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THE DEVELOPING APPLICATIONS OF AI IN PRECISION MEDICINE AND CANCER MEDICATION DEVELOPMENT

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ABSTRACT

The revolutionary effects of machine learning (ML) and artificial intelligence (AI) on cancer research are examined in this review article. It examines deep learning algorithms for picture identification and feature extraction, with a focus on the crucial role AI plays in medical imaging for cancer diagnosis. The study also looks at the difficulties and factors to be taken into account when using AI for picture analysis in cancer detection. Large-scale omics data, including proteomics and genomes, are also mined and analyzed using AI. In order to improve diagnosis and therapy planning, it integrates clinical and molecular data to unravel intricate genetic alterations and signaling networks in cancer. AI applications in cancer medication repurposing, target identification and drug development are also included in the study. Successful uses of AI-driven algorithms are demonstrated via case studies, which are used to forecast medication reactions and find new therapeutic targets. The paper assesses how AI affects clinical judgment and patient care, emphasizing the difficulties and possibilities in putting AI research into clinical settings. The analysis finishes with suggestions for new developments and future directions, examining possible breakthroughs and new trends in AI-driven cancer research.

KEYWORDS

Artificial Intelligence, Cancer Therapy, Precision Medicine, Radiation Therapy and Immunotherapy.

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INTRODUCTION

The term artificial intelligence (AI) describes the intelligence exhibited by human-made machines. It is an all-encompassing discipline that encompasses languages, computer science, neurophysiology, cybernetics and psychology. The Dartmouth conference in 1956 is regarded as the birthplace of artificial intelligence. The term artificial intelligence (AI) has seen significant evolution over the past few decades and is now used to refer to a variety of technologies, including deep learning, machine learning and artificial neural networks[1-3]. One significant area of artificial intelligence[3] is deep learning, which is capable of autonomously extracting features from enormous volumes of data. Furthermore, deep learning can identify information in pictures that the human eye is unable to[4-6]. This is very important for using image data to diagnose cancers early. AI can aid in tumor diagnosis and treatment as well. Multi-layer neural networks, which have great logical reasoning and learning capabilities and can closely mimic human thought processes, are frequently the foundation of artificial intelligence[7,8]. Similar to the human brain, artificial intelligence is capable of making the quickest and most intuitive decisions to address issues. It is easy to conclude that AI has the potential to significantly improve current cancer research models.

AI applications in cancer research and care

The application of AI in cancer research and care is being advanced by NCI research in a number of areas, including drug discovery, cancer surveillance, cancer mechanisms, cancer screening and diagnosis, and health care delivery.

Contributing to the basic understanding of cancer biology

AI techniques are being used to increase our understanding of the mechanisms behind the development, spread and metastasis of cancer. For instance:

A wealth of knowledge and information on cancer may be found in the corpus of scientific literature. Large language models are being used by artificial intelligence specialists to create new computational tools that enhance information extraction from research articles.

As part of the collaboration between NCI and the Department of Energy, researchers are using AI to simulate the atomic behavior of the RAS protein, one of the most commonly mutated proteins in cancer. A better understanding of how RAS interacts with other proteins could help scientists find new avenues to target cancer-causing mutations in the RAS gene.

RESULTS AND DISCUSSION

AI and anticancer drug development

AI can help in the discovery of anticancer drugs or forecast their activity. Data from high-throughput screening methods frequently show the connection between medication activity and the genomic heterogeneity of cancer cells. Additionally, different malignancies and the same treatments may have various reaction patterns. By combining machine learning and screening data, Lind *et al*[9] created a random forest model. The model can forecast how anticancer medications will work based on the genome mutation status of cancer cells. A machine learning technique known as elastic net regression served as the foundation for the drug sensitivity prediction model created by Wang *et al*[10]. It has been demonstrated that machine learning models can accurately forecast the medication sensitivity of patients with endometrial cancer[11,12], gastric cancer[13-15] and ovarian cancer[16-18]. Patients with ovarian cancer treated with tamoxifen, gastric cancer treated with 5-FU and endometrial cancer treated with paclitaxel are among the patients the model predicts to be resistant. It was determined that each of these patients had a bad prognosis. This work demonstrates the enormous potential of artificial intelligence in forecasting the sensitivity of anticancer medications. Additionally, AI is crucial in combating cancer medication resistance[19-21]. By learning and evaluating data on large drug-resistant cancers, AI can rapidly comprehend how cancer cells develop resistance to cancer treatments, which can help enhance drug development and modify medication use (Figure No.2).

AI and chemotherapy

AI in cancer treatment is more concerned with how patients react to medications. AI's primary application accomplishments include optimizing chemotherapy programs, managing the usage of chemotherapy drugs, and predicting chemotherapy drug tolerance[22-25]. AI has the ability to refine and expedite the combination chemotherapy optimization process. In one study, the researchers used "CURATE.AI" (an artificial intelligence platform developed by the National University of Singapore using deep learning and other technologies) to successfully determine the ideal dose of zen-3694 and enzalutamide, improving the combined treatment's efficacy and tolerance[26]. Breast cancer cells that lack homologous recombination (HR) can be treated with poly ADP-ribose polymerase (PARP) inhibitors. A deep learning-based screening system created by Gulhan *et al*[27] can identify which patients would benefit from PARP medicines and detect cancer cells with HR defects with 74% accuracy.

A machine learning system that can forecast breast cancer's tolerance to treatment was created by Dorman *et al*[28]. The study, which looked at the connection between patients' genes and chemotherapy medications, was able to differentiate between the effects of gemcitabine and taxol. Furthermore, research has demonstrated that the deep learning approach outperforms the Epstein-Barr Virus-DNA-based model in risk assessment and induction chemotherapy guidance for nasopharyngeal cancer[29]. This indicates that single-induction chemotherapy for advanced nasopharyngeal cancer may be predicted using the guiding role of the deep learning approach[30].

AI and radiotherapy

The use of AI technology in cancer radiation therapy is more specialized. AI can autonomously plan radiation treatment regimens or assist radiologists in mapping out target areas[31-33]. The three-dimensional convolutional neural network (3D CNN) was utilized by Lin *et al*[34] to automatically detect nasopharyngeal carcinoma with an accuracy of 79%, which is on par with radiation experts. In order to create a predictive model that can assess how well bladder cancer patients respond to treatment, Cha *et al*[35] integrated deep learning technology with radiomics, a technique for obtaining image attributes from radiographic images. Radiation therapy planning took only a few hours thanks to automated software created by Babier *et al*[36] using deep learning technology. The AI software's treatment plan is similar to the patients' traditional therapy plan, although it takes a lot less time (Figure No.3).

AI and immunotherapy

AI is mostly used in cancer immunotherapy to assess treatment outcomes and assist doctors in modifying treatment regimens[37-40]. An AI framework based on machine learning was created by Sun *et al*[41] in order to precisely forecast the therapeutic impact of PD-1 inhibitors. This technology is capable of efficiently assessing the impact of immunotherapy in patients with PD-1 inhibitor-sensitive advanced solid malignancies. A machine learning technique based on the human leukocyte antigen (HLA) mass spectrometry database was created by Bulik-Sullivan *et al*[42] and can enhance the effectiveness of cancer immunotherapy and confirm the identification of cancer neoantigens.

AI reduces cancer overtreatment

To lessen the overtreatment of patients, Hu *et al*[43] created an algorithm that can precisely detect the precancerous lesions that require treatment from digital images of women's cervix. A machine learning technique created by Bahl *et al*[44] can lessen the overtreatment of lesions thought to be breast cancer. By identifying high-risk breast lesions that are likely to develop into cancer, the tool assists physicians in choosing the best course of action and minimizing needless surgery.

AI and clinical decision support systems

Deep learning technology improves the intelligence of cancer treatment decisions. AI can help physicians determine the best course of treatment by learning from clinical large data about cancer patients[33,45-49]. A deep learning-based Clinical Decision Support System (CDSS) was created by Printz *et al*[50] that can provide cancer therapy alternatives by extracting and analyzing a significant amount of clinical data from medical records. The study highlights the value of AI technology in assisting physicians in enhancing cancer treatment regimens for patients.

Machine learning and deep learning in anticancer drug development

High-throughput screening data can be used to train machine learning algorithms to create models that forecast how patients and cancer cell lines will react to novel medications or treatment combinations[51-53]. By generating and creating reverse synthesis pathways for molecules using machine learning, scientists are speeding up the drug development process. A lot of data is generated throughout the entire drug development process.

Processing chemical data and producing outcomes that aid in drug discovery is made possible by machine learning[54-56]. We can quickly interpret data gathered over years or even decades with the use of machine learning[57]. Furthermore, it will enable us to make better-informed choices than we otherwise could by relying on experimentation and prediction[58-60]. Drug discovery is one of the many fields where deep learning, a special machine learning technique, has demonstrated exceptional performance[61-63]. Although the use of deep learning in drug response prediction has just lately been investigated, these models have special qualities that might make them more appropriate for challenging tasks involving the modeling of drug reactions based on biological and chemical data. Computers ability to extract information from photos has lately advanced to previously unheard-of levels thanks to deep learning. The creation of deep learning models using massive data sets has led to intriguing new possibilities for drug reuse. One such instance is the research conducted by Kadurin *et al*[64]. To create a deep learning model, they applied the antagonistic autoencoder to the complete dose-response data recorded in the NCI-60 cell line.

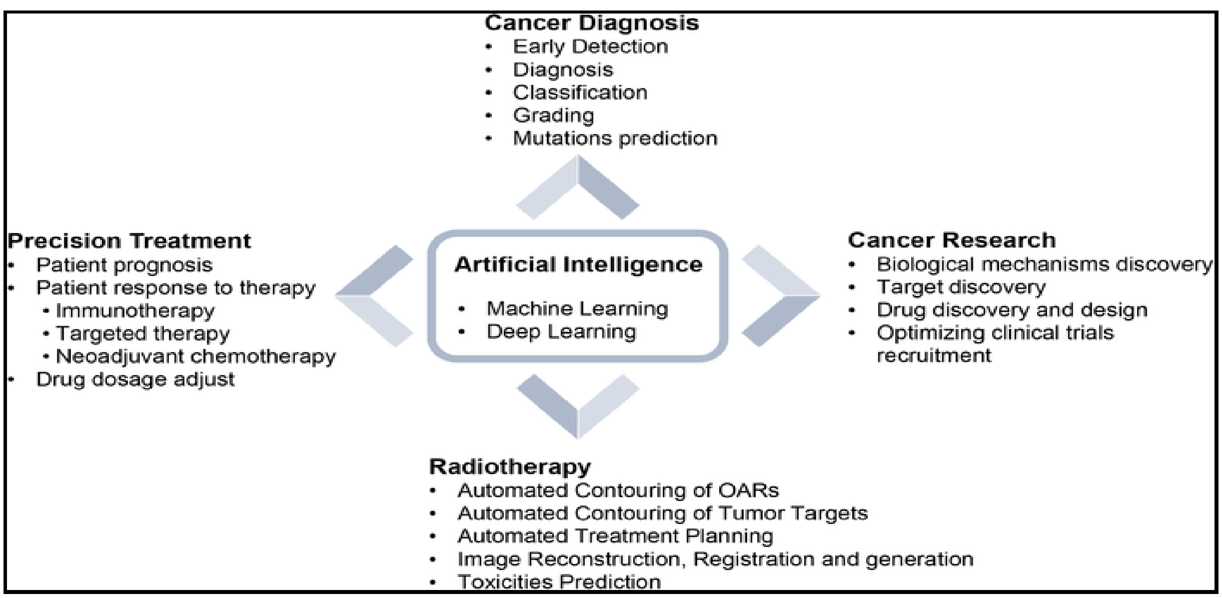

Figure No.1: Applications of AI in cancer diagnosis, treatment and research

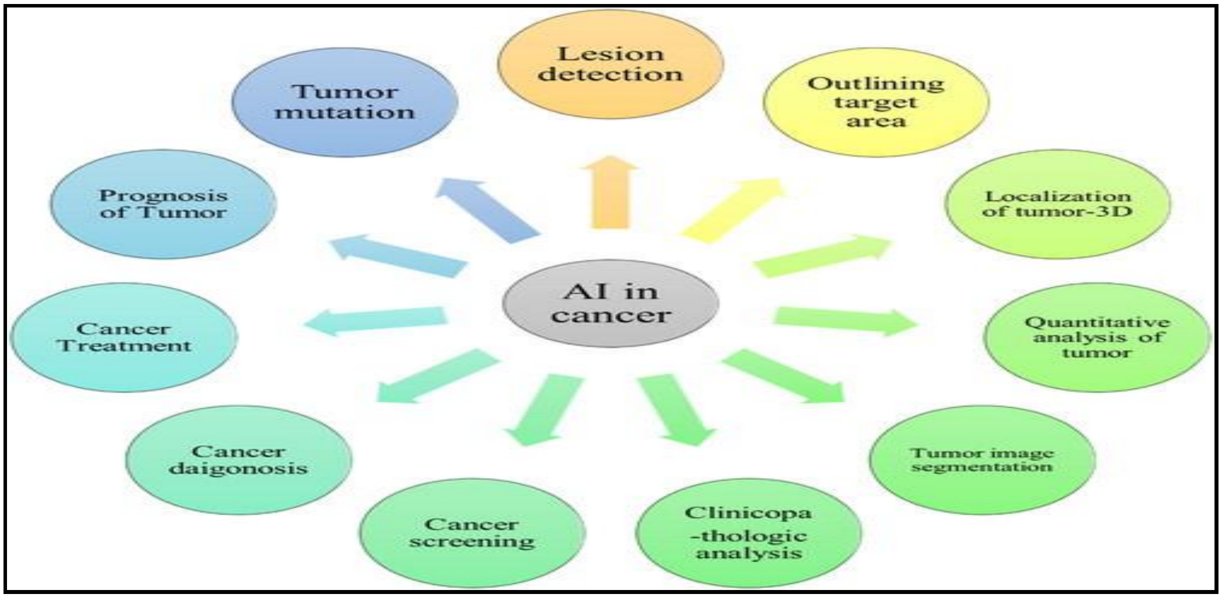

Figure No.2: The applications of AI in tumors

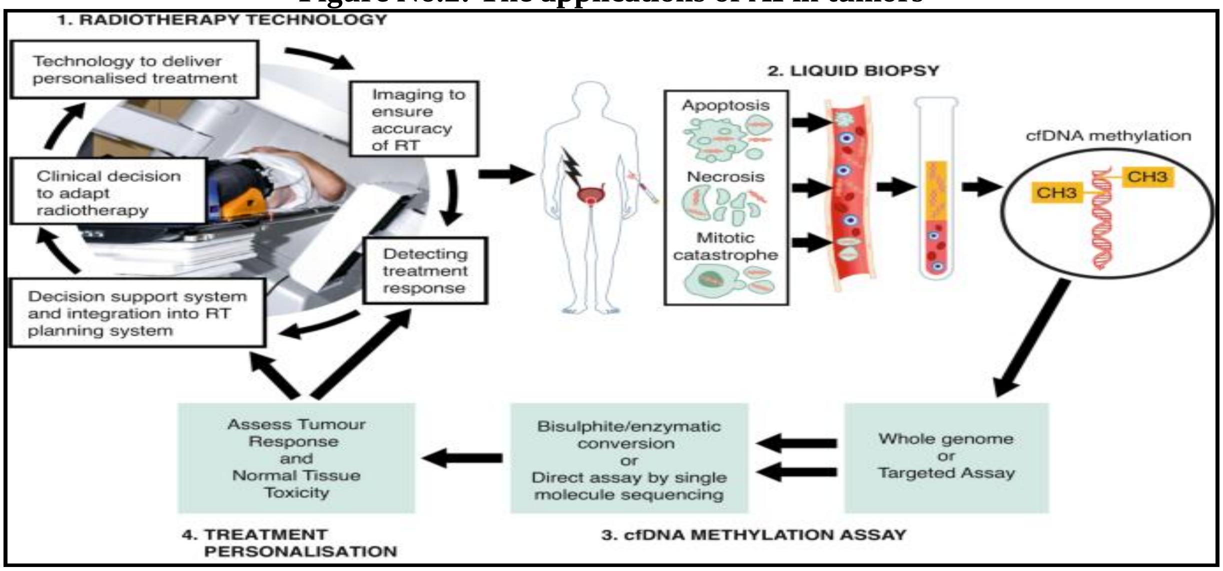

Figure No.3: Redefining precision radiotherapy through liquid biopsy

CONCLUSION

AI has contributed in a novel way to the development and therapy of anticancer drugs[65-67]. Because humans are constrained by their own knowledge, it might be challenging to develop the best course of action. According to this perspective, patients will lose out on important therapy possibilities and may even experience a delay in their health if doctors select unsuitable treatment. It can tailor treatment for each cancer patient and offer crucial insights and information that cannot be discovered through human identification[68-70]. AI has the potential to significantly speed up the development of anticancer medications by accelerating the discovery of novel compounds. AI is anticipated to have a significant role in the future of human cancer research and treatment. We think AI will significantly alter medical technologies in the future.

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CONFLICT OF INTEREST

I declare that I have no conflict of interest.

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