

EDITORIAL

Bridging the Peripheral Divide: The Emerging Horizon of AI-Assisted Peripheral Bronchoscopy

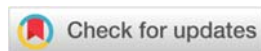
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The AI application is not just limited to localizing lesions but also to the appraisal of tissue gained through the bronchoscopic examination. Pathomics Computational pathology involves artificial intelligence applied to obtain quantitative morphology in histopathology images. Deep learning models have the ability to detect cellular and architectural features which can be hard to detect on a regular basis using traditional microscopic evaluation. Combination of deep pathomic aspects with clinical and radiological variables could enhance the delimiting of

BACKGROUND

Lung cancer screening using low-dose computed tomography (LDCT) has significantly helped to detect numerous small and indeterminate peripheral pulmonary lesions (PPLs). Despite early radiological detection being an opportunity offering a chance to cure the disease, the definite coronation of tissues using small and distal lesions is still a primary issue in interventional pulmonology. Traditional forms of flexible bronchoscopy and early navigational methods might be restricted by CT-to-body divergence (CTBD), respiratory motion, anatomical fluctuation, operator dependence and the inability to keep the catheter intact on the target lesion. This means the vicinity around a lesion is not always reached to attain a diagnostic tissue acquisition¹⁻³.

Artificial intelligence (AI) is also sought out as an adjunctive technology to overcome these limitations. The combination of the so-called deep learning, computer vision, image analysis, and computational pathology with intelligent navigation can turn peripheral bronchoscopy into a more accurate and standardized diagnostic process²⁻⁴. The distal bronchial airways are difficult to visualize due to the tapering airway size and the low optical field. Newer ultra-thin bronchoscopic systems and video probes can allow visualization to a more distal airway and potentially using this system to examine small PPLs directly. Computer vision AI algorithms can also be used to aid in the interpretation of bronchoscopic images, by detecting minute morphological changes that could be related to malignancy²⁻⁵.

Radial-probe endobronchial ultrasound (r-EBUS) is another procedure that is being applied with AI to localize peripheral lesions with common usage. The analysis of the r-EBUS patterns may also be difficult due to the fact that the benign and the benign lesions may display confused or mixed results. Transfer-learning models and CNN-based models demonstrated good diagnostic accuracy in the distinction between malignant and benign peripheral lesions. Lower level CNN-Transformer structures can also be enhanced to improve image classification and segmentation by incorporating both local features detailed and documenting contextual features³⁻⁶.

peripheral pulmonary lesions. These models have shown capabilities to exhibit good diagnostic performance and can also help in further revealing fine malignant features in specimens that can otherwise be challenging to determine^{3,5-7}.

Other applications that have been brought by AI include rapid on-site evaluation (AI-ROSE). In bronchoscopic biopsy, specimen adequacy can be immediately evaluated and specimen additional needs determined. Nevertheless, there is a lack of on-site

cytopathologists in most institutions. Automated evaluation of adequacy of the specimen at the cytological imaging phase using deep learning algorithms and help distinguish between malignant and benign or inflammatory tissue can be applied to the cytological imaging of the sample. Such method can minimise poor sampling and even lessen the use of repeated invasive procedures^{2,4-5}.

The most promising clinical use of AI could be the combination with robotic-assisted bronchoscopy (RAB) and enhanced navigation systems. Robotic systems offer better catheter stability and articulation and distal airway access. These capabilities can be enhanced with the help of AI in the field of automated segmentation of the airways, three-dimensional navigation of the pathways, finding the target and catheter positioning. One significant issue with peripheral bronchoscopy is the CT-to-body divergence, where the position of the lesion at the time of the procedure is not the same as it is on the CT image before the procedure due to respiratory motion, deformation of the lung, atelectasis and changes in patient positioning. AI-aided navigation could be integrated with real-time imaging examinations like cone-beam CT (CBCT) and digital tomosynthesis to find these anatomical discrepancies and enhance distinctions in accuracy of targeting^{3,5,7-9}.

The advent of AI, robotic bronchoscopy, and real-time imaging is hence a significant advance in the direction of precise and controlled biopsy of peripheral lesions. However, the reported diagnostic yields depend on the lesion size, location, bronchus sign, sampling method, experience of the operator and strategy of imaging and need additional prospective assessment.

AI-assisted peripheral bronchoscopy is a promising new frontier of interventional pulmonology. Its uses include bronchoscopic interpretation of images, r-EBUS evaluation, lesion navigation, robotic bronchoscopy, computational pathology, and real-time specimen

evaluation. AI could enhance the capabilities of conventional peripheral bronchoscopy that have a number of shortcomings by enhancing visual interpretation capability, localizing targets better, and assisting in the evaluation of tissue adequacy.

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