining different immune-therapies or immune-therapy with other treatment modalities is gaining prominence. Immune check-point inhibitors, when used together, can unleash robust immune responses against cancer cells, leading to more sustained remissions.[29]

Chemotherapy and targeted therapy

It is a well-established approach. While chemotherapy has a broad cytotoxic effect, targeted therapies have impact on specific molecular alterations. Dual HER_2 blockade, combining Trastuzumab and Pertuzumab, exemplifies this strategy in HER_2-positive breast cancer, achieving better outcomes than single-agent therapy.[30]

Conclusion

The most contemporaneous advancements in treatment are being explored, with a focus on the revolutionary effects of targeted

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therapeutics, precision medicine, immunotherapy, and emerging technology. These developments are changing the landscape of cancer treatment and providing a glimmer of hope for patients. The approach to malignancies is being transformed, yielding improved outcomes and extended lifetimes due to the integration of genetics, immune regulation, and personalized medicines. Modern technologies such as single-cell sequencing and liquid biopsies, combined with well-reasoned drug combinations, have the potential to further enhance therapeutic strategies. Nevertheless, challenges persist, prompting continued research to eliminate resistance mechanisms, refine treatment plans, and enhance patient selection. These advancements underscore the collaborative efforts of the scientific community toward a future in which cancer is not only managed but also overcome, as they navigate this exciting era of oncology.

In conclusion, the ongoing progress in cancer treatment highlights the significant impact of targeted therapeutics, precision medicine, immunotherapy, and emerging technologies. The integration of genetic insights, immune modulation, and innovative therapies is ushering in a new era of oncology. As the researchers embrace these developments, it is important to acknowledge the challenges that persist, motivating us to further research and innovate in order to conquer the complexities of cancer. The collaborative efforts of the scientific community are steering us toward a future where cancer can be not only managed but also defeated, marking a remarkable stride forward in the field of oncology.

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Conflicts of interest

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