Combining Machine Learning and Nanobiosensors for Improving Lung Cancer Detection

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Abstract- Lung cancer is one of the most prevalent types of cancer in the world, and its clinical prognosis and early detection are of great importance. With recent advances in artificial intelligence and nanotechnology, combining machine learning (ML) and nanobiosensors has been considered a novel approach for diagnosing and monitoring lung cancer. Hence, the current review aims to examine the combination of these two technologies for lung cancer diagnosis and explores its potential and challenges. ML can identify patterns associated with lung cancer with its capabilities in processing complex data and simulating predictive models. Nanobiosensors, on the other hand, can detect biological changes at the molecular and cellular levels with high sensitivity. These two technologies allow for more accurate, faster, and non-invasive lung cancer diagnosis. In addition, using these two technologies simultaneously could help identify more advanced changes in the disease, even before clinical symptoms become apparent. In conclusion, combining machine learning and nanobiosensors offers a novel and efficient approach to lung cancer diagnosis that can significantly increase the accuracy of diagnosis and prognosis.

Keywords: Lung cancer, Nanotechnology, Nanobiosensors, Artificial intelligence

INTRODUCTION

The early detection of lung cancer is vital to ensuring effective treatment for this disease, as it is one of the leading causes of cancer deaths worldwide. Data science and artificial intelligence are two rapidly growing areas in the fields of data science and nanotechnology. In particular, the combination of machine learning (ML) and nanobiosensors has created new possibilities for rapid and more accurate diagnosis of lung cancer [1]. It has been shown that machine learning can help identify hidden patterns in biological and medical data, thus providing a more accurate prediction of lung cancer through the study of complex data [2]. Furthermore, nanobiosensors are highly sensitive biological tools that can be used to detect molecular and biochemical changes within the human body, which may serve as a sign of cancer [3, 4]. It is believed that combining these two technologies will result in a substantial improvement in the diagnosis of lung cancer and other chronic diseases soon. Accordingly, this review examines how these two technologies can detect lung cancer.

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI), ML, is progressively used to diagnose many types of cancers, especially lung cancer [5]. ML algorithms can use complex medical data such as medical images (computed tomography scans, magnetic resonance imaging, and radiographs) to identify early signs of cancer. AI is capable of processing and analyzing huge amounts of data in a very short time and can predict treatment outcomes and identify risk patterns [6]. In addition, using deep learning techniques such as neural networks can significantly increase the accuracy of diagnosis.

NANOBIOSENSORS

There is growing evidence that nanobiosensors are effective tools for diagnosing a variety of cancers, including lung cancer [7]. Gold, silver, or metal oxide nanoparticles are useful nanomaterials for nanobiosensors that accurately detect molecular and cellular biological changes [8, 9]. Nanobiosensors in blood and lung secretions can detect lung cancer biomarkers to diagnose early signs of the disease [10]. Moreover, nanobiosensors can monitor the patient's condition and assess their response to treatment continuously in addition to rapid detection. Patients with lung cancer can benefit from non-invasive, more accurate diagnoses through nanobiosensors [11].

COMBINING ARTIFICIAL INTELLIGENCE AND NANOBIOSENSORS

Combining machine learning and nanobiosensors could provide an innovative and comprehensive approach to lung cancer diagnosis [12]. Nanobiosensors collect biological information from patients, and machine learning analyzes this information to detect cancer patterns [13]. For instance, nanobiosensors detect specific molecules altered in cancerous tissues, which can be used to infer the cancer stage from this information and categorize lung cancer patients according to these indicators [14]. Furthermore, it could also be possible to use these two technologies concurrently to detect more advanced changes in a disease, even before clinical symptoms are evident, thereby reducing the risk of fatal disease [15].

CONCLUSION

In the future, it is anticipated that machine learning combined with nanobiosensors will offer a novel and efficient approach to the diagnosis of lung cancer that will contribute greatly to enhancing the accuracy of diagnosis as well as prognosis. The combination of these two technologies can be vital in achieving advanced precision medicine for lung cancer.

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REFERENCES

1. Wang S, Yang DM, Rong R, Zhan X, Fujimoto J, Liu H, et al. Artificial intelligence in lung cancer pathology image analysis. Cancers. 2019;11(11):1673.
2. Chassagnon G, De Margerie-Mellon C, Vakalopoulou M, Marini R, Hoang-Thi T-N, Revel M-P, et al. Artificial intelligence in lung cancer: current applications and perspectives. Japanese journal of radiology. 2023;41(3):235-44.
3. Hajjafari A, Sadr S, Rahdar A, Bayat M, Lotfalizadeh N, Dianaty S, et al. Exploring the integration of nanotechnology in the development and application of biosensors for enhanced detection and monitoring of colorectal cancer. Inorganic Chemistry Communications. 2024:112409.
4. Sadr S, Hajjafari A, Rahdar A, Pandey S, Jafroodi PP, Lotfalizadeh N, et al. Gold Nanobiosensors: Pioneering Breakthroughs in Precision Breast Cancer Detection. European Journal of Medicinal Chemistry Reports. 2024:100238.
5. Chiu H-Y, Chao H-S, Chen Y-M. Application of artificial intelligence in lung cancer. Cancers. 2022;14(6):1370.
6. Svoboda E. Artificial intelligence is improving the detection of lung cancer. Nature. 2020;587(7834):S20-S.

7. Sheervalilou R, Shahraki O, Hasanifard L, Shirvaliloo M, Mehranfar S, Lotfi H, et al. Electrochemical nano-biosensors as novel approach for the detection of lung cancer-related MicroRNAs. Current molecular medicine. 2020;20(1):13-35.
8. Hao Z, Pan Y, Huang C, Wang Z, Zhao X. Sensitive detection of lung cancer biomarkers using an aptameric graphene-based nanosensor with enhanced stability. Biomedical Microdevices. 2019;21:1-9.
9. Chen S, Li M, Weng T, Wang D, Geng J. Recent progress of biosensors for the detection of lung cancer markers. Journal of Materials Chemistry B. 2023;11(25):5715-47.
10. Preetam S, Dash L, Sarangi SS, Sahoo MM, Pradhan AK. Application of nanobiosensor in health care sector. Bio-Nano Interface: Applications in Food, Healthcare and Sustainability. 2022:251-70.
11. Eftekhari-Sis B, Aliabad MA, Karimi F. Graphene oxide based nano-biosensor for the detection of deletion mutation in exon 19 of EGFR gene, leading to lung cancer. Materials Letters. 2016;183:441-3.
12. Chaudhary V, Taha BA, Lucky, Rustagi S, Khosla A, Papakonstantinou P, et al. Nose-on-Chip Nanobiosensors for Early Detection of Lung Cancer Breath Biomarkers. ACS sensors. 2024;9(9):4469-94.
13. Kokabi M, Tahir MN, Singh D, Javanmard M. Advancing healthcare: synergizing biosensors and machine learning for early cancer diagnosis. Biosensors. 2023;13(9):884.
14. Banerjee A, Maity S, Mastrangelo CH. Nanostructures for biosensing, with a brief overview on cancer detection, IoT, and the role of machine learning in smart biosensors. Sensors. 2021;21(4):1253.
15. Ganesh S, Dharmalingam P, Das S, Venkatakrishnan K, Tan B. Mapping Immune–Tumor Bidirectional Dialogue Using Ultrasensitive Nanosensors for Accurate Diagnosis of Lung Cancer. ACS nano. 2023;17(9):8026-40.