STILLBIRTH HISTORY AND TOXOPLASMA GONDII INFECTION IN WOMEN ATTENDING PUBLIC HEALTH CENTERS IN A NORTHERN MEXICAN CITY

C. Alvarado-Esquivel1,*, S. J. Pacheco-Vega1, M. Salcedo-Jaquez1, L. F. Sánchez-Anguiano2, J. Hernández-Tinoco2, E. Rábago-Sánchez3, M. M. Centeno-Tinoco4, I. D. Flores-García3, A. Ramos-Nevarez5, S. M. Cerrillo-Soto5, C. A. Guido-Arreola5, I. Beristain-García5, O. Liesenfeld7, L. O. Berumen-Segovia1, L. Saenz-Soto5 and A. Sifuentes-Álvarez3

1 Biomedical Research Laboratory, Faculty of Medicine and Nutrition, Juárez University of Durango State, Avenida Universidad S/N, 34000 Durango, Mexico
2 Institute for Scientific Research “Dr. Roberto Rivera-Damm”, Juárez University of Durango State, Avenida Universidad S/N, 34000 Durango, Mexico
3 Mothers and Children’s Hospital, Secretary of Health, Durango, Mexico
4 Health Center 450, Secretary of Health, Toma de Zacatecas 129, 34000 Durango, Mexico
5 Clínica de Medicina Familiar, Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado, Predio Canoas S/N, 34079 Durango, Mexico
6 Faculty of Nursing and Obstetrics, Juárez University of Durango State, Avenida Cuauhtémoc 223, 34000 Durango, Mexico
7 Institute for Microbiology and Hygiene, Campus Benjamin Franklin, Charité Medical School, Hindenburgdamm 27, D-12203 Berlin, Germany

Received: March 5, 2015; Accepted: March 11, 2015

Through a cross-sectional study design, 150 women attending public health centers with a history of stillbirths were examined for anti-Toxoplasma gondii IgG and IgM antibodies in Durango City, Mexico. Bivariate and multivariate analyses were used to assess the association of T. gondii seropositivity with the characteristics of the women with stillbirth history.

Of the 150 women (mean age: 32.09 ± 9.16 years) studied, 14 (9.3%) had anti-T. gondii IgG antibodies and six (42.9%) of them were also positive for anti-T. gondii IgM antibodies. Multivariate analysis showed that T. gondii seropositivity was associated with high frequency (4–7 days a week) of eating meat (OR = 5.52; 95% CI: 1.48–20.59; P = 0.01), history of lymphadenopathy (OR = 4.52; 95% CI: 1.14–17.82; P = 0.03), and history of surgery (OR = 8.68; 95% CI: 1.04–72.15; P = 0.04).

This is the first study on the seroepidemiology of T. gondii infection in women with a history of stillbirths in Mexico. The association of T. gondii exposure with a history of surgery warrants for further research. Risk factors for T. gondii infection found in the present survey may help to design optimal educational programs to avoid T. gondii infection.

Keywords: Toxoplasma, stillbirths, epidemiology, seroprevalence, risk factors, cross-sectional study, Mexico

Introduction

Toxoplasma gondii (T. gondii) is a parasite widely distributed around the world [1, 2]. Infections with T. gondii usually occur by ingestion of water or food contaminated by oocysts shed by T. gondii-infected cats or by ingestion of tissue cysts in meat from T. gondii-infected animals [1–3]. The clinical spectrum of T. gondii infections varies from asymptomatic to life-threatening disease [1]. Infections with T. gondii may lead to lymphadenopathy [2], chorioretinitis [4], meningoencephalitis, congenital disease, and neonatal mortality [2, 5].

Congenital toxoplasmosis can cause fetal death and stillbirths or long-term disabling sequelae [6]. Stillbirths due to infections are more common in developing than in developed countries [7]. There is poor knowledge about the epidemiology of T. gondii infection in women with stillbirths. In a study in the Caribbean island of Trinidad, researchers found the highest seroprevalence of T. gondii infection in neonates of mothers who had experienced stillbirths [8]. In a previous study of pregnant women suffering from hypertensive disorders in northern Mexico, we found a higher seroprevalence of T. gondii infection in women with stillbirth history than those without this his-
Materials and methods

Study design and study population

We performed a cross-sectional study of 150 women with a stillbirth history who attended two public primary health centers (Clínica de Medicina Familiar, ISSSTE; Centro de Salud con Servicios Ampliados 450, Secretary of Health) and the Mothers and Children’s Hospital of the Secretary of Health from August 2013 to January 2015 in Durango City, Mexico. Inclusion criteria for enrollment included: 1) women with a history of stillbirth (fetal death after 20 weeks of pregnancy), 2) aged 16–50 years, and 3) who accepted to participate in the study. Occupation, socio-economic status, and educational level were not restrictive criteria for enrollment.

Socio-demographic, clinical, and behavioral characteristics of the women

We obtained the socio-demographic, clinical, and behavioral characteristics from the women studied with the aid of a standardized questionnaire. Socio-demographic data included age, birthplace, residence, occupation, educational level, and socio-economic status. Clinical items included obstetric history (number of pregnancies, deliveries, cesarean sections, miscarriages, and stillbirths), presence of any underlying disease, presence of frequent headaches and impairments of memory, reflexes, vision, and hearing, and history of blood transfusions or transplants. Behavioral data included animal contacts, traveling, consumption of raw or undercooked meat, type of meat consumed (pork, lamb, beef, goat, boar, chicken, turkey, rabbit, deer, squirrel, horse, or other), eating away from home (in restaurants and fast food outlets), consumption of dried or cured meat (chorizo, ham, sausages, or salami), unwashed raw vegetables or fruits, drinking unpasteurized milk or untreated water, and soil contact (gardening or agriculture).

Serology of T. gondii infection

A blood sample was obtained from each participant. Blood was centrifuged and sera were stored at −20 °C until analyzed. Serum samples were examined for anti-T. gondii IgG antibodies by a commercially available enzyme immunoassay “Toxoplasma IgG” kit (Diagnostic Automation Inc., Calabasas, CA, USA). All sera positive for anti-T. gondii IgG antibodies were additionally analyzed for anti-T. gondii IgM antibodies by a commercially available enzyme immunoassay “Toxoplasma IgM” kit (Diagnostic Automation Inc., Calabasas, CA, USA). Both tests were performed following the manufacturer’s instructions.

Statistical analysis

Results were analyzed with the Epi Info version 7 and SPSS version 15.0 software. For comparison of the frequencies, the Pearson’s chi square and the Fisher exact test (when values were small) were used. We performed bivariate analysis followed by multivariate analysis to assess the association between the characteristics of the women and T. gondii infection. All variables with a $P$ value equal to or less than 0.10 obtained in the bivariate analysis were included in the multivariate analysis. Odds ratios (OR) and 95% confidence intervals (CI) were calculated by logistic regression analysis using backward stepwise logistic regression analysis. Goodness of fit of our regression model was assessed with the Hosmer–Lemeshow test. A $P$ value <0.05 was considered as statistically significant.

Ethics considerations

This study was approved by the ethical committees of the Mothers and Children’s Hospital of the Secretary of Health, Centro de Salud de Servicios Ampliados 450, and Clínica de Medicina Familiar of the Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado in Durango City. The purpose and procedures of the study were explained to all participants, and a written informed consent was obtained from all of them.

Results

Of the 150 women with stillbirth history studied, 14 (9.3%) had anti-T. gondii IgG antibodies and six (42.9%) of them were also positive for anti-T. gondii IgM antibodies. Of the 14 anti-T. gondii IgG-positive women, 8 (57.1%) had IgG levels higher than 150 IU/ml, 2 (14.3%) between 100 and 150 IU/ml, and 4 (28.6%) between 9 and 99 IU/ml. Table 1 shows the socio-demographic characteristics of the 150 women and their correlation with T. gondii seropositivity. The mean age of the women studied was 32.09 ± 9.16 years (range 16–50 years). The socio-demographic variable “ethnic group” was associated ($P = 0.01$) with seropositivity to T. gondii by bivariate analysis. Other socio-demographic variables including age, birthplace, residence, occupation, educational level, and socio-economic status showed $P$ values higher than 0.10 by bivariate analysis.
With respect to clinical data, three variables showed $P$ values less than 0.10 by bivariate analysis including “lymphadenopathy” ($P = 0.04$), “history of surgery” ($P = 0.01$), and “history of deliveries” ($P = 0.08$). Other clinical characteristics including number of pregnancies, cesarean sections, miscarriages or stillbirths, presence of any underlying disease, presence of frequent headaches and impairments of memory, reflexes, vision and hearing, and history of blood transfusions or transplants showed $P$ values higher than 0.10 by bivariate analysis. A correlation of seropositivity to $T. gondii$ with a selection of clinical characteristics of the women is shown in Table 2. The frequency of anti-$T. gondii$ IgM antibodies was also significantly ($P = 0.04$) higher in women with surgery history (6/95; 6.3%) than that in women without this history (0/55; 0%). Other clinical characteristics of women were not associated with IgM seropositivity. Stillbirths had occurred from 1 day to 35 years (median 2 years) ago.

Concerning behavioral characteristics, the variable “frequency of eating meat” but no other clinical characteristics including animal contacts, traveling, consumption of raw or undercooked meat, type of meat consumed, eating in restaurants and fast food outlets, consumption of dried or cured meat, unwashed raw vegetables or fruits, drinking unpasteurized milk or untreated water, and soil contact showed $P$ values of less than 0.10 by bivariate analysis.

Table 1. Socio-demographic characteristics of women with stillbirth history and seroprevalence of $T. gondii$ infection

| Characteristics          | No. of subjects tested | Prevalence of $T. gondii$ infection | $P$ value |
|-------------------------|------------------------|-------------------------------------|-----------|
|                         | No. | %      |                               |           |
| Age groups (years)      |     |        |                               |           |
| 30 or less              | 69  | 4      | 5.8                            | 0.26      |
| >30                     | 81  | 10     | 12.3                           |           |
| Ethnic group            |     |        |                               |           |
| Mexicanero              | 1   | 0      | 0.0                            | 0.01      |
| Tepihuano               | 3   | 2      | 66.7                           |           |
| White                   | 8   | 0      | 0.0                            |           |
| Mestizo                 | 138 | 12     | 8.7                            |           |
| Birth place             |     |        |                               |           |
| Durango State           | 138 | 12     | 8.7                            | 0.31      |
| Other Mexican State     | 12  | 2      | 16.7                           |           |
| Residence place         |     |        |                               |           |
| Durango State           | 147 | 14     | 9.5                            | 1         |
| Other Mexican State     | 3   | 0      | 0.0                            |           |
| Residence area          |     |        |                               |           |
| Urban                   | 127 | 11     | 8.7                            | 0.23      |
| Suburban                | 8   | 0      | 0.0                            |           |
| Rural                   | 15  | 3      | 20.0                           |           |
| Educational level       |     |        |                               |           |
| No education            | 3   | 1      | 33.3                           | 0.15      |
| 1–6 years               | 21  | 1      | 4.8                            |           |
| 7–12 years              | 105 | 12     | 11.4                           |           |
| 13 or more years        | 21  | 0      | 0.0                            |           |
| Occupation              |     |        |                               |           |
| Unemployed              | 120 | 12     | 10.0                           | 0.73      |
| Employed                | 30  | 2      | 6.7                            |           |
| Socio-economic level    |     |        |                               |           |
| Low                     | 39  | 4      | 10.3                           | 0.92      |
| Medium                  | 110 | 10     | 9.1                            |           |
| High                    | 1   | 0      | 0.0                            |           |
Table 2. Bivariate analysis of clinical data and infection with *T. gondii* in women with stillbirth history in Durango City, Mexico

| Characteristics                        | No. of subjects tested | Prevalence of *T. gondii* infection | P value |
|----------------------------------------|------------------------|-------------------------------------|---------|
|                                        | No. | %       |                                     |         |
| Clinical status                        |     |         |                                     |         |
| Healthy                                | 119 | 9       | 7.6                                 | 0.15    |
| Ill                                    | 30  | 5       | 16.7                                |         |
| Lymphadenopathy ever                   |     |         |                                     |         |
| Yes                                    | 23  | 5       | 21.7                                | 0.04    |
| No                                     | 127 | 9       | 7.1                                 |         |
| Headache frequently                    |     |         |                                     |         |
| Yes                                    | 73  | 8       | 11                                  | 0.50    |
| No                                     | 77  | 6       | 7.8                                 |         |
| Memory impairment                      |     |         |                                     |         |
| Yes                                    | 42  | 3       | 7.1                                 | 0.75    |
| No                                     | 108 | 11      | 10.2                                |         |
| Dizziness                              |     |         |                                     |         |
| Yes                                    | 50  | 7       | 14                                  | 0.23    |
| No                                     | 100 | 7       | 7                                   |         |
| Reflex impairment                      |     |         |                                     |         |
| Yes                                    | 12  | 1       | 8.3                                 | 1.00    |
| No                                     | 138 | 13      | 9.4                                 |         |
| Hearing impairment                     |     |         |                                     |         |
| Yes                                    | 20  | 1       | 5                                   | 0.69    |
| No                                     | 130 | 13      | 10                                  |         |
| Visual impairment                      |     |         |                                     |         |
| Yes                                    | 45  | 4       | 8.9                                 | 1.00    |
| No                                     | 105 | 10      | 9.5                                 |         |
| Surgery ever                           |     |         |                                     |         |
| Yes                                    | 95  | 13      | 13.7                                | 0.01    |
| No                                     | 55  | 1       | 1.8                                 |         |
| Blood transfusion                      |     |         |                                     |         |
| Yes                                    | 27  | 4       | 14.8                                | 0.28    |
| No                                     | 122 | 10      | 8.2                                 |         |
| Pregnancies                            |     |         |                                     |         |
| One                                    | 21  | 1       | 4.8                                 | 0.69    |
| More than one                          | 129 | 13      | 10.1                                |         |
| Deliveries                             |     |         |                                     |         |
| Zero                                   | 54  | 2       | 3.7                                 | 0.08    |
| One or more                            | 96  | 12      | 12.5                                |         |
| Cesarean sections                      |     |         |                                     |         |
| Yes                                    | 52  | 6       | 11.5                                | 0.55    |
| No                                     | 98  | 8       | 8.2                                 |         |
A selection of clinical characteristics of women and their association with *T. gondii* seropositivity is shown in Table 3. Multivariate analysis of variables with *P* values equal to or less than 0.10 obtained in the bivariate analysis showed that *T. gondii* seropositivity was associated with high frequency (4–7 days a week) of eating meat (OR = 5.52; 95% CI: 1.48–20.59; *P* = 0.01), history of lymphadenopathy (OR = 4.52; 95% CI: 1.14–17.82; *P* = 0.03), and history of surgery (OR = 8.68; 95% CI: 1.04–72.15; *P* = 0.04). The Hosmer–Lemeshow test showed an acceptable fit of our regression model (*P* = 0.86).

**Discussion**

The epidemiology of *T. gondii* infection in women with stillbirth history in Mexico is largely unknown. In the present study, we obtained the seroprevalence and correlates of *T. gondii* infection in women with stillbirth history in the northern Mexican City of Durango. *T. gondii* seropositivity was associated with high frequency of eating meat, history of lymphadenopathy, and history of surgery. Only few reports about the seroprevalence of *T. gondii* infection in women with stillbirths in the world exist. The se-
Toxoplasma and stillbirth

European Journal of Microbiology and Immunology

The seroprevalence (9.3%) found in the present study is slightly higher than the 6.1% seroprevalence of *T. gondii* infection reported in the general population [13] and the 6.7% seroprevalence in women with miscarriage history [14] in Durango City, Mexico. However, the seroprevalence is markedly lower than the 21.4%–66.7% seroprevalences reported in women with stillbirths in Iran [10], Indonesia [11], India [12], and the Caribbean island of Trinidad [8]. The difference in seroprevalences might be a reflection of the seroprevalences of *T. gondii* infection in the general populations among the countries studied, e.g., 39.3% in Iran [15] and 30.9% in India [16].

Consumption of meat is a well-known and important risk factor for *T. gondii* infection [1]. In the present study, subjects who consumed meat 4–7 days a week had a significantly higher seroprevalence of *T. gondii* infection than those who consumed meat up to 3 days a week. This finding suggests that an important number of women with stillbirth history might have acquired *T. gondii* infection owing to frequent consumption of meat. In the current study, we studied women who have had stillbirths from 1 day to 35 years (median 2 years) ago. Therefore, factors associated with *T. gondii* infection found in our study should be further investigated in a larger number of women with recent stillbirths. The association of infection with high frequency of meat consumption has epidemiological importance and points toward the need of educational programs in women to avoid *T. gondii* infection with especial attention to pregnant women with high frequency of meat consumption. Health education may help to reduce the risk of congenital toxoplasmosis [17].

With respect to the association of *T. gondii* infection with a history of lymphadenopathy, our finding suggests that women with stillbirth history may have presented

Table 3. (cont.)

| Characteristics                     | No. of subjects tested | Prevalence of *T. gondii* infection | P value |
|-------------------------------------|------------------------|-------------------------------------|---------|
|                                     |                        | No. | %               |         |
| Frequency of meat consumption       |                        |     |                 |         |
| Up to 3 times a week                | 118                    | 8   | 6.8             | 0.07    |
| 4–7 times a week                    | 31                     | 6   | 19.4            |         |
| Degree of meat cooking              |                        |     |                 |         |
| Raw                                 | 1                      | 0   | 0               | 0.8     |
| Undercooked                         | 3                      | 0   | 0               |         |
| Well done                           | 146                    | 14  | 9.6             |         |
| Raw milk consumption                |                        |     |                 |         |
| Yes                                 | 59                     | 3   | 5.1             | 0.15    |
| No                                  | 91                     | 11  | 12.1            |         |
| Unwashed raw fruits                 |                        |     |                 |         |
| Yes                                 | 51                     | 3   | 5.9             | 0.38    |
| No                                  | 99                     | 11  | 11.1            |         |
| Untreated water                     |                        |     |                 |         |
| Yes                                 | 91                     | 7   | 7.7             | 0.39    |
| No                                  | 59                     | 7   | 11.9            |         |
| Frequency of eating out of home     |                        |     |                 |         |
| Never                               | 11                     | 1   | 9.1             | 0.28    |
| 1–10 times a year                   | 61                     | 3   | 4.9             |         |
| >10 times a year                    | 78                     | 10  | 12.8            |         |
| Washing hands before eating         |                        |     |                 |         |
| Yes                                 | 140                    | 12  | 8.6             | 0.23    |
| No                                  | 10                     | 2   | 20              |         |
| Floor at home                       |                        |     |                 |         |
| Ceramic or wood                     | 65                     | 9   | 13.8            | 0.23    |
| Concrete                            | 73                     | 4   | 5.5             |         |
| Soil                                | 12                     | 1   | 8.3             |         |
clinical signs of toxoplasmosis albeit this disease was not diagnosed during or before pregnancy. Lymphadenopathy is a characteristic sign of toxoplasmosis while not always observed during pregnancy [1, 2]. It is also true that lymphadenopathy is not exclusive of toxoplasmosis but physicians should think of *T. gondii* infection as a differential diagnosis in any pregnant women presenting with lymph node enlargement. Toxoplasmosis in Mexico is a neglected disease and poor knowledge on the clinical manifestations of toxoplasmosis among physicians in the region has been reported [18]. Therefore, our finding further remarks the need for educational programs to physicians attending pregnant women to increase the detection rate of toxoplasmosis and to provide information for preventing *T. gondii* infections to all their patients.

Intriguingly, we found an association of *T. gondii* infection with a history of surgery. In a previous cross-sectional study of psychiatric patients in a public hospital in Durango City, Mexico, we also found an association of *T. gondii* seropositivity with a history of surgery [19]. We are not aware of further studies that had shown this association. The finding of this association in two independent studies with different population groups should prompt further research into the association of *T. gondii* exposure with a history of surgery. In this regard, it is well known that organ transplantation can be a source for *T. gondii* infection [20, 21]. However, none of the women in our study had undergone surgery for transplantation. In a previous study, history of abdominal hernia repair was linked to *T. gondii* seropositivity, although it was not clear whether this link was due to the surgery or by muscle damage by *T. gondii* [22]. However, none of the women in our study had a history of abdominal hernia repair. The association of *T. gondii* exposure with a history of surgery may be caused by a number of factors. In theory, instruments or materials used in surgeries may be contaminated with *T. gondii* via blood or tissues from other *T. gondii*-infected patients undergoing surgery. Alternatively, surgical suture materials such as “catgut” are made of intestines of animals. It is unclear whether catgut was made or is currently made of cat intestines but it is well known that important stages of *T. gondii* life cycle occurs in the intestines of cats and other felids [23]. It is also unclear whether solutions used to preserve catgut may also preserve *T. gondii*. Finally, the association observed here and in another study may not be of causal nature.

**Conclusions**

This is the first study on the seroepidemiology of *T. gondii* infection in women with history of stillbirths in Mexico. Well-established risk factors for *T. gondii* infection found in the present survey may help to design optimal educational programs to avoid *T. gondii* infection. The association of *T. gondii* exposure with a history of surgery warrants for further research.

**Acknowledgements**

This study was supported by Juárez University of Durango State.

**References**

1. Montoya JG, Liesenfeld O: Toxoplasmosis. Lancet 363, 1965–1976 (2004)
2. Dubey JP (2010): Toxoplasmosis of Animals and Humans, 2nd ed. CRC Press, Boca Raton, Florida
3. Hill DE, Chirukandoth S, Dubey JP: Biology and epidemiology of *Toxoplasma gondii* in man and animals. Anim Health Res Rev 6, 41–61 (2005)
4. Maenz M, Schlüter D, Liesenfeld O, Schaeres G, Gross U, Pleyer U: Ocular toxoplasmosis past, present and new aspects of an old disease. Prog Retin Eye Res 39, 77–(2014)
5. Weiss LM, Dubey JP. Toxoplasmosis: A history of clinical observations. Int J Parasitol 39, 895–901 (2009)
6. Moncada PA, Montoya JG: Toxoplasmosis in the fetus and newborn: an update on prevalence, diagnosis and treatment. Expert Rev Anti Infect Ther 10, 815–(2012)
7. Goldenberg RL, Thompson C: The infectious origins of stillbirth. Am J Obstet Gynecol 189, 861–873 (2003)
8. Adesiyun AA, Gooding R, Ganta K, Seepersad Singh N, Ramsewak S: Congenital toxoplasmosis in two health institutions in Trinidad. West Indian Med J 56, 166–170 (2007)
9. Alvarado-Esquivel C, Vázquez-Alaniz F, Sandoval-Carrillo AA, Salas-Pacheco JM, Hernández-Tinoco J, Sánchez-Anguiano LF, Liesenfeld O: Lack of association between *Toxoplasma gondii* infection and hypertensive disorders in pregnancy: a case-control study in a Northern Mexican population. Parasit Vectors 7, 167 (2014)
10. Ghasemi FS, Rasti S, Piroozmand A, Bandehpour M, Kazemi B, Mousavi SG, Abdoli A: Toxoplasmosis-associated abortion and stillbirth in Tehran, Iran. J Matern Fetal Neonatal Med, 1–4 (2015)
11. Gandahusada S: Study on the prevalence of toxoplasmosis in Indonesia: a review. Southeast Asian J Trop Med Public Health 22, 93–98 (1991)
12. Sarkar MD, Anuradha B, Sharma N, Roy RN: Seropositivity of toxoplasmosis in antenatal women with bad obstetric history in a tertiary-care hospital of Andhra Pradesh, India. J Health Popul Nutr 30, 87–92 (2012)
13. Alvarado-Esquivel C, Estrada-Martínez S, Pizarro-Villalobos H, Arce-Quiñones M, Liesenfeld O, Dubey JP: Seroepidemiology of *Toxoplasma gondii* infection in general population in a northern Mexican city. J Parasitol 97, 40–43 (2011)
14. Alvarado-Esquivel C, Pacheco-Vega SJ, Hernández-Tinoco J, Centeno-Tinoco MM, Beristain-García I, Sánchez-Anguiano LF, Liesenfeld O, Ráhago-Sánchez E, Beunen-Segovia LO: Miscarriage history and *Toxoplasma gondii* infection: a cross-sectional study in women in Durango City, Mexico. Eur J Microbiol Immunol (Bp) 4, 117–122 (2014)
15. Daryani A, Sarvi S, Aarabi M, Mizani A, Ahmadpour E, Shokri A, Rahimi MT, Sharif M: Seroprevalence of *Toxoplasma gondii* in the Iranian general population: a systematic review and meta-analysis. Acta Trop 137, 185–194 (2014)
16. Meisheri YV, Mehta S, Patel U: A prospective study of seroprevalence of Toxoplasmosis in general population, and in HIV/AIDS patients in Bombay, India. J Postgrad Med 43, 93–97 (1997)
17. Gollub EL, Leroy V, Gilbert R, Chêne G, Wallon M, European Toxoprevention Study Group (EUROTOXO): Effectiveness of health education on Toxoplasma-related knowledge, behaviour, and risk of seroconversion in pregnancy. Eur J Obstet Gynecol Reprod Biol 136, 137–145 (2008)
18. Alvarado-Esquivel C, Sifuentes-Alvarez A, Estrada-Martinez S, Rojas-Rivera A: Knowledge and practices on toxoplasmosis in physicians attending pregnant women in Durango, Mexico. Gac Med Mex 147, 311–324 (2011)
19. Alvarado-Esquivel C, Alanis-Quinones OP, Arreola-Valenzuela MA, Rodriguez-Briones A, Piedra-Nevarez LJ, Duran-Morales E, Estrada-Martinez S, Martinez-Garcia SA, Liesenfeld O: Seroepidemiology of Toxoplasma gondii infection in psychiatric inpatients in a northern Mexican city. BMC Infect Dis 6, 178 (2006)
20. Fishman JA: Infection in renal transplant recipients. Semin Nephrol 27, 445–461 (2007)
21. Martina MN, Cervera C, Esforzado N, Linares L, Torregrosa V, Sanclemente G, Hoyo I, Cofan F, Oppenheimer F, Miro JM, Campistol JM, Moreno A: Toxoplasma gondii primary infection in renal transplant recipients. Two case reports and literature review. Transpl Int 24, e6–e12 (2011)
22. Alvarado-Esquivel C, Estrada-Martinez S: Toxoplasma gondii infection and abdominal hernia: evidence of a new association. Parasit Vectors 4, 112 (2011)
23. Behnke MS, Zhang TP, Dubey JP, Sibley LD: Toxoplasma gondii merozoite gene expression analysis with comparison to the life cycle discloses a unique expression state during enteric development. BMC Genomics 15, 350 (2014)