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ABSTRACT TITLE:
Artificial Intelligence Based Rapid On-site Evaluation to Improve Bronchoscopy Procedures

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Abstract Specific Information

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Research Abstract

Abstract Content (limited to 350 words in each section below)

Introduction
Rapid On-Site Evaluation (ROSE) has improved patient care with increased diagnostic yield, decreased number of needle passes, reduced complication rate, and cost of bronchoscopy procedures. Despite these benefits, the utilization of ROSE has been fairly limited due to significant challenges including (1) availability of trained cytology personnel, (2) poor reimbursement rates for ROSE procedures, (3) high variability in sample quality, (4) slow specimen preparation leading to extended procedure time, and (5) cumbersome processes in the procedure room. The increased procedure time often associated with Robotic Bronchoscopy Procedures has further strained the limited cytology resources, leading many pathology administrators to stop offering ROSE at their clinical sites.

Objectives
This study aims to develop an artificial intelligence (AI)-based algorithm that automatically identifies suspicious/atypical cells, malignant cells, and infectious cells obtained from the fine needle aspiration (FNA) or biopsy of the lung nodules or lymph nodes. The developed AI algorithm was derived from 600 patient specimen slides that were collected as part of a separate multi-center clinical study performed earlier across different specimen types including those obtained during bronchoscopy procedures.
The goal of this study is to enhance an AI based algorithm that will : (i) image specimen slides collected during FNA of lung nodule with robotic bronchoscopy and/or FNA of lymph nodes with endobronchial ultrasound (EBUS), (ii) provide actionable feedback to pulmonologists regarding the number of suspicious or malignant cells present on the ROSE slides,

(iii) automatically annotate the malignant or suspicious regions on slide images to aid the downstream pathologists after the completion of the bronchoscopy procedure. It is important to note that as part of this IRB study, the AI algorithm did not directly provide the feedback to the proceduralist about the type of the sample obtained during the bronchoscopy procedure.

Materials & Methods

We are currently enrolling patients in a prospective study (goal n= 50) undergoing either robotic bronchoscopy to sample indeterminate pulmonary nodules with FNA or EBUS/FNA to biopsy lymph nodes. The specimens obtained as part of the FNA are first processed by a cytotechnologist using a conventional standard of care method for the adequacy assessment. After confirmation of adequacy, additional FNA passes are processed using an automated sample preparation system (ASP Health, ROSE Prep™). The automated sample preparation system creates a thin monolayer of the FNA specimen on a glass slide and stains the slides utilizing the commonly available DiffQuik® stains. Once the specimen slide is prepared in the bronchoscopy suite, it is digitized using a commonly available slide scanning system (Grundium Ocus40). The individual digitized specimen slides are then segmented into ~ 1200 tiles (1 tile = 500 um x 500 um area). Each tile is then assigned the following ranks: (1) blood, (2) benign cells, (3) suspicious/atypical cells, (4) malignant cells, and (5) infectious cells by a certified cytotechnologist.

The individual tile images were processed using a custom developed AI algorithm that utilizes the following processes: (1) an EfficientNet based convolution neural network was employed to first identify nucleated cells present on the specimen slides; (2) a YOLOv8 model was implemented to further classify the identified nucleated cells into atypical, suspicious, or malignant cells. This two-step process enables real-time AI-assisted workflow that is required during ROSE procedures, facilitating rapid and reliable adequacy assessments. To further enhance the model performance, inference training and layer freezing optimization were employed allowing the EfficientNet and YOLOv8 models to retain valuable pre-trained features while fine-turning deeper layers for domain-specific cell morphology recognition. In addition to this, data augmentation techniques – including random rotations, elastic deformations, contrast adjustments, and Gaussian noise injection were applied to address class imbalances and improve generations.

Discussion/Results

The AI models were first pre-trained on over 600,000 image tiles obtained from 600 patient specimen slides before this study. The AI model yielded an overall accuracy of 90.3% in identifying suspicious or malignant cells. The true positive rate (TPR) was 95.4%, the false negative rate (FNR) was 4.6%, and the overall inference time was 0.02 seconds per image.

We have currently enrolled four patients with adequate samples for analysis with the AI algorithm. The pre-trained AI algorithm was applied to these four patients, resulting in an overall accuracy of 85% with a TPR of 89% and FNR of 11% in identifying suspicious/atypical cells or malignant cells, which was confirmed in the standard of care samples obtained clinically. Albeit early in recruitment, preliminary results show promise for utilizing AI-based ROSE to improve the efficiency of bronchoscopy procedures. Pending further evaluation and verification of preliminary findings, this AI-based approach can be used in clinical sites with limited cytology resources to guide the pulmonologist during their bronchoscopy procedure.

Summary/conclussion

We demonstrate a novel AI-based algorithm that can automatically identify suspicious/atypical cells and malignant cells on ROSE specimen slides. Albeit early in recruitment, preliminary results show promise for utilizing AI-based ROSE to improve the efficiency of bronchoscopy procedures. Pending further evaluation and verification of preliminary findings, this AI-based approach can be used in clinical sites with limited cytology resources to guide the pulmonologist during their bronchoscopy procedure. Future studies will focus on improving the overall performance of the AI algorithm, leading to a multi-center clinical validation.

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