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(Review Article)

Personalized cancer treatment; How AI is shaping precision medicine

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Abstract

The application of artificial intelligence has demonstrated promising outcomes in certain areas of oncology, such as the screening, detection, diagnosis, treatment, and prediction of prognosis for tumors. New learning methods, such as the hybrid learning method, will continue to emerge as artificial intelligence (AI) continues to advance, computer performance continues to improve, and the explosion of various data continues to make it possible for new learning methods to emerge. These new learning methods will further improve the overall performance of the model, including efficient data analysis and accurate prediction. Both machine learning and deep learning have recently produced a model that is capable of analyzing a variety of data sets, which will also boost the prospects of PM. As a conclusion, artificial intelligence-assisted prenatal care has the potential to aid in the early detection, diagnosis, and treatment of cancer. Additionally, it can provide assistance in the selection of the most appropriate treatment plan, so enhancing the prognosis of patients and the outcomes of their treatment.

Keywords: Artificial Intelligence (AI); Machine Learning (ML); Precision Medicine; Tumor Genomic Profiling; Targeted Therapy

1. Introduction

Artificial intelligence (AI) has emerged as a crucial instrument in the field of personalized cancer treatment, providing opportunities for revolutionary methods to diagnosis, treatment, and patient care. When it comes to the study of complicated genomic data, one of the most important uses of artificial intelligence is the identification of specific mutations and biomarkers that are connected with different forms of cancer. Machine learning algorithms can do this. This skill makes it possible to build individualized treatment programs that target the specific genetic profile of a patient's tumor, which in turn increases the effectiveness of targeted medicines. In addition, artificial intelligence plays a significant part in predicting therapy responses and probable adverse effects. This enables oncologists to select the measures that are most appropriate while minimizing the risks involved. Imaging technologies that are powered by artificial intelligence, such as deep learning models, have considerably increased the accuracy of cancer detection and staging. These technologies analyze medical pictures such as magnetic resonance imaging (MRI), computed tomography (CT) scans, and histopathology slides with a precision that frequently exceeds that of human experts[1]. The utilization of this improved diagnostic accuracy guarantees that patients will receive therapies that are both timely and appropriate. Additionally, artificial intelligence makes it possible to continuously monitor patients through the use of wearable devices and mobile applications that monitor vital signs and symptoms. This provides real-time data that may be used to advise therapy modifications and early interventions in the event that issues occur for the patient. Artificial intelligence systems are also capable of collecting and analyzing data from clinical trials and medical literature. This allows them to provide clinicians with insights into future medicines and assist them in staying current with the most recent breakthroughs in oncology. Moreover, decision support systems that are powered by artificial intelligence can

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be of assistance to healthcare providers by recommending the most effective treatment courses. These recommendations are derived from an exhaustive study of patient data, which takes into account genetic, environmental, and lifestyle factors. In the process of developing patient-centered care plans that aim to achieve the best possible treatment outcomes, these personalized recommendations are of great value. It is anticipated that the incorporation of artificial intelligence into cancer treatment will become increasingly more advanced as the field continues to advance. This will result in innovations that have the potential to revolutionize the prognosis and quality of life for cancer patients all over the world.

key areas where AI technologies have made significant contributions[2].

Table 1 AI in heath care [3, 4]

Application Area	Explanation	Examples of AI Technologies Used
Genomics and Precision Medicine	AI analyzes genetic data to identify mutations and suggest personalized treatment plans.	Machine learning algorithms, deep learning, natural language processing (NLP)
Imaging and Diagnostics	AI assists in interpreting medical images for accurate diagnosis and treatment planning.	Convolutional neural networks (CNNs), image recognition software
Drug Discovery	AI accelerates drug discovery by predicting the efficacy and safety of new compounds.	Deep learning, reinforcement learning
Treatment Planning	AI optimizes radiation therapy and chemotherapy plans tailored to individual patient needs.	Optimization algorithms, predictive analytics
Predictive Analytics	AI predicts patient outcomes and potential complications, helping in proactive care management.	Machine learning models, data mining
Clinical Decision Support	AI provides clinicians with evidence-based recommendations to improve decision-making in cancer care.	Expert systems, NLP
Patient Monitoring	AI enables continuous monitoring of patients to detect changes in health status and adjust treatments.	Wearable technology, IoT, real-time data analytics
Pathology	AI analyzes pathology slides to improve accuracy in detecting and classifying cancer types.	Computer vision, deep learning
Biomarker Identification	AI helps identify biomarkers for early detection and treatment response monitoring.	Genomic data analysis, statistical modeling

1.1. Diagnosis and Detection

By greatly improving the accuracy, speed, and efficiency of medical evaluations, artificial intelligence (AI) is bringing about a revolution in the process of diagnosing and detecting cancer. A surprising level of accuracy has been achieved by the utilization of machine learning algorithms and deep learning techniques, in particular convolution neural networks (CNNs), in the process of analyzing medical images such as X-rays, MRIs, and CT scans from a medical perspective. In many cases, these artificial intelligence systems are able to detect minute changes that the human eye could miss, and they are able to recognize patterns and abnormalities that may be suggestive of cancer. By way of illustration, artificial intelligence systems are now able to differentiate between benign and malignant tumors with a high degree of accuracy, which helps in the early detection and timely treatment of illnesses[3, 4]. In addition, artificial intelligence is capable of processing huge volumes of data in a short amount of time, which enables oncologists to gain immediate insights into the condition of a patient and enable personalized treatment strategies. Besides picture analysis, artificial intelligence is also being used to analyze genetic data and predict cancer susceptibility. This can lead to the development of preventative strategies for individuals who are at a high risk of developing cancer. The incorporation of artificial intelligence into cancer diagnostics not only enhances the capacities of medical professionals but also reduces the amount of work they have to do, which enables them to devote more of their attention to the care of patients. In spite of these developments, the successful use of artificial intelligence in clinical settings requires stringent validation, adherence to ethical rules, and continual collaboration between AI developers and medical practitioners in order to guarantee the safety and privacy of patients. They have enormous promise for improving cancer detection and patient outcomes all throughout the world, and this promise is only growing as AI technologies continue to advance[5].

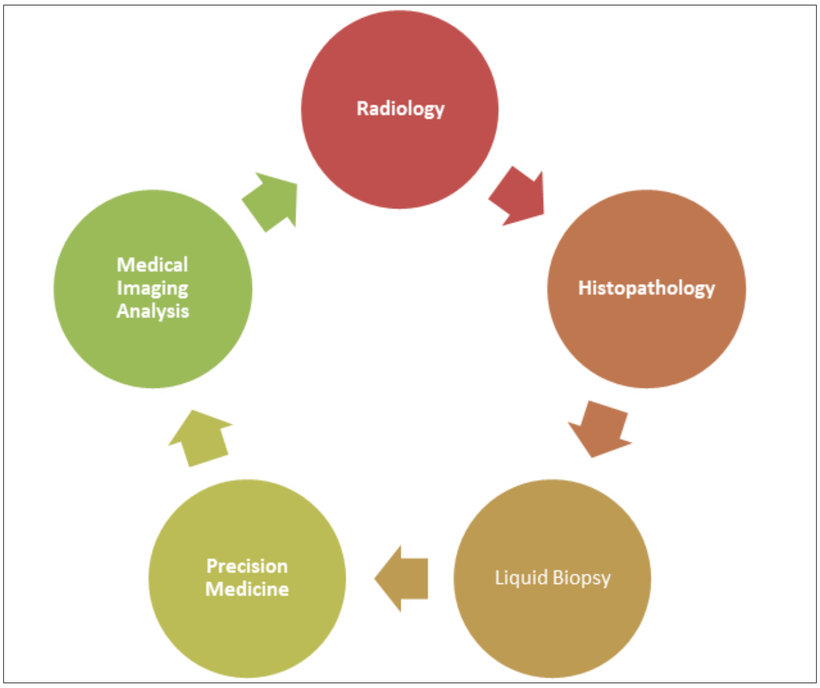

Figure 1 Diagnosis and detection of Cancer by AI

The quantitative and qualitative knowledge of clinicians may be improved by the capabilities of automated artificial intelligence. Multiple lesions parallel tracking, precise volumetric delineation of tumor size over time, phenotypic to genotypic implication nuances of intratumoral translation, and cross-referencing interpretation results of individual tumors to databases of potentially infinitely many comparable cases are all examples of possible applications that could be made possible by these automated capabilities. These are just a few examples of how these capabilities could improve clinical expertise. Within a short period of time, these advantages will eventually result in significant and interventional breakthroughs in clinical treatment and diagnosis that are more quick. Despite the fact that these investigations are still predominantly in the preclinical research stage, the increasing utilization of such automatic radiographic "radiomic" biomarkers may reveal alterations in tumors through clinical action and result in a paradigm shift for the discrimination of cancer over the long term[6, 7].

1.1.1. AI in imaging (e.g., radiology, pathology)

In the field of cancer detection, one of the most significant applications of artificial intelligence (AI) is the automated processing of images. There is a possibility that artificial intelligence algorithms may analyze medical images obtained from CT, MRI, and X-ray scans in order to identify early markers of cancer. This can be especially beneficial in finding malignancies that are difficult to find using conventional procedures or in situations where cancer symptoms have not yet occurred[8]. Medical imaging data can be analyzed by AI algorithms, which can then identify patterns and abnormalities that may indicate the presence of cancer. Artificial intelligence, for example, is able to examine X-rays in order to locate small lumps or nodules that may be indicators of lung cancer. Artificial intelligence is also capable of identifying abnormal tissue patches that may be indicators of breast cancer by analyzing mammograms[8]. It is possible for artificial intelligence to recognize these minute differences in medical imaging and detect cancer at an earlier stage, when it is more controllable. Moreover, automated image analysis has the potential to lessen the workload of physicians, who would otherwise be required to manually examine medical images in order to identify indicators of malignancy. Artificial intelligence algorithms are able to analyze enormous amounts of medical imaging data in a quick and accurate manner, which reduces the amount of time and effort required for cancer detection. The ability of artificial intelligence to automate image processing for early cancer diagnosis has the potential to greatly improve patient outcomes. This is because it enables earlier discovery of cancer, when it is possible to treat it more effectively[9]. It is possible to employ the precision algorithms of artificial intelligence to improve precision medicine by focusing on the appropriate patient for the appropriate treatment at the appropriate time. During the early stages of breast cancer, the scoring of the proliferation marker Ki-67 is extremely important for the diagnosis, classification, prognosis, and treatment of the disease[10]. Automated brain tumor segmentation methods are computational algorithms that provide tumor delineation. These methods have become a significant diagnostic tool in the planning of precision medicine. When it comes to the planning of treatments for colon cancer, accurate identification and detection of lymph node metastases are absolutely necessary processes. Artificial intelligence-based algorithms can be utilized for the digitalized identification of histopathology tumor specimens and image analysis[11]. This is possible due to the complexity and heterogeneity that exists within the cancer data. The use of raw input digitized histopathology for gene mutation prediction and validation has yielded encouraging results for six distinct genetic variants in lung cancer. These mutations include STK11, EGFR, FAT1, SETBP1, KRAS, and TP53[12]. The early diagnosis of cancer can be accomplished by the use of mutations in KRAS and tumor protein P53, as well as the prediction accuracy of these markers. An early signature known as Programmed death-ligand 1 has been developed by clinicians with the use of artificial intelligence. This signature has the potential to forecast the efficacy of cancer immunotherapy. The capabilities of artificial intelligence to analyze data have advanced significantly in recent years, making it possible to forecast cancer at its earliest stages. Through the use of artificial intelligence to process data and screening algorithms for cancer targets, early detection and intervention will be able to be boosted. The conventional methods of cancer detection and therapy are not only costly and time-consuming, but they frequently lead to unsatisfactory results in terms of treatment. For the purpose of addressing this matter, the development of methodologies for machine learning is of utmost importance in the search for novel biomarkers for early diagnostic diagnosis. When it comes to the clinical management of cancer, accurate and timely cancer diagnosis is very foundational. By utilizing solely a patient's own data, artificial intelligence has the potential to speed up the process of drug discovery, utilize biomarkers to precisely match patients to clinical trials, and truly personalize cancer treatment. These advancements are indications that a cancer therapy that incorporates AI and has the potential to revolutionize the profession may be on the horizon[13].

2. AI in diagnosis

Table 2 AI-driven biomarkers used in early cancer detection[14, 15]

Biomarker Type	Cancer Type	AI Techniques Used	Applications
Genetic Biomarkers	Breast, Lung, Colon	Machine Learning, Deep Learning	Genomic sequencing to identify mutations and variations linked to cancer risk.
Imaging Biomarkers	Breast, Lung, Prostate	Convolutional Neural Networks (CNNs)	Analysis of medical images (e.g., mammograms, CT scans) for early tumor detection.
Circulating Tumor DNA (ctDNA)	Various Cancers	Machine Learning, Pattern Recognition	Detecting tumor-derived DNA in blood samples for non-invasive cancer screening.
Proteomic Biomarkers	Ovarian, Pancreatic	Neural Networks, Clustering	Analyzing protein expression patterns in blood or tissue samples to identify cancerous changes.
Metabolomic Biomarkers	Colorectal, Liver	Random Forest, Support Vector Machines (SVM)	Profiling metabolic changes in body fluids that are indicative of cancer.
MicroRNA Biomarkers	Lung, Breast	Deep Learning, Feature Selection	Identifying specific microRNA profiles associated with cancer development.
Epigenetic Biomarkers	Prostate, Breast	Machine Learning, Regression Analysis	Analyzing DNA methylation and histone modification patterns related to cancer.
Immunological Biomarkers	Melanoma, Lung	Machine Learning, Natural Language Processing (NLP)	Assessing immune response patterns to detect cancer presence or progression.

Not only is the research and development of highly accurate artificial intelligence algorithms for the early recognition of the disease essential for the speedy identification and diagnosis of cancer patients, but it is also essential for the treatment of cancer patients. In order to provide optimal patient care, artificial intelligence can be beneficial in clinical diagnosis. Clinical diagnostics would be more effective if they were equipped with useful screening technologies that could accurately diagnose cancer. Some examples of such instruments include mammography, radiography, and image processing. Large data sets have already been used to construct the AI algorithms, which have demonstrated superior diagnostic capabilities compared to clinicians. Artificial intelligence-assisted diagnostics have demonstrated efficacy in a variety of clinical datasets for the detection of cancer at heterogeneous and complex advanced stages. This includes the identification of worrisome lesions in cancer as well as the interpretation of magnetic resonance imaging or computed tomography. The United States Food and Drug Administration has given its approval to a number of artificial intelligence platforms that are currently being developed for use in certain areas of cancer. Artificial intelligence algorithms are available for a variety of applications, including the screening of cancer, the detection of highlighted areas in tumors, the analysis of treatment patterns, and the evaluation of large data sets. In the case of lung cancer patients, for example, there is an artificial intelligence program that can see lung nodules, and there is another AI system that can detect breast abnormalities[14, 15].

2.1. Current applications of AI in cancer diagnosis

Artificial intelligence (AI) is being utilized in various ways to enhance the accuracy and effectiveness of cancer diagnosis and therapy. Presently, there are several uses of artificial intelligence (AI) in the field of cancer detection. Medical imaging: Artificial intelligence algorithms have the capability to examine medical images, including X-rays, CT scans, and MRIs, in order to detect possible tumors and other irregularities[16]. Artificial intelligence (AI) can assist clinicians in identifying cancer at an earlier stage, enhancing precision, and minimizing the necessity for intrusive medical interventions[17]. Artificial intelligence algorithms have the capability to examine tissue samples and detect cancer cells and other irregularities. This allows pathologists to enhance the accuracy of their diagnosis and improve the planning of treatments. Artificial intelligence systems can analyze genomic data to detect cancer-related mutations and aid clinicians in devising individualized treatment strategies that specifically target the genetic attributes of a patient's tumor. Clinical decision support: AI algorithms can offer real-time decision support to doctors by providing treatment alternatives and predicting treatment outcomes. This assists physicians in making well-informed decisions and enhancing patient outcomes. Medical surveillance: Artificial intelligence algorithms have the capability to examine information gathered from wearable technology and other devices in order to oversee patients' well-being and identify alterations that may suggest the presence of cancer or other medical conditions. Clinicians have the ability to identify cancer at an earlier stage and offer more proactive treatment. Artificial intelligence has the potential to enhance cancer diagnosis and treatment through various means. With the ongoing advancement of AI, we can anticipate a proliferation of groundbreaking applications in this field[18, 19].

3. Artificial Intelligence Based Treatment Planning

Artificial intelligence (AI) is revolutionizing the process of cancer treatment planning by improving accuracy, effectiveness, and customization in clinical decision-making. Artificial intelligence (AI) technology, namely machine learning algorithms and deep learning models, have shown great promise in analyzing intricate medical data, such as imaging, genetic, and clinical records. This analysis can offer valuable insights that can enhance treatment options[20]. AI is extensively used in the domain of medical imaging for cancer treatment. Artificial intelligence systems have the ability to analyze and understand pictures obtained from MRI, CT scans, and histopathology slides with a high level of precision, often outperforming human capabilities. This competence facilitates the timely identification, precise assessment, and classification of cancer, which are crucial stages in devising efficacious treatment strategies. For example, artificial intelligence (AI) has the ability to detect minor patterns in medical imaging that could suggest the aggressiveness of a tumor. This can assist oncologists in customizing treatment programs based on this information[21]. Moreover, artificial intelligence improves the accuracy of precision medicine by combining genomic data with clinical factors. Through the examination of genetic mutations and expression profiles of tumors, artificial intelligence (AI) models have the capability to forecast the reactions to different medicines. This empowers oncologists to choose the most efficient treatment for each patient on an individual basis. By adopting a personalized strategy, the chances of therapeutic success are enhanced while the occurrence of undesirable side effects is minimized through the avoidance of ineffective medications[22, 23]. Artificial intelligence (AI) is also essential in optimizing the planning of radiotherapy and chemotherapy. Algorithms have the ability to compute the most effective amounts and timing of medication, reducing the risk to healthy tissues while maximizing the positive effects on cancer cells. By achieving precision, the occurrence of problems associated with treatment is minimized, leading to enhanced patient outcomes[24]. In addition, artificial intelligence enables the process of adaptive treatment planning by constantly acquiring knowledge from patient reactions and making real-time adjustments to treatment protocols. This dynamic strategy guarantees that the treatment stays efficacious throughout the progression of the disease, adapting to changes such as tumor reduction or the emergence of resistance[25]. Integrating AI into cancer treatment planning encounters obstacles such as data privacy concerns, the requirement for extensive and varied datasets for training, and the assurance of transparency and interpretability of AI models. In order to effectively harness the advantages of AI in oncology, it is crucial for technologists, physicians, and regulatory organizations to work together collaboratively to tackle these difficulties. AI technology's ongoing advancement holds the potential to transform cancer therapy, enhancing its precision, personalization, and efficacy, ultimately leading to improved patient survival rates and quality of life[26].

4. Artificial intelligence and personalized medicine

Personalized medicine for cancer is being revolutionized by artificial intelligence (AI), which enables more precise diagnosis, prognosis, and treatment strategies that are tailored to specific patients; this is a significant advancement[27]. Artificial intelligence is able to recognize patterns and insights from complex information, including as genomic sequences, medical imaging, and electronic health records, that are beyond the capabilities of humans. This is made possible by AI's ability to analyze huge amounts of data relatively quickly. The early detection of malignant lesions can be improved by using AI algorithms, which can detect tiny irregularities in medical images such as MRI and CT scans. This helps reduce the number of false positives and improves the accuracy of the diagnosis. Additionally, artificial intelligence can be used to assist in genetic analysis by discovering mutations and biomarkers that can predict a patient's reaction to specific treatments. This can lead to the development of medications that are more accurate and successful. Moreover, prediction models that are powered by artificial intelligence are able to evaluate a patient's risk of cancer recurrence and make recommendations for personalized follow-up strategies[28-30]. The identification of prospective targets for future therapies and the optimization of drug combinations for particular patients are two additional ways in which this technology contributes to the process of drug discovery. Not only can the incorporation of artificial intelligence into personalized medicine improve the precision and effectiveness of cancer therapy, but it also gives medical professionals the ability to administer treatments that are individualized to the genetic make-up and specific characteristics of each individual patient. This ultimately results in better outcomes and a higher quality of life for the patient. However, the application of artificial intelligence in personalized medicine involves ethical and privacy problems, which calls for careful consideration of data protection and informed consent in order to guarantee the confidence and safety of patients[31, 32].

Table 3 Artificial intelligence (AI) is used in personalized medicine for cancer[33, 34]

Application	Description	Example
Predictive Modeling	AI algorithms predict cancer progression and treatment response based on patient data and historical outcomes.	IBM Watson for Oncology uses AI to suggest personalized treatment plans based on patient records and literature.
Genomic Profiling	AI analyzes genetic data to identify mutations and tailor treatments to the specific genetic profile of the cancer.	Tempus uses AI to analyze genomic data to help identify targeted therapies for patients.
Imaging Analysis	AI algorithms analyze medical images (e.g., MRIs, CT scans) to detect cancerous tissues and assess tumor characteristics.	PathAI uses machine learning to improve the accuracy of cancer diagnoses from pathology slides.
Drug Discovery and Development	AI accelerates the identification of new drug candidates and predicts their efficacy in treating specific cancer types.	BenevolentAI uses AI to find new drug targets and potential therapies for cancer.
Patient Monitoring and Management	AI tools monitor patient data in real-time to provide personalized recommendations for treatment adjustments.	Kheiron Medical's AI platform assists in monitoring and managing breast cancer through image analysis.
Clinical Trial Matching	AI matches patients with relevant clinical trials based on their medical history and trial criteria.	Clinical Trials Matching Engine by IBM Watson helps find suitable clinical trials for cancer patients.

Big data technology primarily encompasses the activities of data analysis, data mining, and data sharing. The potential impact of this technology in cancer diagnosis, treatment, prevention, and prognosis is significant. However, the process of converting data into useful information for the benefit of patients is now experiencing a lack of progress. One of the main causes for this is the substantial delay in data analysis compared to data generation. Almost every element of tumor research has been impacted by the reforms brought about by "big data". For instance, the technology may utilize data from Next-Generation Sequencing (NGS) to identify frequently mutated genes, aberrant gene expression, and biomarkers in tumors[35]. This enables precise diagnosis and prognosis prediction, as well as the identification of the underlying cause of a disease[36]. Furthermore, it facilitates the development of targeted medications for effective therapy. The technology has the capability to analyze both visible and invisible aspects in medical images, and extract and refine these features to ascertain information pertaining to diagnosis, therapy, and prognosis[37]. Furthermore, the technology has the capability to examine patients' demographic and clinical data, along with outcome information, in order to forecast the elements that influence the prognosis of cancer patients. Furthermore, AI is employed to examine, extract, and manipulate tumor-related data, construct a healthcare provider platform using a substantial amount of tumor-related data, effectively address the challenge of complex medical therapy for patients, and minimise the inefficient utilisation of unneeded medical resources. The potential of big data reanalysis has not been fully exploited thus far, but it cannot be disregarded. It has the capability to examine the facts within a pre-existing database and offer novel perspectives. For instance, Borziak et al. identified the dedifferentiation indicators of liver cancer by leveraging data from pre-existing datasets. Big data technology is mostly utilized in specific domains, including omics, pathological imaging, and medical imaging[38]. Nevertheless, it fails to amalgamate data from many fields for the purpose of data analysis, mining, and sharing, resulting in incomplete utilization of data and failure to meet the requirements of physicians and patients. Integrating omics and non-omics data can help solve the obstacles associated with diagnosing, treating, and monitoring cancer. Artificial intelligence (AI) can play a crucial role in analyzing complex and diverse high-dimensional data sets, particularly in the fields of multi-omics, intergroup methods, and data integration. This can help uncover the molecular mechanisms of cancer and identify new diagnostic and prognostic biomarkers that can provide precise cancer care[39]. The present data is plagued by various issues, including subpar data quality, disorganized databases, insufficient analytics capabilities, and a lack of efficient delivery methods. Hence, there is a requirement for a more authoritative and dependable prospective database. Furthermore, it is imperative to have a longitudinal database in order to comprehensively comprehend the cancer dynamics of patients along the entire study care continuum. Creating a collection of diverse data sets that priorities the needs and preferences of patients will be essential in the future. Using AI-based big data analysis, patient diagnoses, personalized treatment plans, and prognostic predictions may be automatically generated. This technology assists clinicians in delivering optimal therapy to their patients[40].

5. AI in Genomics and Molecular Profiling

In the field of genomics and molecular profiling of cancer, artificial intelligence is rapidly becoming an indispensable instrument, which is radically altering the way in which researchers and clinicians comprehend and treat a wide range of cancers. By utilizing sophisticated machine learning algorithms, artificial intelligence is able to analyze huge volumes of genomic data, such as DNA sequences, gene expressions, and mutation profiles, at rates and levels of accuracy that have never been seen before. These algorithms have the ability to recognize patterns and correlations within complicated datasets that may be overlooked by conventional methods. As a result, they make it easier to find new biomarkers and treatment targets[41]. When it comes to molecular profiling, artificial intelligence models are helpful in identifying different types of cancer based on genetic and epigenetic abnormalities. This classification can lead to treatment strategies that are more precise and personalized. For instance, AI-driven systems can predict patient responses to particular medicines by comparing genomic data with prior treatment outcomes. This enables treatment methods that are both more successful and more individualized. In addition, artificial intelligence improves the capability of interpreting high-throughput sequencing data, such as that which is produced from next-generation sequencing (NGS), by finding mutations that can be acted upon and probable pathways that are responsible for drug resistance[42]. It is possible for artificial intelligence to play a role in genomics that extends to the integration of multi-omic data. In this process, it combines information from genomes, proteomics, and metabolomics in order to provide a holistic understanding of cancer biology. Not only does this comprehensive approach help increase our understanding of the evolution and variety of cancer, but it also contributes to the creation of focused strategies for treating the disease. Additionally, predictive models that are powered by artificial intelligence have the ability to mimic the influence of genetic mutations on the progression of cancer and the response to treatment, which provides advantageous insights for both research and clinical applications[43]. All things considered, artificial intelligence is improving the accuracy and efficiency of cancer genomics and molecular profiling, which is opening the way for cancer treatment that is more individualized and effective. Because of its capacity to process and analyze vast amounts of data, it continues to drive improvements in the understanding of cancer mechanisms and the development of innovative therapeutic methods[44].

6. Clinical Trials and Drug Discovery of cancer by using AI

The application of artificial intelligence (AI) in clinical trials and drug discovery for cancer represents a transformative advancement in oncology research. AI technologies, particularly machine learning and deep learning algorithms, are significantly accelerating the process of drug discovery by analyzing vast datasets to identify potential drug candidates and predict their efficacy. These algorithms can sift through complex biological data, such as genetic sequences and protein interactions, with unprecedented speed and accuracy, facilitating the discovery of novel drug targets and biomarkers. In clinical trials, AI enhances patient recruitment by identifying suitable candidates based on their genetic profiles and health records, which improves the precision of trials and reduces time and costs. Additionally, AI models can predict patient responses to treatments and potential adverse effects by analyzing historical data, thereby optimizing trial designs and improving the likelihood of successful outcomes. This integration of AI not only accelerates the development of new cancer therapies but also personalizes treatment approaches, ultimately contributing to more effective and individualized cancer care[45, 46].

Table 4 Clinical Trials and applications[45, 46]

Aspect	Description	AI Applications
Data Analysis	Handling vast amounts of data from genomics, proteomics, and clinical trials.	AI algorithms analyze patterns and extract insights from complex datasets.
Predictive Modeling	Forecasting the efficacy of potential drugs and predicting patient responses.	Machine learning models predict how different drugs will affect various cancer types.
Patient Stratification	Identifying subgroups of patients who are more likely to benefit from specific treatments.	AI techniques like clustering and classification help in creating patient profiles for personalized treatment.
Drug Repurposing	Finding new uses for existing drugs that may be effective against cancer.	AI models analyze existing drug data to identify new potential applications.
Biomarker Discovery	Identifying biomarkers that can indicate the presence or progression of cancer.	AI helps in discovering and validating new biomarkers from omics data.
Drug Design	Designing new drug molecules and optimizing their properties.	AI-driven generative models suggest novel compounds and optimize their structures.
Clinical Trial Design	Designing more effective and efficient clinical trials.	AI assists in trial design by optimizing protocols and identifying suitable patient populations.
Patient Recruitment	Finding and enrolling suitable candidates for clinical trials.	AI algorithms match patient profiles with trial requirements to streamline recruitment.
Monitoring & Compliance	Tracking patient responses and ensuring adherence to trial protocols.	AI tools monitor data in real-time and flag deviations from the protocol.
Outcome Prediction	Estimating the likelihood of trial success and predicting long-term outcomes.	AI models predict outcomes based on historical data and current trial data.

7. Future Directions and Innovations

The path forward and the breakthroughs that will be made in the future to combat cancer through the use of AI are both exciting and diverse. A great amount of progress has been made in early detection, personalized treatment, and drug discovery thanks to the rapid evolution of artificial intelligence's role in oncology[47]. Machine learning algorithms are becoming increasingly capable of analyzing huge volumes of medical data, such as imaging, genetic information, and electronic health records, in order to recognize patterns and biomarkers that are related with different types of cancer. This skill improves early detection and diagnosis, making it possible to identify cancers earlier and with greater precision. This can be extremely important for enhancing patient outcomes. Personalized treatment is a form of treatment that involves the use of artificial intelligence systems to adapt therapies to individual patients based on their specific genetic composition and cancer profile[48]. An artificial intelligence system can assist in the prediction of how a patient could react to particular medications or therapies by analyzing data from prior treatments and patient reactions. This allows for the optimization of treatment regimens and the reduction of adverse effects. The goal of this individualized strategy is to enhance the effectiveness of conventional cancer treatments while also reducing the amount of trial and error involved[49]. In the field of drug discovery, artificial intelligence is helping to speed up the process of identifying new therapeutic chemicals and forecasting how effective they will be. In comparison to more conventional approaches, machine learning algorithms are able to analyse chemical structures and biological data in order to identify prospective drug candidates in a more expedient and accurate manner. This not only moves the development process along more quickly, but it also has the potential to result in the discovery of novel therapies that would have been missed otherwise[49].

Furthermore, systems that are powered by artificial intelligence are improving the precision of radiation therapy and surgical planning by offering diagnostic imaging and simulations that are more accurate. Using these techniques, treatment methods may be planned with a high degree of precision, allowing for the targeting of tumors while simultaneously minimizing damage to healthy tissues in the surrounding area. Furthermore, artificial intelligence is making a contribution to the creation of improved screening tools that combine imaging and genomic data. These technologies significantly improve the ability to detect cancer at its early stages, when it is most curable. The application of artificial intelligence (AI) in cancer research and therapy is expected to bring about a revolution in the field, resulting in the development of methods that are more accurate, individualized, and effective in combating this multifaceted and varied disease. There is a strong possibility that the ongoing development of artificial intelligence technologies may significantly improve our capacity to comprehend, diagnose, and treat cancer, which will ultimately result in improved patient outcomes and a reduction in the death rate associated with cancer[50, 51].

8. Conclusions

Through the provision of individualized therapeutic techniques that are based on the profiles of individual patients, artificial intelligence (AI) is bringing about a revolution in regards to personalized cancer therapy. Artificial intelligence is capable of analyzing huge amounts of data, like as genetic information, tumor features, and patient history, in order to determine the most feasible treatment alternatives. This is accomplished through the utilization of complex algorithms and machine learning techniques. This accuracy makes it possible to make more precise forecasts of medication responses and probable adverse effects, which ultimately results in more tailored therapies that reduce the number of treatments that are not necessary and maximize the effectiveness of the treatment. AI-driven tools also make it easier to produce new treatments by simulating how various substances interact with cancer cells. This speeds up the discovery process and makes it possible to develop novel drugs more quickly. In addition, artificial intelligence improves the monitoring and management of cancer by forecasting the evolution of the disease and the consequences for patients. This information enables prompt adjustments to be made to treatment regimens. In general, the incorporation of artificial intelligence into oncology not only enhances the precision of therapies but also personalizes care, which eventually results in improved outcomes and a more efficient healthcare system.

Compliance with ethical standards

Disclosure of conflict of interest

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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