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Original Research Article

A study on gamma-glutamyl transferase and C-reactive protein levels in type 2 diabetes mellitus patients and their correlation with glycosylated hemoglobin levels

Allareddy Sathvika*, Uma M. Anand Kumar, Harish Kumar S., Kotthinti A. Kumar

Department of General Medicine, P.E.S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh, India

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***Correspondence:**
Dr. Allareddy Sathvika,
E-mail: sathvika1111reddy@gmail.com

ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a growing global health concern. Oxidative stress and chronic inflammation have been implicated in its pathophysiology. Gamma-glutamyl transferase (GGT) and C-reactive protein (CRP) are potential biomarkers associated with glycemic control. This study aims to estimate serum GGT, CRP, and glycated hemoglobin (HbA1c) levels in T2DM patients and evaluate their correlation. Aims and objectives of the study were to assess the serum levels of GGT and CRP in T2DM patients and analyze their correlation with HbA1c.
Methods: A cross-sectional observational study was conducted on 93 T2DM patients at P.E.S. Medical College Hospital, Kuppam. Patients underwent testing for serum GGT, CRP, and HbA1c. Data were analyzed using statistical package for the social sciences (SPSS) v26. Correlation between GGT, CRP, and HbA1c was evaluated using Pearson's correlation, with $p<0.05$ considered statistically significant.
Results: The mean age of participants was 59.34±10.7 years; 67.7% were male. Mean GGT, CRP, and HbA1c levels were 41.51±24.8 mg/dl, 11.14±11.4 mg/dl, and 7.83±1.59 mmol/l, respectively. A strong positive correlation was found between serum GGT and HbA1c ($r=0.900$, $p<0.001$), and a weaker but significant correlation between CRP and HbA1c ($r=0.047$, $p=0.030$).
Conclusions: Elevated serum GGT and CRP levels were observed in T2DM patients. GGT showed a strong positive correlation with HbA1c, suggesting its utility as a marker of oxidative stress and glycemic control. CRP also correlated significantly, indicating a role for inflammation in diabetes progression.

Keywords: Type 2 diabetes mellitus, Gamma-glutamyl transferase, C-reactive protein, HbA1c

INTRODUCTION

In 2020, 9.2% of people worldwide have diabetes mellitus (DM).[1] Globally, the prevalence of DM has been rising. Globally, 463 million persons aged 20 to 79 had diabetes in 2019, which is projected to have resulted in 1.5 million deaths. By 2045, this figure is anticipated to increase to 700 million.[2]

The development of diabetes has been linked to elevated levels of gamma-glutamyl transferase (GGT or γ-GT) enzyme and highly sensitive C-reactive protein (CRP), according to recent prospective studies. CRP is a nonspecific biomarker of acute inflammation and is mainly produced in the liver. Several studies showed that serum CRP accelerates or increases diabetes onset, especially in women.[3-5] Its blood level might range from 50 to 100 mg/l in acute infections, but it often doesn't go above 10 mg/l in chronic inflammatory diseases like atherosclerosis.[6] It is well known that CRP has a precise diagnostic and prognostic function in a variety of disorders, including atherosclerosis, cancer, trauma, diabetes mellitus, and cardiovascular diseases. There is growing evidence that liver enzymes, like γ-GT or GGT, which are used as

indicators of liver disease or alcohol consumption, have a dose-response relationship with incident diabetes even within their normal range. They may also be able to predict the onset of diabetes in both sexes without the need for conventional risk factors.[7,8]

GGT, an enzyme in the outer layer of most cells, aids in the absorption of glutathione, an essential component of internal antioxidant defences. Serum GGT's role in controlling the extracellular glutathione (GSH) transport route forms the basis of intracellular antioxidant defences. Numerous pathogenic conditions, including athero-sclerosis, ageing, carcinogenesis, and reperfusion injury, inflammation, are linked with oxidative stress.[9,10] Chronic inflammation causes an increase in the acute phase protein known as high sensitivity CRP. It is composed of five identical non-glycosylated polypeptide subunits that belong to the pentraxin protein family.[11]

To stop the progression and emergence of problems, alternative early markers for the early stages of the pathophysiology of diabetes, oxidative stress, and chronic inflammation were required. Using early indicators of oxidative damage and inflammation to target inflammatory and oxidative pathways may be part of the methods to prevent and manage diabetes and microvascular problems. The study aims to estimate the serum GGT, CRP, and glycosylated hemoglobin (HbA1C) levels in type 2 diabetes mellitus (T2DM) patients and to correlate serum GGT and CRP levels with HbA1C levels in T2DM.

METHODS

This cross-sectional observational study was conducted over 10 months from 01 August 2024 to 31 May 2025 at P.E.S. Medical College Hospital, Kuppam, Andhra Pradesh, India. The study population comprised patients with T2DM who visited or were admitted to the Department of General Medicine during the study period. A purposive sampling method was employed to select participants. The sample size was estimated based on a reported diabetes prevalence of 8.9% in India, as per Ramachandran et al.[12] Using the formula given, where p=8.9%, q=91.1%, and the absolute error, l=6%, the final sample size was determined to be approximately 93 patients.

$$n = 4pq/l^2$$

Patients were included if they had a confirmed diagnosis of T2DM and were receiving care in the general medicine department. Exclusion criteria included chronic alcohol use, obstructive jaundice, pancreatitis, pregnancy, acute febrile illness, known autoimmune disorders such as rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE), and type 1 diabetes mellitus. After obtaining written informed consent, data were collected using a structured proforma that included demographic details, clinical history, medication use, physical examination findings, and results of relevant laboratory investigations.

All enrolled patients underwent a series of investigations including fasting blood glucose, postprandial blood glucose, HbA1c, fasting lipid profile, serum GGT, serum CRP, liver function tests, renal function tests, 12-lead electrocardiography (ECG), fundus examination, and complete urine analysis. Additional investigations were performed as needed to rule out other conditions. All blood tests were performed at the time of admission. Patients were managed according to standard institutional protocols. To assess associations with glycemic control, a comparison of serum GGT and CRP levels was made between patients with HbA1c levels <7% and those with levels ≥7%.

Data entry was done using Microsoft Excel 2021, and statistical analysis using statistical package for the social sciences (SPSS) version 26.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were presented as frequencies and percentages for categorical variables and as means and standard deviations for continuous variables. Correlation analysis was used to evaluate associations, and categorical data were analyzed using the Chi-square test. A p value of less than 0.05 was considered statistically significant.

RESULTS

Around 93 patients were included in the study. Out of the total participants, 63 (67.7%) were male and 30 (32.3%) were female. The majority of patients were in the 61–75 years age group (32%), followed by 46–60 years (27%). The mean age of the study participants is 59.34 years with SD of 10.7 years. Patients aged 30–45 years and those over 76 years each accounted for 10% of the study population. (Table 1). The mean serum GGT level was 41.51±24.8 mg/dl. The mean CRP level was 11.14±11.4 mg/dl, and the mean HbA1c level was 7.83±1.59 mmol/l (Table 2).

Table 1: Socio-demographic profile of study participants.

Category	Frequency (N)	Percentage (%)
Age group (years)		
30–45	9	10.0
46–60	25	27.0
61–75	30	32.0
>76	9	10.0
Gender		
Male	63	67.7
Female	30	32.3

A statistically significant positive correlation was observed between serum GGT and HbA1c levels (r=0.900, p<0.001). A weak but statistically significant correlation was also noted between CRP and HbA1c levels (r=0.047, p=0.030) (Table 3).

Table 2: Mean and standard deviation of serum GGT, CRP, and HbA1c levels (n=93).

Parameters	Mean	Standard deviation
Serum gamma-glutamyl transferase (mg/dl)	41.51	24.80
C-reactive protein (mg/dl)	11.14	11.40
HbA1c (mmol/l)	7.83	1.59

Table 3: Correlation of serum GGT and CRP levels with HbA1c in patients with type 2 diabetes mellitus (n=93).

Variables	Correlation with HbA1c (r)	P value
Serum gamma-glutamyl transferase (mg/dl)	0.900	<0.001*
C-reactive protein (mg/dl)	0.047	0.030*

*-Significant.

DISCUSSION

Among the population, between 30-45 years and >76 years among the 10% of the population each, between 46-60 years among the 27%, and between 61-75 years among the 32% of the population. The mean age of the study participants is 59.34 years with SD of 10.7 years. In Arbab et al study, the mean age of the patients was 54.8±8.2 and the mean age of the controls was 57.3±9.3.[13] In the study by Gautam et al, diabetic cases aged <40 years (17.5%) and >40 years (82.5%) were segregated by gender. Most (57.7%) of the patients were between 40 to 60 years old with a range of 19 to 84 years.[14]

The mean and SD of serum GGT is 41.51 and 24.8 mg/dl. In Arbab et al study, the mean GGT levels of the patients were 35.1±21.2 mg/dl and the mean age of the controls was 16.6±5.7 mg/dl.[13] The mean and SD of CRP are 11.14 and 11.4 mg/dl. In the study by Arbab et al, mean CRP levels of the patients were 26.4±21.3 mg/dl and in controls was 3.4±0.8 mg/dl. In the study by Ammar ul Hassan et al, the mean of serum CRP in group I was (11±6.02 mg/l), group II (62.07±26.94 mg/l) and group III (107.73±57.03 mg/l).[13] In study by Sharma et al, the mean value of Hs-CRP in DM cases was 8.94±2.54 mg/l and 1.52±0.98 mg/l in controls (p value <0.0005), with comparable Hs-CRP levels with gender distribution in cases (9.07±2.78 mg/l in females, 8.81±2.23 mg/l in males, p value 0.657).[15] In the current study, the mean HbA1C levels were 7.83±1.59. In Arbab et al, mean HbA1C levels of the patients were 9.3±2.1 and the mean age of the controls was 5.3±0.6.[13] Of these 154 patients, 29 (18.8%) had their diabetes under control (HbA1C level was less than 5.7%), whereas 39 (25.3%) patients were in a prediabetic state and 86 (55.8%) poorly controlled diabetics (HbA1C level >6.5%).[13] In the study by Sharma et al, the mean value of HbA1C was 9.24±1.97% in cases and 4.35±0.94 in controls (p value <0.0005) with comparable HbA1C levels with gender distribution in cases (9.38±1.93% in females, 9.1±2.04% in males, p value=0.433).[15]

In the current study, a statistically significant positive correlation was observed between serum GGT and HbA1c levels (r=0.900, p<0.001). A weak but statistically significant correlation was also noted between CRP and HbA1c levels (r=0.047, p=0.030). In the study by Sharma et al, there was a significant positive correlation of HbA1C with GGT (r=0.479, p≤0.00001).[15] In Babu et al, the mean hs-CRP levels for those with poor and good glycemic control were considerably higher. Between the three groups, there was a significant difference in hs-CRP levels (p value <0.001).[16] When compared to the control group, the mean serum GGT levels were likewise higher in those with good and poor glycemic control. Serum GGT levels between the three groups, p value <0.001. The mean serum HbA1C levels and fasting blood sugar levels (FBS) were also significantly raised in poor glycemic control and good glycemic control subjects when compared to normal healthy subjects, p value <0.001.

This study was limited by its cross-sectional design, which prevents establishing a causal relationship between GGT, CRP, and HbA1c levels. It was conducted at a single center with a relatively small sample size, which may affect the generalizability of the findings. Additionally, the study did not include a control group of non-diabetic individuals for comparison.

CONCLUSION

This study demonstrated that patients with type 2 diabetes mellitus exhibited elevated serum levels of GGT, CRP, and HbA1c. A strong positive correlation was found between serum GGT and HbA1c levels, indicating a significant association between oxidative stress and glycemic control. Additionally, CRP showed a weaker but statistically significant positive correlation with HbA1c, suggesting that inflammation also plays a role in diabetes pathophysiology. These results highlight the potential utility of serum GGT and CRP as accessible biomarkers for monitoring glycemic status and the underlying oxidative and inflammatory processes in T2DM.

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