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Opinion Article

Precision Oncology: Targeted Therapies Transforming Cancer Treatment

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DESCRIPTION

Cancer, a fatal and complex group of diseases, continues to cause a significant global health challenge. Conventional treatments such as chemotherapy and radiation therapy have been widely used, but their limitations in terms of specificity and associated toxicities have prompted the development of targeted therapies. Targeted therapy, an innovative approach in oncology, focuses on the molecular characteristics of cancer cells to modify treatment strategies. At the core of targeted therapy lies a deep understanding of the genetic and molecular alterations that drive the growth and survival of cancer cells. Unlike traditional treatments that affect both healthy and cancerous cells, targeted therapies aim to selectively disrupt cancer-specific pathways. This is achieved by exploiting mutations, gene amplifications, and aberrant protein expression that are unique to cancer cells.

Many cancers are stimulated by specific genetic mutations known as driver mutations. These mutations extend to a growth advantage to cancer cells by activating oncogenes or inactivating tumor suppressor genes. Targeted therapies are designed to inhibit the activity of these mutated proteins, effectively uneven the uncontrolled cell growth characteristic of cancer. For example, the BCR-ABL fusion protein is targeted by Tyrosine Kinase Inhibitors (TKIs) in Chronic Myeloid Leukemia (CML). Dysregulated signaling pathways play a primary role in cancer development. Targeted therapies often focus on key molecules within these pathways. The Epidermal Growth Factor Receptor (EGFR) pathway is a prime target in several cancers, including Non-Small Cell Lung Cancer (NSCLC).

Inhibitors of EGFR, such as gefitinib and erlotinib, have shown efficacy in inhibiting cancer cell growth driven by EGFR mutations. Tumor growth and metastasis are dependent on the formation of new blood vessels, a process known as angiogenesis. Vascular Endothelial Growth Factor (VEGF) is a catalyst in this process and is targeted by anti-VEGF agents like bevacizumab. By disrupting angiogenesis, these therapies discontinue the blood supply to tumors, inhibiting their growth. The transition of targeted therapy from laboratory to clinic has transformed ideal cancer treatment, providing improved outcomes and reduced side effects.

Trastuzumab, along with other HER2-targeted therapies like pertuzumab and ado-trastuzumab emtansine, has significantly improved the prognosis of patients with this subtype. In melanoma, mutations in the *BRAF* gene are common.

Targeted therapies like vemurafenib and dabrafenib inhibit the activity of the mutated *BRAF* protein. Combination therapy with a MEK inhibitor, such as trametinib, further enhances the efficacy of *BRAF*-targeted treatment, delaying the development of resistance. Anaplastic Lymphoma Kinase (*ALK*) gene rearrangements are prevalent in a subset of NSCLC patients. Crizotinib was the first FDA-approved *ALK* inhibitor, followed by newer generations of *ALK* inhibitors like alectinib and brigatinib.

These inhibitors have exhibited remarkable responses in *ALK*-positive NSCLC, leading to prolonged survival and improved quality of life. Cancer cells are adept at evolving resistance mechanisms to targeted therapies. Combination therapies, adaptive treatment strategies, and continuous monitoring of molecular profiles are being explored to counter resistance. Identifying patients who are most likely to respond to targeted therapies is essential. Biomarker-driven approaches, such as genetic testing and molecular profiling, aid in patient selection. Though targeted therapies are generally better tolerated than traditional treatments, they can still cause side effects. Efforts are being made to understand and manage these toxicities effectively.

CONCLUSION

The molecular basis of targeted therapy in oncology is an evidence to the power of precision medicine. By exploiting the unique molecular characteristics of cancer cells, these therapies provide a more customized and effective approach to cancer treatment.

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