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The role of artificial intelligence in the management of lung cancer: a narrative review

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Abstract

Background: Lung cancer is the primary reason for cancer-related fatalities worldwide. The majority of lung cancer patients experience delayed diagnosis and ineffective treatment. Artificial intelligence is the term used to describe a computer or robot that enables certain tasks under the supervision of a computer in a way that satisfies human demands.

Aim: This study was evaluated in order to comprehensively estimate the advancements achieved by artificial intelligence technology in pathological diagnosis, early detection of cancer through screening based on imaging, prognostic evaluation, genomes examination, and lung cancer treatment.

Methods: In this review, English studies from common databases such as Pubmed/MEDLINE, Web of Science, Scopus, and the Cochrane Library with the keywords "Artificial intelligence," "Machine learning," "treatment," "Diagnosis," combined with keywords, involving "Lung cancer", were involved. The end date for this review is March 2022.

Scientific novelty: Most of the previous studies focused on the diagnostic value of AI evaluation in lung cancer cases without assessing the role of AI in the treatment of lung cancer. The given article evaluated AI's therapeutic and diagnostic advantages for patients with lung cancer.

The practical significance of the result obtained: The results can help physicians to determine the best ways to manage lung cancer and diagnose it early to avoid complications. Additionally, the value of developing AI focused in early lung cancer diagnostic and providing more options for the treatment of lung cancer was explained.

Conclusion: Imaging, histopathological, and genetic analyses of lung cancer all significantly benefit from artificial intelligence. Additionally, artificial intelligence can identify a small number of biomarkers, which is helpful for lung tumor surveillance. Moreover, whether by internal medicine or surgical intervention, the intelligent management of lung tumors has progressively grown to represent the future development trend. AI is anticipated to aid in the early detection of lung tumors and help medical professionals treat each patient uniquely.

Keywords: artificial intelligence, lung cancer, individual treatment, and early diagnosis.

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Introduction

Lung cancer, also known as bronchogenic carcinoma, refers to malignancies that begin in the lung parenchyma or the bronchi. It is a leading cause of cancer-related death. Women have died from lung cancer more frequently than from breast cancer since 1987. Lung cancer is most frequently caused by smoking. 90% of lung cancer cases are thought to be caused by smoking [1,2]. Artificial intelligence (AI) is the term used to describe a computer or robot that can do certain tasks under the supervision of a computer in a way that satisfies human demands [3]. Numerous research has shown that AI is a significant ability for cancer care as it is valid in detection, dynamical monitoring, and quantitative treatment during health protection [4,5]. In this review, the obstacles in clinical application and the use of AI in lung tumors will be covered.

Research Problem

Lung cancer is the primary reason for fatalities related to cancer worldwide [6–9]. Most lung tumor patients experience delayed diagnosis and ineffective treatment [10]. Rapid, sensitive, and precise detection procedures require more focus. Currently, clinicians mostly use imaging characteristics and the clinical characteristics of their patients to diagnose lung tumors. However, these techniques fail to detect lesions fully and promptly [3].

Research Focus

In this article, the current effect of AI utilisation in the management of lung cancer and the advantages of the development of AI in lung cancer diagnosis and treatment were discussed.

Research Questions

1. How is lung cancer usually detected?
2. Is lung cancer easily detected?
3. What is the role of AI in lung cancer detection?
4. What are the recent advances of AI in the field of a lung cancer diagnosis?
5. What is the role of AI in lung cancer treatment?

Research Aim

This study comprehensively evaluated the advancements achieved by artificial intelligence technology in pathological diagnosis, early screening-based medical imaging, prognostic evaluation, genomes examination, and lung cancer treatment.

Research Methodology

In this review, English studies from common databases such as Pubmed/MEDLINE, Web of Science, Scopus, and the Cochrane Library with the keywords “Artificial intelligence,” “Machine learning,” “treatment,” “Diagnosis,” combined with keywords, involving “Lung cancer were involved.” The end date for this review is March 2022. The studies using each set of keyword combinations were then pooled to create an impartial collection of publications. Studies and/or articles that weren't subjected to peer review, as well as proposals, procedures, reviews, letters, and opinions, were eliminated. The references include publications that were chosen according to their relation to the topic. One concentrated on providing an overview of the advancements achieved by artificial intelligence technology in pathological diagnosis, early screening-based medical imaging, prognostic evaluation, genomes examination, and lung cancer treatment.

Research Results | Literature review

The result of the search using the search strategy was 3868 articles. These articles were screened to choose the works related to our topic. A full-text screening of 437 articles after excluding the remaining article by title and abstract screening was accomplished. Finally, 63 articles to gather information about our topic and write this review were used (Figure 1).

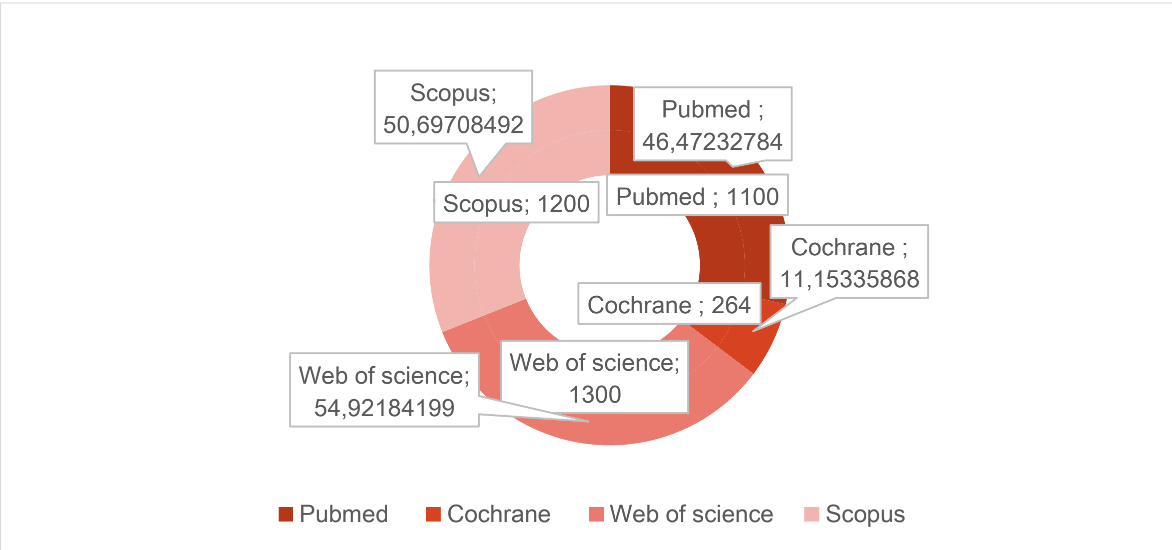

Figure 1 Research results

Detection and AI

Imaging inspection

When a patient feels anxious or has suspected lesions, a clinical scan using digital radiography (DR), magnetic resonance imaging (MRI), positron emission computed tomography (PETCT), or computed tomography (CT) will be performed on the entire body of the patient or only a specific section in order to make a right diagnistic [11,12]. As was already established, these imaging methods are crucial in cancer detecting. The primary practical issue clinicians face is that digital images of visual defects cannot be consistently and accurately integrated into their access to information [13,14]. So, AI should be developed to deal with images with visual defects.

AI created its logical algorithm to detect photographs quickly and gather information. Clinical images determine the target site using computer-aided detection (CAD) technologies [15]. AI-based detection techniques can identify the locations of lesions, decrease observational mistakes, and provide readers with convenience. For example, CAD systems can differentiate bronchioles, walls of the lung, and the lung parenchyma during highlighting abnormal lesions, allowing doctors to detect alterations without error. In contrast, CAD is dedicated to identifying malignant and benign lesions [16]. New methods have so far been developed to find and identify lung nodules smaller than 3 mm [17]. Based on the tumor's texture, personality, stage, and invasion area, AI tries to customise particular solutions for a specific individual.

Early lung cancer imaging findings include pure ground-glass nodules (GGN), partially solid nodules, and solid nodules [18]. The 5-year survival rate for lung cancer, which manifests as partial solid nodules or GGN, can reach over 95% with the early identification and surgical resection of the tumor [19]. It might be challenging to differentiate between benign and cancerous lung nodules early on. Low-dose CT (LDCT) is the best option for lung cancer screening [20]. The early detection and management of lung cancer is the key to its elimination.

The use of AI may help with the radiologists' limited number and may allow for the early diagnosis of lung tumors. The system of CAD of pulmonary lesions has advanced significantly in recent years utilising conventional machine learning (ML) techniques [21]. New articles have demonstrated that the technology of AI is more effective than radiologists in detecting GGNs larger than 5 mm and screening nodules ranging from 0 to 3 mm [22]. But, in practical practice, systems of CAD cannot be used exclusively. The system of vasopressors (VS)-CAD, also known as the ClearRead CT software, can enhance the probability of identification of small pulmonary lesions by suppressing the natural lung structures, especially blood vessels [23]. The CAD system has the ability to detect the small lesions of the lung that radiologists might miss.

Convolutional neural networks (CNNs) and Deep learning (DL) have demonstrated their great potential in the identification of pulmonary lesions and are successful in segmenting and categorising pulmonary lesions with the development of AI [24]. Hua et al. developed a system of DL-based CT detection for the nodules of the lung that exceeds the conventional CAD method in terms of sensitivity and specificity, with 73% and 80%, respectively [25]. By examining the patient's most recent and past CT volumes, Ardila and his colleagues could construct a DL-based model to determine the probability of developing a lung tumor [26]. However, the accuracy of lung nodule detection by AI needs to be tested in real-world scenarios, and additional cases must be corrected [27]. We believe that DL-based CT is more accurate than conventional CAD for detecting lung lesions.

Histopathology inspection

Historically, the most crucial factor in lung cancer diagnosis has been pathological examination, which is a useful method for distinguishing alterations from the tissue surroundings and determining the biopsy species [28–30]. However, the majority of patients that get biopsies are terminal and incurable. Additionally, the sample only represents a portion of the tumor, making it impossible to identify all abnormalities [31]. Most pathological techniques, particularly in poorly differentiated tumors, are restricted to differentiating ambiguous histological characteristics. Histological analysis may create thorough AI diagnosis strategies for biopsy samples using many aspects of AI research [31].

Studies on the development of sensitive and precise diagnostic techniques are well established. A fresh source of huge data for tailored treatment was gathered using image computing and high-throughput whole-slide scanning methods. AI is combined with information of data predicatively and prognostically, as opposed to standard clinical pictures, to produce correct histology slide analysis [32]. Additionally, pathologists can improve efficiencies by utilising mechanised equipment that can provide large volumes of slides and do great analysis [33]. An accessible technique that aids in standardising the assessment of the lung tumor subtype is immunohistochemical (IHC) staining, which uses mucin staining [34]. A trustworthy IHC panel was used in the Koh et al. study to identify the histological subtype of lung cancer. They used a decision tree with a support vector machine (SVM) as two AI techniques to determine the equivocal morphology in 30 tiny lung cancer biopsy cases. They got the maximum accuracy of about 72% using the decision tree model that processed two markers (p63 and CK5/6) in the absence of a 3-marker IHC panel (i.e., TTF-1, Napsin A, and p40) [35]. Although AI speeds up processes and offers priceless images to aid in diagnosing lung cancer, its use in clinical settings is limited. The algorithm of technology has not been adequately enhanced to suit the requirements of extended patients, which is the main cause. The high cost is just another obstacle to AI's wide-scale application.

Monitor and AI

A liquid biopsy is a screening tool that differs from the conventional methods of invasively and laboriously extracting biopsy samples. Liquid biopsy is very helpful in identifying potential genetic changes that will inform therapy choices. Tumor-associated autoantibodies (TAAbs), tumor-associated antigens (TAAs), tumor-educated platelets (TEP), circulating tumor DNA (ctDNA), and other biomarkers have all been the subject of study in recent years [36]. The liquid biopsy is safer, less invasive, and more accurate than the conventional one.

Articles on liquid biopsy for tumor diagnosis now use AI-developed machine learning to find a limited number of biomarkers. As a subset of AI, machine learning (ML) is considered a fantastic technique for discovering millions of fragments of microcirculatory genomes fragments that are easier and more sensitive to discover than conventional approaches [37]. However, there is still much to be done before liquid biopsy can be used in clinical practice because of the restriction of tumor-interstitial heterogeneity [38]. The combination between liquid biopsy and AI will be beneficial for investigating lung lesions.

Treatment and AI

Intelligent lung cancer detection and therapy have gradually become a trend for future development as a result of the advancement of AI. A clinical decision support system (CDSS) is a tool that uses AI to analyse a wide range of clinical experiences (such as evidence-based medicine, clinical guidelines, prescription instructions, etc.) as well as clinical and fundamental data on patients to help doctors make decisions about patient care [39]. Some cancers, including lung cancer, have been diagnosed and treated using Watson for Oncology (WFO), the greatest representative of CDSS. A retrospective study was carried out to assess the consistency of multidisciplinary teams (MDT) and WFO in managing lung tumor cases [40]. According to the findings, lung cancer patients had a 92.4% overall coincidence rate between WFO and MDT. The recommended treatments for lung tumors in stages I and IV are consistent. However, it is relatively low in localized small-cell lung cancer and stage II-III NSCLC. The stage III NSCLC compliance rate, in particular, was only 80.8%.

But CDSS can't take the position of doctors entirely. Instead, it might serve as a complement, particularly for people with complicated illnesses. Additionally, due to the complexity of clinical medicine, shared decision-making and doctor-patient communication can become more crucial in treatment [40]. We can not use AI for the entire process of the management of lung cancer, but the combination between AI and doctors is the ideal way to deal with the disease.

Surgery

Lung cancer has been successfully treated with a lot of video-assisted thoracic surgery (VATS) [41,42]. Numerous earlier research has shown that thoracoscopic lobectomy is associated with a quicker postoperative recovery, less trauma, and fewer problems than thoracotomy [43]. There will be some blind spots throughout the procedure, nevertheless, because of the limitations of surgical equipment and thoracoscopy. Additionally, the instrument arm lacks the flexibility to do more complicated thoracoscopic surgery [44].

AI has the potential to completely change how surgery is learned and performed [45]. Surgeons play a crucial part of incorporating AI into clinical practice. The use of AI by surgeons helps them to assess intraoperative developments in real time, enhance their capacity to make intraoperative decisions, and ultimately improve surgical results. Robotic surgery is a new development of minimally invasive surgery, which is part of the physical branch of artificial intelligence. The Da Vinci-robot-assisted thoracic surgery (RATS), a representative of robot surgery, offers a convenient operation function, and precise system, breaking the limitations of eyes and hands while minimising trauma and discomfort for patients. Several studies have shown the safety and viability of the surgical system of Da Vinci for lobectomy [46–48]. VATS and RATS are similarly efficient and secure in managing non-small-cell lung tumors, although the half-life of RATS is longer. The incidence of surgical complications, intraoperative blood loss, postoperative drainage days, postoperative in-hospital mortality, and postoperative hospital stay was also not significantly different between RATS and VATS. Despite the previous-mentioned benefits of RATS, there are some issues with the RATS technology, such as greater hospital expenses and lengthier operative time, which might prevent RATS from progressing further [46–48]. The utilisation of AI by surgeons may lead to excellent outcomes in surgeries and make them easier and shorter. Also, AI may help the surgeon make the right decision quickly.

Radiotherapy

The conventional therapy for advanced non-small cell lung cancer (NSCLC) that cannot be surgically removed is chemotherapy [49]. Radiology has greatly benefited from the development of AI and radiation, which helps achieve precision therapy [50]. The utilisation of knowledge-based algorithms to plan management, a clinical example of stereotactic body radiation (SBRT) for patients with lung tumors, was created in a study. This article included 105 SBRT plans for treating lung tumor patients, involving 2 three-dimensional conformal radiation therapy (CRT), 6 VMAT, and 97 IMRT. Combining the technologies mentioned above allowed for knowledge-based model (KBM) training, and numerous verification results revealed that the plans of SBRT for lung tumors produced by KBM were comparable to clinical plans. Current radiation treatment methods are intended to destroy malignancies, but they frequently harm healthy tissue. AI will be used to successfully fix the issue and be able to modify the treatment's dosage. In addition, the ideal radiation beam and angle can be chosen automatically without regard to the patient's position [51]. Additionally, intelligent systems can control image, dose rate, and exposure time. Physicians are anticipated to use AI to make decisions quickly and efficiently [52]. Using AI for managing lung cancer by radiotherapy showed good results as it helps in planning, determining dose, and following up.

Targeted therapy

By focusing on chemicals in cancer cells and creating potent blockers to interfere with the process of carcinogenesis, targeted therapy is a novel method for treating cancer with little harm to healthy tissues [53]. When we wish to move forward, figuring out what transpired and which place changed in the region of mutation is a crucial step. AI offers a wealth of data and permits a thorough study, which helps us develop different strategies for preparing for valuable options. Additionally, an intelligent computer creates a linked model to locate and highlight a targeted gene or associated biological pathway. With AI aid, newly identified therapeutic targets may be virtually screened to quickly uncover targeted old medications or new compounds [54]. Reapplying natural items or old medications to new indications may be successful using AI-assisted reverse docking. The DL model of AI can also predict the features of excretion, absorption, toxicity, metabolism, and distribution (ADMET), which will increase the rate of success of in vivo tests [55]. Targeted therapy is developing daily, and its combination with the developing AI will provide good options for managing lung cancer.

Challenges in the future

The use of AI to understand and cure lung cancer is developing, but there are still many challenges to be solved. AI should adhere to unified planning and overall targets in healthcare settings and standard and normalised principles defined by the authorities, which easily provide precise practice details in a real situation [50]. AI, which learns from examples rather than being programmed, is implemented through machine learning (ML). Generally speaking, ML needs more examples to learn a skill than someone does [56]. Data collection is very important. Electronic health records, which provide all the specific information about hospital patients, are a simple method to acquire information on patients' medical records. But many fragmented records offer a problem for AI clinical use due to various recording requirements in various departments or districts [57]. Additionally, sample quantities, patient privacy, language, cultural difficulties, and other issues prevent access to available data [58,59]. AI should be used in different healthcare settings as it gets information from learning, not programming.

Discussion

The findings of Liu et al. demonstrate the high usefulness of the AI-aided diagnosis system based on CT images in diagnosing lung cancer and suggest that it may be pushed as a technique to diagnose lung cancer in clinical settings. Future directions for AI development include integrating various data, including CT images, patient history, pathology, patient follow-up, physician diagnosis, and clinical features, into the AI-assisted diagnosis system to in order provide a complete evaluation of patients. This will not only increase the accuracy of lung cancer diagnosis and lighten the workload of doctors, but it may also alter the established order of medicine and encourage the balanced development of medical resources [60]. One believes that with more development of AI, the diagnosis of lung cancer will be easier and faster than these days with more accuracy.

Thong et al. performed a study that concluded that AI-based imaging could be used in lung cancer screening programs to accurately diagnose the disease. Additional high-quality diagnostic test accuracy (DTA) research on large lung cancer screening populations is needed to support AI's significance in early lung cancer detection [61].

According to Abadia et al., the sensitivity of AI is comparable to a skilled radiologist in a group of patients with complex lung illness, and the tool aids in discovering previously undetected lesions. Due to the rising patient load and requirement for quicker turnaround times, AI also makes it possible for specialists to analyse lung nodules more quickly and assertively, which is advantageous to both patients and hospitals [62]. Thus, the development of AI will make it more sensitive than the skilled radiologist.

A non-randomised clinical study was performed by Chen et al. to determine the role of AI in the diagnosis of non-small-cell lung cancer (NSCLC). They found that doctors can use the AI film reading system based on deep learning as a secondary detection tool to screen for NSCLC; however, it has a greater false positive rate than radiologists for diagnosing the disease. In the meantime, the deep learning-based AI film reading system also has some guiding value for NSCLC diagnosis and therapy monitoring [63]. The diagnosis of lung lesions by AI is steel under question as it has a high rate of false positive diagnosis. So AI needs more developments in this area.

Wu et al**.** compared two methods of double sleeve lobectomy, including thoracotomy and VATS, for the management of NSCLC. They concluded that treating NSCLC with uniportal VATS double sleeve lobectomy is efficient and safe. The uniportal VATS cohort had lower levels of postoperative discomfort. The postoperative survival and complication rates were comparable to those of the conventional thoracotomy method with a large incision [42]. AI needs more development to make a significant difference in the surgical treatment of lung cancer.

AI is able to aid in the treatment of lung cancer, from detection, diagnosis, and decision making through prognosis prediction. AI could reduce the labour work required for low-dose computed tomography (LDCT), chest X-ray (CXR), and pathology slide reading. AI as a second reader in LDCT and CXR scanning minimises radiologists' effort while increasing the accuracy of nodule detection. The future of AI applications in lung cancer may be focused on integration and applications. First, because AI is a data-driven technology, scientists can combine small datasets to produce large data sets for training. But, restrictions governing data sharing provide a significant barrier for researchers. Federated learning, an approach that shares learnt parameters rather than data, is a simple solution. Integrating all variables such as radiography, pathology, demography, and clinical data, as well as both old and new technology, could better reflect reality. The combination of several elements also aids researchers in the development of predictive models. AI models of lung cancer exhibit objectivity, high efficiency, multiplicity, and repeatability. This will surely reduce the stress on clinicians, reduce misdiagnosis due to tiredness, and may transform the current medical model. A rising variety of AI models are being used to monitor diverse data sets, such as electronic health record data, imaging modalities, histopathology, and molecular biomarkers, in order to enhance the accuracy of disease risk prediction, detection, and treatment response prediction. However, AI is still in its infancy and has limitations in lung cancer application. The vast majority of medical AI technologies are only capable of detecting a particular disease. As a result, another difficulty for AI development is disease diagnosis and differentiation. Despite the early findings' potential, more study is needed to standardise AI data and increase both the generalizability and interpretability of outcomes. AI integrated with radiography, genomics, pathology, electronic health records, and other data streams and combined with 5G may be of considerable therapeutic utility in lung cancer. The use of computer-aided detection of lung nodules in screening programmes has changed disease detection. Furthermore, the ability to apply AI techniques to identify patients at risk of acquiring lung cancer during their lifetime can aid in the development of a more targeted screening programme.

Conclusion

1. The aspirations to increase the effectiveness and efficiency of health care continue to stimulate a wide range of innovations, including AI.

2. Medical professionals may make judgments quickly and accurately by using AI technologies in order to evaluate huge amounts of data, including physiological imaging and clinical presentations.

3. The computer-assisted diagnosis will assist in identifying early lesions, improving the prognosis for patients. Although there is still much to be done, the use of AI in lung tumors has a bright future due to the lack of standard databases, standardised principles established by different institutes, and related national policies and regulations. More sensitive and accurate algorithms or machines are required to achieve the goal of individual treatment.

4. AI has become widely used and is crucial for resolving challenging problems across various fields.

5. Research on AI in oncology mainly focuses on dynamic monitoring, diagnosis, and individualised treatment.

6. The use of AI to understand and cure lung cancer is developing, but there are still many challenges to be solved.

7. The use of AI in lung tumors has a optimistic future due to the lack of standard databases, standardised principles established by different institutes, and related national policies and regulations.

8. More sensitive and accurate algorithms or machines are required to achieve the goal of individual treatment.

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