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Assessment of Left Ventricular Remodeling and Myocardial Reperfusion among Diabetics Treated with Primary Coronary Intervention for Acute Myocardial Infarction

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ABSTRACT
Background: Left ventricle (LV) remodeling and poor myocardial reperfusion have been linked in various investigations, particularly in diabetics.
Objective: The aim of this study was to assess the influence of diabetes mellitus on both left ventricular systolic function recovery as well as myocardial reperfusion following primary percutaneous coronary intervention (PCI).
Patients and methods: One hundred primary percutaneous coronary intervention of (IRA) alone was used in 50 diabetic and 50 nondiabetic individuals who had their first STEMI attack, underwent echocardiography (conventional TTE) and coronary catheterization to determine effect of diabetes on LV remodeling and myocardial reperfusion.
Results: ST elevation after 1ry PCI in diabetics differed significantly compared to non-diabetics. Left ventricular end-systolic diameter (LVESD), wall motion score index (WMSI) and incidence of remodeling after 3 months follow up was significantly higher in diabetic group compared to non- diabetics. Follow up beyond 3 months indicated positive significant correlation between ejection fraction (EF) by m-mode and myocardial blush grade (MBG), negative correlation between LVEDV and MBG, positive significant correlation between E/A ratio and MBG negative significant correlation between WMSI and MBG.
Conclusion: It could be concluded that diabetes has a negative impact on cardiac reperfusion in STEMI patients. Patients with diabetes are more likely to experience remodeling than those without diabetes.
Keywords: Myocardial Reperfusion, Diabetes Mellitus, Left Ventricular Remodeling.

INTRODUCTION

People with diabetes mellitus (DM) are expected to increase by more than half by the year 2030, 537 million adults (20-79 years) are living with diabetes - 1 in 10. This number is predicted to rise to 643 million by 2030 and 783 million by 2045 [(1)].

About one-third of patients treated with an acute myocardial infarction (AMI) do not have diabetes mellitus (DM) at the time of admission, even though DM is associated with an elevated risk of cardiovascular disease [(2)]. Mortality from cardiovascular disease (CVD) is two- to four-times higher in those with diabetes mellitus than in healthy individuals without the illness [(3)].

Short- and long-term mortality in patients with acute myocardial infarction (MI) and diabetes mellitus (DM) have both been linked [(4)]. A higher incidence of post-infarction heart failure has been linked to diabetes mellitus [(5)].

Chronic heart failure (CHF) after an acute myocardial infarction (MI) is mostly due to the remodeling of the left ventricular (LV) wall, which is affected by numerous variables, including myocardial reperfusion [(6)].

Only a small amount of evidence about the influence of diabetes on post-infarction LV remodeling is known in diabetic individuals, particularly following primary coronary intervention [(7)]. Several investigations have found a correlation between LV remodeling and poor myocardial reperfusion [(8)].

An enhanced inflammatory response, increased platelets and leukocytes' clogging of the endothelium, and decreased myocardial reperfusion in the initial phase of MI have been linked to diabetes mellitus [(9)].

The aim of the current study was to assess the influence of diabetes mellitus on both left ventricular systolic function recovery as well as myocardial reperfusion following primary PCI.

PATIENTS AND METHODS

This comparative study included a total of 100 patients with STEMI (50 diabetic and 50 non-diabetic), attending at Cardiac Catheterization Laboratory, Cardiology Department, Zagazig University Hospitals and El-Zaitoun Specialized Hospital. All patients underwent PCI for IRA only (culprit-only revascularization). This study was conducted between September 2020 to March 2021.

Acute myocardial infarction diagnosis was based on clinical symptoms, elevated cardiac biomarkers (CK, CKMB, and Troponin), and 12-lead electrocardiogram results [(10)].

Inclusion Criteria:

All patients fulfilling the diagnosis of STEMI and admitted to cath lab for primary PCI.

- Myocardial infarction patients with an elevated ST segment.
- Patients not receiving thrombolytic therapy.
- Patients within 12 hours of presenting symptom.

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Exclusion Criteria

- Myocardial infarction patients and those with ischemic cardiomyopathy.
- Previous coronary artery bypass graft (CABG) or pervious PCI.
- Conditions on ECG confounding the interpretation including left bundle branch block (LBBB), pacing and ectopy or any rhythm other than sinus rhythm.
- Lost patients during the follow-up period.
- Patients with significant pericardial diseases.
- Other congenital or valvular heart disease.

***Ethical Consideration*:**

This study was ethically approved by Zagazig University's Research Ethics Committee. Written informed consent of all the participants was obtained and submitted them to Zagazig University (ZU-IRB#6981). The study protocol conformed to the Helsinki Declaration, the ethical norm of the World Medical Association for human testing.

All studied groups underwent the following

1. History taking: Full history was collected and risk factors for heart diseases, diabetes, hyperlipidemia, systemic hypertension with analysis of current chest pain.

2- Clinical examination: General and cardiac examination was done to all subjects, as regard vital signs (Blood pressure, pulse, Respiratory Rate). Killip class at presentation for evaluation of myocardial infarction [11].

3- Laboratory investigations: Cardiac biomarkers (Troponin, CK and CK-MB). Serum Creatinine and urea, liver enzymes and coagulation tests on admission. Glycated Hemoglobin, and lipid profile.

4- Electrocardiogram (ECG).

5- Echocardiography: using (Philips, GE vivid S5) 3 MHz transducers to assess LV global and regional systolic function and diastolic function.

Global LV systolic function will be assessed as follow:

A modified Simpson approach was utilized to determine the apical two and/or four chamber 2-D study's LV ejection fraction (EF), end-systolic volume (ESV).

$$EF = [LVEDV – LVESV] \div LVEDV$$

Function of the left ventricle (EF equal or more 55%) is considered normal. After repeated assessments in individual patients, the LV remodeling was characterized as an EDV rise of 20% or more.

Regional LV systolic function was assessed as follow:

It was determined that LV remodeling occurred when the EDV increased by 20% or more over time in individual patients [12].

Wall motion score index (WMSI): characterizing the preset segments' wall motion characteristics as being normal =1; hypokinetic =2; akinetic =3; dyskinetic =4; and aneurysmal =5 [12].

Revascularization Strategy:(Primary PCI procedures).

All of the patients had mechanical reperfusion PCI treatment.

Diagnostic coronary angiography was done aiming at: (a) Incidence and prevalence rates for coronary artery disease. (b) To find the infarct-related blood vessel and its blockage (IRA) (proximal, mid-segment or distal). (c) TIMI flow measurement. (d) Examining grades prior to and following the process. (e) Determination of MBG grading after the procedure

TIMI flow was graded as follow: Grade 0: There is no blood flow. Penetration without perfusion in Grade 1, partial perfusion in Grade 2, and full perfusion in Grade 3 [13].

Myocardial blush was graded as follow: There is no dye in the microvasculature (MBG 0). Microvasculature 1. The dye slowly enters but does not leave; Microvasculature has a difficult time absorbing and excreting MBG 2. There are no abnormalities in the flow of the dye via the microvasculature in MBG 3. [14].

A successful PCI was accepted when defined to achieve angiographic success (when TIMI 3 flow is achieved in the infarct-related coronary artery)

Follow up after three months of PCI.

Follow-up was performed at our outpatient clinic.

Statistical analysis

The IBM SPSS software programme version 20.0 was used. The range (minimum and maximum), mean, standard deviation, median, and interquartile range were used to characterize quantitative data (IQR). In order to determine the significance of the acquired results, a 5-percent threshold was used. It was a Chi-square test. For categorical variables, chi-square correction for more than 20% of cells with anticipated count less than 5 was required, Student t-test: to calculate the quantities of data of normal distribution and to compare between two studied groups.

RESULTS

Table (1) shows comparative analysis among the studied diabetic and non-diabetic groups as regard age, gender, and risk factors

There was no statistically significant differences were revealed between both study groups regarding age, gender, hypertension, smoking, and family history of IHD ($p>0.05$). Significant higher prevalence of dyslipidemia in diabetics was revealed compared to non-diabetics ($p<0.001$).

Table (1): Age, gender, and regard risk factors

Demographic data	Diabetic	Non diabetic	P-value (Sig.)
Count	50	50	
Age (years) Mean ± SD	52.2 ± 5.1	49.3 ± 6.2	0.127(NS)
Gender: **Male** No (%) **Female** No (%)	30 (60%) 20 (40%)	35 (70%) 15 (30%)	0.248(NS)
Risk factors			
HTN	46 (92%)	43 (86%)	0.603 (NS)
Smoking	33 (66%)	35 (70%)	0.839 (NS)
Dyslipidemia	48 (96%)	20 (40%)	<0.001 (HS)
Family history of IHD	21 (42%)	24 (48%)	0.534 (NS)

Table (2) shows 3-month echo follow up and Incidence of remodeling:

EF by Simpson's after 3 months follow up was significantly lower, while WMSI after 3 months follow up , and incidence of remodeling was significantly higher in diabetics compared to non- diabetics (p<0.001), (p<0.001), and (p=0.013) respectively. There was no statistically significant differences were revealed between both studied groups regarding LVEDV, LVESV, E/A ratio, DCT E

Table (2): 3-month follow up echocardiographic data and Incidence of remodeling.

3-month follow up echocardiographic data	Diabetics	Non-diabetics	P-value (Sig.)
Number	50	50	
EF by Simpson's (%)			
Median (Range)	47 (35 – 60)	51 (40 – 65)	<0.001(HS)
LVEDV (mL)			
Median (Range)	102 (70 – 145)	105 (65 – 135)	0.583(NS)
LVESV (mL)			
Median (Range)	50 (28 – 80)	53 (32 – 77)	0.144(NS)
E/A ratio			
Median (Range)	0.90 (0.6 – 1.5)	0.87 (0.7 – 1.9)	0.075(NS)
DCT E (ms)			
Median (Range)	213 (82 – 386)	220 (105 – 367)	0.444(NS)
WMSI			
Median (Range)	1.29 (1.06 –	1.20 (1.00 –	<0.00
Incidence of remodeling			
	22 (44%)	10 (20%)	0.013(

Table 3 shows comparative analysis among the diabetic and non-diabetic groups as regard Coronary angiographic and 1ry PCI data (number of diseased vessels, MBG and (TIMI flow post procedure)):
Statistical analysis showed that one diseased vessel was significantly higher in non-diabetics compared to diabetics while two diseased vessels was significantly higher in diabetics compared to non- diabetics (p=0.013). While MBG3 was considerably greater in non-diabetics (p=0.001)., MBG1 and MBG2 were significantly higher in diabetics, according to statistical analyses. In terms of TIMI flow, no differences between the two groups were found to be statistically significant (post procedure) (p>0.05).

Table (3): Comparative analysis among the diabetic and non-diabetic groups as regard Coronary angiographic and 1ry PCI data (number of diseased vessels, MBG and (TIMI flow post procedure)

Coronary angiographic and 1ry PCI data	Diabetic	Non-diabetic	Test	P-value (Sig.)
Count	**50**	**50**		
Number of diseased vessels				
One vessel	38 (76%)	48 (96%)	8.617‡	0.013(S)
Two vessels	9 (18%)	2 (4%)		
Three vessels	3 (6%)	0 (0%)		
MBG				
0	1 (2%)	1 (2%)	11.694‡	0.001(S)
1	6 (12%)	2 (4%)		
2	24 (48%)	7 (14%)		
3	19 (38%)	40 (80%)		
TIMI flow (Post procedure)				
TIMI 2	8 (16%)	3 (6%)	2.554‡	0.110(NS)
TIMI 3	42 (84%)	47 (94%)		

Table 4 shows 3 months clinical outcome (MACEs):
There were 18 (36%) cases with recurrent UA in diabetic group, 7 (14%) in non-diabetic group. Statistical analysis showed significant higher prevalence of recurrent UA in diabetics (p<0.001). There were 12 (24%) cases had HF in diabetic group, 3 (6%) in non-diabetic group. Statistical analysis showed significant higher prevalence of HF in diabetics compared to non-diabetics (p<0.001).

Table (4): Comparison between diabetic and non-diabetic group as regard 3 months clinical outcome (MACEs)

MACE	Diabetic	Non-diabetic	Test	P-value (Sig.)
Count	**50**	**50**		
Recurrent UA	18 (36%)	7 (14%)	6.453 ‡	0.011 (S)
HF	12 (24%)	3 (6%)	6.353 ‡	0.012 (S)

ST elevation after PCI was considerably higher in patients with remodeling than in those without, according to statistical analysis. (p<0.001).

Table (5): Relation between ECG data and Remodeling.

ECG data	Remodeling		Test of sig	p-value
	yes n.27	**no n.73**		
ST elevation (mv) before PCI Median(Range)	4(2-6)	3(0.00-6)	1.544•	0.123
ST elevation (mv) after PCI Median(Range)	2(0.5-4)	1(0.00-4)	3.645•	0.0001 (HS)

Table 6 shows correlation between clinical data and laboratory data with MBG (Table 6):

Significant negative correlations were revealed between Pulse (beat/min), CK-MB and MBG of studied group (p= 0.0001), (p= 0.001). Study participants' systolic blood pressure, diastolic blood pressure, Creatinine, and MBG showed no significant associations (p>0.05). Chest pain duration was found to have a negative connection with MBG (p= 0.0001).

Table (6): Correlation between, clinical data and laboratory data with MBG.

	MBG	
	r	P
Pulse (beat/min)	-0.344 **	0.0001
SBP (mmHg)	-0.112	0.267
DBP (mmHg)	-0.051	0.612
Chest pain duration (hours)	-0.354 **	0.0001
CK-MB (U/L)	-0.325 **	0.001
Creatinine (mg/dL)	0.187	0.062

Table 7 shows Correlation between ECG finding and MBG:

It was found that there was no significant correlation between ECG finding before PCI and MBG of studied group (p>0.05). It was found that there was significant negative correlation between ECG finding after PCI and MBG of studied group (p= 0.001).

Table (7): Correlation between MBG and ECG finding

	MBG	
	Base line	
	r	P
ECG finding before PCI	-0.188	0.061
ECG finding after PCI	-0.332 **	0.001

DISCUSSION

During coronary angiography, patients with acute myocardial infarction (AMI) and diabetes mellitus may have numerous vascular abnormalities. Predictive serum signs are lacking since the underlying process is unknown and there is a dearth of serum biomarkers **[15]**.

In our study regarding to the demographic characteristics, the age difference between the two groups was not statistically significant.

These results were nearly agreed with **Elrabat *et al.* [16]** who found no statistically significant differences in age or gender between the two groups in the study of 100 patients with acute STEMI who underwent primary PCI. In addition, **Soni *et al.* [17]** conducted a multicenter randomized controlled trial that included patients with and without diabetes who had AMI (their first or subsequent AMI), Diabetes and non-diabetes groups did not differ in body mass index.

Regarding to risk factors, no statistically significant differences existed between the two groups in terms of hypertension, smoking, or IHD in family members.

These results were agreed with Soni *et al.* [17] who found that patients with diabetes were more likely to have hypertension, be physically inactive, and have a reduced self-reported history of tobacco use, according to a study. There needs to be a special rehabilitation programme for AMI patients with diabetes because of the distinct distribution of CV risk variables that has been reported.

As regard 3-month echo follow up, our results showed that EF by Simpson's after 3 months follow up was significantly lower in diabetics compared to non-diabetics. On the other hand, no statistically significant difference between both studied groups regarding LVEDV, LVESV, E/A ratio and DCT E (p>0.05). But WMSI after 3 months follow up was significantly higher in diabetic group compared to non- diabetic group.

Ernande *et al.* [18] in the study results, three clusters were found. There was a higher percentage of men with a lower prevalence of obesity or hypertension in Cluster 1 patients, as well as a lower LV mass index and a lower E/e0 ratio (early mitral inflow velocity to mitral annular early diastolic velocity). Those in Cluster 2 were the oldest, most swollen, and had the highest E/e0 ratio; they were also the most female; and their incidence of isolated type 2 diabetes was the lowest (without HTN or obesity). Most of the patients in cluster 3 were men, with similar ages, rates of obesity, and prevalence of high blood pressure (HTN) and left ventricular mass index (LVMI) and volumes (LVEF) as cluster 1 patients. After 67 months of follow-up, the composite objective was attained by 56 patients out of 521 (interquartile range: 40 to 87 months) individuals (10.8 percent). When it came down to it, there was no difference between the first and second clusters when it came to their outcomes, which were both 2.37 (95 percent confidence interval, 1.15 to 4.88) and 2.19 (95% confidence interval, 1.00 to 4.82) respectively.

Also Regarding MBG, Statistical analysis showed that MBG3 was significantly higher in non-diabetic group compared to diabetic group while MBG1& 2 was significantly higher in diabetic group compared to non-diabetic group.

This was in agreement with **Timmer *et al.* [19]** in patients with ST-elevation myocardial infarction and diabetes mellitus, who studied the effects of successful initial PCI on myocardial reperfusion.

As regard 3months clinical outcome (MACEs), there was a significant higher prevalence of recurrent UA and prevalence of HF in diabetic group compared to non-diabetic group.

Furtado *et al.* [20] Dapagliflozin's HR for MACE in the total study was 0.93. MACE occurred in 15.2% of people on dapagliflozin compared to 17.8% of patients on placebo in patients with a history of coronary artery disease (CAD). Patients with a history of coronary artery disease had decreased risks of

MACE, largely due to lower rates of recurrent MI.

In recent study by **Elrabat *et al.*** [16] ECGs were found to be the most statistically important determinants in remodeling, according to logistic regression studies (ST segment resolution) (p=0.027), Smoking (p= 0.025), MBG (p=0.027), saxA C. strain and GLS (p= 0.037), While other factors not affecting remodeling were DM (p= 0.121), HTN (p= 0.631), dyslipidemia (p= 0.372), EF (p= 0.109), E/A ratio (p= 0.590) and GCS (p= 0.941).

CONCLUSION

It could be concluded that it is more difficult for STEMI patients with diabetes to recover their hearts after a heart attack than it is for those without diabetes. Patients with diabetes are more likely to experience remodeling than those without diabetes.

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REFERENCES

1. **Sun H, Saeedi P, Suvi K *et al.* (2021):** IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Research and Clinical Practice, 183: 109119.
2. **Aggarwal B, Shah G, Randhawa M *et al.* (2016):** Utility of glycated hemoglobin for assessment of glucose metabolism in patients with St-segment elevation myocardial infarction. The American Journal of Cardiology, 117(5): 749–753.
3. **Dal Canto E, Ceriello A, Rydén L *et al.* (2019):** Diabetes as a cardiovascular risk factor: An overview of global trends of macro and micro vascular complications. European Journal of Preventive Cardiology, 26(2): 25–32.
4. **Adams T, Mehta T, Davidson L *et al.* (2015):** All-Cause and cause-specific mortality associated with bariatric surgery: A review. Current Atherosclerosis Reports, 17(12): 74-79.
5. **Cortigiani L, Huqi A, Ciampi Q *et al.* (2018).** Integration of Wall Motion, Coronary Flow Velocity, and Left Ventricular Contractile Reserve in a Single Test: Prognostic Value of Vasodilator Stress Echocardiography in Patients with Diabetes. Journal of the American Society of Echocardiography: Official Publication of the American Society of Echocardiography, 31(6): 692–701.
6. **Bolognese L, Carrabba N, Parodi G *et al.* (2004):** Impact of microvascular dysfunction on left ventricular remodeling and long-term clinical outcome after primary coronary angioplasty for acute myocardial infarction. Circulation, 109:1121-1126.
7. **Carrabba N, Valenti R, Parodi G *et al.* (2004):** Left ventricular remodeling and heart failure in diabetic patients treated with primary angioplasty for acute myocardial infarction. Circulation, 110: 1974–1979.
8. **Araszkiewicz A, Grajek S, Lesiak M *et al.* (2006):** Effect of impaired myocardial reperfusion on left ventricular remodeling in patients with anterior wall myocardial infarction treated with primary coronary intervention. Am J Cardiol., 98: 725–728.
9. **Prasad A, Stone G, Stuckey T *et al.* (2005):** Impact of diabetes mellitus on myocardial perfusion after primary angioplasty in patients with acute myocardial infarction. JAm Coli Cardio., 45:508-514.
10. **Kasper D, Fauci A, Hauser S *et al.* (2015):** Harrison's principles of internal medicine. McGraw Hill Education, Pp. 1593–1610. https://accessmedicine.mhmedical.com/content.aspx?bookid=1130&sectionid=79720825
11. **Killip T, Kimball J (1967):** Treatment of myocardial infarction in a coronary care unit. A two-year experience with 250 patients. Am J Cardiol., 20(4):457–464.
12. **Cerqueira M**, **Weissman N, Dilsizian V *et al.* (2002):** Standardized myocardial segmentation and nomenclature for tomographic imaging of the heart. A statement for healthcare professionals from the Cardiac Imaging Committee of the Council on Clinical Cardiology of the American Heart Association. Circulation, 105:539–542.
13. **Chesebro J, Knatterud G, Roberts R *et al.* (1987):** Thrombolysis in myocardial (TIMI) trial, phase I: A comparison between intravenous tissue plasminogen activator and streptokinase. Circulation, 76:142.
14. **Gibson C, Cannon C, Murphy S *et al.* (2000):** Relationship of TIMI myocardial perfusion grade to mortality after administration of thrombolytic drugs. Circulation, 101: 125-32.
15. **She J, Deng Y, Wu Y *et al.* (2017):** Hemoglobin A_{1c} is associated with severity of coronary artery stenosis but not with long term clinical outcomes in diabetic and nondiabetic patients with acute myocardial infarction undergoing primary angioplasty. Cardiovasc Diabetol., 16: 97-102.
16. **Elrabat K, Elkeshk E, Elsayed M *et al.* (2018):** Impact of Diabetes Mellitus on Myocardial Reperfusion and Left Ventricular Remodeling in Patients with Acute Myocardial Infarction Treated with Primary Coronary Intervention. Ar Clin Cardiol Res., 104: 1-9.
17. **Soni D, Ambalam C, Ajay V *et al.* (2018):** Cardiovascular Risk Factors among Acute Myocardial Infarction Patients with and without Comorbid Diabetes Mellitus—Findings from the Yoga-CaRe Trial. Am Diabetes Assoc., 67(1):2361.
18. **Ernande L, Audureau E, Jellis C *et al.* (2017):** Clinical implications of echocardiographic phenotypes of patients with diabetes mellitus. J Am Coll Cardiol., 70:1704–1716
19. **Timmer J, van der Horst I, de Luca G *et al.* (2005):** Myocardial Infarction Study Group. Comparison of myocardial perfusion after successful primary percutaneous coronary intervention in patients with ST - elevation myocardial infarction with versus without diabetes mellitus. Am J Card., 95: 1375-1377.
20. **Furtado R, Bonaca M, Raz I *et al.* (2019):** Dapagliflozin and Cardiovascular Outcomes in Patients with Type 2 Diabetes Mellitus and Previous Myocardial Infarction. Circulation, 139: 2516-2527.