

Commentary

## Advances in Precision Oncology and Drug Development

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## Description

Cancer has long been a formidable adversary in the world of medicine, challenging clinicians and researchers alike with its complexity and adaptability. Historically, treatments for cancer were often characterized by their one-size-fits-all approach, but this paradigm has been gradually shifting towards precision oncology. Precision oncology, also known as personalized medicine, represents a groundbreaking approach that tailors cancer treatments to the unique genetic and molecular characteristics of individual patients and their tumors. This paradigm shift has been driven by significant advances in our understanding of cancer biology, genomics, and drug development. In this study, we will explore the key developments in precision oncology and how they are transforming cancer care.

One of the central pillars of precision oncology is genomic profiling, which involves sequencing the DNA and RNA of cancer cells to identify specific genetic mutations and alterations driving the disease. The advent of next-generation sequencing technologies has made it possible to analyze the entire genomic landscape of a tumor in a costeffective and timely manner. Genomic profiling not only provides insights into the genetic drivers of cancer but also helps identify potential therapeutic targets. For example, the discovery of oncogenic mutations in genes like EGFR, ALK, and BRAF has led to the development of targeted therapies that specifically inhibit these mutant proteins. This approach has shown remarkable success in treating various cancers, including non-small cell lung cancer, melanoma, and colorectal cancer. Moreover, genomic profiling has revealed the heterogeneity of cancer, even within the same type of cancer. This knowledge has led to the realization that a single drug may not work for all patients with a particular cancer type. Instead, treatments can be personalized to match the specific genetic profile of each patient's tumor, increasing the likelihood of a favorable response. The development of targeted therapies represents a major breakthrough in precision oncology. These drugs are designed to interfere with specific molecules or pathways that are essential for the growth and survival of cancer cells. Unlike traditional chemotherapy, which can harm both cancerous and healthy cells, targeted therapies aim to selectively kill cancer cells while sparing normal tissue. One of the earliest success stories in targeted therapy is the drug imatinib (Gleevec), which revolutionized the treatment of Chronic Myeloid Leukemia (CML). Imatinib inhibits the activity of the BCR-ABL fusion protein, which is a hallmark of CML. In addition to imatinib, numerous targeted therapies have been developed for various types of cancer. For example, trastuzumab (Herceptin) targets Human Epidermal growth factor Receptor-2 (HER2) positive breast cancer, and vemurafenib (Zelboraf) is effective against BRAF-mutant melanoma. These drugs

have not only improved patient outcomes but also serve as proof of concept for the precision oncology approach.

Another groundbreaking advance in cancer treatment is immunotherapy, which harnesses the body's own immune system to recognize and attack cancer cells. While immunotherapy is not strictly a precision oncology approach in the same sense as targeted therapies, it has greatly benefited from our increased understanding of cancer genetics. These drugs block the immune checkpoints that cancer cells often exploit to evade detection by the immune system. Importantly, the success of checkpoint inhibitors is closely linked to the presence of specific biomarkers, such as Programmed Cell Death Ligand 1 (PD-L1) expression and Microsatellite Instability (MSI), which can help identify patients most likely to benefit from these therapies. Combination approaches that involve both targeted therapies and immunotherapies have also shown potential. For example, in melanoma, combining BRAF inhibitors with checkpoint inhibitors has led to higher response rates and improved overall survival. This illustrates the potential synergy between precision oncology and immunotherapy. Liquid biopsies are a relatively recent development that holds significant promise in precision oncology. These tests involve analyzing various components of a patient's blood, such as circulating tumor DNA (ctDNA) and Circulating Tumor Cells (CTCs), to detect and monitor cancer. Liquid biopsies offer several advantages. They are non-invasive, making them suitable for serial monitoring of disease progression or treatment response. Moreover, they can provide insights into the genetic changes occurring in a tumor over time, allowing clinicians to adapt treatment strategies accordingly. Liquid biopsies have shown utility in detecting Minimal Residual Disease (MRD) after surgery or other treatments, as well as in tracking the emergence of resistance mutations in response to targeted therapies. Artificial Intelligence (AI) and machine learning have emerged as indispensable tools in precision oncology. These technologies can sift through vast amounts of patient data, including genomic information, medical records, and imaging studies, to identify patterns and correlations that may not be readily apparent to human observers. This not only aids in early cancer detection but also helps in treatment planning and monitoring. AI can also assist in matching patients with clinical trials and treatment options that are most likely to benefit them based on their individual genetic profile and medical history. This level of personalization is a core principle of precision oncology.

## Conclusion

While precision oncology has made remarkable strides, it is not without challenges and limitations. One of the primary challenges is the identification of suitable drug targets and the development of drugs that can effectively target them. Additionally, drug resistance remains a persistent problem, as cancer cells can evolve and adapt to evade treatment. Moreover, the cost and accessibility of precision oncology treatments are significant concerns. Some targeted therapies and immunotherapies can be prohibitively expensive, limiting access formany patients. Ensuring equitable access to these therapies is an ongoing challenge for healthcare systems worldwide.