Results

The study included 50 patients with acute myocardial infarction who were admitted to Benha university hospitals and all of them received thrombolytic therapy.

The included patients were 48 (96%) males and 2 (4%) females.

All of them underwent exercise testing after a mean of 10 (±9) days.

ST segment depression induced by exercise occurred in 27 (54%) patients. In 13 (26%) patients it was found to be isolated, but in the rest it was found to be reciprocal and associated with ST elevation in the leads related to the infarct. And in 23 (46%) of 50 patients there was no change in the ST segment.

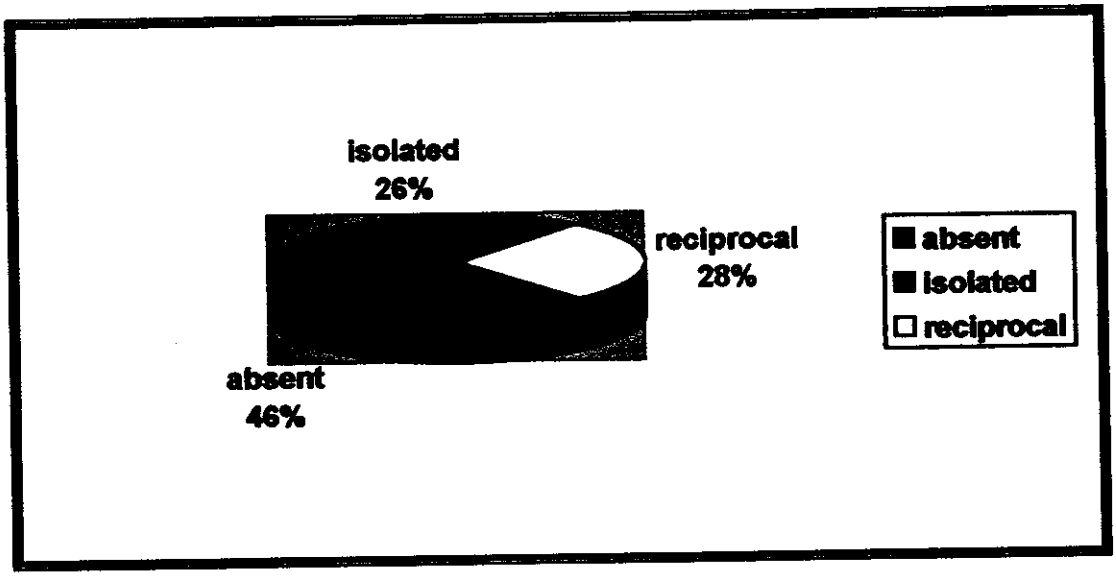

Figure 5: patient groups according to ST segment deviation induced by exercise.

Age in the three groups:

Age	Absent	Isolated	Reciprocal	ANOVA	
				$F_{2,47}$	P value
Mean ±SD	52.3 ± 8.5	53.3 ± 5.4	52.9 ± 6	0.09	0.9
Range	33 – 68	41 – 61	41 – 62		

Table 4: Age in presented cases of absent, isolated and reciprocal ST depression.

The mean age in the group with absent ST change was 52.3 ± 8.5 and it was 53.3 ± 5.4 in the group with isolated ST depression and it was 52.9 ± 6 in the group with reciprocal ST depression (Table 3). There was no statistically significant variation between the three groups as regard the age (P value 0.9).

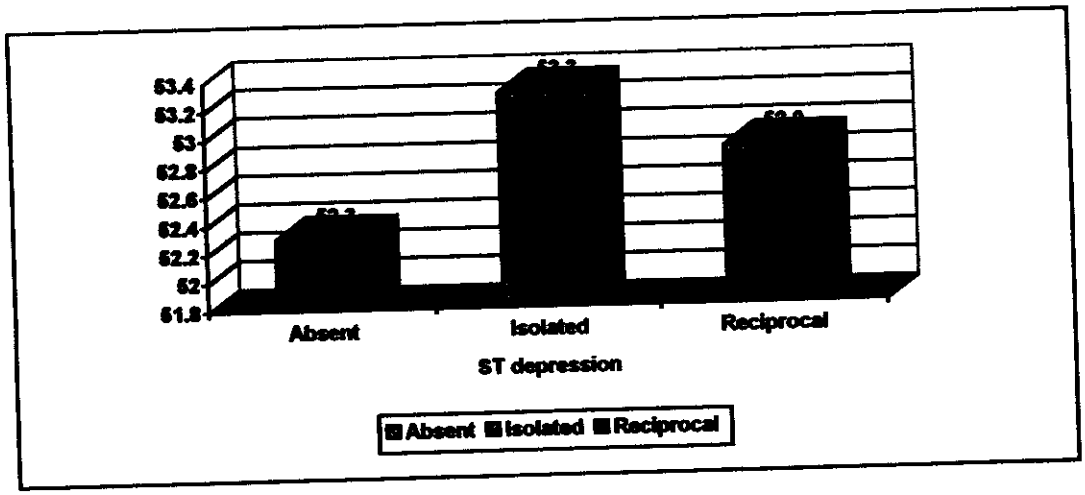

Figure 6: Mean age in the three groups (P value>0.05).

Hypertension in the three groups:

Hypertension	Absent	Isolated	Reciprocal	Total	Chi square	P value
Present	9 (39%)	4 (31%)	5 (36%)	18 (36%)	0.35	0.8
Absent	14 (61%)	9 (69%)	9 (64%)	32 (64%)		
Total	23 (100%)	13 (100%)	14 (100%)	50 (100%)		

Table 5: Number (percent) of hypertensive cases in the three groups.

From this table there was no statistically significant difference between the three groups as regard associated hypertension (P value 0.8).

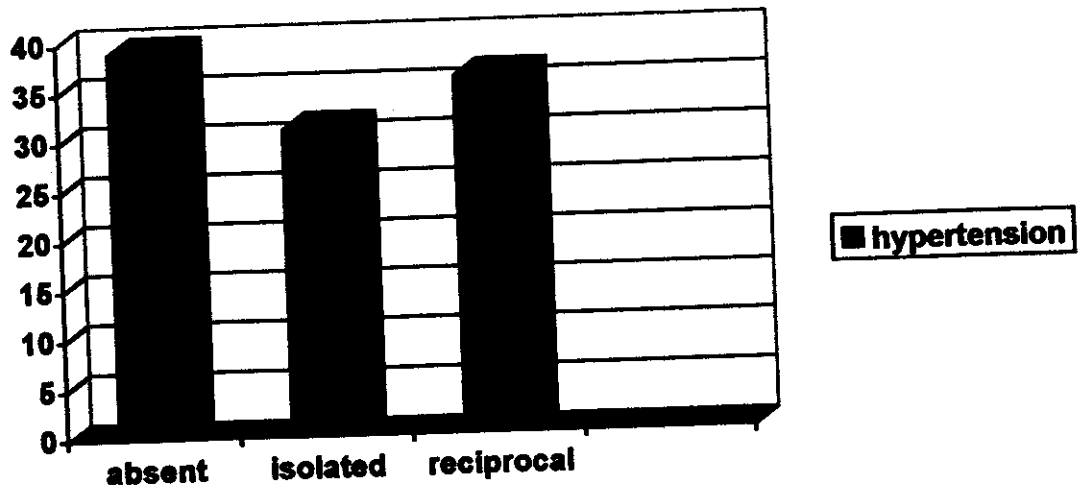

Figure 7: Hypertension (percent) in the three groups (P value>0.05).

Cholesterol level in the three groups :

Hypercholesterolemia	absent	isolated	reciprocal	total	Chi square	P value
Present	10 (43%)	8 (61.5%)	6 (43%)	24 48%	0.83	0.6
Absent	13 (57%)	5 (38.5%)	8 (57%)	26 52%		
total	23 (100%)	13 (100%)	14 (100%)	50 100%		

Table 6: Hypercholesterolemia in the three groups.

From this table there was no statistically significant difference between the mean values of cholesterol level in the three groups (P value> 0.05).

Hypercholesterolemia was noted to be nonsignificantly more in the group with isolated ST depression (P value > 0.05).

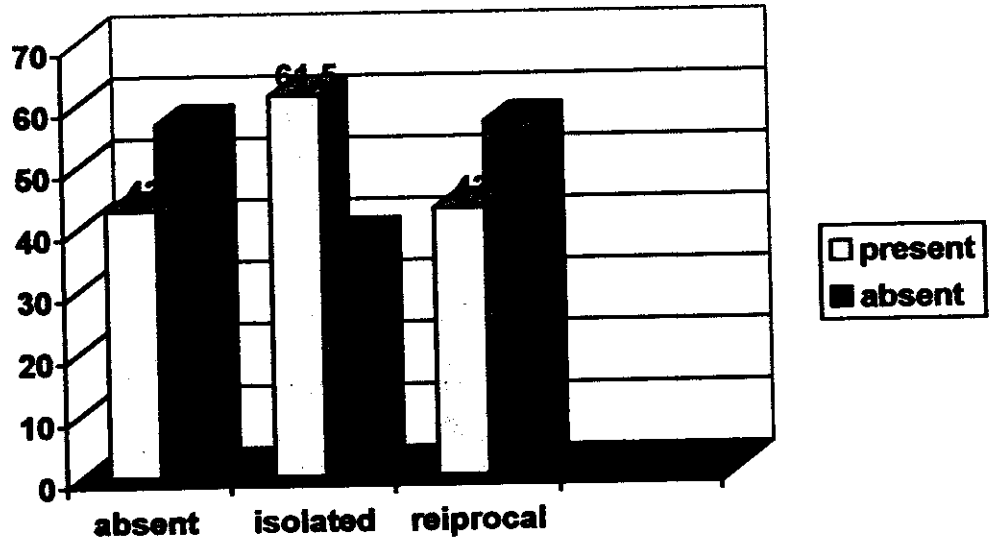

Figure 8: hypercholesterolemia in the three groups.

Diabetes mellitus in the three groups:

Diabetes	Absent	Isolated	Reciprocal	Total	Chi square	P value
Present	8 (35%)	8 (62%)	3 (21%)	19 (38%)	4.84	0.09
Absent	15 (65%)	5 (38%)	11 (79%)	31 (62%)		
Total	23 (100%)	13 (100%)	14 (100%)	50 (100%)		

Table 7: Number (percent) of cases with associated diabetes mellitus in the three groups.

From this table there was no statistically significant difference between the three groups as regard associated diabetes mellitus (p value 0.09).

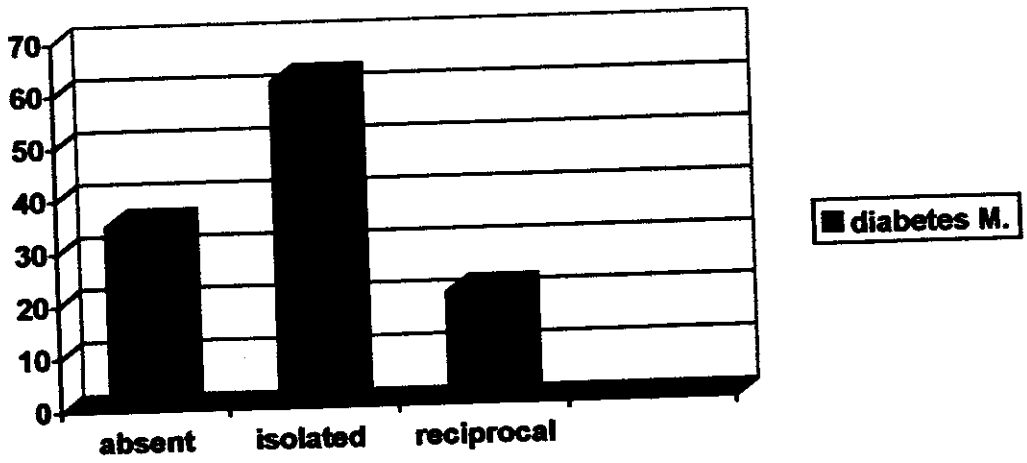

Figure 9: Diabetes Mellitus in the three groups (P = 0.09).

Type of infarction in the three groups:

ECG	Absent	Isolated	Reciprocal	Total	Chi square	P value
Anterior infarction	15 (65)	8 (61.5)	6 (43)	29 (58)	1.87	0.3
Inferior infarction	8 (35)	5 (38.5)	8 (57)	21 (42)		
Total	23 (100%)	13 (100%)	14 (100%)	50 (100%)		

Table 8: Number (percent) of cases with anterior and inferior infarction in admission ECG in the three groups.

From this table there was no statistically significant difference between the three groups as regard type of infarction at presentation (p value 0.3).

It was found that the incidence of anterior infarction is significantly higher in the group with absent ST segment change.

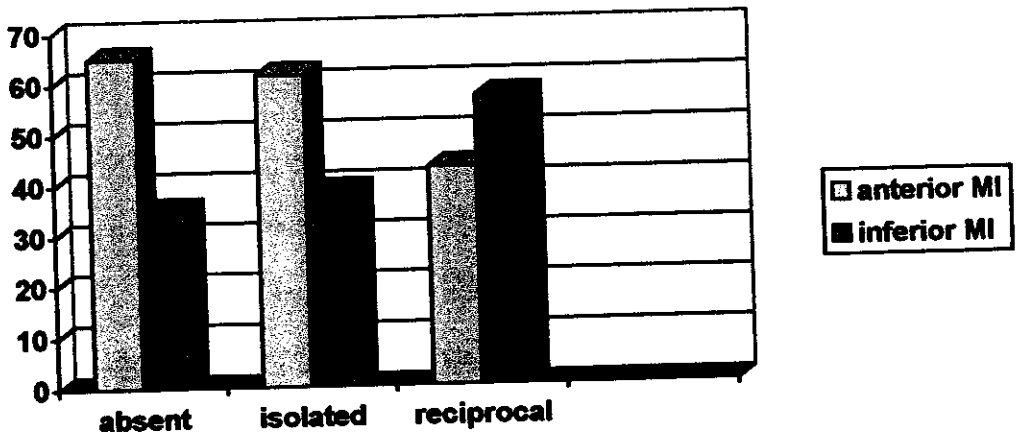

Figure 10: Percent of anterior and inferior MI in admission ECG in the three groups (P value>0.05).

Echo-Doppler findings in the three groups:

		Absent	Isolated	Reciprocal	ANOVA	
					$F_{2,47}$	P value
Ejection Fraction	Mean (SD)	59.3 (3.5%)	57.8 (4.5%)	52.7 (2.2%)	16.5	<0.001
	Range	54-65	53-67	50-58		
ESD	Mean (SD)	3.8 0.19	3.8 0.31	4.05 0.35	6.2	0.03
	Range	3.5-4.1	3.3-4.3	3.5-4.6		
EDD	Mean (SD)	4.5 0.3	4.7 0.38	4.95 0.28	0.9	0.6
	Range	4-5	4.1-5.3	4.5-5.4		
Wall Motion Score	Mean (SD)	30.5 2.86	32 3.8	30 2.22	0.86	0.59
	range	26-35	28-36	25-35		

Table 9: the difference between the three groups as regards Ejection fraction, ESD, EDD and wall motion score.

From this table there was highly significant variation between groups as regarding the Ejection fraction. As the Ejection fraction was significantly lower in the group with reciprocal ST depression (P value<0.001).

It was found that the significant difference within groups is between the group with isolated ST depression and those with reciprocal ST depression.

It was also noted that the End Systolic Diameter (ESD) is significantly increased in patients with reciprocal ST depression (P value<0.05).

There was no statistically significant difference between the three groups as regards to End Diastolic Diameter (EDD) (P value>0.05).

It was found that the group with reciprocal ST depression had the least wall motion abnormality but without significant difference with other groups. (P value>0.05).

Exercise ECG findings in the three groups:

Parameters	Absent	Isolated	Reciprocal	ANOVA	
				$F_{2,47}$	P value
Duration in *seconds*	747.3 ± 194.5 277 – 1060	709.4 ± 123.7 492 – 872	746 ± 164 477 – 1131	0.2	0.8
Peak workload (METs)	6.1 ± 2 1.8 – 8.7	5.8 ± 1.3 3.9 – 6.7	5.9 – 2.1 2.5 – 11.1	0,06	0.9
Maximal H.R (Beat/min)	140 ± 19 97 – 164	153 ± 16 124 –179	140 ± 24 102 –172	2.3	0.1

Table 10: Comparison between the three groups as regarding the duration of the test, peak workloads, and maximal heart rate.

There was no significant difference between patients with isolated and reciprocal ST depression as regard exercise tolerance or haemodynamic responses.

The mean resting heart rate was 86 ± 14.114 b/m and peak heart rate was 145 ± 12.08 b/m.

The mean resting systolic blood pressure was 130 ± 13.6 mmHg and the mean peak systolic blood pressure was 146 ± 16.39 mm Hg.

The mean resting diastolic blood pressure was 81± 4.7 mmHg and the peak diastolic blood pressure was 90 ±7.6 mmHg.

So, there was no statistically significant variation between the three groups as regarding the duration of the exercise test in seconds, peak workload, and maximal heart rate.

Chest pain during exercise:

Angina	Absent	Isolated	Reciprocal	Total	Chi square	P value
Present	3 (13%)	8 (62%)	5 (36%)	16 (32%)	9.07	0.01
Absent	20 (87%)	5 (38%)	9 (64%)	34 (68%)		
Total	23 (100%)	13 (100%)	14 (100%)	50 (100%)		

Table 11: Associated anginal pain during exercise test.

During exercise testing 16 patients had anginal chest pain, of whom 8 patients had isolated ST depression, 5 patients had reciprocal ST depression and only 3 patients had no ST change with exercise.

From this table there was statistically significant difference between the number of cases with angina during the exercise test in the three groups. With high incidence of chest pain in patients with isolated ST depression, and with less incidence in patients either with reciprocal ST depression or without ST change (p value 0.01).

By using post hoc testing (Tukey's honestly significant difference), it was found that: The significant difference was between group without ST depression and that with reciprocal ST depression (Z=1.99).

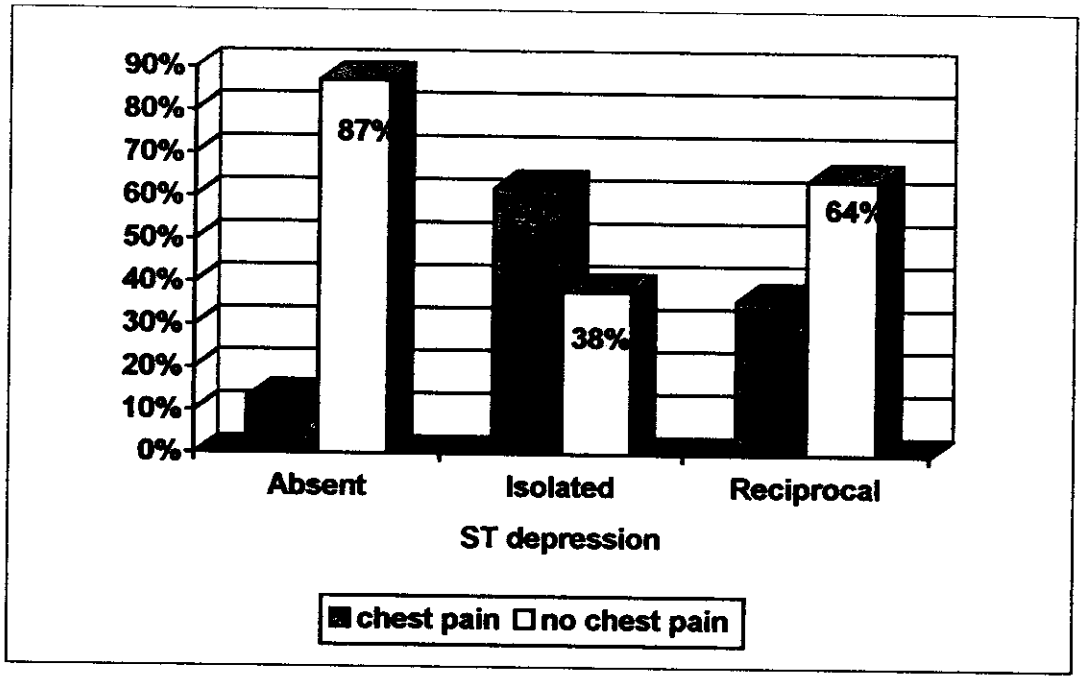

Figure 11: Associated chest pain during exercise testing in the three groups.

Angina induced by exercise occurred in a higher proportion of patients with Isolated ST depression (62%) than in patients either without ST depression (13%) or in those with Reciprocal ST depression (36%) (P value<0.05).

Coronary angiographic findings in the three groups:

Vessel disease	Absent	Isolated	Reciprocal	Total	Chi square	P value
Single	9 (13%)	3 (23%)	10 (71%)	22 (44%)		
Multiple	14 (61%)	10 (77%)	4 (29%)	28 (56%)	6.75	0.03
Total	23 (100%)	13 (100%)	14 (100%)	50(100%)		

Table 12: Coronary angiographic findings as regarding number of diseased vessels.

From this table there was statistically significant difference between the number of cases with single and multiple vessel disease in the three groups. As ST depression induced by exercise was more common in multivessel disease (14 / 27) (51.8%)) than single vessel disease (13 / 27) (50 %)), but the difference was not large and was of limited diagnostic value. Importantly multivessel disease occurred in a higher proportion of patients with isolated ST depression (10/13 (77%)) than in patients either without ST depression (14/23 (61%)) or with reciprocal ST depression (4/14 (29%))(P value< 0.05).

It was found that the significant difference within groups is between those with reciprocal ST depression and those with isolated ST depression (Z=2.3)(P value <0.05).

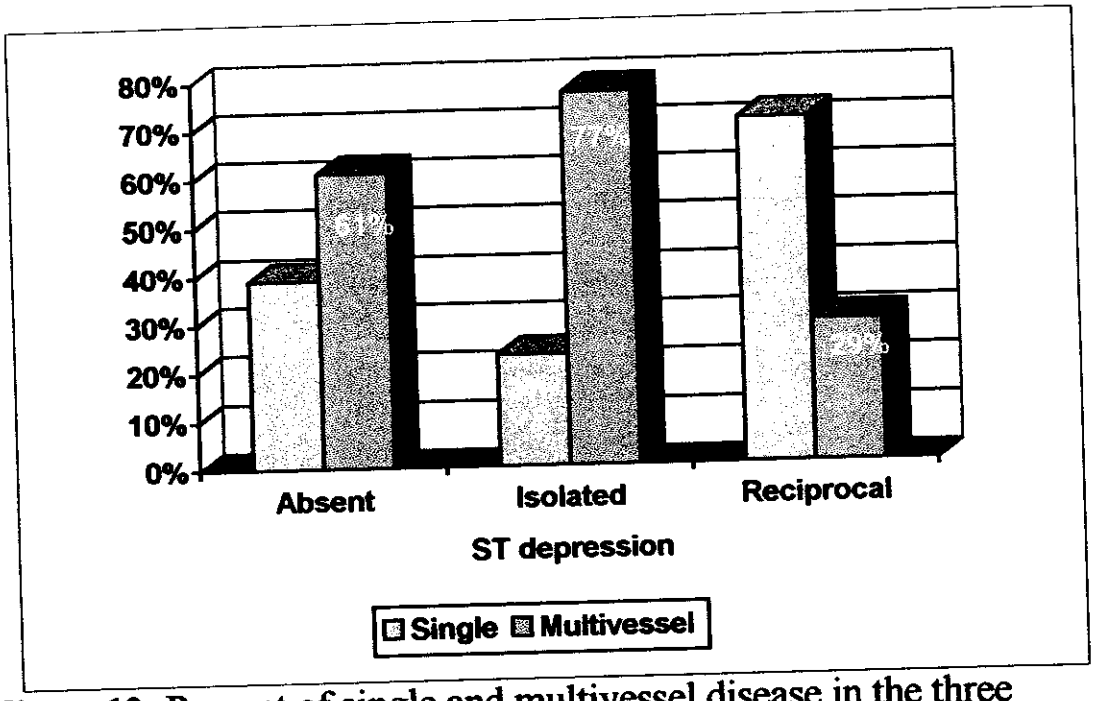

Figure 12: Percent of single and multivessel disease in the three groups.

From this Figure it was found that single vessel disease was significantly higher in the group with Reciprocal ST depression, and that multivessel disease was more common in group with Isolated ST depression.

Testing the sensitivity according to multivessel disease (N= 28):

Multivessel disease (N =28)	**Absent**	**Isolated**	**Reciprocal**
Sensitivity	50	14	36
Specificity	41	55	86
Positive predictive accuracy	52	29	77
Negative predictive accuracy	39	33	51

Table 13: diagnostic value of ST variables for predicting multivessel coronary disease.

Because reciprocal ST depression was not associated with multivessel disease the classification of reciprocal ST depression as a negative response therefore improved the specificity (86%) and predictive accuracy (77%) of ST depression for the diagnosis of multivessel disease, albeit with a reduction in sensitivity (36%).

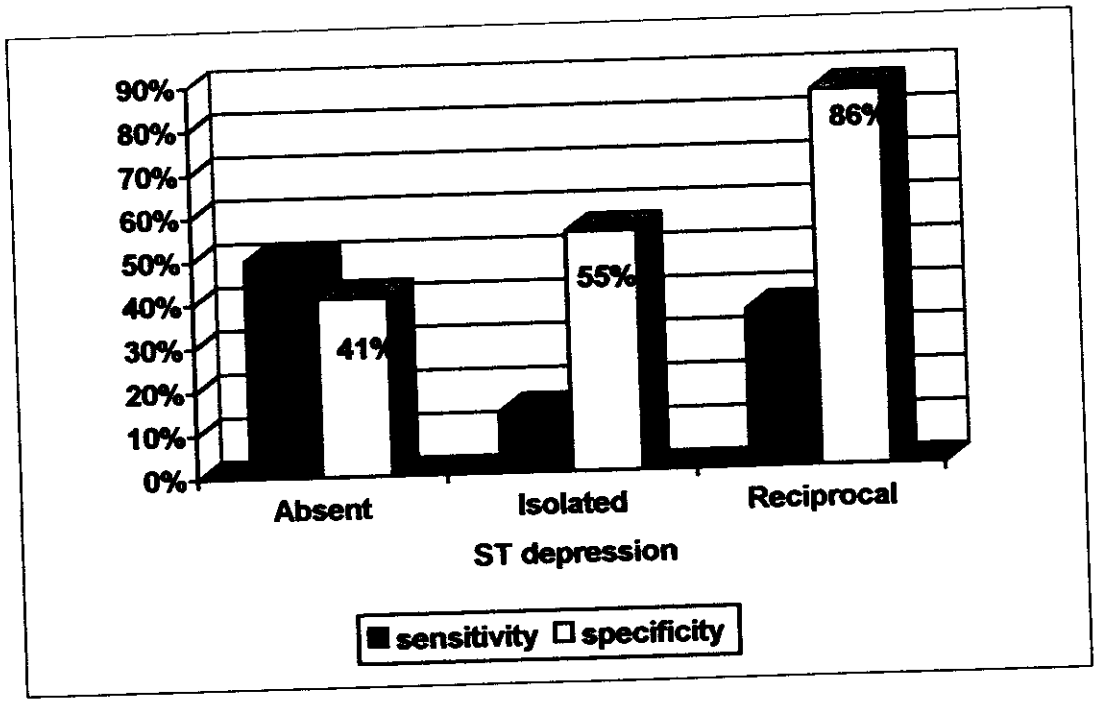

Figure 13: Sensitivity and specificity of ST depression induced by exercise for the diagnosis of multivessel disease.

Patency of the infarct-related artery:

Vessel disease	Absent	Isolated	Reciprocal	Total	Chi square	P value
Total occlusion	4 (17%)	4 (31%)	8 (57%)	16 (32%)	6.37	0.04
Patent artery	19 (83%)	9 (69%)	6 (43%)	34 (68%)		
Total	23 (100%)	13 (100%)	14 (100%)	50 (100%)		

Table 14: Coronary angiographic findings as regarding patency of infarct-related artery.

ST depression induced by exercise was of no diagnostic value for predicting the patency of the infarct-related artery. Coronary occlusion occurred in a higher proportion in patients with isolated ST depression (4/13 (31%)) or reciprocal ST depression (8/14 (57%)) than in patients without ST depression (4/23 (17%)) (P value<0.05).

So there was statistically significant difference between the number of cases with patent or total obstruction of the vessel related to infracted area between the three groups (p value 0.04). As we found that the incidence of patent artery related to infarction was more in the group without ST depression and that the incidence of total occlusion of the artery related to infarction is more in the group with reciprocal ST depression.

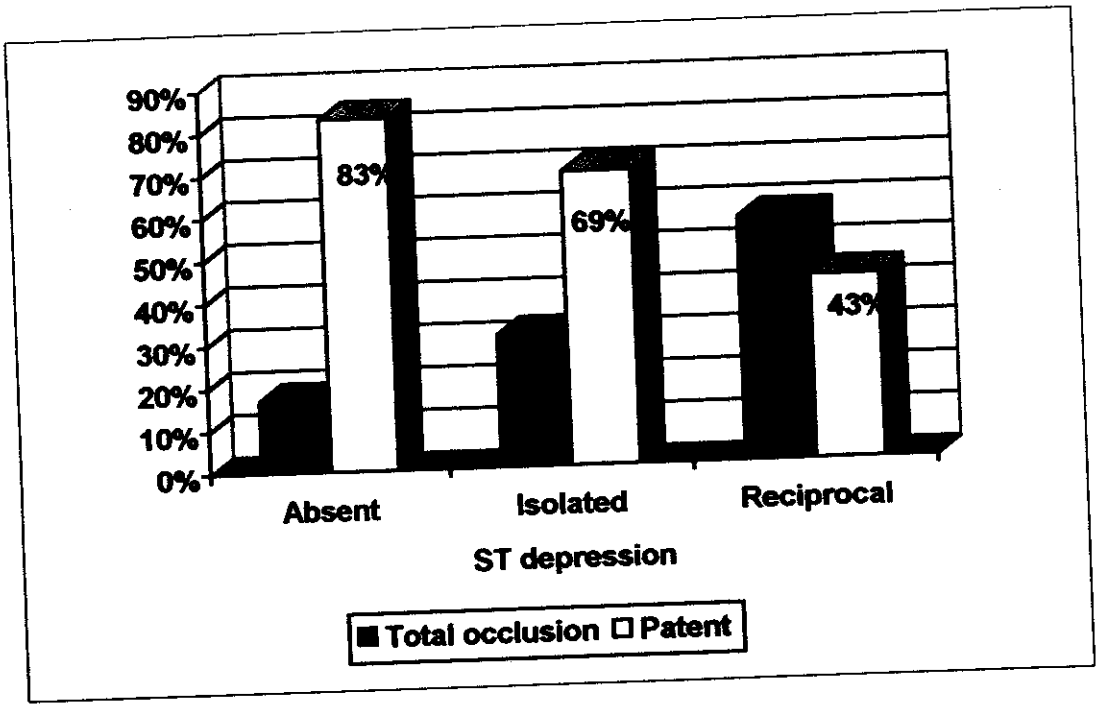

Figure 14: Relation between patency of the infarct related artery and ST segment changes that occur in early exercise stress testing after acute myocardial infarction.

Testing the sensitivity according to the patency of infarct-related artery (N= 34):

Patent artery related to infarct (N = 34)	Absent	Isolated	Reciprocal
Sensitivity	44	18	26
Specificity	25	50	75
Positive predictive accuracy	56	43	69
Negative predictive accuracy	17	22	32

Table 15: Diagnostic value of ST variables for predicting the patency of the infarct-related artery.

The classification reciprocal ST depression as a negative response improved the specificity (75%) and predictive accuracy (69%) of ST depression with a reduction in sensitivity (26%).

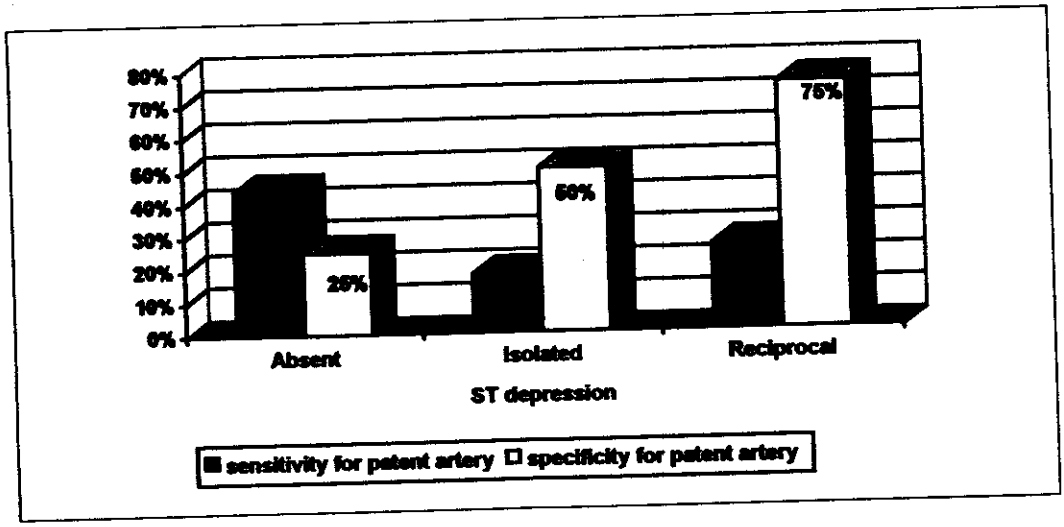

Figure 15: Sensitivity and specificity of ST depression in detection of patent artery related to infarction.

Figure 16: Total obstruction of the left Circumflex coronary artery (case number 2).

Figure 17: multivessel coronary artery disease (case number 49).

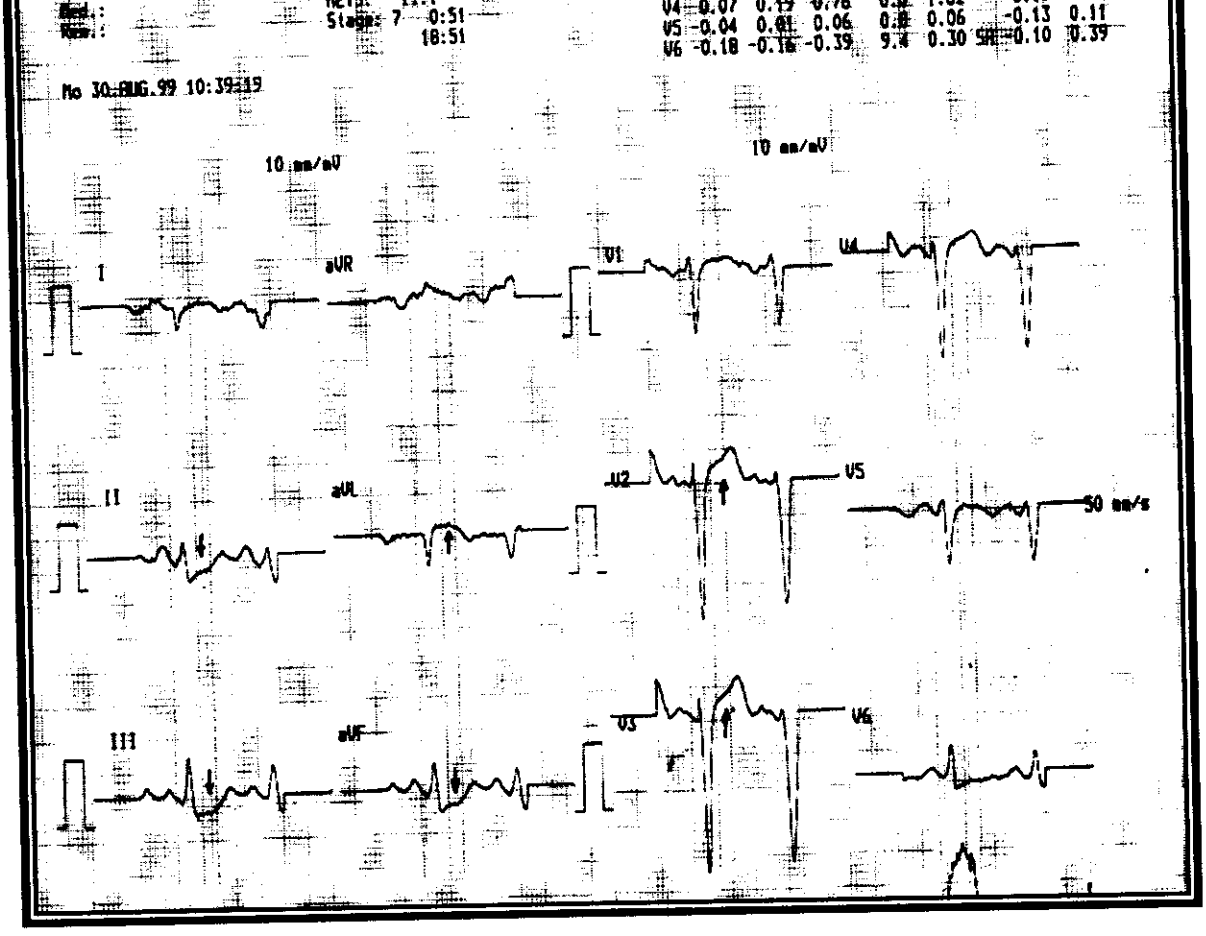

Figure 18: Reciprocal ST depression with exercise (case number 2).

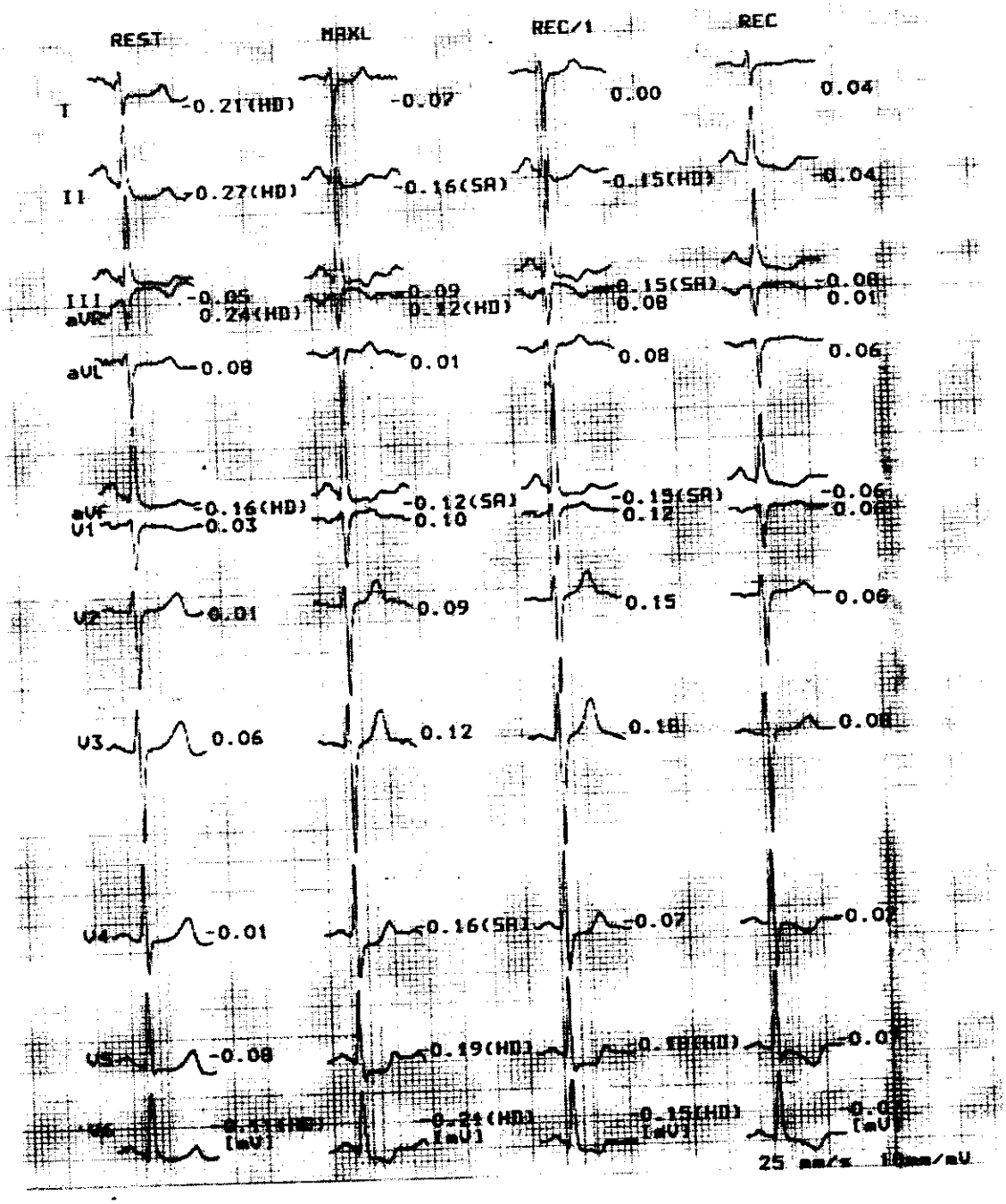

Figure 19: isolated ST depression with exercise (case number 49).

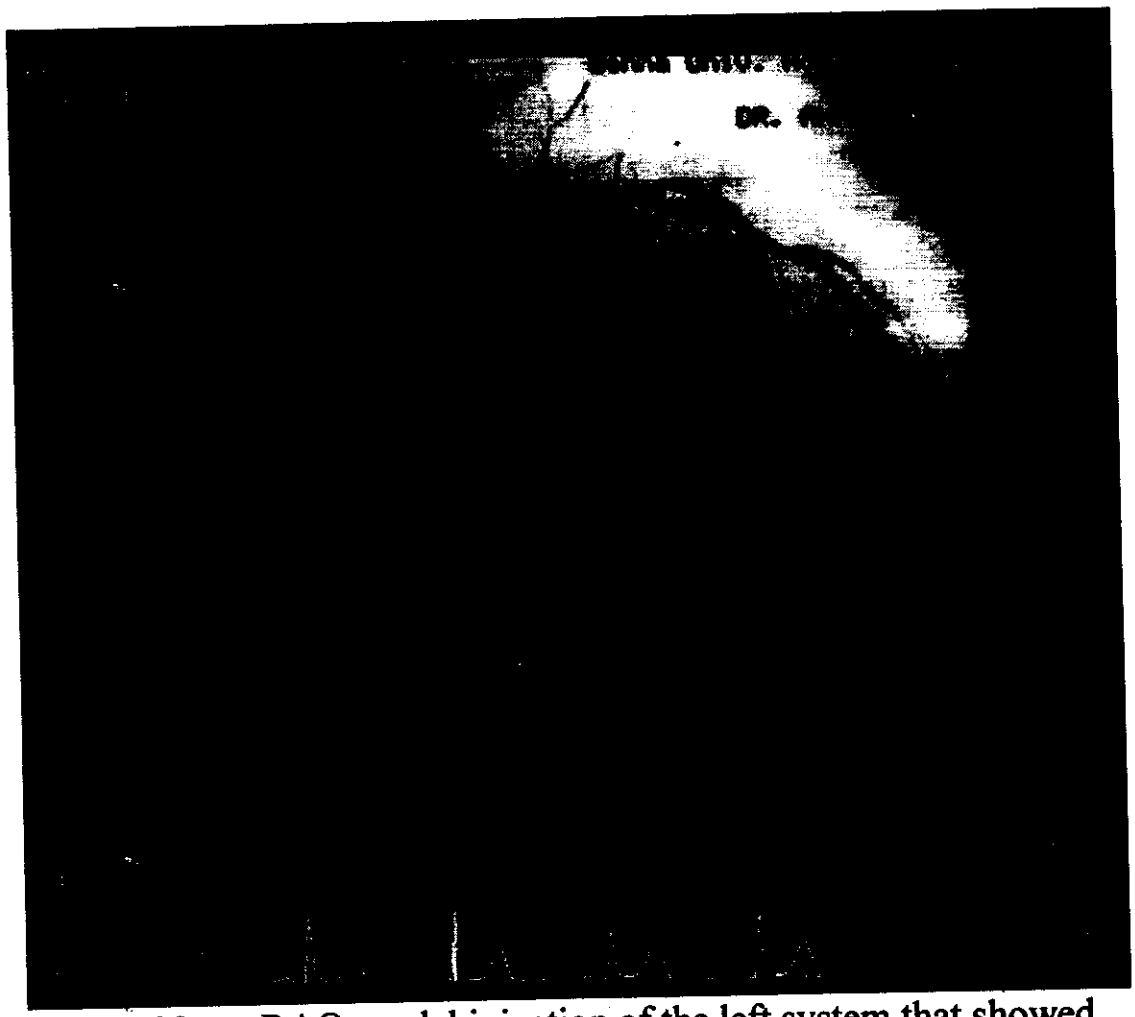

Figure 20: an RAO caudal injection of the left system that showed left circumflex coronary artery lesion (about 80%) in case number 26 that showed no ST segment change with exercise.