Available online at www.sciencedirect.com
ScienceDirect
Forensic Science International 163 (2006) 34–37
Forensic Science International
www.elsevier.com/locate/forsciint

Is *Toxoplasma gondii* a potential risk for traffic accidents in Turkey?☆

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Received 22 November 2004; received in revised form 28 July 2005; accepted 1 November 2005
Available online 5 December 2005

Abstract

In Turkey, traffic accidents are the major causes of mortality and morbidity. According to the statistics made by Turkish Security Headquarters in the year 2000, 7500 people are killed in the traffic accidents every year. Drivers are mostly blamed for the traffic accidents. Tired, weary, sleepy and absentminded driving are common reasons for traffic accidents due to many reasons. Among these reasons mental and reflex conditions of drivers are significant. Toxoplasmosis is one of the most common zoonoses throughout the world. In immunocomponent adults, toxoplasmosis has no clinical signs or symptoms and infection in such people can only be detected by serological examinations. This kind of latent or dormant toxoplasmosis can be located in neural or muscular tissues and cause prolonged reaction times of the muscles. Extended reaction times also lead to deceleration of the reflexes which could be a major cause of the traffic accidents. By the light of this situation, the incidence of *Toxoplasma gondii* is investigated among the population who were involved in a traffic accident while driving. A total of 185 people (100 men and 85 women), aged between 21 and 40 years, living in Izmir and Manisa cities, were enrolled in the study group (SG) during a period of 6 months time. Their informed consents were taken initially and the laboratory tests of all these individuals related to blood alcohol levels after the accidents were found negative. The control group (CG) were also consisted 185 people (95 men and 90 women), residents of the same region, in same age group. The people in CG had no clinical signs or symptoms concerning toxoplasmosis. All collected sera were examined using a commercial IgG and IgM ELISA kit. According to the results of serological tests of the SG, 45 (24.32%) sera were IgG positive, six (3.24%) were IgM positive and 10 (5.40%) were both IgG and IgM positive. On the other hand in CG, 12 (6.48%) people found IgG positive, one (0.54%) found IgM positive and three (1.62%) found both IgG and IgM positive. This data was considered as statistically significant by Yates corrected χ^2-test. ($p < 0.05$). In conclusion, there is an increased risk for traffic accidents for drivers owing to these high seroprevalence of latent toxoplasmosis. Prospective studies are still necessary on this subject but latent toxoplasmosis of drivers should be taken into account while developing strategies to prevent traffic accidents in Turkey.

Keywords: *Toxoplasma gondii*; Toxoplasmosis; Traffic accidents

1. Introduction

Accidents are defined as bad, unusual events in an unplanned and unforeseen time span causing life and/or property loss [1]. Generally, accidents can be categorized into four groups: (i) traffic accidents, (ii) home accidents (in developing countries the definition of home acci-

☆ This paper was presented in IX European Multicolloquium of Parasitology, 18–23 July 2004, Valencia, Spain.

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doi:10.1016/j.forsciint.2005.11.002

dents should also include a special category for home-based work accidents. There is often no distinction between home and work especially in rural areas.), (iii) occupational accidents and (iv) sports accidents [2]. According to the WHO reports, traffic accidents are among the main reasons for public health damage; in the fifth place in undeveloped countries and in the 10th place in developed countries [3]. Traffic accidents are the major cause of mortality and morbidity in Turkey, as well. According to the statistics made by Turkish Security Headquarters, 4,586,082 traffic accidents occurred between 1984 and 2002, where 106,488 people were killed and 1,748,565 people were injured [4]. With these data, Turkey is in the first place in Europe and seventh worldwide. In Turkey, drivers are mostly responsible for the traffic accidents. Tired, weary, sleepy and absent-minded driving are the most frequent causes (19.4%) of traffic accidents due to many reasons. Among these, deterioration of the drivers' mental state and the decrease of psychomotor performance are significant [4].

Toxoplasmosis is one of the most common zoonoses throughout the world. The seroprevalence of antibodies to *Toxoplasma gondii* in human populations in Europe, US and Turkey are 30%, 15.8% and 29%, consecutively [5–7]. In immunocompetent adults, toxoplasmosis has no clinical signs or symptoms and infection can only be detected by serological examinations [8]. This kind of latent or dormant toxoplasmosis can be located in neural or muscular tissues and cause prolonged reaction times of the muscles [9]. Extended reaction times also lead to deceleration of the reflexes, which could be a major cause of accidents; especially traffic accidents.

The aim of this study was to investigate the incidence of *T. gondii* among a population of drivers involved in a traffic accident.

2. Materials and methods

A total of 185 people (100 men and 85 women) involved in a traffic accident as drivers, were selected in the study group (SG) for a period of 6 months time during 2002–2003. The SG was chosen from people living in Izmir and Manisa cities of Turkey, aged between 21 and 40 years having driving license more than a year. Blood alcohol concentration (BAC) was measured at the emergency room and all were found to be lower than 11 mmol/l (the legal limit in Turkey). None reported taking any medication in the previous days that could affect driving. Also, screening for opiates and cannabinoids was performed by using enzyme immunoassay (EIA) method from the blood (threshold value was 10 ng/ml). The control group (CG) was consisted of 185 people (95 men and 90 women), residents of the same region and in same age group. The people in CG did not show any clinical signs or symptoms of toxoplasmosis. All individuals in both SG and CG were informed about the study and their informed consents were taken initially. All serum samples were separated and stored at $-20\ ^{\circ}C$ until the testing.

All collected sera were examined using a commercial IgG and IgM ELISA kit (Atlas Link® Microwell ELISA IgG and IgM). The antibody index interpretation was performed under the NCCLS guidelines [10]. The samples with test positivity index below 0.9 were evaluated as negative, while the samples with a positivity index between 0.9 and 1.1 were evaluated as borderline positive and a correction test was performed to decide. The samples with a test positivity index higher than 1.1 were evaluated as signs of current or previous *T. gondii* infection.

Data were evaluated by SPSS for Windows 6.1® (SPSS Inc.®, New York, US) and Epi Info 3.2 (CDC, Atlanta, US) compatible with Microsoft Windows 98® electronic environment (Microsoft Corp.®, California, US). Because of a low probability of traffic accident, the odds ratio (OR) can be used as a very good approximation of the relative risk in this case-control study. The Fischer exact test between two binary variables was used to test statistical significance. $p < 0.05$ values were considered as statistically significant.

3. Results

According to the results of serological tests of the SG, 45 (24.32%) sera were IgG positive, six (3.24%) were IgM positive and 10 (5.40%) were both IgG and IgM positive. On the other hand in CG, 12 (6.48%) people were found to be IgG positive, one (0.54%) was found to be IgM positive and three (1.62%) were found to be both IgG and IgM positive. The seroprevalence of latent toxoplasmosis in SG and CG was compared by Fischer exact test in Table 1.

Table 1
T. gondii total seropositivity according to age groups and sex

	SG (population/positives)	CG (population/positives)	Odds ratio	CI (95%)	χ^2	p
Age groups						
21–30 years	102/31 (30.39%)	96/10 (10.41%)	3.75	1.63–8.84	10.83	0.0009[a]
31–40 years	83/29 (34.93%)	89/6 (6.74%)	7.43	2.7–21.48	19.37	<0.0001[a]
Sex						
Male	100/32 (32%)	95/6 (6.31%)	6.09	2.27–17.18	16.03	0.0001[a]
Female	85/28 (32.94%)	90/10 (11.11%)	3.93	1.66–9.46	11	0.0009[a]
Total	185/60 (32.43%)	185/16 (8.64%)	5.07	2.69–9.65	30.62	<0.0001[a]

[a] Statistically significant.

Table 2
Distribution of *T. gondii* seroprevalence according to age groups

21–30 years	SG ($n = 102$)	CG ($n = 96$)	Odds ratio	CI (95%)	χ^2	p
IgG (+)	22 (21.56%)	6 (6.25%)	4.13	1.49–12.02	8.34	0.0038[a]
IgM (+)	2 (1.96%)	1 (1.04%)	1.90	0.13–13.84	0.28	0.9578
IgG and IgM (+)	7 (6.86%)	3 (3.12%)	2.28	0.51–11.13	0.77	0.3812
31–40 years	SG ($n = 83$)	CG ($n = 89$)	Odds ratio	CI (95%)	χ^2	p
IgG (+)	23 (27.71%)	5 (6.74%)	5.30	1.9–15.57	12.02	0.0005[a]
IgM (+)	3 (3.61%)	0 (0%)	Undefined	–	1.5	0.2190
IgG and IgM (+)	3 (3.61%)	0 (0%)	Undefined	–	1.5	0.2190

[a] Statistically significant.

Table 3
Distribution of *T. gondii* seroprevalence according to sex

Male	SG ($n = 100$)	CG ($n = 95$)	Odds ratio	CI (95%)	χ^2	p
IgG (+)	25 (25%)	5 (5.26%)	6	2.05–18.86	13.10	0.0002[a]
IgM (+)	3 (3%)	0 (0%)	Undefined	–	1.25	0.2630
IgG and IgM (+)	4 (4%)	1 (10.5%)	3.92	0.4–13.74	0.72	0.3962
Female	SG ($n = 85$)	CG ($n = 90$)	Odds ratio	CI (95%)	χ^2	p
IgG (+)	20 (23.52%)	7 (7.77%)	3.65	1.35–10.18	7.15	0.0075[a]
IgM (+)	2 (2.35%)	1 (1.11%)	2.14	0.15–16.92	0.21	0.9601
IgG and IgM (+)	6 (7.05%)	2 (2.22%)	3.34	0.59 – 15.71	1.37	0.2424

[a] Statistically significant.

To check the integrity of our results we repeated all analyses in two different age strata and in two genders. The distributions of SG and CG according to age and gender groups were shown in Tables 2 and 3. These results were very similar to those reported in Table 1.

4. Discussion

Many studies were made to investigate the seroprevalence of active or latent toxoplasmosis among populations. Joshi et al. examined 60 healthy adults for toxoplasmosis in India and reported the overall seropositivity was 17.2% [5]. In the first serological examination on toxoplasmosis in Turkey, the overall seropositivity was found between 12.8% and 29.4% [7].

There is inadequate data about the effects of asymptomatic toxoplasmosis on psychomotor system in humans, but the decline in psychomotor performance is a well-established finding [11]. In latent toxoplasmosis, life-long presence of cysts in the brain and muscular tissues has no effect on human health. However, it has been shown that infected subjects scored worse in psychomotor performance tests and had different personality profiles than *Toxoplasma*-negative subjects [12]. This may be due to the induction of dopamine production in brain, caused by the *Toxoplasma* cysts. [13]. In another study, mice with acute toxoplasmosis exhibited a 40% of elevated homovanillic acid levels, compared to controls; dopamine levels, however, remained unchanged and norepinephrine levels were found to be 28% lower than controls. In addition, dopamine levels were found 14% higher in the mice with chronic infections than controls. These neurochemical changes were evaluated as the possible factors contributing to mental and motor abnormalities that accompany or follow toxoplasmosis in rodents and, possibly, man [14]. In rodents, it is suggested that neurotropic cysts of *Toxoplasma* could influence animal behaviour, either directly or via the release of metabolic products. Long-standing *Toxoplasma* infection in humans has been linked to cerebral tumour formation and personality shift [15]. Flegr et al. observed personality changes of 230 women diagnosed with acute toxoplasmosis during 14 years and found that *T. gondii* induced changes in their personality profiles [16]. In addition, the researchers reported that the nature of the personality changes associated with toxoplasmosis in men, suggested a possible relation between latent toxoplasmosis and an increase of dopamine level in the brain of infected subjects, which deserved further studies.

As a personality change, it was also reported that latent toxoplasmosis could cause prolonged reaction times and could increase the risk of accidents, especially the traffic accidents. According to this statement, the prevalence of toxoplasmosis in participants in traffic accidents should be higher than in general population. First traffic accident case caused by toxoplasmosis was reported from Miami, USA in 1998, but it was an AIDS case with acute toxoplasmosis [17].

In a study made among 146 traffic accidents victims by Flegr et al. in central Prague, Czech Republic showed that the subjects with latent toxoplasmosis have significantly increased risk of traffic accidents than the noninfected subjects. The authors pointed out that these results suggested that asymptomatic, acquired toxoplasmosis might, in fact, represent a serious and highly underestimated health problem as well as an economic problem [9].

In our study, as seen in both tables, significantly higher rates of seroprevalence were found in SG, compared to CG. There is an obvious increased risk for traffic accidents for drivers owing to high seroprevalence of latent toxoplasmosis. However, it should be noted that until a prospective study is performed, there can be no concrete decision whether the difference in toxoplasmosis prevalence between the victims of traffic accidents and the controls is caused by overrepresentation of *Toxoplasma*-infected subjects among the victims or by their underrepresentation among the controls. Prospective studies are still necessary on this subject, however, latent toxoplasmosis of drivers should be taken into account while developing strategies to prevent traffic accidents in Turkey.

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