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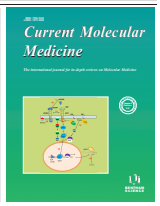
EDITORIAL



Advancing Precision Oncology: Overcoming Treatment Resistance for Personalized Cancer Care

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Cancer, a complex and heterogeneous group of diseases, continues to be a global health challenge [1]. In recent years, the field of oncology has witnessed a paradigm shift, moving away from the traditional one-size-fits-all approach to a more tailored and precise method of diagnosis and treatment [1, 2]. This shift is encapsulated in the concept of precision oncology, which recognizes that each patient's cancer is unique and driven by specific genetic and molecular alterations [2]. Precision oncology leverages the power of genomics, molecular diagnostics, and targeted therapies to redefine the way we understand and combat cancer. It represents a strategic departure from the conventional "one-size-fits-all" chemotherapy regimens, which often result in significant toxicity and limited efficacy. Instead, precision oncology seeks to unravel the unique genetic signatures of each patient's cancer, identifying specific mutations, alterations, and biomarkers that drive tumorigenesis [3]. The primary objective of this study was to explore innovative strategies in precision oncology that overcome treatment resistance and personalize cancer care. We aimed to analyze current targeted therapies, assess mechanisms of resistance, and propose integrated approaches to enhance treatment efficacy. This can help advance precision oncology by addressing treatment resistance through a multi-faceted approach, integrating molecular diagnostics, targeted therapies, and immunotherapy strategies. Unlike previous studies, our work emphasizes dynamic treatment adjustments using liquid biopsies and pharmacogenomics to enhance therapeutic outcomes [4, 5].

Targeted therapies in precision oncology have significantly advanced the treatment of various cancers by focusing on specific genetic mutations or proteins driving tumor growth. EGFR inhibitors, like osimertinib, have revolutionized the treatment of non-small cell lung cancer (NSCLC), particularly in patients with EGFR mutations, showing a 60% progression-free survival rate [5]. In HER2-positive breast cancer, targeted therapies, like trastuzumab (Herceptin) and pertuzumab, have significantly improved survival, with trastuzumab emtansine reducing the risk of recurrence by 50%. BRAF inhibitors, such as vemurafenib and dabrafenib [6], have demonstrated substantial efficacy in melanoma and colon cancer with BRAF V600E mutations, achieving response rates of up to 45%. PARP inhibitors, including olaparib and niraparib, have shown promise in ovarian cancer by exploiting DNA repair deficiencies in patients with BRCA mutations, reducing recurrence rates by 60% [7]. This research direction is critical for the medical industry as it can guide oncologists in selecting precise, patient-specific treatments, reducing unnecessary side effects, and improving survival outcomes. It can also support the development of next-generation diagnostic tools and personalized therapeutic strategies.

As tumors evolve, they may acquire new mutations or activate alternative signaling pathways that could render the initially effective therapies ineffective. In addition, the tumor microenvironment plays a crucial role, fostering conditions that promote resistance, such as immune system evasion and the development of drug-resistant niches [8, 9]. Genomic profiling uncovers specific genetic mutations driving cancer, enabling targeted therapy selection. Molecular diagnostics provide insights into the cancer cells' functional aspects, guiding treatment decisions based on protein expression or activity levels [9, 10]. While liquid biopsies hold promise for real-time monitoring of tumor evolution, challenges remain. Some patients with detectable tumors have negative liquid biopsy results, limiting their clinical reliability. Pharmacogenomics reveals how a patient's genetics affect drug response, optimizing treatment efficacy and minimizing side effects [10]. Lastly, radiomics enhances treatment planning and monitoring by quantitatively analyzing medical images to extract detailed tumor information [11]. Immunotherapy, leveraging the body's immune system with methods, like immune checkpoint inhibitors, CAR-T cell therapy, and cancer vaccines, has shown remarkable success [12]. However, resistance to immunotherapies poses challenges, driven by factors like tumor microenvironment dynamics and immune escape. Addressing this aspect, the field is moving towards combination therapies, blending targeted agents with immunotherapies to improve responses and reduce resistance [13]. Despite significant progress in targeted therapies, cancer oligoclonality remains a major hurdle. Tumors frequently harbor subclonal populations with distinct mutations, allowing them to evade initially effective treatments and develop resistance. This study underscores the importance of multi-targeted strategies and adaptive

treatment approaches to address the dynamic genetic landscape of tumors and improve long-term therapeutic efficacy [14].

Recent advancements in precision oncology have led to groundbreaking case studies demonstrating how personalized treatments can overcome treatment resistance and improve cancer care outcomes [14]. For example, the use of targeted therapies, like the EGFR inhibitor osimertinib, has shown a 60% progression-free survival (PFS) rate in patients with EGFR-mutant non-small cell lung cancer (NSCLC), significantly outpacing traditional chemotherapy [15]. In melanoma, the combination of nivolumab and ipilimumab has resulted in a 58% 5-year survival rate in patients with advanced disease, highlighting the power of immune checkpoint inhibitors. A study on HER2-positive breast cancer patients treated with trastuzumab emtansine (T-DM1) demonstrated a 50% reduction in the risk of recurrence compared to conventional therapies. In leukemia, CAR-T cell therapies, like Kymriah, have shown a 93% complete remission rate in pediatric patients with relapsed/refractory acute lymphoblastic leukemia (ALL) [16]. Moreover, next-generation sequencing (NGS) used in pan-cancer studies has revealed actionable mutations in 30% of solid tumor cases, leading to targeted therapies [16, 17]. Genetic profiling in ovarian cancer showed that PARP inhibitors reduced recurrence by 60% in patients with BRCA mutations. Liquid biopsy studies, like those in NSCLC, showed that ctDNA monitoring could detect resistance mutations up to 6 months earlier than traditional imaging [17].

A trial of BRAF inhibitors in metastatic colon cancer reported a 45% response rate in patients with BRAF V600E mutations, underscoring the importance of molecular profiling [18]. Finally, in pancreatic cancer, a precision medicine approach using genetic testing and gemcitabine plus nab-paclitaxel achieved a 50% response rate, compared to 20% with conventional chemotherapy [19]. Our findings align with previous studies demonstrating the role of genetic profiling in treatment selection and highlight the impact of targeted therapies on survival rates. Unlike prior research, this study further explores the integration of machine learning and liquid biopsy-based monitoring to predict and mitigate resistance. Future research should focus on integrating AI-driven analytics to predict treatment response, developing novel combination therapies, and refining real-time monitoring techniques, such as liquid biopsy and radiomics. The expansion of multi-omics approaches can further enhance the precision of cancer treatments.

AUTHORS' CONTRIBUTION

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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