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Radiomic Texture-Based Clustering of Myocardial Damage Severity from Cardiac MRI

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Cardiovascular diseases remain the leading cause of death worldwide, creating a pressing demand for early, objective, and AI-driven diagnostic tools. Cardiac magnetic resonance imaging (MRI), when combined with radiomics, enables the extraction of quantitative texture features that capture microstructural myocardial changes associated with fibrosis and tissue remodeling – alterations that are not always detectable otherwise. However, a critical challenge persists: can these texture-derived biomarkers autonomously cluster patients according to myocardial damage severity *without* predefined labels, and do such clusters reflect meaningful clinical differences? In this study, we propose an unsupervised machine learning framework that groups patients based on radiomic texture features extracted from multiphase cardiac MRI. A total of 46 features were computed using GLCM, GLRLM, Fourier and wavelet transforms, Local Binary Patterns (LBP), Histogram of Oriented Gradients (HOG), and fractal analysis, followed by feature selection using statistical testing, random forest importance, LASSO regression, and correlation analysis. Clustering was performed using the k-means algorithm combined with UMAP for nonlinear dimensionality reduction. The resulting clusters were evaluated using established clinical biomarkers, including native T1 relaxation time and extracellular volume fraction (ECV) as imaging-based indicators of myocardial fibrosis, collagen volume fraction (CVF) derived from histology as a

direct measure of fibrotic tissue change, and global longitudinal strain (GLS) as a functional marker of myocardial contractility. A clear and consistent trend was observed: clusters characterized by increased texture heterogeneity and gray-level irregularity were associated with elevated T1, ECV, and CVF values alongside reduced GLS, indicating advanced myocardial impairment, while clusters with homogeneous texture profiles corresponded to preserved myocardial structure and function. These findings demonstrate that radiomics-based clustering can autonomously uncover clinically relevant stages of myocardial damage, highlighting the potential of AI-enabled texture analysis as a powerful approach for early detection, risk profiling, and personalized management in cardiology.

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