Original Article

Myocardial Viability Assessment: Comparison between Resting Two Dimensional Visual Assessment of Dobutamine Stress Echocardiography and Strain Rate Imaging

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Background: Patients with ischemic left ventricular dysfunction are increasingly referred for the assessment of myocardial viability. The issue of identifying dysfunctional but viable myocardium has crucial clinical importance, since revascularization increases survival only in patients with viable myocardial tissue. The aim of this study was to compare resting two-dimensional visual assessment of myocardial viability with dobutamine stress echocardiography and strain rate imaging.

Patients and Methods: In this cross-sectional study , thirty-two consecutive patients (age: 55.3 ± 22.7, 4 females) with ischemic left ventricular dysfunction were referred for myocardial viability assessment. Viability was evaluated using resting two-dimensional echocardiograms, dobutamine stress echocardiography and strain rate imaging. Viability was defined by the absence of brightness and thinning (<6 mm thickness) in akinetic segments, improvement by at least one grade or a biphasic response during dobutamine stress echocardiography or an increase in the peak systolic strain rate (more than –0.23 1/s).

Results: A total of 254 segments were studied. Seventy- nine segments by dobutamine stress echocardiography, 70 segments by two-dimensional visual assessment, and 63 segments by strain rate were classified as non-viable ($P< 0.001$). There was an almost perfect agreement among these diagnostic methods.

Conclusions: Two-dimensional visual assessment with measurement of wall thickness is simple and practical methods for viability assessment, with almost perfect agreement with dobutamine stress echocardiography and strain rate imaging.

Keywords: Echocardiography, Stress Imaging, Viability

Introduction

Among patients with ischemic cardiomyopathy and viable myocardium, revascularization is associated with improved systolic function, symptoms and survival, but the best method to identify viable myocardium remains disputed. Many non-invasive techniques have been used for distinguishing viable from irreversibly injured myocardium. Current options include positron-emission tomography to assess myocardial metabolic activity, single-photon emission computed tomography to assess myocardial perfusion and membrane integrity, dobutamine echocardiography and cardiovascular magnetic resonance to assess myocardial contractile reserve.[1-6] The aim of this study was to compare resting two-dimensional visual assessment of myocardial viability, dobutamine stress echocardiography and strain rate imaging.

Patients and Methods

In this cross-sectional study, a total of 32 consecutive patients (age: 55.3 ± 22.7, 4 female) with reduced left ventricular function

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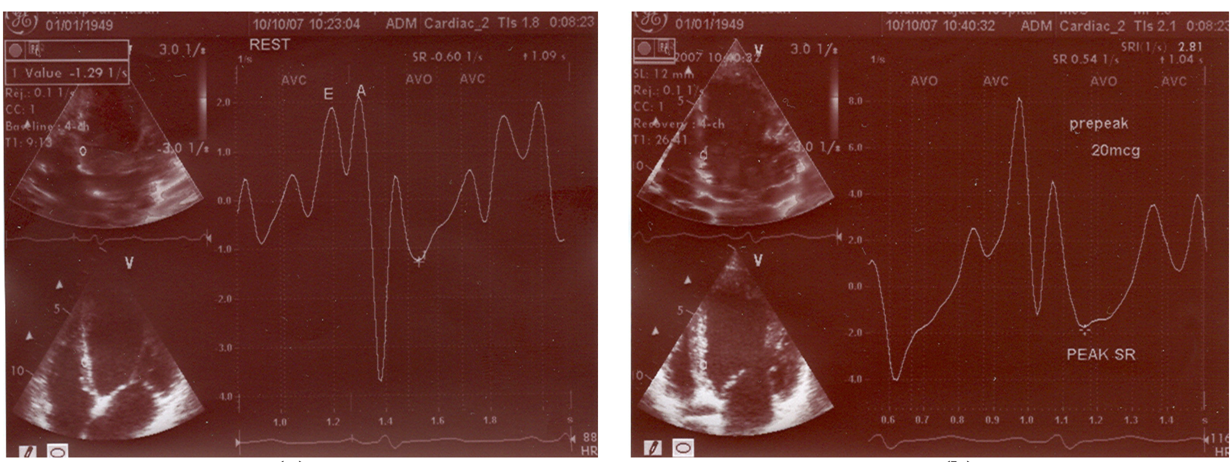
(ejection fraction 27 ± 8 %) due to documented coronary artery disease ,established by history of previous myocardial infarction or coronary angiography, who were referred for myocardial revascularization. All subjects gave written informed consent and patients with significant valvular heart disease or recent infarction (<6 weeks) were excluded.

The study protocol consisted of resting two-dimensional echocardiography, low dose dobutamine stress echocardiography, and strain rate imaging. A total of 254 segments were evaluated by all three methods. This study approved by the ethics committee of Shahid Rajaie Cardiovascular Medical and Research Center.

Digital data were transferred for off-line analysis, applying the software incorporated in the Vivid Seven System and were analyzed by one board certified experienced echocardiologist without knowledge of dobutamine stress echocardiography interpretation by the other echocardiologist. Strain rate imaging was performed from apical two and four chamber views for mid and basal segments at rest and during dobutamine stimulation by placing the sample volume in each segment halfway between the endocardium and epicardium.[7-10] This allowed the determination of a baso-apical velocity gradient within each segment. Three consecutive beats were analyzed. An offset of Δ r = 1 cm was used. The peak systolic SR was determined as the maximal negative SR within 350 ms after the QRS complex. It was determined for each segment at rest and with dobutamine stimulation (Fig. 1a, b). The analysis of strain by Doppler echocardiography is highly angle-dependent. Because of the greater angle between the ultrasonic beam and left ventricular axis for apical segments, determination of SR for apical segments is likely to be less accurate, thus posterior, antero-septal walls and apical segments were excluded.

Dobutamine infusion was started at 5 µg/kg body weight per min for 3 min followed incremental dose every 3 min up to 20 µg/kg body weight per min. Images were acquired continuously on tape and stored digitally at the end of every dose step. The aim was to observe the improvement of contractility. Each left ventricular



(a) (b)

Figure1. (a) Strain rate imaging at rest for one cardiac cycle of a severely hypokinetic inferoseptal segment. (b) Strain rate imaging during dobutamine stimulation for one cardiac cycle of a severely hypokinetic infero-septal segment. There is an increase in the peak systolic strain rate from 1.29/s at rest to 1.84/s during dobutamine stimulation indicating viable myocardium.

segment, depending on the contractility at rest and at low-dose dobutamine were described as 1)viable: severely hypokinetic, akinetic or dyskinetic segments at rest, with biphasic response or sustained improvement by at least one grade with dobutamine administration; and 2)nonviable: severe wall motion abnormality at rest, with no change or worsening with dobutamine. Analysis of dobutamine stress echocardiography was performed in separate reading sessions by an echocardiologist blinded to any other data.

It has long been recognized that the presence of myocardial thinning detected with echocardiography is a marker of chronic myocardial infarction[10,11] but there is controversy on the accuracy of resting echocardiogram and some authors suggested that resting two-dimensional echocardiography is neither sensitive, nor specific for this purpose.[13] Echocardiograms were obtained with Vivid Seven System (GE). Apical two and four chamber views were acquired. The left ventricle was divided according to the 16-segment model of the American Society of Echocardiography.[14] The segments included the base and mid segments of septum, lateral, inferior and anterior walls. Posterior, antero-septal and apical segments were excluded to enhance the accuracy of matching segments in this region. End-diastolic wall thickness was measured at the center of each myocardial segment. Akinetic Segments with thinning (end diastolic wall thickness <0.6 cm) and increased brightness (compare with adjacent myocardium) were considered non-viable in resting two-dimensional echocardiograms. Resting echocardiographic images were analyzed by one expert echocardiologist without knowledge of any other data.

Statistical Analysis

Cochran's Q and McNemar tests were used to find the difference between the results of segmental evaluation from the methods and evaluating intra and inter-observer variability.

A P value <0.05 was considered significant. The agreement among the methods was studied by using multi-rater kappa statistics. STATA 8 SE (Texas, USA) was utilized for the statistical analysis. STARD checklist was considered for reporting the results of the study.

Results

Visual assessment of wall motion at rest and during dobutamine stress echocardiography was possible in all 254 segments and strain rate analysis was possible in all except two segments. There was no gender-base difference in our patients. A total of 70 (27.6%) segments of 254 segments which showed thinning and increased brightness were considered non-viable, and 184 segments were considered viable at resting two-dimensional visual assessment. Seventy nine (31.1%) of 254 segments showed severe dyssynergy at rest and did not show

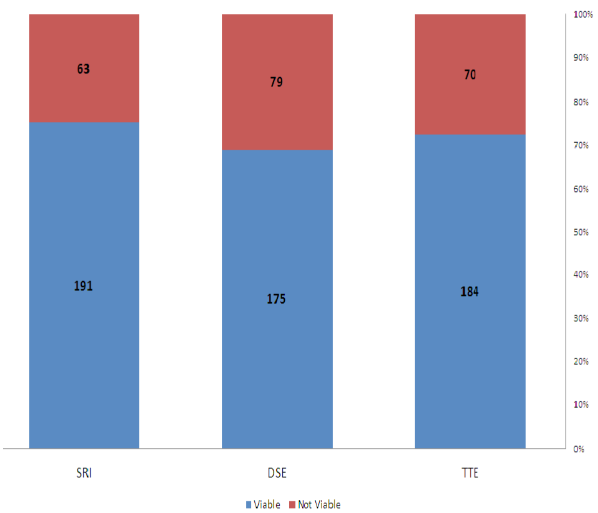


Figure 2. Percentage of viable and non viable segments by TTE, DSE and SRI

Table 1. Comparison between the results of TTE and SRI

		TTE			Dif * [CI 95%] †	P value †	kappa (SE) ‡
		Viable	Not viable	Total			
SRI	Viable	184	7	191	0.028 [0.007 – 0.048]	0.016	0.93 (0.06)
	Not viable	0	63	63			
	Total	184	70	254			

* Dif: Difference between the proportion of detecting non-viable segments by each method † based on McNemar test; CI 95%: 95% Confidence Interval ‡ P values < 0.001

improvement in wall motion with dobutamine stimulation and were considered non-viable. Dobutamine stress echocardiography showed 175 segments to be viable. Analysis of strain rate samplings at rest and during dobutamine stimulation demonstrated non-viability in 63 (24.8%) segments and viability in 191 segments. Of 254 segments, 79 (31.1%) segments were evaluated as non-viable by dobutamine stress echocardiography, 70 (27.6%) by trans-thoracic echocardiography and 63 (24.8%) by strain rate analysis (Fig. 2). All segments evaluated as viable myocardium by trans-thoracic echocardiography were also viable by strain rate and only 7 of 70 segments that evaluated as nonviable by trans-thoracic echocardiography were considered viable by strain rate. Ten segments were considered viable by trans-thoracic echocardiography but considered non-viable by dobutamine stress echocardiography. Using strain rate as reference, trans-thoracic echocardiography seemed to have better sensitivity for detection of viable myocardium than dobutamine stress echocardiography. Significant difference was observed among the segments evaluated as non-viable by the three methods (Cochran's Q test, P < 0.001).

Multi-rater kappa statistics was 0.88 (P < 0.001) which suggested an almost perfect agreement among the tests. Tables 1-3 show the pair-wise comparisons between the results of methods. The result of each diagnostic method for detecting non-viability of cardiac segments was statistically different compared with other methods (P = 0.016 for TTE-SRI, P = 0.012 for TTE-DSE and P < 0.001 for SRI-DSE comparisons).

However, considering the 95% confidence interval for the differences, it can be concluded that no significant differences existed among the methods for evaluation of non-viability. Kappa statistics showed almost perfect agreements between each pair of methods. (κ = 0.93 for TEE-SRI, κ = 0.90 for TEE-DSE and κ = 0.82 for SRI-DSE comparisons; all P < 0.001; all SE = 0.06).

Table 3. Comparison between the results of SRI and DSE

		TTE			Dif * [CI 95%] †	P value †	kappa (SE) ‡
		Viable	Not viable	Total			
SRI	Viable	174	1	175	0.036 [0.010 – 0.060]	0.012	0.90 (0.06)
	Not viable	10	69	79			
	Total	184	70	254			

* Dif: Difference between the proportion of detecting non-viable segments by each method † based on McNemar test; CI 95%: 95% Confidence Interval ‡ P values < 0.001

Table 3. Comparison between the results of SRI and DSE

		TTE			Dif * [CI 95%] †	P value †	kappa (SE) ‡
		Viable	Not viable	Total			
SRI	Viable	174	17	191			
	Not viable	01	62	63	0.063 [0.031 – 0.095]	<0.001	0.82 (0.06)
	Total	184	70	254			

* Dif: Difference between the proportion of detecting non-viable segments by each method † based on McNemar test; CI 95%: 95% Confidence Interval ‡ P values < 0.001

Discussion

Patients with ischemic left ventricular (LV) dysfunction are increasingly referred for the assessment of myocardial viability. The present study demonstrated that, in these patients, with history of infarction, ischemic LV dysfunction and suspected myocardial hibernation, resting visual assessment is an important parameter of myocardial viability and can be used in a routine clinical setting, with reliable accuracy and almost comparable agreement with dobutamine stress echocardiography and strain rate (κ = 0.93 for TTE-SRI, κ = 0.90 for TTE-DSE and κ = 0.82 for SRI-DSE comparisons; all p-values < 0.001; all SE = 0.06).Viability assessment after myocardial infarction remains challenging but is important for prognosis and in deciding whether revascularization is appropriate. The most commonly used methods to assess viability include :dobutamine stress echocardiography (based on presence of contractile reserve), fluorodeoxyglucose positron emission tomography (based on metabolic activity), thallium redistribution single photon emission computed tomography (based on cell membrane integrity), and contrast delayed enhancement (based on replacement by fibrosis) in cardiac magnetic resonance imaging.[2-4] The sensitivity and specificity of these modalities are comparable. However, these techniques alone or in combination entail radiation exposure, high cost and non- availability to patients with ferromagnetic devices or claustrophobia. It is sought that the presence of a wall motion abnormality with no wall thinning is suggestive of a viable but ischemic myocardial segment. There is distinct pathologic change late after myocardial infarction, by the 6th week when infracted area has usually been converted into a firm connected tissue scar with interspersed intact myocardial fibers. Two-dimensional echocardiography has some utility for predicting viability .Thin scarred segments are likely to be non-viable. In an analysis of pooled data from 16 studies,[15] low dose dobutamine stress echocardiography (5–15 µg /kg/min) was found to have a weighted mean sensitivity of 84% (range 71–97%) and specificity of 81% (range 69–96%) for the recovery of segmental resting function after revascularization.[16-19] Myocardial viability was more common in hypokinetic than in akinetic segments and, in agreement with previous studies. Improvement in akinetic segments was extremely specific but moderately sensitive for functional recovery six months after coronary bypass surgery.[18-20] Strain rate imaging which is independent of passive tethering effects from other regions appears promising for quantification of regional myocardial function.[9,10] The advantage of strain rate is that it is not affected by global cardiac displacement and the tethering effects of adjacent segments. It has been suggested that changes in strain rate during dobutamine stimulation allow accurate assessment of myocardial viability and is superior to two-dimensional DSE and tissue Doppler imaging for the assessment of myocardial viability.[6] Comparison of different modalities for viability assessment showed substantial level of correlation. Cwajg et al demonstrated that end diastolic wall thickness measured at rest with echocardiography can predict recovery of function in patients with suspected myocardial hibernation (comparable to Tl-201 scintigraphy). End diastolic wall thickness ≤ 0.6 cm practically excludes relevant amount of viable myocardium and is more sensitive and less specific for recovery of function than biphasic response, during dobutamine stress echocardiography. In regard to the lower sensitivity of dobutamine stress echocardiography in akinetic segments, it has been suggested that some akinetic segments may have exhausted coronary flow reserve and cannot respond to dobutamine with increased thickening despite the presence of myocardial viability. It is therefore suggested that one can conceivably forgo a dobutamine stress echocardiography or other tests for viability if the dysfunctional area of the myocardium is ≤0.6 cm in thickness. However, in patients with an admixture of thin and preserved thickness of dysfunctional segments, dobutamine stress echocardiography would be necessary to assess contractile reserve and ischemia in the latter segments.[14,21,22,23,24]

In conclusion, resting visual assessment (simple measurement of end diastolic wall thickness and increased brightness) is an important, simple and cost effective parameter of myocardial viability and in setting of significant non-viability by resting echocardiography; one can exclude dobutamine stimulation or other tests for viability.

Conflicts of Interest no declare.

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