Tissue Doppler Imaging Versus Conventional Echocardiography In Evaluation Of Diastolic Function In Diabetic Patients

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Abstract: modifications and medical interventions could prevent or delay the subsequent development of heart failure in Diabetic patients. Conventional echocardiography was used to screen for and diagnose left ventricular diastolic dysfunction-LVDD- but the results was not satisfactory and underestimate the magnitude of LVDD due to the pseudonormal pattern in grade 2 diastolic dysfunction. Tissue Doppler imaging is considered a better non invasive and more accurate screening modality. **The work aimed a** comparing tissue Doppler imaging to conventional Echocardiography in diagnosing diastolic dysfunction in diabetic patients. **Patients and methods** forty diabetic patients and 20 age matched volunteers – as a control group – were included in this study individuals with IHD,HTN cardiomyopathy or any obvious liver or renal disease were excluded – blood sugar, lipid profile, ECG, conventional echocardiography and tissue Doppler imaging were done for all individuals. **Results** 22 of the 40 diabetic patients had diastolic dysfunction compared to only one of the control group and from those 22 with diastolic dysfunction 13 was diagnosed by both conventional echo and TDI, 1 patient diagnosed only by conventional echo, while 8 patients were diagnosed by TDI and the superiority of TDI in diagnosing LVDD compared to conventional Echocardiography was statistically significant. Also there was a liner correlation between duration of diabetes and the presence of LVDD that was statistically significant**. Conclusion** diabetics especially with longer disease duration are more prone to have diastolic dysfunction even with normal EF and FS and TDI is a better non invasive method in assessing diastolic dysfunction compared to the conventional Echocardiography.
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1. Introduction

Diabetes is one of the most common diseases in the world (1)and its Cardiovascular complications are known to be the main cause of death and morbidity in diabetic patients, as over 75% of all diabetic patients die from cardiovascular events.There is an increased rate of ischemic heart disease and cardiomyopathy, which may lead to congestive heart failure in the absence of coronary artery disease **(1.2)**

A number of potential mechanisms have been proposed to explain abnormal myocardial function in diabetes. First, small vessel disease both due to structural abnormalities in the vessels as well as functional disturbances (including endothelial dysfunction) may lead to reduced substrate delivery. Second, myocyte function may be abnormal due to alterations of substrate supply and utilization, including disturbances of glucose transporters, free fatty acids, and calcium homeostasis. Third, both apoptosis and myocardial fibrosis have been identified in diabetic subjects, reflecting changes in the hormonal milieu, particularly involving Angiotensin and Aldosterone. Finally, diabetic autonomic neuropathy has been widely described and appears to be associated with left ventricular dysfunction **(3,4,5,)**

The traditional measurements of diastolic function, the Doppler derived mitral valve inflow velocity pattern and its derivatives, have proved difficult to interpret because of the pseudonormal pattern that defines grade 2 dysfunction, but may be mistaken for the normal pattern unless differentiation by the Valsalva maneuver or by assessing pulmonary vein flow is performed. While the clinical course of diastolic dysfunction is characterized by decreasing effectiveness of myocardial relaxation and extension associated with increasing left atrial pressure and size, the respective developments of pressure and filling cannot be mirrored by the traditional Doppler parameters. An even more important limitation, however, is the non-quantitative pattern recognition used for assessing diastolic function and the changes in the course of disease and during preventive therapy**.(6)**

Tissue Doppler imaging is a robust and reproducible ultrasound technique employing the low-frequency and high-amplitude ultrasound signals reflected from the myocardium.

Pulsed tissue Doppler imaging for Detection of systolic or diastolic dysfunction depends on the sensitivity and specificity of the diagnostic technique

used. Tissue Doppler imaging has demonstrated that the systolic myocardial velocity S′ is a more sensitive measure of systolic function than ejection fraction and that the early diastolic myocardial velocity E' and E/E' have the best correlation with left ventricular relaxation and compliance indexes.

Regional left ventricular function is quantified as the myocardial velocity of long-axis motion in cm/s during systole (S′), early diastole (E) and late diastole (A).

Left ventricular global function is the average of these segmental velocities, obtained either at the mitral annulus or very basal myocardium in the apical four- and two-chamber views. **(7,8)**

The aim of this wok is comparing tissue Doppler imaging to conventional echocardiography in diagnosing diastolic dysfunction in diabetic patients.

2. Patients and methods:

The study included 40 diabetic patients from Fayoum university hospital presented to the out patient clinic for controlling their blood sugar and 20 age and sex matched healthy volunteers as a control group. Patients who had valvular heart disease,Ischemic heart disease(excluded by history and ECG,absence of SWMA by Echo), congestive heart failure, overt renal disease or overt renal impairment were excluded from this study the following were done for all individuals Carful history taking, full clinical examination,laboratory investigations include: FBS, 2HPP, lipid profile liver enzymes as well as serum creatinine Echocardiography (using Siemens - Acuson CV70 - system equipped with TDI technology) was performed to all subjects in the left lateral position and 2D & M- mode techniques were used for measurement of the following parameters LVEDD LVESD, EF, FS, LA size, isovolumic relaxation time(IVRT) & DT as well as exclusion of any wall motion abnormalities. Transmitral flow pattern: Using PW Doppler across the mitral inflow tract,two waves were measured :the early E wave corresponding to early ventricular filling and A wave which reflect atrial contraction was typically measured by placing a 2 mm sample volume at the mitral leaflet tips in the four chamber apical view. Tissue Doppler imaging mitral annular velocity was obtained by placing a 5 mm sample volume over the lateral or septal mitral annulus.and also Systolic S' (Sa), early diastolic E (Ea) and the late diastolic velocities A' (Aa) were measured.

Statistical analysis:

Data were analysed using SPSS version 10. Variables as age, sex, duration of diabetes mellitus, EF, FS, Mitral inflow velocities, isovolumic relaxation time and mitral E wave deceleration time on Doppler echocardiography and mean diastolic mitral annular velocities on TDI were compared and. data were expressed as mean ± standard deviation and in percentages.

3. Results

This study included 40 diabetic patients and 20 healthy age and sex matched control persons their age ranged between 18-55 years old.

(Table - 1): Distribution of study groups according to type of diabetes, and type of treatment among cases.

variable	Case (n=40)	
	No.	%
Type of diabetes • Type 1 • Type 2	 11 29	 27.5% 72.5%
Type of treatment • Insulin • Oral hypoglycemic	 14 26	 35% 65%

The percentage of type 1 diabetics was 27.5 % while type 2 was 72.5% The percentage of patients treated with insulin was 35% while those on oral hypoglycemic drugs was 65 %.

(Table--2) Comparison between study groups according to anthropometric measures and investigations.

Variables	Case (n=40)		Control (n=20)		*p*-value	Sig.
	Mean	±SD	Mean	±SD		
Weight	79.2	±14.6	71.7	±12.8	0.2	NS
BMI	28.6	±4.7	28.6	±10.8	0.9	NS
SBP	126.3	±9.5	119.5	±6.9	0.003	HS
DBP	80	±10.6	73.8	±5.8	0.02	S
FBS	187.4	±89.7	89.6	±7.6	<0.001	HS
2HPP	297	±111	175.4	±16.9	<0.001	HS
Creatinine	1.03	±1.2	0.77	±0.1	0.3	NS

- Systolic blood pressure was highly significant in diabetic group as compared with control group (126.3 ±9.5 vs 119.5 ±6.9, *p* value = 0.003)
- Diastolic blood pressure was significantly higher in diabetic group as compared with control group (**80**±10.6 vs 73.8 ±5.8, *p* value =0.02)
- FBS & 2HPP were highly significant in diabetic group as compared with control group with *p* value was <0.001 in both.

(Table 3): Comparison between study groups according to lipid profile

Variables	Case (n=40)		Control (n=20)		*p* value	Sig.
	Mean	±SD	Mean	±SD		
LDL	103.4	±31	86.7	±7.4	0.002	HS
HDL	56.2	±9.7	46.2	±4.5	<0.001	HS
Cholesterol	193.2	±40.5	139.2	±23.8	<0.001	HS
TG	196.6	±81.7	144.6	±39.9	0.002	HS

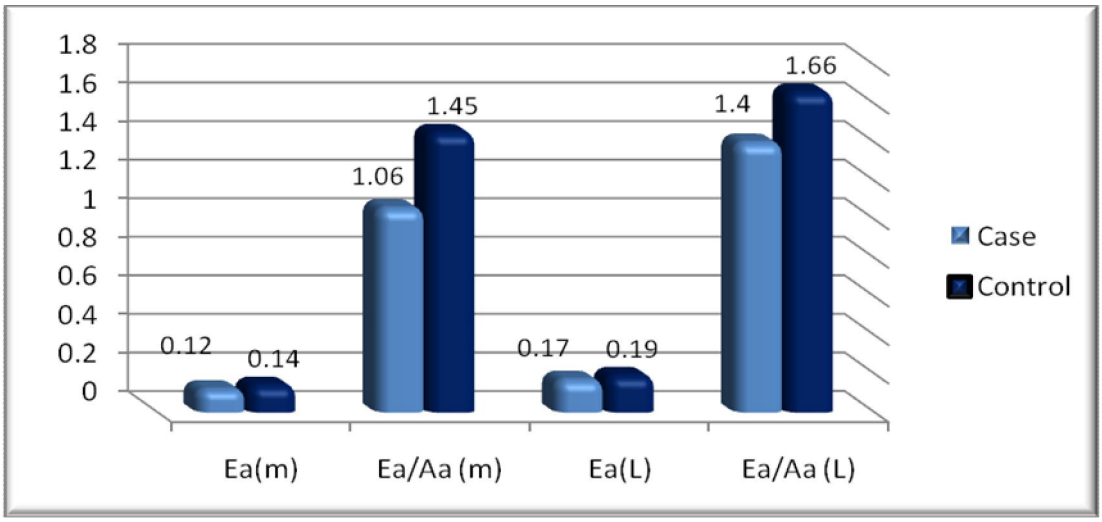
Lipid profile including LDL,HDL, Cholesterol, TG wave highly significant in diabetic group as compared with control group as presented in table 3.

(Table 4): Comparison between study groups according to Echocardiography findings

Variables	Case (n=40)		Control (n=20)		*p* value	Sig.
	Mean	±SD	Mean	±SD		
LVPWd	9.3	±1.5	8.12	±1.4	0.004	HS
LVIDd	47.3	±4.4	43.8	±13.5	0.1	NS
IVSd	8.4	±1.8	9.9	±8.3	0.3	NS
LVIDS	30.9	±3.3	30.6	±4.4	0.7	NS
EF	0.63	±0.05	0.64	±0.07	0.4	NS
FS	0.34	±0.03	0.35	±0.05	0.5	NS
LA size	32.6	±4.6	30.3	±3.7	0.06	NS
E(m/s)	0.78	±0.2	0.8	±0.2	0.6	NS
A(m/s)	0.72	±0.2	0.53	±0.1	<0.001	HS
E/A	1.12	±0.29	1.5	±0.3	<0.001	HS
DT	190.5	±53.5	173.2	±34.7	0.2	NS
IVRT	83.8	±18.4	81.6	±12.6	0.6	NS

Data derived from Echocardiography showed that the left ventricular posterior wall diameter (LVPWd), A wave velocity were significantly higher in diabetic group as compared with control group (*p* value =0.004, <0.001 respectively).

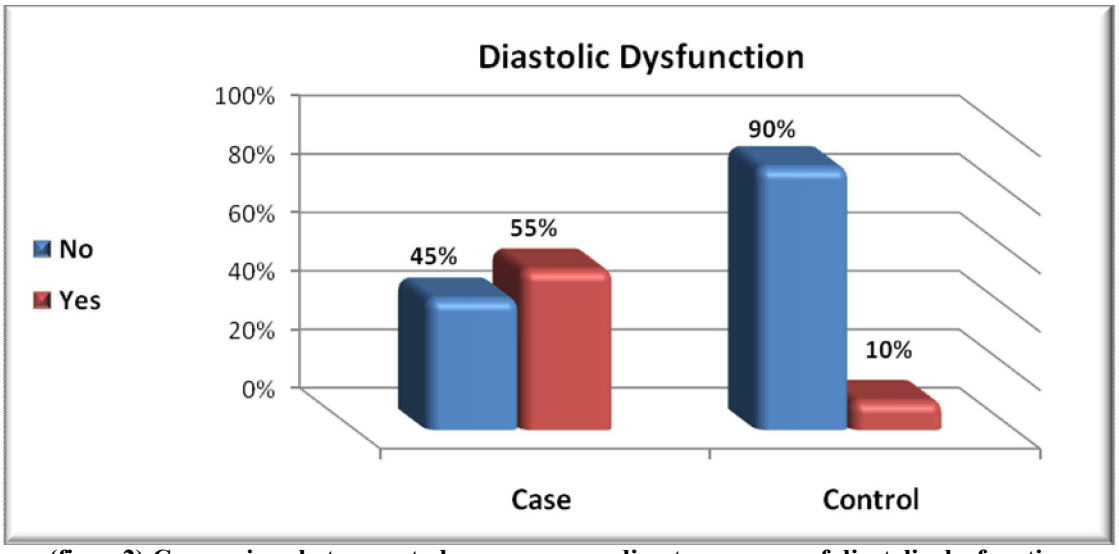
A / E ratio was lower in diabetic group as compared with study group persons with statistically high significance. (*p* value <0.001).



(Figure-1): Comparison between study groups according to Tissue Doppler finding

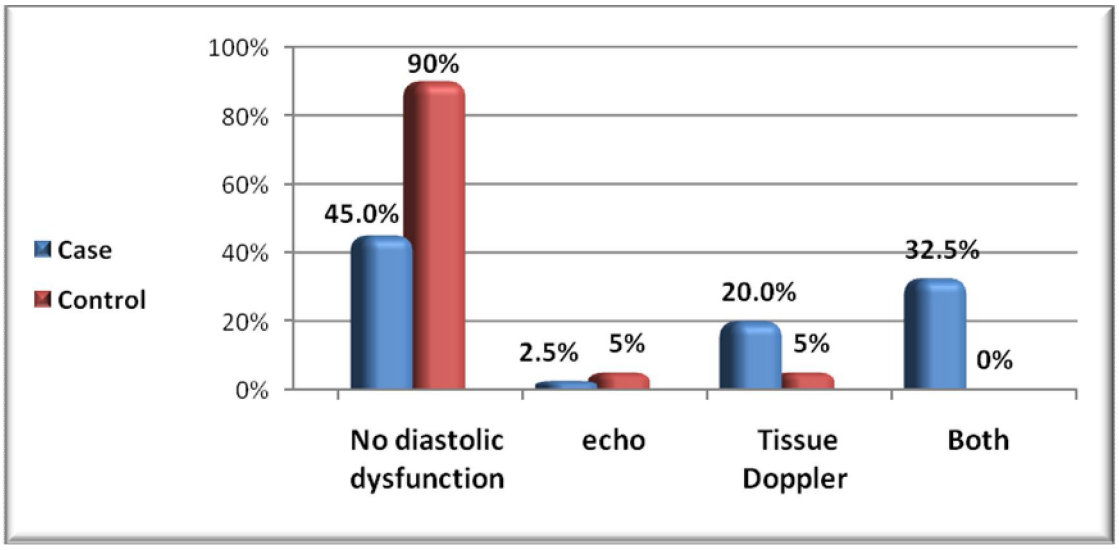
- Septal Ea(m)velocity was highly significant lower in diabetic subjects as compared with control persons with (*p* value <0.001).
- Septal Aa (m) velocity was highly significant higher in diabetic subjects as compared with control persons with (*p* value <0.001).
- Ea/Aa (m) was highly significant lower in diabetic subjects as compared with control persons with (*p* value < 0.001).
- Lateral Aa(L) velocity was significantly higher in diabetic subjects as compared with control persons with (*p* value =0.01).

Ea/Aa (L) was significantly lower in diabetic subjects as compared with control persons with (*p* value = 0.03)



(figue-2) Comparison between study groups according to presence of diastolic dysfunction

From 40 diabetic patients there were 22 patients have diastolic dysfunction with a percentage of 55% while from 20 control persons there were only 2 persons have diastolic dysfunction with a percentage of 10%., this means that there was a highly significant statistical difference (*p* value = 0.001)



Figue-3 : Comparison between study groups according to diagnostic tools used for detection of diastolic dysfunction

Within 22 diabetic subjects having diastolic dysfunction, there were only one patient detected by conventional echocardiography only, 8 patients detected by tissue TDI only AND 13 patients detected by both

This means statistically that tissue Doppler as a tool used in detection of diastolic dysfunction is highly significant more valuable as a diagnostic method than conventional echocardiography. (*p* value = 0.004).

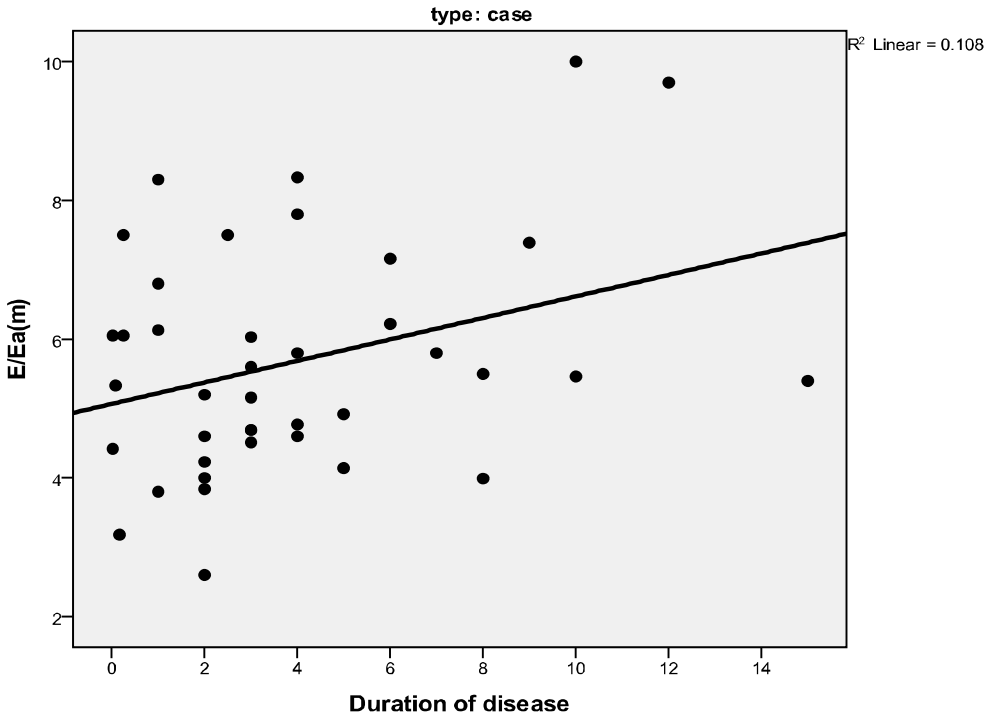


Figure-4 Correlation between duration of DM diastolic dysfunction in TDI measurements.
This figure shows that there is a + correlation which is statistically significant between the duration of the disease and diastolic dysfunction (E / Ea) with (r : + 0.3) and (*P* value = 0.03).

4.Discussion

Early detection of diabetic heart disease is of importance, Numerous studies have attempted to determine the prevalence of left ventricular diastolic dysfunction in asymptomatic diabetic subjects with normal left ventricular systolic function using Doppler assessment of transmitral flow velocity, have underestimated the prevalence of LVDD. The Doppler-derived mitral valve inflow velocity pattern and its derivatives, have proved difficult to interpret because of the pseudo normal pattern, that defines grade 2 diastolic dysfunction, may be mistaken for the normal pattern. Unless differentiation by the Valsalva maneuver or by assessing pulmonary vein flow is performed. Also loading conditions, especially preload, influence the indices obtained from these velocity patterns.. Tissue Doppler imaging (TDI) of mitral annular motion has been proposed as an improved (load-independent) noninvasive method of assessing diastolic function via echocardiography and it does not possess the substantial limitations of previous traditional noninvasive techniques. So TDI appears to be extremely effective for the identification of subclinical left ventricular diastolic dysfunction in diabetic patients.

In this study it was found that when using the conventional echocardiography in screening for LVDD there were 14 diabetic patients out of 40 found to have LVDD versus a single case in the control group out of 20 and the **A wave velocity** was (0.72 **(m/s)** ± 0.2) in diabetics while it was (0.53 **(m/s)** ± 0.1) in control group, this means that the A wave velocity is higher in diabetic patient than in the control persons and this was highly statistically significant (*p* value < 0.001). **E / A ratio** was 1.12 ± 0.29 in diabetics,while it was 1.5 ± 0.3 in control group, this means that E / A ratio is lower in diabetic patient than in the control persons and this was highly statistically significant (*p* value < 0.001) Both study and control groups have normal systolic function with normal EF.

And when using in screening for LVDD 21 diabetics were found to have LVDD out of 40 versus a single case in the control group out of 20 and **the Ea wave velocity** was 0.12 **(m/s)** ± 0.04 in the diabetics while it was 0.14 **(m/s)** ± 0.02 in control group, this means that Ea(m) wave velocity is lower in diabetic patient than in the control persons this was highly statistically significant (*p* value < 0.001).**Ea/ Aa ratio** was 1.06 ± 0.38 in diabetics,while it 1.45 ± 0.35 in control group, this means that Ea / Aa ratio is lower in

diabetic patient than in the control persons and this was highly statistically significant (p value < 0.001).

- **Aa(l) wave velocity** was 0.13± 0.03) in diabetics while it was 0.12± 0.01 in control group, this means that Aa (l) wave velocity is higher in diabetic patient than in the control persons with statistically significant difference (p value = 0.01)**.**
- **Ea/ Aa(l) ratio** was : 1.4 ± 0.44 in case group,while it was 1.66 ± 0.5 in control group, this means that Ea / Aa ratio is lower in diabetic patient than the control persons with statistically significant difference (p value = 0.03)

❖ Also our study showed that from 22 diabetic patients having left ventricular diastolic dysfunction there were one patient only was detected by conventional echocardiography alone, 8 patients were detected by TDI alone, and 13 patients by both. This reflect that Tissue Doppler imaging is more valuable in detection of diastolic dysfunction than conventional Echocardiography with statistically significant difference with (p value = 0.004).

❖ These results support the existence of a distinct diabetic cardiomyopathy that causes diastolic dysfunction formerly. In addition, diastolic dysfunction has been shown to precede systolic dysfunction in diabetics, and even before the presence of pathological findings on clinical examination. Thus, impairment of diastolic parameters may be used as an early preclinical manifestation of diabetic cardiomyopathy

Our results agrees with that found by **Virendra, 2011** who assess Diastolic dysfunction in 127 asymptomatic type 2 diabetes mellitus with normal systolic function and 100 healthy subjects and found that of the total 127 subjects, 69 (54.33%) from the case group had diastolic dysfunction, and 11% amongst 100 subjects in the control group population showed the diastolic dysfunction (P < 0.001).also found that Patients with a longer duration of DM (of 11 to 15 years) had a higher prevalence of diastolic dysfunction (P < 0.02). and so this study reveals high incidence of diastolic dysfunction in asymptomatic diabetic subjects. **(9)**

Diamant *et al. (2003)* stated that early (E) acceleration peak, deceleration peak, peak filling rate, and E/A ratio, and all other indices of diastolic function, were significantly decreased in patients with recently diagnosed, well-controlled and uncomplicated type 2 diabetes compared with the controls ('P' < 0.02). These findings are similar to our results. **(10)**

Also **Boyer *et al.*, (2004)** who assess the Prevalence of ventricular diastolic dysfunction in asymptomatic, normotensive patients with type two diabetes mellitus stated that the prevalence of LV diastolic dysfunction in these subjects is high. Diastolic dysfunction was found in 75% subjects. They also found that, TDI detected diastolic dysfunction more often than any other Echocardiographic parameter.(11)

Our results agree with what was found by **Kamile Gul *et al.* (2009**) who assess early left ventricular dysfunction in 81 patients with type 1 diabetes mellitus and51 healthy volunteers using Tissue Doppler imaging and found that type 1 DM subjects are characterized with impaired diastolic parameters. In addition, DD has been shown to precede systolic dysfunction in diabetics, even before the presence of pathological findings on clinical examination. And that PW Doppler is limited in the setting of pseudo-normal pattern, which can be unmasked by preload reducing conditions such as Valsalva maneuver So TDI is useful to overcome this outstanding problem. Furthermore, addition of TDI to PW Doppler has been reported to improve the Echocardiographic diagnosis of diastolic impairment in diabetic population.,**(12).**

Finally our study demonstrates that the prevalence of pre-clinical diastolic dysfunction is high among the diabetic subjects. and that Tissue Doppler imaging is more valuable than conventional Echocardiographic parameters in diagnosis of this preclinical diastolic dysfunction in diabetic patient.

Study limitations

- We did not perform coronary angiography to exclude coronary artery disease on ethical grounds. So, we carefully excluded the patients with obvious ischemic symptoms, ECG changes, and Echocardiography
- Evaluation of glycemic control on the basis of HbA1c measurement was another limitation in this study due to resources limitations.

5. Conclusion

- DM is a strong independent factor for LV diastolic dysfunction even in absence of ischemic, hypertensive or valvular heart diseases
- Early detection of subclinical cardiac involvement in diabetics may provide an approach for identifying high-risk patients who are likely to benefit from an earlier intervention. And institution of treatment for diastolic dysfunction
- TDI may permit early identification of this subclinical diastolic dysfunction in the presence of normal diastolic function indices by conventional echocardiography.

Recommendations

Diabetic patients should be evaluated early for diastolic function even in the absence of

manifestation of diastolic heart failure.. Diastolic function of diabetic patients can be easily and practically assessed by TDI. Which seems to be more valuable than conventional Echocardiography. The assessment of early myocardial relaxation velocities provides an additional window on LV diastolic function in a manner complementary to evaluation of mitral inflow.

References

(1). Paul Poirier., Bogaty, P., Marois, L., ***et al.,*** **(2000)** Diastolic dysfunction in normotensive men with well controlled type 2 diabetes mellitus. Importance of manoeuvres in echocardiographic screening for preclinical diabetic cardiomyopathy. Diabetes Care 24, 5–10.

(2). Yu CM, Sanderson JE, Marwick TH ***et al.,*** **(2007)** Tissue Doppler imaging. A new prognosticator for cardiovascular disease. J Am Coll Cardiol 49:1903–1914

(3). Trambaiola P, **(2001)** New insights into regional systolic and diastolic left ventricular function with tissue Doppler echocardiography: from qualitative analysis to a quantitative approach. J Am Soc Echocardiograpy. 14:85-96,

(4). Howard BV, Rodriguez BL, Bennett PH, ***et al.,*** **2002**) Prevention conference VI: diabetes and cardiovascular disease: writing group I: epidemiology. **Circulation**;105(18):e132-7.

(5). **Kleinman JC**, Donahue RP, Harris MI, ***et al.,***. **(1988)** Mortality among diabetes in a national sample. **Am. J, Epidemiol**; 128:389-401.

(6). Yu CM, Sanderson JE, Marwick TH ***et al.,*** **(2007)** Tissue Doppler imaging. A new prognosticator for cardiovascular disease. J Am Coll Cardiol 49:1903–1914

(7). Yip G, Wang M, Zhang Y ***et al.,*** **(2002)** Left ventricular long axis function in diastolic heart failure is reduced in both diastole and systole: time for a redefinition? Heart 87:121–125

(8). Kasner M, Westermann D, Steendijk P ***et al.,*** **(2007)** Utility of Doppler echocardiography and tissue Doppler imaging in the estimation of diastolic function in heart failure with normal ejection fraction—a comparative Doppler-conductance catheterization study. Circulation 116:637–647

(9).Virendra C. Patil, Harsha V. Patil, ***et al.,*** J.**(2011)** diastolic dysfunction in asymptomatic diabetic patients. Cardiovasc Dis. Res. Oct. 2(4): 213–222**.**

(10).Diamant M, Lamb HJ, Groeneveld Y, ***et al.,*** (.**2003**). Diastolic dysfunction is associated with altered myocardial metabolism in asymptomatic normotensive patients with well-controlled type 2 diabetes mellitus. J Am Coll Cardiol.;42:328–35.

(11).Boyer JK, Thanigaraj S, Schechtman K, et al., **(2004)** Prevalence of ventricular diastolic dysfunction in asymptomatic, normotensive patients with diabetes mellitus. Am J Cardiol;93:870–5.

(12) Kamile Gul, Aksuyek S C, Fehmi K O ***et al.,*** **(2009)**.Tissue Doppler in assessing left ventricular dysfunction in type -1 diabetes European Journal of Echocardiography 10, 841–846

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