Assessment of the Improvement of Global and Segmental Diastolic Dysfunction after Coronary Arteries Revascularization

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ABSTRACT:

BACK GROUND:

With respect to cardiovascular performance at rest and exercise, diastolic function is of equal importance to systolic function, which is the ability of the ventricle to fill at low left atrial pressure and diastolic HF have hospitalization rates similar to those with systolic dysfunction

OBJECTIVE:

To assess the effect of successful coronary revascularization on segmental LV diastolic dysfunction and the effect of this segmental improvement on global diastolic function.

METHODS:

patients with diastolic LV dysfunction and ischemic heart disease that are documented by coronary angiography were selected randomly in a prospective interventional study at Ibn Al-Bitar Hospital For Cardiac Surgery from June 2012 till April 2013 and followed up to one month post coronary revascularization with Doppler echo-parameters and tissue myocardial velocities for any Improvement in global or regional diastolic dysfunction.

RESULTS:

Twenty nine ischemic left ventricular segments of total 43 segments with diastolic dysfunction showed improvement in diastolic function one month after successful revascularization.

CONCLUSION:

Segmental diastolic dysfunction can be improved with revascularization of the stenotic coronary artery supplying that segment.

KEY WORDS: diastolic dysfunction, coronary arteries revascularization

INTRODUCTION:

Diastolic dysfunction is characterized by a stiff left ventricle with decreased compliance and impaired relaxation, which leads to increased end diastolic pressure that proceed to diastolic heart failure[1], The volume of blood contained in the ventricles during diastole is lower than it should be, and the pressure of the blood within the chambers is elevated, which is reported to be about one fourth to one half of patients with heart failure (Hospital- and community-based reports)[2].

Several studies revealed that patients with diastolic dysfunction have annual mortality rate higher than the general population, and when it ends with diastolic HF it will have similar mortality and hospitalization rates similar to those of patients with systolic dysfunction [3,4,5].

Increased interstitial collagen deposition and/or infiltration of the myocardium, hypertrophy of the cardiomyocytes are shown as evidences supporting diastolic dysfunction in the histologic demonstrates [6]. These events collectively lead to a downhill in distensibility of the myocardial muscle, the ventricle then behaves as a thick rubber balloon.

When the left ventricular diastolic pressure is elevated, venous pressure in the lungs must also become elevated to maintain forward flow. Increased pulmonary venous pressure results in alveolar edema causing the patient to be short of breath [7,8].

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Furthermore, the LV global longitudinal function is often impaired in patients with heart failure with preserved EF (HFpEF), and so may be used to differentiate between normal and abnormal myocardial function. [9]

Diastolic dysfunction can be a result of any process or condition that leads to stiffening of the left ventricle, During cardiac ischemia periods, reversible stiffening can occur. New researchers tested the effect of an investigational drug called givinostat in treating diastolic dysfunction[10]., Until proving that, therapy should be directed at the cause of the left ventricle stiffness.

Using standard pulse wave Doppler, The Canadian Consensus on Diastolic Dysfunction has defined three stages of diastolic dysfunction (See table 1). Using color M-mode, Deceleration time interval (DTI) data and intraventricular pressure gradient measurements a new classification has been evolved [11].

Table I : Classification of Diastolic Dysfunction(10).

Parameter	N	Mild	Moderate	severe
E/A	1-2	< 0.8	0.8-2	≥ 2
DT (ms)	150-200	>200	150-200	<140
IVRT (ms)	50-100	≥100	60-100	≤ 60
E/E'	≤ 8	> 8	9-14	≥ 15

E= mitral annular velocity during early diastole; A= late diastole mitral annular velocity; E' = early diastole mitral annular velocity; E/E' = early diastolic transmitral to mitral annular velocity ratio; IVRT= Isovolemic relaxation time; DT=deceleration time.

Because it provides direct measurement of ventricular diastolic pressure for demonstrating impaired relaxation and filling, cardiac catheterization remains the gold standard, However, in the noninvasive assessment of cardiac diastolic function Doppler echocardiography has assumed the primary role and is used to confirm the diagnosis of left ventricular diastolic dysfunction [12,13].

The concept of Rosetta Stone for diastole was presented first by Rick A. Nishimura und A. Jamil Tajik, J Am Coll Cardiol 1997. After all, it is clear that LV diastolic dysfunction diagnosis cannot be made with only one parameter [14]. It is important to look for consistency between the different parameters. When using such an integrated approach, a reliable estimate of LV filling pressure can be achieved in most patients.[15]

Of echo parameters, tissue Doppler imaging (TDI) has been suggested for quantitative analysis of regional myocardial function [16]

TDI is modified to record low velocities of myocardial tissue and to reject the high velocities generated by blood flow, It allows the assessment of local tissue velocities (point velocities), which is the velocity of a specific LV region [18].

Of TDI parameters, **E'** had been used for long time to assess global diastole status. Recently, new TDI parameters have been evolved to assess focal segment function, of these parameters, myocardial velocity (**EM**) is potentially important to assess segmental myocardial diastolic function [17,18]. (see fig I).

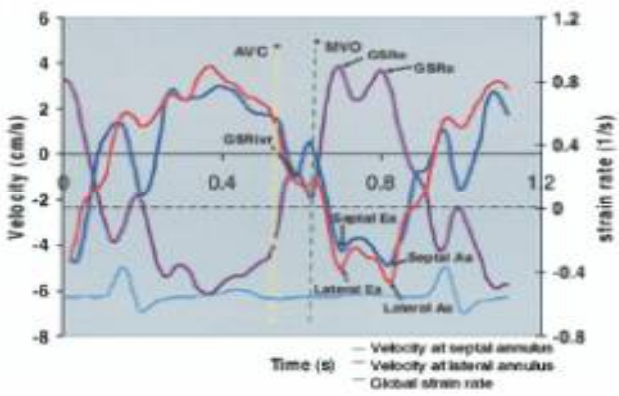

Figure I: TDI shows the myocardial velocity waves for two myocardial segments (septal and lateral) with the global strain rate.

The normal values of TDI parameter for assessing segmental diastolic function (Em) is illustrated in table (II)

Table II: velocity of individual segments determined with Tissue Doppler Echocardiography.

Em cm/sec	septum	lateral	inferior	anterior
Basal	7.9 ± 2.1	8.5 ± 2.7	9.0 ± 2.4	8.0 ± 2.4
Mid	8.3 ± 2.5	6.8 ± 1.8	6.8 ± 3.1	7.2± 2.0
Apical	6.0 ± 2.9	6.7 ± 2.5	4.7 ± 1.9	4.5± 2.9

In general, the best validated parameter is pulse-wave velocity [18]. An emerging parameter is pathologic wave reflection in the arterial tree, and hence late systolic wall stress [19]. The magnitude of wave reflection appears to be independently associated with diastolic dysfunction [20,21]. and increased LV mass [22]. It is specifically an independent predictor of incident heart failure and mortality [23].

When it is applicable, comparison with other studies about changes in diastolic dysfunction grade, can inform about predicting future events, total mortality and treatment decisions [24,25].

There are many researches studied the global diastolic dysfunction but just few studies assessed the segmental myocardial function.

In our study, we investigate the improvement of segmental diastolic dysfunction after correction of the ischemic status, which is supposed to be the cause of that dysfunction, and the impact of this improvement on the global diastolic status.

PATIENTS AND METHODS:

We randomized forty patients with diastolic LV dysfunction and ischemic heart disease in a prospective interventional study, some of them have multiple coronary lesions to deal with. Five patients (eight lesions) were non feasible for PCI or couldn't recanalized at time of revascularization and have been excluded from the study.

The total number of the patients that included in the study were 35, while the total number of lesions revascularized were 43 lesions).

Table 1 shows the baseline characteristics of the patients enrolled in our study.

Table 1: The patients baseline characteristics.

Variables		No.	Total no.
Gender	male	(77%) ٢٧	(100%) ٣٥
	female	(23%) ٨	
Hypertension	present	(26%)٩	(100%) ٣٥
	absent	(74%)٢٦	
Diabetes	present	(20%)٧	(100%)٣٥
	absent	(80%)٢٨	
EF%	≥ 55%	(82%)٢٩	(100%)٣٥
	< 55%	(18%)٦	

One month post coronary revascularization, assessment of segmental and global diastolic dysfunction has been done with Doppler echo-parameters and tissue myocardial velocities for any Improvement in global or regional diastolic dysfunction. statistical analysis of the data obtained from the traditional echocardiogram and tissue Doppler parameters has been done. One month Post successful revascularization, improvement of global diastolic function defined as any decrease of E/E' ratio that was above 8, and improvement of segmental diastolic function is defined as any increment of Em from the base line that was below normal value for this segment. All the culprit segments assessed according to its corresponding vessels and as it shown in table 2.

Table 2: Coronary arteries and its corresponding LV segments.

LV Segment	Corresponding Coronary Artery
Apical anterior Mid anterior Basal anterior Apical septum Mid septum	LAD
Mid lateral Basal lateral	LCX
Apical inferior Apical lateral	LAD/LCX OVERLAP
Mid inferior Basal inferior Basal septum	RCA

Non viable myocardium was defined as LV aneurysm , dyskinetic or akinetic segment assessed by coronary angiography , echocardiography and ECG, Uncontrolled DM, Uncontrolled hypertension or LV hypertrophy , Age > 60 years, History of persistent or paroxysmal atrial fibrillation, Aortic stenosis, Poor quality echo image, have been excluded from the study.

STATISTICAL ANALYSIS:

Descriptive statistics (Mean, SD and P value) were calculated. Data are expressed as mean ± SD. Differences between continuous data were tested by t test, as appropriate. A p value < 0.05 was considered statistically significant.

RESULTS:

Successful revascularization has been achieved for all the 43 lesions defined by TIMI flow 3 with no significant coronary complications such as dissection or no reflow.

Table (3) show the comparison of E/E' ratio, Em and EF% pre and post-revascularization.

Table 3: Distribution of echo-data according to pre and post revascularization.

Variable		MEAN ± SD	P VALUE
E/E' ratio	pre-revascularization	22.77 ± 7.6	P = 0.171
	post-revascularization	22.17 ± 8.3	
Em (cm/s)	pre-revascularization	3.14 ± 0.84	P = 0.00001
	post-revascularization	3.58 ± 1.00	
EF%	pre-revascularization	54.91± 6.97	P = 0.0009
	post-revascularization	56.7 ± 7.55	

Regarding E/E' ratio, there was no significant difference between pre and post revascularization.

The pre and post-revascularization mean ± SD were (22.77 ± 7.6, 22.17 ± 8.3) respectively, the p value was non significant (p = 0.171) , while there was significant difference regarding the early myocardial velocity (Em) pre and post revascularization.

The pre and post-revascularization mean ± SD were (3.14 ± 0.84, 3.58 ± 1.00) respectively, the p value was (p = 0.00001).

Regarding EF%: there was significant difference between the pre and post revascularization. The pre and post-revascularization mean ± SD were (54.9 ± 6.9, 56.7 ± 7.5) respectively, the p value was significant (p = 0.0009).

DISCUSSION:

The transmitral TDI parameter (E/E') has been used for assessing global diastolic function, and the recently evolved measurement of myocardial velocity (Em) used for assessing segmental diastolic function (for the segment that supplied by the culprit vessel we dealt with by PCI).

Despite there are large numbers of studies that used the echo parameters and the TDI parameters for assessing LV diastolic function, Unfortunately after extensive search we got only one study that investigated the effect of revascularization of ischemic coronary disease on diastolic LV function.

The study (Abnormal Regional Left Ventricular Systolic and Diastolic Function in Patients With Coronary Artery Disease Undergoing Percutaneous Coronary Intervention) [26] was designed to characterize both regional left ventricular (LV) systolic and diastolic function after percutaneous coronary intervention by using strain imaging (SI) derived from 2-dimensional speckle-tracking echocardiography (another recently evolving TDI parameter for assessing systolic and diastolic LV function).

In this study they monitored in at-risk segments after percutaneous coronary intervention in 30 patients with coronary artery disease. Strain data in the at-risk segments were compared with values derived from remote non ischemic segments.

They found that upon reperfusion, systolic deformation parameters returned to near-normal pre-occlusion values. However, strain image diastolic index (SI-DI) values in the both proximal and distal at-risk segments decreased 30 min after reperfusion and were still lower in the distal at-risk segment 24 h after reperfusion.

They concluded that SI analysis provides detailed mechanical characterization of regions with myocardial ischemic insult and can demonstrate post-ischemic diastolic stunning despite complete systolic functional recovery after reperfusion.

In our study, the analysis of segments has been performed according to coronary artery distribution and corresponding LV segments and as it shown in table III

The statistical analysis showed significant improvement of the segmental diastolic function represented by the mean myocardial velocity (Em) and the p value was 0.00001. Also we noticed significant improvement of systolic LV function represented by EF% and the p value was 0.0009., So, coronary revascularization is associated with improvement of segmental diastolic dysfunction as well as improvement of systolic LV function.

The study couldn't show significant improvement of global diastolic LV dysfunction assessed by transmitral annular tissue Doppler (E/E' ratio) one month post revascularization, the p value was 0.171.

Explanations for the non significant improvement of global diastolic dysfunction can be suggested as:

- The presence of small coronary vessels disease that are not candidate for PCI.
- The one month period post revascularization may not be enough for the LV to regain its diastolic function especially because diastolic dysfunction is associated with myocardial fibrosis as mentioned in the pathophysiology of diastolic dysfunction.
- And lastly, the sample size may be small to depict the improvement the diastolic function.

Study limitations

- The need for study sample involving patients with IHD without other possible cause for the diastolic dysfunction was a strong factor in limiting the sample size.

-The short term follow up (only one month).

CONCLUSION:

The study indicates that treatment of ischemic heart disease can improve segmental diastolic dysfunction, but it failed to show significant improvement of global diastolic dysfunction, So for more evaluation of this important subject, we recommend a larger sample size study and longer follow up period

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