COMPARISON BETWEEN TRANSPULMONARY VENOUS FLOW AND TISSUE DOPPLER OF DIASTOLIC FUNCTION IN HYPERTENSIVE PATIENTS

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Abstract

Background: Systemic arterial hypertension has clearly been shown to be a major factor in the enhanced incidence of cardiac morbidity and mortality. Relaxation abnormalities are one of the earliest manifestations of cardiac dysfunction and frequently precede systolic dysfunction in hypertension. Severe diastolic dysfunction may cause pulmonary congestion even without any deterioration of systolic function. Thus assessment of left ventricular diastolic filling in individual patients is important from both the diagnostic and therapeutic points of view.

Aim of the work: to evaluate left ventricular diastolic function by pulmonary venous flow with pulse tissue Doppler in hypertensive patients.

Patients and methods: Thirty hypertensive patients of both sexes were included in this study, and admitted at cardiology department of Benha University Hospital during the period from September 2010 to March 2011. The study also included ten apparently healthy volunteers as a control group with matched age and sex. All patients were evaluated by history taken, clinical examination. Conventional echocardiography was performed to all patients to assess LV functions, dimensions and hypertrophy.

Pulmonary venous flow was done by Doppler to measure S, D wave and S/D ratio, also Doppler tissue imaging was performed on mitral annulus at apical four chamber view to measure E", A", and E"/A" ratio.

Results: The maximal early diastolic flow velocity of conventional Echo. of the control group ranged from 45-116 cm/sec with a mean value 75.2±18.9 cm/sec, while that of patients group ranged from 48-76 cm/sec with a mean value 62.1±13.9 cm/sec. there was a significant decrease in mitral E wave in patients than that the control group (P<0.01).

The mean of Em/Am Ratio of the patients group was 0.532±0.10 while that of controls groups was 1.426±0.4. There was significant decrease of E/A Ratio of patient group than in control group (P<0.01). The mean systolic forward flow maximal velocity of patients group was 60.1±9.75 while that of controls was 59.73±6.66, with insignificant difference (P>0.05), also the mean diastolic forward flow maximal velocity of pulmonary venous flow in patients group was 64.8±10.98 while that of controls was 39.09±11.55, with significant increase in D wave in cases than that controls (P<0.01).

The S/D ratio show a significant decrease in patients group than the control in cases it was 0.93±0.11 while in control it was 1.43±0.05, the difference was significant (P<0.05).

The sensitivity of tissue Doppler for detection of diastolic function was 93.3% versus 70% in pulmonary venous flow, specificity was 90% in tissue Doppler while it was 60% in pulmonary venous flow.
**Introduction**

Systemic arterial hypertension has clearly been shown to be a major factor in the enhanced incidence of cardiac morbidity and mortality. Relaxation abnormalities are one of the earliest manifestations of cardiac dysfunction and frequently precede systolic dysfunction in hypertension (1).

Severe diastolic dysfunction may cause pulmonary congestion even without any deterioration of systolic function. Thus assessment of left ventricular diastolic filling in individual patients is important from both the diagnostic and therapeutic points of view (2).

**Patients and methods**

Thirty hypertensive patients of both sexes were included in this study, and admitted at cardiology department of Benha University Hospital during the period from September 2010 to March 2011. The study also included ten apparently healthy volunteers as a control group with matched age and sex.

**Echocardiography**

1-M mode and two dimensional evaluations of cardiac chambers in a standard manner from parasternal views assessing (Masyama et al., 2001)

A) Chamber size:

- Left atruim (normal 19-40 mm).
- Left ventricle End diastolic diameter (nor. 38-57 mm), End systolic diameter (nor. 33-40 mm)

B) Wall thickness:

- Inter ventricular septum (nor. 7-11 mm).
- Left ventricular posterior wall (nor. 7-11 mm).

C) Fractional shortening calculated as follows:

- Left ventricular and diastolic diameter ----left ventricular end systolic diameter.

D) Left ventricular mass:
*It was calculated by Hofmann et al., 1995*; method in which: mass (in grams) = 1.04 \(X\) 
[(posterior wall thickness + septal thickness = left ventricular end-diastolic diameter) \(3\) – (left ventricular end diastolic diameter) \(3\)] - 13.6.(3) 

N.B normal value=180-200 gram

2- Doppler echocardiographic recordings using a Doppler echocardiographic and a transducer array of 3 MH.z, Recordings were made at a paper speed 100 unit/sec:

A) Continuous wave Doppler to assess and exclude intra-cavitary pressure gradients

B) Pulsed wave Doppler echocardiographic recordings using color flow mapping.

1- **Mitral flow velocity pattern.**

It was obtained in the apical four-chamber view with the sample volume carefully placed between the tips of the mitral valve leaflets and recordings maximal flow. The following parameters were recorded and measured.

- E wave maximal velocity (normal range 48 – 76 cm/sec).
- A wave maximal velocity (normal range 45 – 73 cm/sec).
- E/A ratio (normal range 1-1.4)

2- **Pulmonary venous flow velocity pattern:**

It was obtained in the apical four-chamber view. Left atrial filling from the pulmonary vein is characterized by red signal along inter atrial septum in the upper part of the left atrium in the color Doppler mode.

The orifice of the right pulmonary vein is imaged at the bottom of the flame like red signals and the pulsed Doppler sample volume was set just at the orifice of the right pulmonary vein and the waves were recorded

The following parameters were measured:

- S wave maximal velocity (normal range 53-71 cm/sec).
- D wave maximal velocity (normal range 27-47 cm/sec).
- S/D ratio (normal range 1.1 – 1.8).
Tissue Doppler;
- Each left ventricular wall was divided into myocardial segments basal and mid wall. Apical segments were omitted because it is near the field of echo transducer. The Doppler velocity range of -20 to +20 was selected and velocity was measured on line at speed of 55 mm/s.

-Pulse wave TDI of mitral annulus was obtained from the apical four chambers view for the measurement of:

1- E’ = early diastolic velocity (11.1-18.3 cm/sec).
2- A’ = late diastolic velocity (8.2-13.2 cm/sec).
3- E’ at, A’ at = time to peak velocity
4- E’ DT, A’ DT = deceleration time
5- E’ dur, A’ dur = duration of velocity profile

Evaluation of regional diastolic function by TDI in the basal and mid segment in different chambers view (septal and lateral myocardial wall from two (anterior and inferior wall) and four wall) with measurement of:-

1- Peak velocity and rapid filling phase (Em wave)
2- Peak velocity during atrial contraction (Am wave)
3- Em/Am ratio

Results

A- Demographic data of all studied cases

This study included 30 hypertensive patients, 21 males (70%), and 9 females (30%). Their mean age was (55±9.5) years, also ten volunteers apparently normal as a control group 6 male (60%), And 4 females (40%), their mean age was 55±7.1. Table I.
**B- Conventional Echocardiography:**
This means inter-ventricular septum thickness of the patients group was 15.7±1.7 mm, while that of controls was 9.6±6.7, there was a significant group than that the control group (P<0.01)

This mean left ventricular end systolic diameter of patients group was 33.4±11.2 mm while that of controls was 28.3±6.2mm. There was a significant increase is **LVESD** in patients that that of control group (P<0.05)

The mean left ventricular end diastolic diameter was 65.8±9.8 while that of controls was 44.1±9.0 mm, there was a significant increase in **LVEDD** in patients than that the control group (P<0.05)

The mean ejection fraction of patients group was 50.±02.9 while that of controls was 64.1±7.2, there was a significant decrease in **EF** in patients than that the control group (P<0.01).

Mitral flow velocity parameters:

**1- Early diastolic flow maximal velocity (E)**

The maximal early diastolic flow velocity of the control group ranged from 45-116 cm/sec with a mean value 72.2±18.9 cm/sec, while that of patients group ranged from 48-76 cm/sec with a mean value 62.1±13.9 cm/sec. there was a significant decrease in mitral E wave in patients than that the control group (P<0.01).

**2- Atrial systolic flow maximal velocity (A):**

The maximal atrial systolic flow velocity of the control group ranged from 45-73 cm/sec, mean value was 59.2±13.8 cm/sec, while that of patient group ranged from 40-92 cm/sec, with a mean value 75.1±18.9 cm/sec. There was a significant increase in mitral A wave in patients than that the control group (P<0.05).

**C- Analysis of tissues Doppler**

**Doppler imagine of mitral annulus: (Table 2)**

The mean E'm of patients group was 11.16± 3.08 while that of controls was 14.48±2.47, there was a significant decrease in E'm in cases than that in control group (P<0.05).
The mean A'm of patient group was 14.96±3.91 while of controls was 10.15±1.7, there was a significant increase in A'm in cases than that in control group (P<0.01).

The mean (Em'dur) of patients group was 0.08±0.05, while of controls was 0.12±0.04, there was a significant decrease in Em'dur in cases than that in control group (P<0.05).

The mean (Am'dur) of patients group was 0.13±0.05, while it was 0.07±0.02 in control group, with significant increase in Am'dur in cases than in control group (P<0.01).

The mean of Em/Am Ratio of the patients group was 0.53±0.10 while that of controls groups was 1.42±0.4 There was no significant decrease of E/A Ratio of patient group than in control group (P<0.01).

D- Pulmonary venous flow velocity Table(3) :

1- Systolic forward flow maximal velocity (S): The mean systolic forward flow maximal velocity if patients group was 60.1±9.75 while that of controls was 59.73±6.66. The difference between patients and controls show no significant difference (P>0.05)

2- Diastolic forward flow maximal velocity (D) : The mean diastolic forward flow maximal velocity of patients group was 64.8±10.98 while that of controls was 39.09±11.55. There was a very high significant increase in D wave in cases than that controls (P<0.01).

The S/D ratio show a significant decrease in patients group than the control in cases it was 0.93±0.11, while in control it was 1.43±0.05, the difference was significant (P<0.05).

Table (1): Echocardiography parameters

<table>
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<th>variable</th>
<th>patients</th>
<th>control</th>
<th>p</th>
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<td>IVS</td>
<td>15.7±1.7</td>
<td>9.6±0.8</td>
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<td>PW</td>
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<td>8.9±0.7</td>
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<td>LVM</td>
<td>168±23</td>
<td>108±26</td>
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<td>LVEF</td>
<td>50±2.9</td>
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<td>E/A ratio</td>
<td>0.82±0.23</td>
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Table (2) tissue Doppler parameters

<table>
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<td>E m</td>
<td>11.16±3</td>
<td>14.48±2.4</td>
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<tr>
<td>A m</td>
<td>14.9±3.9</td>
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<tr>
<td>Em dur</td>
<td>0.08±0.04</td>
<td>0.12±0.04</td>
<td>&lt;0.05</td>
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<tr>
<td>Am dur</td>
<td>0.13±0.05</td>
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<tr>
<td>E m / A m</td>
<td>0.53±0.1</td>
<td>1.42±0.1</td>
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Table (3) pulmonary venous velocities

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<td>S wave</td>
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<td>59.7±6.6</td>
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<tr>
<td>D wave</td>
<td>64.8±10</td>
<td>39.09±11.5</td>
<td>&lt;0.01</td>
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<tr>
<td>S/D ratio</td>
<td>0.93±0.11</td>
<td>1.430±0.05</td>
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Table (4) Sensitivity and specificity

<table>
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<th>variable</th>
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<td>True positive</td>
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<td>True negative</td>
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<td>6</td>
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<tr>
<td>False positive</td>
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<td>4</td>
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<tr>
<td>False negative</td>
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<td>sensitivity</td>
<td>93.3%</td>
<td>70%</td>
</tr>
<tr>
<td>Specificity</td>
<td>90%</td>
<td>60%</td>
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Discussion

Systemic arterial hypertension has clearly been shown to be a major factor in the enhanced incidence of cardiac morbidity and mortality. Relaxation abnormalities are one of the earliest manifestations of cardiac dysfunction and frequently precede systolic dysfunction in hypertension (1).

Severe diastolic dysfunction may cause pulmonary congestion even without any deterioration of systolic function. Thus assessment of left ventricular diastolic filling in individual patients is important from both the diagnostic and therapeutic points of view (2).
The present work tries to characterize the pulmonary venous flow velocity pattern in hypertensive patients with and without left ventricular diastolic dysfunction and evaluate its usefulness in relation to the tissue Doppler imagining of the mitral annuls and the mitral flow velocity pattern for the assessment of left ventricular diastolic function.

In order to achieve this aim the present work was conducted on 30 hypertensive patients and compared with 10 healthy volunteer of matched age and sex.

**Demographic data:**

This study included 30 hypertensive patients 21 males (70%) and 9 females (30%) their mean age was (55±9.5) years also ten volunteer apparently normal as a control group 6 male (60%) and 4 females (40%) their mean age was (55±7.1). Also patient group had a mean systolic blood pressure 150 mmHg while 120 mmHg in control group with a p value <0.05. The mean diastolic blood pressure was 105 mmHg in patients group and 80 mmHg in control group with a p value<0.05.

**Conventional echo:**

Left ventricular echocardiographic parameters included the mean of IVS was 15.7 mm in patient group versus 9.6 mm in control group with a p value<0.05, and LVPW thickness was 12.2 mm in patients while in control group was 8.9 mm with (p value <0.05), also LV mass was 168 grams in patients versus 108 in control group (p value <0.01). The mitral flow velocity pattern was observed with "E" wave had a mean of 62.1 cm/sec in patient group and 75.2 cm/sec in control group with a p value <0.01,"A" wave mean value was 75.1 cm/sec while in patient group 59.2 with a p value < 0.01 and E/A Ratio had a mean of 0.82 in patient group while 1.23 in control group with a P value < 0.05).

This result is in agreement with, *Tisioufis et al (2005)* who found that essential HTN is accompanied by LV diastolic dysfunction. He studied 106 patients (aged 51 years, 80 males) with essential HTN, and 50 normotensives matched age, sex. LV diastolic function was estimated by echocardiography. Hypertensive compared with normotensive exhibited greater LV mass index than normotensive (155 versus 105 grams the P value <0.001), the mean of E wave was 65 cm/sec in patient group (Hypertensive) and 75.1 cm/sec in control group with a P value < 0.01, the mean of "A" wave was 7.2 cm in control group while in patient group it was 61.1 cm/sec with a P value < 0.01 and the mean of E/A ratio was 0.85 in patient group while 1.31 in control group the p value < 0.05.
Arroja I et al (2001), who studied left ventricular diastolic function in 2 population of normotensive and hypertensive, they studied a group of 50 patients with the diagnosis of HTN (group H), which was compared with population of 50 normal subjects (group N) in each case pulsed Doppler mitral inflow was analyzed they found that the mean of E wave was 63 cm/sec in patient group and was 72.5 cm/sec in control group with a P value < 0.01, the mean of A wave was 74.1 cm/sec while in patient group was 60 cm/sec with a P value < 0.01 and the mean of E/A ratio was 0.80 in patient group while was 1.1 in control group. Sensitivity and specificity of mitral inflow was 70%, 53% respectively.(6)

Brush C et al (2000) studied 2 groups of subjects with ejection fraction > 45% 10 normal volunteer (50±10 y, HYP group). The mitral inflow profile (E, A, E/A) was measured by pulsed Doppler. The mean of E wave was 60 cm/sec in HYP group and it was 77 cm/sec in control group with a P value < 0.01, A wave had a mean of 74 cm/sec while it was 58.6 cm/sec in HYP group with a P value <0.01 and E/A Ratio had a mean of .084 in patient group while it was 1.4 in control group with a P value <0.05, with sensitivity and specificity was 72% and 56% respectively.(7)

Ito T et al (2000) found that specificity and sensitivity of E/A Ratio was 80%, 61% respectively in (41 HTN patient), E/A ratio < 1 with a P value (0.01), so all these studies agree with the present study.(8)

Kakavas A, et al 1999, studied 100 hypertensive patients of average 53±9 years, 50 normotensive subjects of average 53±9 years, and their performed conventional echo of mitral inflow. Their study showed that the mean of peal velocity of E wave decrease from 56 cm/sec in normotensives to 44 cm/sec in hypertensive patients with a P< 0.05. The peak velocity of A wave did not change.(9)

The present study does not agree with kakavas, A, et al (1999) who found that, the mean of A wave peak velocity didn't change in their study of 100 hypertensive patient of (average 53±9 years) they performing conventional echo of mitral inflow and their study shows no difference. This may be due to type of patient and severity of hypertension.

Pulmonary venous flow

The pulmonary venous flow velocity pattern in patients is as "S" wave in patient group, the mean value was 60.1 cm/sec while in the control group it was 59.73 cm/sec with a p value > 0.05 while "D" wave in patient group, mean was 64.8 cm/sec while in control group it was 39.09 cm/sec with a P value < 0.01 so the S/D ratio mean in patient group was 0.93 and in control group was 1.43 the P value < 0.05. Sensitivity and specificity of pulmonary venous flow was 70%, 60% respectively.
This study agreement with Arroja I et al (2001), who studied left ventricular diastolic function in 2 population of normotensive and hypertensive individuals, They had studied group of 50 patients with the diastolic of HTN (group H), which was compared with a population of 50 normal subjects (group N) in each case pulsed Doppler flow of the right upper pulmonary venous and diastolic inflow of the left ventricular cavity was done. Peak velocities of systolic, diastolic waves of pulmonary venous flow was found as "S" wave mean value was 61.1 cm/sec in (group H) while in (group N) it was 58.7 with a P value > 0.05, D wave had a mean of 41.1 cm/sec in (group N) it was 65.3 cm/sec in (group H) with a P value < 0.01. The S/D ratio in patient group (group H) had a mean of 0.91 and in control group (group N) it was 1.4 with a value < 0.05. Sensitivity and specificity of pulmonary flow was 72%, 58% respectively.(6)

Tsioufis et al 2005 found that the essential HTN is accompanied by LV diastolic dysfunction. He studied 106 patients (aged 51 years. 80 males) with essential hypertension, and 50 normotensives with matched age and sex. Left ventricular diastolic function was estimated by pulmonary venous flow. Hypertensive compared with normotensives. The mean of "S" wave in patient group was 60.5 cm/sec and it was 59.3 cm/sec in control group with a P value <0.05, the mean of D wave was 42.1 cm/sec in control group and it was 66 cm/sec in patient group with a P value <0.05. The mean of S/D ratio in patient group was 0.94 and control group was 1.39 with a P value < 0.05, and sensitivity and specificity 45%, 35% respectively. This study doesn't agree with our study in the point of sensitivity and specificity because sensitivity and specificity in our study was 70% and 60% respectively. This is may be due to severity of hypertension and type of patients.(5)

Hofmann et al., 2001; have studied the relation between the pulmonary venous flow and atrial hypertension and left ventricular function in 84 patients (aged 55 years, 70 males) with essential HTN, and 40 normotensive, as control group with matched age and sex. They found that the mean of S wave in patient group was 62.1 cm/sec and 61.8 cm/sec in control group with a p value > 0.05, D wave had a mean of 0.90 and in control group it was 1.44 with a p value <0.05 sensitivity and specificity of pulmonary venous flow was 71.5%, 59% respectively.(4)

Masuyama et al., 2003; compared Transthoracic with Trans-esophageal Doppler echocardiographic measurement of pulmonary venous flow velocity pattern. They concluded that transthoracic measurement of pulmonary venous velocity pattern are feasible and accurate in hypertensive patient and may be used to assess left ventricular systolic function through they study 150 hypertensive patient and 50 normotensive with matched age and sex. They found "S" wave is not significant with a P value <0.05 S/D ratio is significant with a P value < 0.05; pulmonary venous flow had specificity and sensitivity 72, 60.3 respectively in a meaner similar to our results.(3)
**Tissue Doppler**

Tissue Doppler of the mitral annulus revealed that true mean of (E'm wave) in patient group was 11.16 cm/sec and in control group was 14.48 cm/sec with a P value of <0.05, the mean of Em/Am ratio in patient group was 0.532 and in control group was 1.42 with a P value of <0.05, with sensitivity and specificity of Tissue Doppler imaging was 93.35%, 90% respectively.

This study agreement with Tsioufis, et al., 2005; they studied LV systolic function in 2 groups of population normotensives and hypertensive subject. They studied 160 patients (aged 53 years, 150 males) with essentials HTN, and 100 normotensive subjects as a control group with matched age and sex. LV diastolic function was estimated by pulsed tissue imagining (TDI) echocardiography, averaging diastolic mitral annular velocity measurements (E' wave, A' wave, E/A ratio) was calculated. The mean of E wave was 12.1 cm/sec in patients group and it was 15.5 cm/sec in control group with a p value < 0.05 while A wave in patients group had a mean of 16 cm/sec and it was 10.4 cm/sec in control group, with a P value <0.05. The E/A ratio of patients group had a mean of 0.553 and in control group was 1.43, with sensitivity and specificity if tissue Doppler was 95.2%, 92.4% respectively. (5)

Azvedo J et al., 2005, who compared 180 hypertensive patients (aged 54 years, 150 males) and 100 normotensive individuals with matched age and sex to estimate LV diastolic function by tissue Doppler imagining of mitral annulus. They found the mean of E wave in patients group was 11.41 cm/sec and in control group was 14.1 cm/sec with a P value of < 0.05 while A wave in patients group had a mean of 14.81 cm/sec and in control group was 10.21 cm/sec with a P value < , the mean of E/A ratio in patient group was 51.1 and in control group was 1.33 with a p value < 0.05 sensitivity and specificity and tissue Doppler imagining was 92.1, 91.3 respectively. (10)

Schmermud A et al, 2006 they found the diastolic mitral annulus velocity assessed by tissue Doppler echocardiography (TDE) was suggested to provide additional information about LV diastolic function affected by atrial hypertension, they studied 50 hypertensive group (patient group) (aged 50 years, 35 males) and 30 normotensive (control group) with matched age and sex. The mitral systolic, early, and late diastolic velocities of mitral annulus (E, A, E/A ratio) were assessed by pulsed Tissue Doppler Imagining (TDE). All studied individuals had invasive measurement of left ventricular end diastolic pressure during left heart catheter. The mean of E wave in patient group was 12.3 cm/sec and in control group was 14.7 cm/sec with a P value of < 0.05 while the mean of (A') in patient group was 15 cm/sec and it was 10.1 cm/sec in control group with a p value < 0.05, the mean of E/A ratio in patient was 53.3 and in control was
1.32 with a p value < 0.05, with sensitivity and specificity of tissue Doppler imagining 93.4, 92.1 respectively.**(I1)**

**Laraidogolitia et al., 2006,** studied 20 patients with essentials hypertension of average age 54±10 years. They performed DTI of mitral annulus versus conventional eco pulsed Doppler and pulmonary venous flow. Their study showed that TDI show an abnormal relaxation on essential hypertensive patients than with pulmonary venous flow and mitral flow indices. They suggested that DTI in E/A ratio in the mitral annulus is more sensitive by 90% than pulmonary venous flow and trans-mitral Doppler and specificity = 80 %.( **I2**)  

The present study agree with these results because the sensitivity of trans-mitral flow by pulsed Doppler was 66%, specificity of 50% and in pulmonary venous flow the sensitivity was 70% and specificity of 93% detecting LV relaxation abnormalities in hypertensive patients group compared to normal .

In the present study there was a significant increase in both sensitivity and specificity on mitral annulus tissue Doppler than both pulmonary venous flow and mitral in-flow patterns, the pulmonary venous flow is more sensitive and specific than the mitral flow.

**References**


