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Original Research Article

Role of Global Longitudinal Strain (GLS) in Pre and post Cardiac Revascularization Surgery

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Abstract: ***Background***: Global Longitudinal Strain (GLS) is a sophisticated echocardiographic measure that gives sensitive evaluation of left ventricular (LV) systolic performance. It is essential in the surgery course of Coronary Artery Bypass Grafting (CABG) to aid in the risk stratification during preoperative, predicting outcome during surgery and postoperative measuring myocardial recovery. GLS changes have the ability to identify minor myocardial dysfunction at an earlier stage compared to such conventional parameters as left ventricular ejection fraction (LVEF), enabling timely clinical intervention and monitoring of patients over the long term. ***Purpose***: To determine left ventricular performance on the basis of Global Longitudinal Strain pre- and post-cardiac revascularization surgery (CABG). ***Methods***: It is a cohort study that was carried out between September 2022 and March 2023 in the Iraqi Center of Heart Diseases/Medical City. A total of thirty-five patients who were going through elective CABG were recruited according to the predetermined inclusion and exclusion criteria. Preoperative and approximately 3 months postoperative Echocardiographic assessment including GLS assessment with a GE Vivid E9 system was done. Patients who refused to be included, those who had gone through emergency CABG procedures, or had undergone cardiac surgery before were not included. ***Findings***: The research population had 24 males (68.6) and 11 females (31.4) with an average age of 63.88 years with standard deviation of 6.64 years. The comorbidities were hypertension, diabetes and smoking. It was found that GLS improved in 23 patients (66%). Patients who improved on GLS also had significant increases in LVEF after CABG, without a significant difference between LVEF 50% or less ($p = 0.049$). GLS and LVEF were greatly improved after the surgery ($p = 0.0001$ and $p = 0.003$, respectively), whereas LV mass was not. ***Conclusion***: The positive response to GLS after CABG is linked to better LVEF and demonstrates the ability to have a good myocardial outcome. GLS exhibits a significant negative relationship with EF which validates the accuracy of the measure as a sensitive predictor of LV functioning.

Keywords: Global Longitudinal Strain; Coronary Artery Bypass Grafting; Left Ventricular Function; Echocardiography; Myocardial Recovery

INTRODUCTION

Coronary artery disease (CAD) is a major morbid and mortal health concern in all countries around the world and is caused by the progressive atherosclerotic constriction of coronary arteries thereby reducing myocardial perfusion. Clinically, the condition presents itself as angina, dyspnea, myocardial infarction, and heart failure which severely affects the quality of life and survival. Although lifestyle intervention and pharmacological therapy are the primary therapies, most patients with advanced or multivessel disease need coronary artery bypass grafting (CABG) to enhance sufficient myocardial blood circulation and avoid additional ischemic damage [1–7]. CABG is an older method of surgical revascularisation which entails the bypassing of blocked coronary arteries with autologous grafts, which are most frequently an internal mammary or saphenous vein. The process enhances delivery of myocardial oxygen, relieves the symptoms of ischemic conditions, boosts ventricles functioning and cardiovascular mortality among duly chosen patients. Notwithstanding all the demonstrated advantages, CABG is associated with certain perioperative and long-term risks, which require proper preoperative evaluation and effective postoperative analysis of cardiac activities [410]. Echocardiography is a key part of the assessment of patients who have undergone CABG. Being a non-invasive and easily accessible imaging modality, it can be used to make a complete evaluation of cardiac structure and cardiac function pre and post-revascularization. The preoperative echocardiography is also important in giving important information about left ventricular ejection fraction (LVEF), ventricular volumes, wall motion defects, valvular activity, and general myocardial performance. The parameters help clinicians to group risks, plan surgery and estimate prognosis [11–16]. Echocardiography is also necessary postoperative to determine the effectiveness of the revascularization process and the recovery of the left ventricle. Better long-term prognoses are linked with the improvement of LVEF, correction of abnormalities in the wall motions, and positive changes in the ventricular sizes. Moreover, echocardiography cannot be without in the detection of postoperative complications including pericardial effusion and valvular dysfunction, ventricular remodeling and grafts complications, and hence, this diagnosis plays a crucial role in the subsequent patient management [1724]. Though LVEF is the most widely used systolic index of functioning, there are some significant weaknesses. LVEF is load-dependent, ventricular geometry-dependent and tends to miss early or mild myocardial dysfunction. As a result, patients can still have preserved LVEF even with substantial subclinical myocardial impairment especially in the case of ischemic heart disease [5860]. Two-dimensional speckle-tracking echocardiography has given rise to the Global Longitudinal Strain (GLS) which has proven to be a sensitive and reproducible measure of left ventricular systolic function. GLS is a yardstick of the extent of myocardial deformation along the longitudinal axis in systole and is indicated by a negative percentage. The normal values of GLS are considered to be between -16 to -20 per cent with lower values used to imply impaired myocardial contractility [2529]. GLS has a number of benefits as compared to conventional echocardiographic measures. It is able to identify myocardial dysfunction prior to that of the LVEF, less reliant on ventricular geometry and has better reproducibility with less operator bias. The above features render GLS especially useful in the detection of subclinical myocardial injury and in tracking of functional recovery after therapeutic procedures as CABG [30–35]. GLS offers valuable prognostic data in the preoperative setting. Even in patients with intact LVEF, reduced GLS has been linked with higher perioperative risk and adverse postoperative outcome. It has shown that GLS detects myocardial impairment, which cannot be seen on a standard echocardiography, thus improving risk stratification and therapeutic decision-making [3640]. GLS is a strong indication of myocardial recovery and prognosis in the long term after surgery. The recovery of GLS after CABG is an indicator of successful myocardial reperfusion and recovery of myocardial contractile function. On the other hand, continuously lowered GLS could signify the lack of full revascularization, myocardial ischemia, or terminal myocardial damage, which should further be followed-up or receive other interventions. Extensive research has proven the prognostic role of GLS of both immediate and delayed CABG, especially in patients with a preserved LVEF [41–45]. GLS has some limitations in spite of the fact it has clinical utility. It can be influenced by the quality of the images, patient-related factors, and the necessity of special knowledge and devices. Moreover, GLS is not currently universal in any healthcare institutions, especially in resource-restricted ones [4648]. However, the increasing amount of evidence allows incorporating it into regular echocardiographic assessments of patients undergoing cardiac revascularization surgery [49,50]. Since GLS is growing to be a sensitive measure of myocardial activity, it is of significant clinical interest to assess its use in assessing patients undergoing CABG. Knowledge of GLS behavior postoperative and preoperative could improve perioperative outcome by understanding of left ventricular recovery, predictive accuracy of prognosis, and optimal care provision. The limitations of the study included: 1) to evaluate left ventricular performance at four eight weeks of Global Longitudinal Strain pre-cardiac surgery (CABG) and pre-surgery; 2) to determine the correlation between Global Longitudinal Strain and traditional echocardiographic parameters in patients with coronary artery disease.

MATERIALS AND METHODS

The aim of the cohort study was to determine the correlation between Global Longitudinal Strain (GLS) and left ventricular (LV) functioning in patients who have undergone coronary artery bypass grafting (CABG). The research was conducted at college of medicine at university of baghdad in association with Iraqi center of heart diseases/medical city. The data collection was performed during six months, starting on 1 st September 2022, and ending on 1 st March 2023.

The population sample used was 35 consecutive patients who were scheduled to undergo an elective CABG procedure. The entrants were qualified patients who were referred to CABG based on the following conditions; heart failure, left three-vessel coronary artery disease, left main coronary artery disease, acute coronary syndrome, and diabetes mellitus. The criterion for exclusion was that the patients must be less than 18 years of age, left ventricular ejection fraction (LVEF) of below 40 percent, severe or moderate valvular heart disease (dysfunction of the mitral or aortic valves), clinical instability, and chronic diseases (renal and liver failure). Other exclusion criteria were emergency/ rescue CABG, previous cardiac surgery, patient refusal, or missing data. Echocardiographic analysis was undertaken at two points, preoperative as the surgical preparations and postoperative at three months median after CABG. Two-dimensional transthoracic echocardiography was performed on all the examinations through a GE Vivid E9 system at left lateral decubitus position.

They were measured with 2D-STE at 6080 frames per second using standard apical views, which were the apical long-axis, four-chamber, two-chamber and three-chamber views. GLS analysis was performed with the help of EchoPac software (GE Healthcare). The area of interest was hand-manually adjusted in order to capture the entire myocardial thickness and the left ventricle was subdivided into 17 standardized sections. GLS was computed automatically as an average of peak systolic longitudinal strain of the three apical views.

The convenience sampling method was used, which was not randomized. A structured questionnaire based on a 2019 study that assessed strain imaging and echocardiographic outcomes in predicting long-term and early outcomes post-cardiac surgery involving revascularization was employed as a method of data collection.

The Statistical Package of Social Sciences (SPSS) Version 26 was used to carry out statistical analysis. Data were represented in form of frequencies, percentages, means, standard deviations and ranges. Paired sample t-tests, correlation test and the absolute agreement test were used accordingly. The statistical significance was set at 0.05 or lower.

The verbal explanation of the study objectives and verbal consent of all participants were the parts of ethical approval. Since the study was non-interventional and observational, there was no need to have written informed consent. All the data collected were maintained in secrecy and utilized in doing research.

RESULTS

In this study there are 35 patients who visit the echocardiography department during the study period, 24 (68.6%) of the patients were males while the rest 11 (31.4%) were females, their age range between 54-77 years old with a mean age of 63.88 years old and standard deviation 6.64 years. More than half of the patients 19 (54.3%) were hypertensive while diabetes was mentioned among 12 of them (34.4%), 17 (48.6%) of them were smokers (Table 1).

Table 1 Demographic characteristics of patients (N=35)

Demographic characteristics		**Number (N = 35)**	**%**
Age (Years)	Mean ± SD	63.88± 6.64	
Sex	Male	24	68.6
	Female	11	31.4
Co-morbidities	Hypertension	19	54.3
	Diabetes Mellitus	12	34.3
	Smoking	17	48.6

Figure 1 show that patient was partitioned based on Left Ventricular Ejection Fraction (LVEF) percentages, a pivotal metric in evaluating the systolic functionality of the heart's left ventricle. Specifically, 22 patients, constituting approximately 62.86% of the patients, demonstrated an LVEF below 50%, typically indicative of diminished cardiac pumping efficacy, potentially signaling systolic heart failure or other cardiac maladies. These individuals may necessitate a comprehensive cardiac assessment and a tailored management plan to navigate their compromised cardiac functionality and avert associated risks. On the other hand, 13 patients, which represent around 37.14% of the patients, exhibited an LVEF of 50% or above, generally regarded as within a normal or near-normal range, suggesting satisfactory left ventricular pumping capability. It is imperative to note that while these broad LVEF categorizations provide an initial glimpse into cardiac functionality, a nuanced, comprehensive clinical evaluation is indispensable in devising precise, individualized patient management strategies. A thorough interpretation, considering the wider context of each patient’s overarching clinical scenario and history, is vital to assure optimal, personalized patient care and management, irrespective of their categorization, as shown in figure 1.

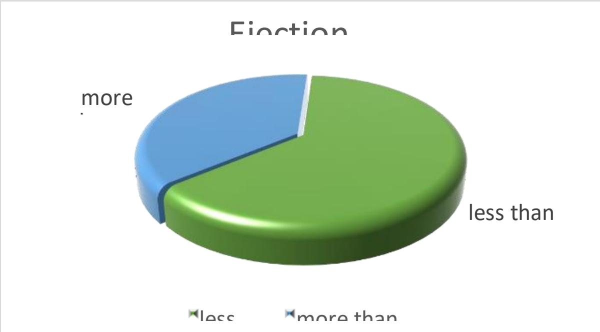

Figure 1 The distribution of the patients according to the LVEF.

Figure 2 show that the distribution of the GLS results among patients before and after CABG and according to it, there was improvement in the GLS among 23 (66.0%) of the patients after CABG while the rest 12 (34.0%) had the same or no improvement in their GLS reading after CABG as shown in figure 2 and 3 respectively.

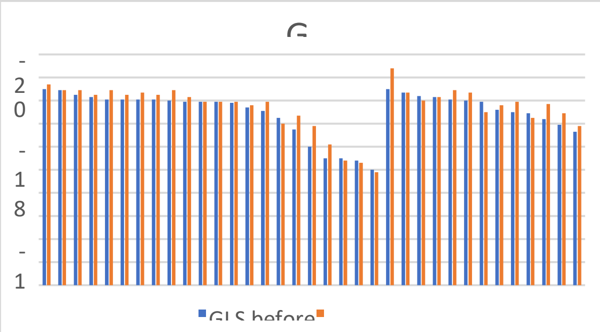

Figure 2 GLS echo for patients before and after CABG.

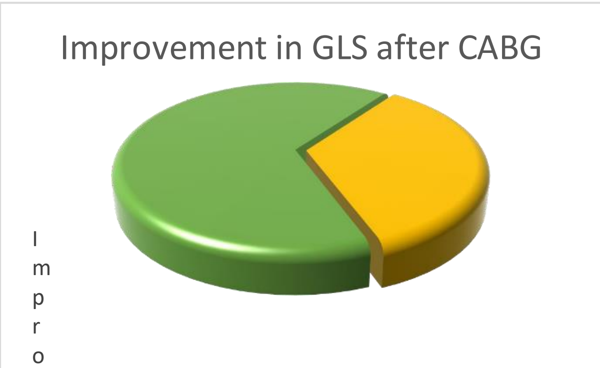

Figure 3 the distribution of the patients according to their GLS reading after CABG.

Table 2 reveals that there was juxtaposition between Left Ventricular Ejection Fraction (LVEF) and Global Longitudinal Strain (GLS) both pre and post-Coronary Artery Bypass Grafting (CABG), bifurcated further into subgroups manifesting improvement and no improvement in GLS post- operatively. In the patients group demonstrating an improvement in GLS (n=23), intriguingly, patients with a preoperative LVEF ≥ 50% exhibited a statistically significant diminution in LVEF post-CABG (p=0.049), whilst those with an LVEF < 50% preoperatively demonstrated a statistically significant enhancement in LVEF post-CABG (p=0.001). Conversely, in the subgroup that did not manifest an improvement in GLS (n=12), alterations in LVEF post-CABG did not attain statistical significance, irrespective of whether the preoperative LVEF was ≥ 50% (p=0.873) or < 50% (p=0.071). This dichotomy in LVEF trajectories amidst the backdrop of GLS alterations post-CABG elucidates a potentially intricate interplay between myocardial deformational mechanics and ventricular ejection efficiencies. The nuanced variations underscore the imperative for a thorough, individualized analytical approach in discerning the multifaceted cardiac adaptations post-CABG. As shown in table 2.

Table 2 Comparative Analysis of Left Ventricular Ejection Fraction Pre- and Post-Coronary Artery Bypass Grafting in Relation to Global Longitudinal Strain Improvements.

Ejection	Improved GLS		No improvement of GLS

fraction	**n=23**			**n=12**		
LV dysfunction	**Pre CABG**	**Post CABG**	**P Value**	**Pre CABG**	**Post CABG**	**P Value**
≥ 50 %	53.5±1.81	51.1±2.14	**0.049**	51.2±0.5	51.5±2.8	0.873
< 50 %	46.7±3.80	50.3±4.66	**0.001**	43.4±5.7	46.8±9.6	0.071

Table 3 show that there were significant statistical differences in the Echo parameters before and after CABG among patients whatever the indication for CABG was, GLS found to be improved after CABG compared to the measurement before CABG and it was significantly different as p value was 0.0001 as shown in table 3.

Also, left ventricular ejection fraction was significantly increased after CABG and the p value was significant (p=0.003).

Left ventricular internal diameter end diastole (LVIDd), Left ventricular internal diameter end systolic (LVIDs), E', E/E' and TAPSE was significantly change after CABG as p value was less than 0.05 as shown in table 3.

While for the left ventricular mass there was no significant differences before and after as p value was 0.068 (Table 3).

Table 3 the association of the differences in the ECHO parameters readings before and after CABG among patients.

Echo parameters	**Pre CABG N=35**	**Post CABG N=35**	**P value**
GLS	-15.53±1.05	-16.13±0.92	**0.0001**
LVEF	49.15±3.57	51.6±2.73	**0.003**
LVIDd, cm	5.105±0.285	5.020±0.206	**0.009**
LVIDs, cm	3.962±0.180	3.912±0.189	**0.014**
LV mass	270.05±14.63	264.42±24.68	0.068
E' (cm/s)	11.051±1.87	11.320±1.61	**0.001**
E/E' ratio	7.97±0.851	9.20±0.812	**0.0001**
TAPSE (mm)	21.92±2.043	18.91±1.884	**0.0001**

For the correlation of the GLS readings with the left ventricular ejection fraction we note that before CABG there was a negative relation meaning that whenever the ejection fraction increase there was decrease in the GLS reading however this correlation was insignificant as p value was 0.480 as shown in figure 4.

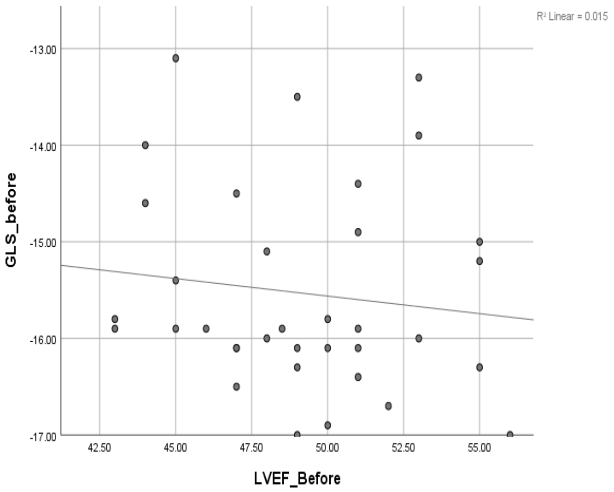

Figure 4 the correlation between GLS readings with the left ventricular ejection fraction among patients before CABG.

While more accurate negative correlation found between GLS readings and the left ventricular ejection fraction after CABG as Pearson Correlation was -0.533 with significant p value (P=0.001) as shown in figure 5.

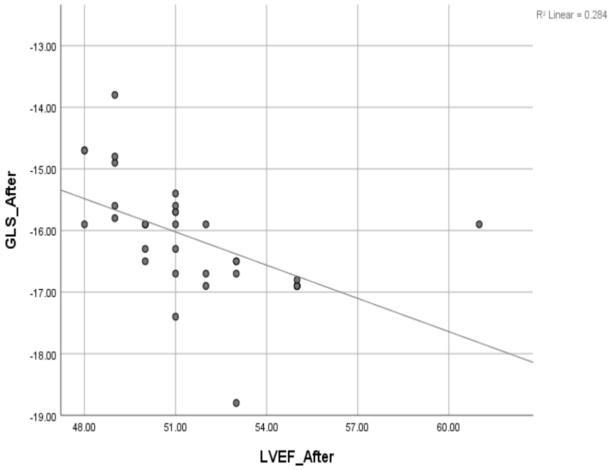

Figure 5 the correlation between GLS readings with the left ventricular ejection fraction among patients after CABG.

DISCUSSION

In this paper, the authors compared the demographic data, the clinical data and the echocardiographic outcomes of 35 patients who underwent coronary artery bypass grafting (CABG), namely, Global Longitudinal Strain (GLS) and its association with the activity of the left ventricle (LV) work. The demographic information also showed that the study population was predominantly male with the sample population of 68.6 per cent and female population of 31.4 per cent. This male bias is consistent with the already existing literature, i.e., Gozdzik et al. (2019) and Xu et al. (2020) studies, which identified a greater occurrence of CABG or PCI in men compared to women [38,51]. These findings are likely to suggest sex specific variations in prevalence of coronary artery disease, referral pattern and treatment options. The average age of the research participants ranged between 54 and 77 years and this implies that the participants were primarily middle-aged and elderly people. Age is a predetermined phenomenon in the results of the postoperative CABG. Though the left ventricular systolic function may not deteriorate considerably over the aging process, the diastolic malfunction and the chances of death are increased as shown by Bello et al. (2020) [52]. The population of the study was comorbid. The prevalence of hypertension was established to be 54.3 percent of the patients which justifies its established importance as a major risk factor of coronary artery disease and LV dysfunction. It has also been closely coupled with impaired relaxation of LV and diastolic dysfunction which can have negative effects on the cardiac performance [53,54]. The incidence of diabetes mellitus was identified to be 34.3 percent which is comparable with the rates of CABG patients. Wang et al. [55] found that diabetes negatively influences the myocardial structure and myocardial functionalities and it is also associated with excessive postoperative morbidity and mortality following CABG. Relative to the current study, Gozdzik et al. contained more prevalence of hypertension and diabetes, which demonstrates the high prevalence of these comorbid conditions in cardiac surgery cohorts [38]. Another risk cardiovascular factor that is essential is smoking among the patients which was reported in 34.3 percent. It has also been related to poor myocardial remodelling, increased LV mass index, reduced myocardial strain, and increased neurohormonal activation that has the possibility of damaging LV functioning and causing heart failure [56,57]. Further, the history of prior percutaneous coronary intervention (PCI) 14.3 percent which points to progressive or recurrent coronary artery disease was present. Although PCI can improve the myocardial perfusion and LV performance of the targeted patients, it cannot decrease the risk of the heart condition in the long term particularly in the patients with large coronary disease [58,59]. The analysis of the baseline LV systolic function revealed that 63.0% of the patients had low left ventricular ejection fraction (LVEF <50%), and 37.0% had normal left ventricular ejection fraction (LVEF 50% and above). This pattern is comparable to those of Fallahzadeh et al. (2021) who observed that approximately two-thirds of the CABG patients were impaired with LVEF prior to surgery [60]. Another high-risk group that may receive an appreciable functional benefit by undergoing surgery revascularization is patients with low LVEF. GLS analysis indicated that 66.0 percent of the patients had improved following CABG and the 34.0 percent had not improved or their GLS did not change post procurement. The preoperative GLS had a range of -17 to -10.8 and mean of -14.61 indicating that there was significant percentage of myocardial deformation in the patients. GLS postoperative values were -18.8 to -9.8 and average value was -15.84 that reflected a common positive variation of longitudinal myocardial functioning. However, GLS change was heterogeneous amongst individuals which does mean that myocardial recovery after revascularization was heterogeneous. This difference can be attributed to such factors as baseline myocardial viability, the degree of coronary disease, and comorbidities. The studies of the past confirm the prognostic significance of GLS improvement. GLS was demonstrated both independent predictors of post-CABG mortality and major adverse cardiovascular events and as an extra risk factor to EuroSCORE-II (Olsen et al., 2021) [42]. In contrast, according to Otterstad et al. (2021), a lack of GLS at three months following CABG did not solely predict bad events, which revealed that GLS repeated measurements were not useful under certain clinical conditions [61]. GLS response showed varied trends in paired comparison of LVEF pre- and post-CABG. Significant changes in LVEF in patients that had a better GLS were statistically significant regardless of the baseline LVEF category. Small but significant EF decrease was observed in patients who had preserved LVEF but large changes in EF were observed in patients who had lower LVEF, indicating that there was an increase in systolic performance after revascularization. These are compatible with other reports that have revealed that there is high amount of EF recovery following CABG in patients with ischemic cardiomyopathy [62,63]. Nevertheless, this was found to be the contrary case in patients that failed to enhance GLS owing to the absence of statistically significant changes in LVEF following the CABG irrespective of pre treatment LVEF. It means that the loss of GLS recovery may also be a sign of no myocardial recovery after revascularization, either due to irreversible damage to the myocardium or due to ineffectiveness of ventricular remodelling.

The usefulness of CABG was also proved by other echocardiographic measurements. The significant reductions in left ventricular internal diastolic (LVIDd) and systolic (LVIDs) sizes were the indicators of the inhibition of the negative ventricular remodelling and the improvement of the LV functioning. These findings are in line with the findings that smaller LV size after CABG is a good outcome, although the big LV size but with low LVEF is also a sign of bad omen [64]. There were also significant changes in the parameters of the diastolic functioning. The more the E + velocity, the higher the relaxation of the myocardium and changes in the E/E + ratio were witnessed in the response to changes in LV filling pressures and hemodynamics. These results are consistent with the articles that were released in the research by Gozdzik et al. that focus on the impact of CABG on systolic and diastolic myocardial performance [38]. The correlations revealed that a negative relationship exists between GLS and LVEF before and after CABG. Though the preoperative correlation was not significant, the postoperative correlation was medium and significant which indicates that there was a higher correlation between development of myocardial deformation and the rise in systolic performance following the process of revascularization. This observation points out the sensitivity of GLS as a measure of myocardial recovery and its complimentary value along with LVEF to cardiac functions. Nevertheless, basing on its strengths, the research has a number of weaknesses, including a relatively limited sample size and a lack of correction of potential confounding factors, including medication use and myocardial viability. Nevertheless, the findings indicate valuable evidence on the significance of GLS as a delicate and a clinically significant measure to determine LV functioning and recovery during the post CABG.

CONCLUSION

In this study discovered that, there were significant increases in left ventricular ejection fraction with improved of Global Longitudinal Strain (GLS) after cardiac revascularization surgery. Echocardiographic parameters like GLS were found to be significantly changed post-operative.

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