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Review Article

Molecular oncology and the role of artificial intelligence in advancing cancer treatment

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ABSTRACT

Artificial intelligence (AI) holds significant promise for advancing molecular oncology and improving personalized cancer care. This review highlights the numerous benefits of AI integration in various aspects of molecular oncology, from data analysis and interpretation to streamlining clinical trial matching. AI systems can aid clinical decision-making by rapidly analyzing complex molecular data, such as next-generation sequencing results, and suggesting treatment options based on the patient's tumor profile. Furthermore, AI can facilitate collaboration among healthcare professionals, monitor treatment response, and serve as a valuable educational resource for oncologists. The incorporation of AI in electronic health records and pharmacogenomics can lead to improved clinical workflows and more personalized therapeutic approaches. In addition, AI can enhance precision oncology research by assisting in the identification of novel molecular targets and uncovering new therapeutic strategies. As AI technology continues to evolve, its role in molecular oncology is expected to expand, leading to better patient outcomes, and more personalized care. Nevertheless, ethical considerations and patient privacy remain crucial aspects that need to be addressed to ensure the responsible and effective use of AI in the field of molecular oncology.

Keywords: Artificial intelligence, Molecular oncology, Personalized cancer care, ChatGPT, Data analysis

INTRODUCTION

Molecular oncology has revolutionized the way cancer is treated, providing oncologists with the ability to identify specific genetic and molecular alterations in tumors to better tailor therapies for individual patients.[1] Artificial intelligence (AI) systems, such as ChatGPT, are poised to play a significant role in the analysis, interpretation, and application of molecular oncology data to optimize patient care. This review will explore how AI can help oncologists find the best possible treatment for advanced cancer patients utilizing molecular oncology.

ROLE OF MOLECULAR ONCOLOGY IN CANCER TREATMENT

The primary aim of molecular oncology is to identify and understand the molecular alterations that drive cancer development and progression. This information can be used to develop targeted therapies, which are drugs that specifically inhibit these oncogenic pathways, offering more effective and less toxic treatments than traditional chemotherapy.[2] Examples of targeted

therapies include imatinib for chronic myeloid leukemia[3] and trastuzumab for human epidermal growth factor receptor 2-positive breast cancer.[4] Molecular oncology has also advanced the field of immunotherapy, which harnesses the patient's immune system to fight cancer.[5]

ROLE OF AI IN MOLECULAR ONCOLOGY

Data analysis and interpretation

One of the most significant challenges in molecular oncology is the vast amount of data generated from next-generation sequencing and other high-throughput technologies [Table 1]. AI can help oncologists navigate this data by rapidly analyzing and interpreting molecular profiles.[6] This includes the identification of actionable mutations, gene fusions, and copy number alterations that may guide treatment decisions.

Treatment recommendations

Based on the molecular profile of a tumor, AI can provide oncologists with treatment recommendations, including U.S. Food and Drug Administration-approved targeted therapies, off-label drug use, and clinical trial options.[7] The AI system can also provide up-to-date information on the efficacy and safety of these therapies, helping oncologists make more informed decisions.

Predictive modeling

AI can use machine learning algorithms to predict treatment response and patient outcomes based on molecular data. This information can help oncologists identify which patients are likely to benefit from specific therapies and aid in treatment planning.[8]

Continuous learning

As new research and clinical data become available, AI can continuously update its knowledge base to provide oncologists with the most current and relevant information for clinical decision-making.[9]

Patient communication

AI can be used as a tool for patient education and communication, providing accessible explanations of complex molecular findings and treatment options.[10] This can help patients better understand their diagnosis and make more informed decisions about their care.

The integration of AI into the field of molecular oncology has the potential to significantly improve the way advanced cancer is treated. By providing oncologists with rapid data analysis, up-to-date treatment recommendations, and predictive modeling, AI can help oncologists optimize therapy selection and ultimately improve patient outcomes.

Multidisciplinary team collaboration

AI can facilitate collaboration among oncologists, pathologists, radiologists, and other healthcare professionals by providing a centralized platform for data sharing and discussion.[11] This can enhance the decision-making process, ensuring that all relevant experts contribute to the determination of the most effective treatment plan.

Personalized medicine and pharmacogenomics

AI can also be used to analyze pharmacogenomic data, which is the study of how an individual's genetic makeup affects their response to drugs. This can help oncologists identify optimal drug dosages and combinations based on a patient's specific genetic profile, minimizing side effects and improving treatment efficacy.[12]

Monitoring treatment response and resistance

AI can be utilized to analyze longitudinal molecular data to monitor treatment response and detect the emergence of resistance mechanisms. This information can help oncologists adjust treatment strategies in real-time, potentially improving patient outcomes.[13]

Educational resource for oncologists

As a continuously updated knowledge base, AI can serve as a valuable resource for oncologists seeking to stay current with the latest research and treatment advances in molecular oncology.[14]

Integration with electronic health records (EHRs)

By integrating AI with EHR systems, oncologists can streamline the process of accessing and interpreting molecular data, leading to more efficient clinical workflows and potentially reducing the time to treatment initiation.[15]

Streamlining clinical trial matching

Identifying and enrolling patients in appropriate clinical trials can be a complex and time-consuming process. AI can streamline this process by analyzing molecular data and matching patients with relevant trials based on their tumor profile, treatment history, and eligibility criteria.[16]

Facilitating precision oncology research

As a powerful tool for data analysis and interpretation, AI can assist researchers in identifying novel molecular targets, elucidating mechanisms of resistance, and uncovering new therapeutic strategies for cancer treatment.[17]

Table 1: Evidence on the benefits of artificial intelligence in molecular oncology.

Benefit	Description	References
Data analysis and interpretation	AI can rapidly analyze and interpret complex molecular data, such as NGS results, aiding clinical decision-making	[6]
Treatment recommendations	AI can suggest treatment options, including FDA-approved therapies, off-label drug use, and clinical trial options	[7]
Predictive modeling	AI can predict treatment response and patient outcomes based on molecular data, guiding treatment planning	[8]
Continuous learning	AI can continuously update its knowledge base with new research and clinical data to inform decision-making	[9]
Patient communication	AI can provide accessible explanations of complex molecular findings and treatment options for patients	[10]
Multidisciplinary team collaboration	AI can facilitate collaboration among healthcare professionals by providing a centralized platform for discussion	[11]
Personalized medicine and pharmacogenomics	AI can analyze pharmacogenomic data to optimize drug dosages and combinations based on a patient's genetic profile	[12]
Monitoring treatment response and resistance	AI can analyze longitudinal molecular data to monitor treatment response and detect resistance mechanisms	[13]
Educational resource for oncologists	AI can serve as a valuable resource for oncologists to stay current with the latest research and treatment advances	[14]
Integration with EHRs	AI can streamline the process of accessing and interpreting molecular data in EHRs, improving clinical workflows	[15]
Streamlining clinical trial matching	AI can match patients with relevant clinical trials based on their tumor profile, treatment history, and eligibility criteria	[16]
Facilitating precision oncology research	AI can assist researchers in identifying novel molecular targets, elucidating resistance mechanisms, and uncovering new therapeutic strategies	[17]
Global collaboration and data sharing	AI can enable and promote global collaboration among oncologists and researchers, facilitating knowledge exchange	[18]
Ethical considerations and patient privacy	AI can help address ethical considerations regarding patient privacy and data security in molecular oncology	[19]

AI: Artificial intelligence, NGS: Next-generation sequencing, EHRs: Electronic health records, FDA: U.S. Food and Drug Administration

Global collaboration and data sharing

AI can enable and promote global collaboration among oncologists and researchers by providing a platform for data sharing and communication. This can facilitate the exchange of molecular oncology knowledge and expertise, accelerating the development of new treatments and ultimately benefiting patients worldwide.[18]

Ethical considerations and patient privacy

AI systems, including ChatGPT, raise important ethical considerations regarding patient privacy and data security. It is essential to ensure that the use of AI in molecular oncology respects patient confidentiality and complies with relevant data protection regulations.[19]

CONCLUSION

The application of AI in molecular oncology has the potential to greatly impact the way advanced cancer is treated by assisting oncologists in various aspects of patient care. As AI technology continues to evolve and improve, it is anticipated that the role of ChatGPT and similar AI systems in oncology will expand, leading to better patient outcomes and more personalized care.

Declaration of patient consent

Patient consent was not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author(s) confirms that there was no use of artificial intelligence (AI)-assisted technology for assisting in the

writing or editing of the manuscript and no images were manipulated using AI.

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