

ADVANCES IN ARTIFICIAL INTELLIGENCE FOR LUNG CANCER: TOOLS, APPLICATIONS, AND LIMITATIONS

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Abstract

Artificial Intelligence (AI) has become a transformative tool in medicine, offering innovative approaches for diagnosis, prognosis, and treatment planning. Lung cancer remains a leading cause of mortality globally, necessitating advanced strategies for early detection and effective management. This review highlights current AI applications in lung cancer, including tools for detection, diagnosis, prediction, and therapeutic planning. It also addresses key challenges in clinical implementation, such as data quality, model interpretability, and integration into healthcare systems. Strategies to overcome these limitations are discussed, alongside future directions for AI development in oncology. By improving diagnostic accuracy, optimizing treatment decisions, and enhancing accessibility, AI holds significant potential to advance lung cancer management and improve patient outcomes worldwide.

INTRODUCTION

AI tools are thought to be the most emerging aspect in the field of medical sciences due to its present and future advancements (Series, Whicher et al. 2023). AI tools are most importantly used in the cancer field for early detection, diagnosis, precaution and cure because of its fast and accurate working if applied in authentic process (Sufyan, Shokat et al. 2023). Lung cancer is one of the leading problem to be results in death for both male and female annually with heavy abundance (Siegel, Miller et al. 2023). Lung cancer observed to be most deadly type of cancer throughout the world and having high mortality rate as 1.8 million deaths result globally due to it (Sung, Ferlay et al. 2021). The early detection of cancer can be helpful for ensuring the more chances of curing and survival of the individual got affected by lung cancer (Field, Vulkan et al.

2021). Lung cancer, if detected at early stages, it is possible to control its more drastic effects which lead to ultimately death because at early stages, the complications are not much spreading in lungs (Burzic, O'Dowd et al. 2022). Some of the lung cancer detection technologies such as LDCT can be used also but having drawbacks like, false positive up to 25%, also exposure to repeated scanning and can also cause tumors that don't show any symptoms (Medicine 2011). Sputum cytology can also be used for detection but having low diagnostic accuracy and more likely the poor detection about peripheral nodules (Thunissen 2003). Ct screening might resulted in much of false results that leads to further complication in the delaminated one (Patz Jr, Black et al. 2001). When there will be false results or the positive results are not true or the detection is not

considerably effective, then it may lead to unnecessary treatment that results in other problems like over diagnosis (Welch and Black 2010). AI algorithms are widely used in medical field for dealing different aspects of it, like detection of disease and different suitable treatments for recovery, protection or control further damage (Lewandowski, Koller et al. 2023). In this review, we will discuss about different aspect of AI emergence in lung cancer detection and its important beneficial future applications.

Basics of AI in Medical Imaging

AI can be termed as the field of computer science that simply defined as the tool, which is used for mimicking human intelligence (Wang, Fu et al. 2024). The massive data set learning can be made now easy and time manageable by the usage of AI generated deep learning system, that give the output in precise way according to prescriptions (Amin, Al Ghamdi et al. 2021). The domain specific tuning, human-AI collaboration, regulatory and technical frameworks and data governance can be possible by the usage of AI technologies in medical field (Zhang, Shi et al. 2024). The careful validation of AI tools in the clinical zone can be useful for informing about prognosis and guidance treatment intensity in certain cases of cancer (Yuan, Cai et al. 2021). For the working of AI tools, different tool will be used for the processing of four command, like CNNs, RNNs and transformers. The CNNs (Convolutional Neural Networks) cover the different aspect of analysis parameters like as radiology, dermatology, pathology and cardiology by giving output as image segmentation and classification (Suganyadevi, Seethalakshmi et al. 2022). The RNNs (Recurrent Neural Network) helpful for the prediction of diagnosis when the sequencing data is given because it also having another form that is LSTM (Men, Ilk et al. 2021). The triage can also be outputted by the combination of RNNs and attention mechanism and also play key role in risk prediction and modeling of irregularly placed data (Xie, Yuan et al. 2022). The GNNs and different transformers combination can lead to modeling of patient drugs dosage (Wang, Chen et al. 2021). Different transformer mechanisms are used for the detection of patient recovery, for

chemical protein engaging, for effectiveness of dose, health record, disease forecasting and survival data about patient (Khader, Kather et al. 2023). AI based radiology technology used for the X-rays analysis of different part for the image, detection, classification and segmentation of any disturbance or any irregular functioning, like pneumonia, cancer detection, and also for chest tuberculosis diagnosis (Nafisah, Muhammad et al. 2024). Data collection and providence, the main key forward to the AI working efficiency, it will include about random forecasting for recognition of pattern, use of unsupervised clustering for anomaly model detection and for the tracking of deviation from healthy person, used model having time series forecasting (Jordan 2025). The training for AI tools will be proceed by fine tuning in response to pre trained architectures, learning with the help of multimodal that includes clinical data, genomics and imaging, also the data in the form of images can be precisely structured by noise removal and augmentation and use ensemble learning and cross validation for improving of generalization (Wang, Maniscalco et al. 2025). The AI transparency, reproducibility and usability is designed for promotion and assessing structure with the help of MOF (Model Openness Framework) (White, Haddad et al. 2024).

Imaging Modalities for Lung Cancer Detection

Different model prepared for the cancer detection, but the key characteristics they having should include basic tasks, as the tumor detection, classification of tumor, and the tumor localization which will ensure about type, location and spreading of the specific tumors (Abdulqader, Abdulameer et al. 2025). The AI based X-Ray analysis provides the better detection accuracy along with enhancing the sensitivity of the operates and the partial AUC gained while focusing about specificity and confidence (Homayounieh, Digumarthy et al. 2021). The 20% reduction in the death rates results by using LDCT (Low Dose Computed Tomography) and also more accuracy in detection rates will be produced by decreasing false results and helpful in early detection of cancer (Radiology 2011). The PET/CT can be used for the analysis of NSCLC (Non-Small Cell Lung Cancer) with involvement of

three models as, deep learning alone, radiomics alone, and combination of both, which result in improved patient therapies and their outcomes (Peng, Wang et al. 2025). The AI used tools helps in imaging multiparametric leveraging for enhancing recurrence sensitivity with the help of MRI in case of soft tissue for cancer case study (Emma 2025). The image enhancing methodologies, like as FNet-based model are used for the better image resolution and interpretation, to avoid the false positive or negative test by clearly knowing the difference among the cancerous and non-cancer cell during the oncology examination for specified organs (Şeker, Akhan et al.).

AI System and Tools for Detection of Lung Cancer

1) Commercial and Open Source AI Tools

The tools generated for the tumor or cancer detection will be based on any of modulated pattern, like in case of modern and evolving working, the cfRNA sample are collected from the both of healthy and effected patient and the comparative study of the cells, tissues and other parameters will make a suitable transcriptomic data for the analyzing process in AI tools for specific algorithms development and then help in further future identification, presence of tumor and their characteristics (Shubin, Shpak et al. 2024).

LYNA: LYNA (Lymph Node Assistant) model is emerging evolution in field of new medical field tool as when combining with AI, because it having accuracy of 94% along with 88% sensitivity, that helps in the identification of tumor and nodes in the cancer case patient for early diagnosis and more survival chances (Jin, Rosenthal et al. 2022).

IBM: IBM Watson Imaging can be used for lung cancer detection AI generated tool, because it carries the data processing with high throughput, integration along with genomic database and prognostic modeling, which can be proffered because it leads to interpretation concerns, overhyped expectations and institutional variability (Dlamini, Francies et al. 2020).

Aidoc: Automatic alert for the danger of lung cancer and nodules, the urgent clinical study requirement approaches and improvement in diagnostic consistency along with radiologist stress reduction with supportive techniques can be also possible by the use of Aidoc (Khalifa, Albadaawy et al. 2024).

Zebra Medical Vision: ZMV (Zebra Medical Vision) also having the ability to broadly covering in different parts and point of cancer which provides a regularity validation and potential with respect to early detection but less integrated as compare to Aidoc (Fujita and technology 2020).

InferRead CT Lung by Infervision: The early detection of nodules and cancer with the help Infervision is important tool in AI medical field because it can also improves clinical triage and radiologist performance that can be useful for both routine workflow and screening purpose (Yu, Zhang et al. 2024).

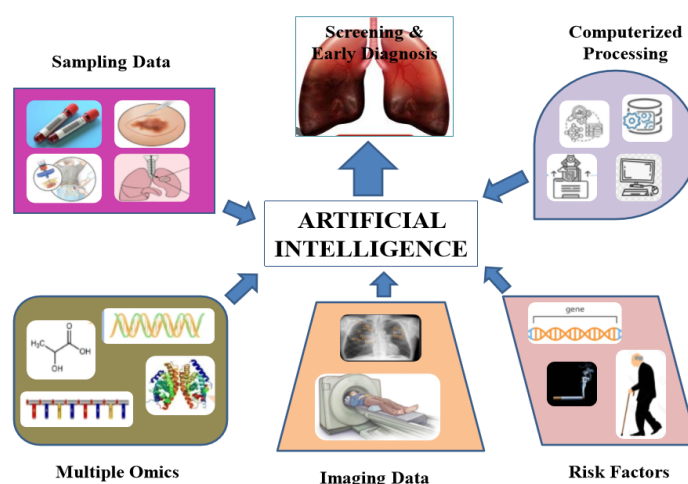
Lung-RADS AI-enhanced systems: The Lung-RADS (Lung Image Reporting and Data System) having beneficial aspects due to manual nodule detection with variability in scoring consistency and faster triage that become more interested with moderate false positives results and radiologist dependent scalability (HaghighiKian, Shirinzadeh-Dastgiri et al. 2024).

2) Academic and Research Based Tools

Pivotal role played by National Institute of Health (NIH) for the research on NCI (National Cancer Institute) or its other branches that play key role in molecular biology, AI diagnosis, immunopathology, population surveillance, that leads to clinical trial and investigation in genomic, and immune relevant targeted cells therapy (Gong, Guo et al. 2021). Stanford and other institute working consciously on AI employed method for the cancer detection, Natural Language Processing (NLP), deep learning, machine learning, and reinforcement learning for the enhancing of diagnosis and lung cancer prognostic workflow (Huang, Yang et al. 2023). The MIT (Massachusetts Institute of Technology) are significantly influencing about the lung cancer research that focuses on robust diagnosis, large

dataset leveraging, prognostic models and AI advancement translation for clinical viable tools that aims to surveillance monitoring, precision treatment and earlier detection (Darvish, Trask et al. 2024). One of the widely used dataset for study of lung cancer that having 1000 annotated CT scan dataset by different radiologists and used for the CT based analysis, lung cancer diagnosis, along with AI model training which is termed as LIDC-IDRI (Lung Image Database Consortium and Image Database Resource Initiative) (Pehrson, Nielsen et al. 2019). Also NLST (National Lung Screening Trial) is a multicenter

project, & this study conducted and controlled by United States that demonstrate the 20% reduction in mortality rate due to lung cancer for the very first time and it uses LDCT instead of standard X-ray, that proved better innovation in oncology field by engaging it with AI tools and models (Yoo, Lee et al. 2021). The Kaggle also provide a big competition platform for the better and more accurate and up to date dataset to study about the lung cancer, its different aspect for deep study and workflow pattern to install in the AI generated models for working more precisely (Yu, Lee et al. 2020).



Clinical Applications and Integration

New innovations are emerging in the field of AI for medical assistant. Some of the important aspects of AI driven tools for lung cancer analysis are given below.

1) AI Assisted Radiology Workflow

The AI models are performed on non-small cells for lung cancer practical consideration and model provide high accuracy curve that offers random forest system and importantly helpful for predicting blood oxygen level, pulmonary function, tumor size and Charlson Comorbidity Index (Rabbani, Kanevsky et al. 2018). AI modulated tools play significant role in the thoracic imaging, for example, nodule detection, radiomics modeling, 3D reconstruction and prognostic modeling for cancer cell analysis (Chassagnon, Vakalopoulou et al. 2020). Different

hybrid model are now available and further more working upon it, which can be useful in terms of the timely detection in microscopic changing that aiding in timely diagnosis and imaging dataset (Wang 2022). In case of emergency radiology concern, the tools are used for the image automated interpretation, performance enhancement, workflow optimization and integration with PACS & RIS (Alabi 2025). AI driven hybrid Multi-Wavelet Transformer (MWT) are now available that use hybrid programming working and leads to more precise results with 95% accuracy, higher sensitivity, specificity & AUC and more competitive as compare to other classifiers (Mostafa, Elrefaei et al. 2022).

2) Decision Support System

The lung cancer having high risk in persons with smoking history and the persons with old age have

more chance of early detection of cancer in their lungs, although also some limitations with traditional methodologies, but AI generated tools can counter many of issues, like accuracy, precision the detection of lung cancer and decision for specific diagnosis treatments and precautionary measures (Shaikh and Rao 2022). Recent surgical planning, like real time DSS tools , that are used in case of lung cancer intra-operative support and also enhancing lymph node and nodule CT imaging (Leivaditis, Maniatopoulos et al. 2025). The precision oncology can be improved by using the analysis techniques in digital pathology and classification of deep CNN images to improve history analysis during decision making with the help of deep neural networks study (Keerthi and Iniyan 2025). For the better real time alerts and better decision making tools, the multi-modal supported with the help of DSS model in case of AI integration in rare and high incidence of cancer is beneficial (Abbas, Asif et al. 2024).

3) Diagnostic vs. Screening Use

AI techniques are now used for the linking of histopathology with the expression of gene, which leads to early detection of cancer and for the segmentation of tumors in the targeted areas with the use of DeepLabV3 technology (Pan, Salvatierra et al. 2025). New AI model are designed for the

and early detection facility (Chapla, Chorya et al. 2024). The decision support system of the AI generated machine learning system can be more helpful as compare to traditional methodologies f screening of NSCLC (Non-Small Cell Lung Cancer) under critical circumstances and it basically focuses on the detection of genetically driven mutations by using of histological images (Tan, Li et al. 2022). In case of lung and gastric cancer, the AI drug repositioning models are used for the screening of tumor in specific parts by combining it with early detecting tumor technologies (Yun, Kim et al. 2025). Different chemical inhibitors are synthesized and designed by using of AI techniques, that are helpful in case of early stage lung andenocarcinoma, by inhibiting tumors and further stopping of their spreading (Sinha, Hawley et al. 2025). The rapid screening of lung cancer for supporting of techniques without genetic sequencing made possible with the help of AI detector EGFR mutations that having high accuracy and multiple directional models to ensure better survival conditions for patient (Park, Brattoli et al. 2025). The combination of AI tools with the methylation analysis of genome can be facilitating during the early detection of cancer and their diagnosis by uses blood plasma as sample, which is based on technique of liquid biopsy (Pass, Melton et al. 2025).

Feature	Diagnostic AI Use	Screening AI Use
Primary Goal	Tumor Characterization & Confirm Diagnosis	Triage & Early detection
Data Type	Biopsy Images, CT, Genomics & PET-CT	LDCT Scans, Chest X-rays & e-Nose Outputs
Challenges	Small Lesion Differentiation & Interpretability	Over Diagnosis & False Positives
Clinical Integration	Precision Medicine & Oncology Clinics	Large Cohorts & Public Health Initiatives,
Examples	Multi-modal Platforms for Diagnostic & CADx Systems	Risk Prediction Models & CADe Systems

4) Rural Healthcare Accessibility and Telemedicine

AI tools can be role player by engaging it with the telemedicine which can leads to better results for patient management, diagnosis and digital therapeutics (Giansanti 2025). The chronic disease

management and predictive diagnosis of the cancer patient can be helpful for life concern of individual by the use of AI and virtual telemedicine technology (James, Olawale et al. 2025). The AI driven telemedicine application are under most concern in

the digital era for the public health crises and emergency situations (Anggo, Rahman et al. 2025). Rural areas are more delayed in any diagnostic facility in case of lung cancer due to less accessibility toward with latest technologies available in urban areas, and thus AI driven tools can be encounter of this problem (Mangayarkarasi, Durairaj et al. 2025). The AI combining with IoT can enables the remote monitoring of health, bridging the rural areas from the healthcare gaps and use wearable sensor with early health care diagnostic technologies for isolated areas (Khan and Javaid 2025). Different machine learning models are now prepared for the reduction in hospitalization and improvement in early intervention for rural areas with health issues (Prasad 2025). The transformation of rural areas is possible through the use of AI techniques that results in AI guided treatment, detection of disease, AI enhanced diagnosis, treatment planning, prioritize critical care, and enabling of personal patient management (Das, Sanyal et al. 2023). AI tools can be revolutionizing in field of medicine and treatment zone due to global spreading technology network and easy availability to every part of globe (Mansoor, Ibrahim et al. 2025).

Challenges and Limitations

Although the AI generated tools and models are much helpful in case study of lung cancer, here are also some limitations in this aspect.

1) Annotation and Data Quality Issues

AI models can be misleading due to annotation error in the immune histochemistry of given data and leads to false results, especially in case of macrophages in NSCLC (Arbel, Ben-David et al.). The unreliable segmentation of lung nodules model generated due to smaller and limited annotation in dataset which is because, it leads to poor accuracy and consistency (Abdani, Ariffin et al. 2025). For the accurate training of AI tools to develop a better model, there will be stress challenging for the areas with invasion of tiny tumors (Kudo, Saito et al. 2025). The variability of observer for the tools training and validation can be affected due to difficulties in the annotation consensus of multi-radiologist (Li, Aruperes et al. 2024). CT imaging for the detection of lung cancer can be limited by the

blurred tumor margin, which is sign of low precision about annotation (Arunachalam, Geetha et al. 2024). Noisy images and low resolution can also effect the AI prediction in case of accuracy concern for lung cancer that shows the high need about high quality images (Sinha, Yadav et al. 2024). Negative impact observed on the early detection of lung cancer when the data records are biased or incomplete (Batra, Nathany et al. 2024). The imaging of lung cancer is directly linked with the data augmentation and preprocessing techniques for the AI tools guider dataset (Seitaj 2025). The false negatives and drifting of model happened due to synthetic dataset or poor quality augmentation (Ashofteh Barabadi, Zhu et al. 2025).

2) Explainability and Algorithm Transparency

Segmentation model of lung nodule for deep learning trade-offs the explainability concern to purpose visual explanation of clinical trust (Zafaranchi, Lizzi et al. 2024). Decision support of surgery about lung cancer having performance and clinical reliability with the bridge of gaps between AI tools and integration of explainable AI (Abbaker, Minervini et al. 2024). The verification of model reasoning about the risks and CT scans complex features in radiomics can be critical for explainable AI (Chetan and Gleeson 2021). Attention is needed about the combining of CNNs approaches by hybridization when the case is about early detection of lung cancer (Wedisinghe and Fernando 2024). The careful concerns are about the patient data privacy, when the visual interpretation of AI decision with the help of Hires-CAM is possible and the framework with explained federated learning is used (Md Siam, Hasan et al.). An assemble model is compulsory for the exact accuracy results about the detection of lung cancer that can improve clinician trust and transparency (Vanitha, Sree et al. 2024). For the improvement of model interpretation, the saliency maps are purposed and retinopathy is focused because this methodology is applied for lung cancer (Lim). Here is need of external auditing because the problems are faced during the use of AI for healthcare due to transparency issues (Zou, Natsiavas et al. 2024). Detection of lung cancer through AI generated models, the basic aim is to

balance performance and transparency optimization framework (Arunachalam, Geetha et al. 2024). The challenges that are faced during breast cancer detecting AI tools are directly applicable to lung cancer, which shows about the black-box-nature of the model and here is need in medical imaging explanation model for resolving it (Bachiri, Azibi et al.).

3) Regulatory Approvals

There is lack of interpretability demands, standardized validation and clinical efficiency evidence before the approval of model and need to focus upon AI models for diagnosis, prognosis and emphasizing of major hurdles in regularity for lung cancer (Hussain and Braxton 2024). For the screening of lung cancer, here is barrier in reproducibility, scalability and clinical trust with the Raman spectroscopy when linked with AI, as an emerging technology (A'dawiah, May Yap et al. 2025). The genomic data approval and safety proof is concern in case of ovarian cancer, but it also directly linked to lung cancer detecting AI tools for approval (Pedersen and Pedersen 2024). The use of ctDNA analysis and liquid biopsy is required for the validation of models in regularity concerns about AI driven tools for lung cancer detection (Ünal, Yazarkan et al. 2024). The lung cancer patient care with clinical compliance and validation through the help of scrutinized AI models uses landscape regularity cancer therapy (Wiktorowska-Owczarek, Iacono et al. 2025). Here is slow pace of approval emphasizing in the clash between the traditional regularity frameworks and AI driven tools of molecular profiling for lung cancer research (Carbone and Immunity 2024).

4) Ethical Concerns

Different issues are concerned like ethical risks which includes lack of informed consent, bias, missing of human oversight by over reliance on AI tools for the diagnosis of cancer (Frasier, Hash et al.). The ethical concerns can leads to the different challenges about the patient consent, security of data and accountability of model that can limits the AI diagnostic efficiency acceptance (Smith and Javaid 2025). For the diagnosis of cancer, different AI

model are ensuring about the transparency, avoidance of algorithms and fairness in the result of experiments while also consideration about the aspect of ethical issues (Idowu and William 2025). By focusing on informed patient autonomy and avoiding about the misuse of predictions generated by AI tools, can be helpful to overcome the ethical challenges (Hovornyan, Ilashchuk et al.). Before the implications of any newly launched AI tool for the cancer detection, there must be surety about the covering of ethical and privacy concern of the patient data history and profile records (Hinostroza Fuentes, Abdul Karim et al.).

5) Integration into Existing Hospital Systems

The installation of AI generated tools in hospitals is also a problem due to emphasizing interoperability, cloud system, clinician trust issue and cyber security concern in hospitals and clinics about these tools and models (Rehan 2024). The AI tools integrated with surgical planning, nodule detection and screening of cancer, which is disrupted by workflow issues and technical challenges for the adaptation in hospitals (Leivaditis, Maniatopoulos et al. 2025). For the successful integration of AI generated images to detect lung cancer, there will be standardized installation of technologies in the hospital are required (Bonmatí, Miguel et al. 2022). There is also risk of over reliance of hospitals on AI generated tools for lung cancer detection and heat-maps in routine workflows difficulties (Kotoulas, Spyrtos et al. 2025). The difficulty is also faced during the transfer of HER (Electronic Health Records) system data toward the AI modeling tools for continuing case study of individual facing cancer issues. Infrastructural barrier also faced in hospital workflows for NSCLC diagnosis with the help of AI integrated tools (El Sabrouy, ELOUADI et al. 2025).

Future Directions

In future, following different aspects of AI generated tools for lung cancer can be revolutionized.

1) Multimodal AI

Imaging through multimodal real time technique, the integration of breast and lung cancer data leads

to holistic patient management from single modality models (Mia and Studies 2024). For the enhancement of detection of lung cancer through the genomics, clinical and radiomics records, the combination can lead to developing multimodal for future outlook (Zeng, Wang et al. 2024). The personalized protocols for screening of lung cancer can be possible by combination of CT & MRI data records to develop new multimodal based tools (BR and Rengarajan 2024). The precision medicines knowledge and immunotherapy can be explored for future multimodal development to manage next generation lung cancer (Kedar, Bhattacharya et al. 2025). The principle of multimodal lung imaging is highly applicable for the early detection of any tumor or cancer (Wen, Chen et al. 2024).

2) Privacy Preserving and Federated Learning AI

Multi-party computational secure system techniques and federated learning can purpose a framework for privacy concerns of AI generated tools (Amin, Hasan et al. 2025). The secure and trustworthy detection of lung cancer can be made easier with the use of explainable AI, synthetic data generation and different multimodal with AI tools (Bhokare 2025). The more careful discussion concerned about the decision based model with the help of image technique to built techniques by considering privacy preservation for the detection of disease in case of methodologies adaptable for cancer dataset (Mridha and Dey 2024). For the explainable AI tools and privacy concerns, the federated AI models are discussed for case study of lung cancer (Aabaah and Appiah 2025). The precision about lung cancer detection and surgery cases is enhanced through federated learning and frameworks of ethical AI (Leivaditis, Maniatopoulos et al. 2025). With the help of CT images, the combination of federated learning and explainable HIRes-CAM maps for interpretation of lung cancer (Md Siam, Hasan et al.).

3) Mobile Health and Real-time Diagnostics

In future, the mobile AI techniques provide a platform to screening programs and prediction of occurrence chances of lung cancer through support system of wearable integrated diagnosis (Mia and

Studies 2024). The screening of lung cancer at national public healthcare level is performed with the help of mobile health platforms that are scalable (Mulshine, Avila et al. 2025). With the use of mobile devices, the remote assessment is obtained in lung cancer risk prediction on the radiomics tools that are mobile based (Martell, Linton-Reid et al. 2025). The conservational AI models are used for the detection of lung cancer through the real time patient interaction with AI assessment (Hasnain, Alotaibi et al.). The inter-operative diagnosis is enhanced through the workflows of real time AI diagnostic tools for the lung cancer and thoracic surgery (Leivaditis, Maniatopoulos et al. 2025). The identification of smaller lung cancer at early stages to evolve smart healthcare of patient is revolutionized through real-time clinical data and analyzing imaging (Muna, Amjad et al. 2025).

4) AI in Prognosis Prediction and Treatment Planning

The machine learning leads to improvement in the lung cancer prediction prognosis at early stages through use of imaging like CT and X-ray for AI models (SRIRAMKUMAR, SELVAKUMAR et al. 2025). With the help of earlier inventions, the timely prognosis prediction is provided, which aim is to reduce the mortality due to lung cancer (Mehrzadi, Maghanaki et al. 2025). The patient prognosis modeling and stratification for the lung cancer are obtained through AI driven bio-banks that are based on the molecular data and combined clinical data (Oskolas, Nogueira et al. 2025). AI tools can be used for the planning of personalized treatment through real time techniques by the integration of genomic data, pathology and imaging for lung cancer (Mia and Studies 2024). The inter-operative decision making is achieved through the real time optimizing plans for the lung cancer treatment through the AI tools and models (Leivaditis, Maniatopoulos et al. 2025). The monitoring models for the treatment of lung cancer and the planning of treatment strategies for the non-invasive tools in the future to shape out about the combination in modeling of PET radiomics and AI dataset (Zhang, Huang et al. 2024).

5) Personalized Medicine Applications

The combination of electronic health records, genomics and imaging technology can lead to evolve personalized diagnostic AI driven model (Mia and Studies 2024). The patient lung cancer specific data can be helpful for the post-operative care and personalized surgical planning through AI models generation (Leivaditis, Maniatopoulos et al. 2025). For the personalized decision about immunotherapy, liquid biopsy and AI integration can be useful tool in future (Lu, Liu et al. 2024). The targeted therapies for precision are operated through combination of AI modeling and genomic data (Chaudhari and Gudadhe 2025). Tailored blueprints for the treatment purpose are designed with the help of AI based radiomic dataset for lung cancer patients (Martell, Linton-Reid et al. 2025). New technologies and modeling ideas are concerned for the personal decision making and detection to treatment strategies for lung cancer (Kedar, Bhattacharya et al. 2025).

Conclusion

The emergence of Artificial Intelligence leads to the significant transformation in the field of lung cancer about the diagnosis, detection, prediction, treatment planning and prognosis. The exploration of AI tools in decision support system, imaging modalities, telemedicine and multi-domain model building leads to improvement in diagnostic strategies, early detection of cancer, increased in healthcare accessibility, personal treatment strategies and accuracy along with precision in working, with most concern for less accessible areas. Although of all above modern strategies and inventions, also some challenges seemed, like algorithm transparency, data quality concern, ethical aspects, regularity hurdles, privacy problem and clinical workflow integration limits the application of AI tools on peak potential. The innovative strategies are concerned by addressing about the barriers to adopt privacy preserving framework, real-time diagnosis, mobile health technologies, application of personalized medicine and multimodal AI tools for better approaches about AI application in cancer field. The advancement in research, ethical, collaborative and patient centralized approach though to be essential

in future for applied AI capabilities, which leads to care about lung cancer transformation and improvement in outcomes of patient throughout the world.

REFERENCES

- A'dawiah, R. t., et al. (2025). "Advancing clinical diagnostics: the potential of analytical Raman spectroscopy in oncology, dermatology, and diabetes." 1-56.
- Aabaah, I. and B. Appiah (2025). "Federated Learning for Lung Cancer Detection: Comparative Analysis and Visual Interpretability."
- Abbaker, N., et al. (2024). "The future of artificial intelligence in thoracic surgery for non-small cell lung cancer treatment a narrative review." 14: 1347464.
- Abbas, S., et al. (2024). "Emerging research trends in artificial intelligence for cancer diagnostic systems: A comprehensive review."
- Abdani, S. R., et al. (2025). "3D-based Convolutional Neural Networks for Medical Image Segmentation: A Review." 16(5): 255-271.
- Abdulqader, A. F., et al. (2025). "Multi-objective deep learning for lung cancer detection in CT images: enhancements in tumor classification, localization, and diagnostic efficiency." 16(1): 529.
- Alabi, M. (2025). "AI for Real-Time Decision Support in Emergency Radiology."
- Amin, A., et al. (2025). "AI-Driven Secure Data Sharing: A Trustworthy and Privacy-Preserving Approach."
- Amin, R., et al. (2021). "Healthcare techniques through deep learning: issues, challenges and opportunities." 9: 98523-98541.
- Anggo, S., et al. (2025). "Telemedicine in the Digital Era: Changing the Face of Health Services with Virtual Technology." 3(1): 30-41.
- Arbel, E., et al. Evaluation of Virtual Stain Multiplexed CD68 for Macrophage Detection in NSCLC PD-L1 Slides. Medical Imaging with Deep Learning.

- Arunachalam, P., et al. (2024). A Feline-Inspired Optimizer Enhanced through Self-Improvement, Coupled with Machine Learning, for the Identification of Lung Cancer in CT Scans. 2024 Second International Conference on Advances in Information Technology (ICAIT), IEEE.
- Ashofteh Barabadi, M., et al. (2025). "Targeted generative data augmentation for automatic metastases detection from free-text radiology reports." 8: 1513674.
- Bachiri, I., et al. "AI Explainability in Medical Imaging: A Case Study on Breast Cancer Detection."
- Batra, U., et al. (2024). "AI-based pipeline for early screening of lung cancer: integrating radiology, clinical, and genomics data." 24.
- Bhokare, M. U. M. J. V.-A. I. M. P.-R. E.-J.-I.-. (2025). "A Survey on Early Lung Cancer Detection using a Deep Learning Algorithm." 10(si4).
- Bonmati, L. M., et al. (2022). "CHAIMELEON project: creation of a Pan-European repository of health imaging data for the development of AI-powered cancer management tools." 12: 742701.
- BR, S. R. R. and A. J. C. M.-N. Rengarajan (2024). "A Comprehensive Review Of Deep Learning Techniques For Lung Cancer Detection And Classification." 6(2): 4031-4042.
- Burzik, A., et al. (2022). "The future of lung cancer screening: current challenges and research priorities." 637-645.
- Carbone, A. J. C. P. and Immunity (2024). "Current Progress in Cancer Pathobiology Research and Management." 1-1.
- Chapla, D., et al. (2024). "An artificial intelligence (AI)-integrated approach to enhance early detection and personalized treatment strategies in lung cancer among smokers: a literature review." 16(8).
- Chassagnon, G., et al. (2020). "Artificial intelligence applications for thoracic imaging." 123: 108774.
- Chaudhari, P. D. and A. Gudadhe (2025). Advanced Lung Cancer Diagnosis and Treatment with Artificial Intelligence: Applications, Methods, and Future Directions. 2025 International Conference on Electronics and Renewable Systems (ICEARS), IEEE.
- Chetan, M. R. and F. V. J. E. r. Gleeson (2021). "Radiomics in predicting treatment response in non-small-cell lung cancer: current status, challenges and future perspectives." 31: 1049-1058.
- Darvish, M., et al. (2024). "AI-enabled lung cancer prognosis."
- Das, S., et al. (2023). Artificial intelligence for rural healthcare management: prognosis, diagnosis, and treatment. AI to Improve e-Governance and Eminence of Life: Kalyanathon 2020, Springer: 1-23.
- Dlamini, Z., et al. (2020). "Artificial intelligence (AI) and big data in cancer and precision oncology." 18: 2300-2311.
- El Sabrouty, R., et al. (2025). "Harnessing AI for Precision Oncology: Transformative Advances in Non-Small Cell Lung Cancer Treatment." 13(1): 347-367.
- Emma, O. (2025). "AI in Radiology: Revolutionizing Imaging for Cancer Recurrence Detection."
- Field, J. K., et al. (2021). "Lung cancer mortality reduction by LDCT screening: UKLS randomised trial results and international meta-analysis." 10.
- Frasier, K., et al. "The Blind Spots of Artificial Intelligence in Skin Cancer Diagnosis."
- Fujita, H. J. R. p. and technology (2020). "AI-based computer-aided diagnosis (AI-CAD): the latest review to read first." 13(1): 6-19.
- Giansanti, D. (2025). The Future of Healthcare Is Digital: Unlocking the Potential of Mobile Health and E-Health Solutions. Healthcare, MDPI.
- Gong, K., et al. (2021). "Tumor necrosis factor in lung cancer: Complex roles in biology and resistance to treatment." 23(2): 189-196.

- HaghighiKian, S. M., et al. (2024). "A holistic approach to implementing artificial intelligence in lung cancer." 1-22.
- Hasnain, M., et al. "ChatGPT as a Bridge between Cancer Patients and AI-based Diagnostic Tools."
- Hinostroza Fuentes, V. G., et al. "AI with Agency: A Vision for Adaptive, Efficient, and Ethical Healthcare." 7: 1600216.
- Homayounieh, F., et al. (2021). "An artificial intelligence-based chest X-ray model on human nodule detection accuracy from a multicenter study." 4(12): e2141096-e2141096.
- Hovornyan, A., et al. "Bridging The Gap: Integrating Artificial Intelligence Into Predictive Medicine For Cancer And Cardiovascular Diseases." 26.
- Huang, S., et al. (2023). Artificial intelligence in lung cancer diagnosis and prognosis: Current application and future perspective. Seminars in cancer biology, Elsevier.
- Hussain, K. and P. Braxton (2024). "Revolutionizing Lung Cancer Care: Artificial Intelligence in Prognosis and Therapeutic Strategies."
- Idowu, M. and B. William (2025). "AI-Powered Diagnostics: Enhancing Accuracy in Healthcare through Machine Learning Models."
- James, O. O., et al. (2025). "Innovations In Chronic Disease Management Using Digital Health Technologies." 2(2): 220-243.
- Jin, D., et al. (2022). "Independent assessment of a deep learning system for lymph node metastasis detection on the Augmented Reality Microscope." 13: 100142.
- Jordan, N. (2025). "Harnessing AI for Early Detection of Cancer Recurrence through Wearable Technology."
- Kedar, P., et al. (2025). "Novel Strategies for the Treatment of Lung Cancer: An In-depth Analysis of the Use of Immunotherapy, Precision Medicine, and Artificial Intelligence to Improve Prognoses."
- Keerthi, P. and S. Iniyan (2025). Lung Cancer Classification Using Deep Neural Networks. 2025 AI-Driven Smart Healthcare for Society 5.0, IEEE.
- Khader, F., et al. (2023). "Medical transformer for multimodal survival prediction in intensive care: integration of imaging and non-imaging data." 13(1): 10666.
- Khalifa, M., et al. (2024). "AI in diagnostic imaging: Revolutionising accuracy and efficiency." 100146.
- Khan, A. and T. Javaid (2025). "AI and IoT-Based Remote Health Monitoring: A Framework for Smart Hospitals and Telemedicine."
- Kotoulas, S.-C., et al. (2025). "A thorough review of the clinical applications of artificial intelligence in lung cancer." 17(5): 882.
- Kudo, Y., et al. (2025). "Preoperative evaluation of visceral pleural invasion in peripheral lung cancer utilizing deep learning technology." 55(1): 18-28.
- Leivaditis, V., et al. (2025). "Artificial Intelligence in Thoracic Surgery: A Review Bridging Innovation and Clinical Practice for the Next Generation of Surgical Care." 14(8): 2729.
- Lewandowski, N., et al. (2023). Transforming medical sciences with high-performance computing, high-performance data analytics and AI, SAGE Publications Sage UK: London, England. 31: 1505-1507.
- Li, A.-H. A., et al. (2024). Lung Nodule Analysis in CT Images: Deep Learning for Segmentation and Measurement. Proceedings of the 2024 8th International Conference on Medical and Health Informatics.
- Lim, W. X. Diabetic retinopathy image classification with quantitative saliency-oriented visual explanation and SLIC-G image preprocessing methods, University of Nottingham Malaysia.
- Lu, Y., et al. (2024). "Ultrasensitive Detection of Biomarkers for Guiding Immunotherapy in Lung Cancer: A Liquid Biopsy Approach." 2(4): 184-194.

- Mangayarkarasi, V., et al. (2025). "Enhancing Cancer Screening and Early Diagnosis in India: Overcoming Challenges and Leveraging Emerging Technologies." 17(2).
- Mansoor, M., et al. (2025). "Large language models for pediatric differential diagnoses in rural health care: multicenter retrospective cohort study comparing GPT-3 with pediatrician performance." 6(1): e65263.
- Martell, M. B., et al. (2025). "Radiomics for Lung Cancer Diagnosis, Management, and Future Prospects." 106926.
- Md Siam, A. S., et al. "Fvcm-Net: Interpretable Privacy-Preserved Attention Driven Lung Cancer Detection from Ct Scan Images with Explainable Hires-Cam Attribution Map and Ensemble Learning."
- Medicine, N. L. S. T. R. T. J. N. E. J. o. (2011). "Reduced lung-cancer mortality with low-dose computed tomographic screening." 365(5): 395-409.
- Mehrzadi, H., et al. (2025). Enhanced Lung Cancer Detection in CT Scans Using Deep Learning Architectures. International Conference on Advances in Computing Research, Springer.
- Men, L., et al. (2021). "Multi-disease prediction using LSTM recurrent neural networks." 177: 114905.
- Mia, M. T. J. J. o. M. and H. Studies (2024). "Enhancing Lung and Breast Cancer Screening with Advanced AI and Image Processing Techniques." 4(5): 81-96.
- Mostafa, F. A., et al. (2022). "A survey on AI techniques for thoracic diseases diagnosis using medical images." 12(12): 3034.
- Mridha, M. and N. Dey (2024). Data-Driven Clinical Decision-Making Using Deep Learning in Imaging, Springer.
- Mulshine, J. L., et al. (2025). "AI integrations with lung cancer screening: Considerations in developing AI in a public health setting." 115345.
- Muna, A., et al. (2025). AI-Powered Cancer Analysis: A Secure and Innovative Approach to Early Diagnosis and Prognosis. 2025 2nd International Conference on Advanced Innovations in Smart Cities (ICAISC), IEEE.
- Nafisah, S. I., et al. (2024). "Tuberculosis detection in chest radiograph using convolutional neural network architecture and explainable artificial intelligence." 36(1): 111-131.
- Oskolas, H., et al. (2025). "Comprehensive biobanking strategy with clinical impact at the European Cancer Moonshot Lund Center." 105442.
- Pan, X., et al. (2025). "TMEseg: Connecting histopathology with spatial transcriptomics through tumor microenvironment segmentation for lung cancer." 85(8_Supplement_1): 2426-2426.
- Park, J., et al. (2025). "AI-based EGFR-mutation prediction from haematoxylin and eosin (H&E) images in non-small cell lung cancer (NSCLC): A global multi-cohort validation study." 85(8_Supplement_1): 2463-2463.
- Pass, H. I., et al. (2025). "The development of a tissue-agnostic genome-wide methylome enrichment assay for lung cancer." 85(8_Supplement_1): 3249-3249.
- Patz Jr, E. F., et al. (2001). "CT screening for lung cancer: not ready for routine practice." 221(3): 587-591.
- Pedersen, M. and G. Pedersen (2024). 177 Clinical validation of RNA-seq treatment navigation platform in ovarian cancer, BMJ Specialist Journals.
- Pehrson, L. M., et al. (2019). "Automatic pulmonary nodule detection applying deep learning or machine learning algorithms to the LIDC-IDRI database: a systematic review." 9(1): 29.
- Peng, M., et al. (2025). "Prediction of PD-L1 Expression in NSCLC patients Using PET/CT Radiomics and Prognostic Modeling for Immunotherapy in PD-L1-Positive NSCLC Patients." 106915.

- Prasad, P. J. I. (2025). "Integration of Predictive Modeling system for Rural Health Outcomes." **21**(4): 93-101.
- Rabbani, M., et al. (2018). "Role of artificial intelligence in the care of patients with nonsmall cell lung cancer." **48**(4): e12901.
- Radiology, N. L. S. T. R. T. J. (2011). "The national lung screening trial: overview and study design." **258**(1): 243-253.
- Rehan, H. J. J. o. M. L. i. P. R. (2024). "Advancing Cancer Treatment with AI-Driven Personalized Medicine and Cloud-Based Data Integration." **4**(2): 1-40.
- Seitaj, O. (2025). Processing and Classification Algorithms of Medical Images. 2025 IEEE 6th International Conference on Image Processing, Applications and Systems (IPAS), IEEE.
- Şeker, D., et al. "A Deep-XAI Method for Histopathological Image Classification: Utilizing Transformer based FNet Architecture and LIME Method." **31**(6): 0-0.
- Series, T. L. H. S., et al. (2023). "Artificial intelligence in health care: The hope, the hype, the promise, the peril."
- Shaikh, F. and D. J. M. T. P. Rao (2022). "Prediction of cancer disease using machine learning approach." **50**: 40-47.
- Shubin, A., et al. (2024). 46 Comprehensive machine learning-driven platform infers key tumor characteristics from blood-derived cfRNA, *BMJ Specialist Journals*.
- Siegel, R., et al. (2023). "CA Cancer J Clin; 2023."
- Sinha, A., et al. (2025). "Massive scale phenotypic screening using generative chemogenomics repurposes safe drugs and discovers new drugs for intercepting early-stage lung adenocarcinoma progression." **85**(8_Supplement_1): 1139-1139.
- Sinha, V., et al. (2024). High Resolution Image Upsampler for Lung Adenocarcinoma diagnosis. 2024 International Conference on Communication, Control, and Intelligent Systems (CCIS), IEEE.
- Smith, J. and T. Javaid (2025). "Deep Learning for Medical Imaging: Enhancing Disease Diagnosis Through AI-Powered Radiology."
- SRIRAMKUMAR, R., et al. (2025). "Advances In Ai For Pulmonary Disease Diagnosis Using Lung X-Ray Scan And Chest Multi-Slice Ct Scan." **103**(7).
- Sufyan, M., et al. (2023). "Artificial intelligence in cancer diagnosis and therapy: Current status and future perspective." **165**: 107356.
- Suganyadevi, S., et al. (2022). "A review on deep learning in medical image analysis." **11**(1): 19-38.
- Sung, H., et al. (2021). "Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries." **71**(3): 209-249.
- Tan, X., et al. (2022). "Predicting EGFR mutation, ALK rearrangement, and uncommon EGFR mutation in NSCLC patients by driverless artificial intelligence: a cohort study." **23**(1): 132.
- Thunnissen, F. J. J. o. c. p. (2003). "Sputum examination for early detection of lung cancer." **56**(11): 805-810.
- Ünal, A. A., et al. (2024). "Revolutionizing Lung Cancer Care: The Multifaceted Approach Of Artificial Intelligence, Liquid Biopsies, And Circulating Tumor Dna In Screening, Diagnosis, And Prognosis." **11**(2).
- Vanitha, K., et al. (2024). "Deep learning ensemble approach with explainable AI for lung and colon cancer classification using advanced hyperparameter tuning." **24**(1): 222.
- Wang, H. J., et al. (2025). "Enhanced dose prediction for head and neck cancer artificial intelligence-driven radiotherapy based on transfer learning with limited training data." e70012.
- Wang, L. J. C. (2022). "Deep learning techniques to diagnose lung cancer." **14**(22): 5569.
- Wang, M., et al. (2021). Medication recommendation based on a knowledge-enhanced pre-training model. IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology.
- Wang, Y., et al. (2024). Introduction of artificial intelligence. Intelligent building fire safety and smart firefighting, Springer: 65-97.

- Wedisinghe, H. and T. Fernando (2024). Explainable AI for Early Lung Cancer Detection: A Path to Confidence. 2024 4th International Conference on Advanced Research in Computing (ICARC), IEEE.
- Welch, H. G. and W. C. J. J. o. t. N. C. I. Black (2010). "Overdiagnosis in cancer." 102(9): 605-613.
- Wen, X.-L., et al. (2024). "Multimodal probes for the detection of bone cancer-related disease in biological systems: Recent advances and future prospects." 118030.
- White, M., et al. (2024). "The model openness framework: Promoting completeness and openness for reproducibility, transparency, and usability in artificial intelligence."
- Wiktorowska-Owczarek, A., et al. (2025). "Old drugs: confronting recent advancements and challenges." 16: 1565890.
- Xie, F., et al. (2022). "Deep learning for temporal data representation in electronic health records: A systematic review of challenges and methodologies." 126: 103980.
- Yoo, H., et al. (2021). "AI-based improvement in lung cancer detection on chest radiographs: results of a multi-reader study in NLST dataset." 31(12): 9664-9674.
- Yu, K.-H., et al. (2020). "Reproducible machine learning methods for lung cancer detection using computed tomography images: Algorithm development and validation." 22(8): e16709.
- Yu, P., et al. (2024). "Spatial resolution enhancement using deep learning improves chest disease diagnosis based on thick slice CT." 7(1): 335.
- Yuan, Q., et al. (2021). "Performance of a machine learning algorithm using electronic health record data to identify and estimate survival in a longitudinal cohort of patients with lung cancer." 4(7): e2114723-e2114723.
- Yun, H., et al. (2025). "Repurposing of pralatrexate in gastric cancer: Inducing cell death via SMO inhibition and GLI1 suppression." 85(8_Supplement_1): 518-518.
- Zafaranchi, A., et al. (2024). Explainability Applied to a Deep-Learning Based Algorithm for Lung Nodule Segmentation. Proceedings of the 1st International Conference on Explainable AI for Neural and Symbolic Methods-EXPLAINS, Scitepress.
- Zeng, M., et al. (2024). "Worldwide research landscape of artificial intelligence in lung disease: A scientometric study." 10(10).
- Zhang, P., et al. (2024). "Generative ai in medicine and healthcare: Moving beyond the 'peak of inflated expectations'." 16(12): 462.
- Zhang, Y., et al. (2024). "PET radiomics in lung cancer: advances and translational challenges." 11(1): 81.
- Zou, W., et al. (2024). AI/ML in pharmacovigilance and pharmacoepidemiology, Frontiers Media SA. 4: 1517365