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Original Article

Investigation of *Toxoplasma gondii* seroprevalence in patients with cardiac diseases

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Abstract

Objective: To determine the prevalence of toxoplasmosis in cardiac patients and investigate the relationship between toxoplasmosis and cardiac diseases.

Methodology: The study included 170 patients followed up in the cardiology department (patient group) and 167 individuals without any disease who were not receiving any immunosuppressive treatment (control group). Blood samples obtained from the study participants were analyzed for anti-*Toxoplasma gondii* immunoglobulin G (IgG) levels via enzyme-linked immunosorbent assay.

Results: Anti- *T. gondii* IgG was detected in 41.2% of the patient group and 29.3% of the control group. Statistical analysis showed a significant correlation between anti- *T. gondii* IgG seropositivity in the patient and control groups. In the patient group, anti- *T. gondii* IgG was detected in 65.7% of those with a history of myocardial infarction (MI), 49.4% of those undergoing coronary angiography, and 48.6% of those undergoing stenting. In the statistical evaluation of patients with a history of coronary angiography, stenting, and MI, and toxoplasmosis seropositivity, significant relationships were found separately ($p = 0.016$, $p = 0.014$, and $p = 0.001$, respectively).

Conclusions: Patients with cardiac diseases were found to be at a higher risk for toxoplasmosis compared to healthy individuals. In individuals with cardiac diseases, it is recommended that patients should be monitored for toxoplasmosis at regular intervals and necessary precautions should be taken, considering that latent infection may be reactivated in case of immune system failure.

Key words: Toxoplasmosis; myocardial infarction; cardiac diseases.

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Introduction

Toxoplasma gondii (*T. gondii*), an obligate, intracellular protozoan, is known to chronically infect approximately two billion people worldwide. The definitive host of the parasite is the Felidae family, and the intermediate hosts include many vertebrates, such as humans. The incidence of the disease varies for many reasons, such as a country's level of development, host susceptibility, dietary habits, the cat population, and climatic conditions [1,2]. In the life cycle of the parasite, some tachyzoites multiply rapidly in host cells and are responsible for acute infection, bradyzoites (tissue cysts) are responsible for chronic infection, and oocysts containing sporozoites that form as a result of the sexual cycle (gametogony) in the intestinal epithelium of the definitive host [2,3].

Transmission of the parasite to humans can occur through food (fruit and vegetables) or water contaminated with infective oocysts, and the consumption of raw or undercooked meat or meat products containing tissue cysts. In addition, toxoplasmosis can be transmitted through various routes, such as organ transplantation, blood transfusion, and placental transmission from mother to infant [2,3]. In the serologic diagnosis of the disease, *Toxoplasma gondii* immunoglobulin M (IgM), IgA, and IgE antibodies are considered as markers of acute infection, while *T. gondii* IgG antibodies are generally considered as markers of chronic infection [3].

In immunocompetent individuals, toxoplasmosis is mostly subclinical. In the acute phase of the disease, clinical symptoms such as mild flu symptoms, ocular toxoplasmosis, myocarditis, myositis, hepatosplenomegaly, or cervical lymphadenopathy may be observed depending on the immune status of the host [4]. Acute toxoplasmosis in immunocompetent individuals is usually subclinical and may not require treatment. In acute toxoplasmosis, tachyzoites proliferate actively in tissues such as the brain, heart, skeletal muscles, and retina. In response to the host's immune system, the rapidly proliferating tachyzoites in these tissues transform into slowly proliferating bradyzoites (tissue cysts). Bradyzoites is the chronic stage of the disease and can remain viable for life in immunocompetent individuals. Tissue cysts in latent form are activated in cases such as an immune system

deficiency of the host, allowing the infection to reactivate [5]. Infection during pregnancy, encephalitis, microcephaly, hydrocephalus, retinopathy, miscarriage, or stillbirth may be observed in the fetus depending on the period of pregnancy and the immune status of the mother [2,3]. In the chronic phase of the disease, the parasite transforms into tissue cysts in muscle and nerve cells and remains in the host for life. Especially in immunocompromised patients, reactivation of the tissue cysts causes severe clinical symptoms [4].

T. gondii shows systemic spread by infecting all nucleated cells of the host. The brain, heart, eyes, lungs, liver, lymphatic system, and skeletal muscles are particularly affected [3,6]. The brain and heart, which are vital organs, are the most affected organs by *T. gondii*. *T. gondii*, which can be localized in the muscle layer of the heart, located in the mediastinal space, is one of the most important parasitic agents causing cardiac diseases such as myocarditis, pericarditis, and cardiomyopathy. Patients with *T. gondii*-induced myocarditis have been reported to have obstructive pericarditis, pericardial effusion, congestive heart failure, atrial and ventricular arrhythmias, and even sudden death [4,7-11]. In addition, *T. gondii*-induced myocarditis resembles the clinical presentation of acute myocardial infarction (MI) and has been reported to lead to misdiagnosis of MI and may be misleading [6].

It is known that *T. gondii* mostly affects the central nervous system in immunocompromised patients. The effects of the parasite on the heart have not been sufficiently investigated because cardiac involvement is less frequent, the clinical presentation is more silent, and cerebral involvement suppresses cardiac involvement [10]. *T. gondii* is known to affect the heart muscle, but its etiology has not been clarified. This study was conducted to determine the prevalence of chronic toxoplasmosis in cardiac patients and investigate the relationship between toxoplasmosis and cardiac diseases.

Methodology

Before the study began, approval was obtained from the Clinical Research Ethics Committee of Van Yuzuncu Yıl University Faculty of Medicine (Decision No: 2024/04-06). The study was conducted between June 1st and December 20th, 2024, on patients with cardiac problems who applied to the cardiology department of Dursun Odabas Medical Center. The study was initiated after obtaining informed consent from each participant. Information on the age and sex, anamnesis findings, and interventions was obtained from the hospital automation system.

Patient and control groups

The patient group included 170 volunteer patients aged 18 years and older with cardiac problems who were followed up in the cardiology department (outpatient clinic, ward, and intensive care unit). The control group consisted of 167 volunteer individuals who had no known chronic diseases, were examined in the cardiology outpatient clinic upon their own request, were found to have no cardiac disorders, and were age-matched with the patient group.

Those who did not volunteer to participate, did not apply to the cardiology department (patient group), and those who had any chronic diseases (control group) were not included in the study. To determine anti-*T. gondii* IgG antibody levels, blood samples were collected from both groups and centrifuged at 3000 rpm, and the separated blood sera were stored at –20 °C until analysis.

Enzyme-linked immunosorbent assay (ELISA)

The presence of anti-*T. gondii* IgG antibody in the sera was determined using a DRG ELISA IgG kit (DRG Instruments GmbH, Marburg, Germany). The serum samples were allowed to thaw at room temperature before testing. The procedure was performed according to the manufacturer's instructions. The samples were classified as negative [antibody level (AL) < 9], borderline (AL = 9-11), and positive (AL > 11; positive AL = [optic density of the samples (OD)/mean OD of cut-off serum) × 10]. The study of suspicious sera was repeated with further dilutions until a negative result was obtained.

Statistical analysis

In the statistical analyses, the χ^2 test, Fisher's exact test, and independent t-test were used. A p of less than 0.05 ($p < 0.05$) was considered statistically significant. Multiple correspondence analysis (permutation tests) was used to determine concordance between the variables. IBM SPSS Statistics for Windows 26.0 (IBM Corp., Armonk, NY, USA) and MINITAB 14.0 were used for the calculations.

Results

Of the 170 patients with cardiac diseases, 84 (49.4%) were male, and 86 (50.6%) were female. Of the 167 individuals without any chronic diseases included as the control group, 95 (56.9%) were male, and 72 (43.1%) were female. The mean age of the patients was 47.5 ± 15 years (min. 18- max. 83), while in the control group it was 45.7 ± 17.2 years (min. 19- max. 82). No statistically significant differences in age ($p = 0.782$) or

gender (p = 0.169) were found between the patient and control groups.

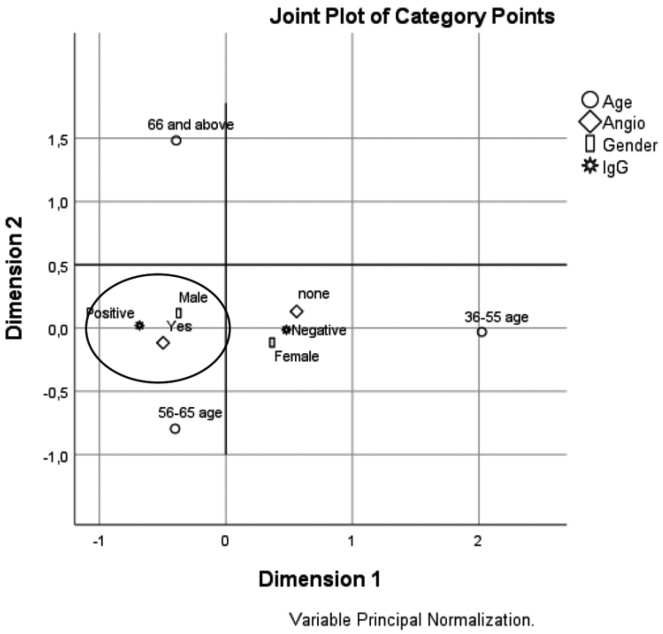
Anti-*T. gondii* IgG was detected in 41.2% (n = 170) of the patient group and 29.3% (n = 167) of the control group. A significant correlation was found in the statistical analysis between anti-*T. gondii* IgG seropositivity in the patient and control groups (Table 1). When the patient group data were analyzed, 35 (20.6%) of the patients had a history of MI, anti-*T. gondii* IgG was detected in 23 (65.7%) of these patients, and they also had higher rates of *T. gondii* seropositivity. Furthermore, the statistical analysis showed a significant correlation between the prevalence of *T. gondii* in these patients and those without a history of MI (p = 0.001, Table 1).

Coronary angiography was performed in 89 (52.4%) of patients who were admitted to the cardiology department with different clinical complaints, such as chest pain, palpitations, shortness of breath, left arm numbness, and fatigue, and 49.4% of these patients were anti-*T. gondii* IgG positive. The difference in toxoplasmosis seropositivity between these patients and those who did not undergo coronary angiography was statistically significant (p = 0.016, Table 1).

Stents were implanted in 72 (80.9%) of the 89 patients who underwent coronary angiography. Anti-*T. gondii* IgG positivity was detected in 48.6% of these stented patients. The statistical analysis revealed a significant correlation between toxoplasmosis seropositivity and stent implantation (p = 0.014, Table 1).

Multiple correspondence analysis showed that anti-*T. gondii* IgG positivity was associated with men undergoing coronary angiography, independent of the age group (Figure 1).

Figure 1. Multiple correspondence analysis showing the relationship between anti- *T. gondii* IgG positivity, age, gender, and angiography status. Dimensions 1 and 2 explained 51.8% and 32.3% of the total inertia, respectively.



Discussion

T. gondii, which has a cosmopolitan distribution, is known to infect approximately 30% of the world population. When studies conducted in Turkey were analyzed, *T. gondii* IgG seropositivity ranging between 14.5-63.4% were reported [12-14]. Different seropositivity can be observed in different regions of the same country. Among the reasons for these differences, many factors such as dietary habits, development level of countries or regions, inadequate sanitation, host susceptibility, and climate can be counted [3,14].

Clinical manifestations of *T. gondii* in cardiac involvement are usually silent. Therefore, the diagnosis is usually made postmortem [15]. In the autopsy findings of AIDS patients, endomyocardial involvement by *T. gondii* has been reported at a rate of 12% to 22% [10,15]. In studies investigating the relationship between cardiac diseases and toxoplasmosis, a correlation was found in 13.8% of

Table 1. Comparison of anti-*Toxoplasma* IgG positivity in the subgroups.

Subgroup	Anti-*Toxoplasma* IgG		*p*
	Negative n (%)	Positive n (%)	
Patient group (n = 170)	100 (58.8)	70 (41.2)	**0.022**
Control group (n = 167)	118 (70.7)	49 (29.3)	
Coronary angiography			
Implemented (n = 89)	45 (50.6)	44 (49.4)	**0.016**
Not implemented (n = 81)	55 (67.9)	26 (32.1)	
Myocardial infarction			
Yes (n = 35)	12 (34.3)	23 (65.7)	**0.001**
No (n = 135)	88 (65.2)	47 (34.8)	
Stent			
Yes (n = 72)	37 (51.4)	35 (48.6)	**0.014**
No (n = 98)	63 (64.3)	35 (35.7)	

cardiac patients in Mexico [4], 64.1% in Romania [1], 63.1% of patients with coronary atherosclerosis in Egypt [16], and 68% of patients with chronic heart failure in Türkiye [17]. In some case studies, *T. gondii* has been reported to cause acute myocarditis [8, 9,18,19]. In the current study, anti-*T. gondii* IgG seropositivity was detected in 41.2% of the patient group and 29.3% of the control group. A significant correlation was found between seropositivity for toxoplasmosis in the control and patient groups (p = 0.022). This study shows that patients with cardiac diseases are more at risk for toxoplasmosis than healthy individuals. *T. gondii* is one of the most important opportunistic parasitic agents. In cases of immunosuppression, the rupture of tissue cysts can release bradyzoites, which may transform into tachyzoites, leading to reactivation of the disease. It is known that if left untreated, repeated infections can cause significant life-threatening clinical symptoms [5]. It is thought that when the immune system of individuals with cardiac disease is weakened or suppressed, latent tissue cysts may rupture and reactivate the infection, leading to serious morbidity and mortality. Therefore, these patient groups should be monitored for toxoplasmosis at regular intervals, and in case of reactivation of the infection, the necessary treatment should be applied to control the disease.

Coronary angiography is the technique of visualizing the coronary anatomy of patients with suspected coronary artery disease by invasive or non-invasive methods [20]. A coronary stent is a treatment method that mechanically opens the blockage in the coronary artery and improves ischemia caused by hypoxia in the myocardium [21]. Both applications are widely used in the diagnosis and treatment of coronary diseases. MI is defined as severe and prolonged ischemia in a part of the heart and the resulting myocardial damage or necrosis [22]. In some studies, it was stated that there was no statistically significant relationship between coronary artery disease and toxoplasmosis [1,16,23]. In some studies, a statistically significant relationship was found between MI and toxoplasmosis, and it was emphasized that toxoplasmosis should be considered in these patient groups [7,11]. In this study, anti- *T. gondii* IgG positivity was detected in 49.4% of patients who underwent coronary angiography, 48.6% of patients who underwent stenting and 65.7% of patients with a history of MI. Statistically significant correlations were found between toxoplasmosis seropositivity and coronary angiography, stent implantation, and a history of MI (p = 0.016, p = 0.014, and p = 0.001, respectively). In this study, similar to the literature [7,11], MI was found to be associated with toxoplasmosis. It was thought that toxoplasmosis should not be ruled out in patients with a history of MI. There was a statistically significant correlation between *T. gondii* seropositivity and angiography and stent applications. However, the causality of this relationship has not been clearly proven, and it is thought that it may be due to the presence of common risk factors (immunosuppression, age, or comorbid diseases) or a coincidental association. Due to the limited number of studies investigating the relationship between *T. gondii* and cardiac diseases, the impact of toxoplasmosis on especially coronary artery disease remains unclear. Further research is needed to better understand this potential association.

While some studies [1,24] have reported that the incidence of toxoplasmosis increased with age due to the increased risk of parasite exposure with increasing age, others [4,25] stated that there was no relationship between age and *T. gondii* seropositivity. In the present study, the multiple correspondence analysis revealed no significant association between age group and *T. gondii* seropositivity. These results indicate that individuals can be exposed to the parasite at any age due to reasons such as living conditions and dietary habits.

Conclusions

In conclusion, patients with heart disease, especially those with myocardial infarction, were found to be at greater risk of toxoplasmosis compared to healthy individuals. Considering that toxoplasmosis should not be ignored in individuals with cardiac diseases, and that latent infection may be reactivated in cases of immunosuppression, it is recommended that patients should be followed up periodically for toxoplasmosis, and necessary precautions should be taken. Further large-scale studies are needed to determine whether the association between cardiac diseases and toxoplasmosis is causal.

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Conflict of interest
No conflict of interest is declared.

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