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# Targeted Cancer Therapies: Current Trends and Future Directions in Oncology Treatment

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**Abstract:**

Cancer is one of the leading causes of death, and as it progresses, it becomes an uncontrollable illness that is challenging to fully treat. As a result, early identification is crucial to raising the survival rate. However, obstacles like cytotoxicity, lack of selectivity, and multi-drug resistance make effective cancer treatment extremely difficult. Nanotechnology's introduction has completely changed the field of cancer diagnosis and treatment.

While important advancements are being made recently, such as stem cell therapy, targeted therapy, ablation therapy, nanoparticles, natural antioxidants, radionics, chemodynamic therapy, sonodynamic therapy, and ferroptosis-based therapy, traditional treatment approaches like surgery, chemotherapy, and radiotherapy have yet to be replaced. Oncology techniques today concentrate on creating effective and safe cancer nanomedicines. Nanoparticles have introduced new diagnostic and treatment possibilities, while stem cell therapy has shown promise efficacy in regenerating and repairing diseased or damaged tissues by targeting both primary and metastatic cancer foci. Targeted therapy had the potential to be a game-changer by preventing some cancer cells from growing and spreading while reducing harm to healthy cells. By determining the risk factors, predictive-AI algorithms can calculate an individual's chance of developing cancer. AI and big data can help doctors create personalized cancer treatments. Diagnosis, treatment, current challenges and future directions are discuss in this review.

**Key Words:** radionics, nanoparticles, nanomedicines, predictive-AI algorithms

## 1. Introduction:

In medicine, the word "cancer" was initially used in the 1600s to describe cells that were growing unexplainably and had the potential to invade or spread to other areas of the body. Thousands of genetic and epigenetic variants exist in cancer, making it a complicated and multifaceted disease, particularly in terms of growth and division. In order to maintain controlled growth, the cells undergo apoptosis, a programmed cell death process. Oncology is currently one of the therapeutic areas with the fastest pace of development in the world. To improve patient survival, cancer must be correctly diagnosed early. AI uses algorithms and programs with the right data to simulate human-like cognitive abilities in order to treat complicated biological anomalies like cancer and other challenging healthcare issues.[1]

Delivering chemotherapeutic chemicals to cancer cells precisely is one of the most important parts of cancer therapy, as it maximizes treatment efficacy while reducing damage to healthy tissue. The possible anticancer effects of bioactive peptides have drawn interest. Improved specificity, decreased toxicity to healthy tissues, and adaptability in addressing different biochemical pathways implicated in the development of cancer are only a few benefits of using peptide-based techniques in cancer treatment[2] When treating lung cancer, radiotherapy is a crucial treatment option.[3] Immuno compromised patients may have cancer as a result of their illness or anticancer treatment.[4]

**Cancer Stastics** :

According to the International Agency for Research on Cancer (IARC), there are 36 different kinds of cancer in the world. They found that one in eight men and one in eleven women will die from cancer, and one in five people will get it at some point in their life. Every year, almost eight million people pass away from cancer [6–8]. Breast cancer and lung cancer are the two cancers with the highest incidence rates in women and males, respectively, according to GLOBOCAN 2020 estimates [9]. According to the Centers for Disease Control and Prevention (CDC), lung cancer accounted for 23% of all cancer related fatalities, making it the most common type of cancer. According to WHO data from 2022 , approximately 10 million fatalities were caused by cancer.[1]

**Need for Targeted Drug Delivery:**

When treating cancer, the specificity of a drug's action becomes crucial because chemotherapeutic and radiotherapeutic treatments are meant to destroy cells. Not only is it clinically necessary to create medication delivery systems that are properly targeted, but they can also aid in curing cancer before it kills the patient. Achieving a complete remission in patients with disseminated disease requires that all cancer cells be destroyed, either directly through the effects of the medication or indirectly through the therapy's bystander impact . Combining a high radiation dosage (about 60–70 Gy) with ongoing infusion of the treatment of locally advanced cancers that are incurable has been studied using chemotherapeutic drugs such as paclitaxel . Many patients are forced to stop their treatment due to significant systemic side effects from the high dose medication needed to maintain a state of complete remission. The majority of these negative consequences seriously impair patients' quality of life (QoL)[5]

**Use of AI in Cancer Diagnosis :**

A critical milestone in patient care, the diagnosis of cancer influences prognosis, treatment options, and overall out comes. Artificial intelligence (AI) has transformed cancer diagnostics in recent years by offering advanced instruments and methods to increase precision, effectiveness, and early detection. An outline of the several uses of AI in cancer diagnosis is given in this section.

Radiological images, such as CT, MRI, PET, and X-rays, are analyzed by artificial intelligence (AI)-driven image analysis algorithms that employ machine learning techniques. **Early detection and screening algorithms**: AI-driven screening algorithms examine many types of data, including imaging studies, biomarker measurements, and patient demographics, using machine learning and pattern recognition[6]

The AI program examines patient breast pictures and is intended to help radiologists evaluate and describe breast lesi.ons for a range of clinical indications and MRI technical protocols.[7] Early cancer identification may be hampered by a number of difficulties in diagnosing mouth cancer. These limitations include the lack of symptoms in the early stages of the illness, trouble seeing the oral cavity, a lack of resources, low awareness, a lack of suitable diagnostic equipment, and trouble telling benign from malignant lesions. [8]

Figure 1a] illustrates how cancer affects different body components.

Thyroid carcinoma is among the most prevalent endocrine maligencies worldwide . The rising prevalence of thyroid cancer and its related mortality are causes for concern .Thyroid cancer is more common in women aged 15-49 (ranked fifth internationally) than in males aged 50-69 according to research.[9]

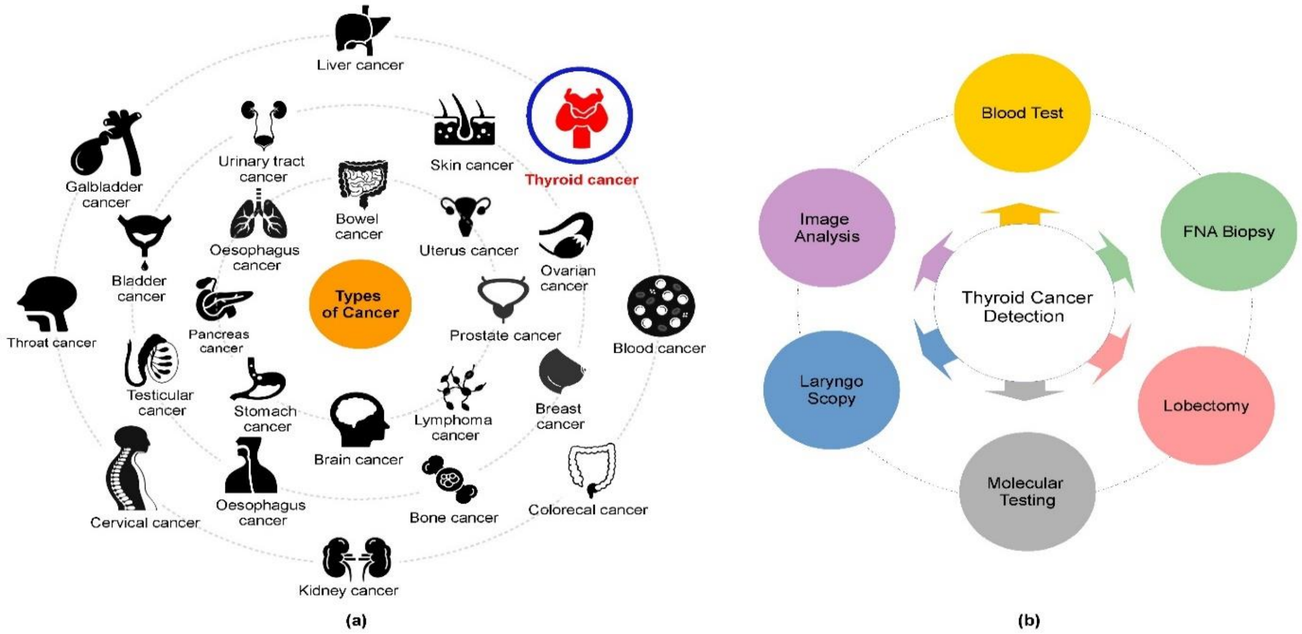
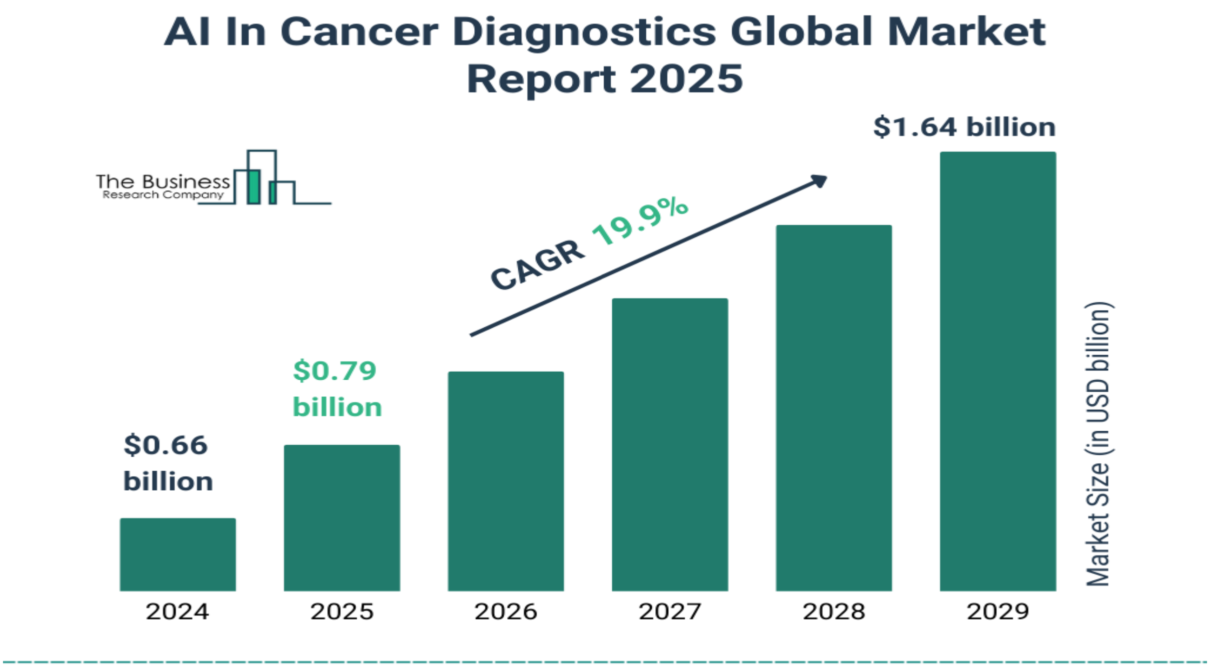



Figure 1: (a) Common cancer types and (b) Thyroid cancer detection techniques.

The graph "AI In Cancer Diagnostics Market 2025" can be found at[10]




[https://www.thebusinessresearchcompany.com/graphimages/AI_In_Cancer_Diagnostics_Market_2025_Graph.webp ]

**Targeted cancer therapy :**

Herbal Compounds With The Potential To Synergize With Antitumor Drugs :- When a combination of components is more effective than a single one, this is known as a synergistic impact. clinically used chemotherapeutic protectors, also known as chemo resistance reducers.

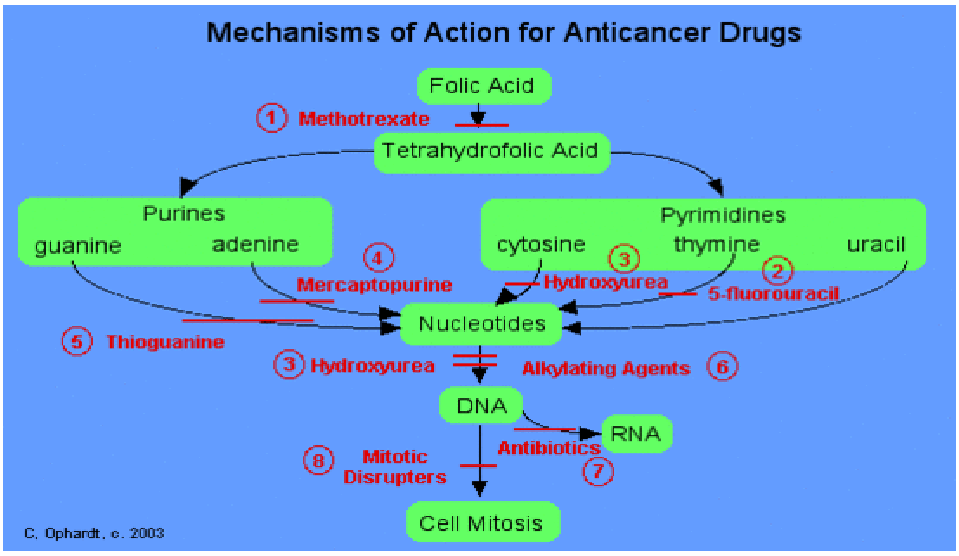
**Vincristine** is a naturally occurring alkaloid that was extracted from **Catharanthus roseus** and is being used to treat neuroblastoma and acute lymphocytic lymphoma. However, its limited therapeutic window and severe cytotoxicity limit its further usage, particularly in pediatric cancer. Among natural compounds, **Curcumin** has been investigated the most.

The most common and deadly cancers, such as colorectal, breast, and lung cancers, are covered in these research. Interestingly, these research on curcumin's ability to increase the effectiveness of chemotherapy (by carboplatin, 5-FU, doxorubicin, and radiation) have demonstrated that curcumin facilitates chemotherapy via controlling the transcription factor NF-κB's expression or activity. [11]

**The Therapeutic Range for Natural Products Is Expanded by Combination Therapy:-**
Through Combination Therapy, the Therapeutic Range of Natural Products Improves. The combination therapy approach is especially significant for TCM-derived bioactive compounds, which are frequently restricted by the relatively low therapeutic effects in the models being studied now, but is fortunate to have ten years of clinical experience. [12]

**Chemotherapeutic Agents :** The majority of chemotherapeutic drugs used to treat cancer work by preventing DNA synthesis or cell division. One of the cell cycle phases is affected by chemotherapy drugs.

There are two types of chemotherapy compounds: cell-cycle specific and cell-cycle non-specific. Chemotherapeutic drugs can be divided into several groups according to how they work, including alkylating agents ,anthracyclines, antimetabolites ,topoisomerase inhibitors,and plant alkaloid [13]

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**Stem cell therapy :**

The characteristics of a tiny number of tumor cells known as cancer stem cells (CSCs)—drug resistance and self-renewal—are the cause of therapy failure and cancer recurrence. The development, maintenance, metastasis, and recurrence of cancer are all influenced by these cells. [14] In the bone marrow (BM), stem cells are undifferentiated cells that have the capacity to develop into any kind of body cell. Stem cell applications are still under exploratory clinical trials; for instance, its potential for repairing other damaged tissue is being investigated. Trials are now being conducted using mesenchymal stem cells (MSCs), which are derived from connective tissues, adipose tissues, and bone marrow. Types of targeted agents such as Monoclonal antibodies , Small molecule inhibitor, Ablation cancer therapy[15]

There are two main types of lung cancer: small cell lung cancer (SCLC) (15%) and non-small cell lung cancer (NSCLC) (85%). NSCLC is divided into three primary types: large cell carcinoma, squamous cell carcinoma, and adenocarcinoma. The most common subtype among them is adenocarcinoma, which accounts for about 40% of lung malignancies.[16] Nine volatile organic compounds (VOCs) were identified using high-resolution mass spectrometry (HRMS) in the urine of lung cancer patients and healthy controls.

These included N-acetyl-S-methyl-L-cysteine, 3-methylhippuric acid, 2-methyl hippuric acid, and N-acetyl-S-(N-methyl carbamoyl).-N-acetyl-S-formysteine, 2-carbamoylethyl(2-carboxyethyl), N-acetyl-S-L-cysteineL-cysteine and N-acetyl-S-(3-hydroxypropyl-1-methyl)In addition to N-acetyl-S-(3-carboxy-2-propyl), L-cysteineThe compounds L cysteine and N-acetyl-S-(2-carbamoylethyl)N-acetyl-S (3,4-dihydroxybutyl)-L-cysteine and L-cysteine, which are produced from aldehydes, alkenes, amides, and aromatics, were found in more than 90% of both samples.[17]Technologies for radiotherapy are developing quickly, resulting in quicker, more precise treatments with fewer adverse effects. Imaging is one of the most important aspects of accurately delivering radiation. Four-dimensional computed tomography (4DCT) is currently often used in radiation planning. The delivery of stereotactic ablative body radiation (SABR) has been made possible by the development of these imaging technologies in conjunction with better techniques for immobilizing patients. SABR is the geometrically precise and accurate delivery of high ablative doses of radiation in smaller fractions[2]

**Nanoparticles In Cancer Treatment :**

The sizes, shapes, and surface properties of NPs utilized in medical treatment are often particular because these three factors significantly impact the effectiveness of nano-drug delivery and, consequently, regulate therapeutic success (Bahrami et al., 2017). NPs having a diameter between 10 and 100 nm are typically thought to be appropriate for cancer treatment because of their capacity to efficiently distribute medications and provide an increased permeability and retention (EPR) effect. Particles larger than 100 nm are likely to be removed from circulation by phagocytes, whereas smaller particles (less than 1-2 nm in diameter) can readily leak from the normal vasculature to harm normal cells and be readily filtered by kidneys (less than 10 nm in diameter) (Venturoli and Rippe, 2005).[18]The ability of each nanocarrier to carry several drug molecules enables the medicine to be successfully delivered to the target tumor at a higher concentration without endangering healthy tissues. Additionally, other anticancer medications can be transported by NP, producing a synergistic anticancer effect. Silver, gold, and platinum nanoparticles (NPs) are examples of metals that are typically tiny, measuring around 50 nm, and have a large surface area. Effectively absorbing light energy and converting it to heat is one of metal nanoparticles' main advantages. To make hyperthermic tumor therapy more targeted, some can be utilized in conjunction with photo stimulating the tumor to generate thermal energy. Due to their distinct chemical, physical, and biological intrinsic features, silver nanoparticles (AgNPs), one of several metal NPs, have found increasing application in the food, pharmaceutical, aerospace, microelectronics, and medical sectors.[19]

**Treatment for Cancer During the COVID-19 Pandemic :**

Oncology in Surgery. The M.D. Anderson Cancer Center (Chang and Liu, 2020) and the University of Alabama-Birmingham (Morrison et al., 2020) have both reported that almost all non-urgent or "elective" procedures have been postponed during times when the community's COVID-19 case count is at its highest. A 3- or 6-month delay in surgery for all stage 1–3 malignancies would result in 4,755 and 10,760 deaths, respectively, among the 94,912 patients who have major cancer resections each year, according to their estimates (Sud et al., 2020).[20] Recent research has demonstrated the possibility of diagnostic techniques based on nanotechnology in precisely identifying extracellular vesicles containing SARS-CoV-2 RNA in plasma, offering a viable substitute for conventional respiratory RNA level detection techniques. With high sensitivity, a broad dynamic range, and remarkable selectivity, the promise of electrochemical nano-biosensors—which use nanomaterials for signal amplification—has been shown in identifying dangerous DNA mutations in neonates. This is a useful tool for screening new borns. In the realm of infectious diseases, such as COVID-19, nanotechnology offers intriguing opportunities for treatment modalities, immunization tactics, and the possible integration of artificial intelligence.[21] In the cancer population, SARS-CoV-2/COVID-19 is linked to higher rates of morbidity and mortality .For some groups, including small children, the elderly, those with weakened immune systems, and people with underlying medical conditions, influenza viruses can be especially dangerous and can even be fatal . The effects of influenza-related infections are particularly severe for cancer patients, particularly those receiving chemotherapy. Immuno compromised patients may have solid tumors and hematologic malignancies as a result of their illness or as a side effect of anticancer treatment.[4]

**Challenges And Future Directions :**

Over the last 20 years, regulated medication delivery technologies have advanced significantly. However, there is still room for development to overcome the constraints and increase the potential for the future.[22]

**CRISPR/Cas9 Genome Editing of YY1 :** The cutting-edge technique known as CRISPR/Cas9 genome editing makes it possible to manipulate the genome precisely and effectively.[23] . The patient's health may deteriorate as a result of this unintentional editing, which may interfere with genes or activate genes that cause cancer. Due to changes in efficiency depending on the type of mutation and the type of cell, using CRISPR for gene editing is challenging; it is also challenging to get results across tissues . The laws controlling CRISPR-based treatments are often changing; some countries forbid modifying genes in germline cells, while others take a more permissive stance. This is particularly important as technology moves from lab tests to human testing [24]. Through a review of the literature, earlier research attempted to predict how AI will be used in cancer care in the future. [25]

Challenge 1: It makes sense to reclassify malignancies according to their DNA repair deficit status since DNA damage, response, and repair are essential to cancer treatment.

Challenge 2: It is important to find early indicators for DNA damage, response, and repair deficiencies so that they can be used to choose cancer treatments.

Challenge 3: Cancer resistance and normal tissue severe side effects are the major obstacles to cancer therapy, the goal of personalized therapy strategy is to overcome these obstacles. Many resistance mechanisms have been reported to chemo-, radio-, and immune therapy

Challenge 4: Although several possible DNA damage repair inhibitors have been approved for clinical studies, the mechanism underlying their action in cancer therapy is still unknown. [26]

**The Challenges of Targeted Cancer Therapy with Metal Complexes-Biomolecule Conjugation**:

Because of their limited water solubility and decreased bioavailability, metallocomplexes have presented new pharmacological difficulties. A core metal atom and a variety of molecules or anions called ligands make up a metal complex, sometimes referred to as a coordination compound. Among the metals examined are transition metals (such as rhodium, vanadium, iron, cobalt, and gold), main group metals (such as bismuth, tin, and antimony), and cerium. Metals, as opposed to organic compounds, offer ligand substitution kinetics, a broad variety of coordination numbers, and accessible redox states for the development of anticancer medication.[27] the review focuses on physically targeting tumors instead of taking advantage of changed signalling pathways.

The kind, stage, and location of cancer determine the physical targeting obstacles [28]

## 2. Future Direction :

More people are "living with cancer" and "living beyond cancer" as a result of current anticancer treatments; many of these patients will continue to experience issues that call for specialized care. For certain patient cohorts, "conventional" therapy might not be the best option . [29] As the use of AI is expanding quickly and seems to reduce human error, a new generation of peptide-based agents may soon be among the most crucial components in clinical management. We are currently working to improve our understanding of how to use AI safely, and its broad adoption in clinical settings is still limited.[2] A significant health concern, chemotherapy-refractory and metastatic triple negative breast cancer (TNBC) leads to poor survival and substantial relapse rates.[30] As new technologies are applied to support the development of novel PDC modalities, the field of drug conjugates as drug delivery systems for the treatment of cancer continues to progress. [31]

**Increased Integration with Healthcare Systems**:

Physicians and wearers of personal health monitoring devices can easily share data if they are connected to healthcare systems. This will streamline the provision of care and raise the likelihood of obtaining comprehensive, well-coordinated, and effective treatment services.

**Developments in Wearable Technology**:

There will be improvements made to wearables to make them more accurate, comfortable, and have longer battery lives. The interface and usefulness will be enhanced by new materials and thick/flexible sensors. [32]

## 3. Conclusion:

According to the WHO, cancer is one of the main causes of death. We discussed the prospects, patterns, difficulties, and potential paths of artificial intelligence in cancer research in this work ,diagnosis and treatment of cancer.

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