Cardiac Strain and Left Ventricular Mass Quantification for Hypertrophic Cardiomyopathy using 4D Echocardiography

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Background: Strain and Left ventricular mass (LVM) determination are essential for the evaluation of the progress and function of hypertrophic cardiomyopathy (HCM). Free of geometric assumptions and angle dependencies, four-dimensional echocardiography (4DE) has been shown to be a superior method in determining myocardial strain and LVM than current conventional methods. However, its feasibility in determining myocardial strain and LVM for HCM has not been reported. Methods: A balloon was sutured into the left ventricle (LV) of 18 porcine hearts and connected to a calibrated pump. The right ventricle free wall was sectioned into quarters and sutured on the septum one at a time to simulate septal wall thickness. 4D and Motion-mode images were obtained at baseline and each simulated HCM level. Full-volume 4D loops were analyzed to quantify global longitudinal, circumferential, radial, and area strain, as well as the regional strain values at the hypertrophied mid-septum segment. Results: Full-volume 4D loops were analyzed; in HCM models, 4D-derived LVM demonstrated superior linear correlation with displacement values ($R^2=0.95$) when compared to M-mode ($R^2=0.55$). However, both methods demonstrated excellent correlations with displacement values (both $R^2>0.90$, $p<0.001$) at baseline. Bland-Altman analyses showed an overestimation in both methods. All global strain and regional strain (MS) were significantly reduced in HCM models when compared to the baseline (all p-values <0.05), signifying decreased function and thereby differentiating physiological and pathological hypertrophy. Conclusions: Full-volume 4DE is a feasible method for left ventricular mass detection and global and regional strain determination in HCM with abnormal septal wall.