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Assessment of the Role of Speckle Tracking Echocardiography in Targeting the Left Ventricular Lead Position in Patients Undergoing Cardiac Resynchronization Therapy

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ABSTRACT

Background: Cardiac Resynchronization Therapy (CRT) is now a well-established treatment for patients with advanced heart failure through biventricular pacing. Optimizing the left ventricular (LV) lead position via echocardiographic speckle tracking guidance could reduce the rate of non-responders to CRT.

Objectives: to assess the role of speckle tracking echocardiography in determining the proper position of the left ventricular lead in patients undergoing CRT.

Methods: the study population comprised 50 patients who were indicated for CRT according to the ESC 2012 guidelines. Speckle tracking echocardiography was done to all patients before CRT implantation or shortly after implantation while switching off pacing to determine the latest activated myocardial wall of the LV. The patients were classified after CRT implantation into two groups; the first group (group A) included 20 patients and represented those with concordance between the most mechanically delayed myocardial wall derived from speckle tracking echocardiography and the coronary sinus lead position, and the second group (group B) included 30 patients that showed discordance between them. Both groups were recruited for follow-up after a period of 6 months to assess clinical response, echocardiographic response and mortality

Results: Significant correlation was observed between echocardiographic response and the LV lead concordance (p value=0.041), and between combined clinical and echocardiographic response and LV lead concordance. There was a nearly significant difference between clinical response and the LV lead concordance (p value=0.057), and there was a trend towards less mortality in the group with concordant LV lead (10.5% in the concordant group versus 24.1% in the discordant group) with no statistical significance (p value=0.286).

Conclusions: we demonstrated an increased benefit with an echocardiographically optimized LV lead position targeting the most delayed myocardial wall by 2D speckle tracking echocardiography.

Key words: resynchronization, speckle tracking, strain, dyssynchrony

INTRODUCTION

Heart failure is a complex clinical syndrome characterized by impaired myocardial performance and progressive activation of neuroendocrine system leading to circulatory insufficiency and congestion. With the increasing age of the population, improved survival of patients with myocardial infarction and reduced mortality from other diseases, incidence of heart failure and the cost of managing patients with heart failure continue to increase. Data suggest that the lifetime risk of developing heart failure is about 20%.[(1)]

Heart failure is an urgent public health need with national and global implications. It is one of the most important causes of morbidity and mortality in the industrialized world.[(2)]

Cardiac resynchronization therapy (CRT) is now an established therapy for patients with advanced heart failure with prolonged QRS duration. Apart from clinical benefits, improvement of left ventricular (LV) systolic function and associated LV reverse remodeling has been reported. [(3)] Recently, improvement of right ventricular function also has been reported**.** [(4)]

So far, better characterization of patients who will respond to CRT has been the main focus

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of ongoing research. However, identification of non- responders to CRT is also of interest**.**

Current inclusion criteria may not be accurate enough to differentiate patients who will or will not respond to CRT. Other pathophysiologic factors such as HF etiology, LV dimensions and function, mitral regurgitation, LV dyssynchrony, position of LV pacing lead, and extent/location of myocardial scar have also shown to influence CRT response. [5]

Speckle tracking echocardiography (STE) is a technique based on pure 2D grayscale ultrasound acquisition allowing calculation of segmental strains. Because of scattering, reflection, and interference of the ultrasound beams in myocardial tissue, speckle formations in gray-scale echocardiographic images represent tissue markers that can be tracked from frame to frame throughout the cardiac cycle.

Aim of the study: This study aims to assess the role of speckle tracking echocardiography in determining the proper position of the left ventricular lead in patients undergoing Cardiac Resynchronization Therapy.

PATIENTS AND METHODS

Patients: This study included 50 patients with congestive heart failure who were indicated for CRT implantation according to ESC (2012) guidelines in the period from May 2013 to April 2015.

The patients were classified after CRT implantation into two groups; the first group **(group A)** included 20 patients and represented those with concordance between the most mechanically delayed myocardial wall derived from speckle tracking echocardiography and the coronary sinus lead position, and the second group **(group B)** included 30 patients that showed discordance between them.

Only 2 patients were lost to follow-up, one from group A and the other from group B

Inclusion criteria:

1. Patients complaining of congestive heart failure symptoms NYHA class III- ambulatory class IV in spite of optimal medical therapy (including beta-blockers, angiotensin enzyme inhibitors or angiotensin II receptor blockers and diuretics)
2. QRS > 120 milliseconds
3. EF ≤ 35 %

Exclusion criteria:

1. Patients having sustained atrial fibrillation.
2. Patients with severe chronic debilitating disorders limiting their lifespan including cancer patients.
3. Patients with recent acute coronary syndromes or coronary revascularization (within the previous 3 months).

Methods:

Each patient was subjected to:

I- History taking with particular emphasis on:

1. **Age.**
2. **Gender.**
3. **Risk factors including:**

- Hypertension
- Diabetes mellitus: Defined as 8 hours fasting plasma glucose ≥ 126 mg/dl, 2hr plasma glucose ≥ 200 mg/dl during an oral glucose tolerance test (OGTT), symptoms of diabetes mellitus and casual plasma glucose ≥ 200 mg/dl or patients who were taking anti-diabetic medications.[6]
- Dyslipidemia: Defined as total cholesterol > 200 mg/dl or low density lipoprotein (LDL) cholesterol >130 mg/dl or treatment by statins, TG >150 mg/dl. [7]
- History of smoking or being a former smoker.
- Positive family history of ischemic heart disease.

4. **Symptoms:**

- Etiology of cardiomyopathy whether ischemic or dilated non-ischemic
- Duration of heart failure symptoms.
- Severity (NYHA class).

Quality of life questionnaire: Minnesota living with heart failure questionnaire (MLHFQ).The Questionnaire was translated into Arabic and each question was scaled from 0 (no effect on quality of life), to 5 (highest impact on QOL) where higher scores reflect poorer QOL. Scoring of the questionnaire was done by summating the responses to all 21 questions. [8]

5. **Drug history:** Types of medications used, with doses and durations.
6. **Other associated medical problems:** Renal disease, chronic liver disease, and bronchopulmonary diseases

II- General and local cardiac examination:

Was done to all patients with particular stress on: Arterial blood pressure, pulse, body mass index (BMI): weight/ height squared, in Kg/ m^2, murmurs & additional heart sounds e.g. S3 as a sign of impaired myocardial performance, and signs of pulmonary and systemic venous congestion.

III- Baseline 12-lead electrocardiogram: to assess:

1. Rate.
2. Rhythm.
3. Baseline intervals.
4. QRS complex duration in milliseconds, BBB pattern, conduction abnormality, pathological Q waves.

Where a. ?

b. Six Minute Walk Distance Test (6MWT)

The six minute walk test was done to assess the exercise tolerance at baseline and in the follow up stage. We measured the distance in meters every patient is able to walk over a total of six minutes on a hard, flat surface. The individual was allowed to self-pace and rest as needed.

Transthoracic Echocardiographic assessment:

Echocardiographic studies were performed with commercially available echocardiography system equipped with a 2.5-mHz multifrequency phased array transducer (vivid 9, GE vingmed, Horton, Norway) with electrocardiographic gating of all acquired images.

Timing of the index echocardiographic study: This was done for all patients within 2 days before implantation or shortly after implantation while switching off the ventricular pacing.

(1) 2-Dechocardiography

A 2-D apical 4-chamber view was obtained to calculate the LVEF by Auto EF method based on grayscale speckle tracking (3-click method).

(2) M-mode echocardiography

M-mode echocardiography from the parasternal short- axis view at the level of the papillary muscles was done to obtain the following measurements.*[9]*

a. LV end-diastolic dimension (LVEDD), b. LV end-systolic dimensions (LVESD).

(3) Pulsed and continuous wave Doppler: along the aortic valve in the apical 5-chamber view:

Aortic valve opening (AVO) and Aortic valve closure (AVC) were marked. (Fig. 1)

(4) Doppler tissue imaging (DTI): Three color-DTI cine loops were obtained for each patient; from eachoftheapical4-chamber, apical 2-chamber and apical long-axis views. These were digitally stored and electronically transferred to the attached workstation for offline analysis using the available ***EchoPAC PC software (GE Vivid software)*** in order to calculate the different dyssynchrony indices. *[10]*

Assessment of the dyssynchrony indices by Doppler tissue imaging

The time to peak systolic velocity (Ts) was measured from the onset of QRS complex to the peak myocardial systolic wave in the ejection phase at each of the twelve basal and mid segments of the LV walls (lateral, septal, anterior, inferior, posterior and anterolateral walls).

Mechanical dyssynchrony index:

The mechanical dyssynchrony index (Ts-SD or Yu index) was estimated, which is the standard deviation of the time- to-peak systolic velocity (Ts) at each of the twelve basal and mid segments of the LV. *[11]*

Ts-SD (standard deviation of time to peak systolic velocity of 6 basal and 6 mid left ventricular segments) was the used dyssynchrony index and it was calculated through a specially designed template using Microsoft Excel. The cut-off value used in this study was 32.6 milliseconds. [11] (Fig. 2)

Speckle tracking Echocardiography (STE):

This was done before CRT implantation in all included patients to determine:

1. the most delayed site of left ventricular mechanical activation via radial strain of the LV short axis view at the level of the mitral valve or the papillary muscles (basal-to-mid level). We made a detailed analysis of the 6 basal segments (mitral annular level) or 6 mid wall segments (papillary muscle level) of the LV in the short-axis parasternal view in terms of time to reach peak radial strain (positive value). Time to peak radial strain was determined for each wall in milliseconds in a parametric fashion enabled in the software and the latest contracting wall was determined, the most delayed region was identified by having the two most delayed adjacent walls.
2. the averaged global peak systolic strain (GLPSS avg.) of the LV via the Bull's eye polar map obtained from the longitudinal strain of the 3 standard apical views, either via semi-automated

endocardial border tracing or automated function imaging (AFI).

c. ***Laboratory data:***
Na+ and K+ levels, coagulation profile and serum creatinine.

d. ***The procedure:***
CRT Implantation

All patients underwent CRT implantation angiographically by conventional techniques after they fulfilled the inclusion criteria, all leads were implanted transvenously.

After CRT, implantation biplane fluoroscopy in orthogonal views (left anterior oblique at 60° and right anterior oblique at 30°) was performed. These images were analyzed to determine the anatomic location of the LV lead. For that purpose a resized 17-segment schema of Bull's eye obtained from 2D STE was projected onto the left anterior oblique fluoroscopic image. (Fig. 7)

e. **Follow up post CRT implantation:**

f. ***Follow up:*** of all patients after 6 months to assess the outcomes, namely clinical response, echocardiographic response, combined response and mortality.

- Clinical follow-up: The patient's clinical improvement through the 6 minute walk test (6MWT) and the improvement in the NYHA class, readmission and mortality.
- Echocardiographic follow-up:
2D Echocardiographic assessment of left ventricular functions, changes in left ventricular volumes, left atrial dimensions and in the grade of mitral regurgitation.

C- Statistical analysis:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical Package for Social Science (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

RESULTS

Description of personal and medical risk factors among cases: The mean age and BMI among cases were 56±12.9 years and 27.8±4.1 kg/m2 respectively. Males represented 82% of cases. Smokers, hypertensive, diabetics and cases with ischemic heart disease were present among 62%, 48%, 40% and 52% of cases respectively.

Comparison between the 2 study groups as regards personal and medical risk factors: There was no significant difference between group A and B cases as regard personal and medical data with the exception of hypertension, where it was present among 65% of concordant cases compared to 36% only of discordant cases which was statistically significant.

Comparison between the 2 study groups as regards echocardiographic findings before intervention: There was a significant difference between group A and B cases as regards baseline LVEDD, LVESD, LVESV and LVEDV. Also a significant difference between both groups as regards the LV diastolic dysfunction grade was found.

Descriptions of echocardiographic findings at follow up among all cases: At follow up, the mean LVEDD, LVESD, LVESV and LVEDV were 72.2±12.2, 64.4±13.4, 124±67.5 and 164.4±73.8 respectively. MR grade one was present among 53.8% of cases. Diastolic dysfunction grade 1 and mild TR were present among 44.7% and 64.7% respectively.

Descriptions of change in echocardiographic findings after intervention among all cases: There was a highly significant difference between group A and B cases as regards change (reduction) in LVESD with higher change among concordant cases (p-value 0.007); also there was a significant difference in favour of group A regarding the LVEDD (p-value 0.039 by Student t test), however a nearly significant difference was found as regards LVESV (p-value 0.075). Nevertheless, no significant difference between both groups as regards LVEDV (p-value 0.139).

Comparison between the 2 study groups as regards change in LVEDD, LVESD, LVESV and LVEDV: The mean change in LVEDD, LVESD, LVESV and LVEDV after intervention was 1.9±5.2, 2.27±5.23, 12.48±28.79, 12±30.09 respectively. About 82% of cases had no change in MR after intervention.

Comparison between the 2 study groups as regards clinical, echocardiographic and combined responses and death: The above table shows a near significant difference between group A and B cases as regards clinical response with higher response (78.9%) among concordant compared to 51.7% among discordant group.

As regards echocardiographic and combined response, a significant difference between group A and B cases was detected, however no significant difference was found between the 2 groups as regards mortality

DISCUSSION

In this study, the intra-procedural priority was to achieve a stable LV lead position with suitable threshold and with absence of diaphragmatic pacing in the posterolateral area. No intra-procedural hemodynamic evaluation was carried out.

There was no significant difference between both groups in the demographic data as regards patient's age, baseline NYHA class, medications or cardiovascular risk factors except for hypertension which was significantly higher in the concordant group (representing 65%) than the discordant group (only in 36%) with a p-value of 0.049. This could be potentially responsible for some masking of the favourable clinical and echocardiographic response in the concordant group and may also in part be a contributory risk factor for mortality that occurred especially in group A.

The distribution of demographic and clinical characteristics among study groups showed male predominance (82% of all patients), the female gender was under-represented in our study groups, as there were only nine female patients (18% of all patients); four were categorized as group A and five were as group B. As there was no statistically significant difference in the female gender, this entity did not have an impact in the percent of response to CRT in our study, as the response to CRT proved to be significantly higher in the female gender.

The difference in the percentage of the echocardiographic responders and combined responders (clinically and echocardiographically) in the two groups showed a statistically significant difference as there were 8 responders in group A and 4 patients in group B (p-value= 0.041).

Those who were clinically responders represented 78.9% of group A as compared to 51.7% of group B with a near significant difference (p-value= 0.057). Regarding the echocardiographic and combined (clinical and echocardiographic) response, group A had a significantly higher responder rate (p-value 0.041 for both responses), all echocardiographic responders were clinical responders as well. Echocardiographic responders constituted 8 patients in group A (42.1%) versus only 4 patients in group B (13.8%).

There was no statistically significant difference in mortality among both groups but there was a trend for improved survival in the concordant group (2 deaths in group A versus 7 deaths in group B).

The responders to CRT implantation in our study were 30 patients (62.5%) clinically and 12 patients (25%) from a volumetric echocardiographic standpoint.

We found a trend towards an increase in LVEF by 2D echocardiography auto EF method depending on speckle tracking in our total study group. The baseline EF was (23.9±7.09 and 21±6.6 %) in group A and B respectively and increased to (31.67±11.5 and 25.55±12.25 %) in group A and B respectively.

The difference between group A and B in the degree of improvement in echocardiographic parameters was much more in favour of group A and did not reach a statistically significant level for the delta change in LVESV (p-value 0.075), while it reached a highly statistically significant value (p-value 0.007) for the delta change in LVESD. Nevertheless, there was no significant difference between both groups as regards change in LVEDV.

The significant reduction of LVESD (p-value 0.007) represents an important effect of CRT implantation in HF patients (LV reverse remodeling) with improving prognosis and symptoms. These significant reverse remodeling were consistent with the results obtained from multiple previous studies. [12,13]

Regarding the delta change in LVEDD, the p-value obtained from Student t test was also statistically significant (p-value 0.039) while that obtained from Mann Whitney test was 0.097. The reduction in the LVEDV was irrespective of the LV lead concordance with the delayed myocardial segment as analyzed by comparing the delta change in both groups which showed no significant difference between them (p-value 0.0139).

In this study we used one of the tissue-Doppler derived indices, which is the Yu index (the SD of time to peak systolic velocity of the 6 basal and the 6 mid LV segments) with a cut-off limit of 32.6 milliseconds to decide whether or not there is intra-left ventricular mechanical dyssynchrony before CRT implantation. There were no significant differences of these parameters between the two groups. Yu index was non-significantly higher in the concordant group (37.72±12.64 milliseconds) than the discordant group (33.73±11.64 milliseconds), reflecting more mechanical dyssynchrony in group A.

The large prospective, multicenter Prospect trial assessed the ability of several conventional two-dimensional echocardiographic variables and techniques to predict response to CRT and revealed poor inter-observer reproducibility with the outcome. [14]

Several studies were published recently using different echocardiographic modalities for selecting optimum LV pacing site.

Speckle Tracking Assisted Resynchronization Therapy for Electrode Region (STARTER) trial is a prospective, double-blind, randomized controlled trial that tested the hypothesis that a potential incremental benefit to CRT would be gained by echo-guided (EG) trans-venous LV lead placement versus a routine fluoroscopic approach. EG LV lead placement was attempted at the site of latest time to peak radial strain by speckle tracking echocardiography. The prespecified primary end point was first HF hospitalization or death of 187 HF patients, 110 were randomized to EG and 77 to routine strategies. They found that patients randomized to an EG strategy had a significantly more favorable event-free survival (hazard ratio, 0.48; 95% confidence interval, 0.28-0.82; P=0.006). [15]

To summarize, our study was conducted to assess, after a follow up period of 6 months, the response of heart failure patients to CRT. Echocardiographic response was determined by a reduction in LVESV by 15%.

These results emphasize the role of CRT and prove its echocardiographic reverse remodeling impact, and were consistent with the results of multiple large previously mentioned studies in short and long term follow up periods.[16,17]

In general we can say that our study results recommend speckle tracking echocardiographic guidance to define the wall/segment with most delayed activation to be the site of optimum LV pacing lead.

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Table (1): Comparison between the 2 study groups as regards personal and medical risk factors

		Group				P	Sig
		Concordant		Discordant			
		Mean	±SD	Mean	±SD		
Age		57.50	9.19	55.00	15.06	.510‡	NS
BMI		27.48	5.01	28.03	3.51	.650‡	NS
Gender	Male (n %)	16	80.0%	25	83.3%	1.0**	NS
	Female (n %)	4	20.0%	5	16.7%		
Smoking	Non-smoker (n %)	8	40.0%	11	36.7%	.812*	NS
	Smoker (n %)	12	60.0%	19	63.3%		
Hypertension	No (n %)	7	35.0%	19	63.3%	**.049***	**S**
	Yes (n %)	13	65.0%	11	36.7%		
DM	No (n %)	13	65.0%	17	56.7%	.652*	NS
	Yes (n %)	7	35.0%	13	43.3%		
Ischemic heart disease	No (n %)	11	55.0%	13	43.3%	.419*	NS
	Yes (n %)	9	45.0%	17	56.7%		

‡Student t test *Chi-square test **Fisher exact test

Table (2): Comparison between the 2 study groups as regards echocardiographic findings before intervention

		Group				P	Sig
		Concordant		Discordant			
		Mean			±SD		
LVEDD		70.95	8.69	78.83	11.41	**.012‡**	**S**
LVESD		59.70	8.96	68.37	12.55	**.010‡**	**S**
LA		46.30	5.81	47.47	5.25	.464‡	NS
LV pre-ejection period (LVPEP)		166.67	19.80	166.26	28.96	.959‡	NS
YU index		37.72	12.64	33.73	11.64	.282‡	NS
Global longitudinal strain %		7.42	4.46	5.77	3.25	.157‡	NS
EF (2D speckle tracking Auto EF)		23.90	7.09	21.00	6.60	.149‡	NS
LVESV		117.70	46.80	167.17	63.81	**.005‡**	**HS**
LVEDV		151.80	52.65	210.07	70.71	**.003‡**	**HS**
RVSP		42.00	10.13	38.45	15.55	.682‡	NS
TAPSE		18.18	3.94	16.86	3.93	.282‡	NS
MR grade	I	8	42.1%	11	36.7%	.598**	NS
	II	6	31.6%	13	43.3%		
	III	4	21.1%	6	20.0%		
	IV	1	5.3%	0	.0%		
Diastolic dysfunction grade	I	10	58.8%	6	20.7%	.024*	S
	II	5	29.4%	12	41.4%		
	III	2	11.8%	11	37.9%		
Intraventricular dyssynchrony	No	5	25.0%	12	40.0%	0.273*	NS
	Yes	15	75.0%	18	60.0%		

‡Student t test *Chi-square test **Fisher exact test

Table (3): Descriptions of change in echocardiographic findings after intervention among all cases

	Mean	±SD	Minimum	Maximum
LVEDD change	1.90	5.20	-3.00	23.00
LVESD change	2.27	5.23	.00	22.00
LVESV change	12.48	28.79	-37.00	97.00
LVEDV change	12.00	30.09	-45.00	117.00

Table (4): Comparison between the 2 study groups as regards echocardiographic findings at follow up

		Group				P	Sig
		Concordant		Discordant			
		Mean	±SD	Mean	±SD		
LVEDD		66.06	8.84	77.36	12.47	**.003‡**	**HS**
LVESD		53.72	10.20	65.95	13.39	**.003‡**	**HS**
LA		44.67	5.96	46.32	5.07	.350‡	NS
Global longitudinal strain %		8.22	4.39	6.43	3.14	.183‡	NS
EF (2D speckle tracking Auto EF)		31.67	11.50	25.55	12.25	.114‡	NS
LVESV		94.56	51.71	148.18	70.32	**.011‡**	**S**
LVEDV		131.11	54.36	191.73	77.53	**.008‡**	**HS**
RVSP		38.38	18.27	37.71	15.53	.941‡	NS
TAPSE		19.50	4.16	18.10	3.74	.288‡	NS
MR grade	I	10	58.8%	11	50.0%	.889**	NS
	II	6	35.3%	9	40.9%		
	III	1	5.9%	2	9.1%		
Diastolic dysfunction grade	I	10	58.8%	7	33.3%	.112**	NS
	II	6	35.3%	7	33.3%		
	III	1	5.9%	7	33.3%		
TR	Mild	6	66.7%	5	62.5%	.599**	NS
	Moderate	2	22.2%	2	25.0%		
	Severe	1	11.1%	1	12.5%		

‡Student t test **Fisher exact test

Table (5): Comparison between the 2 study groups as regards change in LVEDD, LVESD, LVESV and LVEDV

	Group						P	Sig
	Concordant			Discordant				
	Mean	±SD	Median	Mean	±SD	Median		
LVEDD change	4.00	7.19	.00	.18	1.18	.00	0.039*	**S**
LVESD change	4.72	7.09	.00	.27	.88	.00	0.007	HS
LVESV change	20.00	32.29	7.00	6.32	24.64	.00	0.075	**NS**
LVEDV change	18.50	34.71	4.50	6.68	25.30	.00	0.139	NS

Mann Whitney test (and 0.039* by Student t test)

Table (6): Comparison between the 2 study groups as regards clinical, echocardiographic and combined responses and death

		Group				P	Sig
		Concordant		Discordant			
		N	%	N	%		
Clinical response	No	4	21.1%	14	48.3%	.057*	**NS**
	Yes	15	78.9%	15	51.7%		
Echo response	No	11	57.9%	25	86.2%	.041**	S
	Yes	8	42.1%	4	13.8%		
Combined response	No	11	57.9%	25	86.2%	.041**	S
	Yes	8	42.1%	4	13.8%		
Death	No	17	89.5%	22	75.9%	.286*	NS
	Yes	2	10.5%	7	24.1%		

‡Student t test *Chi-square test **Fisher exact test

Fig. (1): AV... and A... e cardiac cycles.

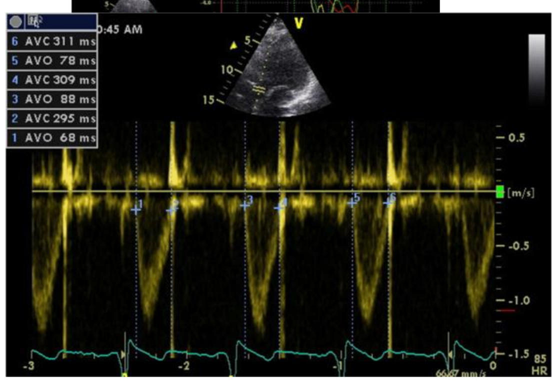

Fig. (2): Off-line analysis of the acquired 2-D color DTI images from each of the apical 4-chamber (A), apical 2-chamber (B) and apical long- axis (C) views to calculate the Yu index .

A

B

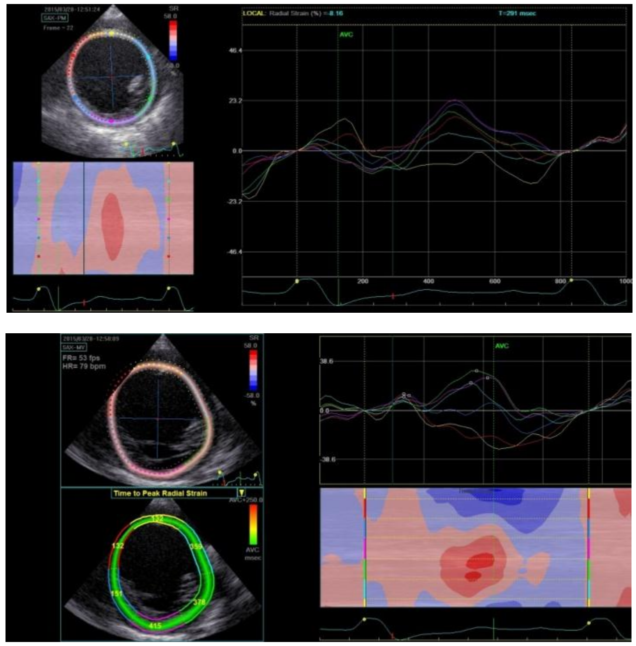

Fig. (3): A: Radial strain curves and B: time to peak radial strain in milliseconds

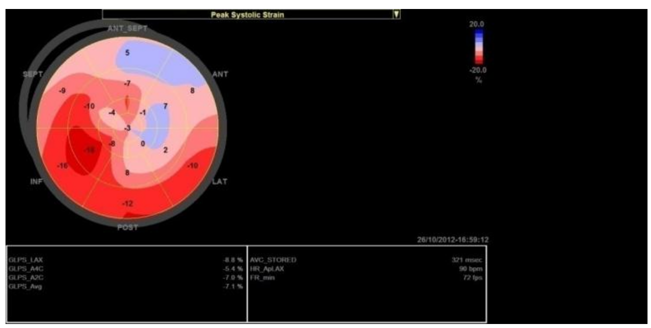

Fig. (4): Bull's eye map showing average global peak longitudinal strain in patient no. It s shown to be -7.1%

Fig. (5): A coronary sinus venogram in the left anterior oblique projection

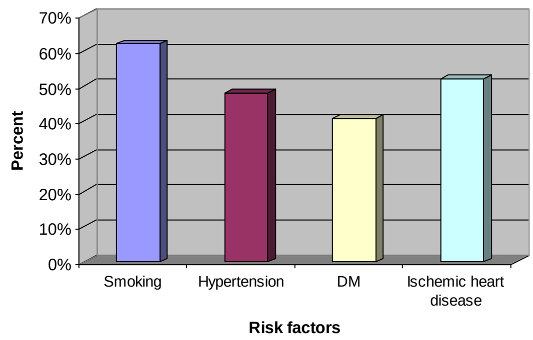

Fig. (6): Description of personal and medical risk factors among cases

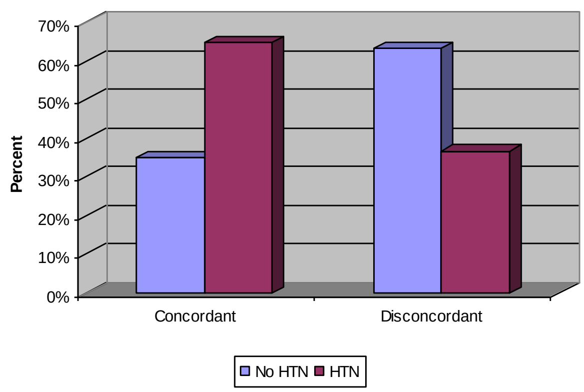

Fig. (7): Comparison between the 2 study groups as regards personal and medical risk factors

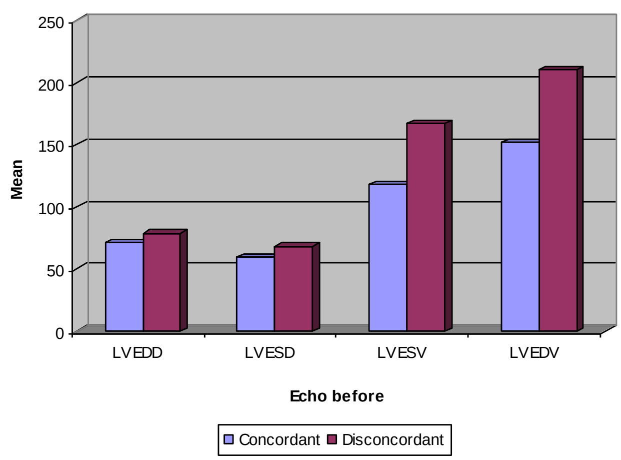

Fig. (8): Comparison between the 2 study groups as regards echocardiographic findings before intervention

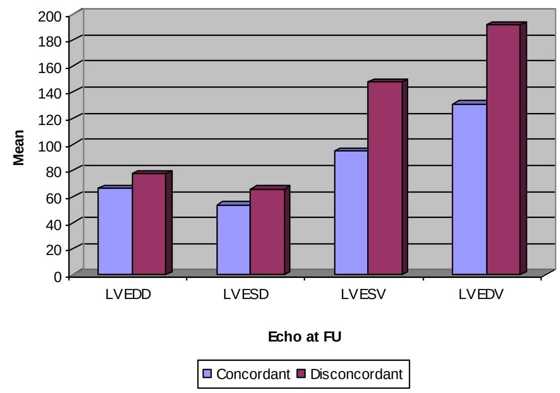

Fig. (9): Comparison between the 2 study groups as regards echocardiographic findings at follow up

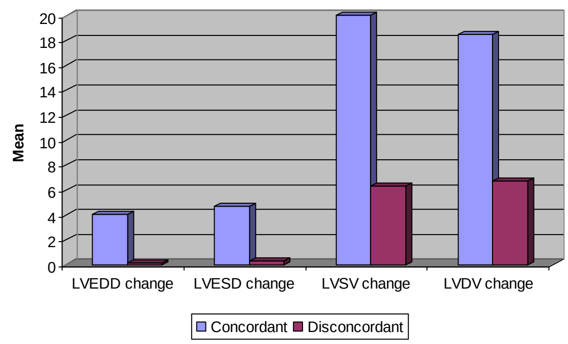

Fig. (10): Comparison between the 2 study groups as regards change in LVEDD, LVESD, LVESV and LVEDV

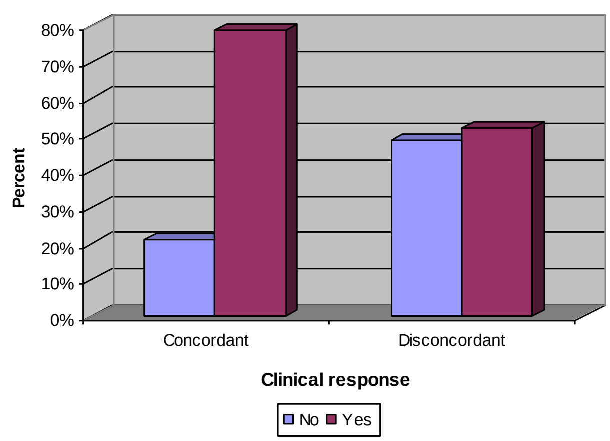

Fig. (11): Comparison between the 2 study groups regarding clinical response

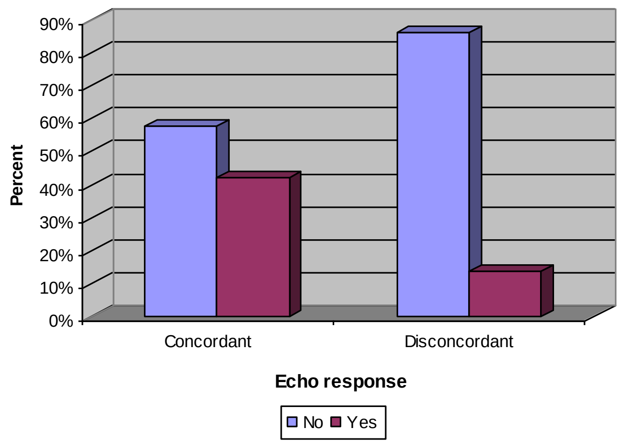

Fig. (12): Comparison between the 2 study groups regarding echocardiographic response

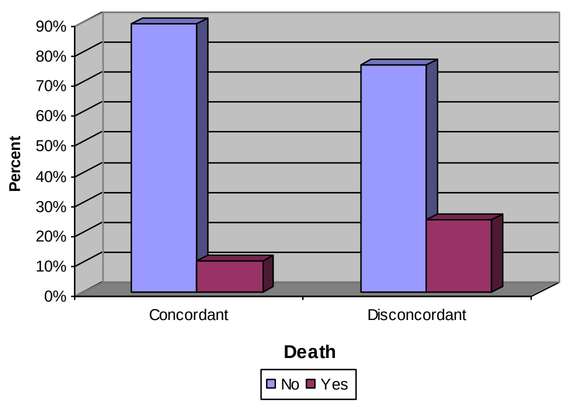

Fig. (13): Comparison between the 2 study groups regarding mortality