Impact of diabetes mellitus on acute and short term left ventricular longitudinal systolic strain recovery after percutaneous coronary intervention in ischemic hypertensive patients

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Abstract

Background: Diabetes mellitus (DM) is linked to an increased risk of cardiovascular disease and almost one-third of patients with acute myocardial infarction (AMI) may have undetected diabetes mellitus (DM) at the time of admission.

Objectives: evaluate the impact of DM on the subtle changes in left ventricular (LV) function before and post revascularization in ischemic hypertensive patients.

Patients and Methods: This was an observational prospective study performed at Qena University Hospital included 140 ischemic hypertensive patients . Patients were divided into two groups: (1) Diabetic group and (2) non diabetic group. A complete medical history, physical examination and laboratory tests were done as well as Trans thoracic Echocardiography (TTE) was done before and after PCI for each patient.

Results: In this study, there was a statistically significant (p-value < 0.05) increase in LV GLS after PCI (-14.0 ± 3.6%) when compared with GLS before PCI (-13.7 ± 1.5%) in diabetic group and highly statistically significant (p-value < 0.001) increased GLS after PCI (-15.8 ± 1.1%) when compared with GLS before PCI (-14.2 ± 0.9%) in non-diabetic group. Also we found that after PCI, diabetic patients had a significant improvement in LV EF and dimensions than the non-diabetic group that resulted in highly significant increase in GLS.

Conclusion: The presence of diabetes mellitus in ischemic hypertensive patients had an impact on subclinical LV function that has been improved after successful revascularization regardless the level of HbA1C.

Keywords: Acute coronary syndromes (ACS; Ischemic heart disease (IHD); percutaneous coronary intervention (PCI); Global longitudinal strain (GLS); Left ventricle (LV).

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Introduction

Despite well-established treatment options including direct revascularization with percutaneous coronary intervention, acute coronary syndrome (ACS) continues to be a significant cause of mortality and morbidity worldwide (PCI) (**Zeitouni et al., 2018).** Coronary angiography makes it easier to clarify whether suspected anginal chest discomfort is caused by myocardial ischemia as a result of coronary atherosclerosis or not. In previous studies and guidelines, the coronary atherosclerosis can be managed by PCI within the same procedure or by coronary artery bypass grafting (CABG), based on the morphology of lesion and the risk profile of patient (**Collet et al., 2021).**

Diabetes Mellitus (DM) and hypertension are the main two risk factors of myocardial ischemia and most ischemic patient who are selected for intervention have DM or/and hypertension. The prevalence of diabetes in coronary artery disease (CAD) patients is up to 50% in many countries. (4) Recently poor blood pressure (defined as an average SBP ≥140 mmHg or an average DBP ≥90 mmHg, among those with hypertension.) and glycemic control, as defined by HbA1c ≥ 7% (normal values: between 4% and 5.6%) have been reported to lead to LV systolic strain reduction in all directions that are independently linked to preclinical LV dysfunction (**Shenouda et al., 2019**). The objective of this study was to identify the influence of DM by measuring HbA1C on LV dysfunction in ischemic and controlled hypertensive patients by using strain imaging versus nondiabetic patients.

Patient and methods

The study design was an observational prospective and it was performed at Qena University Hospital from 2021-2023. All patients provided a written consent was before their involvement in this research.

Inclusion criteria: All patients aged ≥ 40 years old with controlled hypertension and ischemic heart disease and indicated for PCI. Then those patients have been subdivided into diabetic or non-diabetic groups.

Exclusion criteria: Any patients suffering from LV failure with reduced EF <54%, patients with arrhythmia especially AF and uncontrolled hypertension.

The blood level of HbA1C and all routine laboratory investigations with ECG tracing and standard echocardiography were done for all patients at the time of admission. Moreover, the two groups of patients underwent 2D- strain imaging study before and one month after coronary intervention.

All transthoracic echocardiograms were performed using a Philips Affinity machine (Philips Healthcare) (Philips Affinity 70C Ultrasound, Inc.Bothell,WA, USA 2007) with a 2D cardiac probe according to American Society of Echocardiography (ASE) guidelines. (Picard et al., 2011) All views were ECG gated views. A speed of 150mm/s of Doppler sweep was selected as well as the M-mode. The Nyquist limit was set at 50-70cm/s for all spectral Doppler recordings. Tissue Doppler was used for diastolic function assessment. Images were optimized to the right gain, depth and width. The optimization of frequency and the rate of frame was performed in order to permit adequate penetration for both epicardial and endocardial border definition. At least three cardiac cycles of images were recorded. Frame rates of apical 4-chamber, 2-and 3- chamber and long-axis views were between 40-80 fps for 2D- speckle tracking imaging analysis. All echocardiographic views offline analysis were done by using automated Cardiac Motion Quantification (aCMQ) tool of Q-lab software following recommended protocols approved by EACVI for strain imaging analysis. (**Voigt et al., 2015**)

Patients complaining of coronary artery disease manifestations were evaluated for revascularization management by the team of expert cardiologist according to (ESC/EACTS) guidelines. The interventional cardiologists performed the diagnostic coronary angiography under local anesthesia with fluoroscopic guidance and through the femoral artery approach by using Seldinger's technique. Followed by good hemostasis and follow up ECG.

Administrative Design: The study was approved by the local ethics committee with ethical approval code (MED018) 1-8-21,223 at Qena faculty of medicine, South Valley University. Delete the above sentence plz

Research outcome measures: Primary Outcome Measures are: Measuring of the changes of left ventricular global longitudinal strain (LV-GLS) before and one month post elective percutaneous coronary procedure (PCI) in diabetic and non-diabetic ,hypertensive ,and ischemic ones.

Statistical analysis

Data analysis was done using Statistical Program for Social Science (SPSS) version 24. Quantitative variables were represented as mean ±SD. Qualitative variables were displayed as number and percentage. The following tests were done:Chi-square test: was used when comparing between non-parametric data. Independent sample T test: when comparing between two means (for normally distributed data). Paired T test: was used to compare between the results of before and after intervention in the same group. Probability (P-value): P-value < 0.05 was considered significant. P-value < 0.001; highly significant, whereas a P-value > 0.05 is non-significant.

Results

Demographic data

The demographic parameters of the total 140 ischemic hypertensive patients that were divided into diabetic patients compared with the control group were showed in (**Table 1**). There was insignificant variation between the two groups in all parameters except BMI and HbA1C level which were higher in diabetic group.

Table 1. Comparison between studied groups as regard demographic data

Variables		Groups				P-value
		Diabetic (N = 80)		Control (Non-Diabetic) (N = 60)		
Sex	Male	56	70%	38	63.3%	0.406 NS
	Female	24	30%	22	36.7%	
Age (years)	Mean	58.4		57.1		0.341 NS
	±SD	7.1		9.0		
BMI	Mean	31.4		28.0		**< 0.001 HS**

(kg/m²)	±SD	4.3	3.7	
HbA1C (%)	Mean	8.85	4.9	< 0.001 HS
	±SD	2.05	0.3	

SD: standard deviation. N: number. S: p-value < 0.05; significant. HS: p-value < 0.001; highly significant. Independent sample T test and Chi-square test were used. NS: p-value > 0.05; non-significant. BMI: body mass index.

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The echocardiographic changes after intervention in diabetic group

After PCI, diabetic patients had a significant improvement in LV EF and dimensions that resulted in increase in GLS (from -13.8 ± 1.9% to -14.8 ± 2.3%, p-value = 0.006), (**Table.2**).

Table 2. Comparison of studied ECHO data (before & after PCI) in diabetic group

Diabetic group		PCI Before (N = 80)	PCI After (N = 80)	P-value
EF (%)	Mean	57.5	59.6	0.017 S
	±SD	6.04	5.6	
LVEDD	Mean	4.7	5.1	< 0.001 HS
	±SD	0.4	0.6	
LVESD	Mean	3.5	4.1	< 0.001 HS
	±SD	0.5	0.8	
GLS AVG	Mean	-13.7	-14.0	0.006 S
	±SD	1.5	3.6	

S: p-value <0.05 is significant. NS: p-value > 0.05 is non-significant. HS: p-value < 0.001 is considered highly significant. SD: standard deviation. N: number. Paired T test was used. PCI: percutaneous coronary intervention. EF: ejection fraction. LVEDD: left ventricle end-diastolic diameter. LVESD: left ventricle end-systolic diameter. GLS: global longitudinal strain. AVG: average.

The echocardiographic changes after intervention in non-diabetic group

After PCI, patients who had ischemic heart disease manifestations with controlled hypertension without diabetes had a highly significant improvement in EF, LVESD and GLS with higher values than in diabetic patients (GLS from: -14.1 ± 1.0% to -15.6 ± 1.2%, p-value < 0.001), (**Table3**).

Table 3. Comparison of studied ECHO data (before & after PCI) in control group.

Control group		PCI Before (N = 60)	PCI After (N = 60)	P-value
EF (%)	Mean	57.4	61.8	< 0.001 HS
	±SD	4.1	3.3	
LVEDD	Mean	4.6	4.8	0.026 S
	±SD	0.5	0.4	

LVESD	**Mean**	3.5	4.2	**< 0.001 HS**
	±SD	0.5	0.7	
GLS AVG	**Mean**	-14.2	-15.8	**< 0.001 HS**
	±SD	0.9	1.1	

S: p-value > 0.05 is significant. HS: p-value < 0.001 is highly significant.
Paired T test was used. SD: standard deviation. N: number. PCI: percutaneous coronary intervention. EF: ejection fraction. LVEDD: left ventricle end-diastolic diameter. LVESD: left ventricle end-systolic diameter. GLS: global longitudinal strain. AVG: average.

After PCI, diabetic patients had a significant improvement in LV EF and dimensions than the non-diabetic group that resulted in highly significant increase in GLS (**Table.4**).

Table 4. Comparison of studied ECHO data in diabetic and control group after PCI

After PCI		**Group**		**P-value**
		Diabetic (N = 80)	**Control (Non-Diabetic) (N = 60)**	
EF (%)	**Mean**	59.6	61.8	**0.007 S**
	±SD	5.6	3.3	
LVEDD	**Mean**	5.1	4.8	**0.001 S**
	±SD	0.6	0.4	
LVESD	**Mean**	4.1	4.2	**0.442**
	±SD	0.8	0.7	
GLS AVG	**Mean**	-14.0	-15.8	**0.0003 HS**
	±SD	3.6	1.1	

S: p-value <0.05 is significant. NS: p-value > 0.05 is non-significant. HS: p-value < 0.001 is considered highly significant. SD: standard deviation. N: number. Paired T test was used. PCI: percutaneous coronary intervention. EF: ejection fraction. LVEDD: left ventricle end-diastolic diameter. LVESD: left ventricle end-systolic diameter. GLS: global longitudinal strain. AVG: average.

As regard EF (before and after PCI) in this research, there was a statistically potential raise in left ventricular function after one month of intervention regardless the level of HbA1c as shown in (**Fig.1 and 2**).

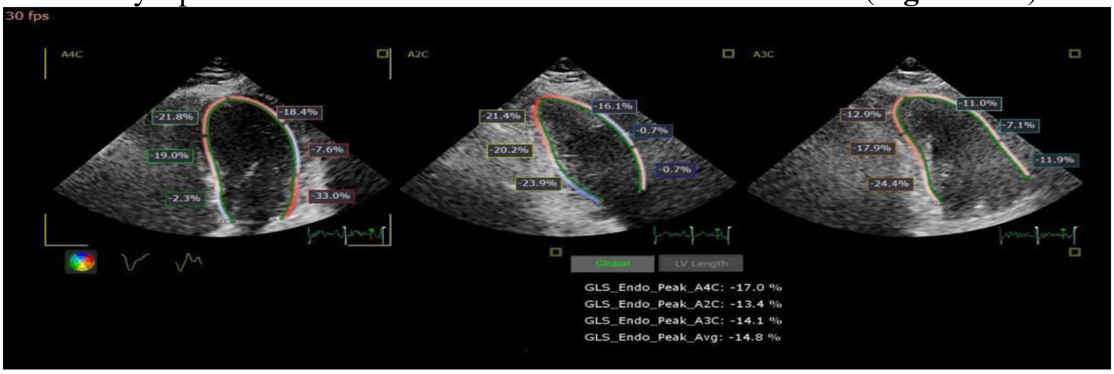

Fig.1. GLS in diabetic and hypertensive patient before PCI.

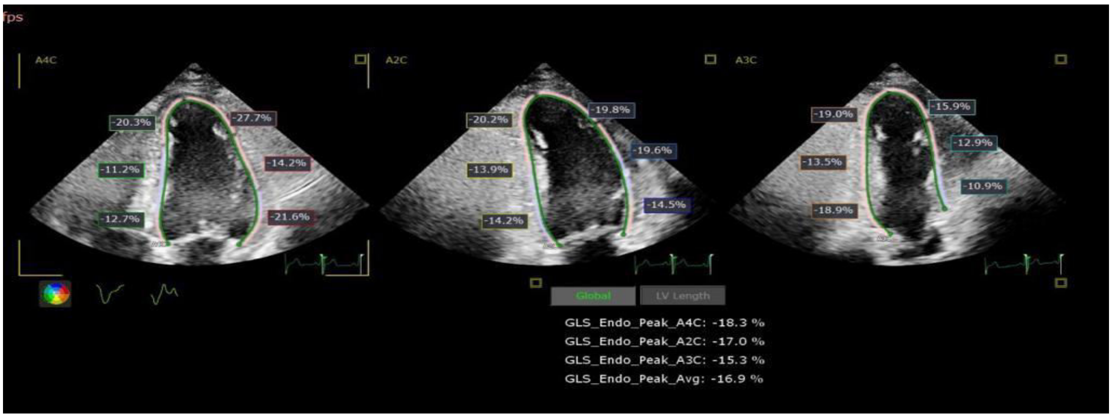

Fig.2. GLS in diabetic and hypertensive patient after PCI

Discussion

DM, HTN are considered the two main cardiovascular risk factors that have an additive deleterious effect on LV function and deformation in ischemic patients especially in the acute stage and even after revascularization **(Li XM et al., 2020).** However, the direct impact of DM on the LV subclinical function is still under debate. As regard EF (before and after PCI). In this study, regardless of the level of HbA1c, there was a statistically significant increase in left ventricular function after a month of intervention with respect to EF (before and after PCI). In agreement with this observation, there was significant difference in LVEF before and after PCI in diabetic and non-diabetic groups according to **Hoogslag et al. (2015).** study.

In agree with our study, **Sikora-Frac et al. (2021)** study, all echocardiographic variables of LV improved considerably post PCI in all cases. Nevertheless, the variations in LVEF between CAD and diabetic cases and CAD patients without diabetes were maintained. Also, in **Zhang et al. (2013)** study, the three groups of controlled DM, uncontrolled DM and non-diabetic patients had similar LVEFs (all P values > .05).

In **Chimura et al. (2019)** study, LVEF (pre-PCI Vs. post- PCI was 50.2±12.3% and 52.4±10.7%, respectively, P = 0.33, pre-PCI Vs. post-PCI was 55.9±8.9% and 53.2±9.9%, respectively P = 0.53).

In this study, there was a remarkable (p-value = 0.006) increased GLS after PCI (-14 ± 3.6%) when compared with GLS before PCI (-13.7 ± 1.5%) in diabetic group. Moreover, in the non-diabetic group, GLS showed a highly significant growth after intervention but with higher values than in diabetic patients (GLS from: -14.1 ± 1.0% to -15.6 ± 1.2%, p-value < 0.001)

In contrast to these results, **Sikora-Frac et al. (2021)** study, they revealed that GLS values elevated by 18% in patients with CAD and suffering from DM and by 14% in CAD patients with no DM. **Ryo et al.(2012)** showed in his study that function improvement of LV was expressed as growth in GLS in 35 IHD cases one month after PCI. **Antoni et al. (2010)** evaluated LV function following acute MI using GLS with a follow-up duration of one year after intervention. All patients displayed elevation in GLS ≥ 10% were considered as improvers.

One of the most interesting results of this study was an up sloping in LV-GLS from a lower baseline level in diabetic than non-diabetic group after successful intervention. This mainly because the diabetic patients had a lower level of LV-GLS in acute stage of ischemia and before intervention than non-diabetic ischemic hypertensive patients. Moreover, both groups of patients showed a significant growth in GLS after intervention regardless the baseline HbA1C. However, **Bauer et al. (2011)** showed that complete revascularization among insulin-dependent patients was less often achieved. There were no significant variations found in hospital mortality between patients with DM and on diet control and those without DM after the adjustment of baseline and interventional variables. However, a significantly higher mortality rate was seen in diabetic patients with insulin therapy and oral medication even with revascularization. Therefore, the successful revascularization impact on LV function in diabetic patients is not considered as indicator of mortality rate but is important for a quality of life.

Conclusion

A successful revascularization in ischemic patients results in significant improvement in subclinical LV function regardless of the HbA1C level. Comparing the uncontrolled diabetic ischemic patients to the controlled ones, whose baseline level of LV-GLS were greater, the uncontrolled diabetic ischemic patients typically had a considerable improvement in LV function after PCI.

Abbreviations:
ACS: acute coronary syndrome.
PCI: percutaneous coronary intervention.
CAD: coronary artery disease.
CABG: coronary artery bypass grafting.
DM: Diabetes Mellitus.
LV: left ventricle
ACMQ: automated Cardiac Motion Quantification.
ESC: European Society of Cardiology.
EACTS: European Association for Cardio-Thoracic Surgery.
GLS: Global longitudinal strain
EF: ejection fraction.
LVEDD: left ventricle end-diastolic diameter.
LVESD: left ventricle end-systolic diameter.
TTE: Trans thoracic Echocardiography.
AMI: acute myocardial infarction .

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