Artificial Intelligence Guided Intraoperative Molecular Imaging Biopsy of Indeterminate Pulmonary Nodules During Robotic Surgery

Objective: There is an increasing detection of indeterminate pulmonary nodules. A substantial number of these lesions are sub-centimeter and not amenable for conventional biopsy techniques. Thus, surgery followed by intraoperative frozen section is utilized, but frozen section can be expensive, prone to human error, and prolong anesthesia time. The purpose of this study was to prospectively evaluate a novel technology combining intraoperative molecular imaging with fluorescent dyes combined with artificial intelligence (AI) imaging algorithms to predict real-time if an indeterminate nodule is cancer or not during a robotic pulmonary resection.

Methods: Patients were infused with a targeted fluorescent contrast agent prior to surgery that causes malignant tumors to fluoresce. Then, a predictive AI image recognition algorithm was developed by logistic regression analysis and MATLAB medical image recognition toolbox from 321 patients from 2014-2022 using 22 parameters (i.e. tumor characteristics, demographics, tracer fluorescence quantification, robotic camera angle and depth of penetration). The AI algorithm was then integrated with Intuitive DaVinci Firefly system and tested prospectively as a proof-of-principle during intraoperative molecular imaging guided lung cancer resection trial.

Results: During the surgery, the AI algorithm localized the lesion within 2.7 seconds compared to 18.1 seconds for visual inspection (p<0.05). The time from lesion detection to malignant diagnosis using this technique was 1.23 minutes as compared to frozen section analysis of 28.11 minutes (p<0.001). AI predicted 21 out of the 23 lesions were malignant. On final pathology, 21/23 patients had a final confirmation of malignancy. On histopathologic analysis, 17 of them were moderately differentiated adenocarcinoma spectrum lesions. The positive predictive value of AI system was 100%, specificity of 94.1%, negative predictive value of 91%, and sensitivity of 78%. All benign lesions were properly classified, and no malignancies were falsely classified as compared to histopathologic analysis. There were no treatment related complications. Median additional time added to operation with AI was 2.11 minutes. Total simulated institution specific cost saving as compared to frozen section analysis was calculated at $7817.

Conclusions: Integration of artificial intelligence with intraoperative molecular imaging can accurately and rapidly predict which indeterminate pulmonary nodules are malignant.
