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ORIGINAL RESEARCH

USE OF TISSUE DOPPLER IMAGING DURING DOBUTAMINE STRESS ECHOCARDIOGRAPHY FOR OBJECTIVE EVIDENCE OF INDUCIBLE MYOCARDIAL ISCHEMIA

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ABSTRACT

AIMS: *1.To compare conventional DSE with strain rate imagining during DSE and find out objective markers of inducible myocardial ischemia in patients of chronic stable angina and* ***2.*** *To determine how left ventricular diastolic filling pressure determined by (E/E') during DSE by TDI is affected by presence of coronary artery disease and to find out cut off for inducible myocardial ischemia.*

METHODS AND RESULTS: We *selected* ***50*** *patients of known or suspected coronary artery disease. All patients underwent stress thallium as per standard protocol. Among 50 patients stress thallium was positive in 28 patients and negative in 22 patients. All patients underwent coronary angiography within one month of stress thallium. Stenosis of greater than 50% was considered as ischemia inducing. Significant coronary artery stenosis was observed in 33 patients (66%) and in 17(34%) patients coronary stenosis was less than 50 percent.Doubtaminestress was done in all patients and strain parameters were recorded using TDI at baseline and at peak doubtamine stress. All observations and comparisons were made at segmental level.Using 18 segment model in all patients 50 x 18 = 900 segment were identified.100 segments were excluded from analysis due to scintigraphic evidence of scar,echocarographic wall motion abnormalties and abnormal baseline strain pattern.*

During DSE, SRpeak ***s****ystolic clearly increased in non ischemic segments (-3.42±0.43) while this increase was clearly reduced in ischemic segments (-2.63±0.74) at peak stress with statistical significance p value of 0.001. Almost similar observation was found for Eet (-15.36±2.86 vs -12.00 ±4.52: p value = 0.001) and Eps (0.26±0.93 vs -5.58±1.96: p value = 0.001).There was no such difference noted in Emax.(-21.8 ±2.96 vs -21.34±2.78:p value 0.16).During ischemia Eps/Emax increases (0.01±0.05 vs 0.27±0.10 :p value 0.001) because of PSS and is the best quantitative parameter to define stress induced ischemia during DSE.*

*By ROC analysis, eps/emax was the best parameter to identify ischemia (**AUC 0.85, (95%CI), p-value** 0.001*). SRI allowed us to quantify PSS and, with a cutoff value of **40%** resulted in a sensitivity of **80%** and specificity of 83**%** for the detection of stress-induced ischemia.*

***CONCLUSION** –Quantifying ischaemia-induced changes in myocardial deformation (Strain, Strain rate) is necessary to define both the ischaemic substrate thus decreasing the subjectivity of the test and at the same time reduce training requirements, allowing the test to be performed and quantified by non-experts. The assessment of E/E'ratio should be combined with wall motion assessment during DSE. The E/E'ratio overcomes the drawback of wall-motion analysis, especially when the development of wall-motion abnormalities is subtle or is hard to interpret because of inadequate image. It can also be applicable in patients even with left bundle branch block, in which wall-motion analysis might be degraded. Furthermore, the value of E/E'index provides a good marker for patients who might have multivessel disease and must be taken into consideration during diagnosis. In addition, because E/E'is a quantitative value and can be obtained at ease without the need of expertise, it is then user friendly and would not require so much skill for handling as compared with when using the conventional visual analysis, hence, would be a better diagnostic tool especially for detecting CAD.*

INTRODUCTION

Dobutamine stress echocardiography (DSE) is well established for detecting inducible ischemia, defined by a regional reduction or deterioration of myocardial thickening or inward motion of the endocardial border.1–3 Reading DSE is subjective and strongly dependent on experience, making more objective markers desirable.4-6 Echocardiographic strain-rate imaging (SRI) 7 reliably measures regional myocardial deformation (strain) and deformation rate (strain rate, SR) compared with sonomicrometry.8 Recent reports on the use of SRI during DSE for viability and ischemia are promising.9,10Thus, this study investigates regional myocardial strain rate and strain response during DSE in patients and compares the results with conventional DSE reading, perfusion scintigraphy and coronary angiography.

During ischemia, left ventricular (LV) diastolic function is affected earlier than the systolic function.11On the basis of this concept, clinical studies have demonstrated that the evaluation of regional LV diastolic function could be a valuable strategy for the identification of reduced myocardial perfusion.12TDI has been used most commonly to evaluate diastolic function and to estimate filling pressures.13 Transmitral flow velocity in conjunction with annular velocity (E/E') has so far been shown to be the best single Doppler predictor of elevated filling pressures at rest .and at stress.14Hence aim of the present study is also to determine whether a quantitative estimation of E/E' provides more reliable information for detecting coronary artery disease during dobutamine stress echocardiography.

MATERIAL AND METHODS

The present was conducted in the Department of Cardiology, KGMU, and Lucknow. **50** patients of known or suspected coronary artery disease attending cardiology OPD who gave written informed consent were taken into study. Patients with LVEF < 35%, Acute coronary syndrome within the previous 2 months, history of ventricular tachycardia requiring therapy for termination, or symptomatic sustained ventricular tachycardia, not in sinus rhythm, with bundle branch block and patients with more than mild valvular heart disease were excluded from the study.

1. **Dobutamine Stress Protocol :**

   All patients underwent dobutamine stress echocardiography as per standard DSE protocol 39 with incremental dobutamine infusion rates of 5, 10, 20, 30, and 40micrograms/kg/min for 3 minutes each and up to 0. 2 to 1mg of atropine if necessary to achieve target heart rate. Criteria for terminating the test was achievement of target heart rate of (220 -age) x0.85 bpm, development or deterioration of wall-motion abnormalities, angina, ischemic ECG changes, systolic blood pressure increase to 240 mm Hg or decrease to 100 mm Hg and severe ventricular or supraventricular arrhythmias.Patients were scanned with a Vivid seven ultrasound scanner (GE Vingmed). At baseline, at each step of the DSE, and during recovery, 3 heart cycles of the apical 4, 2 chamber and 3 chamber view were captured in conventional 2D and color tissue Doppler

mode. Blood pressure was measured by the cuff method every 2 min during and up to 15 min after termination of drug administration Echo data was stored digitally for subsequent offline Analysis. Digital images in quad screen format were analysed for the presence, extent, severity and location of segmental wall motion abnormalities. The left ventricle was divided into 18 segments.Regional myocardial contractile function was graded as normal, hypokinetic, akinetic or dyskinesia, in each myocardial.Segment, with reference to systolic wall thickening rather than endocardial motion. An abnormal echocardiographic stress test result was defined as one showing the development of a new or worsening stress-induced regional wall motion abnormality not present at baseline. **Test abnormality** was further be described by (1) the extent and (2) the severity of the induced wall motion abnormality at peak stress. The extent of induced wall motion abnormality was defined by the number of segments with new wall motion abnormalities. Four degrees are defined (a) at least one segment, (b) at least two segments, (c) at least three segments, (d) at least four segments.

2. **Tissue doppler:**

   All patients were examined with tissue Doppler during DSE. Images were captured in color tissue Doppler mode and stored digitally for offline analysis .Longitudinal strain and strain rate were calculated from color tissue Doppler velocity. Color-coded strain-rate curved M-modes were reconstructed from each myocardial wall (septal, anteroseptal, anterior, lateral, posterior and inferior). Strain curves were baseline-corrected. Timing of aortic and mitral valve opening (AVO, MVO) and closure (AVC, MVC) was derived from the echo recordings.

Following parameters were measured:

1. Peak systolic strain rate (SR peak systolic),
2. the maximum length change during the entire heart cycle (emax),
3. Strains during ejection time (eet).
4. Postsystolic strains (eps), defined as the maximum length change between AVC (aortic value closure) and the regional onset of myocardial lengthening caused by early mitral filling.
5. To account for systolic shortening and overall curve amplitude, the ratioseps/eet and eps/emax was calculated.

Values were expressed in seconds(strain rate) and percent (strain) and are negative in shortening and positive in lengthening myocardium The beginning of myocardial shortening (tbos) and timing of peak systolic strain rate (tpsr) were measured relative to AVO and the end of shortening (teos) relative to AVC. Values were given in milliseconds and as percentage of ejection time. Longitudinal strain and strain rate parameters were calculated at all levels of stress. Left ventricular diastolic filling pressure determined by E/E' was recorded during DSE using TDI.

3. **Stress thallium:**

   Stress thallium was done and treated as gold standard for defining regional ischemia. Stress thallium was carried out in SGPGI.Currently utilized myocardial perfusion tracers for myocardial perfusion imaging include thallium 201 and two technetium 99m agents (Tc-99m sestamibi andTc-99m tetrofosmin). During DSE, the radioactive tracer was injected at peak stress, and dobutamine continued for 2 minutes. Scintigraphic images were acquired within1 hour. Baseline perfusion scintigraphy was performed before the stress test or the day after. Single-photon emission computed tomography (SPECT) was performed with a Multi-SPECT scanner with a low-energy, high-resolution collimator and a gated acquisition protocol. Corrected tracer uptake at baseline and at peak stress were quantified and compared. As in echocardiography,18 left ventricular myocardial segments were defined and assigned as nonischemic, ischemic, or scarred by an experienced reader blinded to DSE results and other patient data.

4. **Coronary Angiography**:

   All patients underwent coronary angiography. Coronary angiograms were obtained within 30 days from the stress echo study and stenosed vessels were quantified. A diameter stenosis of >50% was considered inductive of stress ischemia. Myocardial segments were assigned to the

presumed perfusion territories of stenosed vessels, considering the left coronary to generally supply anterior, anteroseptal, and mid and apical septal segments, the circumflex to supply the lateral wall, and the right coronary artery the basal septal and basal and mid inferior segments. The remaining segments were assigned depending on the relative size of the 3 coronaries and their branches.

STATISTICS:

All continuous variables are expressed as mean ± (SD).All data analysis and comparison between imaging modalities were performed using paired and unpaired students's t- tests, analysis of variance and Pearson's linear correlation for continuous variables and chi-square test for categorical variables as appropriate. In addition analysis was done to compare 2D stress Echo and strain rate reading with scintigraphy. Sensitivities and specificities were calculated for SRI parameters. E/E' was calculated by TDI and correlated with severity of coronary artery disease.significant differences were defined as a p value < 0.05.

OBSERVATION AND RESULTS

All patients underwent stress thallium as per standard protocol. Among 50 patients stress thallium was positive in 28 patients and negative in 22 patients. All patients underwent coronary angiography within one month of stress thallium. Stenosis of greater than 50 % was considered as ischemia inducing. Significant coronary artery stenosis was observed in 33 patients and in 17 patients coronary stenosis was less than 50 percent.Doubtamine stress was done in all patients and strain parameters were recorded using TDI at baseline and at peak doubtamine stress. All observations and comparisons were made at segmental level.Using 18 segment model in all patients 50 x 18 = 900 segment were identified.100 segments were excluded from analysis due to scintigraphic evidence of scar,echocarographic wall motion abnormalties and abnormal baseline strain pattern.

50 patients with known or suspected CAD

Stress thallium test

28 patients positive	22 patients negative

Coronary angiography [within one month}

33 had more than 50% coronary artery stenosis	17 had less than50% coronary artery stenosis
Using 18 segment model in 50 patients{900 segments},out of which 100 segments were excluded	

64 ischemic segments{9 ischemic segments were excluded}	736 non ischemic segments

55 ischemic segments which were supplied by diseased coronary artery were compared with 736 non ischemic segments

On stress thallium 28 patients showed ischemic response in 64 segments. Patients with and without ischemic response did not differ significantly ($p>0.05$) with respect to age ,medication ,risk factors, baseline ejection fraction,average blood pressure and heart rate at baseline and peak stress (Table-1 & Fig.1-3).

Table-1: Basic characteristics of the patients

	Non ischemic	**Ischemic**	**p-value**
No of patients	22	28	
Age	60.32±3.56	60.11±7.52	0.90[a]
Male gender	13 (59.1%)	23 (82.1%)	0.07[b]
Beta blocker	12 (54.5%)	14 (50.0%)	0.74[b]
Nitrate	14 (63.6%)	16 (57.1%)	0.64[b]
Hypertension	11 (50.0%)	9 (32.1%)	0.20[b]
Diabetes	5 (22.7%)	7 (25.0%)	0.85[b]
Smoking	11 (50.0%)	13 (46.4%)	0.80[b]
Ejection fraction	60	61	
Baseline SBP	130.12±23.24	136.22±25.67	0.07[a]
Baseline DBP	76.55±11.23	80.65±14.34	0.27[a]
Peak SBP	140.12±21.25	158.45±24.56	0.007[a]

[a]Unpaired t-test, [b]Chi-square test

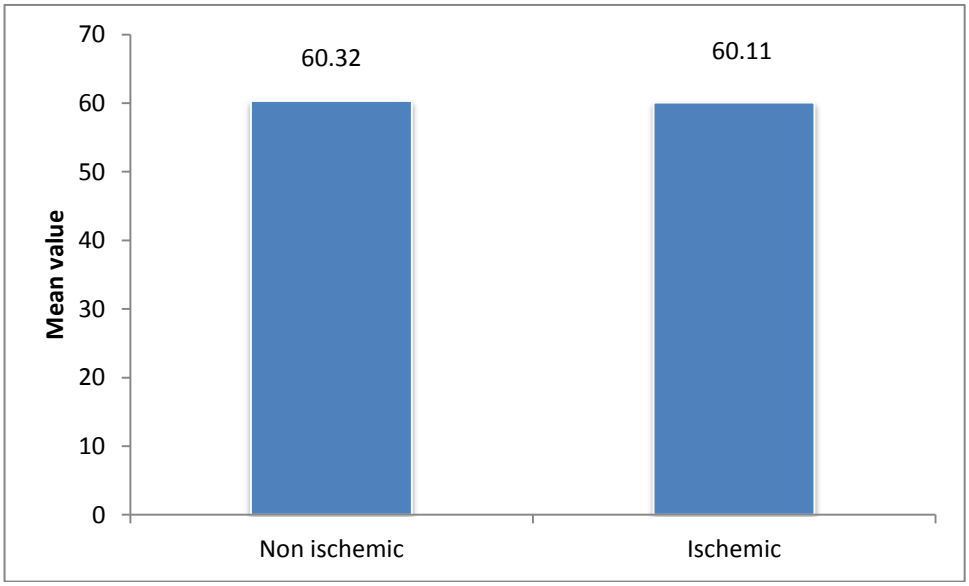


Fig.1: Age distribution of patients

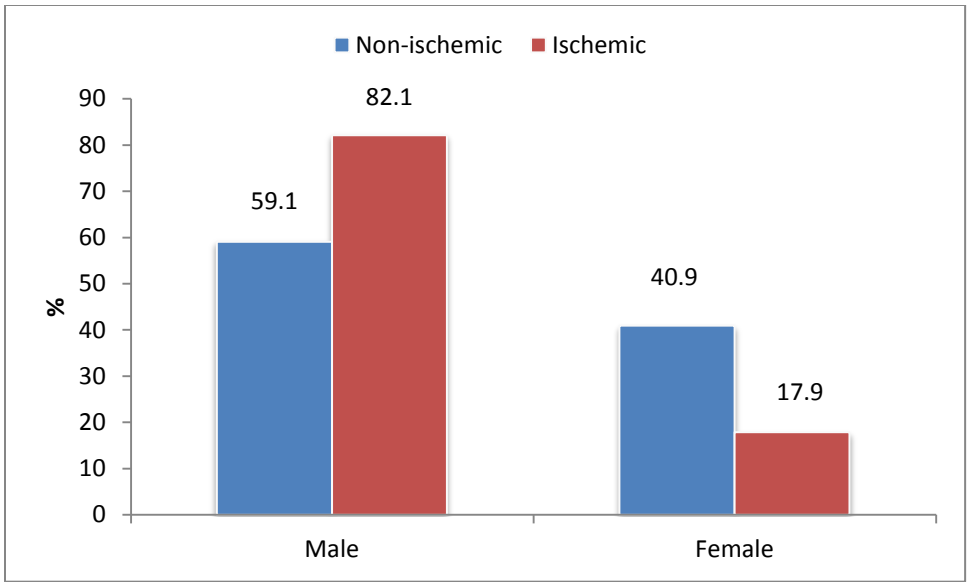


Fig.2: Gender distribution of patients

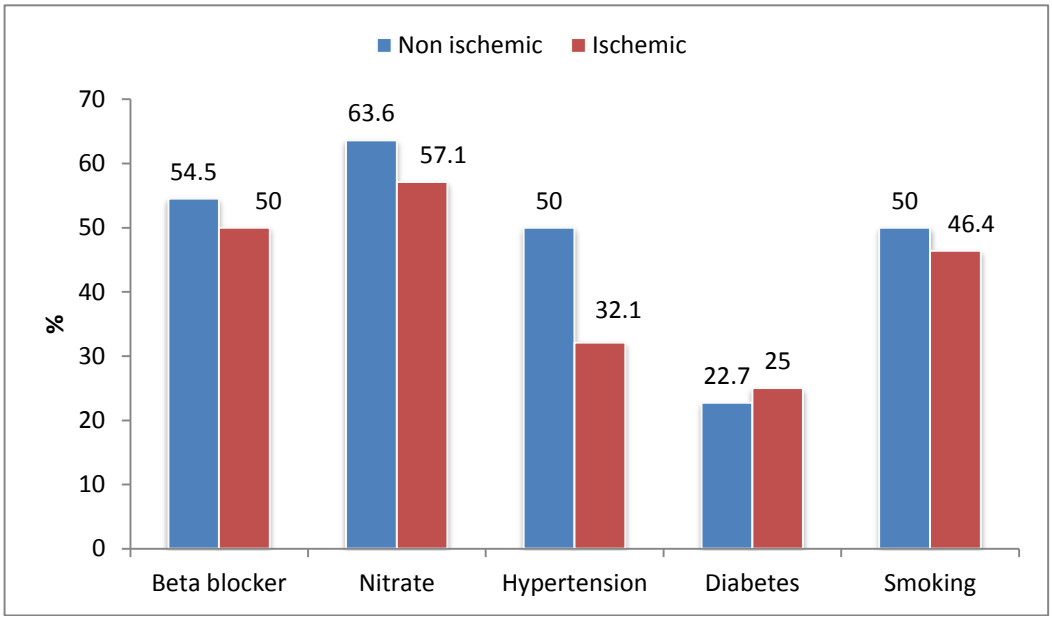


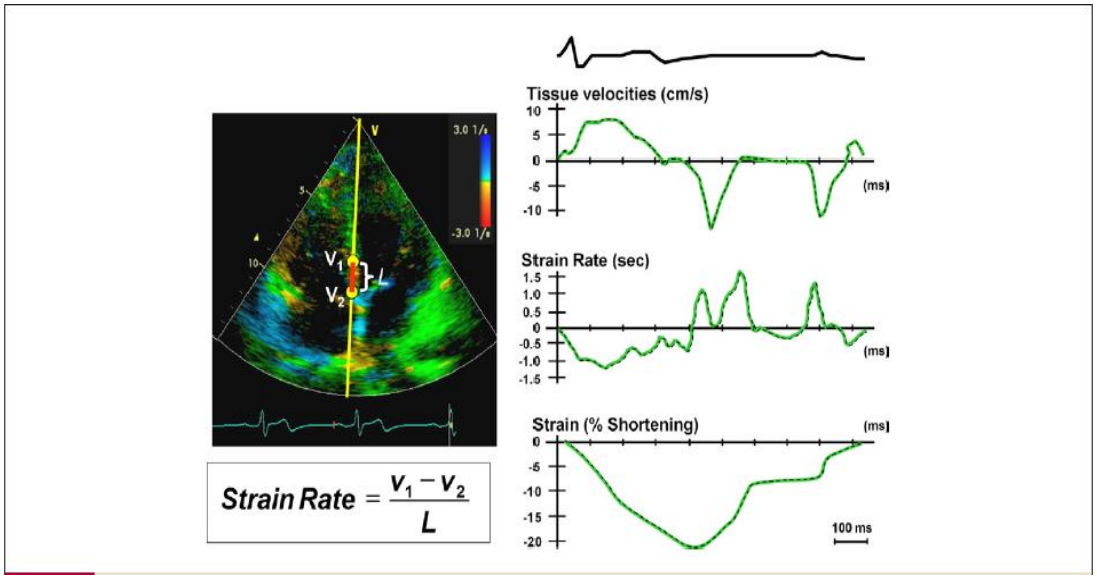
Fig.3: Presenting symptoms

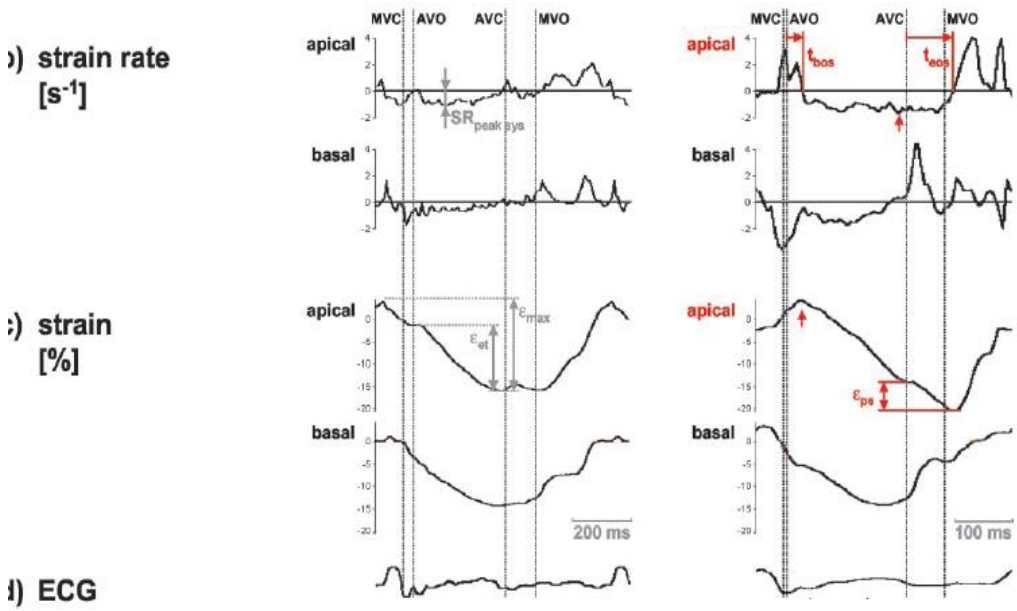
We selected **50** patients of known or suspected coronary artery disease attending cardiology OPD.All patients underwent stress thallium as per standard protocol.Among50 patients stress thallium was positive in 28 patients and negative in 22 patients.All patients underwent coronary angiography within one month of stress thallium. Stenosis of > 50% was considered as ischemia inducing. Significant coronary artery stenosis was observed in 33 patients and in 17 patients coronary stenosis was < 50 percent. Doubtamine stress was done in all patients and strain parameters were recorded using TDI at baseline and at peak doubtaminestress.All observations and comparisons were made at segmental level..Using 18 segment model in all patients 50 x18 =900 segment were identified.100 segments were excluded from analysis due to scintigraphic evidence of scar, echocarographic wall motion abnormalties and abnormal baseline strain pattern. On stress thallium 28 patients showed ischemic response in 64 segments .Patients with and without ischemic response did not differ significantly ($p>0.05$) with respect to age, medication, risk

factors, baseline ejection fraction,average blood pressure and heart rate at baseline and peak stress (Table-1 & Fig.1-3).

We selected 55 ischemic segments which matched with coronary artery disease [selected segments were supplied by coronary artery with more than 5o% stenosis]. Myocardial segments were assigned to the presumed perfusion territories of stenosed vessels, considering the left coronary to generally supply anterior, anteroseptal, and mid and apical septal segments, the circumflex to supply the lateral wall, and the right coronary artery the basal septal and basal and mid inferior segments. The remaining segments were assigned depending on the relative size of the 3 coronaries and their branches.

QUANTITATIVE DSE ANALYSIS





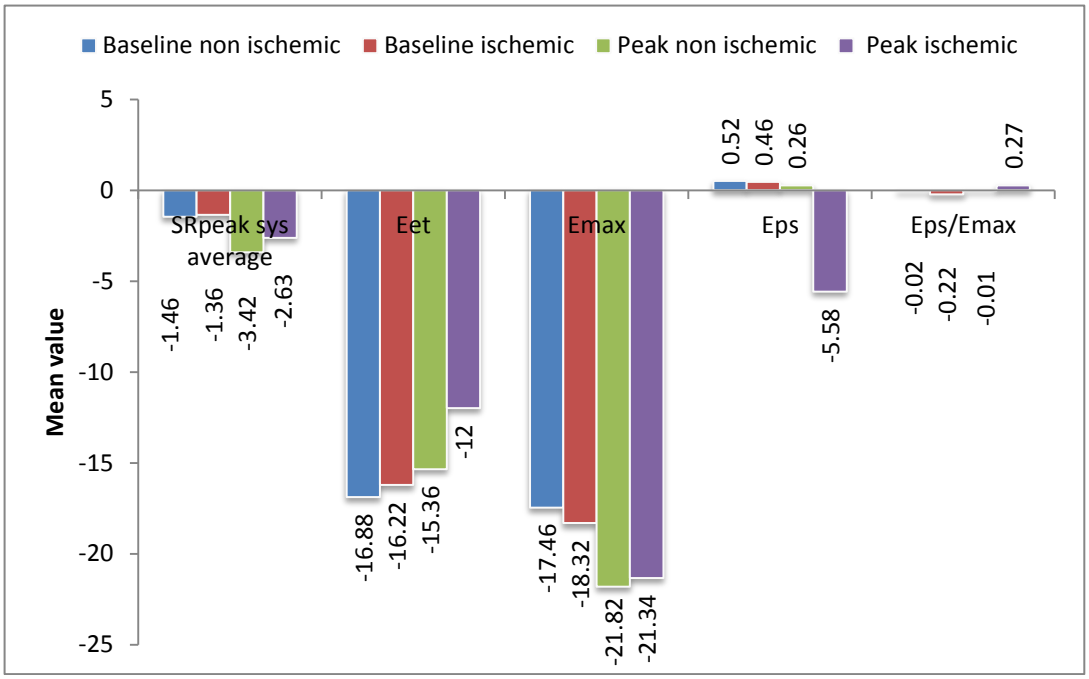
QUANTITATIVE DSE ANALYSIS

During DSE, SRpeak **s**ystolic clearly increased in non ischemic segments while this increase was clearly reduced in ischemic segments at peak stress with statistical significance p value being 0.02 and 0.001. Almost similar observation was found for Eet (Table-2 & Fig.4).

Table-2: Comparison of study parameters

	Baseline non ischemic	Baseline ischemic	p-value[1]	Peak non ischemic	Peak ischemic	p-value[1]
SRpeak sys average	-1.46± 0.40	-1.36±0 .48	0.02*	-3.42±0.43	-2.63±0.74	0.001*
Eet	-16.88±2.62	-16.22±2.84	0.001*	-15.36±2.86	-12.00±4.52	0.001*
Emax	-17.46±7.84	-18.32±7.00	0.42	-21.82±2.96	-21.34±2.78	0.16
Eps	0.52±1.62	0.46±1.47	0.01*	0.26±0.93	-5.58±1.96	0.001*
Eps/Emax	-0.02±0.09	-0.22±0.08	0.61	-0.01±0.05	0.27±0.10	0.001*

[1]Paired t-test, *Significant



ROC analysis of SR peak systolic showed its sensitivity of 77.0% and specificity of 75.0% for inducible myocardial ischemia with cut off value < - 3.55. The sensitivity and specificity were lower in peak non ischemic than peak ischemic (Table-3 & Fig.5).

Table-3: Sensitivity and specificity of SRpeak sys. foridentification of segmental stress-induced ischemia.

	AUC (95%CI), p-value	Cutoff	Sensitivity	specificity
Peak non ischemic	0.77 (0.64-0.90), 0.001*	<-3.35	59.0%	0.72%
Peak ischemic	0.75 (0.61-0.89), 0.002*	<-3.55	77.0%	75.0%

*Significant

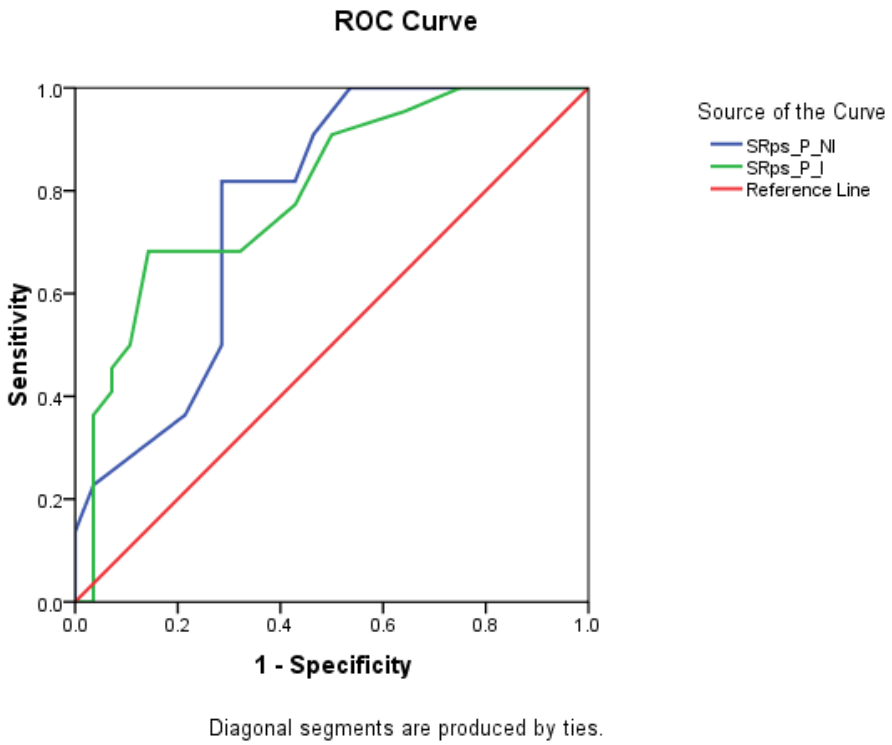


Fig.5: ROC of SRpeak sys for identification of segmental stress-induced ischemia.

Table-4: Sensitivity and specificity of Eet for identification of segmental stress-induced ischemia

	AUC (95%CI), p-value	Cutoff	Sensitivity	specificity
Peak non ischemic	0.61 (0.44-0.78), 0.18	<-15.0	68%	61%
Peak ischemic	0.72 (0.58-0.86), 0.008*	<-15.5	77.3%	57.1%

*Significant

ROC curve analysis of Eet showed sensitivity of 77.3% and specificity of 57.1% for stress induced ischemia with cut off of ≤ 15.5.

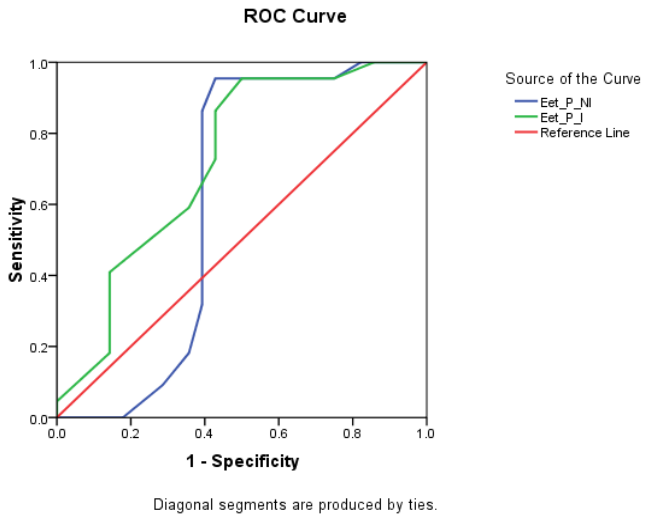


Fig.6: ROC of Eet for identification of segmental stress-induced ischemia.

A low sensitivity and specificity with insignificant (p>0.05) AUC was observed for Emax (Table-5 & Fig.7)

Table-5: Sensitivity and specificity of Emax for identification of segmental stress-induced ischemia

	AUC (95%CI), p-value	Cutoff	Sensitivity	Specificity
Peak non ischemic	0.60 (0.44-0.76), 0.22	<-15.5	68.2%	57.1%
Peak ischemic	0.30 (0.16-0.45), 0.02*	<2.15	50%	32.1%

*Significant

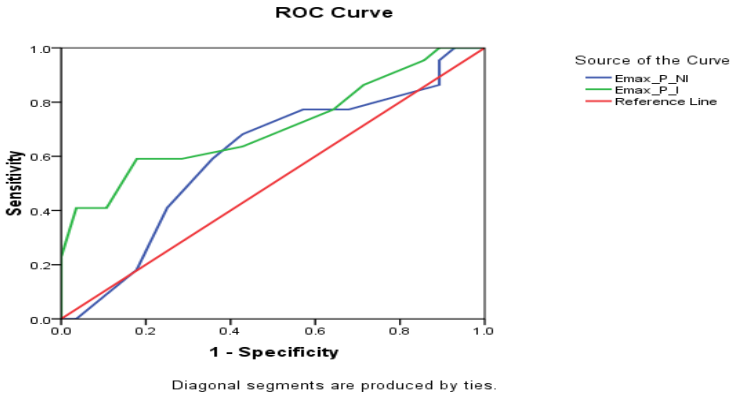


Fig.7: ROC of Emax for identification of segmental stress-induced ischemia.

To separate ischemic from non ischemic PSS and to increase the specificity of this highly sensitive marker of ischemia, its amplitude relative to maximum shortening [which incorporates systolic shortening] was analysed. The AUC was also found to be statistically significant (p=0.001) (Table-6 & Fig.8).

Table-6: Sensitivity and specificity of Eps for identification of segmental stress-induced ischemia

	AUC (95%CI), p-value	Cutoff	Sensitivity	specificity
Peak non ischemic	0.83 (0.71-0.95), 0.001*	>0.45	72.7%	78.6%
Peak ischemic	0.68 (0.53-0.83), 0.07	<-5.95	90%	60.7%

*Significant

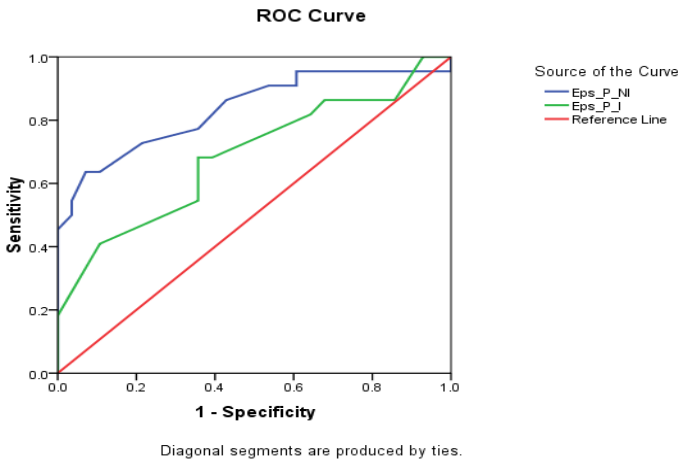


Fig.8: ROC of Eps for identification of segmental stress-induced ischemia

During ischemia **eps/emax** increases because of PSS and reduced systolic shortening. **eps/emax** was best quantitative parameter to define stress induced ischemia during DSE. By ROC analysis, eps/emax was the best parameter to identify ischemia (**AUC=0.85, 95%CI**=0.67-0.92, p=0.001). An eps/emax cutoff of **40%** identified patients with ischemia with a sensitivity of **80%** and a specificity of **83%**. All other SRI parameters had significantly less discriminating power.

Table-7: Sensitivity and specificity of Eps/Emax for identification of segmental stress-induced ischemia

	AUC (95%CI), p-value	Cutoff	Sensitivity	specificity
Peak non ischemic	0.84 (0.73-0.96), 0.001*	<-0.06	72.7%	89.3%
Peak ischemic	0.85 (0.67-0.92), 0.001*	>0.40	80%	83.%

*Significant

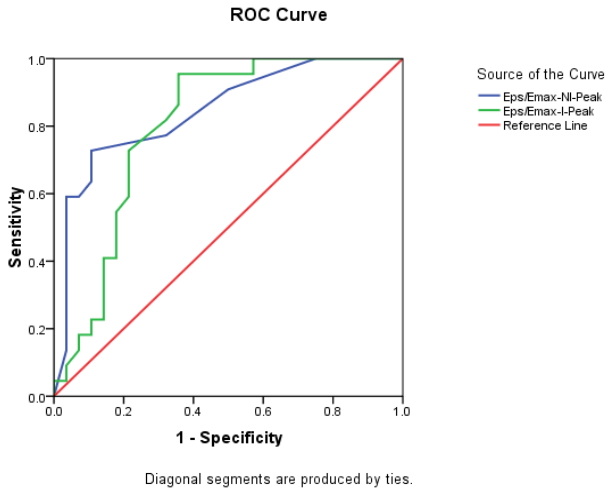
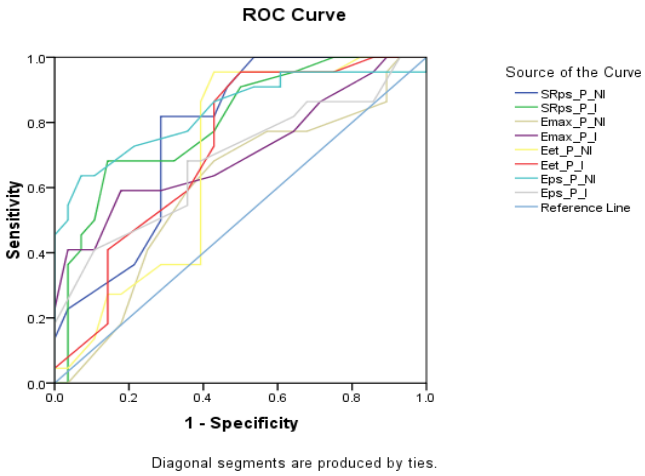


Fig.9: ROC of Eps/Emax for identification of segmental stress-induced ischemia.



DIASTOLIC FUNCTION PARAMETERS

All subjects were examined with DSE and TDI to assess resting, mean **E/E'**at peak stress, **E/E'** change and **E/E'**index. The E/E' peak was significantly (p=0.001) higher among CAD (8.92±0.65) patients compared to Non-CAD (3.51±0.41). Similarly, E/E' change and index were also significantly (p=0.001) higher among CAD patients than Non CAD (Table-8 & Fig.).

Table-8: DSE and TDI examination

	Non CAD	**CAD**	p-value[1]
E/E'Peak	3.51±0.41	8.92±0.65	0.001*
E/E' change	1.06±0.33	1.65±0.29	0.001*
E/E' index	0.67±0.13	1.38±0.17	0.001*

[1]Unpaired t-test, *Significant

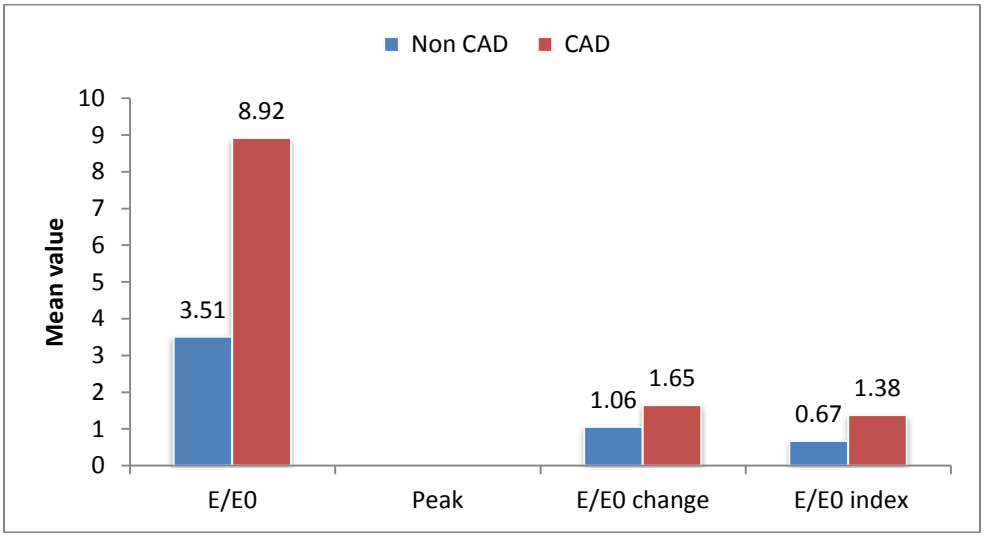


Fig.9: **DSE and TDI examination**

In the present study, **E**'value decreased in CAD group, but increased in non CAD group during stress echo. Consequently,**E/E'**increased significantly in CAD group, but not in non CAD which may be an attribute of the proportional increase in both mitral inflow and annular velocities. Moreover, there were significant differences regarding **E**'peak**, E**'change which decreased in CAD group, but increased in non CAD group. **E/E'**peak and **E/E'**index values showed significant increase in CAD group, but decreased in non CAD group during stress echo. **E/E'**ratio is a good marker for identifying CAD.A receiver operating curve analysis (**ROC curve**) of **E/E'**peak**, E/E'change** and **E/E'index** as an indicator to detect cut-off value of the presence of CAD has been performed. It was found that a cut-off value of **E/E' peak>4.55**had a specificity of **78.6%**, a sensitivity of 81.8**% (AUC=0.88, 95%CI=0.78-0.98, p-value= 0.001)** (Table-9 & Fig.10).

Table-9: Sensitivity and specificity of E/E', Peak,E/E' change,E/E' index for stress-induced ischemia

	AUC (95%CI), p-value	**Cutoff**	**Sensitivity**	**specificity**
E/E'Peak	0.88 (0.78-0.98), 0.001*	>4.55	81.8%	78.6%
E/E' change	0.83 (0.71-0.94), 0.001*	>0.9	80%	71.4%
E/E' index	0.79 (0.66-0.91)	>0.8	68.2%	67.9%

*Significant

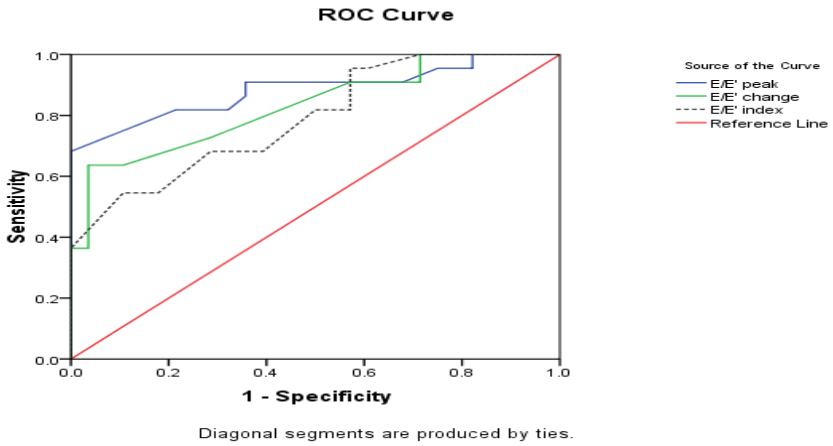


Fig.10: ROC for E/E' peak, change and index

DISCUSSION

Dobutamine stress echocardiography (DSE) is well established test for detecting inducible myocardial ischemia, but its interpretation is subjective and depends on experience of person. There is need to find out parameters for objective evaluation of ischemia during dobutamine stress echo. Echocardiographic strain-rate imaging (**SRI**) 7 reliably measures regional myocardial deformation (**strain**) and deformation rate (**strain rate, SR**).8 In our study, we used strain imaging during DSE to quantitate ischemia and find out cut off value to make its interpretation objective.We also tried to find out parameters of diastolic dysfunction during DSE and their relation to inducible myocardial ischemia.

STRAIN IMAGING PARAMETERS DURING DSE

In non ischemia segments, peak systolic strain rate [**SRpeaksystolic]** increased significantly at peak dobutamine stress. This is in aggrement to previous studies 17, 18.This increase in peak systolic strain rate was markedly reduced in ischemic segments, confirming earlier studies 8,13, 17,18. **emax**,[maximum strain] and **eet** [strain during ejection time] remained unchanged in non ischemic segments duringdoubtaminestress.In ischemic segments **emax** remained almost constant during DSE while **eet** reduced significantly.**emax** was not reduced in ischemic segments during DSE due to increasing or newly occurring PSS[post systolic shortening].This is in agreement to previous studies 8 13 17 18.
In ischemic segments **tbos** [beginning of myocardial shortening] and **teo**s [end of myocardial shortening] increased significantly because of delayed contraction and marked PSS.These are markers of ischemia known for years 9 10.The mere presence of PSS is not specific for ischemia as it can be found at rest.In our study **PSS** was found in maximum ischemic segments at peak stress and in only half of non ischemic segments. This is in aggrement to study by **Voigt et al.** 37

CRITERIA FOR DEFINING STRESS INDUCING ISCHEMIA WITH STRAIN IMAGING

Simple amplitude cut off for **eet** and **SRpeak** systolic to identify ischemia during DSE performed poorly due to differing contractile state of the individuals and noisy strain rate signals.PSS is higly sensitive marker of ischemia but less specific.Toincrease its specificity and to separate ischemic from non ischemicPSS,its amplitude relative to maximum shortening [which incorporates systolic shortening] was analysed.During ischemia **eps/emax** increases because of PSS and reduced systolic shortening. **eps/emax** was the best quantitative parameter to define stress induced ischemia in DSE.By ROC analysis, eps/emax was the best parameter to identify ischemia (**AUC 0.85 ;95%CI: p-value** = 0.001*). SRI allowed us to quantify PSS and, with a cutoff value of **40%** resulted in a sensitivity of **80%** and specificity of 83**%** for the detection of stress-induced ischemia. All other SRI parameters had significantly less discriminating power.

PARAMETERS OF DIASTOLIC DYSFUNCTION DURING DSE BY USING TISSUE DOPPLER
During ischemia, left ventricular (LV) diastolic function is affected earlier than the systolic function 40.On the basis of this concept, clinical studies have demonstrated that the evaluation of regional LV diastolic function could be a valuable strategy for the identification of reduced myocardial perfusion. 41 TDI has been used most commonly to evaluate diastolic function and to estimate diastolic filling pressures. 42 In our study **E/E**'at peak dobutamine stress and **E/E'**index values showed significant increase in CAD group, but decreased in non CAD group during stress echo. This is in accordance with **Tsougos et al.** 43 The **E/E'** peakratio has been proposed as a valuable marker of elevated LV end diastolic pressure,44 a phenomenon that occurs before systolic WMA and ECG changes. The diagnostic accuracy of e/e'peakat dobutamine stress, **E/E'**change, and **E/E**'index for the detection of CAD was assessed by receiver operating characteristic curve indicating that these parameters are good parameters for detecting CAD. Also these results agree with **Hyodo et al**. who found that **E/E'**index during DSE is the best parameter for detecting CAD and provides a good marker for patients who might have multivessel disease. 45.. A receiver operating curve analysis (ROC curve) of **E/E**'peak, **E/E'**change and **E/E'**index as an indicator to detect cut-off value of the presence of CAD has been performed. It was found that a cut-off value of **E/E'**peak **>4.5** had a specificity of 78.6**%**, a sensitivity of **81.8%,E/E'**change cut off >0.9 had a specificity of 71.4%, a sensitivity of 80%.Thus, in our study we find out objective markers with cut off value to quantify ischemia during DSE. **eps/emax** with cut off of **40%** using strain imaging and **E/E'** peak with cut off of **>4.55**, **E/E'** change with cut off**>0.9.**

CONCLUSION
In **conclusion**, quantifying ischaemia-induced changes in myocardial deformation is necessary to define both the ischaemic substrate thus decreasing the subjectivity of the test and at the same time reduce training requirements, allowing the test tobe performed and quantified by non-experts.

The assessment of E/E'ratio should be combined with wall motion assessment during DSE. The E/E'ratio overcomes the drawback of wall-motion analysis, especially when the development of wall-motion abnormalities is subtle or is hard to interpret because of inadequate image. It can also be applicable in patients even with left bundle branch block, in which wall-motion analysis might be degraded. Furthermore, the value of e/e'index provides a good marker for patients who might have multivessel disease and must be taken into consideration during diagnosis. In addition, because e/e'is a quantitative value and can be obtained at ease without the need of expertise, it is then user friendly and would not require so much skill for handling as compared with when using the conventional visual analysis, hence, would be a better diagnostic tool especially for detecting CAD.

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