

THE RELATIONSHIP BETWEEN FASTING BLOOD GLUCOSE LEVELS AND ST- SEGMENT PATTERNS IN PATIENTS WITH ACUTE CORONARY SYNDROME AT KARSA HUSADA HOSPITAL INDONESIA: A CROSS-SECTIONAL STUDY

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ABSTRACT

Assessing the severity of acute coronary syndrome (ACS) based on electrocardiographic (ECG) findings requires considerable clinical expertise. In many primary healthcare facilities in Indonesia, the limited availability of healthcare professionals proficient in ECG interpretation may delay decisions on initial management. In addition, fasting blood glucose (FBG) levels are often elevated in patients with ACS. This elevation may indicate underlying metabolic disturbances associated with endothelial dysfunction and a greater atherosclerotic burden, which may also contribute to ST-segment abnormalities on ECG. This study aimed to examine the relationship between FBG levels and ST-segment patterns in patients with ACS. An analytical observational design was used. Data were obtained retrospectively from the medical records of patients treated between January and June 2025. The required sample size was calculated using the Slovin formula, resulting in 100 participants who met the inclusion criteria. Participants were patients aged 18 years or older with a diagnosis of ACS and complete medical records, including ECG findings interpreted by a cardiologist and laboratory results for FBG. Data on FBG level and ECG findings were retrieved from medical records in the Cardiovascular Care Unit. The associations between variables were analysed using nonparametric statistical methods, including the Chi-square test and the contingency coefficient. Most participants were male (64%) and aged 46–65 years (59%). The majority exhibited elevated FBG levels (71%) accompanied by ECG findings of ST-segment depression (44%). A significant relationship was found between FBG levels and the type of ST-segment pattern ($p = 0.02, < 0.05$), although the strength of the association was weak (Cramer's $V = 0.241$). FBG levels are significantly associated with ST-segment patterns in patients with ACS. However, the association is weak, suggesting that FBG should be interpreted alongside ECG findings and other clinical parameters when assessing disease severity.

KEYWORDS: acute coronary syndrome; electrocardiogram; fasting blood glucose.

INTRODUCTION

Acute coronary syndrome (ACS) has remained one of the major causes of mortality worldwide over the past five years and has become a major public health concern [1]. ACS refers to a group of clinical conditions caused by myocardial ischemia in the coronary arteries, which has three distinct clinical manifestations: ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina pectoris (UAP) [2]. Nowadays, the prevalence of ACS has shifted, increasing substantially in developing nations, including Indonesia [3]. This burden is expected to persist, with the number of related deaths projected to reach 23.3 million by 2030 [4]. In Indonesia, data from the 2018 Basic Health Research reported a prevalence of ACS 1.5%, equivalent to approximately 1,017,299 individuals, and it remains a major contributor to cardiovascular mortality in this country [5].

The clinical outcomes of ACS are strongly influenced by disease severity, which is closely related to the extent of coronary artery obstruction. More extensive occlusion is generally associated with a greater risk of complications and adverse outcomes [6]. Electrocardiography (ECG) provides important clues regarding the presence and possible extent of coronary obstruction [7], although accurate interpretation requires adequate clinical knowledge and experience [8]. ECG also has limitations

because it cannot precisely quantify the degree of occlusion. Complete coronary occlusion commonly produces ST-segment elevations, whereas partial occlusion may present with ST-segment depression, T-wave inversion or flattening or in some cases, no clear ECG abnormalities [9]. Coronary angiography remains the most definitive method for evaluating coronary obstruction. However, this facility is largely limited to tertiary referral hospitals [10], which may delay definitive assessment and management, particularly for patients initially presenting to primary healthcare services [5].

Moreover, Indonesia's geographic conditions make primary health care centres an important first point of contact for many patients. However, these facilities often operate with limited diagnostic equipment, staffing, and expertise in ECG interpretation [8]. ACS in Indonesia is also not only dominated to major cities, as cases are frequently encountered in rural areas [11]. Previous studies showed that many Indonesian patients with ACS work as farmers or manual labourers and have relatively low levels of formal education [12]. These circumstances may affect health-seeking behaviour and access to timely care. Limited health literacy, combined with delays in reaching facilities that provide comprehensive cardiovascular services, may contribute to more advanced disease and a higher risk of death [5]. Therefore it is an urge to develop a simple diagnostic tools to early screening of obstruction among ACS patients in rural areas.

During myocardial ischemia, activation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis results in the release of catecholamines and cortisol. These hormonal responses further stimulate lipolysis and glycogenolysis, thereby increasing blood glucose levels. Hyperglycaemia may worsen myocardial injury by increasing oxidative stress [13, 14]. Wilby et al (2015) reported that ACS patients who presented with hyperglycaemia at hospital admission had a 39% higher risk of mortality. Similarly, Liu et al. (2020) found that elevated fasting blood glucose (FBG) in patients with STEMI was associated with a greater likelihood of plaque rupture, complete coronary occlusion, and more pronounced ST-segment abnormalities. Therefore, assessing FBG in patients with ACS may offer additional information on the metabolic factors associated with the severity of myocardial ischaemia.

However, evidence regarding the relationship between FBG levels and the extent of myocardial injury, as reflected by ST-segment patterns, remains limited in Indonesian patients with ACS [15, 16]. Therefore, this study was conducted to examine this relationship in the Indonesian clinical setting.

Karsa Husada Batu General Hospital was chosen as the study setting because it serves as a regional referral hospital and has experienced a steady increase in ACS cases. A preliminary review in 2023 identified 705 patients with ACS who received treatment at the hospital. A similar pattern was observed in epidemiological data from Malang Regency, Malang City, and Batu City, where the incidence of ACS increased between 2015 and 2019. In 2019, 1,040 cases, representing 45.4% of all recorded coronary heart disease cases, were classified as ACS [12]. Against this background, the present study aimed to examine the relationship between fasting blood glucose levels and ST-segment patterns among patients with ACS treated at Karsa Husada Batu General Hospital. The finding may provide additional evidence to support early, non-invasive risk assessment, particularly in primary healthcare settings where access to advanced cardiac investigations is limited. We hypothesised that higher fasting blood glucose levels would be associated with more pronounced ST-segment abnormalities, especially ST-segment elevation, in patients with acute coronary syndrome.

MATERIALS AND METHODS

Study design

This analytical observational study used a cross-sectional design to examine the relationship between fasting blood glucose levels and ST-segment patterns among patients with acute coronary syndrome treated at Karsa Husada Batu General Hospital. Data were retrospectively retrieved from medical records covering the period from January to June 2025.

Population and sample

The study population comprised all patients with acute coronary syndrome who were admitted to Karsa Husada Batu General Hospital between Januari until Juni 2025. Participants were selected using a consecutive sampling technique, whereby all eligible patients identified during the study period were included until the required sample size was reached. Patients were included if they had been diagnosed with ACS, were aged 18 years or older, had received treatment at Karsa Husada Batu General Hospital during the study period, and had complete medical records containing fasting blood glucose results and

ECG findings interpreted by a cardiologist. Patients were excluded if they had a history of insulin or oral hypoglycaemic agent use, had undergone coronary revascularisation or received antithrombotic therapy before ECG examination, or had another clinical condition that could cause ST-segment elevation or depression. The minimum sample size was calculated using the Slovin formula, resulting in a required sample of 100 patients.

Data collection

Data were retrieved from the electronic medical records of patients treated in the Cardiovascular Care Unit (CVCU) at Karsa Husada Batu General Hospital. The researchers extracted information on ECG findings, fasting blood glucose results, and ACS diagnoses from the inpatient records. Permission to access the records was obtained from the relevant hospital and CVCU authorities, and all data collection procedures were carried out in accordance with the approved ethical requirements.

Data analysis

Data were entered and organised using Microsoft Excel, then analysed with IBM SPSS Statistics version 26.0. Participant characteristics were summarised descriptively and presented as frequencies and percentages. The relationship between fasting blood glucose categories and ST-segment pattern was examined using the Chi-square test. Cramer's V was subsequently calculated to estimate the strength of the association. A p-value of less than 0.05 was considered statistically significant.

Ethical statement

Ethical approval for this study was granted by the Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, UIN Maulana Malik Ibrahim Malang (Approval No. 95/01/EC/KEPK/5/2025). This study part of a broader research project entitled "Exploration of Circulating miRNA as a Biomarker Agent for ACS Diagnosis through Next-Generation miRNA Sequencing."

RESULTS AND DISCUSSION

During the study period, 162 patients with acute coronary syndrome were admitted to or managed in the Cardiovascular Care Unit at Karsa Husada Batu General Hospital. Of these, 62 were excluded because their medical records were incomplete. Specifically, 27 patients had No. ECG recording, 32 had ECG records without a documented interpretation, and 3 had No. fasting blood glucose results. The final analysis, therefore, included 100 patients who met all eligibility criteria.

Respondent Characteristics

Most participants were male (64%), while women accounted for 36% of the study population. The largest age group was 46-65 years (59%), followed by those aged 66+ (28%) and 26-45 years (13%) (Table 1). Regarding clinical characteristics, 71% of participants had elevated fasting blood glucose levels, whereas 24% had normal levels and 5% had low levels. The most common ECG finding was ST-segment depression, observed in 44% of patients, followed by ST-segment elevation in 30%. The remaining 26% showed other ECG patterns, including T-wave inversion, flattened or tall T-waves, and isoelectric findings. Based on the clinical diagnosis, 68% of patients were classified as NSTEMI, 30% as STEMI, and 2% as unstable angina pectoris (UAP) (Table 2).

Among the 100 patients included in this study, 64% were male. This finding is consistent with previous reports showing a higher proportion of men among patients with acute coronary syndrome. One possible explanation is that men tend to develop atherosclerotic disease at an earlier age, whereas premenopausal women may benefit from the vascular effects of estrogen. Estrogen has been associated with improved endothelial function, reduced vascular inflammation, and inhibition of LDL oxidation, all of which may help slow the development of atherosclerotic plaques [17].

In terms of behavior, men have a higher tendency toward unhealthy lifestyles, such as smoking and consuming foods high in saturated fat and sugar, which contribute to an increased risk of cardiovascular disease [17]. A study by Takieddin et al. (2022) in Saudi Arabia found that 79.84% of ACS patients were men, and that STEMI was more common among men than among women. Similarly, in a study by Arechkik et al. (2025) in Morocco, men accounted for 64.5% of the ACS patient population, which is almost identical to the findings in this study. Women tend to experience atypical presentations such as vague chest pain, nausea, extreme fatigue, and are more likely to experience NSTEMI or UAP than

STEMI [17]). This condition needs to be taken more seriously, as it can lead to delayed diagnosis in women [18].

Most respondents were in the 46–65 age group (59%) with an average age of 55.45 years, and there were no respondents aged 18–25 years. This distribution shows that middle-aged and elderly people have a higher risk of ACS due to the aging process, cumulative exposure to cardiometabolic risk factors, and declines in organ function [19]. Insulin resistance increases with age, causing higher FBG levels, known as hyperglycemia [20]. Hyperglycemia can accelerate myocardial ischemia [21]. The absence of respondents in the young age group (18–25 years) also indicates that ACS in young people is relatively rare, except in the presence of specific risk factors such as familial hyperlipidemia, uncontrolled type 1 diabetes mellitus, or congenital heart defects [22].

Based on the clinical data profile analysis of 100 patients with ACS at Karsa Husada Batu General Hospital, the majority of patients experienced hyperglycemia upon admission [23]. Physiologically, hyperglycemia may occur as a result of undiagnosed diabetes mellitus or as an acute stress response to ischemia, a condition referred to as stress-induced hyperglycemia. During ischemic events, elevated levels of counter-regulatory hormones such as cortisol, adrenaline, and glucagon promote insulin resistance and stimulate gluconeogenesis, leading to a marked increase in blood glucose levels even in individuals without a prior history of diabetes [21]. Clinically, hyperglycaemia has been associated with poorer outcomes in patients with acute coronary syndrome, including a higher risk of short-term mortality after acute myocardial infarction and among patients undergoing percutaneous coronary intervention [24]. In addition, hyperglycemia increases the risk of cardiovascular complications with a mortality risk ratio up to 4.47 times higher than in patients with normal glucose levels [21]. Pathophysiologically, hyperglycemia increases free radical formation, reduces nitric oxide release, worsens endothelial function, and increases platelet aggregation, thereby exacerbating ischemia and accelerating and expanding myocardial necrosis [21, 25].

Regarding clinical presentation, NSTEMI was the most common, followed by STEMI and unstable angina pectoris. This pattern is consistent with broader epidemiological trends showing that NSTEMI is increasingly recognised, particularly among older patients with metabolic comorbidities [25]. Improvements in cardiac biomarker testing, especially the use of high-sensitivity troponin assays, have also made it possible to detect myocardial infarction in patients who do not present with ST-segment elevations [26]. Wang et al. (2023) similarly reported that hyperglycaemic patients were more likely to present with NSTEMI and had a higher risk of mortality [23]. Taken together, these findings suggest that metabolic abnormalities, including hyperglycaemia may be associated with differences in the clinical presentation and prognosis of acute coronary syndrome.

ECG finding showed that ST segment depression was the most common abnormality, followed by ST segment elevation and other changes including T-wave inversion and nonspecific repolarisation abnormalities. ST segment elevation generally reflects transmural myocardial ischaemia and is often associated with acute coronary artery occlusion. The resulting electrical difference between ischaemic and non ischaemic myocardial tissue appears as elevation of the ST segment on the ECG. In contrast, ST segment depression is more commonly linked to subendocardial ischaemia in which reduced perfusion primarily affects the inner layer of the myocardium. This pattern may occur in the setting of incomplete coronary obstruction, reduced coronary blood flow, or increased myocardial oxygen demand. This creates an electrical gradient between the subendocardial and subepicardial layers, producing the characteristic ST-segment depression. Meanwhile, T-wave inversion reflects alterations in myocardial repolarization in response to ischemia or reperfusion following coronary occlusion [16, 27]. The predominance of ST-segment depression observed in this study is consistent with the higher incidence of NSTEMI.

Relationship Between FBG Levels and ST Segment Patterns.

Based on the analysis, a statistically significant association was observed between FBG levels and ST-segment patterns in patients with ACS. Among the 71 respondents with hyperglycemia, 44% presented with ST-segment depression, 38% with ST-segment elevation, and 18% with other ECG patterns, including T-wave inversion, flat or tall T waves, and isoelectric changes. In the group with normal FBG levels ($n = 24$), 46% had ST-segment depression, 42% had other ECG patterns, and 13% had ST-segment elevation. Meanwhile, among the five respondents with hypoglycemia, 60% did not present with pathological ST-segment changes but instead showed other ECG patterns, while 40% presented

with ST-segment depression. Statistical analysis yielded a p-value of 0.02 ($p < 0.05$), indicating a significant relationship between FBG levels and ST-segment patterns. The strength of this association, reflected by a Cramer's V coefficient of 0.241, suggested a weak correlation (Table 3).

The Chi-squared analysis identified a statistically significant relationship between fasting blood glucose levels and ST-segment patterns, although the relationship was weak. Among patients with FBG levels of ≥ 126 mg/dL, ST-segment depression and ST-segment elevation were the most commonly observed ECG findings. This suggests that elevated FBG may be associated with more noticeable electrocardiographic abnormalities in patients with ACS [27]. However, the clinical diagnoses were unevenly distributed, with NSTEMI accounting for 68% of cases and STEMI for 30%, which may have influenced the overall pattern of ECG findings. The low Cramer's V value indicates that FBG accounted for only a limited proportion of the variation in ST segment patterns. Therefore, although FBG may provide additional clinical information, it should not be interpreted as a stand-alone indicator of ACS severity and should be considered together with symptoms, ECG findings, cardiac biomarkers, and other relevant clinical parameters [28].

These findings may appear inconsistent with the high proportion of patients who presented with hyperglycaemia, a condition that has been linked pathophysiologically to more extensive myocardial injury and a greater likelihood of STEMI [29]. However, ST segment elevation is not determined by fasting blood glucose alone. Its appearance on ECG is also influenced by the timing of hospital presentation, the extent of coronary artery obstruction, and the condition of the vascular endothelium [30]. Patients who arrive more than 12-24 hours after symptom onset may already have progressed beyond the early phase of transmural infarction, when ST-segment elevation is most apparent. At this stage, the ECG may instead show ST segment depression, T-wave inversion, or partial normalisation, even though substantial myocardial damage has already occurred [31].

Demi et al. (2022) reported that, among patients with STEMI, higher blood glucose levels at hospital admission were significantly associated with greater mortality, larger infarct size, more frequent complications, and longer hospitalization [32]. A similar pattern was observed in patients with NSTEMI. Hao et al. (2017) found that admission hyperglycaemia independently predicted subsequent cardiovascular events, including in patients without a previous diagnosis of diabetes. These findings suggest that elevated glucose levels during an acute coronary event may be linked to more severe myocardial ischaemia and poorer clinical outcomes [31].

Fasting blood glucose was selected as the main metabolic variable because it provides a more standardised assessment of glycaemic status than random glucose measured during an acute illness. Nevertheless, FBG may still be influenced by the physiological stress response associated with ACS and should not be interpreted solely as a marker of long-term glycaemic control. Persistent hyperglycaemia can impair endothelial function by increasing oxidative stress, reducing nitric oxide bioavailability, promoting vascular inflammation, and accelerating atherosclerotic plaque development. These processes may contribute to more extensive coronary artery disease and more pronounced ECG abnormalities during an acute coronary event [13, 14].

From a practical standpoint, fasting blood glucose is an inexpensive laboratory test that is widely available in primary and secondary healthcare facilities. Although it cannot replace ECG examination or cardiac biomarker testing, FBG may provide additional information when evaluating patients with acute coronary syndrome. Its potential value may be particularly relevant in resource-limited settings, where access to advanced cardiovascular investigations is not always readily available [8].

Study Limitations

This study has several limitations. First, the cross-sectional design limits our ability to establish a causal relationship between fasting blood glucose levels and ST-segment abnormalities. Second, several clinically relevant variables, including the duration of diabetes mellitus, time of symptom onset, interval between symptom onset and ECG recording, and serial ECG findings, were not consistently documented in the retrospective medical records and, therefore, could not be analysed. Third, multivariable analysis was not possible because data on the required clinical covariates were incomplete. These factors may have affected the observed association and should be taken into account when interpreting the results.

CONCLUSIONS AND SUGGESTION

A significant association was found between fasting blood glucose levels and ST-segment pattern in patients with acute coronary syndrome. However, the association was weak, as indicated by a Cramer's V value of 0.241. Patients with higher FBG levels tended to exhibit more pronounced electrocardiographic abnormalities, although FBG alone cannot be considered an independent marker of ACS severity. Its interpretation should therefore be combined with ECG findings, clinical presentation, laboratory results, and other relevant cardiovascular risk factors. Further prospective studies are needed to clarify the role of FBG in ACS risk assessment. Future research should include serial ECG recording, information on diabetes history and glycaemic control, the interval between symptom onset and ECG examination, and multivariable analyses to account for potential confounding factors.

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Table 1. Frequency Distribution of Respondent Characteristics

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	64	64.0
	Female	36	36.0
Age	18-25	0	0.0
	26-45	13	13.0
	46-65	59	59.0
	≥ 66	28	28.0

Table 2. Frequency Distribution of Clinical Data Profiles

Variable	Category (mmHg)	Frequency (n)	Percentage (%)
FBG Level	Hypoglycemia (<70)	5	5.0
	Normal (70-125)	24	24.0
	Hyperglycemia (≥ 126)	71	71.0
ST Segment Pattern	Other Patterns	26	26.0
	ST Segment Depression	44	44.0
	ST Segment Elevation	30	30.0
Clinical Diagnosis	UAP	2	2.0
	NSTEMI	68	68.0
	STEMI	30	30.0

Table 3. Correlation between FBG levels and ST segment patterns

FBG Level	ST Segment Patterns			Total	Sig
	Other	Depression	Elevation		
Hypoglycemia	3 (60%)	2 (40%)	0 (0%)	5	0.02
Normal	10 (42%)	11 (46%)	3 (13%)	24	
Hyperglycemia	13 (18%)	31 (44%)	27 (38%)	71	
Total	26	44	30	100	
Cramer (v)					0.241