Results

Patient characteristics (Table 9, figure 7&8):

The present study was carried out on 60 patients including 31 males and 29 females and their age from 45-65 years, with heart failure and their LVEF > or = 30% and less than 50%, the patients were classified into 2 groups:

- **Group I:**
  - Included 30 patients with NYHA functional class I-II.
  - 16 males representing 53.3% of cases and 14 females representing 46.66% of cases in this group.
  - The mean age ± SD was 54.53 ± 6.25 years.
  - There were 10 patients representing 33.3% who were classified as an obese (BMI > 30 Kg/m²), while the remaining 20 patients representing 66.6% were within average body weight.
- **Group II:**
  - Included 30 patients with NYHA functional class III-IV.
  - 15 males representing 50% of cases and 15 females representing 50% of cases in this group.
  - The mean age ± SD was 54.96 ± 6.62.
  - There were 12 patients representing 40% who were classified as an obese (BMI > 30 Kg/m²), while the remaining 18 patients representing 60% were within average body weight.

There was no significant statistical difference between the 2 groups as regards the age (*P* value > 0.05), sex (*P* value > 0.05) and BMI (*P* value > 0.05).

Table (9) Comparison of demographic data among the 2 groups:

Group / Parameter	Group I	Group II	*P* value
Age Mean ± SD in years	54.53 ± 6.25	54.96 ± 6.62	>0.05
Sex **Male** no, (%) **Female** no, (%)	 16, (53.3 %) 14, (46.66 %)	 15, (50 %) 15, (50 %)	>0.05
BMI **Obese** no, (%) **Non obese** no, (%)	 10, (33.3 %) 20, (66.6 %)	 12, (40 %) 18, (60 %)	>0.05

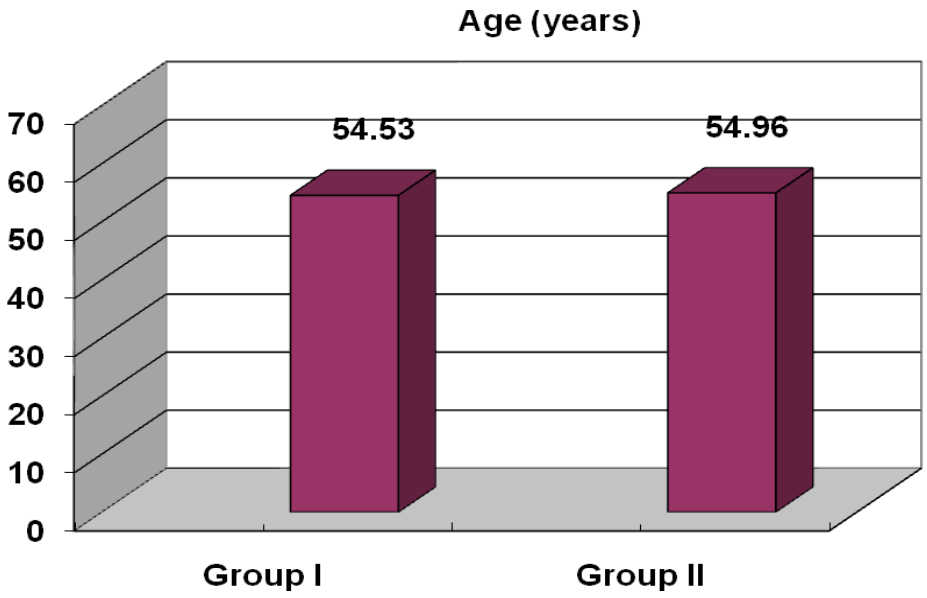


Fig (7): Distribution of age among the 2 groups.

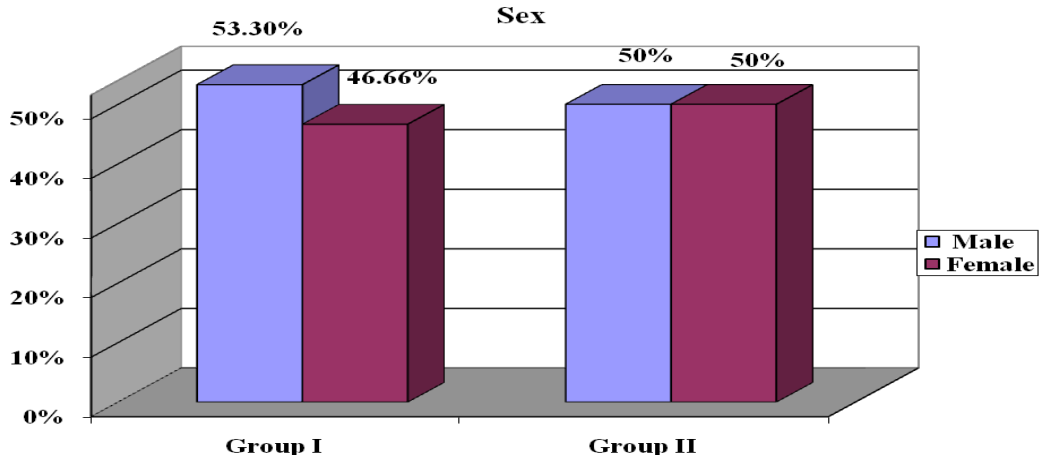


Fig. (8): Distribution of sex among the 2 groups.

Occupation of the studied patients (Table 10):

- **Group I:** There was 16 patients representing 53.3% had no work, and 14 patients representing 46.6% had a work including 10 workers representing 33.3%, and 4 non workers representing 13.3%.
- **Group II:** There was 18 patients representing 60% had no work, and 12 patients representing 40% had a work including 8 workers representing 26.6% and 4 non workers representing 13.3%.

There was no significant statistical difference between the 2 groups as regarding the occupation (*P* value >0.05).

Table (10) Comparison between the 2 groups as regarding occupation:

Occupation		Group I (No)،%	Group II (No)،%	*P* value
No work		(16),53.3%	(18),60%	>0.05
Work	Workers	(10),33.3%	(8),26.6%	
	Non workers	(4),13.3%	(4),13.3%	

Risk factors in the 2 groups (Table 11, Figure 9):

History of Hypertension:

- **Group I:** 13 patients were detected, representing 43% of cases.
- **Group II:** 15 patients were detected, representing 50% of cases.

There was no significant statistical difference between the 2 groups as regards history of Hypertension (*P* value >0.05).

History of Diabetes mellitus:

- **Group I:** 18 patients were detected, representing 60% of cases.
- **Group II:** 14 patients were detected, representing 46% of cases.

There was no significant statistical difference between the 2 groups as regards history of DM (*P* value > 0.05).

Smoking:

- **Group I:** 10 patients were detected, representing 33% of cases.
- **Group II:** 10 patients were detected, representing 33% of cases.
    - There was no statistical difference between the 2 groups as regards smoking (*P* value > 0.05).

Table (11) Comparison between the 2 groups as regarding risk factors:

Risk factor	Group I (NO, %)	Group II (NO, %)	χ^2	*P*
Hypertension	13,43%	15, 50%	0.1	>0.05
Diabetes Mellitus	18, 60%	14, 46%	0.7	>0.05
Smoking	10, 33%	10, 33%	------	---

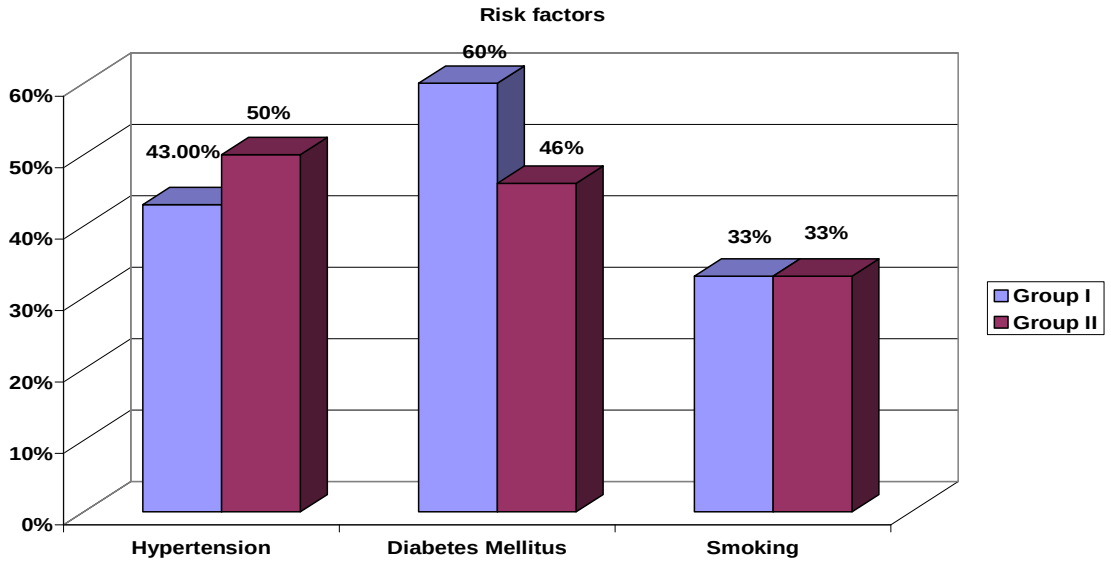


Fig. (9): Distribution of risk factors among the 2 groups.

The underlying Heart disease (the cause of HF) (Table 12, Figure 10):

- **Group I:** 26 patients were detected to have IHD, representing 86.6% of cases, and 4 patients were detected to have non ischemic cause, representing 13.3% of cases.
- **Group II:** 23 patients were detected to have IHD, representing 76.6% of cases, and 7 patients were detected to have non ischemic cause, representing 23.3 of cases.

There was no significant statistical difference between the 2 groups as regards the underlying heart disease (*P* value > 0.05).

Table (12) comparison between the 2 groups as regarding the cause of heart failure:

Cause of HF	Group I	Group II	χ^2	*P*
IHD (NO), %	(26), 86.6%	(23), 76.6%	0.4	>0.05
Non ischemic (NO), %	(4), 13.3%	(7), 23.3%	0.4	>0.05

IHD: Ischemic heart disease No: Number.

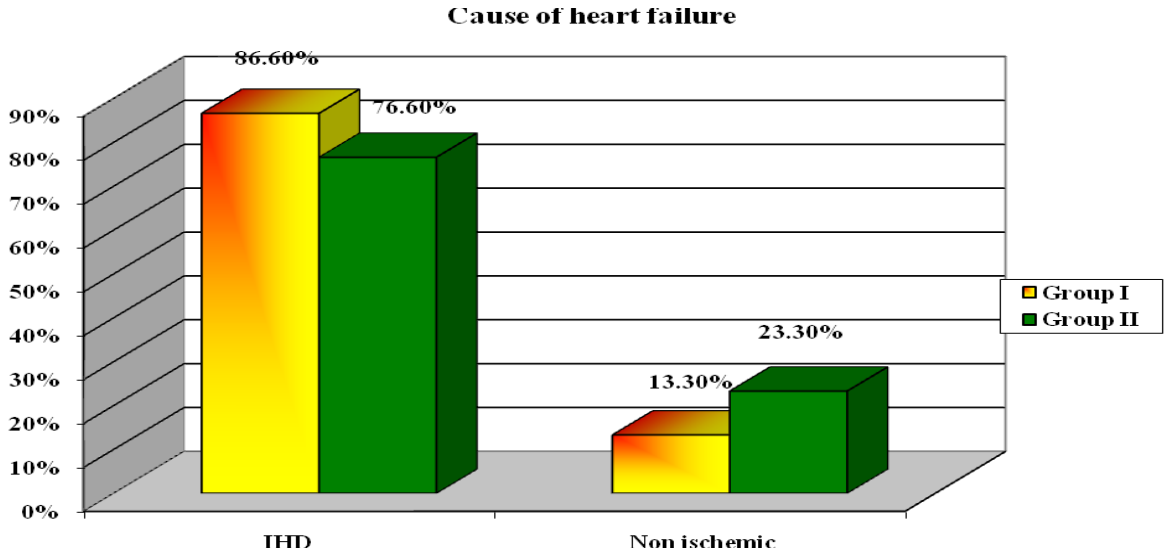


Fig. (10) *The cause of heart failure in the 2 groups.*

Medications used among the two groups (Table 13, figure 11):

- **Group I:** 28 patients representing 93.3% of patients use diuretics, 20 patients representing 66.6% of patients use beta blockers, 19 patients representing 63.3% of patients use ACIs, 9 patients representing 30% of patients use ARBs, 10 patients representing 33.3% of patients use digoxin, 6

patients representing 20% of patients use spironolacton, 26 patients representing 86.6% of patients use nitrates, and 16 patients representing 53.3% of patients use statins.

- **Group II:** 30 patients representing 100% of patients use diuretics, 17 patients representing 56.6% of patients use beta blockers, 20 patients representing 66.6% of patients use ACIs, 7 patients representing 23.3% of patients use ARBs, 10 patients representing 33.3% of patients use digoxin, 8 patients representing 26.6% of patients use spironolacton, 23 patients representing 76.6% of patients use nitrates, and 13 patients representing 43.3% of patients use statins.

There was no significant statistical difference among the two groups as regarding medications used (*P* value >0.05).

Table (13) comparison of medications used among the 2 groups under the study:

Medications	All patients (No),%	Group I (No),%	Group II (No),%	*P* Value
Diuretics	(58),96.6%	(28),93.3%	(30),100%	>0.05
Beta blockers	(37),61.6%	(20),66.6%	(17),56.6%	>0.05
ACEI	(39),65%	(19),63.3%	(20),66.6%	>0.05
ARBs	(16),26.6%	(9),30%	(7),23.3%	>0.05
Digoxin	(20),33.3%	(10),33.3%	(10),33.3%	>0.05
Spironolactone	(14),23.3%	(6),20%	(8),26.6%	>0.05
Nitrates	(49),81.6%	(26),86.6%	(23),76.6%	>0.05
Statins	(29),48.3%	(16),53.3%	(13),43.3%	>0.05

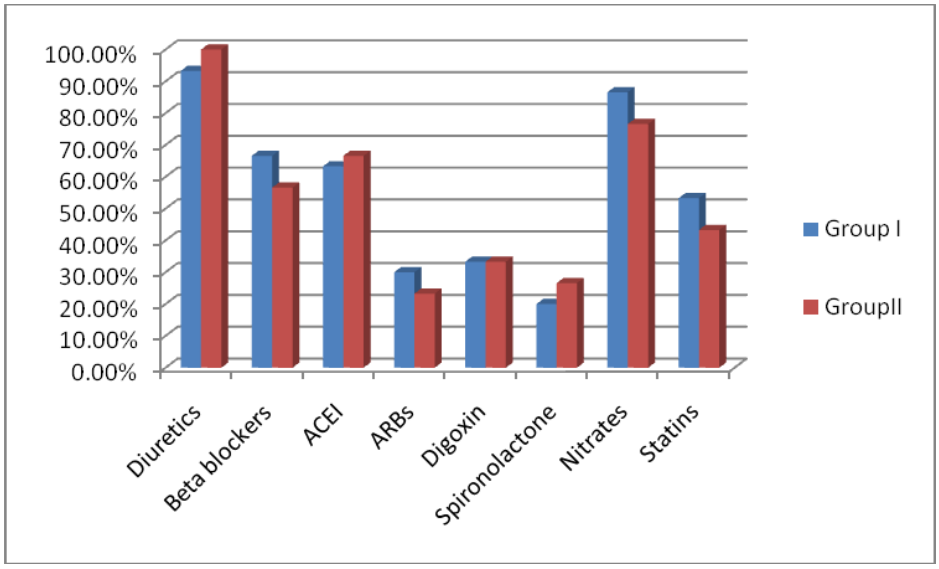


Fig. (11) *Medications used among the two groups.*

Blood pressure and heart rate (Table 14):

Diastolic blood pressure (DBP mmHg):

- **Group I:** A mean DBP ± SD of 77.5 ± 8.68.
- **Group II:** A mean DBP ± SD of 73 ± 11.1.

Systolic blood pressure (SBP mmHg):

- **Group I:** A mean SBP ± SD of 121 ± 16.
- **Group II:** A mean SBP ± SD of 112.66 ± 19.68.

There was no significant statistical difference between the 2 groups as regards the systolic and diastolic blood pressure (*p* value > 0.05).

Heart rate (HR bpm):

- **Group I:** A mean HR ± SD of 79.46 ± 10.64.
- **Group II:** A mean HR ± SD of 90.93 ±13.04.

There was significant statistical difference between the 2 groups as regards the HR with increase in HR among group II (*P* value <0.05).

Table (14) Comparison of Blood pressure and HR among the 2 groups:

Group / variable	Group I	Group II	t	*p*
	Mean ± SD	Mean ± SD		
DBP	77.5 ± 8.68	73 ± 11.18	1.74	>0.05
SBP	121 ± 16.04	112.6 ± 19.68	1.797	>0.05
HR	79.4 ± 10.64	90.9 ± 13.04	3.73	<0.05

Electrocardiographic findings (ECG) (Table 15):

- **Group I:** Normal ECG presents in 6 patients, representing 20% of cases, Ischemic changes present in 20 patients, representing 66.6% of cases, LVH (voltage criteria) present in 6 patients, representing 20% of cases and LBBB presents in 3 patients, representing 10% of cases.
- **Group II:** Normal ECG presents in 4 patients representing 13.3% of cases, Ischemic changes present in 21 patients, representing 70% of cases, LVH (voltage criteria) presents in 8 patients, representing 26.6% of cases, and LBBB presents in 4 patients representing 13.3% of cases.

There was no significant statistical difference as regards the ECG findings between the 2 groups (*P* value >0.05).

Table (15) Comparison of ECG findings among the 2 groups:

Group / ECG Finding	Group I (no),%	Group II (no),%	χ^2	*p*
Normal	(6), 20%	(4), 13.3%	0.1	>0.05
Ischemic changes	(20),66.6%	(21),70%	0.01	>0.05
LVH	(6), 20%	(8),26.6%	0.1	>0.05
LBBB	(3), 10%	(4),13.3%	0.01	>0.05

Laboratory tests (Table 16):

- **Group I:**

-Serum creatinin: A mean ± SD of 1.22 ± 0.24 mg/dl.

- Blood urea: A mean ± SD of 24.26 ± 9.2 mg/dl.

-Hemoglobin (Hb%):A mean ± SD of 11.7 ± 2.3 gm%.

- **Group II:**

-Serum creatinin: A mean ± SD of 1.29 ± 0.188 mg/dl.

-Blood urea: A mean ± SD of 27.6 ± 10.09 mg/dl.

-Hemoglobin: A mean ± SD of 12 ± 2.5 gm%.

There was no significant statistical difference between the 2 groups as regards the serum creatinin, blood urea, and hemoglobin (*P* value > 0.05).

Table (16) Comparison of laboratory tests among the 2 groups:

Group / variable	Group I	Group II	t	*p*
	Mean ± SD	**Mean ± SD**		
S.creatinin	1.22 ± 0.24	1.29± 0.18	1.228	>0.05
Bl.urea	24.26 ± 9.23	27.63 ± 10.09	1.347	>0.05
Hb	11.73 ± 2.31	12 ± 2.54	0.419	>0.05

Conventional echocardiographic parameters (Table 17, Figure 12 to figure 17):

- **M-mode and two dimensional echocardiography :**

1. ***Left ventricular end-diastolic diameter (LVEDd):***

- **Group I:**

- A mean value ± SD of 5.376 ± 1.205 cm.

- **Group II:**
  - A mean value ± SD of 6.073 ± 1.00 cm.

There was significant statistical difference between the two groups with larger LVEDd among group II patients (*p* value < 0.05).

2. ***Left ventricular end-systolic diameter (LVESd):***
   - **Group I:**
     -A mean value ± SD of 4.49 ± 0.60 cm.
   - **Group II:**
     -A mean value ± SD of 5.07 ± 0.99 cm.

There was significant statistical difference between the two groups with larger LVESd among group II patients (*P* value < 0.05).

3. ***Left atrial diameter (LAD):***
   - **Group I:**
     -A mean value ± SD of 4.24 ± 0.7 cm.
   - **Group II:**
     -A mean value ± SD of 4.75 ± 0.6 cm.

There was significant statistical difference between the two groups *(P* value < 0.05) with larger LAD in group II than group I.

4. ***Left ventricular ejection fraction (LVEF):***
   - **Group I:**
     -A mean value ± SD of 41.06 ±6.6%.
   - **Group II:**
     -A mean ± SD of 35.36 ± 7.08%.

There was significant statistical difference between the two groups with lower LVEF% in group II patients *(P* value < 0.05).

5. ***Left ventricular stroke volume (SV):***
   - **Group I:**
     -A mean value ± SD of 77.12 ± 27.5 ml.
   - **Group II:**
     -A mean value ± SD of 61.7 ± 21.06 ml.

There was significant statistical difference between the two groups as regarding SV with group II patients have left ventricular SV lesser than group I patients (*P* value < 0.05).

- **Doppler echocardiography results:**

1. ***Early transmitral E wave:***
   - **Group I:**
     -A mean value ± SD of 76.44 ± 24.78 cm/s.
   - **Group II:**
     -A mean value ± SD of 81.56 ± 25.24 cm/s.
2. ***Atrial "late" transmitral velocity A wave:***
   - **Group I:**
     -A mean value ± SD of 55.53 ± 24.05 cm/s.
   - **Group II:**
     -A mean value ± SD of 49.53 ± 18.63 cm/s.
3. ***Ratio of early to late transmitral flow velocity (E/A):***
   - **Group I:**
     -A mean value ± SD of 1.67 ± 0.91.
   - **Group II:**
     -A mean value ± SD of 1.94 ± 1.03.
4. ***Deceleration time of E wave (EDT):***
   - **Group I:**
     -A mean value ± SD of 141.23 ± 35.49 ms.
   - **Group II:**
     -A mean value ± SD of 118.73 ± 35.56 ms.

There was no significant statistical difference between the two groups as regard E wave (*P* value > 0.05).

On the other hand there was significant statistical difference between the two groups as regards DT which was shorter in group II than group I (*P* value < 0.05).

Table (17) Comparison of conventional echocardiographic parameters between the 2 groups:

Group / parameter	Group I	Group II	t	*p*
	Mean ± SD	**Mean ± SD**		
LVEDd (cm)	5.3767 ± 1.20507	6.0733 ± 1.00548	2.431	<0.05
LVESd (cm)	4.49 ± 0.6	5.07 ± 0.99	2.71	<0.05
LAD (cm)	4.24 ± 0.76	4.75 ± 0.66	2.739	<0.05
LVEF%	41.06 ± 6.61	35.36 ± 7.8	3.22	<0.05
SV(ml)	77.12 ± 27.5	61.76 ± 21.06	2.429	<0.05
E wave (cm/s)	76.44 ± 24.78	81.56 ± 25.24	0.794	>0.05
A wave (cm/s)	55.53 ± 24.05	49.53 ± 18.63	1.08	>0.05
E/A ratio	1.67 ± 0.91	1.94 ±1.03	1.061	>0.05
EDT (ms)	141.23 ± 35.49	118.73 ± 35.56	2.453	<0.05

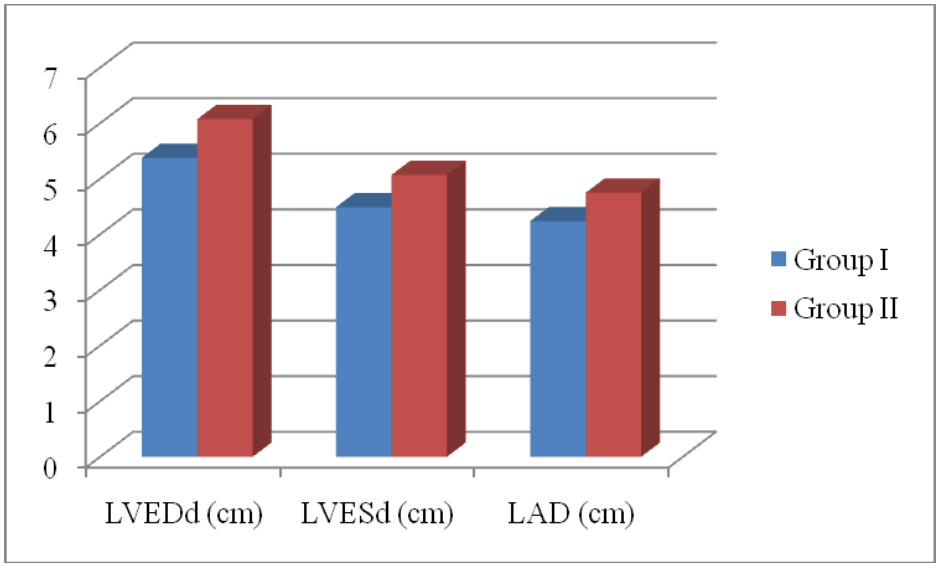


Fig (12) *LVEDd, LVESd, and LAD in the 2 groups.*

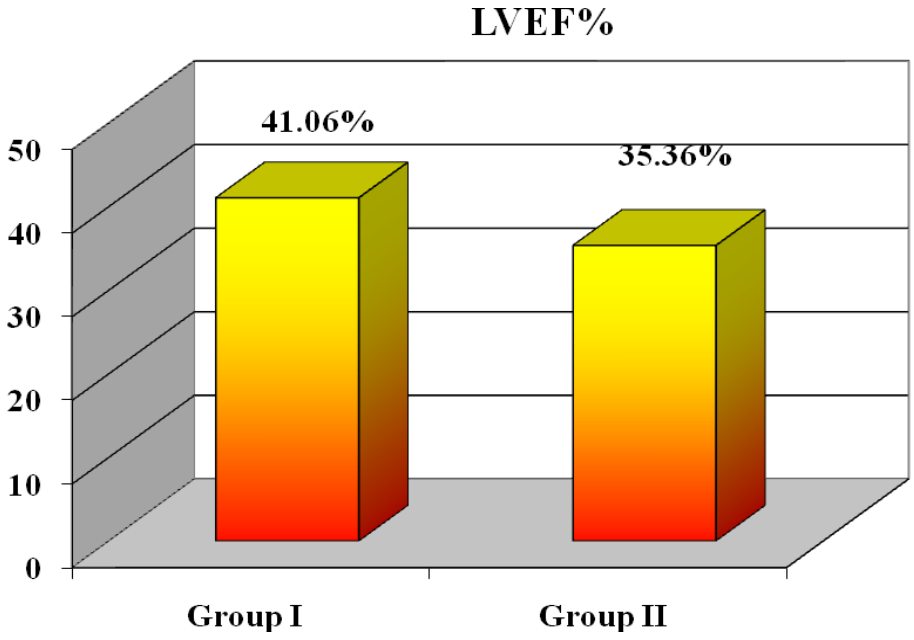


Fig (13) *LVEF% among the 2 groups.*

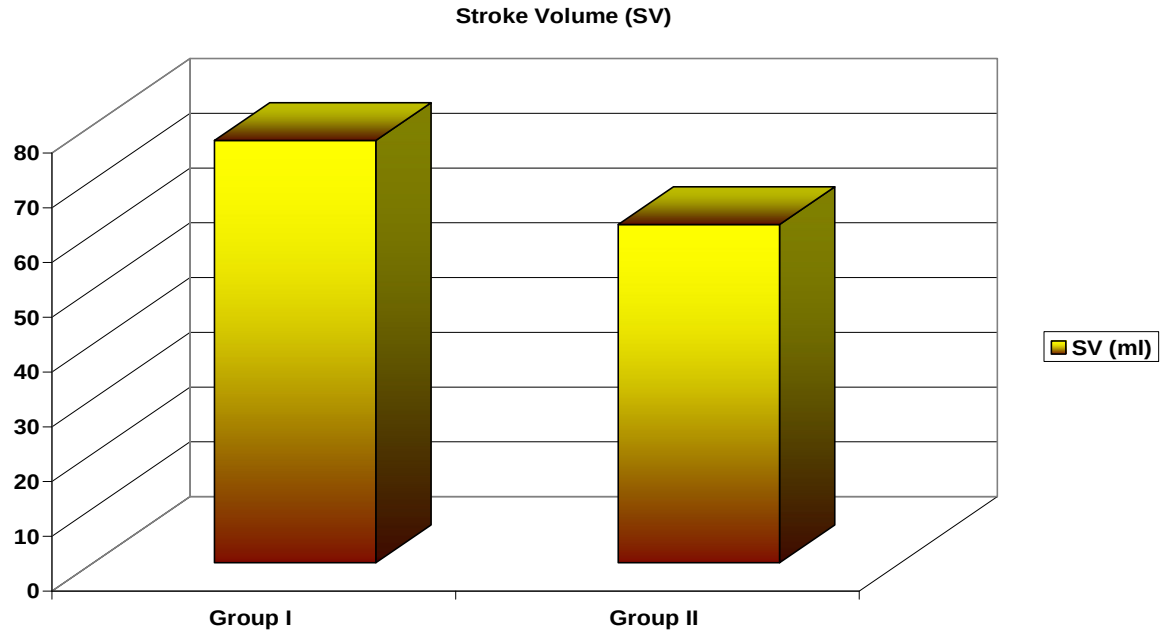


Fig (14) *Stroke volume (SV) in the 2 groups.*

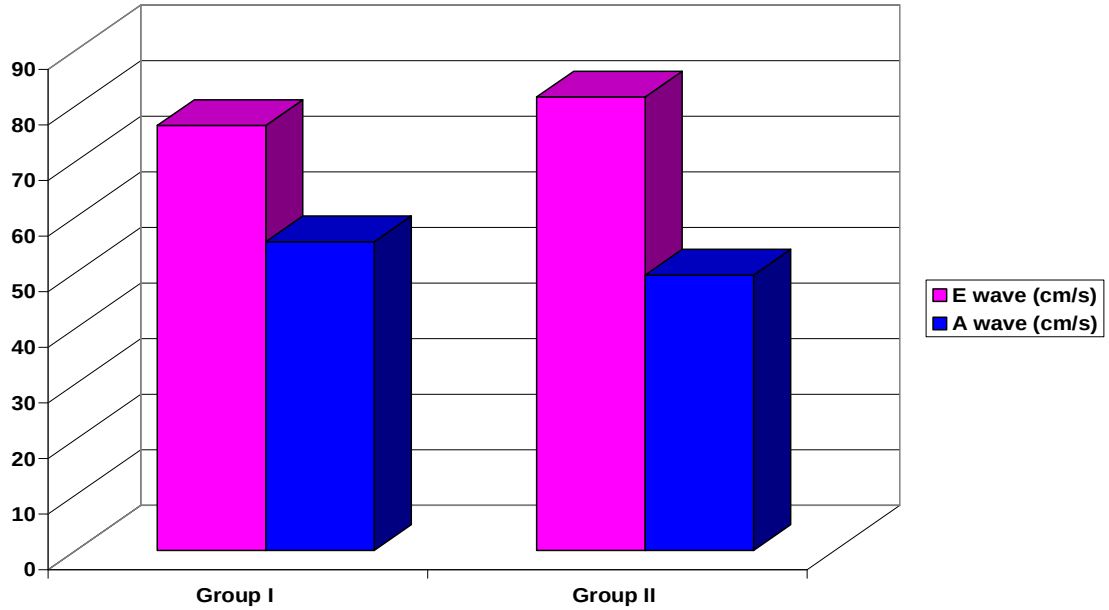


Fig (15) *Transmitral Doppler E, and A velocities in the 2 groups.*

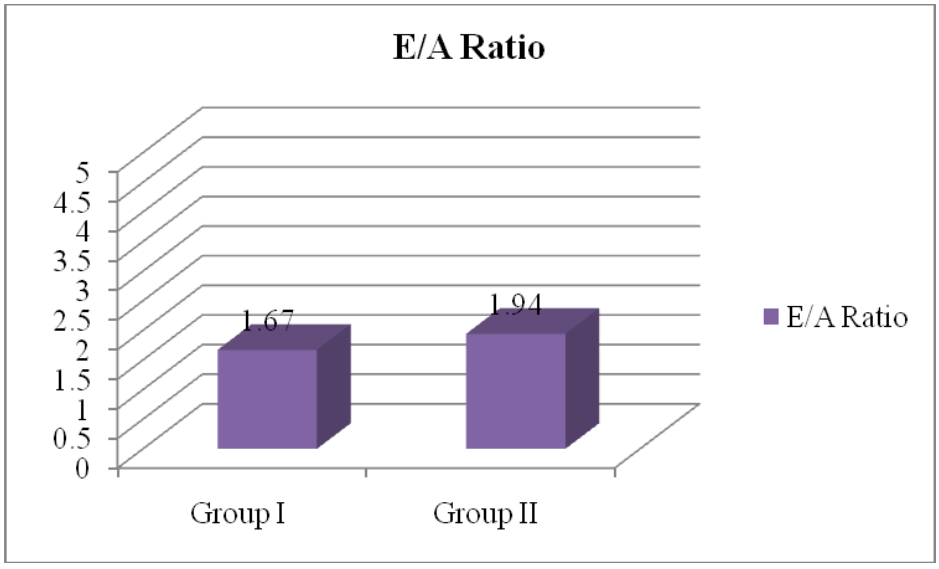


Fig (16) *E/A ratio in the two groups.*

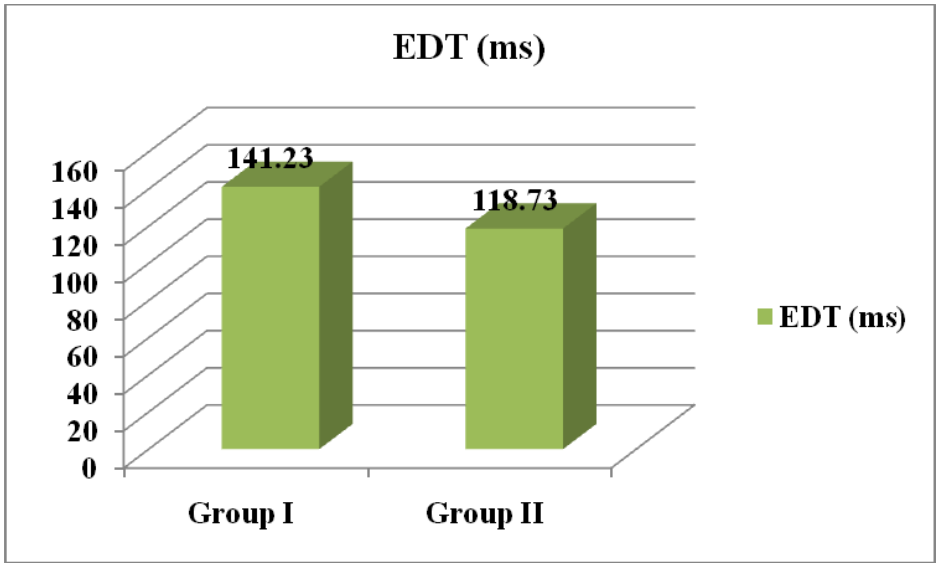


Fig (17) *Mitral E deceleration time (EDT) in the 2 groups.*

***5)* Mitral regurgitation (MR) (Table 18, figure 18):**

- **Group I:** 13 patients representing 43.3% of patients had mild MR, 6 patients representing 20% of patients had moderate MR.
- **Group II:** 15 patients representing 50% of patients had mild MR, 7 patients representing 23.3% of patients had moderate MR.

There was no significant statistical difference between the 2 groups as regarding mild and moderate MR (*P* value >0.05).

Table (18) Comparison between the 2 groups as regarding mild and moderate Mitral regurgitation (MR):

MR	All patients (No),%	Group I (No),%	Group II (No),%	*P* Value
Mild MR	(28),46.6%	(13),43.3%	(15),50%	>0.05
Moderate MR	(13),21.6%	(6),20%	(7),23.3%	>0.05

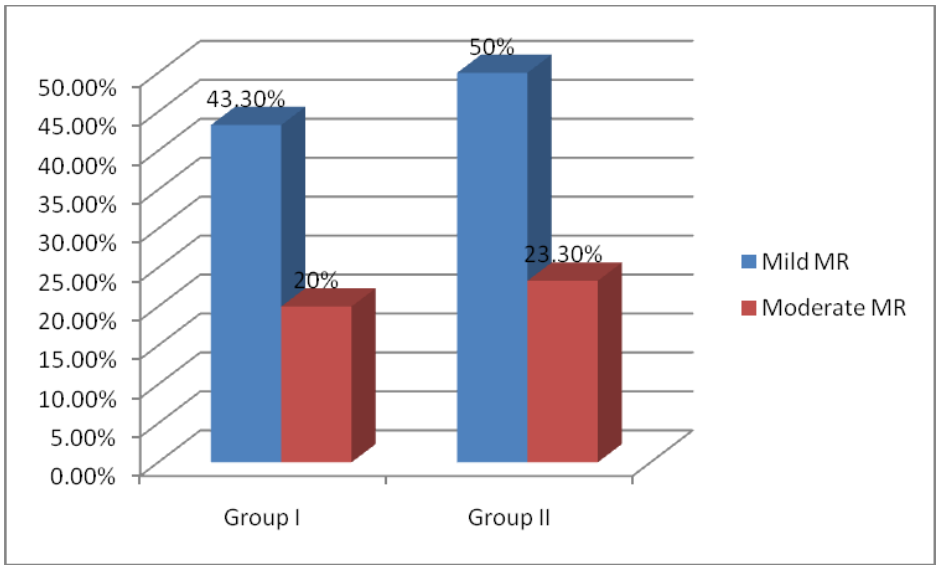


***Fig (18)** Distribution of mild and moderate MR among the 2 groups.*

Resting regional wall motion abnormalities (RWMA) (Table 19, figure 19):

- **Group I:** There were 26 patients had resting RWMA and 4 patients had no RWMA.
- **Group II:** There were 23 patients had resting RWMA and 7 patients had no RWMA.

Table (19) Comparison between the 2 groups as regarding site of wall motion abnormalities among patients with IHD:

Site of WMA	Group I (No),%	Group II (No),%	*P* Value
Anterior	(15),57.6%	(11),47.8%	>0.05
Inferior	(12),46.1%	(10),43.4%	>0.05
Lateral	(10),38.4%	(9),39.1%	>0.05
Septal	(10),38.4%	(9),39.1%	>0.05
Posterior	(10),38.4%	(10),43.4%	>0.05

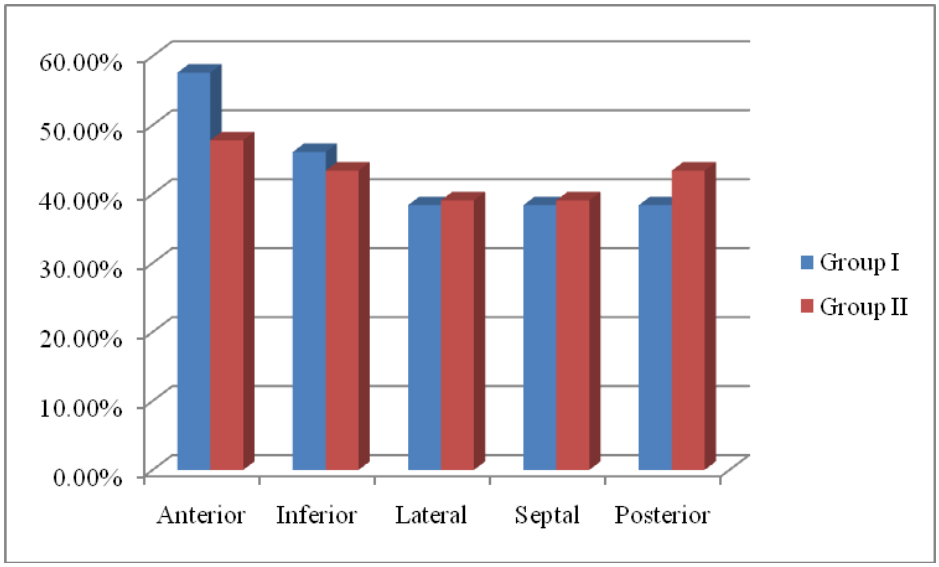


Fig (19) Distribution of wall motion abnormalities among the 2 groups.

(4) Tissue Doppler imaging (TDI) results (Table 20, Figure 20, 21):

1. ***The systolic mitral annular velocity (Sa):***
   - **Group I:**
     -A mean ± SD of 6.1833 ± 1.2140 cm.
   - **Group II:**
     -A mean ± SD of 4.4690 ± 0.5716 cm.

   There was highly significant statistical difference between the two groups (*P* value < 0.001) with lower Sa velocity in group II patients than group I.
2. ***The early diastolic mitral annular velocity (Ea):***
   - **Group I:**
     -A mean ± SD of 7.98 ± 1.79 cm.
   - **Group II:**
     -A mean ± SD of 5.51 ± 1.65 cm.

   There was significant statistical difference between the two groups (*P* value < 0.05) with lower Ea velocity in group II patients than group I.
3. ***The late diastolic mitral annular velocity (Aa):***
   - **Group I:**
     -A mean ± SD of 7.08 ± 2.47 cm.
   - **Group II:**
     -A mean ± SD of 5.56 ± 1.28 cm.

   There was significant statistical difference between the two groups (*P* value < 0.05) with lower Aa velocity in group II patients than group I.
4. ***The ratio of early to late mitral annular velocities (Ea/Aa):***
   - **Group I :**
     -A mean value ± SD of 1.23 ± 0.51.
   - **Group II:**
     -A mean value ± SD of 1.03 ± 0.32.

   There was no significant statistical difference between the two groups (*P* value > 0.05).
5. ***The ratio of transmitral E velocity to early mitral annular velocity Ea (E/Ea):***
   - **Group I :**

     -A mean value ± SD of 9.73 ± 2.97.

- **Group II:**

  -A mean value ± SD of 15.7 ± 6.6.

There was highly significant statistical difference between the two groups (*P* value < 0.001) with higher E/Ea ratio in group II patients than group I.

Table 20: Comparison between the 2 groups as regarding TDI parameters:

Group / parameter	Group I	Group II	t	*p*
	Mean ± SD	Mean ± SD		
Sa (cm/s)	6.18 ± 1.21	4.46 ± 0.57	6.998	<0.001
Ea (cm/s)	7.98 ± 1.79	5.51 ± 1.65	5.522	<0.05
Aa (cm/s)	٧,٠٨ ± ٢,٤٧	5.56 ± 1.28	2.985	<0.05
Ea/Aa	1.23 ± 0.51	1.03 ± 0.32	1.813	>0.05
E/Ea	9.73 ± 2.97	15.7 ± 6.6	4.509	<0.001

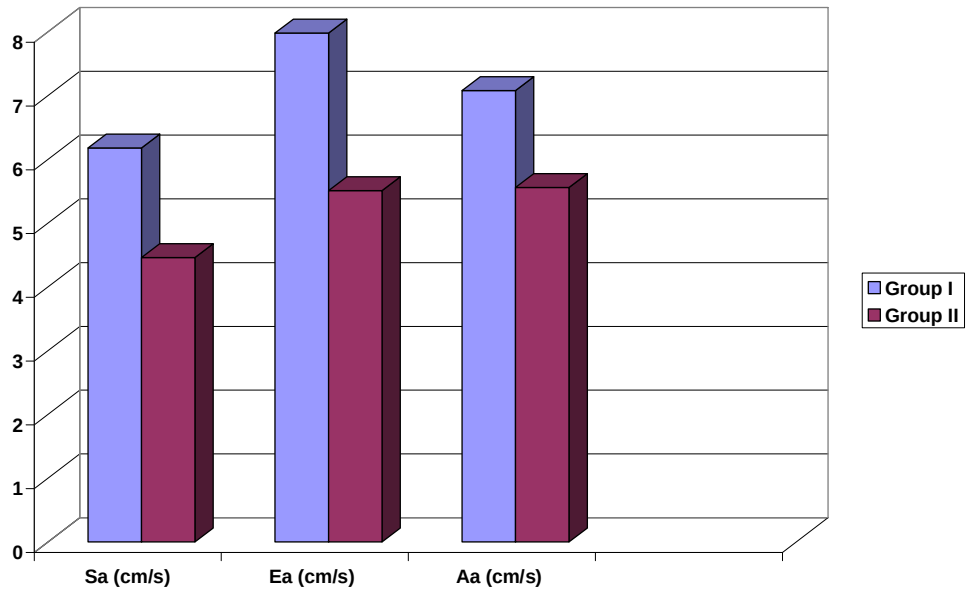


Fig (20): Comparison of systolic mitral annular velocity (Sa), The early diastolic mitral annular velocity (Ea), the late diastolic mitral annular velocity (Aa) among the 2 groups.

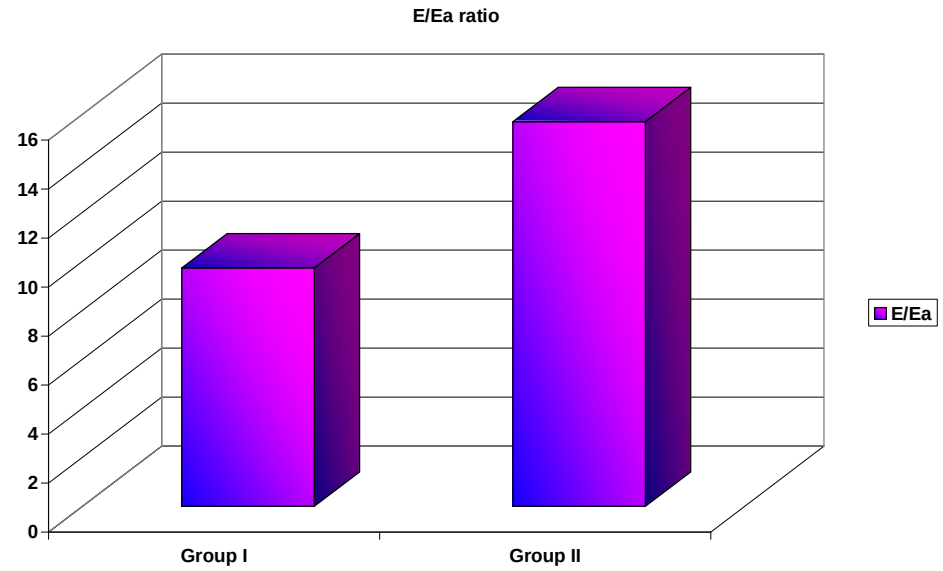


Fig (21): Comparison of E/Ea ratio among the 2 groups under the study.

A correlation between NYHA functional class and different conventional and TDI echocardiographic parameters is shown in table (21), (Figure 22 to figure 29).

*** Concerning conventional echocardiographic parameters:**

NYHA functional class showed significant positive correlations with LVEDd, LVESd, and LAD (*P* value < 0.05), and showed significant inverse correlations with LVEF, SV, and mitral DT *(P* value < 0.05).

Mitral E and A velocities and E/A ratio were not correlated with NYHA functional class (*P* value > 0.05).

***Concerning TDI echocardiographic parameters:**

NYHA functional class showed significant inverse correlation with Sa, Ea, and Aa velocities (*P* value < 0.05); and showed positive correlation with E/Ea ratio (*P* value < 0.05).

Ea/Aa ratio was not correlated with NYHA functional class (*P* value > 0.05).

Table (21): Correlation between NYHA class and different conventional and TDI echocardiographic parameters:

parameter	r	*P* value
LVEDd	0.31	<0.05
LVESd	0.34	<0.05
LVEF	-0.46	<0.05
SV	-0.26	<0.05
LAD	0.44	<0.05
EDT	-0.27	<0.05
Sa	-0.56	<0.05
Ea	-0.44	<0.05
Aa	-0.26	<0.05
Ea/Aa	-0.24	>0.05
E/Ea	0.46	<0.05
E	0.14	>0.05
A	0.16	>0.05
E/A ratio	0.17	>0.05

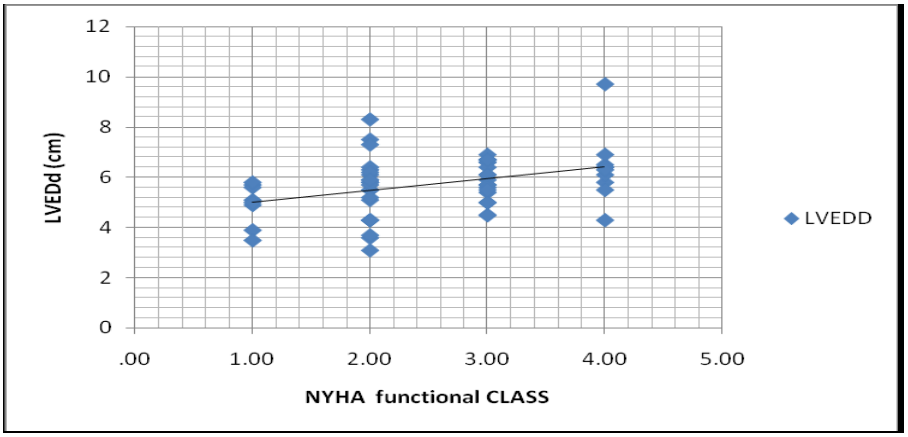


Fig (22): *Correlation between left ventricular end-diastolic diameter (LVEDd) and NYHA class.*

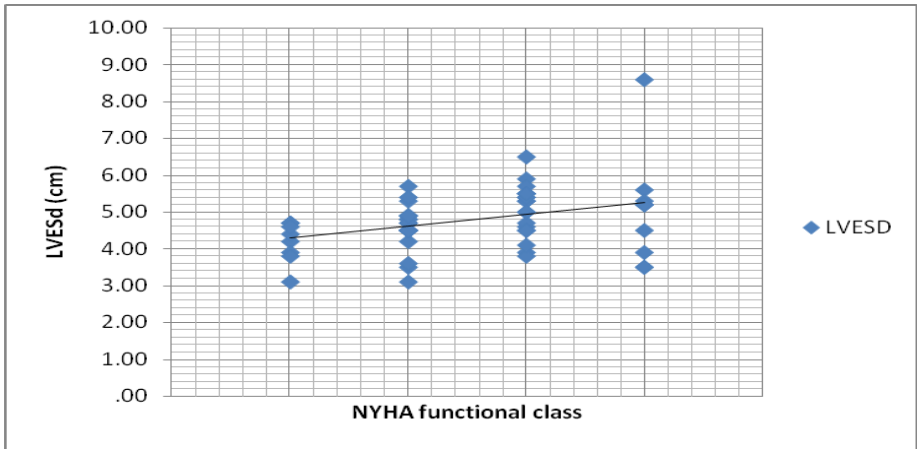


Fig (23): *Correlation between left ventricular end-systolic diameter and NYHA class.*

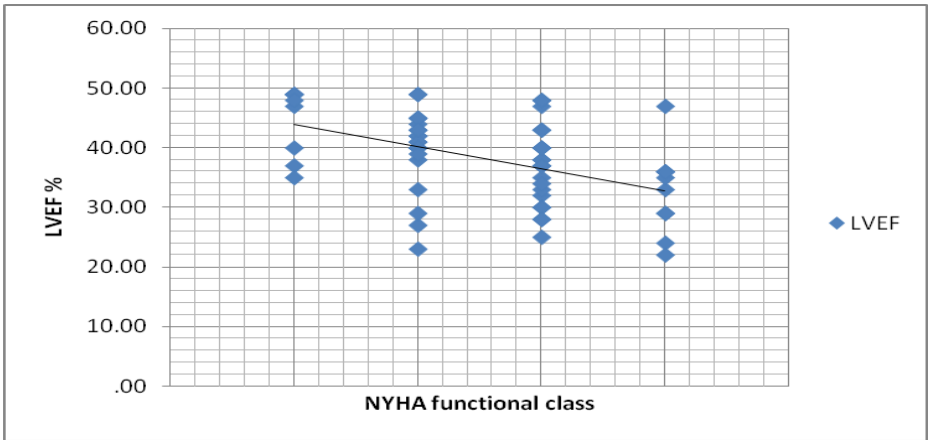


Fig (24)*: Correlation between the left ventricular ejection fraction (LVEF) and NYHA class.*

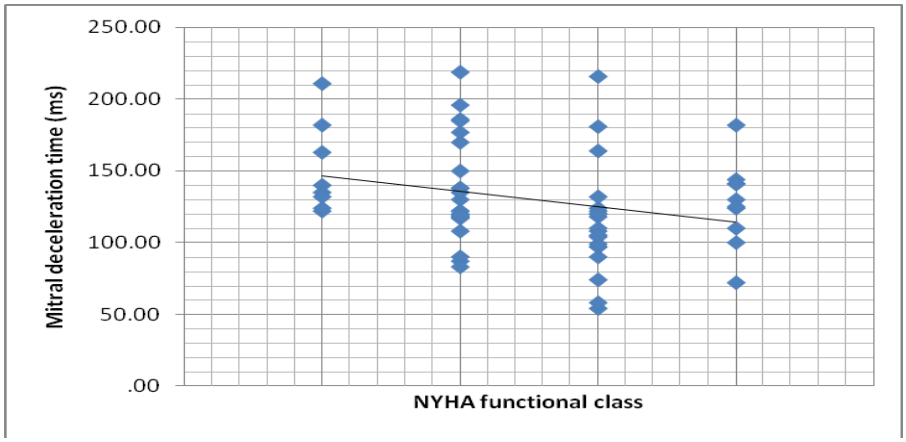


Fig (25): *Correlation between E wave deceleration time (EDT) and NYHA class.*

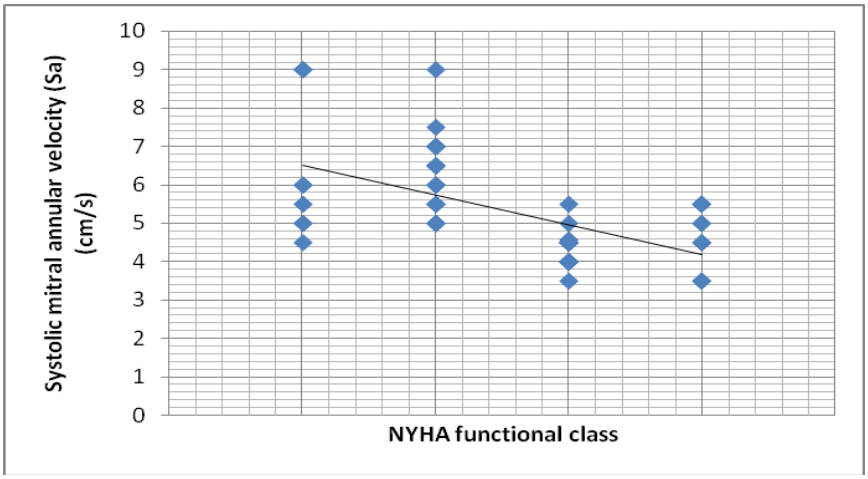


Fig (26): *Correlation between mitral annular systolic velocity (Sa) and NYHA class.*

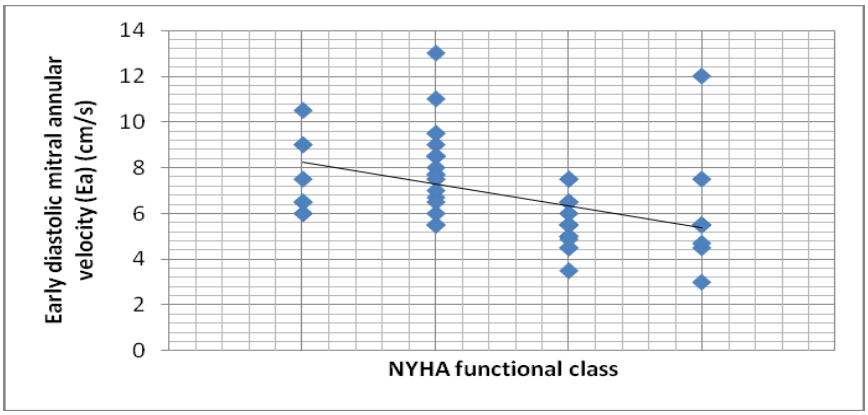


Fig (27): *Correlation between early diastolic mitral annular velocity (Ea) and NYHA class.*

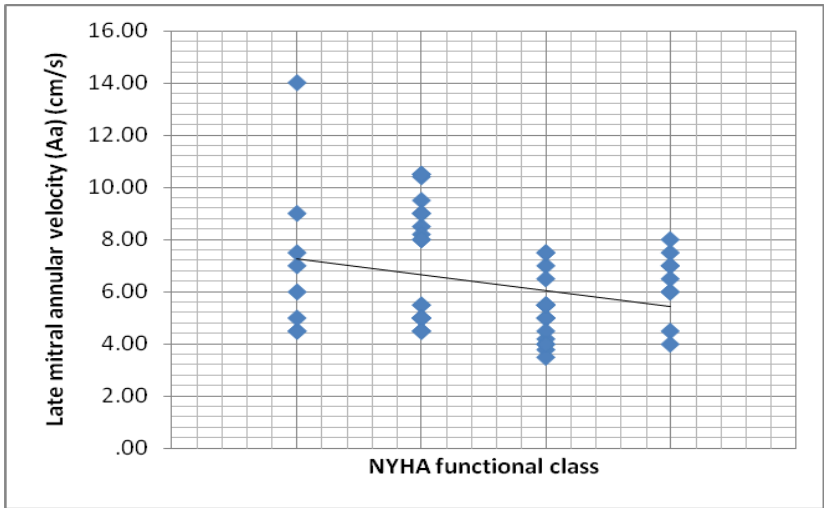


Fig (28): *Correlation between late mitral annular velocity (Aa) and NYHA class.*

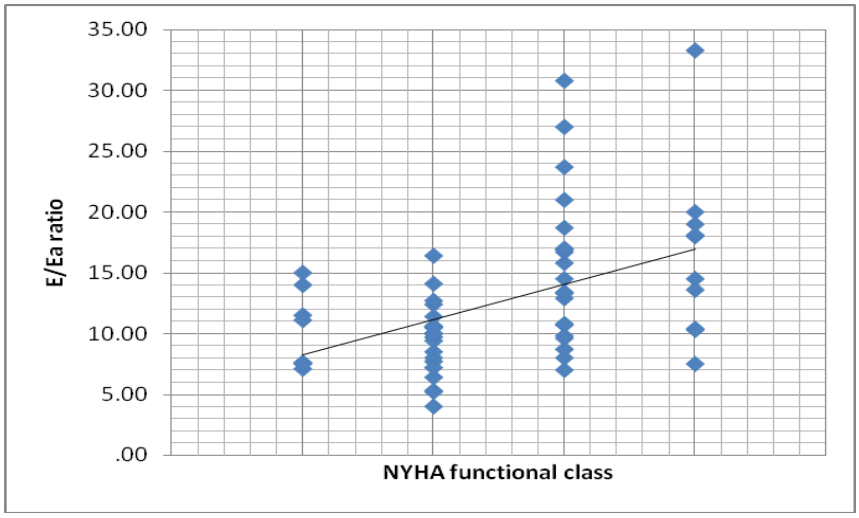


Fig (29): *Correlation between transmitral E/Ea ratio and NYHA class.*

A linear regression analysis of different conventional and TDI parameters is shown in table (22) illustrates that the systolic mitral annular velocity (Sa) and left ventricular ejection fraction (LVEF) were independent parameters of functional capacity (beta= -0.295, *P* value < 0.05 and beta= -0.287, *P* value < 0.05 respectively).

Table (22): A linear regression analysis of conventional and TDI parameters:

parameter	Beta (β)	*P*
LVEDd	-0.155	0.141
LVESd	0.047	0.736
LVEF	-0.287	0.042
SV	-0.03	0.86
LAD	0.238	0.089
E	0.113	0.535
A	-0.03	0.893
E/A ratio	0.052	0.862
DT	-0.049	0.631
Sa	-0.295	0.019
Ea	-0.264	0.038
Aa	0.06	0.625
Ea/Aa ratio	-0.043	0.961
E/Ea ratio	0.254	0.047

A correlation was done between left ventricular ejection fraction LVEF% (by modified Simpson method) and systolic myocardial velocity (Sa) averaged from the septal and lateral mitral annular sites and showed highly significant positive correlation (r=0.361, *P* value <0.01) **(Figure 30)**.

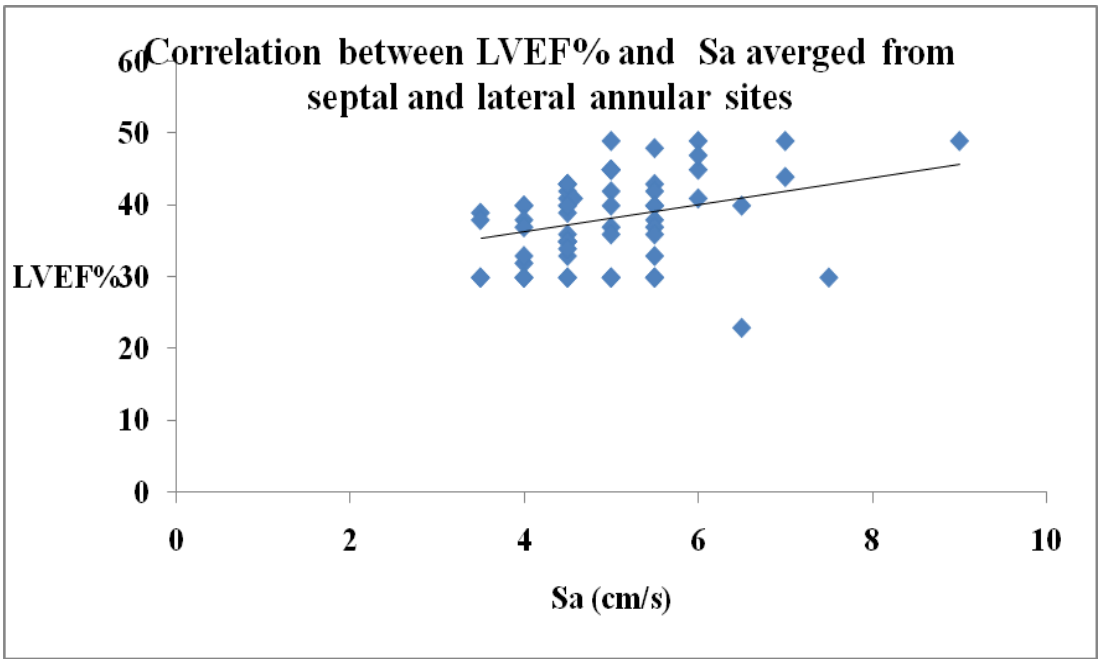
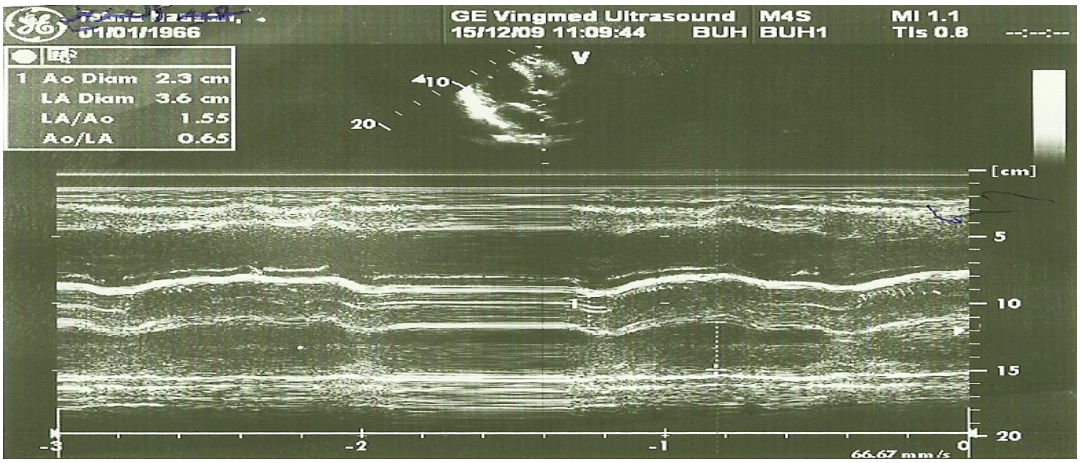


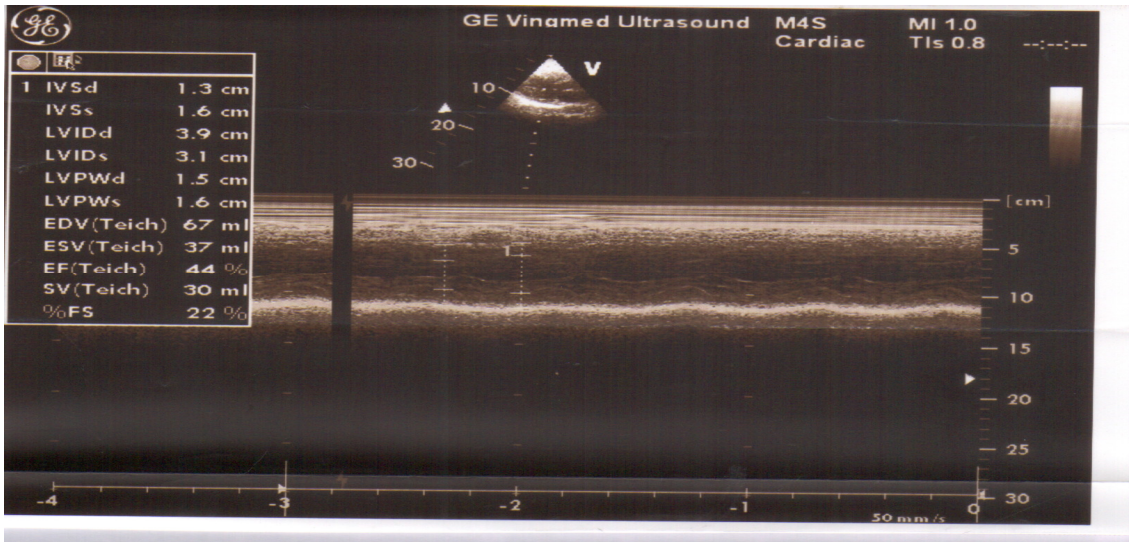
Figure (30) Correlation between LVEF% and systolic myocardial velocity (Sa).

Illustrated cases

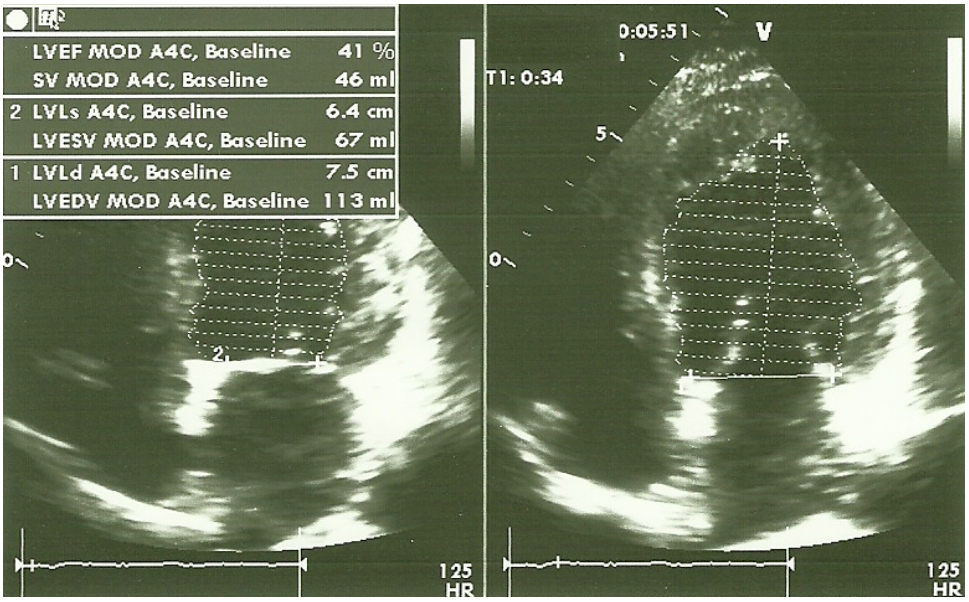
Case I: 52 years old male patient, known to be diabetic and hypertensive with history of IHD on B blocker, diuretic, ARBs and nitrates presented by dyspnea on more than ordinary work (class I), the admission BP was 130/90 and HR was 85 b/m, normal routine investigations, the ECG showed LVH. Conventional and TDI echocardiography was done. (Case NO 1 in group I).



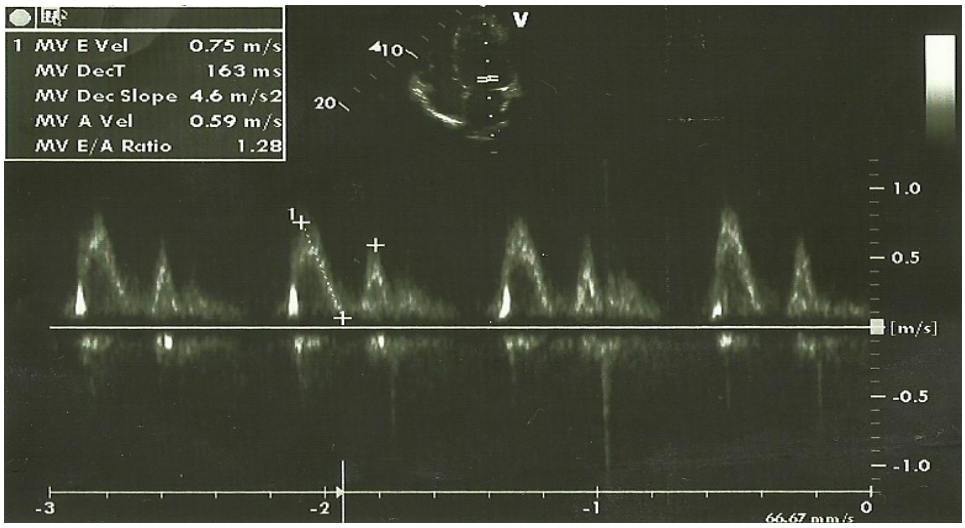
M-Mode shows LAD = 3.6 cm in patient No (1) in group I.



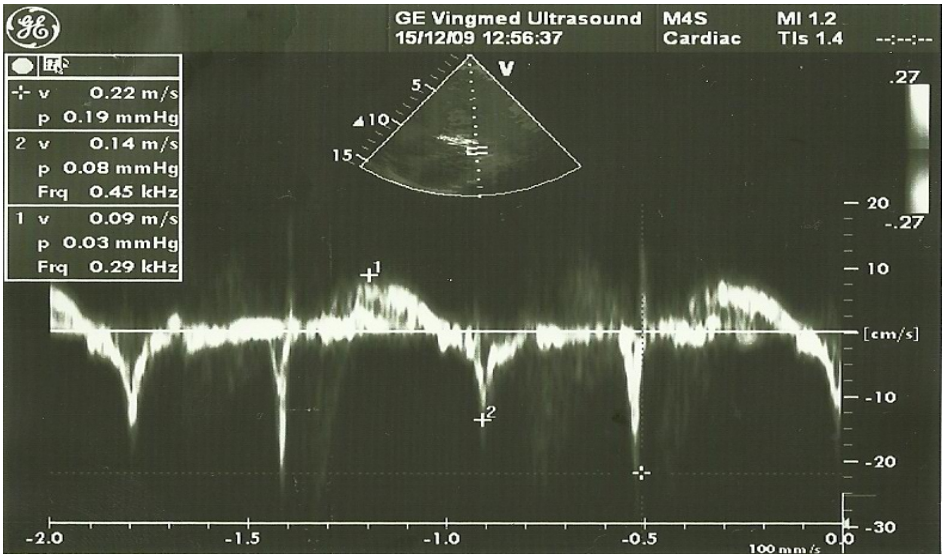
M-Mode shows LVEDd =3.9 cm, LVESd = 3.1 cm in patient No (1) of group I.



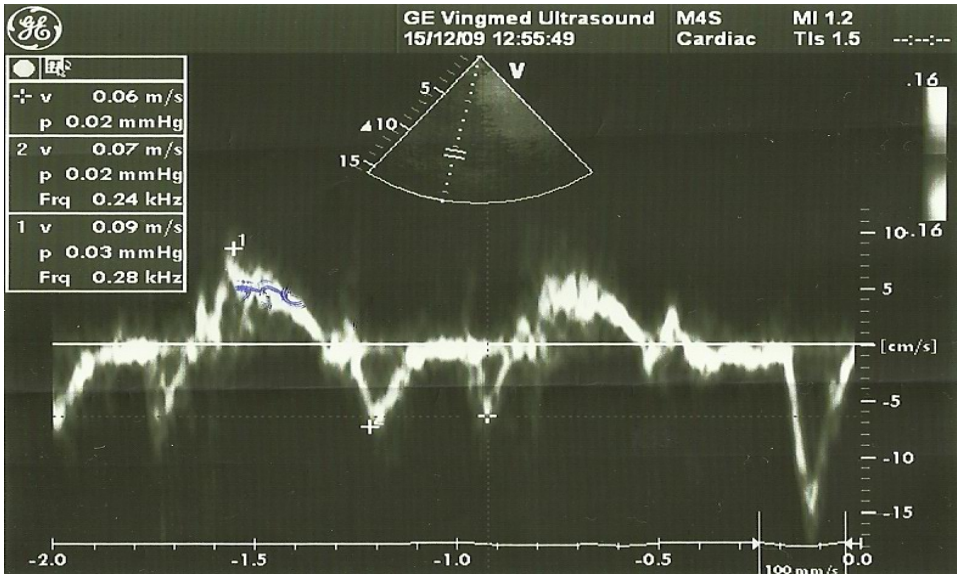
LVEF 41% (modified Simpson method), SV 46ml in case no (1) in group I.



Transmitral Doppler velocities in patients No (1) of group I shows : Peak E wave velocity: 75 cm/s, peak A velocity: 59 cm/s, mitral DT: 163 ms, E/A ratio: 1.28.

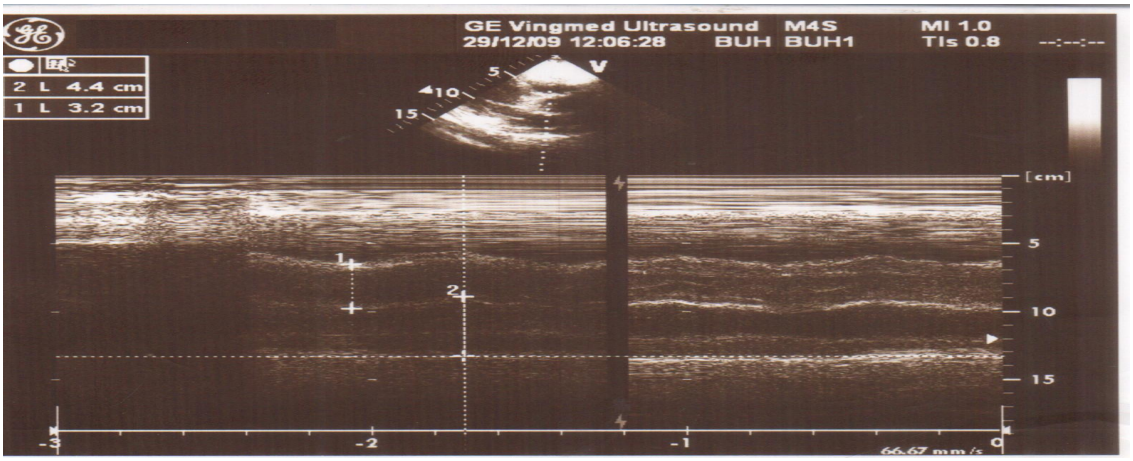


TDI echocardiography at the lateral site of mitral annulus in patient No (1) of group I showing: Sa: 9 cm/s, Ea: 14 cm/s, and Aa: 22 cm/s.

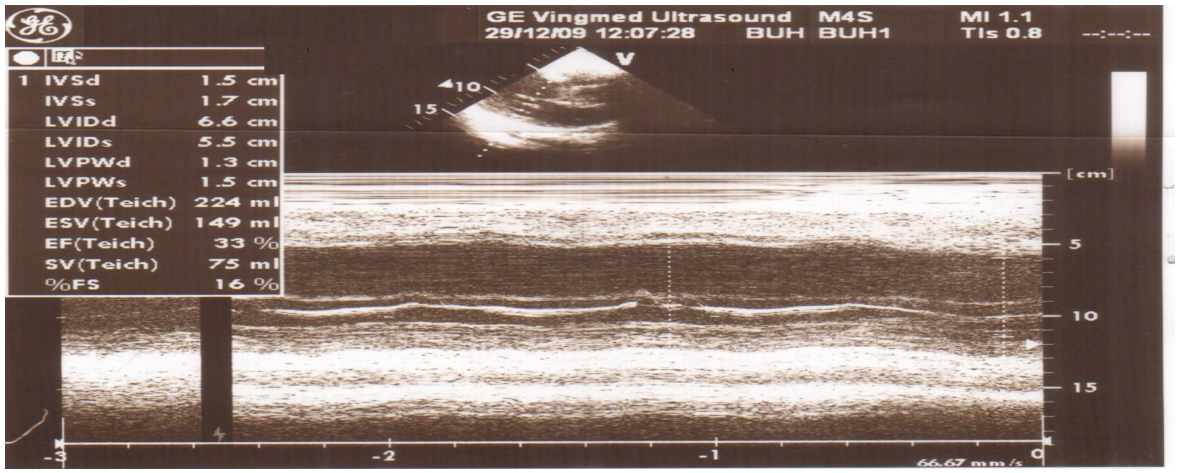


TDI echocardiography at the septal site of mitral annulus in patient No (1) in group I showing: Sa: 9 cm/s, Ea: 7 cm/s, and Aa: 6 cm/s.

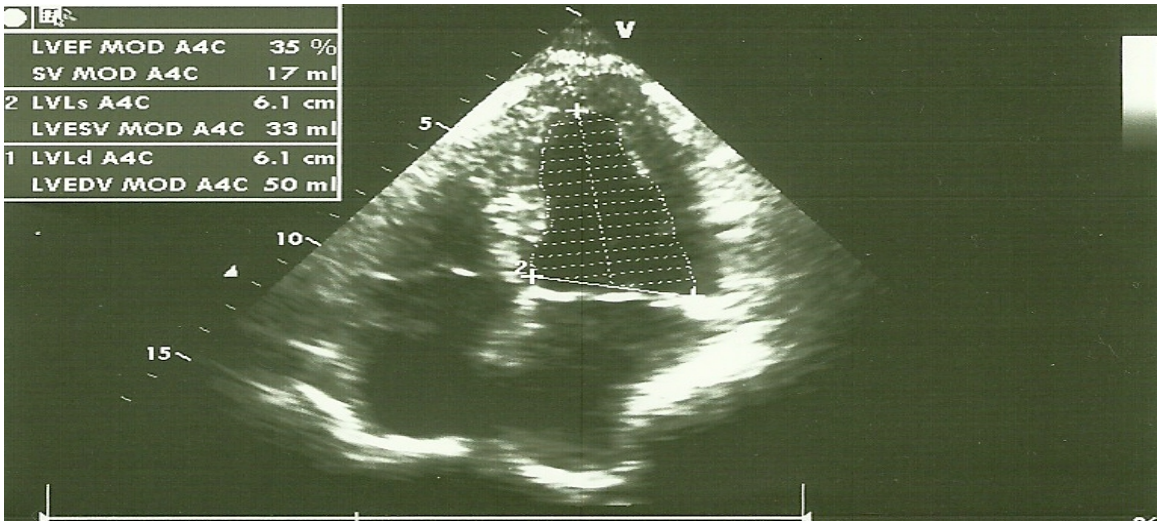
Case II: 61 years old female patient, not known to be diabetic or hypertensive with history of IHD, B blocker, diuretic, ARBs and nitrates and spironolacton. Presented by dyspnea on less than ordinary work (NYHA classIII), the admission BP was 125/80 and the HR was 75bpm, the ECG showed pathological Q waves from V1-V4. Conventional and TDI echocardiography was done. (Case No 7 in group II).



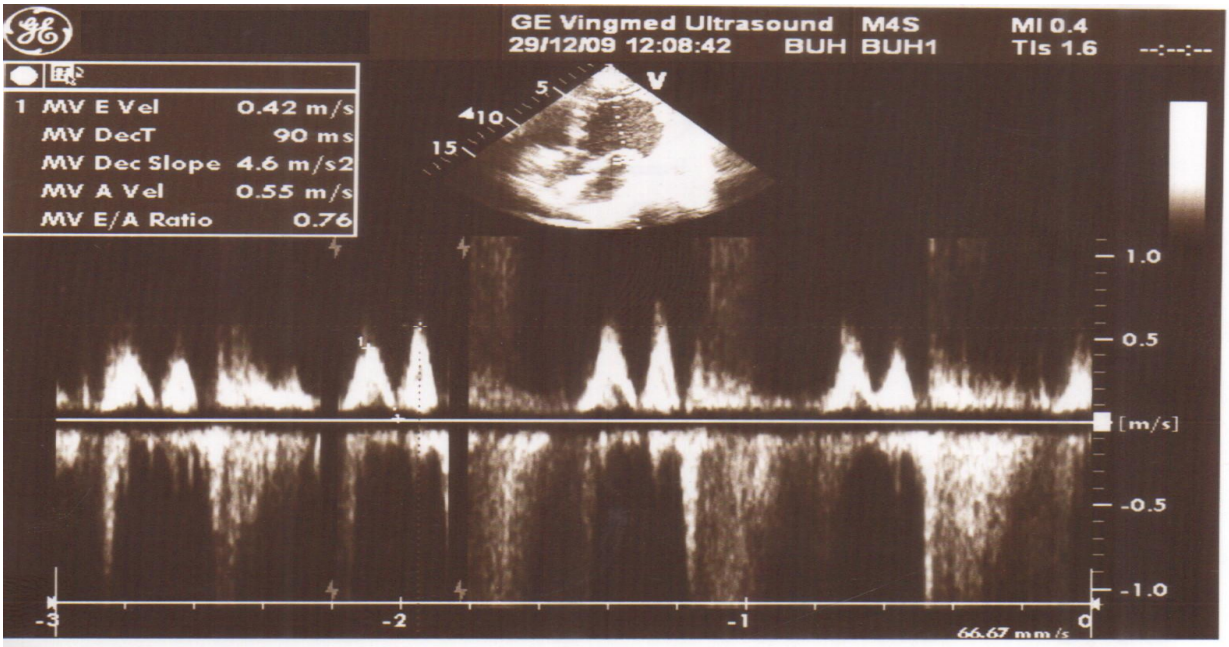
M-Mode showing LAD: 4.4 cm in patient No (7) of group II.



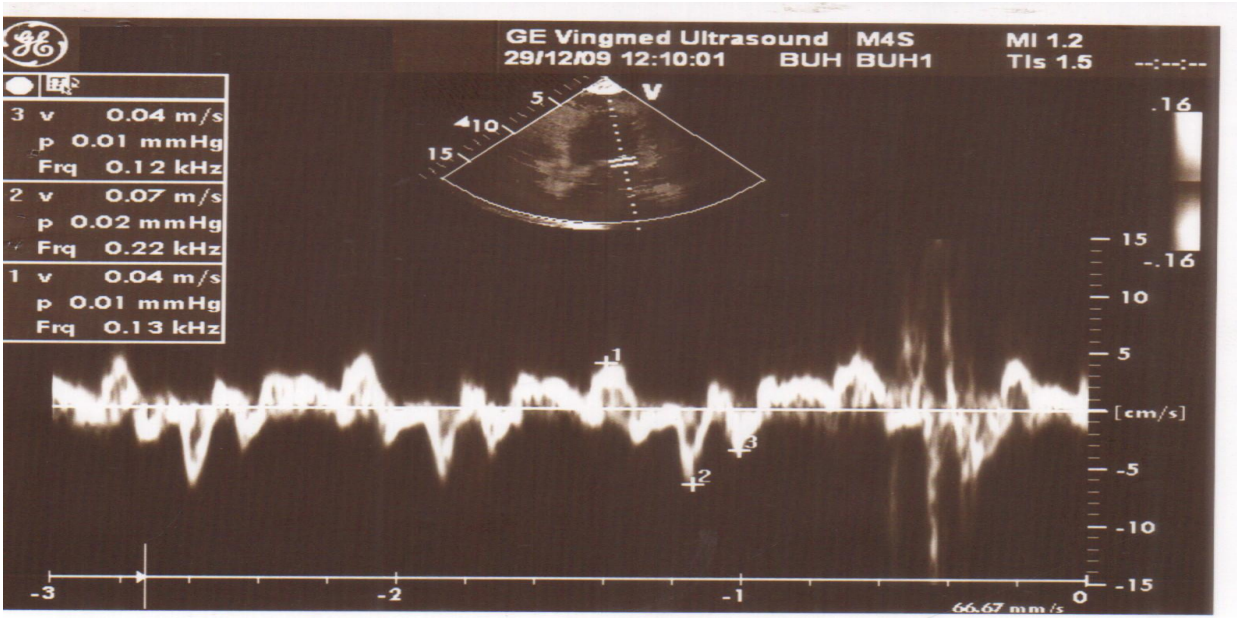
M-Mode shows LVEDd =6.6 cm, LVESd = 5.5 cm in patient No (7) of group II.



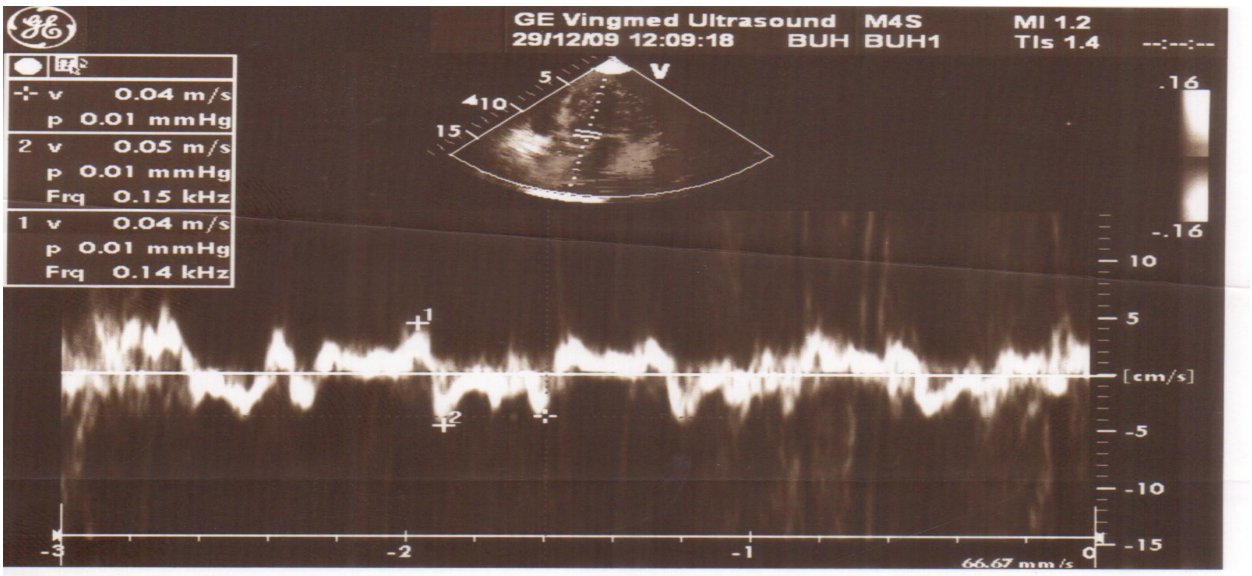
LVEF 35% (modified Simpson method) and SV 17 ml in case no (7) in group II.



Transmitral Doppler velocities in patients No (7) of group II showing: Peak E wave velocity: 42 cm/s, peak A velocity: 55 cm/s, mitral DT: 90 ms, E/A ratio: 0.76.



TDI echocardiography at the lateral site of mitral annulus in patient No (7) of group II showing: Sa: 4 cm/s, Ea: 7 cm/s, and Aa: 4 cm/s.



TDI echocardiography at the septal site of mitral annulus in patient No (7) in group II showing: Sa: 4 cm/s, Ea: 5 cm/s, and Aa: 4 cm/s.

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