Using Vector Velocity Imaging (VVI) to Measure Left Ventricular Systolic Strain and Diastolic Strain Rate in Cine MRI

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Introduction: Quantification of systolic strain and diastolic strain rate provide more sensitive indicators of myocardial dysfunction than subjective image interpretation. Vector Velocity Imaging (VVI) is a processing method developed to quantify myocardial strain and strain rate from 2D echocardiography images. VVI works by tracking features on the endo- and epicardial surfaces of the myocardium. We sought to investigate the feasibility of using VVI to estimate left ventricular strain and strain rate from standard steady-state free-precession (SSFP) cine MRI, potentially obviating the need for specialized acquisition schemes such as tagging, DENSE, or SENC.

Materials and Methods: Short-axis and long-axis cine MRI images (segmented SSFP, TR/TE = 3.0/1.3 ms, temporal resolution 42 ms, 1.9mm x 1.4mm x 6mm voxel size) were acquired from nine normal, healthy subjects (3 females, 6 males, average age 31 ± 5.05). VVI software (Siemens Ultrasound, Mountain View, CA) was used to calculate left ventricular (LV) peak systolic strain (circumferential, radial, and longitudinal) and peak diastolic circumferential and longitudinal strain rates based on automated tracking of the endo- and epicardial surfaces. The results were compared to literature values generated using MR tissue tagging methods (1 - 6).

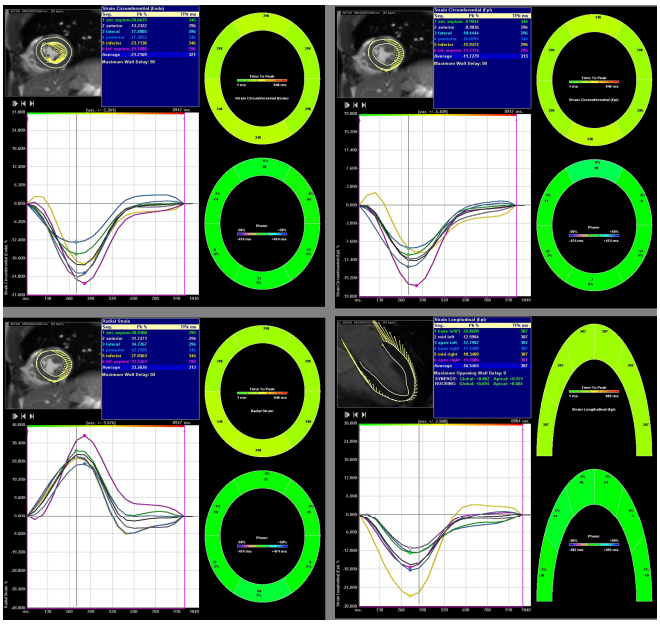

Figure 1 – Left ventricular (A) endocardial circumferential (B) epicardial circumferential (C) radial and (D) longitudinal strain from one subject. Curves are shown for individual segments as well as the average.

Results: Figure 1 shows the VVI myocardial strain results for a single mid-ventricular short-axis slice and a four-chamber long-axis slice. The calculated values for left ventricular peak systolic strains and diastolic strain rates were comparable to the literature values (see Tables 1&2).

Conclusions: The similarity of our acquired values to the literature values implies that VVI may be used to calculate left ventricular strain and strain rate from conventional SSFP cine MRI, obviating the need for additional time-consuming tissue tagging, displacement, or strain encoding methods. However, due to the variability of results in the literature references, additional data will be acquired to determine the expected range of strain values in normal subjects before moving on to clinical studies.

Table 1 – Comparison of VVI-derived systolic peak strain results in 9 normal subjects with published values based on tissue tagging.

Average	VVI (Peak %)	Ref 1 (Peak %)	Ref 2 (Peak %)	Ref 3 (Peak %)
Radial Strain				
Apex	45.8 ± 6.5	42.0	28.0	47.8
Mid	42.5 ± 8.8	40.8	29.0	41.8
Base	40.7 ± 11.8	35.0	34.0	45.0
Circumferential Strain				
Apex	-24.3 ± 6.5	-29.3	-24.0	-22.3
Mid	-17.8 ± 2.7	-27.2	-21.0	-19.3
Base	-19.6 ± 2.8	-22.6	-19.0	-18.5
Longitudinal Strain	-16.0 ± 3.6	-17.6	-16.0	-16.0

Table 2 – Comparison of VVI-derived strain rate results in 9 normal subjects with published values based on tissue tagging.

Average	VVI	Ref 4	Ref 5	Ref 6
Circumferential Diast. Strain Rate	1.47 ± 0.43	2.2 ± 1.1	1.0 ± 0.3	X
Longitudinal Diast. Strain Rate	1.13 ± 0.26	X	1.0 ± 0.5	0.8 ± 0.3

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