Evaluation of Pediatric Pulmonary Tuberculosis Diagnosis with Deep Learning Models: X-Ray Image Analysis Using VGG16 and DenseNet121

Beyzanur Güney[1] Omar Alomari[1], Eshagh Shahnavazi[2], Ceren Çetin[3], Edib Moukresh[1], İrem Sarı[4], Emine Çalışkan[4], Fatıma Zehra Hazıroğlu[5], Halil Kurt[5], Ayşe Karaaslan[5]

[1]University of Health Sciences, Hamidiye International Faculty of Medicine, Istanbul, Türkiye

[2]Istanbul Technical University, Mechanical Engineering, 34840, Istanbul, Türkiye

[3]University of Health Sciences, Hamidiye International Faculty of Medicine, Department of Medical Biology, Istanbul, Türkiye

[4]University of Health Sciences, Kartal Dr. Lütfi Kırdar City Hospital, Department of Pediatric Radiology, Istanbul, Türkiye

[5]University of Health Sciences, Kartal Dr. Lütfi Kırdar City Hospital, Department of Pediatric Infectious Diseases, Istanbul, Türkiye

Introduction: Tuberculosis is an infectious disease caused by Mycobacterium tuberculosis, transmitted through the respiratory tract and frequently affecting the lungs. Diagnosis is made by evaluating clinical, radiological and laboratory findings together. Artificial intelligence-based deep learning techniques, especially convolutional neural networks, have significant potential in the diagnosis of tuberculosis in lung X-ray images. In this study, we aim to evaluate the potential of deep learning models to assist physicians in the diagnosis of pediatric pulmonary tuberculosis.

Materials & Methods: X-ray images of children under the age of 18 who were followed up with the diagnosis of pulmonary tuberculosis at SBÜ İstanbul Kartal Dr. Lütfi Kırdar City Hospital between 2015-2024 were examined. Pediatric radiologists analyzed the pathological findings specific to tuberculosis. In the study, the last 10 layers were solved and fine-tuned using VGG16 and DenseNet121 models pre-trained on ImageNet. Data pre-processing included resizing the images to 224x224 pixels, normalization, and extensive augmentation techniques. Training was performed with Adam optimizer with 1e-4 learning rate, categorical cross-entropy loss, early stopping, and regularization methods. Evaluation was made with accuracy, AUC-ROC, F1 score, sensitivity, specificity, and confusion matrix.

Results: A total of 41 pediatric patients were included in the study, 25 (61%) of the patients were female and 16 (39%) were male. 22 (53.7%) of the participants were over 10 years old. When the patients' lung radiological images were examined, infiltration was detected in 31 (75.6%), hilar fullness in 14 (34.1%), pleural effusion in 13 (31.7%), cavity in 5 (12.2%), miliary tuberculosis in 4 (9.8%) and fissuritis in 3 (7.3%). In both VGG16 and DenseNet121

models used for binary classification in images, 90% accuracy was determined. Both models had 80% sensitivity and 99% specificity. F1-score was found as 0.889. AUC-ROC values were calculated as 1.00 for VGG16 and 0.96 for DenseNet121. Due to the small data set, the fact that the training loss continued to decrease while the validation loss plateaued showed signs of overfitting.

Conclusion: In our study, these two deep learning models yielded successful results in the diagnosis of pediatric pulmonary tuberculosis and showed the potential to assist physicians in the automatic detection of tuberculosis. The results emphasize the need for improvement methods to increase the generalization ability of the model and studies with larger patient groups.

Keywords: Pediatric pulmonary tuberculosis, chest X-ray imaging, deep learning, convolutional neural networks, computer-aided diagnosis