Characterization of Late Gadolinium Enhancement Heterogeneity in Hypertrophic Cardiomyopathy using Quantitative Texture Analysis

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Target Audience: Cardiac radiologists, cardiologists, and imaging scientists interested in fibrosis characterization, pattern recognition and computer-aided diagnosis.

Purpose: Hypertrophic cardiomyopathy (HCM) results in myocardial disarray, hypertrophy and fibrosis [1]. Late gadolinium enhanced MRI (LGE) can assess the presence and extent of fibrosis, which is associated with the development of arrhythmias and sudden cardiac death. However, enhancement may not always be present or only sparsely distributed [2]. Thus, one of the challenges is how best to describe heterogeneous LGE patterns in an objective fashion that informs clinical decision making. Computer-aided pattern recognition techniques may provide clinicians with an objective means of describing the degree of heterogeneity in HCM. Quantitative analysis of image gray-level patterns, or "texture analysis" has been successfully applied to tumour characterization and in several neuroimaging applications [3]. We hypothesized that hypertrophied segments would exhibit greater grey-level heterogeneity than both (a) non-hypertrophied segments in HCM patients, and (b) healthy volunteers.

Methods: We prospectively recruited 12 HCM patients and 4 healthy volunteers. Functional (bSSFP cine) and LGE (phase-sensitive inversion recovery spoiled GRE, 10-15 min post injection of 0.2 mmol/kg Gd-DTPA) images were acquired in short-axis orientation (SAO), as well as in one 4-chamber slice. We measured the maximum thickness on the end-diastolic cine frame in the 17 segments (AHA model). Segments measuring >15 mm on SSFP images were considered hypertrophic (H+). The presence of myocardial fibrosis was assessed on LGE images using the same AHA segments. Segments were categorized as fibrotic (F+) if > 20% of pixels were enhanced (>5 SD nulled myocardium). LGE image textural features (run-length non-uniformity, RLNU, and grey-level non-uniformity, GLNU [4]) were computed for each segment using MaZda version 4.6 (P.M. Szczypiński, Institute of Electronics, Technical University of Lodz, Poland) [5]. Differences in RLNU and GLNU among segment groups (H+/F+, H+/F-, H-/F+, H-/F-, and healthy) were assessed by Kruskal-Wallis tests.

Results: Of 192 segments we found; 7 H+/F+, 9 H+/F-, 29 H-/F+, and 147 H-/F-. Median +/-interquartile ranges for RLNU and GLNU for each HCM group, as well as for the 64 segments obtained from healthy volunteers are depicted in Fig.1 ($P < 0.0001$, for RLNU and GLNU). Post-hoc analysis revealed that RLNU and GLNU were significantly greater in H+ than H- segments ($P=0.006$ and $P=0.0002$, respectively). Both RLNU and GLNU in H-/F- HCM segments were greater than in healthy volunteers ($P=0.009$ and $P < 0.0001$, respectively).

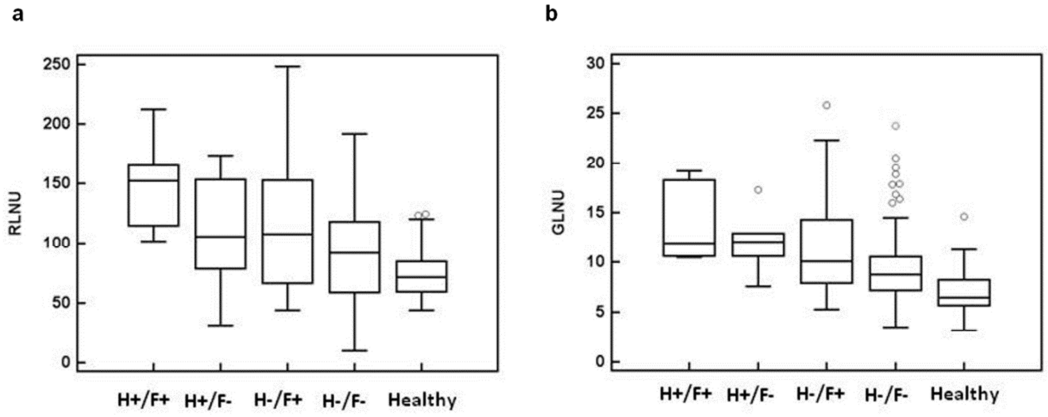

FIGURE 1: Box and whisker plots indicating median and interquartile ranges for run-length (a), and gray-level non-uniformity (b) features: Hypertrophic/Fibrotic (H+/F+), Hypertrophic/Non-Fibrotic (H+/F-), Non-hypertrophic/Fibrotic (H-/F+), Non-hypertrophic/Non-Fibrotic (H-/F-), and Healthy segments.

Discussion: Quantitative textural features related to LGE heterogeneity appear elevated in patients with HCM, even in non-hypertrophic segments. In addition, significant statistical differences were found in the textural features between non-hypertrophic, non-fibrotic segments of HCM patients and healthy volunteers.

Conclusion: Gray-level run-length heterogeneity features show potential as markers of incipient cardiomyopathy among HCM patients and may provide tools for differentiating diverse phenotypic expressions of the disease from healthy patients.

References:

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