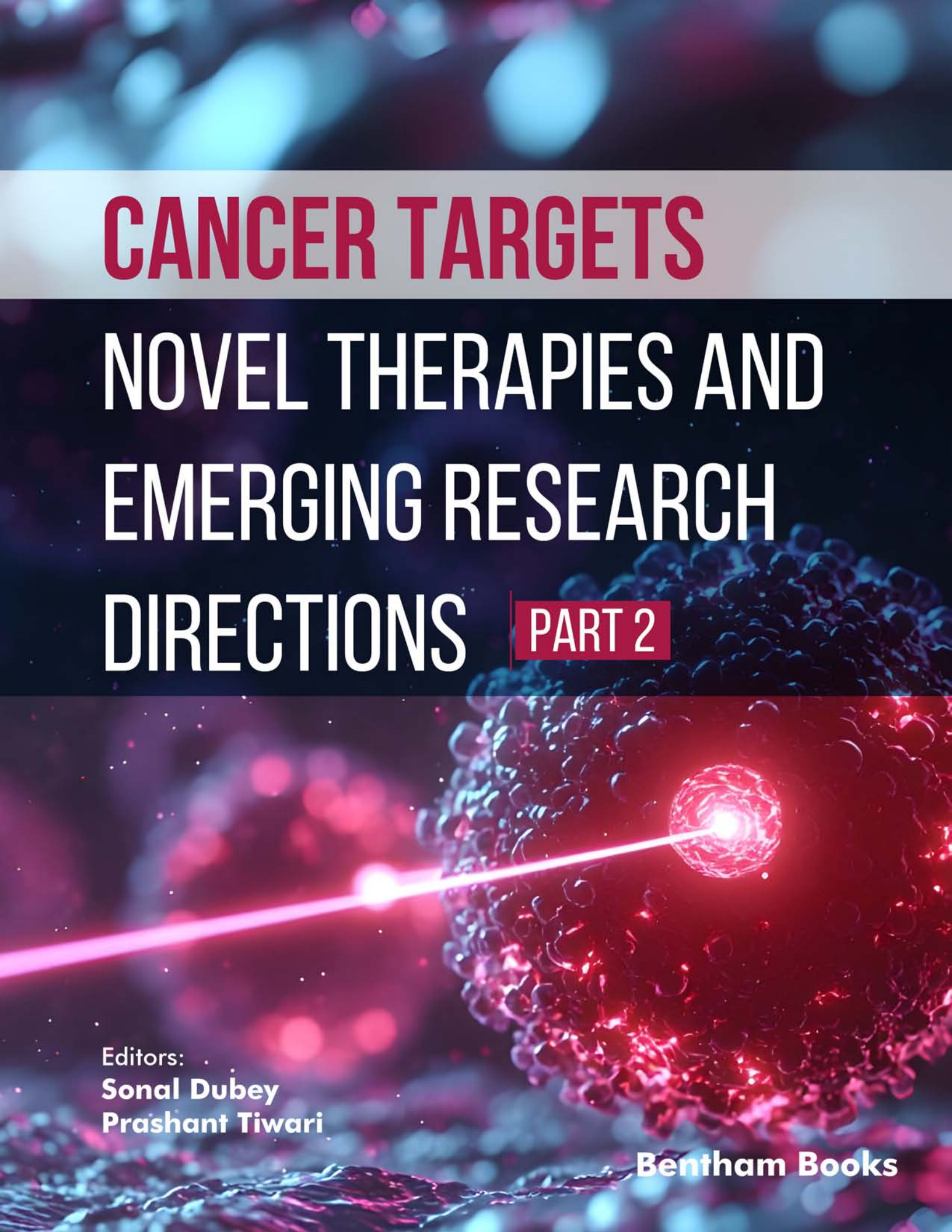
CANCER TARGETS

NOVEL THERAPIES AND EMERGING RESEARCH DIRECTIONS

PART 2



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Cancer Targets: Novel Therapies and Emerging Research Directions *(Part 2)*

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(Part 2)

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CONTENTS

FOREWORD

It is with great enthusiasm that I present "Cancer Targets: Novel Therapies and Emerging Research Directions," edited by Dr. Sonal Dubey and Dr. Prashant Tiwari, and published by Bentham Science. This book represents a vital contribution to the ongoing battle against cancer, a disease that continues to challenge scientists and clinicians worldwide. With advancements in research and technology, we find ourselves at the cusp of transformative breakthroughs in cancer treatment and management.

As we know, cancer is a complex and heterogeneous group of diseases characterized by uncontrolled cell growth. Traditional therapies such as chemotherapy and radiation have long been the mainstay of treatment; however, they often come with significant limitations and side effects. The need for novel therapeutic strategies that are more effective and less toxic is more pressing than ever. This volume delves into the innovative research and emerging methodologies that are redefining our approach to cancer treatment, focusing specifically on novel therapeutic targets and mechanisms.

The chapters within this book encompass a wide array of topics, including targeted therapies, immunotherapy, and personalized medicine. Each contribution reflects the latest advancements in the understanding of cancer biology, molecular mechanisms, and potential therapeutic interventions. Dr. Dubey and Dr. Tiwari have meticulously curated a collection of expert opinions and research findings that not only highlight current trends but also provide insights into future directions for cancer therapy.

Furthermore, this book addresses the critical need for interdisciplinary collaboration in cancer research. By integrating knowledge from various fields, including molecular biology, pharmacology, and clinical medicine, we can accelerate the development of effective treatments. The insights shared in this volume will empower researchers and clinicians to explore new avenues of investigation and improve the therapeutic landscape for cancer patients.

In an era where precision medicine is gaining momentum, understanding cancer targets at a molecular level is essential. The contributions in this book pave the way for innovative approaches that could significantly improve patient outcomes and quality of life.

I am confident that "Cancer Targets: Novel Therapies and Emerging Research Directions" will serve as an invaluable resource for researchers, clinicians, and students alike. It not only informs but also inspires continued exploration in the relentless fight against cancer.

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Preface

Cancer remains one of the most complex and multifaceted diseases of our time. Despite tremendous advances in treatment modalities, such as surgery, chemotherapy, radiation, and immunotherapy, there is still a pressing need for more effective, targeted therapies that can enhance patient outcomes and reduce the collateral damage to healthy tissues. The scientific community's concerted efforts to unravel the underlying mechanisms of cancer development, progression, and resistance have paved the way for the discovery of novel molecular targets and therapeutic strategies.

This book, Cancer Targets: Novel Therapies and Emerging Research Directions, aims to provide a comprehensive overview of the latest advancements in the identification of molecular targets for cancer therapy and the development of novel therapeutic approaches. The chapters in this volume delve into various cutting-edge research areas, from the molecular biology of cancer to the preclinical and clinical evaluation of novel agents. By focusing on the emerging directions in cancer research, the book highlights the potential of targeted therapies to transform the landscape of cancer treatment in the coming years.

We have collaborated with leading experts in the field to present a diverse range of perspectives and insights. These contributions offer a deep dive into the molecular mechanisms that drive cancer growth, metastasis, and drug resistance, while also addressing the challenges and opportunities associated with translating these discoveries into clinical practice.

This compilation will serve as a valuable resource for researchers, clinicians, and students who are keen to explore the frontier of cancer research and therapy. We believe the insights shared in this volume will inspire continued innovation in cancer treatment and foster new approaches to tackle this formidable disease.

We are grateful to all the contributors for their invaluable input and dedication to advancing cancer research. Special thanks are extended to Bentham Science for their support and for providing a platform for this important work.

We hope this book will serve as a beacon for future research endeavors and as a testament to the progress being made in the fight against cancer.

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CHAPTER 1

Combination Therapies: Synergizing Treatments for Enhanced Efficacy

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Abstract: Combination therapies have become a crucial approach in cancer treatment, focusing on improving effectiveness while addressing issues like drug resistance and the diversity of tumors. This chapter offers a thorough overview of the principles, mechanisms, and clinical uses of combination therapies in oncology. It starts with a historical perspective, tracing the development of cancer treatments and emphasizing the need for combinations to enhance patient outcomes. The mechanisms of synergy—such as targeting various oncogenic pathways, adjusting the immune response, and altering the tumor microenvironment—are examined in detail, showing how these strategies can enhance therapeutic results. Important combinations, including chemotherapy paired with targeted therapies and immunotherapy, are discussed, highlighting their synergistic potential as demonstrated in recent clinical trials across different cancers, such as breast, lung, and colorectal cancers. Furthermore, the chapter explores the role of precision medicine in selecting effective combinations based on individual genetic profiles and tumor characteristics. Challenges like increased toxicity, complex dosing, and drug-drug interactions are critically assessed, along with strategies for optimizing combinations, including adaptive trial designs and the use of artificial intelligence. Lastly, we look at future directions, emphasizing the significance of new drug classes, nanomedicine, and gene-editing technologies in advancing combination therapies. This chapter highlights the transformative potential of synergistic treatments in achieving more effective, personalized, and adaptive cancer therapies, paving the way for better patient care and outcomes in oncology.

Keywords: Artificial intelligence, Chemotherapy, Clinical trials, Combination therapy, Drug resistance, Immunotherapy, Synergy, Targeted therapy, Tumor heterogeneity.

INTRODUCTION

Cancer therapeutics have experienced a lot of change in the past 100 years, from basic ways to sophisticated methods. Surgery to remove tumors was the main

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method of treatment at first, and radiation therapy emerged in the early 1900s. Whilst these therapies were shown to be efficacious for treating primary localised tumours, they impacted metastatic cancers less effectively. In the 1940s, chemotherapy, in particular with alkylating agents such as nitrogen mustards, was introduced, heralding systemic cancer treatments that could reach and target cancer cells almost anywhere throughout the body. Chemotherapy is not target-specific and therefore destroys both cancerous cells as well as normal body cells to the extent that they become highly toxic for human health [1, 2].

The second half of the 20th century would be instrumental in the establishment of targeted therapy because of molecular biology developments. Drugs such as the tyrosine kinase inhibitor imatinib, which has transformed the treatment of Chronic Myeloid Leukemia (CML) by directly inhibiting common cancer-driving mutations, have revolutionized cancer therapy. Although targeted therapies are more specific than chemotherapy, they also frequently result in resistance because tumors can find pathways around the new ways to target them with additional mutations [3]. Immunotherapy, especially immune checkpoint inhibitors, represented a revolution in the early 21st century by harnessing how our body's own defence mechanism could fight cancer. The potential of immunotherapy was further thrust into the spotlight with approvals for melanoma and a variety of cancer types, this approval room being exemplified by pembrolizumab (Merck) and nivolumab from Bristol-Myers Squibb. Among the many reasons why immunotherapy still has room for improvement is its limited potential for treating numerous cancer types. The two primary challenges are variable patient responses (it does not always work) and the risk of immune-related adverse events (side effects) [4].

Emergence of Combination Therapies: Addressing Drug Resistance and Tumor Heterogeneity

Combination therapies are developed to respond to the imbalance between tumor heterogeneity and drug resistance. Tumor heterogeneity refers to the divergence of cell types and mutations in a tumor that hinders the complete eradication of the cancer from the body through a single-agent therapy. Cancer cells can adapt to targeted therapies or generate resistance through mutations on the target itself or, alternatively, by activating other survival pathways. The other concerted assaults are brought about by using the combination of agents in their own combination therapies. Combination strategies that hit malignant cells with distinct agents are capable of achieving strengthening of their efficacy *via* additive or synergistic mechanisms. Also, it allows for the possibility of minimizing the required doses of each agent in combination, further lowering the dose-dependent toxicities to normal tissue [5]. A very effective combination is that of immunotherapy with

chemotherapy or targeted therapies. Chemotherapy and targeted therapies will kill cancer cells directly, but also by enabling a favourable tumor microenvironment for immunotherapy to take effect. It is this synergy that provides a rationale for so many successful combinations that see use in oncology [6].

Overview of the Different Types of Combination Therapies

Combination therapies can be broadly categorized into several types, based on the agents used:

Chemotherapy Combinations: Different chemotherapy agents are often combined, taking advantage of their different modes of action, such as inhibiting DNA replication, blocking mitosis, or inducing apoptosis [7, 8]. Well-established examples include the combination of cisplatin plus paclitaxel to treat ovarian cancer and the CHOP regimen (cyclophosphamide, doxorubicin, vincristine, and prednisone) in non-Hodgkin lymphoma. These combinations give a greater chance of destroying cancer cells at all stages of growth [9, 10].

Targeted Therapy Combinations: Some of the targeted therapies include the inhibition of specific molecules involved in cancer growth and survival, for instance, those targeting EGFR or VEGF [11, 12]. Combined targeted therapies may target multiple pathways together to surmount resistance mechanisms in several cancers. One such example is the combined use of BRAF and MEK inhibitors (dabrafenib and trametinib), which increased outcome in melanoma patients with BRAF mutations [13, 14].

Immunotherapy Combinations: Immunological checkpoint inhibitors such as PD-1 or CTLA-4 blockers have met with astounding success in cancer treatment; however, they can become augmentative to the other treatment modalities by working synergistically with the other concomitant treatment modalities [15, 16]. For instance, the chemistry of pembrolizumab (PD-1 inhibitor) creates an improvement in NSCLC due to enhancement of the immune system's ability to recognize and kill cancer cells, in combination with the administration of chemotherapy [17, 18].

Radiotherapy Combinations: Radiation therapy, in conjunction with chemotherapy and immunotherapy, synergistically enhances the effects of one another: radiation can ignite an immunogenic cell death process to release tumor antigens for the immune system to recognize in attacking cancer [19 - 21]. The immunotherapy agents can, themselves, augment the immune response against radiation-induced damage [22].

CHAPTER 2

Targeted Therapies: Precision in Cancer Treatment

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Abstract: Cancer is one of the most complicated illnesses and one of the main causes of death in the world. The fundamental factors include a unique genetic susceptibility, extended exposure to various environmental stressors, and an inadequate diet. When these risk factors are present, genetic changes or mutations accumulate in important proteins inside cells, which speeds up the process of carcinogenesis. The cornerstone of cancer treatment has been traditional chemotherapy. Chemotherapeutic drugs are designed to target cancer cells—which proliferate quickly—as well as certain healthy cells, like the intestinal epithelium. A new class of cancer treatments has arisen in recent years: targeted cancer medications. A precise medical intervention that targets abnormal cells specifically is called targeted therapy. A cell that differs from other cells in certain ways is called an aberrant cell. It might also make use of a normal cellular process, but it would do so excessively, making it entirely dependent on it. Pharmacological medications are used in targeted cancer therapies; these medications, like conventional chemotherapy, slow the growth of the disease, increase cell death, and prevent it from spreading. Targeted cancer therapy falls into two primary categories: small molecule inhibitors and monoclonal antibodies. A medication containing small molecules can enter cells easily and damage their internal structures. They can also be used to disturb molecules that are on the surface of the cell. Larger in size, monoclonal antibodies work extracellularly—that is, outside the cancer cells. They target substances that are either on the surface of cancer cells or very near them. These are produced by cloned cells that produce antibodies that interfere with the particular chemical that is the target. Another use for monoclonal antibodies is the targeted delivery of a cytotoxic agent straight into a cancerous cell.

Keywords: Carcinogenesis, genetic susceptibility, genetic changes, proliferate, monoclonal antibodies, cytotoxic agent.

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Sonal Dubey & Prashant Tiwari (Eds.)

INTRODUCTION

A multitude of genetic and molecular alterations cause uncontrollable cell development and multiplication in cancer, a condition that is broad and multifaceted and rapidly increases the amount of tissue in the affected areas of the body. Under normal conditions, an organism's cells get signals to die and be replaced by new, healthier cells. Cancer cells multiply by taking up oxygen and growth ingredients from the body, depriving other cells of regular growth nutrition and supplements. These cells possess the capacity to influence the milieu, deceive the immune system, and adapt the physiologies of other cells to their own needs [1, 2]. Several biomarkers, such as Human Epididymis protein 4 (HE4), carcinoembryonic antigen (CEA), legumain, mesothelin, osteopontin, and vitamin E binding plasma protein, are currently employed for cancer detection. Many naturally occurring chemicals and anti-cancer drugs have been created over time that can stop tumor growth in different ways. Certain drugs and substances influence essential biological enzymes, while others may alter the way cells metabolize [3 - 5]. They have also shown the capacity to impede several essential biological processes, including apoptosis, drug resistance, immunological responses, DNA damage, and programmed cell death.

These medications exhibit unique mechanisms of action and selectivity towards various types of cancer. However, even little changes in their molecular composition can render them completely ineffective against cancer. The concept of chemotherapy, which utilizes toxic chemicals and drugs to eradicate cancer cells, was derived from observations of mustard gas causing harm to lymphatic and bone marrow tissues [5 - 7]. Subsequently, nitrogen mustard, an efficient gas derivative that successfully regressed lymphoma tissues, was used to corroborate the findings in mice. The first patient treated with this nitrogen mustard was a 48-year-old man who had lymphosarcoma; initially, the cancerous growth softened and eventually went away. Unfortunately, he relapsed and died later, but this clandestine military experiment at Yale University laid the foundation for the field of cancer chemotherapy and made it possible to treat numerous malignancies with chemicals [7 - 9].

Cancer and its Molecular Basis

Cancer is the term used to describe the uncontrolled and unrestricted growth of cells. Within a therapeutic context, it presents itself as a proliferation. Neoplasms are abnormal clumps of tissue that grow uncontrolled, even without the presence of stimuli that promote growth. A tumor is considered benign when it has characteristics suggesting that it will not metastasize to local or distant locations, can be readily excised, and does not pose a significant threat to the patient's life

[10 - 12]. The term “cancer” is used as a collective name for malignant tumors because they penetrate tissues in a crab-like fashion. A malignant tumor has the ability to invade nearby structures, causing their destruction, and then spread to distant locations (metastasize), finally resulting in death.

Not all malignancies lead to mortality; certain cases can be successfully treated with accurate diagnosis and proper medical attention. Cancers arise due to unique molecular changes triggered by either internal or external stimuli. Genetic vegetables, tobacco usage, fast food, and mutations can be passed down through generations or acquired due to exposure to environmental factors. Some examples of environmental agents include: Malignant neoplasms possess traits such as fast proliferation, the ability to invade nearby tissues, and the propensity to metastasize to distant sites. Cancer cells exhibit several crucial alterations, including autonomous proliferation, insensitivity to growth-inhibitory signals, resistance to apoptosis, angiogenesis, invasion of neighbouring tissues, metastasis to remote organs, and impaired DNA repair [13 - 15].

What are the Prevalent Types of Cancer in the Human Body?

The most common cancers among guys worldwide include lung, prostate, colorectal, stomach, and liver cancers. Common cancers found in women include breast, colorectal, lung, cervical, and stomach cancers. The most common types of cancer in men in India are oral, lung, stomach, and colon cancers [16 - 18]. However, there has been a decrease in their frequency. The most prevalent malignancies in females, ranked by frequency, include breast, cervix, colon-rectum, ovary, and mouth cancers. The occurrence rates of these malignancies vary based on geographical location, prevailing societal norms, and socioeconomic position [19 - 21]. Mouth cancer has a higher prevalence in the Indian subcontinent compared to Western nations. This is a result of a surge in the consumption of chewable tobacco products such as gutkha, paan, paan masala, khaini, supari, and others.

Cervical cancer is more prevalent among women from lower socioeconomic strata due to insufficient genital hygiene. Individuals who consume a diet characterized by a high fat content and a low fiber content have an increased likelihood of developing colorectal cancer.

What are the Early Signs of Cancer?

Timely identification is crucial for administering suitable treatment for cancer. Cancer can manifest in several forms. The following are ten prevalent indicators of cancer:

CHAPTER 3

Liquid Biopsies: A Window into Tumour Dynamics

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Abstract: Despite the progress made in treatments and molecular profiling technologies, cancer remains a significant cause of death globally. Treating cancer places a substantial financial strain on public health systems. In the area of both cancer diagnosis and its treatment, tissue biopsy provides insights into the genetic characteristics of a tumour, permitting the estimation of disease progression and the body's reaction to therapeutic regimens. Tissue biopsies have demonstrated that tumours evolve heterogeneity at different stages, due to which a particular therapeutic path becomes problematic in cancer treatment. Obtaining tumour samples through invasive biopsy and conducting molecular analysis has enhanced the ability to plan treatment, assess effectiveness, and track recurrence in cancer patients.

Therefore, it is feasible to investigate an alternative method or non-tissue source in early cancer diagnosis and prognosis, like the liquid biopsy technique. Liquid biopsies involve blood analysis, as well as other body fluids like urine or faeces, from cancer patients to detect tumor-specific markers. Liquid biopsy is a preferable type of biopsy compared to older procedures due to its reduced invasiveness, increased sensitivity, and ability to allow repeated samples. This approach enables the consideration of tumour heterogeneity by repeatedly sampling blood or other bodily secretions, as circulating components like circulating tumour DNA, circulating tumour cells, exosomes, or ECV proteins are produced from each cancer clone. This allows for analysis based on time, providing more accurate and up-to-date knowledge of cancer development. Liquid biopsies are currently utilized in various cancer scenarios and serve as the foundation

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Sonal Dubey & Prashant Tiwari (Eds.)

for numerous oncology clinical trials. This chapter presents early diagnostic techniques that focus on several analytes for liquid biopsies. These tests utilize advanced technology and aim to make the initial identification of cancer a routine aspect of preventive medicine, along with healthy living, in the next decade.

Keywords: Blood sampling, Cancer, Diagnosis, Liquid biopsies, Treatment, Tumour.

INTRODUCTION

The concept that bodily fluids can serve as indicators of sickness has its origins in ancient Greek history, specifically with the introduction of the humoral hypothesis by Hippocrates (ca. 460–370 BCE). This idea maintains that the individual body contains four primary fluids or humours (blood, black bile, phlegm, and yellow bile) that require balance to sustain optimal health and well-being [1]. At present, blood and urine are the primary body fluids that have been thoroughly examined. However, additional biological liquids, including cerebrospinal fluid, seminal fluid, and saliva, also possess considerable diagnostic and prognostic capabilities [2, 3]. Given that cancer is confirmed to be a prominent cause globally, continuous efforts are being undertaken to improve its diagnosis and therapy. Tissue biopsies have traditionally been the approach of choice for assessing tumors and detecting cancer, but they have plenty of limitations. Tissue biopsies may offer little knowledge regarding the development of cancer cells and are generally intrusive, thus rendering it tricky to obtain specimens from expected anatomic regions. Tumor heterogeneity is additionally an outcome of epigenetic and genetic mutations that cancer cells encounter throughout their lifetime. The reliability of diagnostics and medical recommendations depending on these specimens may be affected by this variability [4]. The significant alterations happening within and between tumors are frequently not entirely represented by individual biopsies, which renders it challenging to choose an appropriate route of action, considering relatively minimal data [5]. The passage of time, consistency, elderly patients, pain, expense, and significant clinical implications are just some of the factors that render laparoscopic biopsies inappropriate for providing a complete tumor description, detecting lesions across multiple locations, or prospectively tracking the disease [6].

As an alternative strategy for resolving these challenges, liquid biopsies offer a more accurate and compassionate method for predicting, assessing, and monitoring diseases. In biopsy specimens for cancer, tumor-specific markers detected throughout different body fluids—usually blood—are analyzed [7]. A liquid biopsy is explained by the National Cancer Institute as a method of diagnosis that includes examining a blood sample for the identification of

cancerous cells that have migrated from tumor cells that exist inside the circulatory system [8]. Several benefits are associated with this method, including reduced invasiveness, lessened cost, actual time tumor details, and the capacity to address the tumor heterogeneity issue [5]. The procedure of gathering and evaluating bodily secretions like bone marrow, saliva, blood, urine, and cerebro-spinal fluid (CSF) is referred to as a liquid biopsy [9]. They may enhance present methods of tracking the beginning of sickness and the effectiveness of therapy in real-time by assisting with diagnosis, prognosis, and therapy allocation [10].

The purposes of liquid biopsies may be divided into 2 categories based on biological variations. The first group includes macromolecules or micromolecules that exist in bodily fluids but lack cells or subcellular structures, like carbohydrates, lipids, proteins, DNA, and additional minute metabolites, as well as metal ions. The second group comprises targets that involve structures that are cellular or subcellular, such as individual or grouped Extracellular Vesicles (EVs), circulating mitochondria, immune cells, Tumor-Educated Platelets (TEPs), Circulating Tumor Cells (CTCs), and circulating cancer-related fibroblasts (CAFs) [11 - 13]. Precision oncology is a developing area of study that concentrates on cancer biomarkers obtained from the primary tumor or parts of the metastatic location that are circulating. Tumour cells discharge a variety of biological materials into the bloodstream of cancer individuals, such as Extracellular Vesicles (EVs), exosomes, Circulating Tumor Cells (CTCs), cell-free DNA (cfDNA), and RNA (mRNA and miRNA) [14]. The cancer-related elements found in patients' biofluids offer important genomic, epigenetic, transcriptomic, and proteomic information on tumors and sites of metastases. This information eventually enhances cancer screening and the evaluation of therapy effectiveness [15 - 17].

Currently, liquid biopsy is a highly effective method for developing customized treatments for lung, stomach, breast, and prostate cancers. Recent work on gastric cancer indicates that Circulating Tumour Cells (CTCs) play a prognostic function in every disease phase. Moreover, the detection of cfDNA and ctDNA can offer insights into the likelihood of stomach cancer recurrence and the spread of metastases [18].

IMPORTANCE OF LIQUID BIOPSIES IN CANCER DIAGNOSIS

Due to restrictions on the utilisation of individual samples, novel methods for monitoring tumour dynamics as well as tumour genetics have emerged. The release of the research report in 1948, which detailed the occurrence of circulating free DNA (cfDNA) and RNA inside individual blood circulation, unknowingly marked the initial stage in the development of the 'liquid biopsy'. Identifying

CHAPTER 4

Artificial Intelligence in Oncology: Revolutionizing Cancer Care

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Abstract: The integration of Artificial Intelligence (AI) into oncology is transforming cancer care by improving diagnosis, treatment planning, and patient outcomes. AI—with its ability to analyse vast datasets—offers unprecedented insights into the complexities of cancer biology, enabling more accurate and personalized approaches to treatment. This chapter explores how AI-driven technologies, such as Machine Learning (ML), deep learning, and Natural Language Processing (NLP), are revolutionizing cancer detection, prognosis, and therapeutic strategies. AI's role in oncology spans from early cancer detection, where image recognition algorithms improve the accuracy of radiology and pathology assessments, to advanced treatment personalization through predictive analytics. Machine learning models trained on patient data can identify patterns and predict responses to therapies, enabling oncologists to design more effective, individualized treatment plans. AI tools are also being utilized for drug discovery, identifying novel therapeutic targets, and optimizing clinical trial designs, accelerating the development of new cancer therapies. In addition, AI-driven precision medicine is enhancing the management of complex cancers by integrating genomic data, medical records, and real-time patient monitoring. AI helps predict cancer progression, recurrence, and potential adverse treatment effects, improving decision-making for clinicians and patient care. Despite these advancements, challenges remain, including the need for large, high-quality datasets, algorithm transparency, and addressing ethical concerns regarding patient privacy. The chapter discusses these challenges and potential solutions to ensure responsible and effective AI adoption in oncology. In conclusion, AI is poised to revolutionize cancer care, offering the potential to improve survival rates and quality of life for patients. By enhancing diagnostic accuracy, personalizing treatment, and accelerating therapeutic

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Sonal Dubey & Prashant Tiwari (Eds.)

discoveries, AI is driving a paradigm shift in oncology that promises a future of more effective and accessible cancer care.

Keywords: Artificial intelligence, Cancer care, Machine learning, Oncology, Precision medicine.

INTRODUCTION

Overview of AI in Oncology

The integration of AI into healthcare, particularly in the field of oncology, has transformed cancer care significantly [1]. By leveraging AI algorithms to analyse comprehensive patient information and employing deep learning sources to identify subtle signs of malignancy, the collaboration between AI and oncology offers promising opportunities for early cancer detection and innovative treatment approaches. The utilization of computational methods has greatly expanded the toolkit for detecting cancer at its earliest stages [2]. AI's capacity to identify radiological and pathological data has led to an enhancement in the approval of diagnostic tools by agencies like the Food and Drug Administration [3 - 5]. These aim to improve early identification, thereby reducing the rate of illness and disease progression associated with cancer. This alliance is the essential need for an in-depth understanding of oncological and AI approaches [6]. As data science experts and oncologists collaborate to examine the complexities in assessment and treatment strategies for cancer, a shared understanding of AI fundamentals becomes essential. By exploring the fundamentals of AI, clinicians and researchers get a profound understanding of computational tools and methods driving advancements in cancer identification and management. Facilitating cooperation and communication among the various disciplines is essential for using collective knowledge to create and execute solutions obtained from AI that influence the outcomes of a patient. AI principles equip collaborators in oncology with the ability to effectively communicate the data-driven world of healthcare. This includes using machine learning techniques to forecast cancer progression and employing deep neural learning for image analysis. Promoting interaction and association across diverse fields is crucial for collective expertise to create and implement AI-powered solutions that significantly affect patient outcomes. The machine learning techniques facilitate predictive modelling to forecast diseases and deep learning for image analysis. This primer focuses on the approach, significance, and practical uses of AI. AI-enhanced personalized care plans by analyzing and predicting data of cancer patients [7]. This functions as a comprehensive resource for investigators and policymakers to emphasize AI-based patient care and outcomes in the future.

Exposure to AI in the Field of Oncology

A primer on AI in oncology elucidates the utilization of computer-designed programs for making predictions based on data. Algorithms are constructed by researchers to instruct computers on analyzing data and making decisions [8, 9]. The ability to find a sequence may not be easy for an individual to identify, but Statistical learning algorithms can do. As ML algorithms are exposed to new data, their capacity to understand and analyze data improves with time [10]. ML data consists of two main methodologies: Supervised learning and unsupervised learning. Supervised learning: where the algorithm works by using known and labelled data. Unsupervised learning operates without preset data outcomes. Both approaches use different pattern recognition to showcase diverse outcomes, such as the identification of cancer, survival rates, or categorization of individuals in risk cohorts.

Recent advancements have particularly emphasised Deep Learning (DL), a subset of ML [11, 12]. DL involves the utilization of networks to find out patterns with minimum human intervention. These algorithms employ Artificial Neural Networks (ANNs) to process information in a manner comparable to the human brain. ANNs emulate the way brain cells interpret signals from the body [13, 14]. Fig. (**1**) depicts the significant divides being discussed. In oncology, an increasingly popular tool is OpenAI's ChatGPT [14, 15], which falls under the category of generative pre-trained transformers, a type of Large Language Model (LLM). It is considered a form of generative AI, which is a part of DL. A total of 693 AI systems were approved by the FDA as of Oct 23, with 77% of them being utilized in radiology (Fig. **1**). The initial FDA approval of an AI-enabled medical device dates back to 1995 for cervical slide interpretation, and a significant portion of currently authorized devices are geared towards early cancer identification. Several applications utilize DL architecture, which will be discussed later before examining specific examples [16, 17].

Advancements and Obstacles in Utilizing Artificial Intelligence for Diagnosing, Predicting Outcomes, and Administering Precise Treatments in Neuro-Oncology

Tumors originating in the brain or spreading from another site of the body significantly impact global health, with over 250,000 cases reported annually [18, 19]. In the United States alone, approximately 26,670 cancerous and 66,806 non-cancerous CNS tumors were recorded in 2022 [20]. Among these, glioblastoma, a particularly aggressive type of tumor found in the brain, stands out as a major factor in health problems and mortality, with a survival rate of 5 years of only 6.9% and causing around 10,000 deaths annually [21, 22].

CHAPTER 5

Patient-Centered Approaches in Cancer Management

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Abstract: Patient-Centered Communication (PCC) is an important part of patient care that the Institute of Medicine says is important for improving health. The National Cancer Institute's National Leadership Strategic Plan outlines the need for evaluation of PCCs in cancer care. Although our study focused on cancer care, these PCC measures can be applied to other medical conditions and diseases because patient care is still a strategic goal. We are also exploring considerations for the development of PCC measures for research, quality control, and monitoring purposes. Key findings from nursing research and their impact on cancer patients are patient-centered communication: It is important to put the patient first. Implementation of effective communication can improve care quality, increase self-efficacy, and increase trust in physicians. Participation in care: Participation in self-care may increase patients' confidence in cancer-related information provided by healthcare providers. Factors Affecting Confidence and QOC: Understanding Next Steps: Patients who understand the next steps in their treatment experience improved QOC and confidence. Addressing emotions: Acknowledging and addressing a patient's emotional well-being can have a positive impact on trust and QOC. Clear definition of the problem: A clear definition of the medical problem helps in getting better results. Spending enough time with doctors: Spending enough time with doctors can increase confidence and QOC. Addressing uncertainty: Strategies for managing uncertainty can have a positive impact on the patient experience. Opportunities to ask questions: Allowing patients to ask questions can increase trust in the doctor. Technology: Fortunately, technology does not affect interactive learning. Recommendations: Patient-centered strategies should be based on patient needs and focus on targeted implementation to improve overall outcomes. In summary, patient-centered care can lead to better patient experience, trust, and overall cancer outcomes. Common symptoms: Pain, nausea, and fatigue are common symptoms in children and adolescents receiving cancer treatment. Individualized Evaluation: It is important to evaluate the symptoms of the child or young person. This includes considering reporting preferences and focusing on the most important symptoms. Evidence-based guidelines: There is some evidence for managing symptoms, especially pain and nausea. These guidelines can guide individual interventions to provide self-care. Exchange information, foster positive relationships,

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Sonal Dubey & Prashant Tiwari (Eds.)

identify and resolve emotions, manage uncertainty, make decisions, and achieve patient autonomy. The goal is to define the patient's approach to quality care. Objectives and Key Findings: Participants expressed the need for better planning and preparation for long-term care after cancer treatment. Prior Practice: These key activities highlight opportunities to improve patient care at all levels: Individual Level: Practices that directly impact patients. Interpersonal Level: Applying the interaction between patients and doctors. Associate Level: Practice in cancer clinics and clinics. Interventions for people with cancer include: Good cancer care must be based on the patients' first, and the findings help build a foundation of care that can achieve better outcomes for survivors and is already in place, to ensure that survivorship care reaches clinical outcomes and patients.

Keywords: Cancer diagnosis, Cancer management, Cancer Prevention, Cancer treatment, Cause of cancer, Patient-centered approaches, Patient-centered communication, Patient-centered care.

INTRODUCTION

Annually, the American Cancer Society estimates new cancer cases and deaths in the U.S., compiling data on population-based cancer incidence and outcomes. It uses mortality data from the Centers for Disease Control and Prevention (up to 2021) and incidence data from major cancer registries (up to 2020). For 2024, projections indicate 2,001,140 new cancer cases and 611,720 cancer deaths in the U.S. Since 1991, over 4 million deaths have been prevented due to reduced smoking, early detection of certain cancers, and improved treatments for adjuvant therapies and metastases. However, progress is challenged by the rising incidence of six of the ten major cancers [1 - 3]. Between 2015 and 2019, annual increases included 0.6% to 1% for breast, pancreatic, and uterine cancers, and 2% to 3% for melanoma, prostate, liver (in women), kidney, and oral cancers. Cervical cancer (ages 30-44) and colorectal cancer rates also rose by 1% to 2% annually. Globally, cancer remains the leading cause of death, with rising prevalence despite efforts to mitigate risk factors [4]. Current treatments involve precise cancer staging followed by radiation, chemotherapy, or surgical resection. However, these therapies, which target rapidly dividing cells, cause significant side effects, impacting both cancerous and healthy cells. Anticancer drugs face challenges like toxicity, limited effectiveness, and poor biodistribution due to low solubility, instability, and rapid metabolism. Developing effective formulations is critical to overcome these issues, enabling targeted tumor treatment while preserving healthy tissue viability [5].

Various factors, such as environment, lifestyle, host traits, infectious agents, and genetics, are associated with cancer development. Understanding these etiologic and risk factors is crucial for identifying high-risk groups, improving screening, and implementing preventive strategies. Among these, infectious agents represent

a significant preventable cause of cancer [6]. Viruses, the most common agents in this category, play a key role in the pathophysiology of human cancers. Recent decades of research on viruses have deepened our knowledge of cancer biology, particularly how they influence cell signaling and growth regulation pathways leading to malignancy. Studies on the evolving properties of viruses have supported the hypothesis that they contribute to human neoplasia [7, 8].

Major Risk Factors Causing Cancer and their Management

There are several types of cancer-causing factors that must be considered during treatment and prevention. The same is illustrated in Fig. (**1**). Endogenous damage refers to internal factors that harm the body's lipids, proteins, and DNA, primarily due to oxygen byproducts from normal metabolism. This damage can accelerate aging, trigger cancer, and contribute to heart disease and neurological disorders. Antioxidants like carotenoids, ascorbate, and tocopherols can mitigate this damage. Weak antioxidant defenses lead to DNA oxidation, causing cumulative harm. Aging somatic cells also play a significant role in degenerative diseases. Mitochondrial DNA, highly vulnerable to oxidative stress, accumulates mutations over time. As people age, mitochondria generate more oxidants, further driving the aging process [9, 10].

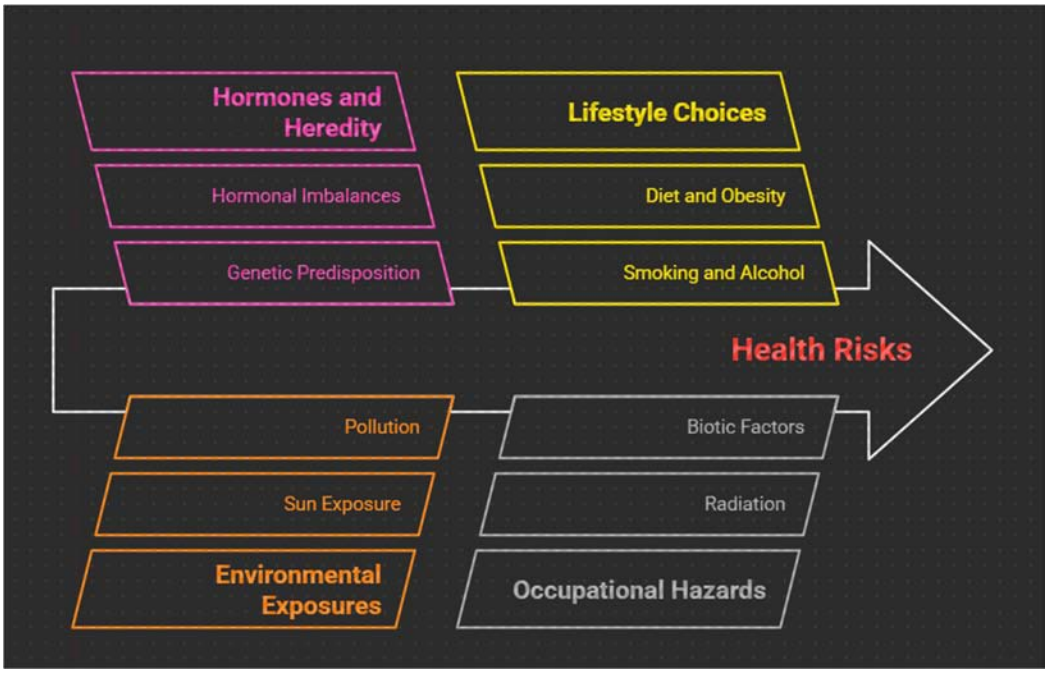

Fig. (1). Major Risk Factors that are responsible for causing cancer.

CHAPTER 6

Future Horizons: Emerging Technologies and Trends in Cancer Research

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Abstract: Cancer is a significant worldwide health problem. The resulting poor survival rates can be attributed to several factors, including the lack of early detection and intervention, as well as the restricted availability of prompt and standardized therapies. Considerable advancements have been achieved in recent years to create dependable, economical, and potent cancer diagnostics. This article offers a comprehensive summary of the most recent advancements in cancer diagnostic technology, specifically focusing on the many kinds of biomarkers that have been studied. These biomarkers include nucleic acids, proteins, enzymes, and Circulating Tumor Cells (CTCs), which are complete cancer cells that are present in the circulation. The text discusses some influential studies that use cancer treatment that involves multi-field detection as a substitute for conventional screening approaches. We have conducted a thorough evaluation of the many detection methods utilized for each kind of biomarker. The objective of this book chapter is to give readers a thorough

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Sonal Dubey & Prashant Tiwari (Eds.)

look at where cancer biosensing is at the moment, focusing on its practicality and rationality. In addition, to give readers a thorough look at where cancer biosensing is at the moment we examine the latest developments in the detection of cancer biomarkers utilizing innovative multiplexed and integrated platforms that provide precise and effortless results. We also address the technological constraints and current obstacles in reaching high sensitivity and selectivity. This initiative aims to foster interdisciplinary collaboration in order to develop personalized and user-friendly point-of-care solutions. The ultimate objective is to allow early cancer detection and substantially decrease cancer death rates.

Keywords: Biomarker, Cancer, Detection, Diagnostics, Research, Technology.

INTRODUCTION

The word “cancer” encompasses a wide variety of disorders characterized by the unchecked expansion of abnormal cells beyond their typical boundaries. The primary factor in cancer deaths is metastasis; if not treated early, these malignant cells may travel from the main tumor to other bodily components, including other organs. The elimination of cancer rates is a crucial step towards achieving the universal goal of a longer life expectancy [1]. Based on a 2019 study by the World Health Organisation (WHO) [2], in 112 countries, in 23 nations, cancer is the third or fourth major cause of mortality before 70. The GLOBOCAN database, which provides global cancer statistics, estimates that there were around 18.1 million new instances of cancer in 2018, and that the illness was directly responsible for 9.6 million deaths [3]. By 2020, these figures were expected to soar to nearly 10 million deaths and 19 million new cases.

With a 47% rise from 2020, the projected number of new cases of cancer globally in 2040 is 28.4 million [4]. Cancer is a big health concern that affects people in terrible ways and has enormous monetary implications due to both direct medical expenses and the value of people lost through early death. Poor survival rates are a direct result of delayed and inaccurate cancer diagnosis, as symptoms do not manifest until the disease has progressed significantly and metastasized to other parts of the body. Unfortunately, Cancer is frequently identified at an advanced stage, and there is often a lack of access to appropriate treatments, making treatment and recovery even more challenging [5, 6].

Thus, early detection is crucial for toxicity monitoring and, ultimately, for cancer therapy. Cancer “biomarkers” are substances or activities that may be identified and examined; they are useful for detecting cancer. Biomarkers are substances that may be detected in blood or tissues and can indicate things like tumor growth, metastasis, or the cancer's pharmacological reaction to a treatment. The long-term aim of studying these cancer biomarkers is to create methods that can reliably and

inexpensively identify and categorize tumors in their earliest stages, when patients are more likely to respond to therapy and have a better chance of survival [7, 8]. Furthermore, these biomarkers may be tracked to assess the development, improvement, or recurrence of a disease. Scientists have come a long way in creating effective cancer indicators that show promise. Many different methods have been studied recently, such as Surface Plasmon Resonance (SPR), surface enhanced Raman spectroscopy (SERS), fluorescence techniques, colorimetric test, electrochemical assay, polymerase chain reaction (PCR), and many more. There has been a lot of work put into cancer biosensors, but they still don't meet the criteria for clinical quantitative, sensitive, and specific diagnoses.

These problems stem from two major aspects of cancer biomarkers: Secondly, there is no feasible single biomarker for the identification of cancer since the word encompasses a multiplicity of illnesses in different sections of the body. This proves that there isn't currently "a single ideal biomarker" that can identify every kind of cancer. Another piece of evidence supporting the first point is the idea that monitoring several biomarkers is necessary for diagnostic, prognostic, and predictive evaluations [9, 10]. Hence, discovering novel biomarkers for cancer diagnoses with clinical relevance is both essential and difficult. Secondly, these biomarkers have problems with strong background signals and false positives due to their intrinsic features, such as their limited specificity to existing tests and their presence in diagnostic fluids in minute quantities with large numbers of non-target species. In order to guarantee accuracy and reduce false positives, researchers have focused on developing sophisticated detection techniques. One example is multiplexed platforms, which can selectively identify numerous cancer biomarkers [11 - 15]. Liquid biopsy is another illustration of this trend; it is non-invasive, very repeatable, and very convenient, and it has attracted a lot of attention recently [16, 17]. Designing biosensors involves developing strategies for detecting analytes, enhancing signal strength, and minimizing unwanted noise to improve analytical performance [18]. Innovative diagnostic technologies with multiplexed detection and user-friendly readouts are also becoming possible because of too fast advancements in nanotechnology and sophisticated manufacturing processes (Table **1**).

We provide a thorough analysis of the new developments in cancer diagnosis in this chapter of the book. We show and discuss cancer detection depending on the kind of biomarker applied to guarantee readability and understanding of the present state of this study area. We are hopeful that our study will inspire others from many fields to work together in order to develop technology that can reliably detect cancer in its early stages.

CHAPTER 7

Nanotechnology in Cancer Therapy: Small Wonders, Big Magic

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Abstract: Cancer continues to be one of the most life-threatening diseases globally, necessitating the development of more effective and less toxic therapeutic strategies. Among emerging approaches, nanotechnology offers a transformative platform for both diagnosis and treatment. Nanoparticles—engineered from carbon-based, organic, inorganic, and metal oxide materials—are being designed to selectively deliver anticancer agents to tumor tissues, thereby enhancing bioavailability, reducing systemic toxicity, and improving therapeutic outcomes. This chapter highlights the diverse nanocarrier systems—ranging from liposomes and dendrimers to gold nanoparticles and micelles—that have shown promise in enhancing drug solubility, prolonging circulation time, and enabling precise targeting of tumor tissues *via* passive and active delivery mechanisms. These carriers utilize passive targeting through Enhanced Permeability and Retention (EPR) or active targeting *via* ligands for tumor-specific uptake. Novel designs now integrate imaging and therapeutic capabilities (theranostics), addressing the limitations of traditional therapies such as multidrug resistance and non-specific cytotoxicity. Despite challenges in translation, including manufacturing scalability and regulatory hurdles, nanomedicine holds unprecedented potential to revolutionize personalized and targeted cancer therapy. This chapter also examines the progress in clinical trials and emphasizes the future prospects of nanotechnology in bridging the lab-to-clinic gap.

Keywords: Cancer, Clinical trials, Nanoparticles, Nanotechnology, Targeted drug delivery, Theranostics.

INTRODUCTION

Cancer is still the world's greatest cause of death despite tremendous advancements in the medical field. The cells in cancer show malignancy and

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Sonal Dubey & Prashant Tiwari (Eds.)

become unresponsive to the signals regulating cellular life. Over time, they develop resistance through rapid division of cells and transform normal cells into cancerous cells. These cells possess the ability to bypass apoptosis despite the circumstances. And once the cancer cells proliferate sufficiently within a tissue, they metastasize to adjacent tissues, converting healthy cells to become cancerous following the multiple genetic alterations. This metastasis and recurrence of cancer also contribute to rising mortalities, as there are numerous types of mutations per cell; identifying the specific mutation responsible for cancer is an exceptionally challenging task [1].

As per the estimation of GCO, approximately 35 million new cancer sufferers would succumb to the disease by 2050. The mortality rate of cancer is significant, with a substantial economic burden on the community. Consequently, initiatives for prevention, detection, and treatment of cancer are of paramount significance [2]. In spite of numerous modalities, like surgery, radiation, and chemotherapy, the mortality count of cancer remains elevated due to the inherent shortcomings of each treatment option. Considering this as the biggest challenge, researchers are in need of other options to predict, diagnose, and eradicate tumor cell growth [3].

Here, nanoscience has proven to be a boon for cancer therapy, the advent of which has potentially benefited the treatment by reducing the drawbacks of conventional treatments. The field of nanoscience primarily focuses on nanotechnology, which involves creating functional structures using individual atoms and molecules. Nanotechnology integrates physics, chemistry, engineering, and biology to design and produce nanomaterials. The fundamental nature and potential of nanoscience and nanotechnology are demonstrated by the significant changes in material characteristics, especially when dimensions are reduced to less than 100 nm. Nanostructured materials can achieve specific performance or novel characteristics by slight modifications, even certain macromolecules and particles exhibit unique physicochemical characteristics, enabling them to reach the target site, which is a novel tool for cancer diagnosis and treatment [4].

Overview of Nanotechnology

Basically, the prefix 'nano' originates from the Greek word meaning 'dwarf' or something exceedingly little, denoting 10^{-9} m. Nanoscience encompasses the examination of structures at the nanoscale, specifically between 1 and 100 nm, and the practical applications of this knowledge in any technology are referred to as nanotechnology. For example, the thickness of a human hair strand is about 60 nm, and the DNA double helix is 1 nm in radius. The origins of nanoscience date back to the 5^{th} century BCE., with the Greeks and Democritus, who contemplated that matter comprises tiny particles, now known as atoms [5].

Nanotechnology holds its place amongst the promising advancements of the 21st century, involving the translation of nanoscience theory into practice *via* observing, measuring, manipulating, assembling, controlling, and fabricating materials in a nanometric range. It has been defined by the National Nanotechnology Initiative (NNI) as "conduction of science, engineering, and technology at the nanoscale while applying this unique phenomenon on various fields of chemistry, physics, biology, medicine, engineering, and electronics" [6]. The definition implies the existence criteria for nanotechnology. The primary concern is scale: nanotechnology focuses on manipulating structures by altering their shape and dimensions at the nanoscale level. The second difficulty is the novelty: nanotechnology must engage with diminutive entities in a manner that leverages certain properties inherent to the nanoscale [7].

This emerging scientific discipline has diverse applications ranging from energy generation to industrial manufacturing processes and biomedical uses. The swift advancement of nanotechnology has demonstrated potential in enhancing human and veterinary health and in combating lethal diseases such as cancer. Over 150 years ago, Michael Faraday synthesized nanoscale gold particles, marking a significant achievement that facilitated substantial advancements in the medical field. Subsequently, researchers conjugated colloidal gold particles with antibodies to develop immune-gold staining, a technique for target-specific staining. This was first regarded as a precursor to modern nanotechnology-based drug delivery systems [8]. After that, numerous nano materials have been fabricated at the atomic and molecular scale that encompass nanoparticles, nanotubes, etc., in a size range of 1 to 1000 nm in at least one dimension [9]. The emergence of nanotechnology has enabled the implementation of nanomedicines in the therapy of cancer to mitigate the limitations of chemotherapy. Nanotechnology not only enhances the stability, biocompatibility, and cell permeability but also helps in delivering to target receptors or cells. It also enables the earlier detection of cancer by loading diagnostic agents with nanoparticulate carriers. Various studies have been conducted in recent years involving nanomaterial-based chemotherapy, targeted therapy, and theranostic agents in oncology, facilitating the earlier diagnosis with tailored and effective drug delivery in cancer. Gold nanoparticles (AuNPs) are widely utilized drug delivery vehicles for treating breast and prostate malignancies [10, 11].

Types of Nanomaterials Used in Cancer Therapy

The materials used in nanotechnology have a nano-sized range, hence are utilized in the design and manufacture of therapeutic medications and devices, with a reduction in dimensions to the nanoscale, distinctive electrical, magnetic, and optical properties arise, distinguishing the nanocompounds from conventional

CHAPTER 8

Implementation of *In-silico* Tools and Techniques for the Validation of Drug Repurposing

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Abstract: Traditional drug research and advancement processes are time-demanding and risky, employ validation and target recognition, lead molecule discovery and development, and preclinical and clinical studies. Over the last few years, the anticipated price of getting a novel medication to market has reached billions of dollars, with a 96% attrition rate among drug candidates. Low drug effectiveness, inadequate drug absorption, distribution, metabolism, and excretion, along with noxious effects, comprise the causes of this high attrition rate. Repurposing existing and accepted medications is a beneficial method because it minimizes the duration and cost of the drug development pathway, along with lowering the likelihood of unknown adverse effects. Drug repurposing has the capacity to introduce drugs with well-established safety characteristics to a new population of patients. A variety of new computational methods, both experimental and *in silico*, have made progress in making standardized repurposing of screens. The potential to rapidly select molecules *in silico* and restrict the count of potential repurposing molecules makes computational repurposing significantly interesting. Computer-aided drug discovery (CADD) methods also help to alleviate the time, scale, and cost challenges that traditional experimental methods confront. In order to enhance the precision and efficacy of CADD processes, many CADD techniques have recently been created and linked with machine learning techniques. CADD employs two techniques: Structure-Based Drug Discovery (SBDD) and Ligand-Based Drug Discovery (LBDD). The availability of target protein structure information influences the choice of an appropriate CADD technique. The purpose of this review is to demonstrate the utility of these computational methods in predicting relationships and identifying medication candidates for repurposing in new indications of specific disorders.

Keywords: Computer-Aided Drug Discovery (CADD), Drug repurposing, *In silico* drug design, Ligand-Based Drug Discovery (LBDD), Structure-Based Drug Discovery (SBDD).

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Sonal Dubey & Prashant Tiwari (Eds.)

INTRODUCTION

In spite of a great increase in the capital for research and development, the variety of novel medications that come to the pharmaceutical market is declining. Mergers and investments can enhance the drug process in a limited period; however, their positive results are very confined, and in a few instances have disturbed the research and development process [1]. Also, there has been a notable contribution on behalf of pharmaceutical industries to improve the drug advancement process, making use of the developed methods such as HTS, combinatorial chemistry, 'omics', and structure-based drug design approach. However, the effect of these transformations is not certain to be observed in the coming time. Drug repositioning, also called drug repurposing, is 'the method of determining different applications beyond the horizon of the parent medical implications for already available compounds and displaying a novel and favorable pathway [2, 3].

Compounds in support of repositioning are generally marketed medications or drugs that are taken out of clinical trials for causes other than safety issues. As the safety behavior of these medications is reported, clinical phases for other implications are affordable, quick, and have limited hazards compared to the *de novo* drug advancement process. In the year 2009, amongst the 51 novel drugs along with vaccines that came to market, new implications, new compositions, and novel mixtures of already marketed drugs resulted in an amount of 30% or greater [4]. Drug repositioning has received extensive recognition from the company, including academic and government organizations. Current progress in drug repositioning has mainly become the outcome of coincidence and clinical observations, like the noticed applications of sildenafil to treat pulmonary arterial hypertension and erectile dysfunction, along with multiple myeloma and leprosy, for thalidomide [5]. Methodical pathways are more rational and convenient for investigating repositioning challenges. For instance, phenotypic screens, which are similar to the medication advancement process, could be utilized with respect to organized repurposing, although this method too needs the supplementary effort of forming suitable screening tests for every disorder being examined. Bioinformatics and chemoinformatics give a remarkable chance to convert the one-drug-at-a-time, unexpected approach to a reasonable and comprehensive investigation of each available repositioning chance with regard to the majority of drugs, dependent on available data. The *in silico* drug repositioning implies different techniques to combine and examine datasets methodically from various sources. A major obstacle in this method is determining if a bioinformatics work process is feasible and can be utilized as a common method [6].

Potential benefit of repositioning compounds is mainly estimated through investigational validation with regard to some good yielding molecules by making use of a technique like binding affinity techniques. Although the repositioning method is time-consuming and material-intensive, this experimental confirmation is necessary to verify *in silico* results. Consequently, it is best utilized as a validation method rather than being an additive device for enhancing the *in silico* repositioning process during the initial discovery phase, which frequently involves studying various bioinformatics characteristics and approaches.

The selection of the bioinformatics process is based on the intended purpose of repositioning [7 - 9].

Purpose of Repurposing

There are two commonly used methods for drug repositioning: finding newer evidence for an already available drug (drug-centric) and recognizing efficacious medicine with regard to a particular disease condition (disease-centric) (Fig. **1**). Within the drug-centric phase, pharmaceutical industries primarily have an eye on drug compounds shown to be effective with Phase I clinical trials, although they did not succeed because of potency problems in succeeding Phases II and III clinical trials. It becomes complicated to evaluate the success rate of this method, due to the certainty that a promising repurposing cannot always transform into a marketed drug [10, 11]. In order to bring a successful repurposed medication to market, it relies on a variety of aspects such as the scope of new evidence with regard to market demand, cost, and profit tradeoff. Due to the uncommon behavior of drugs that do not make it through the phases of clinical trial, many academic and government organizations have an eye on the marketed medications that include off-patent, prescription, and Over-The-Counter (OTC) medications. Various advantages can result from repurposing marketed medication, like searching for novel treatments for unmet medical requirements, detecting higher potent methods, substituting costly drugs with rational ones, drugs with side effects with safer drugs, and expanding the utility of effective medications amongst larger people. For a variety of complicated diseases, such as cancers and HIV, treatments with very restricted effectiveness are present, and so novel methods are required. In the disease-centric phase, repositioning data generally focuses on particular disorders, especially incurable diseases that are devoid of safe and efficacious therapeutic alternatives for a long period of therapy and disease balance, like inflammatory bowel symptoms. An alternate attempt with regard to this includes preventing rare and neglected diseases [12]. Rare diseases influence a limited group of people (fewer than 200,000 in the USA), while neglected disorders include generally tropical transmissible disorders that affect the developing sections. Due to limited yield on investment, these sections have

SUBJECT INDEX

E

F

G

H

I

L

M

N

O

P

Q

R

S

T

V

W

Sonal Dubey

Dr. Sonal Dubey is an eminent academician and researcher in pharmaceutical education and scientific inquiry. She brings a wealth of expertise shaped by 23 years of teaching and 25 years of dedicated research experience. A former CSIR fellow, Dr. Dubey earned her doctorate from the University Institute of Pharmaceutical Sciences (UIPS), Panjab University—one of India's premier institutions in pharmaceutical education. Her scholarly contributions include four patents and six major research grants awarded by prestigious bodies such as DST, AICTE, and RGUHS, as well as DSU, where she has served as both Principal Investigator and Co-Principal Investigator. She has authored several book chapters, one book, and more than 60 research publications.

Dr. Dubey has mentored number of postgraduate and doctoral scholars, fostering innovation and academic excellence. Her research interests span a broad spectrum of therapeutic areas, including anticancer, antimicrobial, antitubercular, anti-HIV, and neurodegenerative disorders. She is particularly recognized for her expertise in computational drug design, integrating advanced modelling techniques to accelerate drug discovery and development.

With a career marked by academic leadership, impactful research, and a commitment to nurturing future scientists, Dr. Sonal Dubey continues to be a driving force in the field of pharmaceutical sciences.

Prashant Tiwari

Dr. Prashant Tiwari is a distinguished academician and researcher in pharmaceutical sciences with over 15 years of teaching and research experience across reputed institutions in India. Previously, he served as an Assistant Professor at Arka Jain University, Jamshedpur; Royal College of Pharmacy, Raipur; and the School of Pharmacy, CEC, Bilaspur. He also held a prestigious Senior Research Fellowship (SRF) under the Indian Council of Medical Research (ICMR) at Siksha O Anusandhan University, Bhubaneswar, where he conducted advanced research in neuropharmacology and drug development.

Dr. Tiwari's innovative research is reflected in multiple national and international patents. These include the microencapsulation of celecoxib to improve solubility for Alzheimer's therapy, AI-driven strategies for cancer drug analysis, and a smart IV fluid controller with advanced locking mechanisms. He has received research grants from the Department of Biotechnology (DBT), Government of India, along with seed project funding from DSU.

He has authored and edited more than 30 scholarly books and book chapters with leading publishers such as Springer, CRC Press, Cambridge Scholars, De Gruyter, Bentham Science, Taylor & Francis, and Nirali Prakashan. Notable works include The 3R's Approach in Preclinical Pharmacology (2025), Enzymatic Targets for Drug Discovery Against Alzheimer's Disease (2024), and Brain Tumor Drug Development (2024). Dr. Tiwari has organized national conferences, delivered lectures, and chaired sessions at international forums. His achievements have earned him prestigious honors, including the SPSR Excellence Award (2025), Dr. P. D. Patil National Award (2022), Young Scientist Award (2023), IPES Fellowship (2021), and the ICMR Senior Research Fellowship (2016–2019). His research interests include neurodegenerative diseases, drug interactions, pharmacokinetics/pharmacodynamics, and metabolic disorders.