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" *Assessment of Glycated Albumin in Patients with Acute Coronary Syndrome and Its Correlation with Short-Term Outcomes* "

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ABSTRACT:

Background: Acute coronary syndrome constitutes a major global health burden, significantly contributing to morbidity and mortality. While glycated albumin (GA) has emerged as a promising indicator of glycemic control, its prognostic value in patients experiencing ACS remains unclear.

Aim of the Study: This study aims to investigate the association between glycated albumin levels and short-term complications in patients with acute coronary syndrome, considering clinical, biochemical, and echocardiographic characteristics.

Materials and Methods: The study included 100 patients admitted to the Damietta Cardiology Gastroenterology Center with acute coronary syndrome from January 2022 to June 2023. Patients were divided into two groups: those with complications and those without. Data were collected on clinical, biochemical, and echocardiographic factors, including glycated albumin levels, ejection fraction, SYNTAX score, and complications. The predictive value of glycated albumin was analyzed using receiver operating characteristic curve analysis.

Results: Elevated glycated albumin levels were significantly associated with complications especially cardiogenic shock. A glycated albumin level of 13.7% was identified as a cutoff for predicting worse clinical outcomes. Multivariate analysis revealed hypertension and lower ejection fraction as independent risk factors for complications. However, glycated albumin was not a significant predictor after adjusting for other variables.

Conclusion: Glycated albumin is a promising biomarker for predicting complications in acute coronary syndrome patients. Although it was associated with short-term complications in univariate analysis, hypertension and lower ejection fraction were the primary independent risk factors for complications, suggesting that glycated albumin may not provide additional predictive value when adjusting for other clinical factors.

Key Words: Acute coronary syndrome, Complications, Glycated albumin, Risk stratification

Background:

Coronary artery disease (CAD) continues to be a major global contributor to morbidity and mortality, arising from an imbalance between the heart muscle's oxygen supply and demand due to obstructions in the coronary arteries, frequently caused by atherosclerotic plaque buildup **(Zhao et al., 2019)**. Acute coronary syndrome (ACS) is a sudden and critical presentation of cardiovascular disease, carrying a significant risk of mortality and leading to severe complications, including cardiac arrest and cardiogenic shock **(Rawshani et al., 2018).**

Coronary artery disease arises due to a combination of modifiable factors, such as smoking, abnormal lipid levels, and obesity, alongside non-modifiable factors like age, gender, and genetic predisposition. **(Mirza et al., 2018)**. Among these, diabetes mellitus (DM) stands out as a significant contributor, markedly increasing the likelihood of cardiovascular conditions, including CAD, heart failure, and myocardial infarction **(Ahmed et al., 2014).** Remarkably, individuals with diabetes but no prior history of cardiovascular disease have a comparable risk of cardiovascular events and mortality to those without diabetes but with established cardiovascular disease **(Martín-Timón et al., 2014).**

Hyperglycemia, a defining feature of diabetes mellitus, significantly heightens cardiovascular risk. Markers such as fasting blood glucose (FBG) and glycosylated hemoglobin (HbA1c) have traditionally been employed to assess glycemic control. Elevated FBG levels, particularly those ≥10 mmol/L, have been linked to increased short-term mortality in non-diabetic patients admitted with acute coronary syndromes (ACS) **(Gencer et al., 2020)**. However, the variability of FBG over time reduces its reliability for predicting long-term outcomes **(Kohzuma et al., 2021)**. Similarly, while HbA1c provides a robust measure of average blood glucose levels over a three-month period, its accuracy diminishes in patients with fluctuating glucose levels, chronic kidney or liver diseases, or hemoglobinopathies **(Kohzuma et al., 2021).**

Glycated albumin (GA) has recently gained attention as a promising biomarker for glycemic control, especially in situations where fasting blood glucose (FBG) and glycosylated hemoglobin (HbA1c) are less dependable. GA provides insight into blood glucose levels over a shorter period of 2–4 weeks, remains unaffected by red blood cell lifespan or dietary intake, and offers a quicker and more cost-efficient evaluation **(Shimizu et al., 2019; Zendjabil, 2020)**. Its enhanced glycation rate and multiple glycosylation sites contribute to its greater sensitivity compared to HbA1c **(Anguizola et al., 2013).** Notably, GA has been associated with coronary artery disease (CAD), ischemic stroke, heart failure, and cardiovascular mortality **(Selvin et al., 2015).** In addition, among patients ACS, GA has demonstrated superior predictive value over HbA1c for identifying the presence and severity of CAD, as well as for forecasting major adverse cardiovascular events (MACE), particularly in cases of non-ST elevation myocardial infarction (NSTEMI) managed with percutaneous coronary intervention **(Liu et al., 2022).**

The association between glycated albumin (GA) and coronary artery disease (CAD) is based on underlying pathophysiological processes, including the generation of Amadori products and advanced glycation end-products (AGEs). These substances play a role in promoting vascular inflammation, oxidative stress, and impaired endothelial function. **(Pu et al., 2007)**. Elevated GA levels in the bloodstream have been associated with the promotion of atherosclerotic plaque development and the activation of pro-inflammatory mediators, further accelerating the process of atherogenesis **(Hattori et al., 2002)**. Due to its distinct advantages, GA shows promise as a key biomarker for assessing short-term glycemic control and predicting adverse outcomes in patients with acute coronary syndromes (ACS) **(Zhang et al., 2022).**

This study seeks to investigate serum glycated albumin levels in ACS patients and explore their correlation with in-hospital complications, such as new-onset heart failure, reinfarction, life-threatening arrhythmias, and in-hospital mortality. By analyzing the predictive capacity of GA in ACS cases, the research aims to clarify its role as a superior biomarker for short-term glycemic management and adverse cardiovascular outcomes.

Patients and methods:

This cross-sectional analytical study was carried out at the Damietta Cardiology-Gastroenterology Center, targeting patients admitted with acute coronary syndrome (ACS), which included ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTE-MI), and unstable angina. Patients were excluded if they had a previous history of cardiac arrest, diagnosed malignancy, liver disease, a glomerular filtration rate below 30 ml/min/1.73m² **(Delanaye et al., 2017)**, or a body mass index (BMI) under 18.5 kg/m². A total of 132 patients were initially assessed, and after applying the exclusion criteria, 100 patients were included in the final analysis.

Participants were selected using a convenient sampling technique. The sample size was determined based on an anticipated prevalence of 36.4% for the outcome variable (highest quartile of infarct volume), a 95% confidence level ($Z\alpha/2 = 1.96$), and a margin of error of 10%. Using the formula by Dawson & Trapp (2004) and accounting for a 20% dropout rate, the required sample size was determined to be 99 patients.

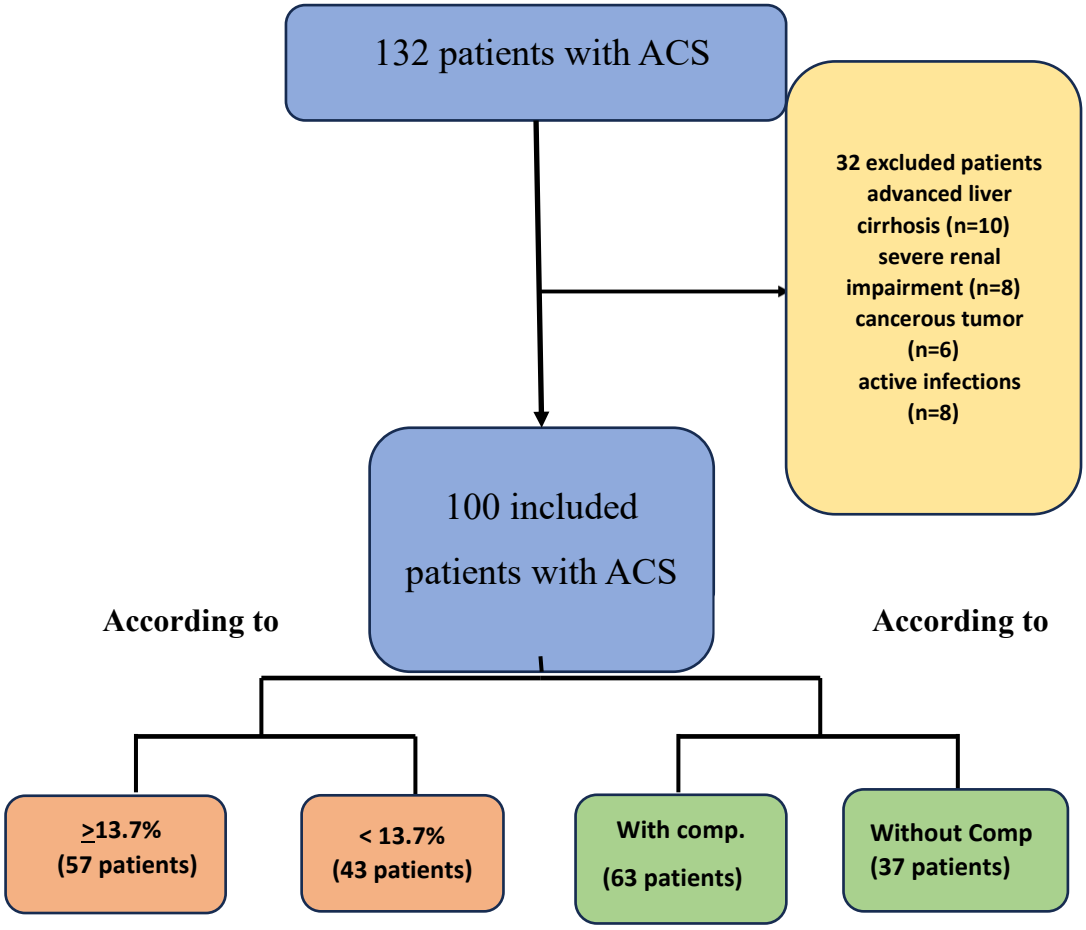

Figure (1) Diagram of included patients.

Data collection involved a thorough clinical evaluation during the hospital stay. A detailed medical history was recorded, including demographic information such as age and gender, along with risk factors like diabetes, hypertension, and smoking. Hypertension was identified by a systolic blood pressure equal to or greater than 140 mmHg, a diastolic blood pressure of 90 mmHg or more, or a prior history of using antihypertensive medications **(Ramzy, 2019; Žaliaduonytė-Pekšienė et al., 2017).** Diabetes mellitus (DM) was diagnosed using criteria such as fasting plasma glucose levels of at least 126 mg/dL, random plasma glucose levels of 200 mg/dL or higher, or the use of antidiabetic therapy **(Cai et al., 2020).** Dyslipidemia was characterized by HDL cholesterol levels below 40 mg/dL in men and below 50 mg/dL in women, or LDL cholesterol levels exceeding 100 mg/dL **(Yuan et al., 2021).** Chest pain was categorized as acute coronary syndrome if it persisted for more than 20 minutes and was accompanied by other symptoms like nausea, vomiting, shortness of breath, or excessive sweating **(AHA, 2022; BostonScientific).**

The clinical examination included measurements of heart rate, blood pressure, and BMI, calculated as weight (kg) divided by height squared (m^2) **(Weir & Jan, 2019).** Cardiac examination focused on signs of heart failure, such as orthopnea, paroxysmal nocturnal dyspnea (PND), and reduced exercise tolerance, as well as cardiac auscultation for murmurs or gallop rhythm. Laboratory investigations included measurements of serum creatinine, troponin, lipid profile, glycated albumin (GA), complete blood count (CBC), and C-reactive protein (CRP). Normal reference ranges were followed for all laboratory parameters, as per published standards.

Electrocardiograms (ECG) were recorded at admission, after revascularization therapy, daily during the hospital stay, and whenever chest pain occurred. ECG abnormalities indicative of ACS included ST-segment elevation, Q waves, or new-onset left bundle branch block. Transthoracic echocardiography was performed using a VINO machine to measure left ventricular parameters, including wall thickness, chamber dimensions, and ejection fraction, following the guidelines of the American Society of Echocardiography (ASE).

Coronary angiography was performed to assess the affected vessels, including left main (LM) lesions, total occlusions, bifurcations, and lesion types. The SYNTAX score, calculated using the web-based score calculator, was used to quantify the complexity of coronary artery disease **(BostonScientific).** Patients were categorized into low or intermediate (<22) and high (>22) SYNTAX score groups **(Safarian et al., 2014).**

Ethical approval was obtained before initiating the study. Informed consent was secured from all participants, ensuring their voluntary participation. Patients were assured of the confidentiality of their data and informed of their right to withdraw from the study at any point without compromising their care. Additionally, any unexpected findings during the procedures were communicated to the patients and managed appropriately.

Statistical analysis was performed to analyze the collected data with the help of IBM SPSS software package version 20.0. (New York: IBM Corp., 1970). Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Appropriate statistical tests were applied to determine the significance of associations, with a p-value of <0.05 considered statistically significant.

Results:

The demographic characteristics of the study population revealed that the majority of patients were male (78%), with a mean age of 56.89 ± 10.46 years. Hypertension was the most common risk factor, affecting 70% of patients, followed by smoking (60%) and diabetes mellitus (48%), while 24% had a positive family history of cardiovascular disease. The mean systolic and diastolic blood pressures were 135.10 ± 32.30 mmHg and 83.30 ± 18.43 mmHg, respectively, with a mean heart rate of 84.10 ± 21.32 beats per minute. Clinically,

non-ST-elevation myocardial infarction (NSTEMI) was the predominant presentation, occurring in 60% of cases, while 40% presented with ST-elevation myocardial infarction (STEMI).

Laboratory findings showed a mean glycated albumin level of 14.12 ± 4.98 and normal serum albumin levels of 3.81 ± 0.47 g/dl. Inflammatory markers were elevated, with a mean CRP level of 16.91 ± 8.0. Renal function was within acceptable limits, with a mean serum creatinine level of 1.24 ± 0.41 mg/dl. The lipid profile revealed elevated total cholesterol (mean 257.0 ± 36.14 mg/dl) and triglyceride levels (mean 187.8 ± 35.29 mg/dl). Hematological parameters included a mean hemoglobin level of 11.72 ± 1.66 g/dl, platelet count of 280.7 ± 109.7 ($x10^3/mm^3$), and white blood cell count of 10.44 ± 4.12 ($x10^3/mm^3$). Cardiac injury markers demonstrated elevated Troponin T (mean 3.49 ± 5.74 ng/ml) and CK-MB (mean 94.40 ± 59.99 ng/ml).

Echocardiographic and angiographic assessments showed a mean ejection fraction (EF) of 52.66% ± 9.74, with half of the patients (50%) having an EF ≤50%. The mean Syntax score was 14.96 ± 9.36, with 77.9% of cases scoring ≤22 and 22.1% scoring >22. During clinical follow-up, complications were observed in 63% of patients. Lethal arrhythmias occurred in 20% of cases, heart failure in 26%, cardiogenic shock in 13%, and complete heart block in 4%. The remaining 37% of patients experienced no complications.

The results of this study revealed several key differences between patients with complications (Group B) and those without complications (Group A). The age of patients in Group B was significantly higher (58.56 ± 10.75 years) compared to Group A (54.05 ± 9.40 years; $p = 0.037$). The prevalence of hypertension and diabetes mellitus was also notably higher in Group B, with 88.9% and 66.7% of patients in Group B having these conditions, respectively, compared to 18.9% and 16.2% in Group A ($p < 0.001$ for both). Blood pressure readings were significantly lower in Group B, with systolic and diastolic blood pressure averaging 128.1 ± 36.18 mmHg and 78.41 ± 20.42 mmHg, respectively, compared to 147.0 ± 19.56 mmHg and 91.62 ± 10.14 mmHg in Group A ($p = 0.001$ and <0.001, respectively). A higher proportion of patients in Group B experienced STEMI (50.8%), compared to 21.6% in Group A ($p = 0.004$). However, no significant differences were found between the groups in terms of gender, smoking status, family history, or heart rate.

Laboratory findings showed that Group B had significantly higher levels of C-reactive protein (18.18 ± 8.78 mg/L) compared to Group A (14.76 ± 5.97 mg/L; $p = 0.045$). Similarly, creatine kinase-MB levels were elevated in Group B (104.8 ± 64.27 ng/ml) compared to Group A (76.74 ± 47.66 ng/ml; $p = 0.032$). Glycated albumin levels were also significantly higher in Group B (15.29 ± 4.57%) compared to Group A (12.13 ± 5.09%; $p = 0.007$), indicating poorer glucose control among patients with complications. Triglyceride levels were significantly elevated in Group B (193.8 ± 34.38 mg/dl) compared to Group A (177.6 ± 34.91 mg/dl; $p = 0.004$). No significant differences were observed between the groups for other laboratory parameters,

including hemoglobin, platelet count, white blood cell count, serum creatinine, serum albumin, troponin T, HbA1c, and total cholesterol.

Among patients who experienced cardiogenic shock, glycated albumin levels were significantly higher (median: 17.23) compared to those without this complication ($p = 0.037$). However, no significant differences in glycated albumin levels were observed in patients with other complications such as fatal arrhythmias, complete heart block, or heart failure ($p = 0.326$, $p = 0.253$, and $p = 0.966$, respectively).

Cardiac function was also significantly impaired in Group B, with a lower ejection fraction of 49.63 ± 9.68% compared to 57.81 ± 7.48% in Group A ($p < 0.001$). A higher proportion of patients in Group B had an ejection fraction ≤50% (65.1%) compared to Group A (24.3%; $p < 0.001$). The Syntax score did not show any significant differences between the two groups, with similar distributions of scores ≤22 and >22 ($p = 0.933$).

The ability of glycated albumin to predict complications was evaluated using receiver operating characteristic (ROC) analysis. The area under the ROC curve (AUC) was calculated to be 0.662 ($p = 0.007$), reflecting a moderate level of diagnostic accuracy. A glycated albumin threshold of greater than 13.77% was determined as the optimal cut-off, demonstrating a sensitivity of 65.0% and a specificity of 62.16%. The positive predictive value was 48.1%, whereas the negative predictive value was 76.7%. These results indicate that glycated albumin has moderate diagnostic utility, with its higher negative predictive value suggesting it could serve as an effective biomarker for excluding short-term complications in patients presenting with acute coronary syndrome (Table 2, Figure 2).

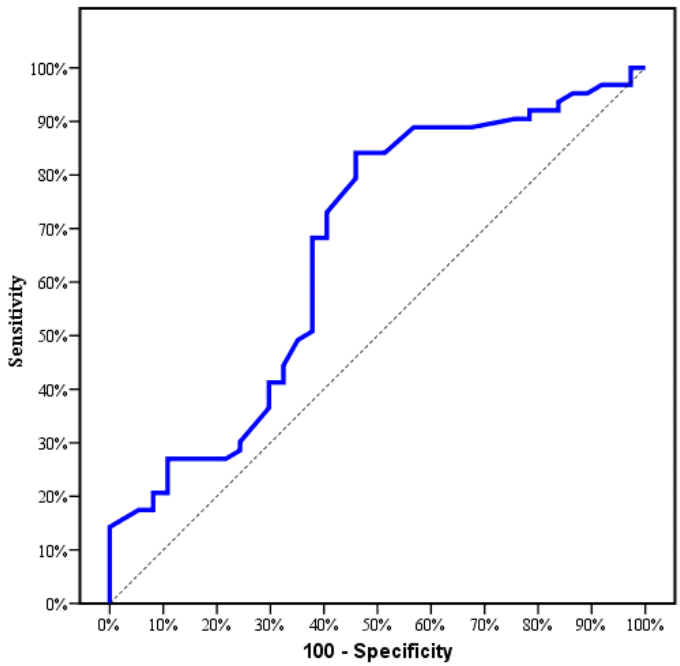

Figure (2): ROC curve for Glycated Albumin to discriminate complication (n = 63) from non-complication (n = 37)

Patients were categorized into two groups based on glycated albumin levels: Group I (≤13.77%) and Group II (>13.77%). Group II had a significantly higher prevalence of hypertension (73.7%) and diabetes mellitus (66.7%) compared to Group I (48.8% and 23.3%, respectively). Group II also had a higher proportion of STEMI cases (54.4% vs. 20.9%). No significant differences were observed between the groups for smoking status, family history, or heart rate. Laboratory analysis revealed significantly higher levels of C-reactive protein (CRP), Troponin T, CK-MB, HBA1C, and triglycerides in Group II. However, there were no significant differences in hemoglobin, platelet count, white blood cell count, serum creatinine, ALT, serum albumin, or total cholesterol levels.

Echocardiography findings showed that Group II had significantly lower ejection fractions (49.82% vs. 56.42%), with a higher percentage of patients having an ejection fraction ≤50% (63.2% vs. 32.6%). The Syntax score was also significantly higher in Group II (17.72 vs. 11.24), with a greater proportion of patients exhibiting a Syntax score >22 (33.3% vs. 6.9%).

In the univariate analysis, several factors, including hypertension, diabetes, systolic and diastolic blood pressure, CRP, CK-MB, glycated albumin, and triglycerides, were significantly associated with complications. Higher ejection fraction was protective against complications. In the multivariate analysis, hypertension remained a significant predictor of complications, while higher ejection fraction continued to show a protective effect. Other variables, such as CRP, CK-MB, glycated albumin, and triglycerides, did not retain significance in the multivariate model (Table 4).

The incidence of complications was significantly higher in Group II (75.4% vs. 46.5%), although no significant differences were found for specific complications such as fatal arrhythmias, complete heart block, heart failure, or cardiogenic shock (Table 3). A significant positive correlation was found between glycated albumin levels and overall complications. Cardiogenic shock showed a significant association with glycated albumin levels (Tables 5).

Table (1): Relation between Complications and different parameters (n = 100)

	Complications		Test of Sig	P
	No (n = 37)	Yes (n = 63)		
Sex (Male)	28 (75.7%)	50 (79.4%)	χ^2= 0.185	0.667
Age	54.05 ± 9.40	58.56 ± 10.75	t=2.115*	0.037*
HTN	7 (18.9%)	56 (88.9%)	χ^2=48.958*	<0.001*
Duration (years)	10.27 ± 4.50	9.31 ± 5.02	U=444.0	0.269
DM	6 (16.2%)	42 (66.7%)	χ^2=23.770*	<0.001*
Duration (years)	9.33 ± 3.56	7.62 ± 3.91	U=88.0	0.249
Smoking	22 (59.5%)	38 (60.3%)	χ^2=0.007	0.933
Family History	9 (24.3%)	15 (23.8%)	χ^2=0.003	0.954
Typical anginal pain	37 (100.0%)	60 (95.2%)	χ^2=1.816	FEp=0.294
Duration before admission (Hours) (n = 97)	4.95 ± 2.01	7.60 ± 6.52	U=976.50	0.305
Blood pressure (mmHg)				
Systolic	147.0 ± 19.56	128.1 ± 36.18	t=3.394*	0.001*
Diastolic	91.62 ± 10.14	78.41 ± 20.42	t=4.309	<0.001*
Heart Rate (beats/min)	84.86 ± 8.70	83.65 ± 26.11	U=1029.0	0.313
Diagnosis				
Non-STEMI	29 (78.4%)	31 (49.2%)	χ^2= 8.265*	0.004*
STEMI	8 (21.6%)	32 (50.8%)		
HGB (g/dl)	11.68 ± 1.50	11.75 ± 1.76	t=0.214	0.831
PLT (x10³/mm³)	269.7 ± 110.0	287.2 ± 109.8	U=1111.50	0.699
WBCs (x10³/mm³)	9.94 ± 3.21	10.73 ± 4.57	U=1110.50	0.694
Serum Creatinine (mg/dl)	1.21 ± 0.22	1.27 ± 0.49	U=1099.50	0.630
Serum albumin (g\dl)	3.85 ± 0.25	3.78 ± 0.56	U=1085.50	0.554
CRP level	14.76 ± 5.97	18.18 ± 8.78	U=888.500*	0.045*
Troponin T	3.14 ± 6.19	3.70 ± 5.50	U=909.000	0.066
CK-MB (ng/ml)	76.74 ± 47.66	104.8 ± 64.27	U=867.000*	0.032*
Glycated Albumin	12.13 ± 5.09	15.29 ± 4.57	U=787.0	0.007*
HBA1C %	7.27 ± 2.07	7.08 ± 1.85	U=1118.0	0.729
Total cholesterol (mg/dl)	255.0 ± 38.22	258.1 ± 35.12	U=1051.50	0.401
Triglyceride (mg/dl)	177.6 ± 34.91	193.8 ± 34.38	U=773.000*	0.004*
EF % (Biplane method)	57.81 ± 7.48	49.63 ± 9.68	U=582.500*	<0.001*
≤35	0 (0.0%)	1 (1.6%)		
35 – 55	15 (40.5%)	44 (69.8%)	χ^2=9.332*	MCp=0.004*
>55	22 (59.5%)	18 (28.6%)		
Syntax score	14.71 ± 7.85	15.09 ± 10.17	U=521.500	0.933
≤22	21 (87.5%)	32(72.7%)		
23 – 32	2 (8.3%)	9 (20.5%)	χ^2=1.878	MCp=0.503
≥33	1 (4.2%)	3 (6.8%)		

MC: Monte Carlo, **FEp**: Fisher's Exact Probability, **χ2**: Chi-Square Test, **SD**: Standard Deviation, **t**: Student's t-Test, **U**: Mann-Whitney U Test, **p**: p-value (Probability Value) for Relation between complications and different parameters, *****: Statistically significant at p ≤ 0.05

Table (2): Diagnostic performance for Glycated Albumin to discriminate complication (n = 63) from non-complication (n = 37)

	AUC	p	95% C.I	Cut off#	Sensitivity	Specificity	PPV	NPV
Glycated Albumin	0.662	0.007*	0.547 – 0.777	>13.77	65.0	62.16	48.1	76.7

AUC: Area Under a Curve, **p** value: Probability value, **CI:** Confidence Intervals, **NPV:** Negative predictive value, **PPV:** Positive predictive value, *****: Statistically significant at p ≤ 0.05, #Cut off was choose according to Youden index

Table (3): Relation between Glycated Albumin and different parameters (n = 100)

	Glycated Albumin		Test of Sig	P
	≤13.77 (n = 43)	>13.77 (n = 57)		
Sex (Male)	31(72.1%)	47(82.5%)	χ^2= 1.534	0.216
Age	55.74 ± 10.57	57.75 ± 10.38	t=0.951	0.344
>60	15(34.9%)	24(42.1%)		
HTN	21(48.8%)	42(73.7%)	χ^2=6.492*	0.011*
Duration (years)	9.25 ± 4.85	9.80 ± 4.89	U=517.50	0.657
DM	10(23.3%)	38(66.7%)	χ^2=18.505*	<0.001*
Duration (years)	6.50 ± 3.17	8.18 ± 4.00	U=146.50	0.274
Smoking	27(62.8%)	33(57.9%)	χ^2=0.245	0.621
Family History	12(27.9%)	12(21.1%)	χ^2=0.631	0.427
Typical anginal pain	42(97.7%)	55(96.5%)	χ^2=0.118	FEp=1.000
Duration before admission (Hours)	4.88 ± 3.62	7.89 ± 6.18	U=765.50*	0.003*
Blood pressure (mmHg)				
Systolic	141.4 ± 28.50	130.4 ± 34.38	t=1.754	0.083
Diastolic	86.98 ± 14.73	80.53 ± 20.48	t=1.832	0.070
Heart Rate (beats/min)	87.09 ± 14.93	81.84 ± 24.99	U=1084.0	0.308
Diagnosis				
Non-STEMI	34(79.1%)	26(45.6%)	χ^2= 11.431*	0.001*
STEMI	9(20.9%)	31(54.4%)		
HGB (g/dl)	11.70 ± 1.44	11.75 ± 1.82	t=0.154	0.878
PLT (x10³/mm³)	266.8 ± 100.5	291.2 ± 115.9	U=1073.0	0.287
WBCs (x10³/mm³)	10.06 ± 3.54	10.72 ± 4.52	U=1151.50	0.605
Serum Creatinine (mg/dl)	1.19 ± 0.20	1.28 ± 0.52	U=1144.50	0.565
Serum albumin (g\dl)	3.78 ± 0.58	3.82 ± 0.37	U=1183.50	0.762
CRP level	15.08 ± 8.54	18.30 ± 7.35	U=828.50*	0.005*
Troponin T	2.05 ± 3.88	4.57 ± 6.65	U=607.0*	<0.001*
CK-MB (ng/ml)	69.90 ± 44.34	112.9 ± 63.86	U=736.50*	0.001*
HBA1C %	6.14 ± 1.60	7.91 ± 1.81	U=559.50*	<0.001*
Total cholesterol (mg/dl)	250.9 ± 35.91	261.5 ± 35.95	U=1012.0	0.125
Triglyceride (mg/dl)	180.0 ± 34.02	193.7 ± 35.39	U=932.0*	0.037*
EF % (Biplane method)	56.42 ± 8.10	49.82 ± 9.97	U=709.0*	<0.001*
≤50	14(32.6%)	36(63.2%)	χ^2=9.180*	0.002*
>50	29(67.4%)	21(36.8%)		
Syntax score	11.24 ± 7.27	17.72 ± 9.85	U=353.50*	0.008*
≤22	27(93.1%)	26(66.7%)	χ^2=6.761*	0.009*
>22	2(6.9%)	13(33.3%)		
Complication				
No	23(53.5%)	14(24.6%)	χ^2=8.798*	0.003*
Yes	20(46.5%)	43(75.4%)		
Arrythmias	7(16.3%)	13(22.8%)	χ^2=0.653	0.419
Complete Heart block	1(2.3%)	3(5.3%)	χ^2=0.551	FEp=0.632
heart failure	9(20.9%)	17(29.8%)	χ^2=1.008	0.315
Cardiogenic Shock	3(7.0%)	10(17.5%)	χ^2=2.420	0.120

SD: Standard Deviation, **t**: Student's t-Test, **U**: Mann-Whitney U Test, **χ^2**: Chi-Square Test, **FEp**: Fisher Exact Probability, **p**: p-value (Probability Value) for Relation between complications and different parameters, *****: Statistically significant at $p \leq 0.05$

Table (4): Univariate and multivariate Logistic regression analysis for the parameters affecting complication

	Univariate		#Multivariate	
	p	OR (LL – UL 95%C.I)	p	OR (LL – UL 95%C.I)
HTN	<0.001*	34.286(10.99 – 106.95)	<0.001*	99.741(10.618–936.909)
DM	<0.001*	10.333(3.730 – 28.630)	0.512	1.772 (0.321 – 9.785)
Duration before admission (Hours)	0.034*	1.141(1.010 – 1.289)	0.716	1.058 (0.782 – 1.430)
Systolic	0.006*	0.980(0.966 – 0.994)	0.561	1.025 (0.943 – 1.115)
Diastolic	0.001*	0.953(0.926 – 0.981)	0.154	0.904 (0.787 – 1.039)
Diagnosis	0.005*	3.742(1.483 – 9.442)	0.805	0.777 (0.104 – 5.785)
CRP level	0.043*	1.067(1.002 – 1.135)	0.534	0.966 (0.866 – 1.077)
CK-MB (ng/ml)	0.028*	1.009(1.001 – 1.017)	0.321	1.012 (0.989 – 1.036)
Glycated Albumin	0.003*	1.145(1.047 – 1.252)	0.513	1.070 (0.873 – 1.313)
Triglyceride (mg/dl)	0.031*	1.015(1.001 – 1.029)	0.146	1.014 (0.995 – 1.034)
EF % (Biplane method)	<0.001*	0.904(0.857 – 0.952)	0.045*	0.871 (0.762 – 0.997)

OR: Odds Ratio, **C.I**: Confidence Interval, **LL**: Lower Limit, **UL**: Upper Limit, χ^2: Chi-Square Test, **p**: p-value (Probability Value), *****: Statistically significant at $p \leq 0.05$

Table (5): Correlation between Glycated Albumin and complications.

Complications	*r*	*p-value*	*OR (95% CI)*
No			
Yes	0.187	0.043	1.4 (1.24–1.65)
Arrhythmias	0.006	0.951	0.77 (0.56–2.40)
Complete Heart Block	0.070	0.490	0.62 (−1.91–3.16)
Heart Failure	0.144	0.152	0.483 (−1.24–0.28)
Cardiogenic Shock	0.230	0.021	1.7 (1.16–1.55)

r: Correlation Coefficient, **p**: p-value (Probability Value), **OR**: Odds Ratio, **LL**: Lower Limit, **UL**: Upper Limit, **95% C.I.**: 95% Confidence Interval

Discussion:

This study investigated the clinical, biochemical, and echocardiographic characteristics of 100 patients admitted with acute coronary syndrome (ACS) at Damietta Cardiology Gastroenterology Center between January 2022 and June 2023. Sixty patients had STEMI, while 40 patients were diagnosed non-STEMI. The study participants were divided into two groups based on the presence or absence of complications, with 63 patients experiencing complications. Heart failure was the most common complication, followed by fatal arrhythmias and cardiogenic shock, while complete heart block occurred in only one patient (2.3%).

A significant relationship was observed between GA levels and the development of in-hospital complications in ACS patients, with an odds ratio (OR) of 1.4. Among different types of complications, only cardiogenic shock showed a significant association with higher GA levels (OR = 1.7). These findings align with **(Zhang et al., 2022)**, who reported that elevated GA levels were associated with adverse cardiac outcomes in ACS patients who underwent revascularization therapy, particularly those with pre-existing diabetes. In another study by **(Zhang et al., 2024)**, higher GA levels were linked to an increased risk of major adverse cardiovascular and cerebrovascular events (MACCEs), ischemia-driven revascularization, and all-cause mortality in ACS patients without standard modifiable cardiovascular risk factors (SMuRFs).

Additionally, **(Lin et al., 2022)** found a significant relationship between GA levels and the increased risk of in-stent restenosis in ACS patients undergoing percutaneous coronary intervention (PCI). In diabetic chronic kidney disease (CKD) patients, GA was suggested as a potential marker for predicting cardiovascular diseases and related complications, as noted by **(Vijayaraghavan et al., 2020). (Yang et al., 2015)** also supported the prognostic role of GA, demonstrating that elevated GA levels were associated with a higher risk of cardiac death, myocardial infarction, and stroke in diabetic patients with stable coronary artery disease (CAD) during follow-up after PCI.

In this study, receiver operating characteristic (ROC) curve analysis was performed to evaluate the predictive value of glycated albumin (GA) for various clinical outcomes in patients with acute coronary syndrome (ACS). The optimal GA cutoff value identified was 13.7%, which provided the best balance between sensitivity and specificity for predicting infarction severity, ejection fraction (EF), SYNTAX score, and complications. Based on this cutoff, patients were divided into two groups: those with GA ≤13.7% and those with GA >13.7%.

The study's findings are consistent with previous research. Liu et al. identified a GA cutoff of 14.4% in ACS patients, associating higher GA levels with increased incidence rates of MACCE, all-cause mortality, non-fatal myocardial infarction (MI), and ischemia-driven revascularization **(Liu et al., 2022). (Zhang et al., 2022)** also found that a GA level above 15.9% could significantly predict poor outcomes in ACS patients, with a sensitivity of 69% and specificity of 57%, correlating higher GA levels with an increased risk of MACCE.

(Mihara et al., 2020) revealed that individuals in the highest quartile of GA (≥ 15.7%) had a significantly higher risk of coronary artery disease (CAD) and stroke, independent of preexisting diabetes. **(Lu et al., 2016)** confirmed the prognostic value of GA, establishing a GA cutoff of 16.4% for predicting both in-hospital mortality and MACCE in ACS patients. **(Moustafa et al., 2024)** further demonstrated that GA had a remarkable predictive ability for in-hospital mortality in ACS patients, with an area under the curve (AUC) of 0.979, identifying a GA cutoff value of 89.250 pmol/ml with 100% sensitivity and 93% specificity.

Additionally, **(Norimatsu et al., 2015)** determined a GA cutoff of 17.9% for predicting CAD in diabetic patients. In line with these findings, the current study found that higher GA levels (>13.7%) were associated with lower EF, indicating a potential role for GA as a biomarker for cardiac dysfunction. Among patients who underwent coronary angiography, those with elevated GA levels also exhibited significantly higher Syntax scores, suggesting more severe coronary artery disease. These results underline the potential utility of GA as a biomarker for both cardiac dysfunction and the extent of coronary artery disease, offering valuable implications for prognostic assessment and risk stratification in ACS patients.

(Chen et al., 2024) found no significant differences in ejection fraction (EF) or heart failure (HF) type when comparing groups based on glycated albumin (GA) levels, although they did find a higher prevalence of coronary artery disease (CAD) in patients with GA levels >17%. In contrast, (Norimatsu et al., 2015) identified GA as a significant predictor of CAD in diabetic patients. In our study, while we found a significant difference in mean age between ACS patients with and without complications, no significant relationship was found between age and GA levels. **(Jousilahti et al., 1999)** also reported that advancing age increases the likelihood of coronary heart disease (CHD).

Diabetic patients are more prone to early-onset and accelerated CAD, often with less favorable outcomes **(Mihara et al., 2020; Moses et al., 2004).** Our study confirmed a significant association between complications, GA levels, and diabetes, with higher GA levels and complications found in diabetic patients. **(Zhang et al., 2022)** also found that the prognostic significance of GA was limited to diabetic patients, even after adjusting for traditional risk factors.

Hypertension (HTN), a significant contributor to cardiovascular diseases, was more prevalent in ACS patients with complications in our study ($p = 0.001$). Hypertensive patients also had higher GA levels. However, no significant relationship was found between GA levels and systolic or diastolic blood pressure. **(Liu et al., 2022)** similarly reported higher systolic and diastolic blood pressure in patients with higher GA levels.

Regarding smoking, although it is a risk factor for CAD complications, no significant relationship was found between smoking and ACS complications or GA levels in our study. This contrasts with **(Koga & Kasayama, 2010)**, who found lower GA levels among smokers, possibly due to inflammation-induced acceleration of albumin metabolism. This difference may be due to our small sample size and the lower smoking rates among females, suggesting further investigation is needed.

In this study, laboratory tests were conducted to identify factors associated with short-term complications in acute coronary syndrome (ACS). The findings revealed that CRP levels were significantly higher in ACS cases with complications, and a strong association between CRP and glycated albumin (GA) levels was observed. This suggests that higher GA levels correlate with increased inflammation, potentially due to

atherosclerosis, which contributes to coronary heart disease (CHD). These findings are consistent with **(Shrivastava et al., 2015)**, who highlighted inflammation's role in plaque destabilization and cardiovascular events, and with **(Soomro et al., 2022),** who identified CRP as an independent biomarker for coronary artery disease (CAD) in diabetic patients. **(Ghafoor et al., 2015)** also found a correlation between GA, CRP, and the degree of coronary artery narrowing, further supporting the study's results.

While HbA1c did not predict complications in this study, it was found that patients with GA levels >13.7% had significantly higher HbA1c levels. The study suggested that GA is a better marker of glucose fluctuation, providing a more accurate reflection of short-term blood glucose variations compared to HbA1c. This aligns with the work of **(Zhang et al., 2022)** and **(Hashimoto et al., 2015)**, who also advocated for GA as a superior marker for monitoring diabetes and predicting complications like ACS. Additionally, **(Yazdanpanah et al., 2017)** proposed GA as a better predictor of diabetes complications, particularly cardiovascular disease. **(Chen et al., 2024)** found that combining GA and HbA1c levels predicted worse outcomes in heart failure, further supporting the potential value of combining both markers for predicting adverse outcomes.

Regarding cardiac biomarkers, the study found that mean CK-MB levels were significantly higher in ACS cases with complications, while troponin levels did not show a significant difference. Elevated levels of both CK-MB and troponin correlated with higher GA levels, suggesting that GA may serve as an independent predictor of ACS complications. This is in line with previous research indicating that cardiac biomarkers like CK-MB are linked to cardiovascular outcomes, but further studies are needed to explore the exact relationship between GA and these markers.

Lastly, triglyceride levels were significantly associated with ACS complications, with higher triglyceride levels observed in patients with elevated GA levels. **(Guo et al., 2022)** also identified the triglyceride glucose index as a predictor of adverse cardiovascular events in pediatric ACS patients, suggesting its potential as a prognostic marker in patients with prediabetes and ACS, reinforcing the study's findings.

A logistic regression analysis was carried out to diagnose the most significant predictors of short-term complications in acute coronary syndrome (ACS). The univariate analysis highlighted hypertension (HTN), diabetes (DM), blood pressure levels, STEMI, CRP, CK-MB, triglycerides, lower ejection fraction (EF), and glycated albumin (GA) as significant predictors. However, after adjusting for confounding factors, the multivariate analysis identified HTN and lower EF as independent risk factors for ACS complications. GA remained significant in the multivariate analysis, emphasizing its relevance in managing ACS cases.

Comparison with other studies revealed differing findings. **(Zhang et al., 2022)** reported that elevated glycated albumin levels were associated with a heightened risk of complications following successful PCI; however, this relationship was significant only in diabetic patients after adjusting for conventional risk

factors. **(Liu et al., 2022)**, in contrast, showed that GA was an independent predictor for MACCE in NSTEMI patients undergoing PCI, regardless of diabetes status, with a higher predictive value in non-diabetic patients. Additionally, **(Norimatsu et al., 2015)** identified GA as a significant independent predictor of CAD, along with age, gender, and hypertension.

The study came with its limitations, including a small sample size, the single-center design, and the cross-sectional nature, which prevents establishing causal relationships. The study also lacked assessment of potential confounders like medication adherence and dietary patterns, and did not evaluate other markers of glucose control such as HbA1c and fructosamine, limiting a broader understanding of glycemic variability.

Conclusion:

This study highlights the significant role of glycated albumin (GA) as a marker for glucose control and a predictor of complications in acute coronary syndrome (ACS) patients. Elevated GA levels were associated with higher prevalence of hypertension, diabetes mellitus, and STEMI, as well as worsened cardiac function and an increased rate of complications, particularly cardiogenic shock. GA demonstrated moderate sensitivity and specificity in predicting ACS complications, emphasizing its potential utility in identifying high-risk patients who may require more intensive monitoring and management. These findings suggest that glycated albumin could be a valuable tool for improving patient care in ACS settings.

Abbreviations:

Abbreviation	*Full Term*
ACS	Acute Coronary Syndrome
AGEs	Advanced Glycation End-Products
ALT	Alanine Transaminase
ASE	American Society of Echocardiography
BMI	Body Mass Index
CAD	Coronary Artery Disease
CBC	Complete Blood Count
CHD	Coronary Heart Disease
CI	Confidence Interval
CK-MB	Creatine Kinase-Muscle/Brain
CKD	Chronic Kidney Disease
CRP	C-Reactive Protein
DM	Diabetes Mellitus
ECG	Electrocardiogram
EF	Ejection Fraction
FBG	Fasting Blood Glucose
GA	Glycated Albumin
HDL	High-Density Lipoprotein
HF	Heart Failure
HTN	Hypertension
HbA1c	Glycosylated Hemoglobin
LDL	Low-Density Lipoprotein
MACCE	Major Adverse Cardiovascular and Cerebrovascular Events
MACE	Major Adverse Cardiovascular Events
NSTE-MI	Non-ST-Elevation Myocardial Infarction
NSTEMI	Non-ST Elevation Myocardial Infarction
OR	Odds Ratio
PCI	Percutaneous Coronary Intervention
PND	Paroxysmal Nocturnal Dyspnea
ROC	Receiver Operating Characteristic
SMuRFs	Standard Modifiable Cardiovascular Risk Factors
SPSS	Statistical Package for the Social Sciences
STEMI	ST-Elevation Myocardial Infarction
Syntax Score	A grading system used to determine the complexity of coronary artery disease
non-STEMI	Non-ST-Elevation Myocardial Infarction

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