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Review paper

Decoding Oncogenesis: Molecular Insights Guiding Precision Oncology Strategies

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Abstract

Background and aim: Cancer, a global health challenge, arises from genetic alterations in proto-oncogenes, leading to oncogenes that drive cell growth. Molecular insights in the realm of precision oncology are essential for tackling its complexity.

Methods: In our research, we conducted a comprehensive search across academic databases and online resources, employing key terms such as “oncogenes” and “precision oncology”." This search was conducted on reputable platforms including PubMed, Web of Science, and Google Scholar. Inclusion criteria encompassed peer-reviewed articles in English that focused on oncogenes' molecular aspects and precision oncology. Exclusion criteria consisted of non-English articles, duplicates, conference abstracts, ensuring the selection of pertinent and high-quality research for our review.

Results: Our study extensively examines the role of oncogenes in the context of precision oncology, specifically focusing on their implications for early cancer detection. We elucidate the intricate molecular processes, emphasizing the transition from proto-oncogenes to oncogenes and their significance in precision oncology. Our findings underscore the crucial role of oncogenes in the context of precision diagnosis, prognosis, and targeted treatment strategies, highlighting their potential as key components in advancing precision oncology methodologies.

Conclusion: Comprehensive comprehension of oncogenesis at the molecular level is imperative for early cancer detection and the advancement of precision oncology.

Keywords: *Oncogenesis, Molecular insights, Precision oncology*

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Introduction

Cancer persists as a formidable challenge in contemporary medicine, necessitating innovative approaches and comprehensive strategies for accurate diagnosis and treatment. The complexity of oncogenesis, marked by a multitude of genetic and molecular alterations, emphasizes the imperative for a profound comprehension to pave the path for precision oncology interventions.In recent years, progress in genomic technologies and high-throughput methodologies has yielded unprecedented insights into the genetic aberrations that underlie various types of cancer. The understanding of oncogenesis has evolved, revealing its highly intricate etiology that encompasses various levels of regulation. Beyond chemical influences, it is now recognized that endogenous molecular pathways can instigate mutations in vital genes. This process involves the generation of reactive oxygen species, capable of damaging cellular macromolecules, notably DNA [1], [2].

Despite cancer's longstanding presence in the human species over millions of years, the development of effective cures targeting molecular and cellular pathways has remained elusive. Various cellular targets have been scrutinized for cancer prevention or treatment, encompassing, but not limited to, transcription factors, kinase-mediated cell signaling pathways, and more recently, the epigenetic modulation of oncogenes and tumor suppressors [3].

The term "precision medicine" has gained popularity, replacing "personalized medicine." While the personalized approach in the doctor–patient relationship is not new, recent biomedical advances provide substantial information beyond observable signs and symptoms. Precision medicine emphasizes the incorporation of diverse individual data, including clinical, lifestyle, genetic, and other biomarker information, representing a comprehensive and novel approach [4], [5]. The advancing precision medicine paradigm in oncology underscores tailored therapeutic interventions aligned with the unique genetic profiles of individual tumors. This review delves into the molecular insights guiding strategies in precision oncology.

Methodology

In our research, we systematically explored academic databases and online resources using key terms such as "oncogenes," and "precision oncology." This search was conducted on reputable platforms, including PubMed, Web of Science, and Google Scholar. Our inclusion criteria encompassed peer-reviewed articles in English specifically concentrating on the molecular aspects of oncogenes and precision oncology. Exclusion criteria were applied to non-English articles, duplicates, and conference abstracts to ensure the selection of relevant and high-quality research for our review.

Brief Review of Literature

In a 2016 review study the authors adopt a measured perspective on the promise of precision oncology. Rather than focusing on the overarching promise, the authors direct their attention to the critical threshold at which success is declared. The study delves into an extensive review of precision oncology reports, juxtaposing them with findings from precision diagnostics and innovative radiotherapy approaches. The authors arrive at the conclusion that the current trajectory of precision oncology is likely to face challenges in achieving success, necessitating significant adjustments, at a minimum, for it to prove successful [6].

In a 2017 study conducted by Shin et al, precision oncology is defined as the strategic alignment of the most precise and efficient treatments with individual cancer patients. The identification of crucial gene mutations, such as BRCA1/2, which play a pivotal role in carcinogenesis, has laid the foundation for precision diagnosis in cancer. Extensive research into oncoproteins and their

associated signaling pathways has facilitated the development of targeted precision therapies for various cancer types. Despite existing challenges that may impede the success of precision oncology, the utilization of state-of-the-art tools for precision diagnosis and therapy is anticipated to address and overcome many of these obstacles [7].

In a 2017 study by Senft et al., the authors emphasized that current efforts in precision oncology predominantly center on the advantages of genomics-guided therapy. However, advancements in sequencing techniques offer an unprecedented insight into the intricate genetic and non-genetic heterogeneity present within individual tumors. In this context, we delineate the advantages of integrating genomic and transcriptomic analyses for an enhanced approach to precision oncology. The authors provide a summary of pertinent computational methodologies aimed at identifying novel drivers and genetic vulnerabilities, suitable for therapeutic exploration. The study also reviews clinically relevant platforms designed to functionally test predicted drugs or drug combinations tailored for individual patients. Notably, the study highlights the significance of technological strides in single-cell analysis of tumor specimens, suggesting that such advances may ultimately pave the way for the development of next-generation cancer drugs capable of addressing the challenges posed by the genetic and phenotypic heterogeneity inherent in current anticancer therapies [8].

In a 2017 study, it was asserted that precision oncology, characterized by the molecular profiling of tumors to identify targetable alterations, is rapidly advancing and has become integral to clinical practice. The genomic testing process involves multiple stakeholders collaborating in a coordinated manner to deliver high-quality tissue samples to reputable laboratories. These laboratories employ state-of-the-art next-generation sequencing (NGS) molecular analysis to generate actionable results. Clinicians are advised to acquaint themselves with the genomic variants reported by the laboratory and the technologies employed to derive these results, taking into account the limitations of current testing methodologies and reports. The interpretation of genomic results is most effectively approached with multidisciplinary input, aiming to minimize uncertainty in clinical recommendations associated with documented variants [9].

In a 2018 study, it was asserted that precision oncology has progressed to concentrate on aligning the most precise and effective treatments, considering not only the genetic profile of the patient and their cancer but also other distinctive characteristics that set one patient apart from another. Each individual possesses a unique combination of genome, proteome, epigenome, microbiome, lifestyle, diet, and other factors, all interacting to shape the processes of oncogenesis, disease progression, viable treatment options, drug tolerance, remission, and relapse. With cancer comprising several hundred heterogeneous diseases, variations exist not just between cancer cells among different patients but also within the cancer cells of a single patient. Cancer continually evolves characteristics to evade destruction, contributing to the lack of a singularly effective "cure." Precision oncology now entails leveraging a composite of each patient's unique characteristics to guide both immunotherapy and targeted therapies [10].

In a 2018 study conducted by Fountzilas et al., it was documented that precision medicine has brought about substantial changes in the diagnostic and therapeutic realms of cancer. To effectively implement precision medicine, there is a critical need for translational and bioinformatics infrastructure, supporting the refinement of treatment selection. The array of available interventions includes targeted therapy, immunotherapy, T-cell therapy either independently or in conjunction with cytotoxic treatments or other effective therapeutic approaches. Additionally, the provision of innovative clinical trials incorporating adaptive design principles should be extended to all patients [11].

In a 2020 study authored by Brown et al., it was emphasized that genomic testing plays a pivotal role in tailoring clinical management to individual cancer patients based on molecular alterations within cancer cells. The results of genomic sequencing can be employed for cancer detection and classification, prognosis prediction, and the identification of targeted therapies. The advent of next-generation sequencing has revolutionized cancer genomics by facilitating rapid and cost-effective sequencing of extensive genomic segments. This technological advancement has propelled precision oncology into a tangible paradigm for guiding the treatment of cancer patients. However, the efficient transition of next-generation sequencing from research applications to routine clinical practice faces numerous challenges, including the utilization of specimens commonly available in the clinical setting, addressing the processing, storage, and management of large volumes of sequencing data, deciphering the interpretation and prioritization of molecular findings, and coordinating healthcare professionals across various disciplines [12].

In a 2022 study by Mateo et al., it was noted that the escalating utilization of genomic profiling for diagnosis and therapy guidance across various tumor types is swiftly transforming cancer care through precision oncology. Nonetheless, the present course of drug development in oncology presents a paradox: the development of drugs may have limited impact if advanced diagnostics remain inaccessible to patients. To bridge this gap, a multi-stakeholder approach encompassing evidence generation, value assessment, and healthcare delivery is imperative. This collaborative effort is crucial for translating the strides made in precision oncology into tangible benefits for cancer patients on a global scale [13].

In a 2023 study, it was highlighted that the adoption of high-throughput methods to explore the omic landscapes of tumors has swiftly ushered cancer specialists into the precision oncology era. The fundamental insight gleaned from precision oncology underscores the imperative for personalized treatment, recognizing that the intricate molecular and immune landscapes of each cancer vary among patients. Transformative therapies now extend to targeting the consequences of molecular abnormalities and immune mechanisms, with previously considered undruggable pathways becoming viable targets. A crucial tenet of applying precision medicine is the recognition that the selection of the right combination of drugs, tailored to each patient, is paramount and should be administered at the appropriate stage of the disease [14].

Discussion

Precision oncology stands at the forefront of revolutionary advancements in cancer care, harnessing molecular insights to meticulously customize therapeutic strategies for each individual patient. This cutting-edge approach marks a paradigm shift, moving away from traditional one-size-fits-all treatments towards a highly personalized and targeted model. By delving into the intricate molecular landscape of tumors, precision oncology aims to unravel the unique genetic and molecular signatures that govern each patient's cancer journey. This nuanced understanding enables oncologists to craft treatment plans that specifically address the underlying biological mechanisms propelling the disease, ultimately leading to more effective and tailored interventions. As precision oncology continues to evolve, it not only transforms the way we approach cancer treatment but also holds the promise of unlocking novel therapeutic avenues and improving patient outcomes in the quest for more precise, effective, and compassionate cancer care [13].

At the heart of precision oncology lies a foundational pillar: a profound comprehension of the genomic landscape inherent to tumors. This cornerstone principle underscores the pivotal role that genomic information plays in guiding tailored and individualized cancer care strategies. Delving into the intricacies of the tumor's genetic makeup, precision oncology endeavors to unravel the

unique genomic alterations that drive cancer initiation, progression, and therapeutic responses. This comprehensive genomic understanding empowers oncologists to pinpoint specific genetic anomalies, allowing for the development of targeted therapies that address the specific molecular underpinnings of each patient's cancer. As our knowledge of the genomic landscape deepens, precision oncology not only refines our therapeutic approaches but also opens avenues for groundbreaking discoveries that hold the potential to revolutionize the landscape of cancer treatment [15].

Expanding beyond the realm of genomics, molecular insights intricately navigate the complex interplay between the tumor and its microenvironment. This dynamic interaction represents a critical frontier in understanding the holistic nature of cancer biology. By examining the molecular intricacies of the tumor microenvironment, precision oncology aims to unravel the intricate crosstalk between cancer cells and surrounding tissues, immune cells, blood vessels, and other elements that collectively shape the tumor milieu. Beyond genomic alterations within cancer cells, these molecular insights shed light on the broader ecosystem in which tumors thrive and evolve. This broader perspective is pivotal in deciphering the factors influencing treatment response, immune evasion, and the emergence of resistance mechanisms. As our understanding of the molecular dynamics within the tumor microenvironment deepens, it not only enriches our comprehension of cancer biology but also holds the potential to unveil novel therapeutic targets and strategies to enhance the effectiveness of precision oncology interventions [16].

While molecular insights drive precision oncology progress, challenges persist. Tumor heterogeneity, resistance mechanisms, and data management complexities require innovative solutions. Advances in single-cell sequencing, liquid biopsy, and artificial intelligence play vital roles. Multidisciplinary collaboration is essential for effective translation of molecular insights into clinical applications. Overcoming these challenges is crucial for unlocking the full potential of precision oncology and benefiting cancer patients globally [17].

The translation of molecular insights into clinical applications is a pivotal aspect of precision oncology. Precision oncology requires collaboration across diverse disciplines, from molecular biology to clinical practice.

Conclusion

A thorough understanding of oncogenesis at the molecular level is crucial not only for the early detection of cancer but also for driving the progress of precision oncology. By unraveling the intricate molecular processes underlying the formation and development of cancer, we can enhance our ability to detect malignancies at their earliest stages. This knowledge serves as a cornerstone in the evolution of precision oncology, allowing for the development of targeted and personalized treatment strategies based on the specific molecular characteristics of each patient's cancer. In essence, the more deeply we comprehend oncogenesis at the molecular level, the more effectively we can pave the way for advancements in both early cancer detection and the precision oncology landscape.

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Conflict of interests

The authors declare that there are no competing interests.

Reference

[1]. Peters JM, Gonzalez FJ. The Evolution of Carcinogenesis. Toxicol Sci. 2018;165(2):272-6.
Kontomanolis EN, Koutras A, Syllaios A, Schizas D, Mastoraki A, Garmpis N, Diakosavvas M,
[2]. Angelou K, Tsatsaris G, Pagkalos A, Ntounis T, Fasoulakis Z. Role of Oncogenes and Tumor-suppressor Genes in Carcinogenesis: A Review. Anticancer Res. 2020;40(11):6009-15.
[3]. Patterson AD, Gonzalez FJ, Perdew GH, Peters JM. Molecular Regulation of Carcinogenesis: Friend and Foe. Toxicol Sci. 2018;165(2):277-83.
[4]. König IR, Fuchs O, Hansen G, von Mutius E, Kopp MV. What is precision medicine? Eur Respir J. 2017;50(4):1700391.
[5]. Middleton G, Robbins H, Andre F, Swanton C. A state-of-the-art review of stratified medicine in cancer: towards a future precision medicine strategy in cancer. Ann Oncol. 2022;33(2):143-57.
[6]. Prasad V, Fojo T, Brada M. Precision oncology: origins, optimism, and potential. The Lancet Oncology. 2016;17(2):e81-6.
[7]. Shin SH, Bode AM, Dong Z. Addressing the challenges of applying precision oncology. NPJ precision oncology. 2017;1(1):28.
[8]. Senft D, Leiserson MD, Ruppin E, Ze'ev AR. Precision oncology: the road ahead. Trends in molecular medicine. 2017;23(10):874-98.
[9]. Schwartzberg L, Kim ES, Liu D, Schrag D. Precision oncology: who, how, what, when, and when not?. American Society of Clinical Oncology Educational Book. 2017;37:160-9.
[10]. Bode AM, Dong Z. Recent advances in precision oncology research. NPJ precision oncology. 2018;2(1):11.
[11]. Fountzilas E, Tsimberidou AM. Overview of precision oncology trials: challenges and opportunities. Expert review of clinical pharmacology. 2018;11(8):797-804.
[12]. Brown NA, Elenitoba-Johnson KS. Enabling precision oncology through precision diagnostics. Annual Review of Pathology: Mechanisms of Disease. 2020;15:97-121.
[13]. Mateo J, Steuten L, Aftimos P, André F, Davies M, Garralda E, Geissler J, Husereau D, Martinez-Lopez I, Normanno N, Reis-Filho JS, Stefani S, Thomas DM, Westphalen CB, Voest E. Delivering precision oncology to patients with cancer. Nat Med. 2022;28(4):658-65.
[14]. Wahida A, Buschhorn L, Fröhling S, Jost PJ, Schneeweiss A, Lichter P, Kurzrock R. The coming decade in precision oncology: six riddles. Nature Reviews Cancer. 2023;23(1):43-54.
[15]. Canzoneri R, Lacunza E, Abba MC. Genomics and bioinformatics as pillars of precision medicine in oncology. Medicina (B Aires). 2019;79(Spec 6/1):587-92.
[16]. Malone ER, Oliva M, Sabatini PJB, Stockley TL, Siu LL. Molecular profiling for precision cancer therapies. Genome Med. 2020;12(1):8.
[17]. Pich O, Bailey C, Watkins TBK, Zaccaria S, Jamal-Hanjani M, Swanton C. The translational challenges of precision oncology. Cancer Cell. 2022;40(5):458-78.