Development of Non-Invasive Imaging Biomarkers for Predicting Immunotherapy Response in Breast Cancer Patients

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Purpose: Breast cancer is a leading cause of cancer death in women, and while immunotherapies are effective, many patients do not benefit. Current methods to assess tumor immune activity rely on invasive biopsies and gene-based tests, which are costly, prone to sampling error, and limited by tumor heterogeneity. This project developed a non-invasive radiogenomic machine-learning model predicting immune activity from mammograms. Procedure: Quantitative radiomic features (texture, shape, intensity) were extracted from mammograms and paired with transcriptomics-derived immune scores reflecting cytotoxic CD8-positive T-cell activity. A supervised machine-learning algorithm was trained to classify tumors as having high or low immune activity based on imaging features. Results: Tumors with sharper edges and complex textures associated with CD8-positive T-cell infiltration. Higher contrast showed a negative correlation, indicating immune-rich tumors appear more uniform. The model predicted overall immune infiltration with high accuracy (Pearson r=1) and correlated strongly with CD8-specific scores (Pearson r=0.845; Spearman r=0.985) in a small cohort (n=45). Independent testing (n=5) showed moderate performance (R^2=0.475; RMSE=0.546). Conclusions: Integrating radiomic features with genomic immune profiling provides a rapid, non-invasive, and reliable assessment of tumor immune activity. This approach may improve patient selection for immunotherapy, reduce invasive procedures, and advance precision medicine. Future work will expand the cohort to improve model performance.

Awards Won: