Predicting Immune Checkpoint Inhibitor Pneumonitis in Lung Cancer Patients Using Deep Learning and Baseline CT scans

Amgad Muneer[1†], Eman Showkatian[1†], Mehmet Altan[3], Ajay Sheshadri[2], Jia Wu[1,3*]

† Contribute equally

Authors' affiliations:

[1] Department of Imaging Physics, MD Anderson Cancer Center, Houston, TX USA
[2] Departments of Pulmonary Medicine, MD Anderson Cancer Center, Houston, TX, United States
[3] Department of Thoracic/Head and Neck Medical Oncology, MD Anderson Cancer Center, Houston, TX, USA

Abstract

Background: Immune checkpoint inhibitors (ICIs) have revolutionized immunotherapy but are associated with immune-related adverse events, such as pneumonitis. Differentiating ICI pneumonitis from normal cases and other interstitial lung abnormalities (ILAs) at an early stage is crucial for patient management.

Purpose: This study aims to develop and validate a predictive model using baseline CT scans to differentiate ICI pneumonitis from normal cases at early stage and identify patients at increased risk of developing this condition.

Materials and Methods: We developed the PANDA (Pneumonitis ANomaly Detection using AttentionU-Net) model to address this challenge, leveraging advanced deep learning techniques to improve the early predicting of ICI-induced pneumonitis. Baseline CT scans from 349 patients undergoing ICI therapy were analyzed to train and vali-date the model. The PANDA model utilizes the Attention U-Net architecture, incorporating attention mechanisms to enhance feature extraction and anomaly detection capabilities. Data augmentation techniques, including brightness normalization and pixel shuffling, were applied to improve model robustness. The model was trained on normal cases using an autoencoder-based method with anomaly detection through mean squared error (MSE) distribution, followed by testing on pneumonitis cases.

Results: The PANDA model demonstrated outstanding performance, achieving a precision of 77%, sensitivity of 79%, specificity of 79%, an F1-score of 78%, and a Precision-Recall AUC of 82%. These metrics significantly surpass those of traditional models, including both clinical and radiomics approaches. Specifically, the clinical model recorded a precision of 75%, sensitivity of 73%, specificity of 71%, an F1-score of 76%, and a Precision-Recall AUC of 67%. Although the classical radiomics model exhibited improvements over the clinical model, with a precision of 81%, sensitivity of 80%, specificity of 76%, an F1-score of 79%, and a Precision-Recall AUC of 72%, it nonetheless fell short of achieving the robust performance demonstrated by the PANDA model.

Conclusion: The predictive model, utilizing deep learning-based autoencoder feature extraction, effectively distinguishes between non-pneumonitis cases and those at risk of developing ICI-induced pneumonitis. This tool can significantly enhance clinical decision-making and improve patient outcomes by potentially reducing the incidence and severity of pneumonitis.