https://doi.org/10.15218/zjms.2023.027

Evaluation of serum gamma-glutamyl transferase among patients with coronary artery disease in Erbil city

Received: 31/07/2022 Accepted: 07/09/2022

Shadan Neemat [1]* Kamaran Y. Muhammad Amin [2]

Abstract

Background and objective: The leading cause of morbidity and mortality globally is coronary artery disease (CAD). One of the recent new parameters for evaluating CAD is Serum GGT, which has been shown to be a predictor of coronary artery status irrespective of the traditional cardiovascular risk variables. This study aimed to evaluate and assess the correlation between serum GGT and other variables among patients with CAD in comparison with healthy subjects.

Methods: A case-control prospective study. Subjects were grouped into Group I (CAD patients-117 individuals) and Group II (healthy Subjects-83 individuals) based on their Coronary Angiographic profile at surgical specialty Hospital-Cardiac Center-Erbil/Iraq. Parameters of S. GGT, S. total cholesterol, S.HDL-C, S.LDL-C, S. VLDL-C, and S.TG, S. (25)OH vitamin D, serum troponin T, S.CK-MB, and CRP were assessed for both groups.

Results: The study population included 58% of male and 42% of female participants, with an age range of 30-77, with a mean of 56.13± 10.5 years old. The Pearson's correlation coefficient of serum GGT with other variables showed that the relation between serum GGT with VLDL-C, CRP, and Triglyceride among CAD patients was found to be a weakly positive correlation and statistically significant (r=0.3, *P* = 0.004), (r=0.2, *P* = 0.031), and (r=0.3, *P* = 0.007) respectively.

Conclusion: The present study showed that S.GGT as a new potential biochemical marker for preclinical atherosclerosis, would be a useful and important marker for assessing and evaluating risk factors of coronary artery disease and to further evaluations for CAD.

Keywords: Coronary artery disease; Gama Glutamyl Transferase; Atherosclerosis.

Introduction

Coronary artery disease (CAD) is the main cause of morbidity and mortality worldwide despite major advancements in primary prevention and treatment measures.[1] The most common underlying pathological mechanism responsible for the majority of clinically significant CAD is coronary artery atherosclerosis. Atherosclerotic CAD encompasses asymptomatic subclinical atherosclerosis as well as its clinical complications; such as angina pectoris, myocardial infarction (MI), and sudden cardiac arrest.[2]

There are modifiable and non-modifiable risk factors that play an important role in the unwanted development of atherosclerosis of the coronary arteries. According to a 2019 study, age, sex, and race accounted for 63 to 80% of prognostic performance, whereas modifiable risk variables had little role. On the other hand, controlling modifiable risk factors resulted in significant decreases in CAD occurrences.[3]

The elevation of serum gamma-Glutamyl transferase (GGT) which is a long-standing hepatobiliary dysfunction marker, has been

[1] Department of Clinical Biochemistry, College of Health Sciences, Hawler Medical University, Erbil, Iraq.
[2] Department of Clinical Biochemistry, University of Salahaddin, Erbil, Iraq.
Correspondence: shadan.nihmat@gmail.com

https://doi.org/10.15218/zjms.2023.027

established as a risk factor for both coronary and cerebrovascular events in both unselected populations and individuals with confirmed CAD.[4] Moreover, GGT found in atherosclerotic plaques may make lesions more vulnerable by increasing oxidative stress, cellular apoptosis, plaque rupture, and eventual thrombosis.[5,6] GGT has been shown to be a predictor of cardiovascular (CV) mortality in CAD patients irrespectively of the traditional CV risk variables.[7]

Previous studies have demonstrated the association of serum GGT with cardiovascular disease, diabetes, and metabolic syndrome,[5,8] it has been suggested as a predictive factor for the incidence of CAD and cardiovascular-related mortality.[7,9] Also, it has been shown that GGT might be used as an essential marker for cardiovascular disorders, including CAD.[7,10]

As there are insufficient data regarding the association between GGT and CAD in our region, we aimed to evaluate and assess the association between Serum GGT and other variables among patients with CAD in comparison with Healthy control subjects, as well as investigate the possibility of using this parameter as a contributing biomarker when compared to levels amongst the healthy subjects.

Methods

1. Study population and design of the study:

A case-control prospective study. The subjects of our study were grouped into two categories:

CAD patients (group I): included a hundred and seventeen patients with coronary artery disease (CAD), who attended surgical specialty hospital- Cardiac Center/ Erbil City-Iraq and were diagnosed with CAD based on angiographic profile.

Healthy controls (group II): eighty-three selected subjects served as controls, all were healthy volunteers and had no evidence of CAD.

2. Collection of blood samples:

A total of 200 blood samples were collected from 117 CAD patients and 83 healthy controls. The obtained samples underwent a 10-minute centrifugation process at 3500 rpm. The separated serums were used for the measurement of S. GGT (for males is (8-61 U/L) and for females (5-36 U/L), S. total cholesterol (below 200 mg/dl in adults), S.HDL-C (35-45 mg/dl for females and 45-55g/dl for males), S.LDL-C (Below 100 mg/dl), S. VLDL-C (less than 40 mg/dl), VLDL-C was calculated by using the fried Ewald equation (VLDL-C (mg/dl) = TG/5), S.TG (below 150 mg/dl), S. 25 OH vitamin D (≥ 30 ng/mL), serum troponin T hs (below 25 pg/dl.), S.CK-MB (below 25 IU/L for males and females), and CRP (5 mg/L).

3. Devices and principles for determining the laboratory parameters

Fully automated biochemistry analyzer COBAS E 411 ROCH Germany for 25-hydroxyvitamin D (25(OH) D) and Troponin T hs measurement. Fully automated biochemistry analyzer COBAS Integra 400 plus ROCH Germany for lipid profile, CK-MB, GGT, S. Creatinine, and CRP measurements. Lipid profile, S. Creatinine, and S.GGT were determined for cases and controls by an enzymatic colorimetric method.

Regarding the principle of CRP, Human CRP binds to latex particles that have been coated with monoclonal anti-CRP antibodies. The precipitate is determined turbid metrically at 552nm. The electrochemiluminescence binding assay is used for the determination of Serum 25-hydroxyvitamin D (25(OH) D) and the electrochemiluminescence immunoassay “ECLIA” for the determination of Troponin T hs. The Immunological UV assay principle was used for determining CK-MB.

4. Inclusion and exclusion criteria:

Both genders, adults aged 30 years and above were included, Exclusion criteria were previous percutaneous coronary intervention within 12 months before enrollment, vitamin D/multivitamin

https://doi.org/10.15218/zjms.2023.027

supplements and/or calcium supplementation within 12 months before enrollment, cancer (being under treatment and/or diagnosed with malignancies), chronic kidney disease—stage 3 or higher), liver dysfunction (including viral hepatitis, cholestasis jaundice), ischemic or hemorrhagic stroke during 12 months before admission.

5. Study timeline:

The present study was carried out from the 5th of September 2021 to the 20th of December 2021 at SSH/Cardiac Center- Erbil/Iraq.

6. Statistical analysis:

All statistical data were analyzed using SPSS Statistics 25 (SPSS Inc., Chicago, IL, USA), Graph Pad Prism 9 (Graph Pad Software Inc., San Diego, CA, USA), and MedCalc. The Shapiro–Wilk test and Kolmogorov-Smirnov test were used to determine whether a random sample was normally distributed. The student t-test for two independent sample groups was used. The results were expressed as counts and percentages for the categorical data and mean ± standard error of mean or median and inter quartile range (lower and upper quartiles) for the continuous normally or non-normally distributed variables respectively.

To examine the significance of relationships between independent and dependent variables, the Chi-Square test was applied. The relationship between GGT and other variables was evaluated by Pearson's and Spearman's rank correlation coefficient test depending on the normality result. A p-value equal to or less than 0.05 was regarded to be statistically significant.

6. Questionnaire form design:

The data collection instrument is a structured direct interviewer-administered face-to-face questionnaire that is pretested with modifications made before its use in the study,in conjunction with access to medical records or documents that are individually identifiable, include sensitive personal data, and are not readily available to the public. The questionnaire includes the demographic variables (name, age, gender, home address, time, and date), clinical risk factors of the patient, family history, and smoking habits of the patient.

The weight of the study subjects was determined using a calibrated digital scale (Seca 890), along with participants dress in loose clothing and taking off their shoes. The participant's weight was predicted to be reduced by an average of one kilogram to compensate for the weight of their clothing. Using a portable tape measure that was mounted on the wall, the participants' heights were calculated in centimetres. Participants were instructed to stand barefoot with their backs to the wall. Body Mass Index (BMI), which is calculated by dividing an individual's weight in (kilograms) by the square of their height (in meters). A BMI of 18.5 to 24.9 or higher was viewed as normal weight, a BMI of 25 or higher is regarded as overweight, and a BMI of 30 or higher is considered obese.

7. Ethical considerations:

Ethical approval was obtained from the ethics committee of Hawler Medical University. Verbally Informed consent was taken from each patient. A Complete explanation of the nature and aim of the study was given to each participant, and reassuring about the confidentiality of the data and their anonymity.

Results

A total of 200 subjects from both groups were included, 58.5% of them were cases and 41.5% were controls and the mean age was 56.13±10.5 with a range of 30-77 years old. In regards to the risk factors among case and control groups of the study population, the Chi-square test analysis observed that there is a statistically significant difference between the two groups of subjects in most of the risk factors of CAD, including hypertension, Diabetes mellitus, hyperlipidemia, stressful life, watching Television, smoking, lifestyle, gender, age, and physical inactivity with a *P*-vale of (0.002, <0.001,< 0.001, 0.010,

https://doi.org/10.15218/zjms.2023.027

0.019, 0.003, 0.005,<0.001, 0.001, and 0.005), respectively.

Furthermore, upon analyzing the risk factor differences between patients and healthy individuals the frequency of DM was higher (44.4%) among the case group than in the control group (20.5). The prevalence of hypertension among the case group was (58.1%) and among the control group was (36.1%). Hyperlipidemia as a strong risk factor for CAD was higher among all case groups (48.7%) compared to a smaller population of control groups which was (24.1%). The frequency of CAD was higher among male patients in comparison to the healthy male controls. The percentage of physical inactivity was significantly higher among CAD-established patients compared to a smaller group of control groups. this information is summarized in Table 1.

Table 1 The baseline characteristics of the studied individuals.

Characteristics	Patients (no. %)	Control (no. %)	*P*-value*
Hypertension	68 (58.1)	30 (36.1)	0.002
Age (in years)			
≤49	21 (17.9)	34 (41)	
50-59	35 (29.9)	24 (28.9)	0.001
60-69	43 (36.8)	21 (25.3)	
≥70	18 (15.4)	4 (4.8)	
Hyperlipidemia	57 (48.7)	20 (24.1)	<0.001
Gender			
Male	84 (71.8)	32 (38.6)	<0.001
Female	33 (28.2)	51 (61.4)	
Diabetes mellitus	52 (44.4)	17 (20.5)	<0.001
BMI			
Normal weight	19 (16.4)	13 (15.7)	
Overweight	42 (36.2)	33 (39.8)	0.877
Obese	55 (47.4)	37 (44.6)	
Physical-inactivity	82 (70.1)	43 (50.5)	0.005
Smoking Status			
Smoker	17 (14.5)	13 (15.7)	
Non-smoker	72 (61.5)	65 (78.3)	0.003
Ex-smoker	28 (23.9)	5 (6.0)	
Watching Tv	92 (78.6)	64 (77.1)	0.019
Lifestyle			
Active	35 (29.9)	41 (49.4)	0.005
Inactive	82 (70.1)	42 (50.6)	
Stressful life	64 (54.7)	30 (36.1)	0.010
Family history	53 (45.3)	47 (55.3)	0.123

*Data are analyzed by Chi-square test and results are presented as frequency (percentage).

https://doi.org/10.15218/zjms.2023.027

There was a significant difference between the mean level of total cholesterol among the cases and controls. Unsurprisingly, the case had a higher total-cholesterol level (241.5±10.4) compared to the control (99.18±1.52). This was significant with a *P*-value of <0.001. The controls had higher HDL levels (35.43±0.94) compared to the cases (31.77±0.72) and were statistically significant with a *P* = 0.002.

The cases had higher mean LDL-cholesterol levels (111.5±2.87) than the control (61.93±2.59) and were highly significant, with a *P* <0.001. The mean of VLDL-cholesterol levels was higher among non-CAD subjects (33.65±2.03) than those in CAD patients (29.39±1.63) but statistically non-significant with a *P* = 0.103. The mean triglyceride level was found to be higher among the controls (165.5±8.87) rather than in the cases (149.2±7.85), but not statistically significant *P* = 0.167.

The serum Gamma-Glutamyl Transferase levels were found to be higher among the cases (36.04±3.00) compared to their levels in controls (26.95±1.93), and this was statistically significant with a *P*-value of 0.011. The cases had a higher CRP level (6.27±0.92) than the controls (2.91±0.33), with a statistically significant *P* value of (0.010). Although the mean serum vitamin D levels were found to be higher among controls (23.07±1.53) in comparison to cases (21.86±1.13), but statistically non-significant, with *P* = 0.531.

Unsurprisingly the mean of troponin T levels was found to be very high among CAD patients (60.06±13.95), compared to normal subjects (6.86±0.46), and this was statistically significant *P* = 0.002. The mean of CK-MB levels was higher among CAD patients (16.27±1.07) compared to healthy subjects (12.02±0.58), and statistically significant with a *P* value of 0.002. This information is summarized in Table 2.

Table 2 A comparison of the mean value of laboratory parameters among CAD patients and non-CAD patients.

Parameters	Patients (mean ±SE)	Controls (mean ±SE)	*P*-value
Total Cholesterol (mg/dl)	241.5±10.4	99.18±1.52	<0.001
HDL-C (mg/dl)	31.77±0.72	35.43±0.94	0.002
LDL-C (mg/dl)	111.5±2.87	61.93±2.59	<0.001
VLDL-C (mg/dl)	29.39±1.63	33.65±2.03	0.103
Triglycerides (mg/dl)	149.2±7.85	165.5±8.87	0.267
CRP (mg/L)	6.27±0.92	2.91±0.33	0.010
25(OH)D (ng/ml)	21.86±1.13	23.07±1.53	0.531
GGT(U/L)	36.04±3.00	26.95±1.93	0.011
Troponin T hs (pg/ml)	60.06±13.95	6.86±0.46	0.002
CK-MB (IU/L)	16.27±1.07	12.02±0.58	0.002

* Data are analyzed using an independent T-test and results are presented as (Mean±SE).

https://doi.org/10.15218/zjms.2023.027

Searching for correlation of Serum GGT with other variables, the Pearson's rho correlation coefficient test between Serum GGT with VLDL-Cholesterol, CRP, and Triglyceride among CAD patients was found to be a weakly positive correlation and statistically significant (r=0.3, *P* = 0.004), (r=0.2, *P* = 0.031), and (r=0.3, *P* = 0.007) respectively, hence Ha is supported. This information is provided in Table 3.

Table 3 The Correlation Analysis between Gamma-Glutamyl Transferase Levels and Coronary Artery Disease Risk Factors and laboratory parameters.

Parameters	Gamma Glutamyltransferase CAD patients (n=117)	
	R	***P*-value**
Total Cholesterol (mg/dl)*	0.1	0.281
LDL-Cholesterol (mg/dl)*	-0.05	0.564
HDL-Cholesterol (mg/dl)*	-0.01	0.880
Triglycerides (mg/dl)*	0.3	0.007
VLDL-Cholesterol (mg/dl)*	0.3	0.004
Serum CK-MB (IU/L)*	0.06	0.518
SerumTroponinThs(pg/ml)*	0.07	0.448
CRP (mg/l)*	0.2	0.031
25(OH)D (ng/ml)*	-0.1	0.452
Age (years)**	-0.16	0.088
Body Mass Index**	-0.08	0.375

*****Data are analyzed by Pearson's correlation coefficient test.
****** Data are analyzed by spearman's correlation coefficient test.

https://doi.org/10.15218/zjms.2023.027

Discussion

Although there are many available preventive and therapeutic approaches for cardiovascular disease, coronary heart disease is still regarded as one of the leading causes of death. We have set out to assess the serum GGT in patients with CAD. Numerous studies suggest that GGT may serve as a biochemical indicator of preclinical atherosclerosis. It was detected in atheromatous plaques of carotid and coronary arteries, triggering the oxidation of low-density lipoproteins (LDLs).[6,11] The present case-control study aimed to shed light on the main risk factors of CAD among healthy and CAD patients and to assess the association of S. GGT among each group.

Based on findings most of the patients diagnosed with CAD were among old aged groups, aged between 60-69 years old 43 (36.8%), as Age is a significant independent risk factor for CVD and the prevalence of most types of CVDs is considerably higher among older adults as compared with the general population.[12] Moreover,about two-thirds of patients with CAD were male (71.8%), in line with this finding, Jamee et al reported that incidents of CAD were higher in males than in females.[13] The logical reason for this might be due to the protective effects of the female –Estrogenic- hormone.

Findings of this study have shown that 47% of patients with CAD were obese, similar results to those reported by Ndumele and co-workers, mentioning that obese patients were twice as likely to have coronary heart disease after adjustment for demographics, smoking, physical activity, and alcohol intake.[14] Common risk factors for atherosclerosis including dyslipidemia, diabetes mellitus, hypertension, smoking, and advanced age all play a part to stimulate the production of free oxygen radicals, either by endothelial cells or by vascular smooth muscle cells and adventitial cells. According to our study findings, the frequency of smokers was significantly higher in the CAD-affected group compared to a non-CAD-affected group, similar observations have been made by Ghatge and his colleagues, who showed that smokers were twice likely to have coronary artery disease.[15]

The incidence of hypertension was also significantly higher among CAD patients, in line with this finding, sheikh and co-authors revealed that the CAD-affected subjects had a higher frequency of hypertension compared to the unaffected subjects.[7] The rate of diabetes mellitus was about three times significantly higher in CAD-affected patients compared to the healthy control group, similar to results reported by Ghatge and his colleagues, who mentioned that The CAD-affected subjects had high-frequency diabetes compared to the unaffected subjects.[15]

The findings demonstrated that the mean LDL-C was significantly higher among CAD patients in comparison to the control group, by contrast, a study conducted Ghatge and co-workers, indicated that the affected subjects had a lower level of LDL-C compared to the unaffected, possibly due to statin usage in this group.[15] Patients with coronary events significantly had higher total cholesterol levels, parallel to results reported by Meisinger et al.[9] However, HDL-C levels were significantly lower in the patient group in two studies carried out by,[9,16] and these results are parallel to our study's outcomes.

In the present study, a pilot investigation was performed to show this possible association between CAD and GGT levels. This research clearly demonstrates that serum GGT levels were higher among CAD patients compared to the healthy control group (36.04±3.00 U/L versus 26.95±1.93U/L, P = 0.01), several studies support these results, in a study done by Demircan et al. GGT levels were higher in patients with CAD than in the control group,[17] Emiroglu et al had found similar results.[18] Another study done by Ghatge *et al.* showed that the mean GGT levels were significantly higher in CAD-affected subjects in comparison with

https://doi.org/10.15218/zjms.2023.027

the non-CAD subjects.[15]

In regards to this study's findings, the mean CRP levels were significantly higher in CAD-affected subjects in comparison with the unaffected subjects. Atherosclerosis is generally accepted as an inflammatory disorder. CRP level is a strong predictor of cardiovascular events in patients with CAD. In our study, similar to GGT activity, CRP levels were significantly different between patients with and without CAD, but this was in contrast to the study done by Ghatge et al, there was no significant difference in CRP in CAD patients compared to healthy control groups.[15]

Previously several studies have shown the association of increased GGT levels with CAD risk factors and CAD development however, to the best of our knowledge, there are no studies evaluating the association of increased Serum GGT levels among CAD patients in this region. A prospective study including 469 patients with ischemic syndrome and CAD confirmed that GGT activity is an independent prognostic marker of incidence of cardiac death and infarction.[6] In addition, a positive and independent correlation between baseline levels of GGT and the risk of sudden cardiac death in the general male population was confirmed in a cohort study with a 22-year follow-up.[19] We found that GGT has a significant positive correlation with triglyceride levels, similar to results reported by akpek et al and Jimba et al.[16,20] This study's Findings emphasize that Serum GGT levels correlated positively according to (Spearman's rho) with VLDL-C, in agreement with the results of Dhanju and co-authors, who showed that there is a statistically significant positive relationship in GGT with VLDL-C among CAD patients.[21] The available data have shown a significant positive relationship between GGT and CRP, these results are also supported by Akpek and his colleagues.[16] Another study by Emiroglu supported our results, who performed a comparative analysis of serum GGT and CRP in a trial involving 219 patients presenting with the acute coronary syndrome (ACS) and 51 control subjects, Results of the investigation revealed that blood GGT and hs-CRP levels were greater in ACS patients compared to controls and that there was a modest but significant association between GGT and CRP.[18]

Conclusion

In summary, to the best of our knowledge, this is the first study assessing Serum GGT among CAD-established patients in this region. Our study has identified a link between GGT and the Pathophysiology of CAD. Additionally, Serum GGT activity has shown a mild to moderate positive correlation with Serum triglycerides, S.VLDL-C, and CRP, taken together, these changes might further contribute to a higher cardiovascular risk in CAD patients. Further large-scale studies are warranted to corroborate the causality relationship. Under the findings of this study, we conclude that Serum GGT would be a useful and important biomarker for assessing and predicting the risk of CAD. Screening for Serum GGT is an accurate and less cost-effective test that could quickly identify patients with CAD or patients who need baseline evaluation of the pathophysiology of underlying undetected CAD.

Funding

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Amen SO, Baban ST, Yousif SH, Baban ZT, Hawez AH, Jalal DMF. High Prevalence of Vitamin D Deficiency in Patients with Acute Myocardial Infarction: An Iraqi Single-Center Study. Med *J Babylon* 2020; 17(4):5. DOI: 10.4103/MJBL.MJBL_67_19
2. Dai X, Wiernek S, Evans JP, Runge MS. Genetics of coronary artery disease and myocardial infarction World J Cardiol 2016; 8(1):1–23. https://doi.org/10.4330%2Fwjc.v8.i1.1

3. Brown JC, Gerhardt TE, Kwon E. Risk Factors for Coronary Artery Disease. StatPearls Publishing, Treasure Island (FL) 2020.
4. Emdin M. Prognostic value of serum gamma-glutamyl transferase activity after myocardial infarction. Eur Heart J 2001; 22(19):1802–7. https://doi.org/10.1053/euhj.2001.2807
5. Ndrepepa G, Colleran R, Kastrati A. Gamma-glutamyl transferase and the risk of atherosclerosis and coronary heart disease. Clin Chim Acta 2018; 476:130–8. https://doi.org/10.1016/j.cca.2017.11.026
6. Wang J, Li X, Pu J, Jin S, Jia L, Li X, et al. Association between Gamma-Glutamyl Transferase and Coronary Atherosclerotic Plaque Vulnerability: An Optical Coherence Tomography Study. Biomed Res Int 2019; 2019:1–11. https://doi.org/10.1155%2F2019%2F9602783
7. Sheikh M, Tajdini M, Shafiee A, Sotoudeh Anvari M, Jalali A, Poorhosseini H, et al. Association of serum gamma-glutamyl transferase and premature coronary artery disease. Neth Heart J 2017; 25(7–8):439–45. https://doi.org/10.1007/s12471-017-0964-5
8. Danikiewicz A, Hudzik B, Nowak J, Kowalska J, Zieleń-Zynek I, Szkodzinski J, et al. Serum Gamma Glutamyl transferase Is Associated with 25-Hydroxyvitamin D Status in Elderly Patients with Stable Coronary Artery Disease. IJERPH 2020; 17(23):8980. https://doi.org/10.3390/ijerph17238980
9. Meisinger C, Döring A, Schneider A, Löwel H. Serum γ-glutamyltransferase is a predictor of incident coronary events in apparently healthy men from the general population. Atherosclerosis 2006; 189(2):297–302. https://doi.org/10.1016/j.atherosclerosis.2006.01.010
10. Bharani V, Ramesh V, Rao RN, Tewari S. Evaluation of gamma-glutamyl transferase as a marker of cardiovascular risk, in 200 angiographically proven coronary artery disease patients. Indian Heart J 2017; 69(3):325–7. https://doi.org/10.1016/j.ihj.2017.03.010
11. Kotani K, Tsuzaki K, Sakane N. The Relationship Between Gamma-Glutamyltransferase (GGT), Bilirubin (Bil) and Small Dense Low-Density Lipoprotein (sdLDL) in Asymptomatic Subjects Attending a Clinic for Screening Dyslipidaemias. Ann Acad Med Singap 2014; 43(4):216–9.
12. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, et al. Heart Disease and Stroke Statistics—2018 Update: A Report From the American Heart Association. Circ J 2018; 137(12). https://doi.org/10.1161/cir.0000000000000558
13. Jamee A, Abed Y, Jalambo MO. Gender Difference and Characteristics Attributed to Coronary Artery Disease in Gaza-Palestine. GJHS 2013; 5(5):51. https://doi.org/10.5539/gjhs.v5n5p51
14. Ndumele CE, Matsushita K, Lazo M, Bello N, Blumenthal RS, Gerstenblith G, et al. Obesity and Subtypes of Incident Cardiovascular Disease. JAHA 2016; 5(8). https://doi.org/10.1161/JAHA.116.003921
15. Ghatge M, Sharma A, Vangala RK. Association of γ-glutamyl transferase with premature coronary artery disease. Biomedical Reports 2016; 4(3):307–12. https://doi.org/10.3892/br.2016.576
16. Akpek M, Elcik D, Kalay N, Yarlioglues M, Dogdu O, Sahin O, et al. The Prognostic Value of Serum Gamma Glutamyl Transferase Activity on Admission in Patients with STEMI Undergoing Primary PCI. Angiology 2012; 63(8):579–85. https://doi.org/10.1177%2F0003319711431880
17. Demircan S, Yazici M, Durna K, Kilicaslan F, Demir S, Pinar M, et al. The Importance of Gamma-Glutamyltransferase Activity in Patients with Coronary Artery Disease. Clin Cardiol 2009; 32(4):220–5. https://doi.org/10.1002/clc.20345
18. Emiroglu MY, Esen ÖB, Bulut M, Karapinar H, Kaya Z, Akcakoyun M, et al. Gamma glutamyl transferase levels and its association with high sensitive C-reactive protein in patients with acute coronary syndromes. N Am J Med Sci 2010; 2(7):5. https://doi.org/10.4297/najms.2010.2306
19. Kunutsor SK, Bakker SJL, Kootstra-Ros JE, Gansevoort RT, Dullaart RPF. Circulating gamma glutamyl transferase and prediction of cardiovascular disease. Atherosclerosis 2015; 238(2):356–64. https://doi.org/10.1016/j.atherosclerosis.2014.12.045
20. Jimba S, Nakagami T, Oya J, Wasada T, Endo Y, Iwamoto Y. Increase in γ-Glutamyl transferase Level and Development of Established Cardiovascular Risk Factors and Diabetes in Japanese Adults. Metab Syndr Relat Disord 2009; 7(5):411–8. https://doi.org/10.1089/met.2008.0082
21. Dhanju AS, Singla D, Singh P, Chhabra A, Kaur S. Study on evaluation of serum gamma-glutamyl transferase (GGT) levels in acute coronary syndrome. IJAR 2021; 39–40. http://dx.doi.org/10.36106/ijar/4109004