AI-Driven Predictive Modeling and Therapeutic Optimization for Respiratory Diseases

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Asthma and chronic obstructive pulmonary disease (COPD) are complex respiratory disorders with variable disease progression and heterogeneous treatment responses. While biologic therapies such as omalizumab and dupilumab have improved patients' outcome, there remains a critical need to personalize treatment strategies based on individual biological profiles and diagnostic indicators. This research applies computational biology methods to develop an AI powered framework that predicts disease progression, treatment response, and risk stratification in asthma and COPD patients as clinical guided tools. A multi-modal dataset was constructed, integrating pulmonary function test results (spirometry, DLCO), inflammatory biomarkers (eosinophils, serum and local IgE), imaging data from CT, electrical impedance tomography (EIT), and photoacoustic tomography (PAT). Deep learning models, including convolutional neural networks and transformers, were trained to detect hidden patterns across data types and generate individualized predictions. Initial results demonstrated high accuracy, with AI models achieving a sensitivity of 91.3% and specificity of 88.7% in predicting biologic therapy response. Local IgE concentrations and radiological imaging features were among the most predictive factors. In addition, the models successfully identified early indicators of disease exacerbation, supporting preemptive clinical action. This tool will potentially enable clinicians and researchers to better understand disease mechanisms, improve biologic therapy targeting, and optimize long term disease management. This research shows how computational biology can bridge molecular insights and clinical decision making through integrative, AI based modeling in respiratory medicine.

Awards Won: