REVIEW ARTICLE

Artificial Intelligence Could be the Personalized Treatment Strategy for Cancer

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ABSTRACT

Cancer is one of the world's most serious medical challenges. Because of its great heterogeneity, persons with similar tumors could react in a different way to the same drugs or surgical methods, prompting the development of more accurate tumor treatment approaches as well as patient-specific tailored treatments. To establish targeted therapy choices for patients, it is critical to have a full acceptance of the changes that tumors endure, counting modifications in their genetic factors, proteins, and cancer cell behaviors. Tumor treatment requires precise targeting. Big data-driven artificial intelligence (AI) may reveal patterns, insights, and related information hidden inside huge volumes of data. To identify exact data from transcriptomics, radiomics, genomes, proteomics, digital pathological images, etc., subsets of AI's machine learning capability may be explored. This may help clinicians get a better and more comprehensive knowledge of malignancies. In addition, to provides the optimal therapy for each patient and improves clinical outcomes.

Keywords: Artificial intelligence, Cancer, Medical imaging, Precision medicine.

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INTRODUCTION

Cancer is a serious threat to mankind because of its huge death rate and increasing prevalence. Nonetheless, current cancer treatments are not optimal.[1] Prostate, colorectal, and cervical cancers all have significant and rising mortality rates. Patients with these cancers do not get prompt and efficient care since there are no effective screening or therapy options available.[2] Second, cancers are quite different, which may make therapy challenging. As a result, innovative, patient-specific diagnostic and therapeutic approaches are required.[3] Precision medicine (PM) could be an auspicious way that use each patient's genetics and routine to understand, diagnose, and cure diseases while also generating a personalized treatment plan for patients.[2] Furthermore, artificial intelligence (AI), which is mostly comprised of deep learning (DL) and machine learning (ML) uses computers or other technologies to do tasks that mimic or imitate human intellect.[1] AI's advanced data processing abilities may help PM's new findings. AI has shown tremendous capabilities in data management, extraction, and analysis. This data might be used to create a number of project management models. Tumors are often detected during exams for high-risk populations.[2] The identification of malignancies that cause clinical symptoms is the other. After the malignancy has been identified, patients may be subjected to further testing, such as imaging, pathology, physical examination, and serum tumor markers. These findings will aid in the precise identification, staging, and classification of cancers, enabling patients to get targeted therapy.[3] AI may enhance tumor prognosis, diagnosis, therapy, screening, and prevention. When AI is utilized in clinical practice, the screening approach becomes more successful and the rate of lesion discovery increases. Second, by assisting medical staff in discriminating between real and simulated illness development, AI may increase diagnosis accuracy. Finally, AI may analyze the benefits and shortcomings of many therapy options before proposing the best course of action for patients. This article also includes a framework (Figure 1) that demonstrates the many phases involved in tumor patient identification, diagnosis, and treatment, as well as the potential advances that artificial intelligence might provide.[1] Next-generation sequencing (NGS) technology has enabled the collection of omics data, including transcriptomics, proteomics, and genomes.[1] The rapid progress and widespread accessibility of patient health data, such as electronic health information, clinical documents, and medical imaging, signaled the start of the "big data" era. AI-based data analysis is the most effective way to extract significant knowledge, hidden patterns, and critical information from data using ML

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and DL.[4] The collected data is utilized to compile information about the condition for clinical analysis. By analyzing omics data, ML and DL may predict pharmacological activity and treatment response, develop personalized medicines, identify molecular changes such as RNA, DNA, and protein, and offer biomarkers for diagnosis, classification, and prognosis.[5] Furthermore, unlike single-omics, multi-omics enable a deeper understanding of the information flow that underpins disease. To get a comprehensive knowledge of complicated biological processes, many omics must be merged. When combined with a unique longitudinal experimental design, multi-omics may aid in PM discovery by revealing critical roles or problematic phenotypes, hence explaining the fundamental association and useful mechanisms of complex diseases. Quantitative picture analysis may assist in cancer therapy and is a suitable use for PM.[4] Models for detecting, monitoring, and predicting metastasis and recurrence, as well as biomarkers and prognosis, were created utilizing quantitative image data extraction, ML, and DL. AI may leverage the aforementioned data to provide a thorough study of tumors for clinical decision-support systems. As AI algorithms, computer hardware, and software advance, technology will improve and become more extensively employed in the medical industry.[6] Thus, PM for cancer will continue to advance. In the medical industry, AI is extensively used. The ground-breaking research, including radiography, dermatology, ophthalmology, and many more, impacted numerous therapeutic fields. Significant performance gains have been achieved by applying AI technology to basic biology, pharmacology, and medicine; in fact, several applications have outperformed human professionals. Early AI techniques mostly depended on conventional information-based and symbol-based expert systems.[7] ML has greatly aided the advancement of AI. When working with huge, high-quality data, a variety of algorithms known as ML, a traditional AI method, may improve judgment or prediction accuracy. Researchers developed methods for diagnosing and treating cancer. Most healthcare data is publicly available, and DL refers to a collection of methods that use neural network models to address problems beyond the scope of traditional ML.[8] Cancer-related issues may be solved quickly, accurately, and effectively with the use of DL and ML models on distributed datasets. Distributed data analysis may make use of sophisticated federated learning models. Some of the most cutting-edge treatment approaches include virtual biopsies, deep sequencing for whole-blood cancer diagnosis, and NLP to forecast health trajectories using medical data.[9] In oncology, empirically based medication scoring systems are often used for risk assessment, prognostic staging, diagnosis, treatment, and surveillance monitoring. From simple light microscopy observations, these methods have evolved to more complex tests such as next-generation sequencing of somatic and germ-line genomes and gene expression experiments. Combining many medications to treat cancer has also become possible thanks to AI. The involvement of individuals without any previous computer skills in AI-powered cancer research may be possible if robust AI core services and resources.[10] Through data mining, electronic health records (EHR), and radiological image interpretation, algorithm-based AI is anticipated to become more prevalent in clinical settings and digital health care in the future, allowing more precise cancer therapy. Marketing businesses that do cancer research predict that by 2021, intelligent AI will save the US healthcare system $52 billion.[11,12] If sufficient data are available to build ML and DL models, then AI involvement in cancer research may increase. The digital information explosion of the last 20 years has brought AI back to life and showed promise in the field of cancer research. There is now a significant quantity of molecular-level tumor data from cancer patients accessible due to the massive rise in dataset number and variety.

AI has been employed in cancer research for more than two decades. Cancer research has made encouraging progress, with expert-level findings obtained. Many firms and industrial research organizations use AI to detect, diagnose, and treat cancer. IBM (Armonk, NY) has made a deliberate effort to establish the standard for using AI in therapeutic settings. In order to provide medical AI for cancer research, IBM developed Watson in 2014. Similarly, a team of academics and computer scientists at Microsoft's research labs hopes to employ machine learning and natural language processing to program biology for cancer treatment. AI is, therefore, expected to have a transformative effect on diagnostic speed and accuracy, treatment ideas and recommendations, and, eventually, prognosis outcomes.

AI and Chemotherapy

AI in cancer therapy focuses on the interactions between patients and drugs.[5] AI's primary uses include managing chemotherapy medication usage, predicting chemotherapy drug tolerance, and refining chemotherapy regimens.[12] AI has the ability to simplify and speed up the process of optimizing combination chemotherapy. In one research, the National University of Singapore's "CURATE.AI" AI stand was used to calculate the optimum dosage of enzalutamide and zen-

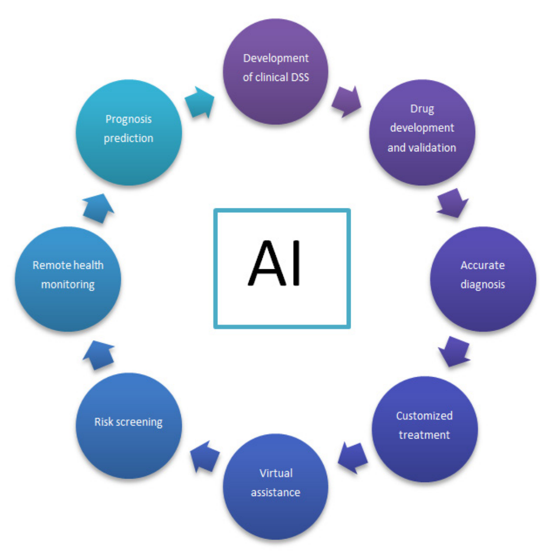

Figure 1: Role of AI in cancer clinical research

3694. This enabled the scientists to increase the effectiveness and tolerability of the combination therapy by using DL and other tools. PARP inhibitors are a treatment option for breast cancer cells that do not undergo homologous recombination. Gulhan's coworkers developed a DL-based showing approach that detects cancer cells with HR abnormalities with 74% accuracy and identifies patients who may need help from PARP medications. Dorman et al. created an ML algorithm that predicts whether breast cancer patients would accept therapy. The data, which examined the association between chemotherapy treatments and patients' genes, was able to identify the effects of two chemotherapy drugs: gemcitabine and taxol. Furthermore, studies have shown that the DLT beats the Epstein-Barr Virus-DNA-based model for determining risk and commencing therapy for nasopharyngeal cancer. DLT has the potential to improve the use of single-induction chemotherapy for advanced nasopharyngeal cancer.

AI models could also aid with the mentioned terms, such as

- Reducing blood tests: For low-risk patients, AI models can help reduce the number of blood tests needed.
- Predicting drug tolerance: AI can help doctors to accomplish the benefits of chemotherapy drugs and expect how well they are tolerated.
- Identifying toxicities: AI can help predict likely toxicities, which can benefit the patient.[13]
- Optimizing regimens: AI can help doctors make precise treatment choices and optimize the chemotherapy regimen.[14]
- Reducing unnecessary surgeries: AI can support physicians in making accurate treatment choices and lessen needless surgeries.
- Improving treatment plans: AI can help doctors to recover patients' cancer treatment plans.[15]

AI and Radiotherapy

AI technology is being employed in cancer radiation therapy. Radiologists may utilize AI to construct radiation treatment regimens or map out target areas autonomously. Lin et al.'s automated nasopharyngeal cancer delineation utilizing a three-dimensional convolutional neural network (3D CNN) achieved 79% accuracy, which is comparable to that of radiation specialists.[8,16] Cha created a prediction model that measures the efficacy of bladder cancer therapies using deep learning technology and radionics—a method for extracting visual qualities from radiographic pictures. Radiation treatment planning takes several hours, but Babier's automation tool, based on DLT, reduces it to only a few hours.[17] The AI algorithm generates therapy plans that are identical to the patients' typical treatment plans but substantially shorter in length.

AI's key uses in cancer radiation include automated treatment plan development, detection, and cancer target area determination[7]. The AI system can automatically define radioactive pictures without requiring any process. In addition, AI can provide more tailored medications by predicting 3-D dosage supplies based on mapped organs and target locations.[8]

AI is used in many aspects of radiotherapy, including

- The volume of interest segmentation

The U-shaped convolutional neural network (U-net) is a common application for this task.

Image guidance

- AI-based image guidance techniques can enable radiotherapy in scenarios where it wasn't previously possible.
- CBCT image quality

AI can improve the quality of CBCT images, which can enable more accurate patient positioning.[7,8]

AI and Immunotherapy

AI is mostly used in cancer immunotherapy applications to assess treatment efficacy and assist clinicians in changing treatment regimens. Sun created an ML-based AI approach that reliably predicts the therapeutic effectiveness of PD-1 (programmed cell death protein) inhibitors. This platform is useful for determining the effectiveness of immunotherapy in patients with PD-1 inhibitor-sensitive advanced solid malignancies[7]. Bulik-Sullivan created an ML technique based on a database of human leukocyte antigen (HLA) mass spectrometry that might increase cancer immunotherapy effectiveness and neoantigen detection.[6]

AI for neoantigen prediction

The foundation of cancer immunotherapy is the body's antitumor immunity, which starts with the activation of certain T cells to eradicate tumors[17]. Neoantigens are somatic mutation-produced peptides unique to tumors that have the ability to trigger T-cell immunological responses. As such, they provide a promising target for cancer immunotherapies.[16,17] Nonetheless, a relatively small percentage of tumor peptides are identified by T cells. In this instance, accurate neoantigen identification is required.

AI-aided design of therapeutic monoclonal antibodies

Since the USA approved the first monoclonal antibody (mAb), rituximab, in 1997 to treat patients with non-Hodgkin's lymphoma, mAbs have played a significant role in cancer therapy and are currently the best-selling medications globally, partly because of their high levels of efficacy and specificity. However, the majority of antibodies available today were created via the use of traditional discovery methods, such as animal vaccination and display library screening.[18]

AI for predicting immunotherapy response

It has been shown that ICI-based immunotherapy is an efficient treatment for a variety of tumor forms. The selection of patients and the forecasting of treatment response are two major problems that restrict the use of cancer immunotherapy.[21] Reducing the likelihood of unfavorable clinical outcomes and expensive therapy may be accomplished in part by being able to identify individuals in advance who would benefit most from a certain treatment strategy.[21]

AI reduces cancer overtreatment

Hu created an algorithm that can effectively detect precancerous lesions needing therapy from digital images of women's cervixes, hence decreasing patient overtreatment.[19] Bahl created a machine learning technique to avoid unneeded therapy for breast cancer tumors.[20] Using this technology, practitioners may prevent needless surgery and make informed choices about patient care by recognizing high-risk breast lesions with the potential to progress into cancer.[20]

AI and clinical decision support systems

DLT expands the intellect behind cancer therapy decisions.[21] Based on its understanding of clinical big data from cancer patients, AI may support doctors in selecting the best course of therapy.[22] Printz created a DL-based clinical decision support system (CDSS) to provide cancer treatment alternatives by gathering and analyzing vast volumes of clinical data from medical records.[23] The study underscores the importance of AI technology in clinicians' efforts to enhance cancer treatment regimens.

AI a novel approach to life sciences

AI is a powerful tool that has the potential to hasten the development of new cancer therapies and diagnostic methods[25]. Advances in AI have allowed robots to analyze and manage huge volumes of data with the goal of mimicking human brain activities. A vast quantity of data is used in healthcare operations, and this data is now more easily accessible because to advances in AI and processing power. Finally, AI has opened up an astonishing amount of options.[23]

AI applications in multiple cancer diagnoses

Cancer killed ten million people in 2020, making it one of the deadliest diseases, with over 100 different types.[24] As per the Centre for Disease Control (CDC), cancer will be the top reason of death in developed countries by 2030. Cancer has the lowest survival rate when it has spread across the body, is unpredictable in timing and location, and often recurs, making therapy difficult. Cancer medicines have advanced significantly in the previous 15 years, with a greater understanding of how tumors operate throughout treatment.

AI applications in cancer medical imaging

Scientists and academics have been interested in AI because of its capacity to do deep learning and tackle unique issues. Alan Turing pioneered the concept of AI in the nineteenth century with his "Computing Machinery and Intelligence" project.[24] In the last decade, AI has received less attention in the modern period, with little research focusing on AI in medical imaging. However, in the 2016-2017 year, the indicated publication number. It is useful for the detection of various kinds of cancers such as lung cancer, prostate cancer, gastric cancer, colorectal cancer, etc.[25]

Challenges of AI to be overcome

AI can deal with nonlinear, complex relationships, multiprocessing, fault tolerance, and learning, given its ability to change on its own and deal with quantitative and qualitative inputs simultaneously. Diverse clinical data from several disciplines have shown its practical use. AI is being applied in a wide range of clinical and healthcare contexts. It not only makes use of many parts of clinical diversity, but it also aids in the healing process.

Merits of AI in the Treatment Plan for Cancer

Precision medicine

AI can analyze massive amounts of patient data, including genomic information, lifestyle factors, and medical history, to tailor treatments precisely to individual patients. This precision reduces the risk of ineffective treatments and minimizes side effects.

Early detection

AI algorithms can perceive cancer at its earliest stages by analyzing imaging scans, blood tests, and other diagnostic data with high accuracy. Early detection significantly improves prognosis and treatment outcomes.

Treatment optimization

By continuously analyzing patient responses to treatments, AI can optimize therapy regimens in real time, ensuring that patients receive the most effective and timely interventions.

Personalized drug selection

AI algorithms can predict how individual patients will respond to various drugs based on genetic markers and other factors. This enables oncologists to select the most suitable medications for each patient, maximizing treatment efficacy.

Reduced healthcare costs

Personalized treatment plans can help avoid unnecessary treatments and hospitalizations, reducing healthcare costs in the long term. Additionally, AI-driven predictive analytics can identify high-risk patients who may benefit from early interventions, further reducing healthcare expenditures.

Improved patient outcomes

By tailoring treatments to each patient's unique biology and circumstances, personalized cancer care can lead to better treatment outcomes, including higher survival rates and improved quality of life.

Reduced treatment toxicity

AI-guided treatment plans can minimize the toxicity of cancer therapies by optimizing dosages and treatment schedules based on individual patient characteristics. This reduces the risk of adverse effects and improves patients' tolerance to treatment.

Empowering patients

Personalized treatment plans involving AI provide patients with a greater understanding of their condition and treatment options. Empowered with this knowledge, patients can actively participate in decision-making regarding their care, leading to better adherence and satisfaction.

Challenges of AI in the treatment plan for cancer

Data dependence and quality

AI relies heavily on data, including medical records, genetic information, and treatment outcomes. If the data used to train

AI algorithms are incomplete, biased, or of poor quality, it can lead to inaccurate predictions and suboptimal treatment recommendations.

Ethical concerns

There are ethical considerations surrounding the use of AI in healthcare, particularly regarding patient privacy, consent, and the potential for discrimination or bias in decision-making algorithms. Ensuring transparency and fairness in AI systems is crucial to maintaining patient trust.

Cost and access

Implementing AI-driven personalized treatment plans may require significant financial investment in infrastructure, training, and technology. This could potentially limit access to these advanced treatments for patients in underserved or resource-limited areas.

Complexity and interpretability

AI algorithms used to personalize cancer treatment plans can be complex and difficult to interpret, even for healthcare professionals. Understanding how AI arrives at its recommendations and ensuring that clinicians can interpret and validate these recommendations is essential for effective implementation.

Overreliance on technology

There's a risk that healthcare providers may become overly reliant on AI-driven treatment recommendations, potentially overlooking important clinical factors or relying too heavily on algorithmic predictions without exercising independent judgment.

Regulatory challenges

The regulation of AI-driven healthcare technologies presents challenges, including ensuring safety, efficacy, and compliance with existing regulatory frameworks. Navigating these regulatory requirements can slow down the adoption of AI in personalized cancer treatment.

Lack of human touch

While AI can provide valuable insights and recommendations, it may lack the human touch and empathy that is crucial in patient care. Maintaining a balance between technological advances and personalized patient-provider relationships is essential in cancer treatment.

CONCLUSION

AI is a disruptive force in the field of personalized cancer therapy, providing unparalleled opportunities to unravel the complexity of cancer biology, predict treatment results, and enhance therapeutic approaches. AI enables oncologists to provide individualized treatment regimens that suit each patient's specific requirements and features because to its capabilities in data analysis, predictive modeling, and clinical decision support. As we start on this revolutionary path toward AI-driven customized cancer treatment, let us embrace technology's promise to change oncology and usher in a new age of hope and healing for patients throughout the globe.

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