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Early detection of lung cancer: Advances in imaging and molecular biomarkers.

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Introduction

Lung cancer poses a significant global health burden, with survival outcomes heavily dependent on the stage at diagnosis. Traditional diagnostic methods often identify the disease only after symptoms arise, by which time it has often progressed to advanced stages. Consequently, there has been a major shift toward proactive screening and early detection. Modern imaging and molecular technologies have revolutionized this approach, improving the potential for curative treatment and long-term survival [1].

Early-stage lung cancer (Stage I or II) is typically asymptomatic, but if detected, it is often amenable to surgical resection or targeted therapies. Five-year survival rates can exceed 60% for early-stage disease compared to less than 10% for advanced-stage cancers. Thus, identifying high-risk individuals and applying sensitive screening tools are key to altering the disease trajectory [2].

LDCT has emerged as the gold standard for lung cancer screening in high-risk populations, such as long-term smokers aged 50–80 years. The National Lung Screening Trial (NLST) and NELSON study demonstrated that LDCT reduces lung cancer mortality by detecting tumors before clinical symptoms develop. It offers high sensitivity and acceptable specificity, although challenges such as overdiagnosis and false positives remain [3].

Beyond LDCT, newer imaging modalities are being explored to enhance detection accuracy. Positron emission tomography-computed tomography (PET-CT) improves characterization of pulmonary nodules by identifying metabolic activity. Artificial intelligence (AI) tools integrated with CT imaging are also showing promise in nodule detection and malignancy prediction, potentially reducing radiologist variability and improving diagnostic precision [4].

Molecular biomarkers are biological molecules found in blood, sputum, or tissue that can indicate the presence of cancer. Advances in genomics and proteomics have led to the identification of biomarkers such as circulating tumor DNA (ctDNA), microRNAs (miRNAs), and autoantibodies. These markers are being investigated for their ability to detect lung cancer early, differentiate between benign and malignant nodules, and predict therapeutic response [5].

Conclusion

Early detection of lung cancer through advanced imaging and molecular biomarkers offers the best hope for improving survival and reducing mortality. As technology evolves, integrating imaging with blood-based biomarkers and AI holds promise for a future where lung cancer is routinely caught at a curable stage. Continued research, multidisciplinary collaboration, and equitable implementation will be key to realizing this potential.

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