WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

SJIF Impact Factor: 6.711

ISSN: 2457-0400
Volume: 8.
Issue: 10
Page N. 27-33
Year: 2024

Original Article www.wjahr.com

SERUM GAMMA GLUTAMYL TRANSFERASE AS A MARKER OF ISCHEMIC HEART DISEASE AND ITS RELATIONSHIP WITH RISK FACTORS

Mustafa Mohammed Abd Alwahid*[1] and Dr. Ala Hussain Haider[2]

[1](M.B.Ch.B.) Merjan Teaching Hospital.
[2]Consultant Physician Professor of Internal Medicine (M.B.Ch.B, F.I.C.M.S) Babylon University, Hammurabi College of Medicine.

Article Received date: 30 July 2024 **Article Revised date:** 20 August 2024 **Article Accepted date:** 10 Sept. 2024

***Corresponding Author: Mustafa Mohammed Abd Alwahid**
(M.B.Ch.B.) Merjan Teaching Hospital.

ABSTRACT
Background
Serum gamma glutamyl transferase is an enzyme involved in glutathione metabolism, has been implicated in oxidative stress and inflammation, both key contributors to atherosclerosis and coronary artery disease. **Aim of the study to** Evaluate gamma glutamyl transferase's predictive role in coronary disease severity and establish correlations with coronary heart disease risk factors. **Patients and Methods** a cross-sectional study conducted in Merjan teaching hospital and Shaheed Al-Mehrab Cardiovascular center from the 1st Jan 2023 to the 1st Oct 2023. The study involved the assessment of 100 patients scheduled for coronary angiography due to suspected coronary artery disease. The gamma glutamyl transferase measurements were conducted using established laboratory techniques. An elevated level was deemed to be present when it exceeded 71 IU/L in male patients and 42 IU/L in female patients according to laboratory reference values. **Results** The mean age of the patients was 60.5 ± 11.3, regarding sex distribution, 60 percent were male and 40 percent were female. In this study, gamma glutamyl transferase levels, with a median of 40.5 (IQR: 21.0-56.2), showed elevation in 24.0% of patients. A comparison between normal and abnormal angiography revealed significantly higher gamma glutamyl transferase levels (46.0 vs. 23.0, $p < 0.001$) in the latter group. **Conclusion** The current study concluded that serum gamma-glutamyl transferase is prevalent among those with ischemic heart disease, revealing a significant association with positive angiography findings.

KEYWORD: Serum gamma glutamyl transferase; Coronary heart disease.

INTRODUCTION

As of the latest available data, there are approximately 126.5 million cases of ischemic heart disease worldwide, making it a widespread and significant global health issue.[1,2] Ischemia, characterized by inadequate oxygenated blood flow to the myocardium, can result from decreased oxygen in the blood or reduced blood flow. Predisposing risk factors for coronary heart disease (CHD), defined as those that worsen independent risk factors include[3], family history of premature CHD, occurring in a first-degree male relative < 55 years of age, or first-degree female relative < 65 years of age, metabolic or insulin resistance syndrome (defined as ≥ 3 of the following: abdominal obesity [male >102 cm waist, female > 88 cm], fasting glucose ≥110 mg/ dL, systolic pressure >130 mm Hg, diastolic ≥ 85 mm Hg, triglycerides ≥150 mg/dL, HDL cholesterol < 40 mg/dL in males and < 50 mg/dL in females), obesity (body mass index > 30 kg/m2), physical inactivity and other factors.[4] Gamma-glutamyl transferase (GGT) is a glycosylated protein embedded in the outer surface of the plasma membrane. It has a role in the homeostasis of both glutathione and cysteine.[5] GGT is a microsomal enzyme that is responsible for transferring the glutamyl groups from gamma-glutamyl peptides to other peptides. With the exception of muscle cells, GGT is distributed in all other organs. GGT catalyzes the synthesis and transmembrane transport of proteins, counteracts oxidative stress by providing cysteine for regeneration of intracellular glutathione, and contributes to the detoxication of ammonium of some drugs.[6] GGT has been proposed to be a predictive biomarker for cellular antioxidant deficiency and several disease states.[7] GGT makes a significant contribution to oxidant activity. In addition, there are variations in GGT levels based on gender, ethnic, and regional differences and an upward trend in levels which suggests an environmental factor.[8] Whether GGT offers prognostic information that is incremental to the information provided by conventional risk factors remains questionable. Despite using coronary angiography—the gold standard for diagnosis of CHD—studies that assessed GGT in patients with established CHD included smaller numbers of patients and had a short follow-up. Furthermore, teasing out the intricate relationship and interdependence between CVD risk factors, GGT and CHD remains difficult.[9,10] The confounding impact of percutaneous coronary intervention—suggested to abolish the association of GGT with coronary events should be considered.[11]

Aim of the study

1- Assess the prediction of high gamma-glutamyl transferase levels on the severity of coronary heart disease.

2- Show the correlation between gamma-glutamyl transferase with the coronary heart disease risk factors.

PATIENTS AND METHODS

This study was designed as a cross-sectional study conducted in Merjan teaching hospital and Shaheed Al-Mehrab Cardiovascular center from the 1st Jan 2023 to the 1st Oct 2023. The study involved the assessment of 100 patients scheduled for coronary angiography due to suspected coronary artery disease. Nonrandomized convenient sampling was done to enroll patients.

Inclusion criteria

1. Patients who are scheduled for coronary angiography to evaluate coronary artery disease.
2. Aged 18 years or older.

Exclusion criteria

Patients with severe comorbidities such as advanced cancer, severe liver disease, defined by clinical criteria and liver function tests, or severe renal disease (eGFR < 30 mL/min/1.73 m²) or other conditions that may significantly affect the study results or their ability to undergo coronary angiography

1. Patients who had experienced a myocardial infarction within the last three months due to the potential acute effects on gamma-glutamyl transferase (GGT) levels.
2. Patients who had undergone coronary artery revascularization procedures (e.g., percutaneous coronary intervention or coronary artery bypass grafting) within the last three months.
3. Pregnant individuals due to the potential influence of pregnancy on GGT levels and the associated risk factors.
4. patients with a history of alcohol consumption were excluded, as alcohol is known to influence GGT levels.

Data collection and measurement

Detailed socio-demographic data, medical history, and clinical information had been obtained through patient interviews and medical records. These information included age, sex, occupation, medical history, medication use, and lifestyle factors, such as smoking history (which included current and ex- smokers), and Family history of IHD (history of premature CHD, occurring in a first-degree male relative < 55 years of age, or first-degree female relative < 65 years of age).

BMI, an indicator of obesity, was calculated by measuring the participant's weight and height. The BMI was calculated using the formula:

BMI = weight (kg)/ height^2 (m^2).

Blood pressure was measured using standard procedures to determine hypertension status, defined by systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or the current use of antihypertensive medication.[12] laboratory tests were conducted to assess various risk factors, including those associated with liver and renal function, the presence of diabetes mellitus, and dyslipidemia. The patient was considered to have diabetes mellitus if he had one of the following criteria: Hemoglobin A1C equal to or greater than 6.5%, Fasting plasma glucose equal to or greater than 126 mg/dl, Random blood sugar equal to or greater than 200 mg/dl or the patient had history of diabetes on treatment.[13]

Liver function tests encompassed liver enzyme measurements (alanine transaminase and aspartate transaminase), while renal function was assessed by serum creatinine levels and blood urea nitrogen. Blood samples were analyzed to assess random blood sugar, and the lipid profile, which includes total cholesterol, low-density lipoprotein cholesterol, and triglyceride levels, to define dyslipidemia. Blood samples were collected to measure GGT levels, which serve as the primary focus of this study which had been correlated with angiographic findings and the various risk factors. The GGT measurements were conducted using established laboratory techniques. An elevated GGT level was deemed to be present when it exceeded 71 IU/L in male patients and 42 IU/L in female patients according to laboratory reference values of BS-230/ Mindray/ China. Coronary angiography was typically performed in a specialized cardiac catheterization lab. It is an invasive procedure in which a thin, flexible tube (catheter) is inserted into a blood vessel, usually in the groin or wrist, and threaded up to the coronary arteries. A contrast dye is injected through the catheter directly into the coronary arteries, which makes them visible on X-ray images. The procedure assesses the extent and severity of coronary artery disease. The images obtained can help doctors identify which coronary arteries are affected and to what degree.[14] **Statistical analysis** Continuous variables were expressed as means and standard deviations. Categorical variables were expressed as frequency and percentages. univariate logistic regression was used to calculate the odds ratio for the risk of having three or four vessels of coronary disease. Pearson's rank correlation Coefficient was used to study the correlation between study parameters. A P-value less than 0.05 was considered statistically significant. R software packages (dplyr, gt_summery and ggplot) were used for data processing, visualization, and statistical analysis ("R version 4.3.0, R Foundation for Statistical Computing, Vienna, Austria").

RESULTS

This study had enrolled 100 patients suspected to have ischemic heart disease. The mean age of the patients was 60.5 ± 11.3, regarding sex distribution, 60 percent were male and 40 percent were female. The mean body mass index of the participants was 30.7 ± 5.3. In regards to the occupation, the highest percentage (28.0%) were housewives, gainer (20.0%), and retired (19.0%).

Table 1: Description of socio-demographics of the patients.

Characteristic	Patients, N = 100[1]
Age (years)	60.5 ± 11.3
Sex	
Male	60 (60.0%)
Female	40 (40.0%)
BMI (kg/m^2)	30.7 ± 5.3
[1]Mean ± SD; n (%)	

Regarding the comorbidities, hypertension was observed in (71%), and diabetes (60%). (49%) of the patients had a smoking history while (43%) had a positive family history of ischemic heart disease.

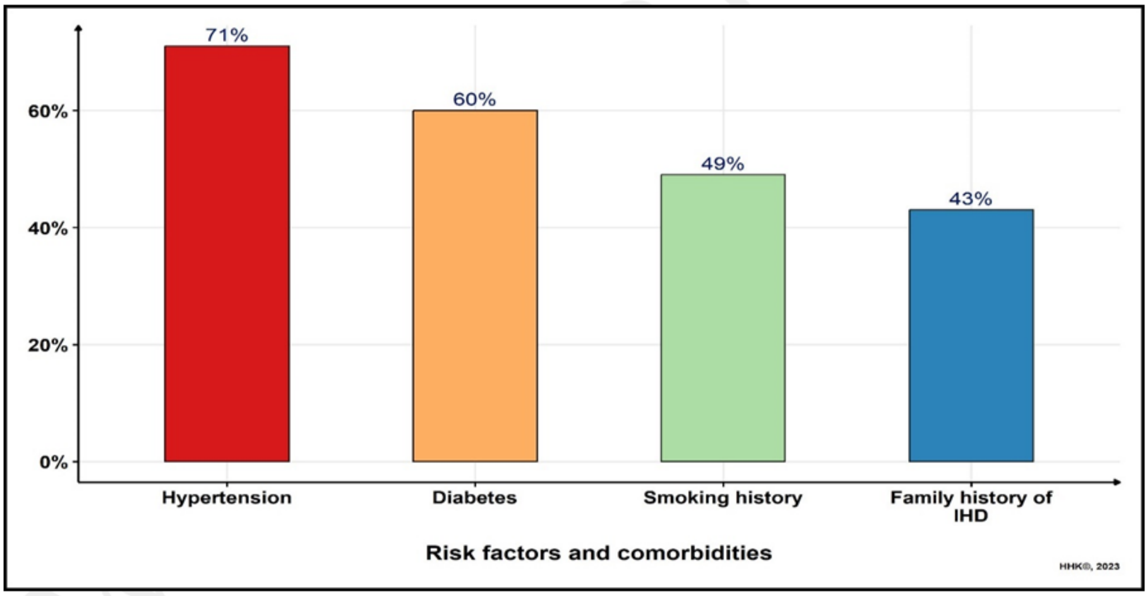

Figure 1: Bar chart showing the risk factors and comorbidities of ischemic heart disease among the participants.

The laboratory tests showed that the mean of the gamma-glutamyl transferase was 46.9 ± 30.8, it was elevated in (24.0%) of the patients.

Table 2: Description of laboratory parameters of the participants.

Characteristic	Patients, N = 100[1]	Normal value
Lipid profile		
Total cholesterol (mmol/L)	3.7 ± 1.1	< 5.18 mmol/L
Serum triglyceride (mmol/l)	1.5 ± 0.9	< 1.82 mmol/L
Low-density lipoprotein (mmol/L)	1.6 ± 0.9	< 2.4 mmol/L
Serum gamma-glutamyl transferase (SGGT)	40.5 (21.0 - 56.2)	Male 10-71IU/L Female 6-42 IU/L
Elevated gamma-glutamyl transferase	24 (24.0%)	
[1]Mean ± SD; Median (IQR) n (%)		

In regards to the angiographic findings, it had been noticed that the left anterior descending artery was the most vessel affected by ischemia (51%), while the left main stem was the least affected (17%).

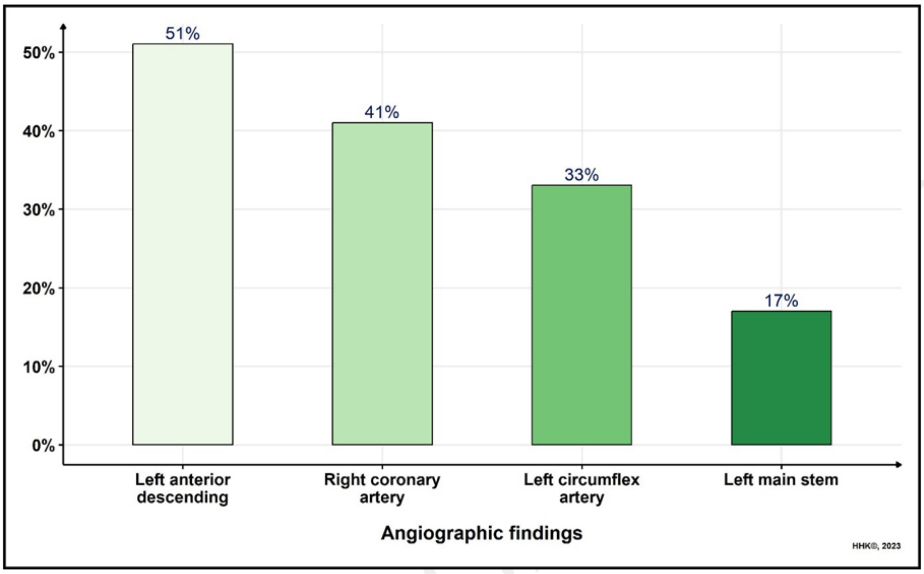

Figure 2: Bar chart showing the angiographic findings of the four vessels affected by ischemia.

The patients were grouped according to the angiographic findings into normal angiography (N = 37) and those with abnormal angiography (N = 63). The groups exhibited similar mean ages (60.2 ± 11.4 vs. 60.6 ± 11.3 years) and sex distributions, although the sex showed a trend towards significance (p = 0.076). Smoking history was significantly higher in the abnormal angiography group (p = 0.011). Other variables, including a family history of ischemic heart disease, and BMI did not show statistically significant differences between the groups. However, random blood sugar levels (p = 0.014), lipid profile components (total cholesterol, p = 0.047; low-density lipoprotein, p = 0.017), and gamma-glutamyl transferase (p < 0.001) demonstrated significant associations with abnormal angiography.

Table 3: Patients Characteristics According to Angiographic Findings.

Characteristic	Normal Angiography, N = 37[1]	Abnormal Angiography, N = 63[1]	p-value[2]
Age, years	60.2 ± 11.4	60.6 ± 11.3	0.9
Sex			0.076
Male	18 (48.6%)	42 (66.7%)	
Female	19 (51.4%)	21 (33.3%)	
Smoking history	12 (32.4%)	37 (58.7%)	**0.011**
Family history of IHD	13 (35.1%)	30 (47.6%)	0.2
BMI (kg/m^2)	31.8 ± 5.0	30.0 ± 5.5	0.10
Random blood sugar (mmol/l)	7.7 ± 2.9	9.6 ± 4.5	**0.014**
Lipid profile			
Total cholesterol (mg/dl)	3.5 ± 0.8	3.9 ± 1.3	**0.047**
*Serum triglyceride (*mmol/l)	1.4 ± 0.8	1.6 ± 0.9	0.3
Low-density lipoprotein (mg/dl)	1.3 ± 0.7	1.8 ± 1.0	**0.017**
Gamma-glutamyl transferase (SGGT)	23.0 (18.0 - 42.0)	46.0 (34.0 - 62.5)	**<0.001**
Elevated SGGT	6 (16.2%)	18 (28.6%)	0.2

[1]Median (IQR); Mean ± SD; n (%)
[2]Wilcoxon rank sum test; Welch Two Sample t-test; Pearson's Chi-squared test

Patients with abnormal angiography were categorized into four categories according to the number of vessels affected. The mean ages across the groups were relatively similar, showing no significant differences (p = 0.8). Regarding sex distribution, a trend is observed (p = 0.11), with a higher percentage of males in the later groups. Smoking history, family history of ischemic heart disease, and lipid profile components (total cholesterol, triglyceride, LDL) did not exhibit significant differences among the groups. However, BMI showed statistical significance (p = 0.007), with Group One having a higher mean BMI compared to the other groups. Random blood sugar (RBS) levels also demonstrate a marginal p-value (p = 0.095), with higher mean levels in Group Four. Gamma-glutamyl transferase (SGGT) levels did not significantly differ among the groups. The prevalence of elevated SGGT levels was consistent across the groups (p = 0.7).

Table 4: Classification of patients according to the number of vessels affected.

Characteristic	One, N = 22[1]	Two, N = 14[1]	Three, N = 16[1]	Four, N = 11[1]	p-value[2]
Age, years	60.0 ± 13.7	59.6 ± 7.9	60.2 ± 9.8	63.6 ± 12.9	0.8
Sex					0.11
Male	11 (50.0%)	9 (64.3%)	12 (75.0%)	10 (90.9%)	
Female	11 (50.0%)	5 (35.7%)	4 (25.0%)	1 (9.1%)	
Hx of Smoking	12 (54.5%)	7 (50.0%)	9 (56.2%)	9 (81.8%)	0.4
FHx of IHD	12 (54.5%)	6 (42.9%)	8 (50.0%)	4 (36.4%)	0.8
BMI (kg/m^2)	33.0 ± 5.5	28.7 ± 6.0	27.3 ± 4.6	29.9 ± 3.2	**0.007**
RBS	8.3 ± 2.7	9.8 ± 4.1	9.1 ± 4.9	12.4 ± 6.4	0.095
Total cholesterol	3.8 ± 1.1	3.8 ± 1.2	3.9 ± 1.5	4.1 ± 1.6	0.9
Triglyceride	1.5 ± 0.7	1.4 ± 0.6	1.6 ± 1.3	1.9 ± 1.1	0.6
LDL	1.7 ± 0.8	1.8 ± 1.0	1.8 ± 1.2	1.8 ± 1.3	0.9
SGGT	40.5 (23.5 - 60.0)	45.5 (37.0 - 54.2)	50.5 (39.8 - 57.2)	47.0 (34.5 - 79.0)	0.5
Elevated	7 (31.8%)	5 (35.7%)	3 (18.8%)	3 (27.3%)	0.7

[1]Median (IQR); Mean ± SD; n (%)
[2]Kruskal-Wallis rank sum test; One-way ANOVA; Fisher's exact test

Upon stratifying patients based on their SGGT status, distinguishing between normal and high SGGT levels, a noteworthy association emerged in the comparison of patient characteristics, particularly concerning patient sex (p-value = 0.01). However, no statistically significant associations were observed for the other variables under consideration.

Table 5: Comparison of Demographic Factors and Anthropometric Measures According to SGGT Status.

Characteristic	Normal SGGT, N = 76[1]	High SGGT, N = 24[1]	p-value[2]
Age	60.4 ± 10.9	60.8 ± 12.6	0.9
Sex			**0.010**
Male	51 (67.1%)	9 (37.5%)	
Female	25 (32.9%)	15 (62.5%)	
Body mass index (BMI)	30.4 ± 5.2	31.7 ± 5.7	0.3

[1]Mean ± SD; n (%)
[2] Welch Two Sample t-test; Pearson's Chi-squared test

Characteristic	Normal SGGT, N = 76[1]	High SGGT, N = 24[1]	p-value[2]
Smoking history	39 (51.3%)	10 (41.7%)	0.4
Family history of IHD	32 (42.1%)	11 (45.8%)	0.7

[1]n (%)
[2]Pearson's Chi-squared test

Characteristic	Normal SGGT, N = 76[1]	High SGGT, N = 24[1]	p-value[2]
Random blood sugar (mmol/l)	9.1 ± 4.5	8.4 ± 2.5	0.3
Lipid profile			
Total cholesterol (mmol/L)	3.6 ± 1.1	4.1 ± 1.4	0.2
Serum triglyceride (mmol/l)	1.5 ± 0.9	1.5 ± 0.8	0.8
Low-density lipoprotein (mmol/L)	1.5 ± 0.9	1.9 ± 1.1	0.093

[1] Mean ± SD
[2]Welch Two Sample t-test

Characteristic	Normal SGGT, N = 76[1]	High SGGT, N = 24[1]	p-value[2]
Angiography			0.2
Abnormal	45 (59.2%)	18 (75.0%)	
Normal	31 (40.8%)	6 (25.0%)	

[1]n (%)
[2]Pearson's Chi-squared test

DISCUSSION

Accumulating evidence from epidemiological studies highlights the association between elevated γ-glutamyl transferase (GGT) levels and cardiovascular disease (CVD), including atherosclerosis, underscoring GGT's potential as a biomarker for cardiovascular risk.[15] In this study, patients had an average age of 60.5 ± 11.3 years, with 60% being male and a mean BMI of 30.7 ± 5.3. Aging, often linked with obesity, increases cardiovascular risk by contributing to arterial stiffness and lipid metabolism changes, especially in males who generally face a higher IHD risk due to hormonal and non-hormonal factors.[16, 17] Comparable findings from Christoffersen et al.[18] reported a median age of 56 years in IHD patients and a BMI range of 23 to 28. Hypertension and diabetes were prevalent in 71% and 60% of participants, respectively, with 43% having a positive family history of IHD. These findings are consistent with Rashid et al.'s study[19] in Malaysia, reinforcing the role of these comorbidities as significant IHD risk factors.[20] Angiographic analysis revealed that 37% had normal results, while 22% had single-vessel disease, 14% had two vessels affected, and 16% had three-vessel disease. The left anterior descending artery was the most commonly affected vessel, followed by the right coronary artery and left circumflex artery, similar to findings in Kurdistan by Mohammad et al.[21] and Haider et al.[22] A significant association between smoking, random blood sugar levels, and abnormal angiography was observed, echoing results from Mathew et al.[23] The study found a median GGT value of 40.5, elevated in 24% of patients, with higher GGT levels associated with abnormal angiography ($p < 0.001$) but not with the number of affected vessels.[24] Previous studies by Singh et al.[25] and Arasteh et al.[26] reported progressive GGT increases with the severity of coronary artery disease, while Elahi et al.[27] observed higher oxidative stress in patients with elevated GGT. No significant difference was noted in lipid profiles between patients with normal and elevated GGT, although LDL levels were marginally higher in the latter group.[28] A significant association between GGT levels and sex was observed, with 62.5% of females exhibiting elevated levels, suggesting potential sex-related differences in GGT metabolism and cardiovascular pathology, warranting further research.

CONCLUSION

The current study concluded that serum gamma-glutamyl transferase is prevalent among those with ischemic heart disease, revealing a significant association with positive angiography findings.

REFERENCES

1. Virani SS, Alonso A, Benjamin EJ, et al. Heart Disease and Stroke Statistics—2020 Update: A Report From the American Heart Association. Circulation., 2020; 141(9). doi:10.1161/CIR.0000000000000757
2. Nowbar AN, Gitto M, Howard JP, Francis DP, Al-Lamee R. Mortality From Ischemic Heart Disease. Circ Cardiovasc Qual Outcomes., 2019; 12(6). doi:10.1161/CIRCOUTCOMES.118.005375
3. Cobb FR, Kraus WE, Root M, Allen JD. Assessing risk for coronary heart disease: beyond Framingham. Am Heart J., 2003; 146(4): 572-580. doi:10.1016/S0002-8703(03)00500-3
4. Lippi G, Franchini M, Cervellin G. Diagnosis and Management of Ischemic Heart Disease. Semin Thromb Hemost., 2013; 39(02): 202-213. doi:10.1055/s-0032-1333543
5. Shengyang Jiang DJYT. Role of gamma-glutamyltransferase in cardiovascular diseases. Exp Clin Cardiol., 2013; 18(1): 53-56.
6. Neuman MG, Malnick S, Chertin L. Gamma glutamyl transferase – an underestimated marker for cardiovascular disease and the metabolic syndrome. Journal of Pharmacy & Pharmaceutical Sciences., 2020; 23(1): 65-74. doi:10.18433/jpps30923
7. Koenig G, Seneff S. Gamma-Glutamyltransferase: A Predictive Biomarker of Cellular Antioxidant Inadequacy and Disease Risk. Dis Markers., 2015; 2015: 1-18. doi:10.1155/2015/818570
8. Franco R, Schoneveld OJ, Pappa A, Panayiotidis MI. The central role of glutathione in the pathophysiology of human diseases. Arch Physiol Biochem., 2007; 113(4-5): 234-258. doi:10.1080/13813450701661198
9. Vanni E, Bugianesi E, Kotronen A, De Minicis S, Yki-Järvinen H, Svegliati-Baroni G. From the metabolic syndrome to NAFLD or vice versa? Digestive and Liver Disease., 2010; 42(5): 320-330. doi:10.1016/j.dld.2010.01.016
10. Lonardo A, Ballestri S, Marchesini G, Angulo P, Loria P. Nonalcoholic fatty liver disease: A precursor of the metabolic syndrome. Digestive and Liver Disease., 2015; 47(3): 181-190. doi:10.1016/j.dld.2014.09.020
11. Emdin M. Prognostic value of serum gamma-glutamyl transferase activity after myocardial infarction. Eur Heart J., 2001; 22(19): 1802-1807. doi:10.1053/euhj.2001.2807
12. Huang Z, Wang G, Jonas JB, et al. Blood pressure control and progression of arteriosclerosis in hypertension. J Hypertens., 2021; 39(6): 1221-1229. doi:10.1097/HJH.0000000000002758
13. Siu AL. Screening for Abnormal Blood Glucose and Type 2 Diabetes Mellitus: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med., 2015; 163(11): 861-868. doi:10.7326/M15-2345
14. P Green ·. Optimal angiographic views for invasive coronary angiography: a guide for trainees. British Journal of Cardiology. Published online 2016. doi:10.5837/bjc.2016.028
15. GHATGE M, SHARMA A, VANGALA RK. Association of γ-glutamyl transferase with premature coronary artery disease. Biomed Rep., 2016; 4(3): 307-312. doi:10.3892/br.2016.576
16. Usmanov MM, Chimed-Ochir O, Batkhorol B, Yumiya Y, Hujamberdieva LM, Kubo T. Obesity, Burden of Ischemic Heart Diseases and Their Ecological Association: The Case of Uzbekistan. Int J Environ Res Public Health., 2022; 19(16): 10447. doi:10.3390/ijerph191610447
17. Gheisari F, Emami M, Raeisi Shahraki H, Samipour S, Nematollahi P. The Role of Gender in the Importance of Risk Factors for Coronary Artery Disease. Cardiol Res Pract., 2020; 2020: 1-6. doi:10.1155/2020/6527820

18. Christoffersen M, Frikke-Schmidt R, Schnohr P, Jensen GB, Nordestgaard BG, Tybjærg-Hansen A. Visible Age-Related Signs and Risk of Ischemic Heart Disease in the General Population. Circulation., 2014; 129(9): 990-998. doi:10.1161/CIRCULATIONAHA.113.001696
19. Rashid NA, Nawi AM, Khadijah S. Exploratory analysis of traditional risk factors of ischemic heart disease (IHD) among predominantly Malay Malaysian women. BMC Public Health., 2019; 19(S4): 545. doi:10.1186/s12889-019-6855-5
20. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Canadian Journal of Cardiology, 2018; 34(5): 575-584. doi:10.1016/j.cjca.2017.12.005
21. Ameen M Mohammad HHRQSHBHR and SYS. Demographic, clinical and angiographic profile of coronary artery disease in kurdistan region of Iraq. Am J Cardiovasc Dis., 2021; 11(1): 39-45.
22. Haider KH, Alshoabi SA, Alharbi IA, et al. Clinical presentation and angiographic findings of acute myocardial infarction in young adults in Jazan region. BMC Cardiovasc Disord., 2023; 23(1): 302. doi:10.1186/s12872-023-03335-3
23. Mathew J, Krishna A, Hallak AAI, et al. Clinical and angiographic findings in black patients with suspected coronary artery disease. Int J Cardiol., 1997; 62(3): 251-257. doi:10.1016/S0167-5273(97)00253-2
24. Ndrepepa G, Kastrati A. Gamma-glutamyl transferase and cardiovascular disease. Ann Transl Med., 2016; 4(24): 481-481. doi:10.21037/atm.2016.12.27
25. Singh K, Kapoor A, Khanna R, et al. Serum Gamma Glutamyltransferase (GGT) in coronary artery disease: Exploring the Asian Indian Connection. Ann Card Anaesth., 2022; 25(4): 408. doi:10.4103/aca.aca_62_21
26. Arasteh S, Moohebati M, Avan A, et al. Serum level of gamma-glutamyl transferase as a biomarker for predicting stenosis severity in patients with coronary artery disease. Indian Heart J., 2018; 70(6): 788-792. doi:10.1016/j.ihj.2017.11.017
27. Elahi M, Shabbir S, Khan D, Khan F, Matata B. Serum Gamma Glutamyl Transferase: A Novel Biomarker for Screening of Premature Coronary Artery Disease. Heart Lung Circ., 2010; 19: S35. doi:10.1016/j.hlc.2010.06.747
28. Neemat S, Y. Muhammad Amin K. Evaluation of serum gamma-glutamyl transferase among patients with coronary artery disease in Erbil city. Zanco J Med Sci., 2024; 27(3): 244-252. doi:10.15218/zjms.2023.02