ORIGINAL ARTICLE

# Comparative Assessment Of Predictors Of Diastolic Dysfunction As Derived By Tissue Doppler And Conventional Mitral Inflow Doppler.

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**ABSTRACT**

**BACKGROUND:** To assess various echocardiographic predictors using tissue Doppler imaging and conventional mitral inflow Doppler,to study impact of predictors over disease severity and compare the efficacy of both. **METHOD**: 45 subjects, between age group of 15 to 75 and who are known cases of ischemic heart disease,hypertension,diabetes,post-myocardial infarction, cardiomyopathy with or without symptoms were recruited. Baselinecharacteristics, necessary laboratory parameters and predictors for diastolic dysfunction were studied using conventional mitral inflow and tissue Doppler imaging. **RESULTS**: Mean age of subjects with diastolic dysfunction in various age group was less than 65 with higher male prevalence. Prevalence of diastolic dysfunction was higher in hypertensive against hypertension plus(80% vs 70%) and diabetes against diabetes plus(70% vs 50%),whereas lower in IHD against IHD plus(70% vs 80%).Subsets having chronic diseases have higher prevalence as compared to acute illness. BMI> 25 and LVH are important factor for severity of illness. Control of hypertension (51%vs41%) and diabetes(67% vs 33%) have positive impact .Tissue Doppler imaging have higher sensitivity compared to conventional mitral inflow Doppler (65.92% vs 51.02%), detection of LVH(85% vs 77%),even in early phases of diastolic dysfunction,in subjects with fair control of diabetes and hypertension and psuedonormalization. **CONCLUSION**: Diastolic dysfunction precedes the systolic dysfunction in patients with hypertension,diabetes,ischemic heart diseases and cardiomyopathy.It may remain asymptomatic while progressive,more prevalent with chronicity of disease.Tissue Doppler is more sensitive index to assess diastolic dysfunction compared to conventional mitral inflow.

**Keywords**: Diastolic dysfunction Conventional mitral inflow Doppler imaging Tissue Doppler imaging

## INTRODUCTION

Importance of systolic left ventricular dysfunction in genesis of congestive heart failure has well been recognized. It is since the last 1 - 2 decades; the left ventricular diastolic dysfunction's contribution to symptoms in individuals with normal or near normal cardiac function has been recognized. Clinical importance of diastolic function is unquestioned. In condition such as pressure overload left ventricular hypertrophy and hypertrophic obstructive cardiomyopathy or restrictive cardiomyopathy leads to cardiac failure even when systolic function is normal.

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During acute myocardial infarction left ventricular diastolic dysfunction precedes systolic dysfunction. Questions concerning the precise meaning of diastolic function and its evaluation are complex. Unlike systolic function which represents the properties and effects of myocardial contraction alone, diastolic function encompasses several distinct hemodynamic phases which are fundamentally different in their properties. Before 1981 most of studies on left ventricular diastolic function were performed using invasive techniques and complex methods which depend upon high fidelity of invasive measures of instantaneous pressure, volume, mass and walls stress which could not be done on a routine basis. With the advent of Doppler echocardiography intra-cardiac blood flow velocities can now be assessed noninvasively. It is easy to perform, reproducible and correlates well with

invasive studies. Among patients who have heart failure (HF), as many as 40 to 50 percent[1,2] have normal systolic function, which is usually defined as a Left ventricular ejection traction (LVEF) >50 percent. In such patients, diastolic dysfunction is the presumed cause of HF. Asymptomatic diastolic dysfunction is much more common than symptomatic disease. The major causes of isolated diastolic dysfunction include:

- Chronic hypertension with left ventricular hypertrophy (LVH); a hypertensive hypertrophic cardiomyopathy with LVEF above 75 percent has been described in the elderly
- Hypertrophic cardiomyopathy (HCM),
- Aortic stenosis with a normal LVEF
- Severe chronic ischemic heart disease
- Restrictive cardiomyopathy, which can be idiopathic or called by infiltrative diseases of the heart

Symptom wise diastolic and systolic dysfunction are almost alike while on examination in left ventricular diastolic dysfunction, signs of LVH, pulmonary edema, S4 may be present. Studies have shown a significant reduction in diastolic dysfunction with appropriate therapy. Therapy wise diastolic dysfunction differs as It reverts back to normal on therapy unlike systolic dysfunction which can be controlled but not reverted back to normal. Diuretics which are amongst main therapy in systolic failure are harmful here. Drugs mainly being used are,

1. Calcium channel blockers
2. Beta blockers
3. Angiotensin receptor blockers
4. ACE inhibitors.

**AIMS AND OBJECTIVES**

- Study of LV function in subgroups DM, IHD, HT and Elderly.
- To study the functional status of patients with diastolic dysfunction.
- To study presence of end organ damage in relation to LV diastolic dysfunction in these subgroups.
- To correlate LVH with diastolic dysfunction in patients.
- To study other rare subgroups with DD.
- Comparative analysis of various parameters to study diastolic dysfunction as derived by tissue Doppler imaging and conventional mitral valve Doppler.

**MATERIAL AND METHOD**

45 subjects of suspected diastolic dysfunction based on symptom status enrolled on following inclusion and exclusion criteria;

**Inclusion Criteria:** Subjects between ages 15 to 75 years, known cases of Hypertension, Diabetes, Post-Myocardial Infarction without or with symptoms like angina, dyspnea, palpitation, fatigue classified according to NYHA classified were included.

**Exclusion Criteria:** Subjects with valvular heart diseases, atrial fibrillation, dilated cardiomyopathy, end stage renal diseases, cardiac diseases with ejection fraction <50%, autonomic neuropathy or subjects on cardiac medications who alters relaxation were excluded.

After all clinical parameters were met each; complete hemogram with ESR, urine analysis, electrocardiography, blood urea and serum creatinine, fasting and post prandial sugar, HbA1c, lipid profile, x-ray chest, dilated fundus, conventional 2D echocardiography and Tissue Doppler imaging was performed. rans mitral inflow using 2.5 Mhz transducer probe on VIVID 7 machine was performed, where parameters like LV ejection fraction, Percentage fractional shortening, Early mitral inflow velocity(E),Late mitral/peak atrial inflow velocity(A),Deceleration time, Isometric relaxation time, E/A ratio were calculated. Tissue Doppler was performed and analyzed using Echopac with QTVI software to record low-velocity, high-intesity signals with frame rate 120/min. Parameters studies were Peak early diastolic velocity(Em; cm/s),Peak late diastolic velocity (Am;cm/s), Myocardial E deceleration time (DTm; msec), Isovolumic relaxation time (IVRT) performed.

**RESULTS**

Various subgroups presenting with or without manifestations of heart failure were studied with main focus on efficacy to detect diastolic dysfunction, its impact on overall spectrum, to assess magnitude of risk and compared via conventional

Trans mitral inflow and tissue Doppler imaging. E/A <1 on mitral valve Doppler was seen in average 51.02% subjects whereas Em/Am<1 on TDE was 65.92%. This finding suggested Tissue Doppler imaging is better modality for detection for prediction of diastolic dysfunction even in early phase with fair control of glycaemia, hypertension and ischemic heart diseases. Several studies have proven decrease height and slope of early diastolic flow and increase descent of late diastolic flow is seen with increasing age. In present study the mean age group was less than 65 removing age as confounding factor. In a group of diastolic dysfunction male subjects (57.14%) outnumbered females (42.86%).Diastolic dysfunction is one paradox in women which despite of preserved systolic function there are symptoms of heart failure. In the present study 72.85% subjects with diastolic dysfunction were symptomatic for the same. Obesity is associated with abnormal filling pressure. In present study, 63.6% subjects were overweight with diastolic dysfunction. LVH,LV mass correlate signifactly with waist to hip ratio and diastolic parameters in obese as compared to lean persons. .BMI> 25 and LVH are important factor for severity of illness. Control of hypertension(51%vs41%) and diabetes(67% vs 33%) have positive impact.Tissue Doppler imaging have higher sensitivity compared to conventional mitral inflow Doppler (65.92% vs 51.02%), detection of LVH(85% vs 77%), even in early phases of diastolic dysfunction, in subjects with fair control of diabetes and hypertension and psuedonormalization.

**DISCUSSION**

Heart failure can be defined physiologically as inability of the heart to provide adequate forward output at normal filling pressures to meet the perfusion and oxygenation requirement of the tissue. There are two major mechanisms by which this can occur:

- Systolic Dysfunction - in which there is impaired cardiac contractility.
- Diastolic Dysfunction - in which there is impaired filling of one or both ventricles.

Systolic dysfunction is easily assessed by measuring ejection fraction and regional wall motion abnormality. Diastolic heart failure is an insidious heart disease. Insults to the myocardium are followed by a series of compensatory changes that are beneficial in the short run but have long term deleterious effects. Factors increasing diastolic pressure are as follows:

- -Impaired Ventricular Relaxation
- -Decreased Ventricular Compliance
- -Hypertrophy
- -Myocardial ischemia
- Hypertension
- Collagen deposition and fibrosis
- Cellular Disarray
- Regional Asynchrony
- Myocardial infiltration
- Increased preload, after load
- Pericardial constriction or restriction
- Abnormal Calcium flux
- Right Ventricle and Left Ventricle interactions
- Tachycardia

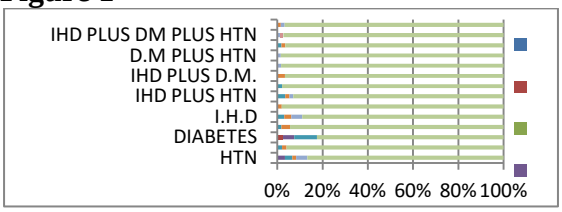
Both ischemia & hypertrophy impair relaxation in early diastole - ischemia by restricting supply of high energy phosphate required for rapid removal of calcium from the cytoplasm and hypertrophy by slowing the rate of myosin - actin dissociation. Hypertrophy also decrease left ventricular compliance in all phases of diastole. The probability of ischemia or left ventricular hypertrophy increases with age. Additional conditions of aging such as hypertension and increased interstitial collagen deposition resulted in decreased left ventricular compliance. It is thus not surprising that old age is the most frequently cited risk factor for isolated diastolic dysfunction. Other leading causes of the condition are - coronary artery disease, hypertension, diabetes, obesity, HOCM, Aortic stenosis, cardiomyopathy, pericardial disease. Clinical manifestation of a pure left ventricular systolic dysfunction includes a decreased cardiac output, increased heart rate and peripheral vasoconstriction. However, patients hospitalized with congestive heart failure almost always present with the additional symptoms of

shortness of breath at rest or with exertion due to pulmonary congestion which is due at least partly to left ventricular diastolic dysfunction. In the present study relative impact on diastolic dysfunction of various factors known to science was studied. Effect and influence of multiple factors was also analyzed to assess total magnitude of risk.

**Table1: Age Distribution**

| Ihd Plus Htn | | Ihd Plus D.M. | | M Plus Htn | | Ihd Plus Dm Plus Htn | |
|---|---|---|---|---|---|---|---|
| With D.D | N.Lv Fun | With D.D | N.Lv Fun | With D.D | N.Lv Fun | With D.D | N.Lv Fun |
| | | | | | | | |
| 2 | 1 | | | | 1 | | |
| 1 | | 2 | | | 1 | | 1 |
| 1 | | | 1 | 1 | | 1 | 1 |
| | | | | | | 1 | |
| 52.25 | 48 | 57.5 | 60 | 65 | 54 | 71.5 | 60 |

**Figure 1**




Several studies have shown that aging is associated with a decreased height and slope (descent) of early diastolic flow velocity curve and increase in height of late diastolic flow velocity curve. Hence, it is crucial to consider the impact of aging when formulating normal limits for Doppler indices, when assessing whether wave form alterations in disease constitute true deviation from normal. The age group of patients found to have diastolic dysfunction and those with normal left ventricular function were same in subgroups in our study. All of the groups had mean age below 65 years, hence ruling out the effect of age on diastolic dysfunction. This was true except for the elderly subgroups where mean age was above 75 years in both patients with diastolic dysfunction and normal left ventricular function. The elderly subgroups had no evidence of hypertension, diabetes or ischemic heart disease on examination and on investigation both. In the present study 80% of elderly people had diastolic dysfunction and 20% had normal left ventricular function compared to study by, Fagerberg[4] et al (1998) where 50% of elderly subjects had diastolic dysfunction. Study conducted at Baker Memorial Institute, Australia by Raj Kumar et al in subjects about 67 years of age showed a positive correlation between diastolic dysfunction & reduced arterial compliance[5].

**Table 2: Prevalence Of Diastolic Dysfunction -In Subgroups**

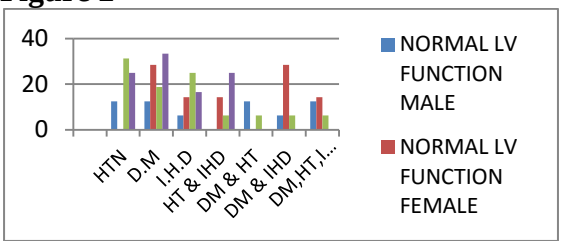
| Subjects | Dd Pre | Dd Abs |
|---|---|---|
| Htn | 8 | 2 |
| Htn Plus Groups | 7 | 5 |
| | | |
| Subjects | Dd Pre | Dd Abs |
| Dm | 7 | 3 |
| Dm Plus Groups | 5 | 5 |
| Subjects | Dd Pre | Dd Abs |
| Ihd | 7 | 1 |
| Ihd PlusGroups | 8 | 4 |

- In diabetic groups prevalence of DD was 70%. Cecchi et al (1994)[5] found a prevalence ranging from 48% in IDDM without microagniopathic complications to 90% in those with microangiopathic complications. Pearson P et al (Jan 2000)[6] in NIDDM subjects found 28% having pseudonormalization pattern, 32% having impaired relaxation.
- In hypertensive subgroups 76% had diastolic dysfunction in present analysis. Aranda et al (Apr 2000)[7] found prevalence of DD to be 48.8%. Pitozali MV et al (May 99)[8] found DD prevalence to be 31%. Our study had a higher prevalence of DD.
- In IHD group 68,6% had DD. Gerlie C. et al (Jan -IBS/)[9] found evidence of DD in 77% of CAD subjects. Poulson et al (1999)[10] studying LVDD in first episode of AMI found LVDD in early phase of AMI with signs of impaired relaxation or restrictive -pattern in 38% and 24% patients respectively- Impaired LV relaxation was found in 60% patients after 1 year of follow up. This correlates with our observation.

**Table 3: Sex Distribution In Study**

| Sr. No | Subjects | Normal Lv Function | | Lv DiastolicDys | |
|---|---|---|---|---|---|
| | | Male | Female | Male | Female |
| | | | | | |
| 1 | Htn | 12.5 | 0 | 31.25 | 25 |
| 2 | D.M | 12.5 | 28.5 | 18.75 | 33.3 |
| 3 | I.H.D | 6.25 | 14.25 | 25 | 16.6 |
| 4 | Ht & Ihd | 0 | 14.25 | 6.25 | 25 |
| 5 | Dm & Ht | 12.5 | | 6.25 | |
| 6 | Dm & Ihd | 6.25 | 28.5 | 6.25 | 0 |
| 7 | Dm,Ht,Ihd | 12.5 | 14.25 | 6.25 | |
| | Total | 58.82 | 41.18 | 57.14 | 42.86 |

**Figure 2**




In our study, in the normal left ventricular function group 74.97% were males while 24.98% were females. In the group with left ventricular diastolic dysfunction 70.38% were males while 29.54% were females. Lisa et al (1997)[11] at Boston Medical compared prevalence of congestive heart failure in women with men undergoing diagnostic cardiac characterization and concluded that diastolic dysfunction is one of the paradox of more frequent heart failure symptoms inspite of better preserved left ventricular systolic function in women.

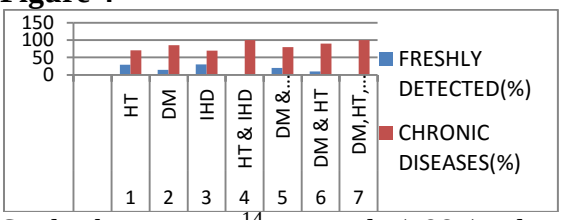
**Symptom Status Of Subgroups:** Symptoms of left ventricular diastolic dysfunction include exertional dyspnea but it is difficult to differentiate on the basis of symptoms between systolic and diastolic dysfunction. In present study 47.88% of patients with diastolic dysfunction were symptomatic for it. A study by Fruhwala FM et al (1997)[12] showed that extent of left ventricular diastolic dysfunction correlated with subjective physical capacity. The more the left ventricular filling pattern changed from normal towards restricted, the greater were the patients symptoms.

**Body Mass Index And Lvdd:** As per Framigham Heart Study, obesity reveals a significant higher mortality in heart failure. Hypertension, hypercholesterolemia and a distinct eccentric left ventricular hypertrophy rather than concentric one as produced by hypertension tends to co - exist with obesity. In the present study all patients with morbid obesity were excluded. In our study 41.49% overweight subjects had diastolic dysfunction. This difference was not statistically significant. Wafeia B et al[13] in their study of 30 obese subjects with BMI more than 25 kg/m2 compared with 15 healthy normal lean subjects having the same heart rate, height, systolic & diastolic blood pressure found that 53% of obese group had. LVH, LV mass correlated significantly with waist hip ratio and diastolic parameters were impaired in obese compared to lean subjects. In the diabetic subgroups 7.69 % of patients had diastolic dysfunction on first presentation while 92.3% of patients with diastolic dysfunction had the disease for more than one year. In the hypertensive subgroups 29.41% had diastolic dysfunction on presentation compared to 70.58% who had hypertension for over an year same was true for other subgroups.

**Table 5: Duration Of Disease In Subgroups**

| | Nor.Lv.Fun(%) | Lv.Dia.Dys(%) |
|---|---|---|
| Control | 66.66 | 32.14 |
| Uncontrolled | 33.33 | 67.86 |
| | Nor.Lv.Fun(%) | Lv.Dia.Dys(%) |
| Control | 51.5 | 41.7 |
| Uncontrolled | 48.4 | 58.3 |

**Figure 4**



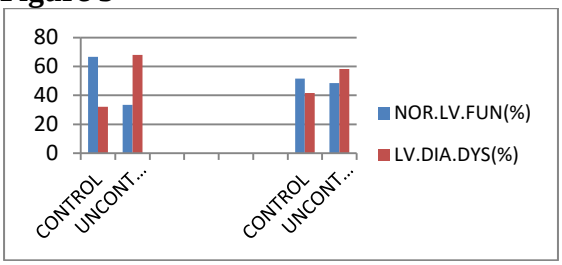

Study by Inoye [14]in et al (1984) also proved the presence of early diastolic dysfunction in mild to moderate hypertension. Cecchi E[15] et al in 1994 in study of 55 subjects of recently diagnosed insulin dependant diabetes mellites documented that slight preclinical diastolic dysfunction 'is present in young 'recently diagnosed diabetes without microangiopathy. More dysfunction is there when there is macroangiopathy.Poulsen[16] S et al in 1997 assessed 65 patients with first myocardial infarction found that diastolic function measurements of left ventricle complemented to systolic function measurement and identifies patients at risk of developing congestive heart failure post myocardial Infarction.

**able 6: Correlations Between Control Of Hypertension And Diastolic Dysfunction**

| Sr. No | Subject | E/A<1 (%) | E/A>1 (%) | Em/Am<1 (%) | Em/Am>1(%) |
|---|---|---|---|---|---|
| | | DD PRE | | DD PRE | |
| 1 | Ht | 6.38 | 14.89 | 17.02 | 4.25 |
| 2 | Dm | 12.76 | 8.5 | 14.89 | 6.38 |
| 3 | Ihd | 12.76 | 4.25 | 14.89 | 2.12 |
| 4 | Ht & Ihd | 4.25 | 6.38 | 6.38 | 4.25 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Dm & Ihd | 2.12 | 4.25 | 4.25 | 2.12 |
| 6 | Dm &Ht | 6.38 | 0 | 2.12 | 4.25 |
| 7 | Dm,Ht,Ihd | 4.25 | 4.25 | 4.25 | 4.25 |
| 8 | Hocm | 2.12 | 2.12 | 2.12 | 2.12 |
| | Total | 51.02 | 48.98 | 65.92 | 34.08 |

**Figure 5**




In our study in various subgroups of hypertension, diastolic dysfunction was present in 51.51 % of patients whose blood pressure was under control i.e. 140/90 while 48.48% had uncontrolled blood pressure i.e. > 140/90. DD and uncontrolled HT were not significantly corelated. Also the E/A valves were similar in both controlled and the uncontrolled groups suggesting that there are multiple other factors that increased blood pressures which contribute to diastolic dysfunction. Regression of left ventricular hypertrophy has been proved to occur with treatment, and the same can be said about diastolic dysfunction. However a study by Inoye et al[14] (1984) showed that antihypertensive therapy with diuretics β - blocks and calcium channel block failed to consistently reverse left ventricular diastolic abnormalities.

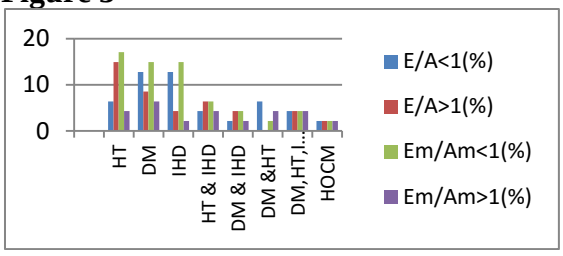
**Clinical Signs Of Lvh :** LVH was said to be present if palpation revealed forceful, apical impulse with or without change in position, associated with 84 or ECG showed LVH. Only 23.9% of subjects with DD in this study had evidence of left ventricular hypertrophy. This supported other studies which had defected subclinical presence of diastolic dysfunction and also proved that echocardiographic evidence of diastolic dysfunction precedes its clinical presence. Hence all subjects at risk of diastolic dysfunction should be screened and treated as early as possible for the same.

**Retinopathy And Nephropathy In Subgroups:** In our study, end organ damage was assessed by ocular fundus examinations and urinary albumin and blood urea and serium creatinine & effort was made to find the correlation between them and diastolic dysfunction.56.24% of subjects had a normal fundus examinations in the group having evidence of diastolic dysfunction. Hypertensive subjects showed grade I or II retinopathy if present while diabetics showed presence of background or preproliferative retinopathy. However the pressure and severity of retinopathy could not be correlated with the parameters of left ventricular function. Ejection fraction was normal in all subgroups in the study. Posterior wall thickness in diastole and septal wall thickness in diastole was more in hypertensives compared to the rest of subgroups. This is a know fact since secondary hypertrophy concentric or eccentric develops in patients with hypertension as a result of chronic rise in after load on myocardium (because of rise in arterial blood pressure). Rest of the parameter was same in all the subgroups.

**Table4: 2d Echocardiographic Parameters**

| Sr.No | Subject | Freshly Detected(%) | Chronic Diseases(%) |
|---|---|---|---|
| | | | |
| 1 | Ht | 29.41 | 70.58 |
| 2 | Dm | 14.25 | 85.75 |
| 3 | Ihd | 30.45 | 69.55 |
| 4 | Ht & Ihd | | 100 |
| 5 | Dm & Ihd | 20 | 80 |
| 6 | Dm & Ht | 10 | 90 |
| 7 | Dm,Ht,Ihd | | 100 |

**Figure 3**




**Peak Flow Rate In Subgroups (Table 4):**Indices derived from Doppler wave form show only velocity of diastolic blood flow and not the actual volume of transmitral flow of filling rate which might be a precise indicator of actual ventricular filling. Attempt to analyze the same using both Doppler and 2D Echocardiography has resulted in the development of this index which suggests that the highest filling rate during early diastole measured as a product of peak of E wave and mitral valve cross - sectional area. In our study mean peak flow rate was 385.8 ± 79.7 in

subjects with normal left ventricular function and lower in hypertensive groups with diastolic dysfunction, i.e. 379.3 ± 109. It is however not a sensitive indicator of left ventricular diastolic function.

**Doppler Parameter In Subgroups (Table 4):** Left ventricular diastolic functions has been shown to be affected at earlier stage even when systolic function remains normal. Doppler echocardiography has been of help Identifying these abnormalities. The velocity derived indices have proven to be a sensitive indicator of impaired left ventricular filling in a wide range of myocardial disease even though they vary with age, heart rate and left ventricular loading conditions. In present study, parameters of left ventricular diastolic function namely reversal of mitral flow velocities i.e. E/A ratio is less than one and in pulmonary vein Doppler through the transthoracic route was done looking for reversal of flow velocities i.e. S/D <1 or prolongation of atrial reversal. E/A<1 on mitral valve Doppler was seen in 46.07% of subjects while it was less than one in 53.93% of subjects. In these 53.93%, there was a reversal of S/D ratio or atrial reversal or both was found on pulmonary vein Doppler in 46.37% suggesting diastolic dysfunction which might be missed on mitral valve Doppler, might be picked up on pulmonary vein Doppler. A pseudonormalization phenomenon was seen.

**Left Ventricular Mass And Left Ventricular Mass Index:** Both left ventricular mass and LVMI is known to be greater in patients with systemic hypertension. Of patients with high B.M.I i.e. >25 Kgm-2 46.2% had evidence of LVH and diastolic dysfunction. This was statistically significant. Wafeiba et al[12] have demonstrated 53% obese patients had evidence of LVH with LVM being significantly different in central obesity than other groups. A similar result was found in our study.

**Evaluation Of Other Subgroups:** We evaluated patients with hypertrophic obstructive cardiomyopathy, hypothyrodism, and acromegly. An evidence for diastolic dysfunction was present in all of them.

## CONCLUSION

Diastolic dysfunction precedes the systolic dysfunction in patients with hypertension, diabetes, ischemic heart diseases and cardiomyopathy. It may remain asymptomatic while progressive ,more prevalent with chronicity of disease. Tissue Doppler is more sensitive index to assess diastolic dysfunction compared to conventional mitral inflow.

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