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Right ventricular function assessment in single LAD lesion patients using strain and strain rate imaging

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KEYWORDS

Right ventricle;
Tissue Doppler imaging;
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Abstract *Background:* Strain and strain rate imaging is currently the most popular echocardiographic technique that reveals subclinical myocardial damage, and data are not available on this imaging method with regard to assessing right ventricular involvement in single LAD lesion.
Aim: To evaluate right ventricular regional functions using strain and strain rate imaging tissue Doppler method in patients with single LAD lesion.
Methods: The patient group was composed of 60 patients who had experienced first anterior myocardial infarction and had undergone successful percutaneous coronary intervention for LAD lesion. Twenty patients were selected for the control group. The right ventricular myocardial samplings were performed in three regions: the basal, mid, and apical segments of the lateral wall. The individual myocardial velocity, strain, and strain rate values of each basal, mid, and apical segment were obtained.
Results: The right ventricular tissue Doppler parameters (Sm, E, A, E/A ratio, IVA, E/E″) of the patients group were significantly decreased than controls. In addition, changes in the right ventricular mean strain and strain rate values were significantly lower in patient group than controls.
Conclusion: Right ventricular involvement in LAD lesion patient is significant even after PCI and recanalization of LAD. TDI, strain and strain rate are new, useful imaging techniques for detection of subclinical RV dysfunction in patients with LAD lesion.

1. Introduction

Echocardiographic RV functional parameters have independent and additive prognostic value in patients with LV dysfunction.[1]

Right ventricle (RV) dysfunction may be primarily attributed to abnormality of RV myocardium or secondary to left ventricle (LV) dysfunction, as a consequence of "**Ventricular Interdependence**" between the two ventricles, as they are encircled by common muscle fibers, share a common septal wall and

Abbreviations: RV, right ventricle; TDI, tissue Doppler imaging; LAD, left anterior descending; IVA, isovolumic acceleration; LV, left ventricle; PCI, percutaneous coronary intervention; E, early filling velocity; A, late filling velocity; IVS, interventricular septum; MACE, major adverse cardiac events; MI, myocardial infarction

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are enclosed within a common pericardium.[1] Hence earliest recognition of RV dysfunction is warranted but till today it remains a challenging task because of complex structure and asymmetric shape of RV.[2]

Doppler tissue imaging is more sensitive than other echocardiographic modalities in evaluation of ventricular functions.[18] Earlier studies have depended upon M-Mode, 2-D or pulsed Doppler evaluation.[3–6] Previous studies using Doppler tissue imaging have selectively evaluated lateral tricuspid annulus alone or in combination with RV lateral wall.[7,8]

Subclinical RV dysfunction is known in patients with right coronary territory ischemia. Right ventricular functions in LV anterior infarction has been subject of several studies but with significant discrepancies in results.[3,7,9–12]

The aim of the present study was to assess right ventricular systolic and diastolic function in patients with proximal LAD lesion by the use of Doppler echocardiography, tissue Doppler and strain imaging parameters.

2. Patients

The study included 60 single LAD patients underwent successful PCI for LAD after 1st time MI (clinically no MACE during 12 weeks after PCI, angiographically TIMI flow 3, patients of slow flow or no reflow phenomenon were not included in the study, and ECG showed more than 50% ST segment resolution with preserved Rwave) from January 2012 to July 2013 (Group A) who were admitted to cardiology and internal medicine departments in Tanta University Hospital and 20 persons as a control group (group B). Ecocardiographic and tissue Doppler evaluation was done after 12 weeks of PCI, and none of the patient had interventricular delay or mitral regurgitation.

3. Exclusion criteria

- Pulmonary hypertension
  - Valvular heart disease.
  - Lung disease.
  - Cardiomyopathy.
  - Renal, hepatic, hematological disorders.
  - Malignancy.

4. Methods

All selected patients were subjected to following:

1. Full history taking.
2. Full clinical examination.
3. Body Mass Index.
4. Resting standard 12 leads surface ECG.
5. Lipid profile.
6. *Conventional echocardiography and tissue Doppler assessment*:

Study was performed on GE VIVID 7 echocardiography equipment with Doppler tissue imaging technology.[2–4] MHz phased array transducer was used. Nyquist limit was set at 20 cm/s. Sample volume of 5 mm was used. Examination was performed in left lateral decubitus position during shallow breathing. Angle of incidence was kept as minimum as possible.

4.1. Evaluation of LV

End-diastolic dimension (EDD), end systolic dimension (ESD), fractional shortening (FS), regional wall motion score index, ejection fraction (EF) (modified Simpson method), trans-mitral flow and E/A ratio calculation. DTI of lateral mitral annulus in apical 4 chambers view (mean Sm, IVA calculated).[13–15]

4.2. Evaluation of RV

Included dimensions of RV, pulsed Doppler imaging of flow of tricuspid valve (E, A, E/A ratio) calculation. DTI and strain of RV lateral wall in apical four-chamber view (apical, basal, mid segment) and the mean values were calculated.[16]

4.3. Isovolumic acceleration time

Myocardial acceleration during isovolumic contraction is defined as the peak isovolumic myocardial velocity divided by time to peak velocity and is typically measured for the right

Table 1 Demographic and clinical parameters.

	Patients	Control	p value
Age (years)	45.15 ± 7.3	42.35 ± 3.19	0.1
Gender			
M	39 (65.0%)	12 (60%)	NS
F	21 (35%)	8 (40%)	
Body mass index (BMI) (kg/m^2)	26 ± 3.1	25 ± 2.4	0.19
Total cholesterol (mg/dl)	260 ± 35.5	175 ± 20.8	0.0001*
HDL-C (mg/dl)	35.1 ± 4.4	37.5 ± 5.6	0.052
LDL-C (mg/dl)	124. ± 25.3	108 ± 13. 8	0.017*
Triglycerides (mg/dl)	142.2 ± 15.9	132.8 ± 12.67	0.01*
Diabetic cases	(28.3%) 17	0%	–
Systolic (mm Hg)	132 ± 21.6	124 ± 24.5	0.16
Diastolic (mm Hg)	80.25 ± 13.63	75 ± 11.42	0.12

P value < .05 is significant and P value > .05 is nonsignificant.

ventricle by Doppler tissue imaging at the lateral tricuspid annulus. For the calculation of isovolumic acceleration, the onset of myocardial acceleration is at the zero crossing point of myocardial velocity during isovolumic contraction.

$IVA = IVV \setminus \Delta T$.[17]

4.4. Statistics

Statistical presentation and analysis of the present study was conducted, using the mean, standard deviation and unpaired *t*-test by SPSS. Multivariate linear regression correlation was conducted in-between different parameters.

5. Results

This study included 60 LAD lesion patients as group (A), and 20 normal persons as a control group (group B). Demographic data are summarized in Table 1.

M-mode indices, Pulsed Doppler indices (E, A, E/A), Pulsed-wave Tissue Doppler indices contain mean systolic velocity (S), mean early diastolic (E), mean late diastolic (A), E/E″ ratio, IVA time, mean strain, strain rate data are summarized in Tables 2–4 and correlation between different parameters are summarized in Table 5.

Table 2 M-mode echocardiographic data of study group and controls.

Parameters	Patients	Controls	*P* value
LV FS%	34.1 ± 3.2	36.7 ± 8.4	0.7
LV EF%	62.1 ± 6.5	67.3 ± 8.2	0.67
R.V. free wall thickness (cm)	0.73 ± 0.12	0.60 ± 0.17	0.019
Septum thickness (cm)	1.20 ± 0.23	1.10 ± 0.18	0.528

FS = fractional shortening, EF = ejection fraction P value < .05 is significant and P value > .05 is nonsignificant.

Table 4 RV strain, strain rate, IVA of patients and controls.

	Patients	Control	*p* value
Strain (%)	−21.85 ± 4.49	−26 ± 5.26	0.001*
Strain rate	−1.54 ± 0.55	−2 ± 0.78	0.0048*
IVA (m/s)	0.19 ± 0.12	1.70 ± 0.61	0.0001*

IVA = isovolumic acceleration, P value < .05 is significant and P value > .05 is nonsignificant.

Table 5 Positive correlation in between RV diastolic TDI parameters, LVED pr, mitral E/A ratio (multivariate linear regression correlation analysis).

Parameters	*F* value	*p* value
Mitral E/A ratio VS Tricuspid Ea/Aa	11.79	0.0089*
Tricuspid Sm VS LVFS%	46.94	<0.0001*

Ea-early diastolic wave, Aa-wave during atrial contraction, Sa-systolic wave, FS = fractional shortening, LV = left ventricle, P value < .05 is significant and P value > .05 is nonsignificant.

6. Discussion

The importance of right ventricle (RV) function as a predictor of outcome among patients with heart failure, myocardial infarction, and pulmonary embolism has been established.[18] RV dysfunction is associated with high in-hospital morbidity and mortality. Hence early recognition of RV dysfunction is warranted, but until today it remains a challenging task because of complex structure and asymmetric shape of RV. 2 Standard 2-dimensional echocardiographic evaluation of RV volumes and ejection fraction is cumbersome due to difficulty in exact delineation of RV endocardial borders because of prominent trabeculations and crescentic shape of the RV.[19]

Several explanations have been proposed for RV dysfunction in anterior LVMI. Systolic dysfunction of IVS and systolic ventricular interaction, impaired relaxation of LV

Table 3 Doppler and tissue Doppler parameters.

Parameters		Patients	Control	*p* value
Transmitral Doppler & lateral mitral annular TDI	E (m/s)	0.75 ± 0.20	0.88 ± 0.19	0.15
	IVA	1.52 ± 0.11	1.99 ± 0.24	0.049*
	A (m/s)	0.81 ± 0.22	0.79 ± 0.25	0.73
	Sm	7.42 ± 0.7	10.65 ± 1.8	0.045*
	E/A	0.89 ± 0.45	1.10 ± 0.32	0.057
	E/E″	8.50 ± 2.24	5.1 ± 1.2	0.0001*
Trans tricuspid Doppler	E (m/s)	0.59 ± 0.25	0.71 ± 0.23	0.06
	A (m/s)	0.51 ± 0.24	0.46 ± 0.17	0.39
	E/A	0.98 ± 0.34	1.19 ± 0.23	0.012*
Lateral tricuspid annulus T.D.I	S (m/s)	0.11 ± 0.02	0.14 ± 0.07	0.03*
	E/E″	4.61 ± 0.72	5.76 ± 1.56	0.0001*
	E (m/s)	0.08 ± 0.01	0.13 ± 0.06	0.0001*
	A (m/s)	0.12 ± 0.03	0.14 ± 0.034	0.014*
	E/A	0.72 ± 0.15	1.1 ± 0.46	0.0001*

Ea-early diastolic wave, Aa-wave during atrial contraction, Sa-systolic wave, IVA = isovolumic acceleration, TDI = tissue Doppler imaging, E/E″ = early diastolic flow by conventional Doppler/early diastolic flow by TDI.
P value < .05 is significant and P value > .05 is nonsignificant.

and diastolic ventricular interaction, annular interaction, pericardial interaction effect of tethered LV anterior myocardium. Mittal et al. reported that Left ventricular anterior myocardial infarction due to isolated occlusion of LAD is accompanied by impairment of Diastolic DTI parameters in all segments of RV more so along medial and lateral tricuspid annulus, impairment of systolic DTI parameters along Tricuspid annulus and lateral and anterior wall of RV and ''Myocardial interaction'' can explain these observations.[20]

The present study showed significant diastolic dysfunction in LAD group evidenced by markedly decreased tissue Doppler E, A and E/A ratio and significant systolic dysfunction by low Sm, IVA time, strain and strain rate parameters in LAD group than control. The uniqueness of our study is that it is the first one confirmed RV dysfunction in LAD patients even after recanalization and normal LV systolic function and it also ensures and supports the theory of myocardial interaction and supports results of Mittal et al. by its larger number of cases than Mittal study (60 cases in our study, 14 cases in Mittal study).

7. Conclusion

Right ventricular involvement in LAD lesion patient is significant even after PCI and recanalization of LAD. TDI, strain and strain rate are new, useful imaging techniques for detection of subclinical RV dysfunction in patients with LAD lesion.

Conflict of interest

The authors declare that there are no conflict of interest.

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