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The Application of Artificial Intelligence in Lung Cancer Research

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Abstract

The advent of artificial intelligence in healthcare is transforming medical research and clinical practice, with significant advancements in the areas of oncology. This commentary explores the pivotal role artificial intelligence plays in lung cancer research, offering insights into its current applications and future potential.

Plain Language Summary

Artificial intelligence is changing the medical research and clinical practice, with significant advancements in the areas of cancer. This commentary explores the important role artificial intelligence plays in lung cancer research, offering insights into its current applications and future potential.

Keywords

artificial intelligence, diagnosis, education, lung cancer, medical, research, treatment

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In recent years, artificial intelligence (AI) has emerged as a transformative force across various sectors, and the field of healthcare is no exception. The advent of AI in healthcare is transforming medical research and clinical practice, with significant advancements in the areas of oncology. Lung cancer, one of the most prevalent and lethal cancers worldwide, is benefiting from AI-driven innovations that enhance early detection, personalize treatment, and improve patient outcomes. During the past 20 years, lung cancer research utilizing AI has been growing significantly, with 2931 research studies published and 15,848 authors from 92 countries/regions involved.[1] This commentary explores the pivotal role AI plays in lung cancer research, offering insights into its current applications and future potential.

Early Detection and Diagnosis of Lung Cancer

Early detection is crucial in improving survival rates for patients with lung cancer. Traditional diagnostic methods, including imaging and biopsies, are often time-consuming and dependent on the expertise of radiologists. AI technologies, particularly *machine learning algorithms*, are enhancing the accuracy and efficiency of lung cancer detection.[2] AI systems can analyze medical images, such as CT scans and chest X-rays, with remarkable precision.

The role of AI in enhancing diagnostic accuracy of lung cancer cannot be overlooked. Diagnostic errors can have serious consequences, leading to incorrect treatments or delayed interventions. AI technologies, particularly those leveraging *deep learning*, have shown impressive capabilities in analyzing medical images. Depending on the purpose of

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processing images (detection, classification, prediction, and prognosis) of lung cancer, *convolutional neural networks (CNN), generative adversarial network (GAN), K-nearest neighbor (KNN), deep neural network (DNN), support vector machine (SVM), and random forest (RF)* could be used.[3] One common application is the use of CNN to detect anomalies in imaging data.[4] These networks can be trained to identify subtle patterns and nodules indicative of lung cancer, even in early stages when tumors are small and difficult to detect. Studies have shown that AI models can match or even exceed the performance of experienced radiologists, leading to earlier diagnosis and better prognosis.[4]

Utilizing AI in lung cancer screening programs can benefit populations at high risk of lung cancer. AI algorithms can integrate data from CT imaging studies to identify lung cancer even before symptoms appear. This integration not only enhances diagnostic accuracy but also supports the development of personalized treatment plans tailored to individual patients' unique cases. In addition, using *AI diagnosis system* can decrease burden for radiologists and supplement the scarcity of radiologists in rural areas.[5] By having comparable accuracy to that of experienced radiologists, AI can be used as a primary or secondary reader to lessen the work required of radiologists.[5]

Currently, we are conducting some research projects related to AI and lung cancer screening in the U.S. The research project is based on our previous experience in a similar study in Hong Kong.[6] We planned to use AI diagnosis system in the mobile van which is equipped with the CT device. We charted a geographic map created by AI which showed areas having low screening rate of lung cancer in Minnesota. We planned to send the equipped mobile van to those areas to help the underserved high-risk population get screened for lung cancer.

Personalized Treatment Plans for Lung Cancer

Personalizing treatment or precision medicine is a cornerstone of modern oncology, and AI is playing a crucial role in this process. By analyzing vast amounts of data from patient records, genetic information, and clinical studies, AI can uncover patterns and correlations that might be missed by traditional methods. These insights enable researchers to understand the genetic basis of lung cancer and to develop targeted therapies that are more effective and have fewer side effects. With the combination of radiology, pathology, genomics, and proteomics data, AI can be used as a digital biopsy method to assist with clinical decision making, showing great potential in the predictive application of cancer treatment.[7]

In addition, based on individual's unique characteristics, such as individual genetic, environmental, and lifestyle factors, AI can help develop tailored treatment plans. For lung cancer, *AI algorithms* can integrate data from genomic sequencing to identify specific mutations which drive the cancer's growth. This enables the identification of targeted therapies that are more likely to be effective for a particular patient. *AI-driven tools* also help in predicting how patients will respond to various treatments, allowing for more precise and individualized therapeutic strategies. For example, *AI-driven computational pathology* can help to overcome the limitation of human bias in PD-L1 (programmed death ligand 1) TPS (tumor proportion score) IHC testing (a test measures the percentage of cells in a tumor that express PD-L1). Instead of subjective classification performed by humans, AI can quantify tumor-infiltrating lymphocytes and other biomarkers accurately, resulting in a more precise evaluation of patients' responses to immunotherapy.[8]

The Watson for Oncology (WFO) is one example clinical decision support system which has been applied in the treatment of lung cancer.[9] WFO learns from stored literature, protocols, and patient charts using *computational reasoning approaches*. Its data are updated to the latest every one to two months. By inputting a patient's case, WFO will automatically generate a treatment plan for the patient.[9] With the help of AI, precision medicine is moving closer to the goal of providing personalized care that improves outcomes and enhances patient experiences.

Drug Discovery and Development for Lung Cancer

One of the most significant contributions of AI to medical research is its role in accelerating drug discovery and development. Traditional methods of drug discovery are time-consuming and costly, often taking over a decade and billions of dollars to bring a new drug to market. AI has the potential to drastically reduce these timelines. Through machine learning algorithms, AI can help to identify drug target interactions and hits, recognize drug reactions, design innovative drugs, and repurpose drug usage.[10] *AI-powered simulations* can simulate how drugs will affect cancerous cells at a molecular level, significantly speeding up the identification of promising candidates.[11] These algorithms can also predict how different compounds will interact with biological targets, thus streamlining the initial stages of drug development.[11]

In lung cancer research, AI is being used to discover novel drug targets and repurpose existing medications. This approach helps to reduce costs, making new treatments more accessible to patients. For example, *AI-driven platforms* like DeepMind's AlphaFold (https://alphafold.ebi.ac.uk/) have demonstrated remarkable success in predicting protein structures with unprecedented accuracy. Understanding protein folding is crucial for drug design of lung cancer, as it directly influences how drugs interact with their targets.[12] By providing clearer insights into protein structures, AI is paving the way for the development of more effective and personalized drug therapies of lung cancer.

Lung Cancer Prediction Models

Accurate prediction of lung cancer risk is essential for effective treatment planning and patient management. AI enhances prediction models by analyzing diverse data sources, including imaging, clinical history, and genetic profiles. These models can predict lung cancer progression and patient survival rates with high accuracy. For example, *AI algorithms* can evaluate patterns in longitudinal imaging studies to forecast tumor growth and response to treatment. By combining these predictions with clinical data, healthcare providers can make more informed decisions about treatment adjustments and patient care.

With the help of AI, researchers have developed several prediction models which can provide more precise and efficient analysis, reduce false positives and false negatives, and offer an accurate result to evaluate the risk and prognosis of lung cancer. As of October 2023, 39 prediction models have been developed for lung cancer detection, showing the rapid application of AI on lung cancer and the potential of AI in lung cancer prediction research.[13]

Currently, we are planning to implement a research project focusing on building a robust prediction model to qualify lung cancer risk in Asian Americans, combining various environmental, biological, behavioral, and socio-economic factors. Data from the 2024 National Health Interview Survey will be analyzed, and relevant prediction model validation will be conducted. Using a prediction model specific to the target Asian American population can ensure the precision and accuracy of the prediction.

Lung Cancer Education

AI makes lung cancer education more accessible, personalized, and impactful for healthcare providers, patients and public. AI revolutionizes lung cancer education by enhancing learning platforms, supporting medical training, and facilitating continuing education. *AI-powered tools* create personalized, interactive educational experiences through virtual simulations, real-time feedback, and immersive technologies like *virtual reality* and *augmented reality.* For medical professionals, AI aids in training with diagnostic simulators, up-to-date resources, tailored content, and tracking progress, ensuring effective skill development and knowledge acquisition. AI also improves patient education by providing customized, easy-to-understand information and interactive support tools. Furthermore, AI contributes to public awareness campaigns by analyzing data to promote lung cancer prevention and early detection.

Recent research on the quality of medical information generated by AI showed that AI chatbots (ChatGPT, Perplexity, Chatsonic, and Bing AI) can generate high-quality responses to cancer information inquires and have a low possibility of spreading misinformation.[14] The average DISCERN score of the AI generated information was rated at 5 out of 5, and the PEMAT understandability score was rated at 66.7% out of 100%, showing a good quality and no misinformation with moderate understandability.[14]

Currently, we are conducting an online education research program focusing on enhancing lung cancer screening knowledge and increasing uptake of lung cancer screening among high-risk long-term smokers. We used *natural language processing tool* and *AI video generating tool* to develop the education modules. The education modules include five sessions, titled lung cancer epidemiology, etiology, signs, and symptoms; lung cancer treatment and care; lung cancer prevention methods; lung cancer screening guidelines, benefits, and risks; and lung cancer screening procedures and results interpretation. We are testing the feasibility and effectiveness of the online education intervention using the quasi-experimental pre and posttest design with assessment questionnaires.

Challenges and Future Directions

Despite its transformative potential, the application of AI in lung cancer research faces several challenges. *Data quality and interoperability* remain significant issues, as AI systems require large, high-quality datasets to function effectively.[15] Ensuring that AI models are validated and generalizable across diverse populations and clinical settings is also critical to avoid perpetuating existing health disparities. Furthermore, integrating AI into clinical workflows requires *collaboration* between data scientists, clinicians, and regulatory governances. Ethical considerations, such as *data privacy and security, and algorithmic bias*, must be addressed to ensure that AI technologies are used responsibly and equitably.[15]

Patients also expressed some concerns for incorporating AI to cancer research and care. General concerns such as *data privacy, ethical issues, and the reliability of AI system* were prevalent.[16] With necessary actions taken, such as active efforts to *collect representative datasets, using advanced encryption technologies, conducting external validations*, etc., we can overcome some of the challenges and use AI properly.[17] When using the AI in lung cancer medical fields, the four core principles of medical ethics should always be aligned: autonomy, informed consent, data protection, and empathy.[16] Placing ethics and human rights at the center of the AI design and use is important.[17]

Looking forward, the future of AI in lung cancer research holds great promise. Continued advancements in AI technology and its integration with other innovations, such as precision medicine and genomics, are expected to further enhance the capabilities of lung cancer diagnosis, treatment, and management. Future directions such as integrating multi-omics data to produce AI-based models to treat lung cancer and predict lung cancer prognosis, collaborating with interdisciplinary teams to optimize AI utilization, and translating laboratory research study to clinical application, should be explored.[18] With the help of AI, the diagnostic accuracy of

lung cancer could be further improved, and health care providers' workload can be reduced. This will advance the current medical model and promote the balanced development of medical resources.

Conclusions

AI is undeniably revolutionizing lung cancer research by improving early detection, personalizing treatment, accelerating drug discovery, enhancing prediction models and lung cancer education. While challenges remain, the continued development and application of AI hold the promise of transforming healthcare into a more efficient, effective, and personalized system. As AI technology continues to evolve, its applications in oncology are likely to expand, offering new hope for lung cancer patients and contributing to the overall advancement of medical research. By addressing existing challenges and fostering collaboration, the potential for AI to transform lung cancer care and outcomes is immense, heralding a new era in cancer research and treatment. As we navigate this new era of medical research, embracing the potential of AI while addressing its ethical implications will be key to unlocking its full benefits for patients and society at large.

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Ethical statement

Ethical approval

This work is a commentary. The Author has read and follow the ethical requirements for publication in Cancer Control and confirm that the current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

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Data Availability Statement

All the mentioned research reports are available online.

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