v. 4, n. 11, 2024

International Journal of Health Science

ARTIFICIAL INTELLIGENCE TECHNIQUES FOR EARLY CANCER DIAGNOSIS: A LITERATURE REVIEW

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Abstract: Objective: To evaluate how Artificial Intelligence (AI) techniques can be applied to facilitate the early diagnosis of cancer. **Methods:** Narrative bibliographic review using the PubMed database, applying the search strategy: (artificial intelligence) AND (diagnosis) AND (cancer). 4,119 articles were found and after applying the inclusion and exclusion criteria, only 17 articles were selected to compose the study. **Discussion:** The role of Artificial Intelligence (AI) in the early diagnosis of cancer is highlighted, with an emphasis on Machine Learning (ML) and Deep Learning (DL) techniques. ML uses algorithms to analyze patterns in large data sets, improving cancer diagnosis and treatment. DL, a subset of ML, uses multi-layer neural networks to interpret complex data, such as medical images, improving accuracy in identifying neoplasms. Although promising, these technologies face challenges such as the applicability of AI processes and the interpretation of genomic data, aiming to advance precision oncology and improve clinical practice. Such procedures have also been criticized for not explicitly highlighting how the model analyzes the data and makes decisions based on certain inputs, raising ethical questions about their applicability. **Final considerations:** Therefore, Artificial Intelligence and Deep Learning (DL) and Machine Learning (ML) emerge as crucial tools in the diagnosis and early treatment of cancer, improving patient survival and the efficiency of radiotherapy. Although promising, these technologies face accessibility challenges and the need for greater understanding in their application in oncology.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Diagnosis, Cancer.

INTRODUCTION

Cancer represents one of the primary causes of global mortality, associated with a growing and aging population, as well as multiple risk factors such as smoking, stress, physical inactivity, inappropriate eating habits and genetic predispositions. Given this panorama, and considering the prolonged and costly oncological treatment, medicine has pursued advances aimed at improving diagnostic accuracy in the early stages of the disease, with the aim of increasing the survival rates of affected individuals. In this scenario, Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL) emerge as revolutionary technological tools in recent clinical oncology research (HUANG S. et al., 2020).

The application of AI has gained prominence in helping to diagnose cancer, attributed to its high precision and accurate prognoses regarding susceptibility, recurrence and survival of patients (HUANG S. et al., 2020). As elucidated by D'Amore B. et al. (2021), AI is configured by the ingenious application of computing and software development in solving complex problems, such as increasing oncological detection through routine exams, improving tumor classification and selecting the optimal treatment for each patient. Kann BH, et al. (2022) emphasizes the ability of AI to provide a more specific and individualized perspective of each patient, guiding clinical decisions and outlining therapeutic approaches throughout treatment, supported by a robust database and images, consolidating clinical information, patient history and pertinent tumor and genomic characteristics.

D'Amore B. et al. (2021) defines ML as a subset of AI, which uses DL for self-learning. Huang S. et al. (2020) complements, indicating the use of ML in the construction of predictive models to predict patient survival, while Kurant DE (2023) highlights the usefulness of AI and ML in determining genetic predispositions to cancer, crucial for guiding risks to cancer. patient and their family members. Added to this, Bhinder B. et al (2021) highlights that AI, operating on vast databases, minimizes socioeconomic biases, increasing the accuracy of results when considering human diversity.

AI is also beneficial in predicting the effectiveness of oncology drugs, based on molecular data, and augurs a promising future for pathological treatment and staging, contributing to increased life expectancy and potential eradication of the disease (BHINDER B. et al, 2021). This article aims to evaluate the applicability of Artificial Intelligence techniques in the early diagnosis of cancer, examining the current applications of AI in oncology with an emphasis on the most promising AI techniques in the analysis of oncological diagnostic data.

METHODOLOGY

This is a narrative bibliographic review developed according to the criteria of the PVO strategy, an acronym that represents: population or research problem, variables and outcome. Used to prepare the research through its guiding question: "How can Artificial Intelligence (AI) techniques improve the diagnostic accuracy of cancer in patients at risk?". In this sense, according to the parameters mentioned above, the population or problem of this research refers to patients with suspected cancer who have undergone diagnostic methods that incorporate AI techniques for different algorithms and artificial intelligence models applied to early cancer diagnosis to evaluate the effectiveness and accuracy of AI techniques in the early diagnosis of cancer, including sensitivity and predictive value. The searches were carried out by searching the PubMed Central (PMC) database. The search terms were used in combination with the Boolean term "AND": (artificial intelligence) AND (diagnosis) AND (cancer). From this search, 4,119 articles were found, subsequently submitted to the selection criteria. The inclusion criteria were: articles in the English language, published in 2022 and that addressed the themes proposed for this research, review-type studies, meta-analysis and observational studies available in full. The exclusion criteria were: duplicate articles, available in abstract form, which did not directly address the proposal studied and which did not meet the other inclusion criteria. After applying the inclusion and exclusion criteria, a total of 17 articles were selected to compose the present study.

DISCUSSION

With population aging, an increase in certain pathologies is expected. Among them, neoplasms and their numerous subtypes currently occupy one of the most common positions as causes of death globally, especially in developed countries, such as Japan – where almost 1 million individuals are diagnosed with cancer, and almost 400,000 die from it. disease annually (SHIMIZU H.; NAKAYAMA KI, 2020). In this scenario, artificial intelligence (AI) emerges as a promising solution to counter this phenomenon inherent to demographic change, by facilitating early diagnosis and significantly assisting in patient care.

In addition to the direct benefit to the patient, AI has the potential to catalyze significant changes in labor relations in healthcare services by optimizing diagnostic processes. According to Shimizu H. and Nakayama KI (2020), the various applications of AI can reduce the number of professionals in a medical team dedicated to tumor classification, maintaining or often exceeding the effectiveness of these analyses.

AI encompasses several technologies with the common purpose of computationally simulating human intelligence. Machine learning (ML) is a subgroup of AI that focuses on making predictions by identifying patterns in data through mathematical algorithms. Deep learning (DL) is a subgroup of ML that focuses on making predictions using multilayer neural network algorithms, inspired by the neurological architecture of the brain. Using and interpreting different types of high-dimensional data for translational research or clinical tasks requires significant time and expertise. Additionally, integrating multiple data types consumes more resources than interpreting individual data types (TRAN KA et al., 2021).

Several studies have already demonstrated that false negatives can be mitigated by expanding the perception of specialists in the oncology field, further improved with the use of advanced technologies. According to Bhinder B. et al (2021), by training a DNN (Inception-V3 architecture) based on images of 757 skin lesions, the AI managed to surpass medical accuracy in identifying carcinomas and melanomas in analyzed dermatological plaques. Furthermore, applications have been used to predict the risk of lung and breast malignancy through the analysis of tomography and mammograms, respectively, demonstrating performance equal to or sometimes superior to that of experts in the field (KANN BH et al., 2022).

Furthermore, AI can facilitate radiotherapy with respect to target volume and organs at risk (OAR) delineation and automated treatment planning. Its accuracy depends on the radio-oncologists who, depending on their experience, can affect the result. Thus, AI has been established as a state-of-the-art tool in the automated delineation of RAO in head and neck, chest, abdomen and pelvic regions (CHEN Z. et al., 2021).

Another notable applicability is that AI is capable of improving health performance and equity. In the example of breast cancer screening, current risk assessment tools do not support the ideal that the approach must be age-based, but also risk-based. Traditional models rely heavily on patients' memory of characteristics such as age at onset of menstruation, previous breast procedures, and family history of breast cancer. However, they are not affordable and do not work equally for everyone, while AI-based models can predict future breast cancer risk based on mammography images alone, having the potential to be more objective and usable by any woman, regardless of your history. This learning model outperformed both traditional clinical risk factor models, with an area under the receiver operating characteristic curve (AUC) for cancer prediction of 0.68 versus 0.57 for both traditional models (LEE CI et al., 2022).

AI also promises to facilitate access to diagnostic tests, promoting greater accessibility and, therefore, increasing the chances of early detection of cancerous pathologies. According to Bhinder B. et al (2021), smartphone applications have already been created so that lay users can record and anticipate the analysis through their own devices, thus reducing the path from potentially harmful injuries to a better prognosis, based on this promising facilitator. Additionally, the potential of AI in the early diagnosis of neoplasms can be improved as algorithms are trained to detect subtle and early abnormalities, which are probably not apparent to the eyes of radiologists (D'AMORE B. et al.,2021).

Aiming at patient comfort and greater procedural safety, liquid biopsy was developed to guarantee a minimally invasive technique through a detailed analysis of a simple blood test (BHINDER B. et al, 2021). According to the researchers, the response to treatment with endometrial cancer immunotherapies can be monitored based on the detection of ctDNA obtained from this blood collection.

Many multiomics integration studies have proposed the applicability of DL for cancer diagnosis and prognosis. However, there are some challenges and limitations to the extensive implementation of multiomics DL in clinical practice. Firstly, the main problem encountered is the difficulty in elucidating the relationship between compressed characteristics and biological meanings (PARK MK. et al., 2022; KHOA A. et al., 2021). To evaluate explainable performance in real applications, it is necessary to perform a clinical study with external cohorts, followed by full functional analysis. Secondly, due to the large number of parameters, DL algorithms are challenging to train, need to be precisely tuned, have unclear methods for handling data variability arising from data transformation and normalization, and often suffer from overfitting (PARK MK. et al., 2022; TSENG H. et al., 2021). In summary, DL has the potential to dramatically transform cancer care and bring it closer to the promise of precision oncology.

In an era where genomics is being implemented in healthcare delivery and healthcare data is becoming increasingly digitized, it is anticipated that artificial intelligence and DL will be utilized in the development, validation and implementation of supporting tools to decision making to facilitate precision oncology. Notably, the combination of multimodal learning and explainability can reveal new insights. Important requirements for the widespread adoption of DL in the clinical environment are phenotypically rich data for model training and clinical validation of the biological relevance of insights generated by DL (TRAN KA et al., 2021). The rise of digitalization of pathology workflows, coupled with the rapid pace of advances in ML, promises to accelerate scientific discovery and the creation of assistive tools for oncologists across a variety of cancers. As the field moves from research to translation and implementation, there is a need to recognize the purposes of predictive systems in the clinical workflow and translate the technical requirements that a system must meet into research challenges (COOPER M. et al., 2023). Deep learning (DL) methods have gained considerable interest in medical imaging research.

In contrast to traditional ML approaches, deep learning (DL) models based on convolutional neural networks (CNN) do not require a predefined definition of image features, but are capable of learning relevant features directly from image data (FEUERECKER B. et al., 2022). In addition to imaging, DL approaches have been applied to various aspects of cancer research, including the investigation of biological bases, the development of anticancer therapies, and the implementation of randomized controlled trials (RCTs). To discover the biological mechanisms of cancer, studies have used DL to analyze the relationship between genotypes and phenotypes with a substantial number of findings already reported. As in a recent study using DL algorithms, the role of F-box/WD repeat-containing protein 7 (Fbw 7) in the oxidative metabolism of cancer cells was discovered through gene expression signatures from The Cancer Gene Atlas dataset. (CHEN Z. et.al, 2021). Studies that published the results of an international competition in identifying metastatic breast cancer deposits in lymph nodes, where they compared performance between LD models and human experts. These results provide the most robust evidence to date that DL models have the potential to achieve expert pathologist-level performance, albeit in a restricted task (LEVINE AB et al., 2019).

Furthermore, DL has recently shown its potential in imitating human cognition and challenging human intellectual abilities, from video/board games to medicine. It provides DL models with the unique ability to easily integrate different data modalities, for example, medical data, images, genomic data and clinical information, into a single 'end-to-end optimized' model (TSENG H. et al., 2021). With the increasing quality of medical data and the development of algorithms, DL methods have great potential to improve the accuracy and efficiency of cancer diagnosis and treatment. Furthermore, the FDA's positive stance towards AI medical devices further expands the perspective of practical application of DL in oncology (CHEN Z. et al., 2021).

Cancer represents a pathology with high mortality, the detection of which has become progressively more challenging. Medical professionals employ a diverse range of methods aimed at early diagnosis of the disease. Artificial intelligence encompasses several technologies with the common purpose of computationally simulating human intelligence and providing accurate images of the body's internal structures to detect any abnormalities; although early, the results have been promising (PATEL V. et al., 2023). AI has also demonstrated several applications that transcend diagnosis, including the characterization of underlying genetic and epigenetic heterogeneity. This feat can be accomplished using histopathological images, such as, for example, through WSI (whole slide imaging), where common mutations in liver cancer with AUCs >0.71 (Area Under the Curve) were identified. Finally, it is imperative to highlight that, despite numerous advances, AI has been criticized for being a "black box" that does not explain how the model generates results from certain inputs. The wide number of parameters involved makes it difficult for oncologists to understand how models analyze data and make decisions (CHEN Z. et.al, 2021).

FINAL CONSIDERATIONS

This study highlights the vital contribution of Artificial Intelligence (AI) in the field of oncology, amid the global challenge posed by neoplasms. The increasing incidence of cancer, influenced by factors such as lifestyle, genetics and changes in the population profile, highlights the need for advanced tools for diagnosis and treatment. AI emerges as a crucial tool in this aspect, enhancing the early detection and treatment of neoplasms, optimizing the management of the disease's course and contributing to improving patient survival. AI is currently having a significant positive impact on radiotherapy, improving understanding of target organs and risk factors, as well as assisting in the analysis of malignancy in lung and breast cancers. Furthermore, it contributes to increasing equity and quality in healthcare and the genetic characterization of tumors. However, its accessibility is still limited, which restricts its widespread use. Deep Learning (DL), a branch of AI, is particularly promising in precision oncology. Your ability to extract relevant details from medical images is crucial, especially regarding prognostic factors. Refining the correlation between image characteristics and their biological meanings, through clinical studies with external cohorts, is essential. A current challenge in the application of AI in oncology is understanding how it processes and interprets detailed data, which can sometimes complicate the conduct of oncologists. In the long term, the importance of AI is undeniable, aiming to improve the detection of cancers, reduce the time to diagnosis and, consequently, increase patient survival and the population's life expectancy.

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