



Muhammed Fuad USLU^{1, a}
Sevler YILDIZ^{2, b}
Muhammed Fatih TABARA^{3, c}

¹ Elazığ Fethi Sekin City
Hospital,
Department of Internal
Medicine,
Elazığ, TÜRKİYE

² Elazığ Fethi Sekin City
Hospital,
Department of Psychiatry,
Elazığ, TÜRKİYE

³ Fırat University,
Faculty of Medicine,
Department of Psychiatry,
Elazığ, TÜRKİYE

^a ORCID: 0000-0001-6300-5130

^b ORCID: 0000-0002-9951-9093

^c ORCID: 0000-0002-7479-5622

Investigation of Triglyceride-Glucose Index and Triglyceride/HDL Levels in Criminalized Schizophrenia Patients

Objective: Recently, changes in hemogram and biochemical blood parameters in schizophrenia patients have been associated with disease symptoms. We aimed to investigate triglyceride-glucose index and triglyceride/hdl ratio in patients with schizophrenia who had committed crimes.

Materials and Methods: The study included 49 healthy controls and 51 patients diagnosed with schizophrenia who had committed crimes. A sociodemographic and clinical data form was applied to all participants and routine blood tests were evaluated after an average 12-hour fasting period. Fasting Triglyceride-Glucose index $\ln[\text{fasting triglyceride (mg/dl)} \times \text{fasting plasma glucose (mg/dl)} / 2]$ value and TG/HDL level were calculated.

Results: When the types of crimes committed by the case group were analyzed, it was found that 10 (19.6%) were minimally violent, 20 (39.2%) were moderately violent, 16 (31.4%) were moderately serious and 5 (9.8%) were seriously violent. While no significant difference was found between the groups in terms of WBC, Hgb, Plt, Glucose and AST values, Urea, Creatine and ALT parameters were significantly higher in the control group. No significant difference was found between the groups in terms of Triglyceride-Glucose index and Tg/HDL ratio ($p > 0.05$). There was a significant positive correlation between crime severity and disease duration ($r = 0.439$, $p = 0.001$). There was a significant negative correlation between crime severity and Tg/HDL ratio ($r = -0.387$, $p = 0.005$).

Conclusion: We suggest that there is a negative correlation between the severity of the crime and Tg/HDL ratio in patients with schizophrenia and that this parameter can be used in the forensic follow-up of these patients who have committed crimes. Additionally, the exclusion of female patients limits the generalizability of the findings, and further research including female participants is needed to assess gender-related variations in these parameters. The clinical implications of these findings suggest potential biomarkers for risk assessment, while the forensic aspect underscores the importance of monitoring metabolic health in criminalized schizophrenia patients.

Key Words: Crime, schizophrenia, triglyceride-glucose index, triglyceride/HDL

Suç İşlemiş Şizofreni Hastalarında Trigliserid-Glukoz İndeksi ve Trigliserid/HDL Düzeylerinin Araştırılması

Amaç: Son zamanlarda, şizofreni hastalarında hemogram ve biyokimyasal kan parametrelerindeki değişiklikler hastalık belirtileri ile ilişkilendirilmiştir. Bu çalışmada suç işlemiş şizofreni hastalarında trigliserit-glukoz indeksi ve trigliserit/hdl oranını araştırmayı amaçladık.

Gereç ve Yöntem: Çalışmaya 49 sağlıklı kontrol ve suç işlemiş 51 şizofreni tanılı hasta dahil edildi. Tüm katılımcılara sosyodemografik ve klinik veri formu uygulandı ve ortalama 12 saatlik açlık süresinin ardından rutin kan testleri değerlendirildi. Açlık Trigliserid-Glukoz indeksi $\ln[\text{açlık trigliserid (mg/dl)} \times \text{açlık plazma glukozu (mg/dl)} / 2]$ değeri ve TG/HDL düzeyi hesaplanmıştır.

Bulgular Vaka grubunun işlediği suç türleri incelendiğinde, 10'unun (%19.6) hafif şiddet, 20'sinin (%39.2) orta şiddet, 16'sinin (%31.4) orta derecede ciddi ve 5'inin (%9.8) ciddi şiddet içerdiği bulunmuştur. Gruplar arasında WBC, Hgb, Plt, Glukoz ve AST değerleri açısından anlamlı bir fark bulunmazken, Üre, Kreatin ve ALT parametreleri kontrol grubunda anlamlı derecede yüksek bulunmuştur. Trigliserid-Glukoz İndeksi ve Tg/HDL oranı açısından gruplar arasında anlamlı bir fark bulunmamıştır ($p > 0.05$). Suç şiddeti ile hastalık süresi arasında anlamlı pozitif korelasyon vardı ($r = 0.439$, $p = 0.001$). Suç şiddeti ile Tg/HDL oranı arasında anlamlı bir negatif korelasyon vardı ($r = -0.387$, $p = 0.005$).

Sonuç: Şizofreni hastalarında suçun şiddeti ile Tg/HDL oranı arasında negatif bir korelasyon olduğunu ve bu parametrenin suç işlemiş bu hastaların adli takibinde kullanılabileceğini düşünmekteyiz. Ek olarak, kadın hastaların dışlanması bulguların genelleştirilebilirliğini sınırlar ve bu parametrelerdeki cinsiyete bağlı varyasyonları değerlendirmek için kadın katılımcıları içeren daha fazla araştırmaya ihtiyaç vardır. Bu bulguların klinik etkileri risk değerlendirmesi için potansiyel biyobelirteçler önerirken, adli yön suçlu şizofreni hastalarında metabolik sağlığın izlenmesinin önemini vurgular.

Anahtar Kelimeler: Suç, şizofreni, trigliserid-glukoz indeksi, trigliserid/HDL

Correspondence

Muhammed Fuad USLU
Elazığ Fethi Sekin City
Hospital,
Department of Internal
Medicine,
Elazığ - TÜRKİYE

dr.fuslu@gmail.com

Introduction

Violence is the physical and/or psychological force applied against a person or persons with the intent to harm another person (1). Crime, on the other hand, encompasses violent or non-violent acts that are punishable by law. Violent crimes include acts that intentionally harm or attempt to harm others, such as murder, rape, etc (2, 3). The number of studies reporting that rates of violent crime are higher among people with psychiatric illness than in the general population is increasing (4). Peripheral inflammatory markers, including hemogram and other biochemical changes, can help explain the biological aspects of these behaviors in psychiatric patients (5).

It is known that violent crime occurs more frequently among patients with schizophrenia than in the general population (6). Blood lipid levels in patients with schizophrenia have been shown to be associated with both the severity of psychiatric illness and violent behavior (7, 8). Lipids play crucial roles in functions like intracellular communication and endocytosis, and changes in lipid levels can influence neuronal transmission and plasticity. Therefore, cholesterol deficiency or excess in the brain may lead to serious consequences. Additionally, it is known that cholesterol regulates serotonin (9, 10). It has been suggested that reduced peripheral and central lipid levels impair transmission in the serotonergic system, indicating a potential relationship between suicide and lipid levels (11).

Blood lipids (triglycerides, total cholesterol, LDL, HDL) are associated with certain systemic diseases and can contribute to mental symptoms in psychiatric conditions (12). Patients with schizophrenia are also at an elevated risk for physical diseases, such as metabolic syndrome and cardiovascular disease, compared to the general population (13). This heightened risk, which increases mortality and morbidity, is exacerbated by the side effects of antipsychotics and poor living conditions (14, 15). Patients with schizophrenia exhibit higher serum triglyceride levels and lower serum HDL cholesterol levels than those in healthy controls (16). Additionally, studies have shown that high-density lipoprotein cholesterol (HDL-c) in patients with schizophrenia can induce morphologic changes in the brain by influencing oxidative stress, which may affect symptom severity (17).

Recently, studies have used inexpensive and accessible blood parameters to assess both the relationship between psychiatric illness and crime and the metabolic risk in these patients (5, 18). Insulin resistance, prediabetes, and type 2 diabetes are common comorbidities in patients with schizophrenia (19). It has been shown that the triglyceride-glucose index (TyG index) and the triglyceride/HDL (TG/HDL) ratio are associated with insulin resistance and can aid in cardiovascular risk assessment and prognosis (20, 21). We conducted a study to evaluate whether there is a reliable relationship between lipid profile (total cholesterol, high- and low-density lipoprotein cholesterol,

and triglycerides) and crime, self-harm, and self-injury in patients with schizophrenia. To the best of our knowledge, no studies have evaluated TG/HDL and TyG index in schizophrenia patients within the increasingly available forensic psychiatry services in our country. The aim of this study was to investigate whether TyG index and TG/HDL values might be suitable for routine use in understanding the links between crime, metabolic syndrome, and schizophrenia.

Materials and Methods

Research and Publication Ethics: This study was conducted in accordance with the ethical standards specified in the Declaration of Helsinki, 2013 revision. Approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Firat University (05.03.2024 on with the number 2024/04-15).

Sample size was calculated using sample size calculating software G*Power version 3.1.9.2 (Universität Kiel, Germany). With 95% power, 0.07 level of statistical significance and effect size of 0.5, sample size for each group was calculated to be 45.

Inclusion Criterion:

- Patients over 18 and under 65,
- literate,
- not mentally disabled, and
- without a history of systemic disease were included in the study.

Exclusion Criterion:

- Patients under the age of 18 and over the age of 65,
- illiterate,
- mentally retarded and
- patients with alcohol/substance abuse in the last six months were not included in the study.
- Patients with a known history of systemic diseases (cardiovascular disease, metabolic syndrome, diabetes mellitus, renal and hepatic dysfunction, known malignancy and local and/or systemic inflammatory diseases) were also excluded.

Study Design: The study included 55 schizophrenia patients who had committed a crime and were hospitalized in the Forensic Psychiatry Service, and 55 healthy individuals without chronic diseases who applied to the internal medicine outpatient clinic for routine check-ups. Since the women's service was not active at the time of the study, the sample group consisted only of men. Later, 4 patients diagnosed with schizophrenia and 6 healthy controls were excluded from the study.

The psychiatrist who performed the assessment then administered the sociodemographic and clinical data form. The demographic and clinical evaluation form

included demographic information such as age, marital status, and education level. After the patients in the case group were admitted to the ward, the results of routine blood tests taken from all participants after an average of 12 hours of fasting were checked from the hospital registration system. The triglyceride level was checked from the lipid panel and then the fasting Triglyceride-Glucose index $\ln[\text{fasting triglyceride (mg/dL)} \times \text{fasting plasma glucose (mg/dl)} / 2]$ value and TG/HDL level of the patients were calculated and the relationship of these levels with clinical variability was examined.

Scales Used

Sociodemographic and Clinical Data Form: This is a semi-structured form that includes clinical data such as age, place of residence, duration of illness, and marital status.

Taylor Crime Violence Rating Scale: The Crime Severity Rating Scale, which was developed by Taylor and consists of 5 items, grades crime severity as (0) Non-violence, (1) Minimal violence, (2) Moderate violence, (3) Moderately serious violence and (4) Serious violence (22).

Statistical Analysis: Statistical Package for the Social Sciences, version 22.0 (SPSS) (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Shapiro Wilk test was used to determine whether the data were normally distributed. Chi-square test was used to compare categorical variables. Continuous numerical data with normal distribution were evaluated with Student's t-test. Pearson correlation analysis was used to investigate the relationship between continuous numerical data.

Results

The mean age of the case group was 36.12 ± 10.76 years, while the mean age of the control group was 39.88 ± 9.66 years ($p > 0.05$). Both groups consisted entirely of male participants. Sociodemographic comparisons of the groups are presented in Table 1.

When the types of crimes committed by the case group were analyzed, it was found that 10 (19.6%) were minimally violent, 20 (39.2%) were moderately violent, 16 (31.4%) were moderately serious violent and 5 (9.8%) were seriously violent.

The mean duration of disease in the case group was 6.57 ± 4.17 years.

The case and control groups were similar in terms of height; however, body weight and BMI values were significantly higher in the case group.

No significant difference was found between the groups in terms of WBC, Hgb, Plt, glucose, and AST values, while urea, creatinine, and ALT levels were significantly higher in the control group.

In terms of lipid panel comparison, TG, LDL, HDL, and total cholesterol values were similar in both groups ($p > 0.05$).

Again, no significant difference was found between the groups in terms of TyG index and Tg/HDL ratio ($p > 0.05$). Comparison of the groups in terms of body measurements and blood parameters are shown in Table 2.

The Pearson correlation test was used to analyze the relationships between crime severity, duration of illness, TyG index, and Tg/HDL ratio. A significant positive correlation was found between crime severity and duration of illness ($r = 0.439$, $p = 0.001$). Additionally, there was a significant negative correlation between crime severity and the Tg/HDL ratio ($r = -0.387$, $p = 0.005$). However, no significant correlation was observed between crime severity and the TyG index.

Table 1. Sociodemographic comparisons of the groups

		Case Group (n=51)	Control Group (n=49)	Test Statistic	p
Age		36.12±10.76	39.88±9.66	-1.835 ^a	0.069*
Gender	Male	51 (100%)	49 (100%)	-	
Marital status	Single	40 (78.4%)	11 (22.4%)	31.340 ^b	<0.001**
	Married	11 (21.6%)	38 (77.6%)		
	Illiterate	4 (7.8%)	0		
Education status	Primary school graduate	38 (74.5%)	6 (12.2%)	49.483 ^b	<0.001**
	Above primary education	9 (17.6%)	43 (87.8%)		
Smoking	Yes	40 (78.4%)	20 (40.8%)	14.733 ^b	<0.001**
	No	11 (21.6%)	29 (59.2%)		
Alcohol	Yes	6 (11.8%)	0	6.133 ^b	0.027**
	No	45 (88.2%)	49 (100%)		

Age data are presented as mean and standard deviation and other data are presented as number and percentage.

*Student's t-test

**Chi-square test.

a t-test value

b chi-square test value

Table 2. Comparison of body measurements and blood parameters of the groups

	Case Group (n=51) Mean±SD	Control Group (n=49) Mean±SD	Test Statistic	p*
Height (cm)	174.16±5.97	172.12±4.91	1.863	0.066
Weight (kg)	77.31±12.08	66.75±6.01	5.565	<0.001
BMI (kg/m ²)	25.45±3.62	22.59±1.47	5.194	<0.001
White blood cell (10 ³ /mm ³)	7.84±2.15	7.76±2.12	0.196	0.845
Hemoglobin (mg/dL)	15.07±2.00	15.27±1.34	-0.597	0.552
Platelet (10 ³ /mm ³)	254.65±56.98	246.90±60.3	0.660	0.511
Glucose (mg/dL)	93.69±20.55	90.18±10.84	1.072	0.287
Urea (mg/dL)	25.86±7.31	29.33±7.86	-2.279	0.025
Creatinine (mg/dL)	0.75±0.09	0.83±0.12	-3.464	0.001
AST (U/L)	22.31±5.79	25.10±9.74	-1.766	0.081
ALT (U/L)	23.61±13.93	32.37±24.50	-2.186	0.032
TG (mg/dL)	140.39±73.57	135.35±74.80	0.340	0.735
LDL (mg/dL)	102.82±31.75	103.33±25.46	-0.088	0.930
HDL (mg/dL)	45.86±10.62	43.57±8.89	1.171	0.244
Total Cholesterol (mg/dL)	176.75±38.74	173.39±32.81	0.468	0.641
TyG index	8.63±0.58	8.57±0.54	0.54	0.591
Tg/HDL	3.32±2.04	3.30±2.09	0.063	0.950

*Student's t-test

Mean±SD: Mean and standart deviation, BMI: Body Mass Index, TG: triglyceride, LDL: Low Density Lipoprotein, HDL: High Density Lipoprotein, TyG index: triglyceride-glucose index

Discussion

In this study, we compared the clinical characteristics, hemogram, and biochemical parameters of patients with schizophrenia who had committed crimes and those of healthy controls within a forensic psychiatry service. Among the patients with schizophrenia, 36 (70.6%) committed crimes involving moderate to moderately serious violence (such as assault causing bodily harm, wounding, looting, or other criminal offenses). These patients had higher body weight and body mass index, as well as elevated kidney and liver function markers, including urea, creatinine, and ALT, which may be relevant to hepatosteatosis. Furthermore, we observed no significant differences in blood lipid levels or insulin resistance between the case group and healthy controls. A significant negative correlation was found between crime severity and the Tg/HDL ratio.

Recently, hemogram and biochemical parameters have been investigated in patients with schizophrenia in relation to the disease severity (23). In a study, Juchnowicz reported higher WBC levels in patients with schizophrenia compared to healthy controls, and elevated WBC levels were associated with positive symptoms of schizophrenia (23). WBC plays an immune defense function and is involved in antibody formation and the elimination of foreign substances (24). It was shown that hemoglobin levels were higher in 609 male and female patients with schizophrenia than in healthy controls (25). In 2021, platelet counts in schizophrenia patients were found to be similar to those in the healthy control group (26). We did not observe differences in the WBC, Hgb, or Plt levels in our schizophrenia patients. The small size of our sample and the ongoing psychiatric

drug treatment of the patients may account for differences in the relevant parameters. Fasting blood glucose and AST levels of schizophrenia patients with criminal offenses were similar to those in the control group, while urea, creatinine, and ALT levels were significantly higher in the control group. The prevalence of metabolic syndrome in schizophrenia is generally estimated to be double that of the general population (27). In one study, a positive correlation was found between the emergence of psychotic symptoms in dementia patients and increased retention markers in serum, including creatinine and urea levels (28). Tzeng et al. (29) stated that the risk of chronic kidney disease is high in schizophrenia patients. It has been suggested that ALT levels, even mild elevations within the normal range, are a predictor of metabolic syndrome risk in male schizophrenia patients (30). Our findings align with the literature in this respect, indicating that schizophrenia patients with criminal offenses may be predisposed to renal diseases and are at risk for fatty liver disease and metabolic syndrome.

In a study including 120 female patients with and without aggressive behavior, low HDL cholesterol was found to be significantly associated with aggression in women with schizophrenia (31). A meta-analysis concluded that most studies reported an association between low cholesterol and violence against others, while conflicting evidence exists regarding the association between low cholesterol and suicidality in schizophrenia (32). Additionally, another study observed low levels of triglycerides, LDL-C, and HDL-C in schizophrenia patients with violent behavior compared to the control group. In contrast, patients with schizophrenia who attempted suicide showed low total

cholesterol levels (33). In another study, it was reported that low cholesterol levels affected suicidal behavior through mechanisms such as neuroinflammation and neurotransmission (11). We found that Tg, LDL, HDL, and total cholesterol levels were similar in schizophrenia patients and healthy controls. This difference may be due to the impulsivity of the patients, which may trigger criminal behavior, and the fact that the BMIs of the study groups were not similar. Furthermore, no significant difference was observed between the groups in terms of the TyG index and Tg/HDL ratio. The similarity of these ratios, which are indicators of insulin resistance, between the schizophrenia and healthy control groups, along with a negative correlation between crime severity and the Tg/HDL ratio, suggests that the Tg/HDL ratio can be used in forensic processes. This suggests that lipid metabolism disturbances may play a role in the expression of violent behavior. The triglyceride-glucose index and Tg/HDL ratios in patients with schizophrenia who have committed crimes have not been studied before, making our study the first in this field. In addition, there was a significant positive correlation between the severity of crime and the duration of schizophrenia. In schizophrenia, treatment compliance decreases, and symptoms worsen as the duration of the illness prolongs (34). Increasing symptoms of schizophrenia may increase the violence the person inflicts on themselves and others (35). Clarification of this relationship may serve as a marker to help psychiatrists make decisions about the risk of violence and treatment in patients with schizophrenia.

The limitations of our study include its cross-sectional design, its focus solely on males, the relatively small sample size, and the absence of a group of non-offending schizophrenia patients. The exclusion of female patients in this study was due to the unavailability

of an active women's forensic psychiatry service at the time. However, the absence of female participants limits the applicability of the findings to the general schizophrenia population. Prior research suggests that metabolic parameters, including lipid profiles, may differ by gender, influencing both psychiatric symptoms and behavioral outcomes. Future studies should aim to include female patients to determine whether similar correlations exist across genders.

As a result, increasing crime rates in society are becoming more prevalent among schizophrenia patients. Since the etiopathogenesis of violence needs clarification to prevent it, we believe that cost-effective and practical hemogram and biochemistry tests can serve as predictors of crime and the types of crimes in schizophrenia patients. Additionally, the clinical and forensic applications of our findings warrant further discussion. Clinically, the significant relationship between crime severity and the triglyceride/HDL ratio suggests that lipid profiles could serve as a potential marker for evaluating psychiatric patients at risk of violent behavior. This could inform psychiatric treatment strategies and monitoring practices, emphasizing metabolic health as part of a comprehensive care plan. Forensically, these findings highlight the necessity of considering metabolic risk factors when assessing criminal responsibility and recidivism in schizophrenia patients. Incorporating metabolic health evaluations into forensic psychiatry protocols may enhance the assessment and rehabilitation of offenders with psychiatric disorders. We believe that recognizing and preventing violence through blood changes in schizophrenia patients may reduce instances of violence caused by psychiatric diseases; therefore, our findings will guide further studies involving larger sample sizes.

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