

Editorial

Artificial Intelligence for Precision Management of Lung Adenocarcinoma

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Lung cancer remains the leading cause of cancer-related mortality worldwide, with lung adenocarcinoma (LUAD) representing the most common histological subtype. Despite improvements in low-dose computed tomography (CT) screening and surgical management, recurrence and disease progression continue to challenge long-term outcomes. Several pathological features, including spread through air spaces (STAS), lymph node metastasis (LNM), lymphovascular invasion, visceral pleural invasion, and high-grade histological patterns, are strongly associated with recurrence and poor survival. However, many of these risk factors are difficult to identify accurately before or during surgery using conventional approaches. As a result, optimizing risk assessment and surgical decision-making remains a critical public health priority in lung cancer care.⁽¹⁾ Recent advances in artificial intelligence (AI), particularly deep learning, offer promising opportunities to address these challenges. AI-driven models can analyze large volumes of medical images and pathology data, extracting subtle patterns that may not be readily detectable by human observers. Emerging evidence suggests that these technologies can improve the prediction of clinically important pathological risk factors, support individualized treatment decisions, and reduce dependence on invasive diagnostic procedures.

One of the most promising applications of AI is the preoperative assessment of tumor aggressiveness using CT imaging. Deep learning models have demonstrated the ability to predict high-risk pathological features, including lymph node metastasis and other indicators associated with recurrence. Such approaches may help surgeons select the most appropriate surgical strategy and avoid under-treatment of patients whose tumors appear early-stage on conventional imaging but harbor aggressive biological characteristics.^(1,2) Given the increasing use of low-dose CT screening worldwide, integrating AI into imaging workflows could strengthen the effectiveness of early detection programs while improving risk stratification. AI also has potential value during surgery. In a recent multicenter prospective study, Yao and colleagues developed a deep learning model based on smartphone photographs of surgical resection specimens. The model enabled rapid intraoperative assessment of pathological invasiveness and improved diagnostic performance among surgeons. Importantly, the use of readily available smartphone imaging suggests a feasible and scalable approach that could be implemented in diverse healthcare settings, including institutions with limited access to specialized pathology resources. Such innovations may shorten waiting times associated with frozen-section analysis and facilitate more precise surgical decision-making.⁽³⁾

Beyond radiological and macroscopic imaging, digital pathology is emerging as another important area for AI application. Deep learning models have shown encouraging performance in identifying STAS and predicting recurrence directly from pathology images. These tools may provide additional prognostic information beyond traditional histological classification and help identify patients who could benefit from intensified surveillance or adjuvant therapy. Compared with molecular assays and genomic testing, which may be costly and inaccessible in many settings, image-based AI approaches have the potential to offer more equitable and scalable solutions.^(4,5) Despite these advances, several challenges remain before widespread clinical implementation can be achieved. Many AI models require external validation across diverse populations and healthcare systems. Issues related to model transparency, data quality, interoperability, and ethical governance must also be addressed. Furthermore, AI should be viewed as a decision-support tool rather than a replacement for clinical expertise. Future research should focus on prospective multicenter studies, integration of multimodal data sources, and evaluation of real-world clinical impact, including cost-effectiveness and health equity outcomes. As lung cancer continues to impose a substantial global health burden, AI offers an important opportunity to advance precision medicine across the continuum of care. From preoperative risk prediction to intraoperative decision support and postoperative recurrence assessment, AI-driven technologies may enhance diagnostic accuracy, optimize treatment selection, and ultimately improve patient outcomes.

Competing Interests

The authors declare no conflict of interest.

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