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Artificial Intelligence for lung cancer diagnosis and treatment: A comprehensive review

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Abstract

Lung cancer is a leading cause of cancer-related deaths worldwide. Artificial intelligence (AI) has emerged as a transformative force in modern healthcare, revolutionizing diagnostic accuracy, treatment efficacy, and patient management. This review aims to investigate the current state of AI and machine learning applications in lung cancer care, focusing on critical studies, achievements, and future directions. AI technologies, such as machine learning and deep learning, have shown promise in improving lung cancer diagnosis, predicting treatment outcomes, and enhancing patient care. The benefits of AI in healthcare, including personalized recommendations, improved diagnostic accuracy, and enhanced patient outcomes. Also explore the applications of AI in lung cancer, including image analysis, risk prediction, and treatment planning.

Keywords: Artificial Intelligence; Lung Cancer; Machine Learning; Deep Learning; Diagnosis; Treatment

1. Introduction

Cancer is one of the most common causes of mortality and disease worldwide [1]. Cancer is the greatest cause of mortality in humans, and it is seen as a severe danger to global life expectancy improvement [2]. Cancer is a serious public health concern, accounting for the majority of deaths and morbidities worldwide [3]. Artificial intelligence and machine learning are frequently lauded for their ability to transform health care, and lung cancer diagnosis is no exception [4]. Artificial intelligence (AI) is an innovative technology in the medical industry that enables the resolution of complicated issues that involve information processing skills, such as decision making based on available data [5]. Artificial intelligence systems have the ability to elevate clinical decision making, thereby enhancing patient outcomes [6]. AI can aid in the personalization of screening programs by risk stratifying based on the gathering and analysis of massive amounts of imaging and clinical data [7]. Physicians can make speedy and precise choices by using intelligent machines to interpret large amounts of data, such as clinical presentations and physiological pictures [8]. This literature review intends to investigate the current state of AI and machine learning applications in lung cancer care, focusing on critical studies, achievements, and future directions in this quickly growing field [9]. Before an artificial intelligence system can be used to make actual decisions, it must be trained with relevant data to develop a logical decision-making process [10]. AI includes a variety of technologies, including machine learning (ML) and deep learning (DL) [11]. We plan to do a quantitative and qualitative analysis, as well as visualization, of the research development and current state in the field of artificial intelligence applied to lung cancer by collecting relevant data from databases during the previous 20 years [12]. This review will provide a summary of the current literature on using AI for outcome prediction in lung cancer [13]. Developing aimed at further reducing the lung cancer burden [14].

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2. Artificial intelligence in healthcare

The current technological revolution is reshaping several scenarios, with health being one of the most affected. According to the World Health Organization (WHO), the ethical and efficient use of technology allows for resource optimization and public health service management [15]. The healthcare industry's significant investment in AI technology, as well as the adoption and deployment of AI solutions in healthcare, is still in early stages. Some of the most significant current difficulties facing healthcare are reduced spending, physician shortage and burnout, and the shift towards chronic disease management [16].

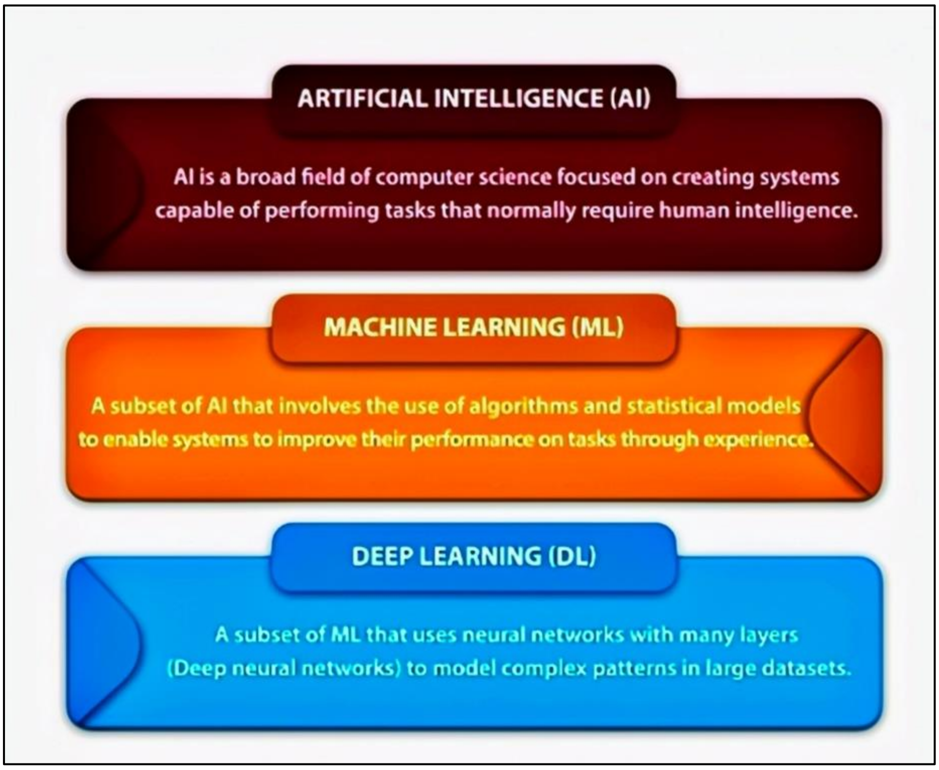

Figure 1 Some key definitions pertaining to AI [17]

Table 1 Current applications of artificial intelligence in health care [20]

Technology	Application scheme	Appplication area
1] Robotics	Provide high quality treatment by improving the precision and accuracy of the surgical procedure	Medical device, Health IT
2] Image processing	Quickly process large amount medical image and apply the findings in judging the disease type and negative and positive test result	Diagnostic medical image, IT
3] Natural language processing	Convert long unstructured text data, such as medical charts, to be easily read and interpreted	Medical device, Health IT
4] Voice recognition	Capture patient voice and language and store important information in electronic medical records	Medical device, Health IT
5] Statistical analysis	Predict patient treatment result through rapidly analyzing large amounts of patient health record	Medicine, Health IT
6]Protective modeling	Predict treatment outcomes, such as predicting risky diseases, by applying mathematical models	Medicine, Health IT

Artificial intelligence (AI) has emerged as a transformative force in modern healthcare, revolutionizing diagnostic accuracy, treatment efficacy, and patient management [18]. Enthusiasm for applications of AI in healthcare has continued to grow, with early successes involving Chatbots, diagnostic tools, and radiological image analysis [19]. Unlike the typical technologies that deal with physical realms, AI technology is breaking new ground, as it has implications in more psychological realms such as experience, intelligence, and judgment of the experts [20]. AI research in radiology is an active field in healthcare owing to its affinity for imaging, with the number of AI-related publications and medical device certifications increasing annually [21]. Artificial intelligence technologies, such as machine learning and deep learning, have the potential to greatly improve healthcare quality. Identifying trends in diagnostics, detecting anomalies, and, ultimately, giving decision assistance are all influencing standards of care and clinical practice [22]. AI with demonstrable medical applications gained traction in the 1970s. INTERNIST-1, the world's first automated medical consultant, was developed in 1971. The system used a search algorithm to provide clinical diagnoses based on patients' symptoms [23]. AI applications can also help to improve diagnostic and therapeutic accuracy, as well as the entire clinical treatment process [24]. As a result, several studies on the application of AI-based technologies in health care are now underway [20].

3. Benefits of ai in healthcare:

Finding acceptable and bioactive drug molecules within the vast amount of chemical space that exists in the order of molecules is the most challenging and disheartening stage of the drug research and development process [25]. AI-powered chatbots have been identified as a useful, simple, and successful method for improving healthcare outcomes such as patient safety, physical and mental well-being, and pain management [26]. The study's primary findings are the identified processual phases and actions that an adopting healthcare organization must carry out when AI systems are used in normal practice [27]. Algorithms can give patients with personalized recommendations for staying healthy [28]. This contributes to increased confidence in artificial intelligence systems and their long-term favorable impact on public healthcare [29]. They include animated avatars, such as virtual personal health advisors, that patients can converse with in natural language via tablet or hospital TV [30]. The financial industry eliminates loss and fraud by collecting vast amounts of data ahead of time, and e-commerce may learn about consumption habits from customer browsing history [31]. Provides substantial benefits for facilitating self-directed learning in open learning environments; nevertheless, its success is dependent on students' past knowledge as well as their cognitive and metacognitive levels [32]. AI systems assist clinicians in forecasting patient prognosis, including treatment response, tumor recurrence rate after surgery, radiation response, and side effects [33]. Artificial intelligence could help doctors diagnose lung cancer earlier and treat patients more effectively [34]. AI Predictive analytics is the application of artificial intelligence systems to estimate future events based on past and present data [9]. AI algorithms can integrate numerous imaging modalities and clinical data, resulting in a more comprehensive diagnostic assessment. AI models rely on high-quality data, such as patient demographics, clinical history, and genetic profiles. can predict treatment outcomes and aid in the selection of effective remedies [35]. Through these many applications, AI not only improves diagnostic accuracy and therapy planning, but it also promises to usher in a new era of personalised medicine, eventually enhancing patient outcomes [11].

4. Lung cancer

Respiratory infections are among the most frequent diseases in the population, affecting the respiratory system. These are noncommunicable diseases that are widely disseminated over the world as a result of environmental and lifestyle changes [36]. Lung cancer remains the greatest cause of death worldwide, accounting for 1.8 million reported deaths each year [6]. Lung cancer is a very heterogeneous disease with several histological and molecular features, making accurate diagnosis and classification difficult [37]. Lung cancer is the world's biggest cause of cancer-related fatalities and the second most commonly diagnosed malignancy. The average 5-year survival rate is below 15% [38]. Every year, 1·8 million persons are diagnosed with lung cancer, resulting in 1·6 million deaths [39]. Lung cancer is often asymptomatic and difficult to diagnose without improved imaging and interpretation techniques [40]. Lung cancer is mostly caused by late-stage illness; patients with conventional and well-known symptoms are more likely to present late-stage disease, and approximately 80% of patients are referred in a disseminated stage (3 or 4), resulting in more intrusive therapy and a worse prognosis [41]. Lung cancer is caused by permanent genetic changes, including point mutations, deletions, translocations, amplifications, and epigenetic modifications that affect chromatin-dependent processes like histone modifications, DNA methylation, and microRNA regulation [42]. Histopathological, lung cancer is classified into two types: non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC). NSCLC is further categorized into three subtypes: squamous cell carcinoma (SCC), adenocarcinoma (ADC), and no other specific (NOS) [43]. As seen in Figure, large cell carcinoma is present throughout the lung.

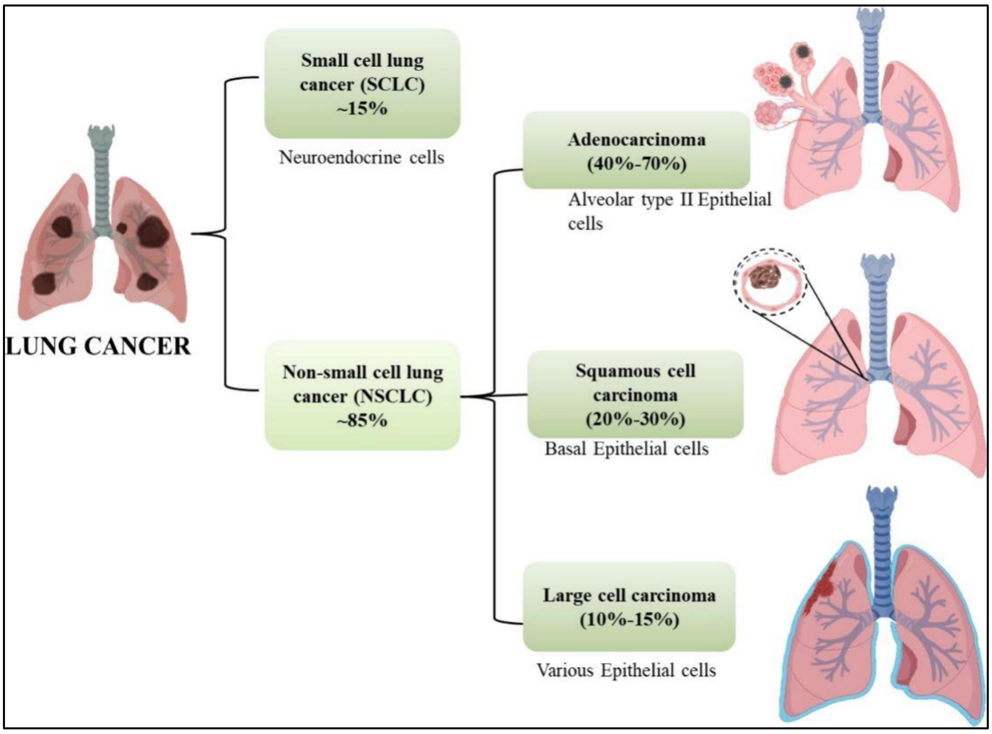

Figure 2 Subtypes of lung cancer [42]

5. Epidemiology

Lung cancer ranks fourth among all cancers, regardless of gender. It ranks second among malignancies in males and third among women [44]. Lung cancer is a major global burden, killing roughly 1.8 million people, with male mortality being two times higher than female mortality [45]. Most people who get lung cancer are between the ages of 50 and 69 year old [46]. When compared to other cancers, lung cancer remains the greatest cause of death, accounting for 1.8 million fatalities or 18% of all cancer deaths worldwide [47]. It is the most frequent cancer in men and the fifth most prevalent cancer in women. By 2025, the number of lung cancer cases is anticipated to skyrocket, reaching 81,219 for men and 30,109 for women [48].

6. Etiology and risk factor

Smoking is the leading cause of lung cancer. It is estimated that smoking causes 90% of all lung cancer cases. The risk of lung cancer from passive smoking rises by 20 to 30% [49]. Tobacco usage, including cigarette smoking, is responsible for up to 90% of all lung cancer fatalities globally. Fewer than 20% of cigarette smokers acquire lung cancer, indicating that other variables contribute to the disease [50]. The high occurrence of lung cancer in some families is linked to a genetic tendency to overactivated carcinogenic chemicals found in tobacco smoke or to eliminate these compounds from the body too slowly [51]. Occupational exposures, particularly occupational agents and conditions of exposure, have a crucial role in the development of lung cancer [52]. It was discovered that the main risk factors for lung cancer were cigarettes, air pollution, unhealthy foods, chemical compounds, occupation, family history of cancer, lack of physical activity, alcohol intake, and the patient's history of lung illness [53]. A positive family history of lung cancer has been identified as a risk factor in various registry-based studies that have revealed a substantial familial risk for early-onset lung cancer [54]. The other lung cancer risk variables are substantially less important on a population level. These include exposure to ionising radiation, asbestos, cadmium, lead, nickel, and arsenic. It has also been demonstrated that long-term exposure to coal and liquid fuel emissions increases the risk of lung cancer [55].

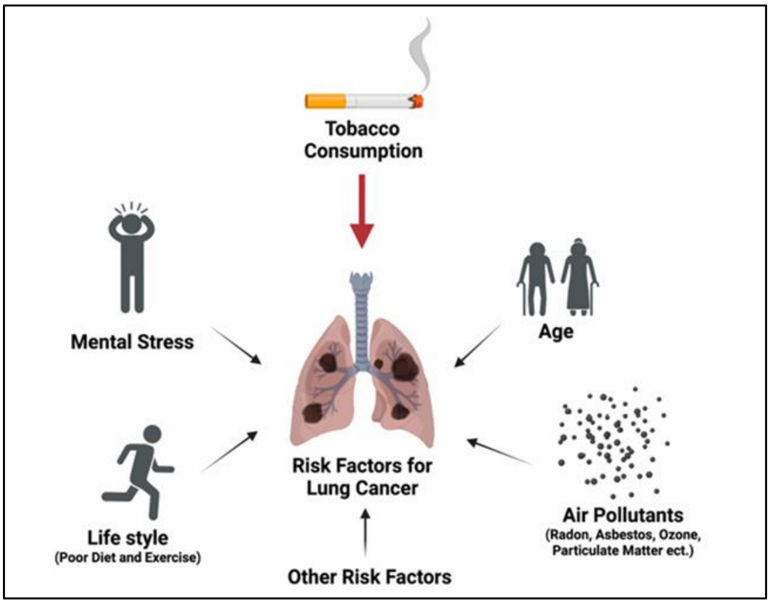

Figure 3 Risk factor for lung cancer development [56]

7. Pathophysiology

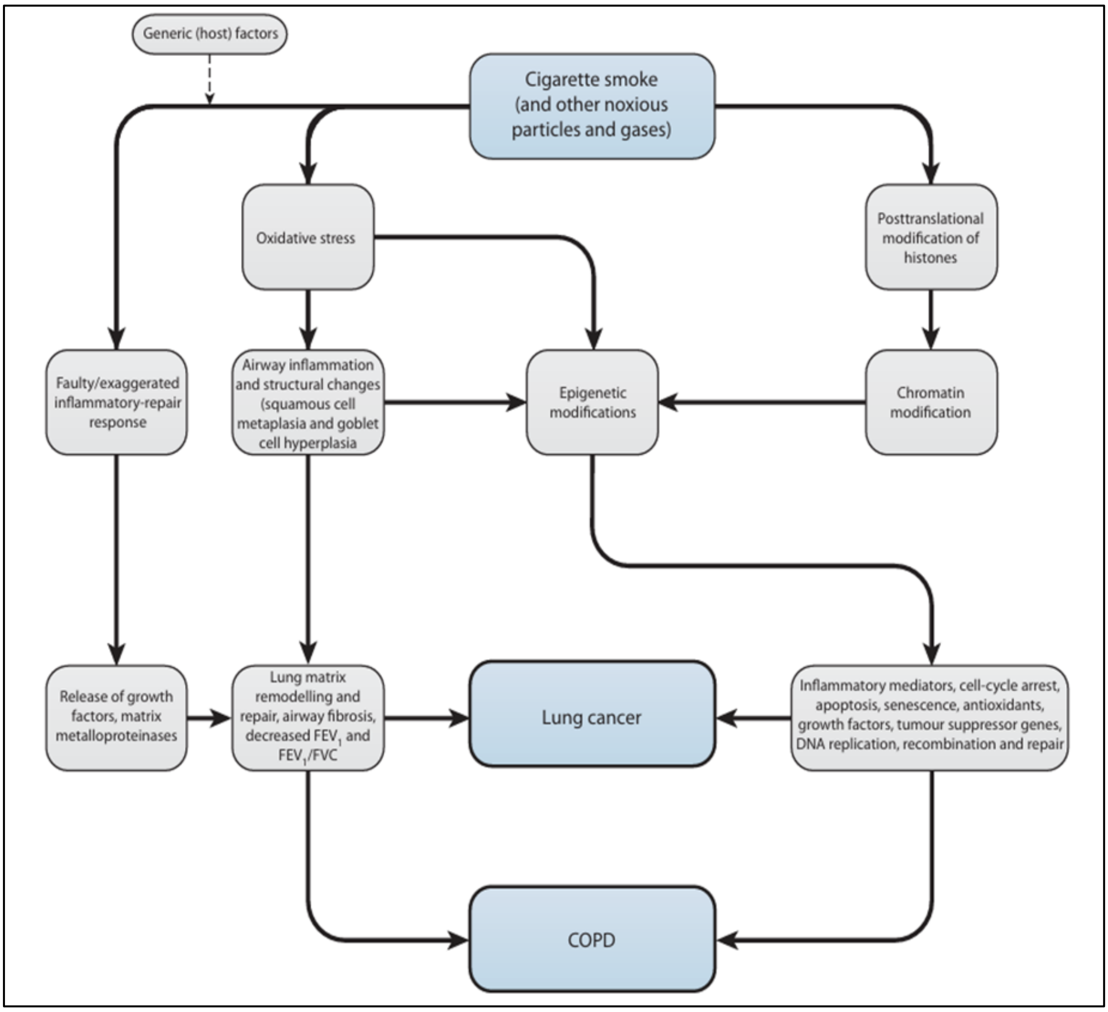

Figure 4 Pathophysiology of lung cancer [58]

The pathophysiology of lung cancer is extremely complex and poorly understood. It is hypothesised that repeated exposure to carcinogens such as cigarette smoke causes lung epithelial dysplasia. If the exposure persists, it causes genetic changes and disrupts protein production [49]. This simultaneous inactivation of tumor suppressors contrasts from the key oncogenic drivers of many other solid tumors, such as non-small-cell lung cancer (NSCLC), which appear to require activating oncogenic mutations for carcinogenesis. Changes in the lung stroma and immune microenvironment are hypothesised to promote SCLC carcinogenesis [57].

8. Sign & symptoms [59]

- Peer pressure
- Yellow fingers
- Chronic disease
- Fatigue
- Wheezing
- Couching
- Swallowing difficulty
- Shortness of breath
- Chest pain

9. Application of artificial intelligence in lung cancer

The primary goal of medical AI is to create AI programs that aid in disease prediction, diagnosis, treatment, and management [36]. AI algorithms have been researched for nodule detection and categorization using X-rays, CT, MRI, and PET scans, with the majority of studies focusing on CT imaging. Both machine learning and deep learning AI models have performed comparably to or better than radiologists in nodule detection[6]. AI is a means of teaching algorithms how to make decisions [60]. The primary goal is to identify patterns, structures, or clusters in the data [7].

10. AI models

10.1. Deep learning

Early CNN models for lung cancer diagnosis relied mostly on 2D slices of CT scans, with each slice serving as an independent image input. Such 2D CNNs obtained reasonable accuracy and were computationally practical, but they were unable to detect context between adjacent slices [40]. Convolutional neural networks (CNN), deep convolutional neural networks (DCNN), and recurrent neural networks (RNN) are the most commonly utilized unsupervised learning techniques in medical pictures [61]. The suggested network is made up of two concatenation layers, primary and secondary, that are independent of one another [62]. The models were assessed on training and testing accuracy in terms of precision and recall [63].

10.2. Machine learning

The ML training method is divided into three categories: supervised learning, unsupervised learning (UL), and semi-supervised learning (SSL) [64]. Machine learning to construct a collection of high-accuracy models for detecting lung cancer as early as 9-12 months before clinical diagnosis [65]. The machine learning algorithms employed were convolutional neural networks (CNN), support vector machines (SVM), and other shallow neural networks [66]. These models' discrimination and accuracy differed between datasets. To select the final model, each model's predictive performance was evaluated and compared on the testing dataset [67]. lung cancer early detection using sequencing technologies, data integration and biomarker extraction from multi-omics datasets, treatment response and prognosis prediction, and immunotherapy research [68].

10.3. Sybil

Sybil was created to predict future lung cancer risk using a 3D convolutional neural network architecture [69]. Sybil is a previously established deep learning-based method for predicting future lung cancer risk using a single LDCT [70]. The Sybil model was applied to the prospective cohort to evaluate its risk prediction performance for persistent lung nodules in this hospital-based cohort. The Sybil model demonstrated high specificity, showing its potential for properly detecting non-cancer cases and reducing unnecessary follow-up [71].

10.4. Radiomics AI

Radiomics is a fast-expanding area that employs quantitative data collected from medical images like computed tomography (CT), magnetic resonance imaging (MRI), and position computed tomography (PET) to provide a more precise characterization of tumors [72]. Our methodology, which combines radiomics with deep learning, provides a robust and clinically usable tool that surpasses current methods, paving the door for more precise and personalized patient treatment [73]. AI approaches have already been used to great success in radiomics research [74].

11. Application and future of A.I. in healthcare

Three major obstacles include potential biases in AI models, protecting patient privacy, and obtaining clinician and public trust in the use of AI in health care [75]. With the extensive use of AI technologies in the healthcare industry, care providers are becoming increasingly reliant on the knowledge of consultants, specialists, and experts in ICT, convergence, and human resource management. As a result, care services have evolved into a team sport including both external and internal experts [76]. AI approaches can extract therapeutically important information from huge amounts of data, hence assisting clinical decision making [77]. The use of distributed ledger technologies such as blockchain in the healthcare business is still in its early stages, thus academics need to produce more proofs-of-concept and prototypes [78]. These skills in computer vision, reading comprehension, conversational systems, and multimodal applications can assist health professionals in making more informed decisions (for example, a doctor making a diagnosis, a nurse developing a care plan, or a social services agency arranging services for an elderly person) [79]. One of the field's major challenges is reducing the amount of human intervention needed to develop these designs [80].

12. Conclusion

AI has the potential to revolutionize lung cancer diagnosis and treatment. By leveraging AI technologies, healthcare professionals can improve diagnostic accuracy, predict treatment outcomes, and enhance patient care. The applications of AI in lung cancer are vast, ranging from image analysis to risk prediction and treatment planning. However, there are challenges to be addressed, including potential biases in AI models, protecting patient privacy, and obtaining clinician and public trust. Further research is needed to fully realize the potential of AI in lung cancer care. With continued advancements and innovations, AI is likely to play a significant role in improving lung cancer outcomes and saving lives.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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