Open Access

OBM Transplantation

Case Report

Toxoplasmosis: "An Often Forgotten Cause for Fever of Unknown Origin in Liver Transplant Recipients". Case Report and Review of Literature

Jose A. Morillas [*], Sherif Beniameen Mossad

Department of Infectious Diseases, Respiratory Institute and Transplant Center, Cleveland Clinic Foundation, Cleveland, OH, USA; E-Mails: morillj@ccf.org; mossads@ccf.org

* **Correspondence:** Jose A. Morillas; E-Mail: morillj@ccf.org

Academic Editor: Yasuhiko Sugawara

Special Issue: Infections in Liver Transplantation

OBM Transplantation
2019, volume 3, issue 4
doi:10.21926/obm.transplant.1904091

Received: October 24, 2019
Accepted: November 15, 2019
Published: November 18, 2019

Abstract

Toxoplasmosis in liver transplantation (LT) is uncommon, especially in the current era of universal prophylaxis with trimethoprim-sulfamethoxazole (TMP-SMX) for *Pneumocystis jirovecii* pneumonia (PJP). Here we present a case of a 55-year-old woman LT recipient, on dapsone or PJP prophylaxis due to sulfa allergy, who presented on day 25 after LT with fever, diarrhea and abdominal pain. Initially she was diagnosed with cytomegalovirus-associated colitis and was treated with intravenous ganciclovir, with good clinical response. On day 39 after LT she started having fevers again. In the setting of Toxoplasma IgG seropositive donor, recipient's toxoplasma serologies were checked, and IgM was positive with weakly positive IgG. Qualitative polymerase chain reaction in blood confirmed Toxoplasmosis. Donor-derived infection was considered "probable" because retrospective testing of stored pre-transplant recipient serum was not performed. No evidence of toxoplasma disease was documented. Patient was treated with pyrimethamine, clindamycin and leucovorin; later changed to atovaquone due to intolerance, with good clinical response. Our case highlights the importance of considering toxoplasmosis in the differential diagnosis of undifferentiated febrile illness, especially in LT recipients who are at high risk for primary infection with this organism and not receiving antimicrobial prophylaxis active against toxoplasmosis.

Keywords
Toxoplasma gondii; liver transplant; donor-derived

1. Introduction

Toxoplasmosis is a zoonosis that infects humans worldwide; prevalence and clinical severity vary by geographic area [1-3]. In 2018, the United States (US) Centers for Disease Control and Prevention (CDC) estimated that infection rates vary from 11% in the US population to over 95% of the population in some countries (Western Europe, Africa, and South and Central America) [4, 5].

Although infection is asymptomatic in more than 80% of immunocompetent hosts, T. gondii may be fatal in immunocompromised hosts with mortality approaching 100% if untreated [1, 6]. In the solid organ transplant (SOT) population, toxoplasmosis is well described after cardiac transplantation. However, it has been considered rare after liver transplantation (LT), with few sporadic cases reported over the years [7-9].

Donor-derived infection (DDI) is considered a possible mechanism for toxoplasma infection in LT [6-9]. This is supported by a mouse model of toxoplasmosis, which has shown that liver could be a target for Toxoplasma encystment, although parasitic loads appeared to be much lower than in the heart [10]. Without specific antecedent immunity (toxoplasma IgG seronegative recipient) and in the context of immunosuppression, bradyzoites transform into tachyzoites (active replicative form) without any control and can result in a potentially fatal infection [2]. On the other hand, reactivation of latent toxoplasma infection in the toxoplasma IgG seropositive recipient is rare in all SOT types, and usually occurs in the context of augmented immunosuppression for treatment of rejection [8, 9].

Here we report a case of “probable” donor-transmitted toxoplasmosis in a LT recipient at our transplant center and review current published literature.

2. Case

A 55 year-old woman with history of end-stage liver disease due to autoimmune hepatitis (AIH) underwent orthotopic LT. She received antirejection therapy with tacrolimus, mycophenolate mofetil (MMF), and prednisone, without induction immunosuppression. Prior to transplant she had been receiving azathioprine and prednisone for AIH for 2 years. Her pre-transplant IgG cytomegalovirus (CMV) serology was negative and the donor’s was positive. Epstein-barr virus (EBV) IgG serology was positive in both the recipient and donor. Her early post-transplant course was uneventful. She was on acyclovir for Herpes simplex virus and Varicella zoster virus prophylaxis and periodical blood quantitative CMV polymerase chain reaction (PCR) for pre-emptive monitoring. Because of a history of severe rash with sulfa, she received oral dapsone for *Pneumocystis jirovecii* pneumonia (PJP) prophylaxis rather than trimethoprim-sulfamethoxazole (TMP-SMX).

On post-transplant day 25, she developed fever up to 38.8 ^{o}C, associated with nausea, diarrhea, poor appetite, and abdominal pain. Laboratory tests showed white blood cell count of 6.4x10^{3}/uL, hemoglobin of 9.0 g/dL, platelet count of 190x10^{3}/uL, and creatinine 1.06 mg/dL. Stool

Clostridiodes difficile PCR was negative. Bacterial stool culture was negative for *Escherichia coli*, *Salmonella* species and *Shigella* species. Campylobacter species and Shiga toxin-producing bacteria by enzyme immunoassay were negative. Norovirus PCR in stool was negative. Stool microscopic exam for ova and parasites was negative. Blood cultures were negative. Nasopharyngeal swab for viral respiratory pathogens (including Influenza A, Influenza B, Respiratory syncytial virus, Parainfluenza virus, Metapneumovirus, Rhinovirus and Adenovirus) by PCR was negative. CMV blood PCR was 474 IU/mL (175 IU/mL one week prior). MMF was held due to diarrhea. Intravenous (IV) ganciclovir (GCV) was started at 5 mg/kg every 12 hours and subsequently IV piperacillin-tazobactam was added for persistent fever. Computerized tomography (CT) of the abdomen with oral and IV contrast showed moderate periportal edema but no fluid collections. Colonoscopy was performed due to persistent profuse diarrhea, which showed CMV colitis by immunohistochemical staining (IHCS). GCV dose was increased to 10 mg/kg every 12 hours, which resulted in transient leukopenia and thrombocytopenia. CMV blood PCR peaked at 3,281 IU/mL. After 10 days of treatment with IV GCV, fever and gastrointestinal symptoms resolved. However 4 days later, she developed recurrent high-grade fevers without localizing symptoms, as well as methemoglobinemia that required discontinuation of dapsone and initiation of monthly inhaled pentamidine. At the same time, leukopenia had resolved, but alkaline phosphatase increased to 259 U/L, alanine aminotransferase 39 U/L, and aspartate aminotransferase 62 U/L, while total bilirubin remained normal. Blood CMV PCR had decreased to 547 IU/mL and blood cultures remained negative. CT chest showed small bilateral pleural effusions, and repeat abdominal CT with IV contrast showed improved periportal edema and stenosis of right hepatic vein and common hepatic artery, which was managed by percutaneous endovascular stenting. No liver lesions or biliary dilation were seen on CT. Endoscopic retrograde cholangiopancreatography showed mild common bile duct stenosis that was managed by endoscopic stenting. Liver function normalized, however fevers persisted. Repeat colonoscopy was grossly normal, and tissue IHCS for CMV was negative. Histoplasma urine antigen and serum Cryptococcal antigen were negative, and blood CMV PCR was detectable, but ≤ 137 IU/mL. Since the donor's toxoplasma IgG was positive, the recipient was tested for Toxoplasmosis. Toxoplasma IgM by chemiluminescence immunoassay was 160 AU/mL (negative < 8), IgG 10.8 (positive >8.8 IU/mL). Toxoplasma qualitative real-time PCR in blood was positive; confirming Toxoplasma infection. Magnetic resonance brain imaging with IV contrast did not show space-occupying lesions suggestive of toxoplasma encephalitis. Cerebrospinal fluid analysis was not performed because there was no clinical suspicion for encephalitis. Since she did not have visual symptoms, dilated fundoscopic ophthalmologic exam was not pursued. She was treated with pyrimethamine, clindamycin and leucovorin. Fever resolved 6 days after initiating this therapy. Later on, regimen was changed to atovaquone due to diarrhea; suspected to be due to clindamycin. Patient completed 6 weeks of this therapy with complete resolution of symptoms. No lifelong suppression to prevent recurrence of toxoplasmosis was offered, because the likelihood of reactivation was assumed to be low after LT. No clinical relapse was documented over a 2 year period of follow up.

3. Literature Review

A Medline/PubMed search was performed for "toxoplasmosis" and "LT". We encountered a total of 14 adult cases of toxoplasmosis in LT recipients published in the English Literature from 1999 through September 2019 [7, 11-20]. Most of them occurred in Europe and only 2 in the United States. Table 1 illustrates the main characteristics. There were 2 cases of combined liver with another organ transplant [15]. Lung involvement was the most common presentation. Two cases had disseminated involvement [12, 16]. Among cases with documented toxoplasma serologies, 6 of them had pre-transplant mismatched serostatus (donor seropositive/recipient seronegative) [7, 11, 14, 16, 18, 19], 5 occurred in seropositive recipients, and serologies were not reported in 3 cases. The median number of days from LT to onset of illness in the 14 patients was 38 days, in mismatched cases was 32 days, and in seropositive recipients was 41 days, with the earliest one occurring after 12 days in a mismatched case [14]. 12 LT recipients were on steroids, which have been associated with propagation of both tachyzoites and bradyzoites in infected mice [21]. 4 recipients had received antithymocyte globulin (ATG). Immunosuppressive therapy was not reported in 3 seropositive recipients [17]. The latest reported case presented 7 months after LT with Chorioretinitis, despite having received TMP-SMX prophylaxis for the first 3 months after LT [19]. 8 of the cases included in the current review were not receiving TMP-SMX prophylaxis at the time of Toxoplasmosis diagnosis. In 5 cases, it was not documented whether prophylaxis was given or not. In the single case that was receiving prophylactic TMP-SMX 4 times per week, this did not prevent the development of toxoplasmosis [13]. Of note, that patient was treated with ATG for rejection and the degree of compliance with immunosuppressive medications and prophylactic TMP-SMX was not specified. 9 of the 14 patients survived. Of those nine, 6 were documented to have received secondary prophylaxis [7, 13, 17, 19]. Secondary prophylaxis was discontinued in 1 patient when CD4 count reached > 200 cells/mm^3 [13]; and in another due to myelosuppression [19]. After an average duration of follow-up of 16 months that was reported in 6 of the 9 survivors, no relapses were documented despite the discontinuation of secondary prophylaxis.

4. Discussion

Toxoplasmosis has been infrequently reported after LT. Even in toxoplasma donor seropositive/recipient seronegative patients, the risk of transmission is lower than in heart transplant recipients (20% vs 50%) [22]. For that reason, toxoplasmosis is not usually entertained in the differential diagnosis of febrile illness in LT recipients.

We described a case of a LT recipient who was diagnosed with "probable" donor derived toxoplasmosis based on the early onset of symptoms (day 39 after LT), strongly positive toxoplasma IgM, weakly positive IgG, positive blood PCR, and the lack of other obvious routes of acquisition. Patient had not been tested pre-transplant and unfortunately retrospective testing of stored pre-transplant recipient serum could not be performed to consider "proven" donor derived infection [23].

Table 1 Published cases of Toxoplasmosis in liver transplant recipients.

Publication year	Country	Age/Gender	D/R	IS	Concomitant Prophylaxis for PJP	Clinical presentation	Days from LT to presentation	Outcome	Secondary prophylaxis	Relapse /follow-up duration
2000 (11)	France	43/F	D+/R-	Cyclosporine, prednisone	none	Panuveitis	21	Survived	none	none / 1 year
2002 (12)	France	53/NA	D?/R+	ATG, tacrolimus, prednisolone	NA	Disseminated (lung, heart, liver, kidneys, pancreas, spleen)	22	Died	-	-
2002 (13)	Argentina	53/F	D?/R+	ATG (rejection), tacrolimus, prednisone	TMP-SMX 160/800mg 4xweek during episode	Pneumonia	41	Survived	Pyrimethamine x1y (stopped once CD4>200)	none / 18 months
2002 (14)	France	27/F	D+/R-	methylprednisolone, tacrolimus, MMF	NA	Fever, pancytopenia/Pneumonia	12 /26	Died	-	-
2002 (15)	Germany	65/F*	D?/R?	ATG, cyclosporine, azathioprine, prednisolone	NA	Encephalitis	88	Died	-	-
2002 (15)	Germany	32/NA**	D?/R?	ATG, cyclosporine, azathioprine, prednisolone	NA	Encephalitis	13	Survived	none	none / 2 years
2006 (7)	US	52/M	D+/R-	prednisone, tacrolimus, MMF. High dose steroids x rejection	Inhaled pentamidine (sulfa allergy)	Pneumonia	32	Survived	sulfadiazine +pyrimethamine, then atovaquone + pyrimethamine***	none / 1 year
2007 (16)	Netherlands	36/M	D+/R-	prednisone, cyclosporine, MMF	NA	Disseminated (lung, liver, spleen)	44	Died	-	-

2008 (17)	Turkey	NA	D+/R+	NA. No rejection	TMP-SMX discontinued	Fever, visual disturbances	44	Survived	TMP-SMX	NA
2008 (17)	Turkey	NA	D+/R+	NA. No rejection	TMP-SMX discontinued	Fever, visual disturbances	34	Survived	TMP-SMX	NA
2008 (17)	Turkey	NA	D+/R+	NA. No rejection	TMP-SMX discontinued	Fever, nauseas	54	Survived	TMP-SMX	NA
2016 (18)	France	62/F	D+/R-	prednisone, tacrolimus, MMF	none	Pneumonia	31	Died	-	-
2016 (19)	UK	32/F	D+/R-	prednisone, tacrolimus, MMF. High dose steroids x rejection (2)	TMP-SMX first 3 months	Chorioretinitis	210	Survived	TMP-SMX. Stopped for myelosupression	none / 2 years
2019 (20)	US	62/F	D?/R?	prednisone, tacrolimus, MMF	Inhaled pentamidine (renal issue)	Encephalitis	90	Survived	NA	none / 6 months
2019 (PR)	US	55/F	D+/R?	prednisone, tacrolimus, MMF	Dapsone (sulfa allergy)	Fever without localizing symptoms	39	Survived	none	none / 2 years

M, male;F, female; LT, liver transplant; NA, not available; D+, seropositive T gondii donor;D-, seronegative T gondii donor; R+, seropositive T gondii recipient; R-, seronegative T gondii recipient; IS, immunosuppression; PR, present report; ATG, thymoglobulin; MMF, mychopenolate mofetil; TMP-SMX, trimethoprim-sulfamethoxazole.

*combined liver-pancreas-kidney; **combined liver-pancreas; ***Developed kidney stones on sulfadiazine.

Pre-transplant universal screening of LT candidates for toxoplasma serology has not been a standard practice in countries with low prevalence such as the US, in contrast with some European countries [24]. However, current guidelines from the Infectious Diseases Community of Practice (IDCOP) of the American Society of Transplantation (AST) recommends screening "all" donors and recipients with toxoplasma IgG, in order to identify patients at higher risk (donor seropositive/ recipient seronegative) and implement prophylactic strategies (strong recommendation, high quality of evidence) [4].

It is uncertain how much the lack of use of prophylactic TMP-SMX could have predisposed our patient for toxoplasma infection. It is thought that wide use of TMP-SMX for PJP prophylaxis provides additional protection against toxoplasma infection. Data supporting the efficacy of toxoplasma-specific prophylaxis in LT are limited, unlike in heart transplant recipients, where this is clearly indicated [9, 25]. Two large multicenter studies in areas with high seroprevalence of toxoplasmosis have shown that most cases were reported in patients not receiving prophylaxis [5, 26]. Conversely, a Canadian single center study found that although TMP-SMX prophylaxis was given in just 58% of mismatched LT recipients, only 1 of them experienced asymptomatic seroconversion in the setting of short interruption of TMP-SMX [1]. Interestingly, current transplant guideline highlights that prophylaxis with TMP/SMX should be considered for D+/R non-cardiac recipients [4].

The time of presentation for donor-derived toxoplasmosis in LT recipients is usually within the first 3 months after transplantation, but cases occurring as early as 2 weeks post-transplant have been described in the literature [8, 14]. Clinical presentation is usually non-specific and includes fever, respiratory distress, neurologic manifestations and bone marrow suppression [27]. The severity of clinical features depends on the degree of antecedent immunosuppression and timing of institution of specific anti-toxoplasma therapy [8]. Our patient presented with isolated fever without any evidence of multi-organ involvement, which is unusual in the very immunocompromised host (Table 1). One explanation could be that induction immunosuppression with a T cell depleting agent was not employed. On the other hand, the use of highly sensitive diagnostic tests (PCR) allowed a rapid confirmation and early initiation of therapy. It is well known that delay in treatment of toxoplasmosis can result in high fatality rate [1, 4, 9, 22].

Laboratory diagnosis of toxoplasmosis traditionally relies on the presence of IgM antibodies or on IgG seroconversion. However, in immunocompromised patients, seroconversion may be delayed and even absent [2, 8]. Due to its better sensitivity and specificity, PCR of blood and body fluids is strongly recommended for a timely diagnosis of acute toxoplasmosis in SOT recipients [4].

CMV co-infection has been previously reported in LT recipients who developed toxoplasmosis, and this also occurred in our patient. Fernandez-Saba *et-al* found that diagnosis of CMV disease within the preceding 6 months was significantly associated with toxoplasmosis in SOT recipients on univariate analysis [OR 7.81, CI 1.81–33.59; p=0.004] [5]. However, this association was not significant by logistic regression multivariable analysis. Up to 50% of recipients with CMV and toxoplasma co-infection in Galvan's systematic review had fatal outcomes, which might suggest that CMV could worsen outcomes by its indirect immunomodulatory effects [6, 13].

The 2019 updated guidelines from the IDCOP of the AST recommends that lifelong antimicrobial secondary prophylaxis/suppression should be considered in all SOT recipients, since such medications are effective against the proliferative tachyzoite form but not the encysted

parasite [4]. We decided not to administer secondary prophylaxis to our patient, because toxoplasma bradyzoites are less likely to be harbored in the liver, and the level of immunosuppression in our patient was already low.

In summary, toxoplasmosis should be considered in the differential diagnosis of non-specific febrile illnesses in LT recipients, especially those known to be at increased risk due to seropositive donors/seronegative recipients, and inability to tolerate TMP-SMX prophylaxis. Early clinical suspicion, use of high quality diagnostics such as PCR, and early initiation of effective antimicrobial therapy may prevent fatal outcomes in this patient population. If universal pre-transplant screening of LT recipients is not an option in a transplant program, retrospective testing of stored pre-transplant recipient serum should be considered when toxoplasmosis is suspected clinically; particularly when the donor is seropositive and the recipient was not on any prophylactic regimen with anti-toxoplasma activity.

Author Contributions

These authors contributed equally to this work.

Competing Interests

The authors have declared that no competing interests exist.

References

1. Gourishankar S, Doucette K, Fenton J, Purych D, Kowalewska-Grochowska K, Preiksaitis J. The use of donor and recipient screening for toxoplasma in the era of universal trimethoprim sulfamethoxazole prophylaxis. Transplantation. 2008; 85: 980-985.
2. Derouin F, Pelloux H, Parasitology ESGoC. Prevention of toxoplasmosis in transplant patients. Clin Microbiol Infect. 2008; 14: 1089-1101.
3. Robert-Gangneux F, Meroni V, Dupont D, Botterel F, Garcia JMA, Brenier-Pinchart M-P, et al. Toxoplasmosis in transplant recipients, europe, 2010–2014. Emerg Infect Dis. 2018; 24: 1497-1504.
4. La Hoz RM, Morris MI, Transplantation IDCoPotASo. Tissue and blood protozoa including toxoplasmosis, chagas disease, leishmaniasis, babesia, acanthamoeba, balamuthia, and naegleria in solid organ transplant recipients—guidelines from the american society of transplantation infectious diseases community of practice. Clin Transplant. 2019; 33: e13546.
5. Fernàndez-Sabé N, Cervera C, Fariñas MC, Bodro M, Muñoz P, Gurguí M, et al. Risk factors, clinical features, and outcomes of toxoplasmosis in solid-organ transplant recipients: A matched case-control study. Clin Infect Dis. 2011; 54: 355-361.
6. de la Luz Galvan-Ramirez M, Sánchez-Orozco LV, Gutiérrez-Maldonado AF, Pérez LRR. Does toxoplasma gondii infection impact liver transplantation outcomes? A systematic review. J Med Microbiol. 2018; 67: 499-506.
7. Assi M, Rosenblatt J, Marshall W. Donor-transmitted toxoplasmosis in liver transplant recipients: A case report and literature review. Transpl Infect Dis. 2007; 9: 132-136.
8. Khurana S, Batra N. Toxoplasmosis in organ transplant recipients: Evaluation, implication, and prevention. Trop Parasitol. 2016; 6: 123-128.

9. Dhakal R, Gajurel K, Montoya JG. Toxoplasmosis in the non-orthotopic heart transplant recipient population, how common is it? Any indication for prophylaxis? Curr Opin Organ Transplant. 2018; 23: 407-416.
10. Autier B, Dion S, Robert-Gangneux F. The liver as an organ at risk for toxoplasma transmission during transplantation: Myth or reality? J Clin Pathol. 2018; 71: 763-766.
11. Chiquet C, Fleury J, Blanc-Jouvan M, Wallon M, Boibieux A. Acquired ocular toxoplasmosis (panuveitis) after liver transplantation. J Fr Ophtalmol. 2000; 23: 375-379.
12. Wendum D, Carbonell N, Svrcek M, Chazouilléres O, Flejou J. Fatal disseminated toxoplasmosis in a toxoplasma seropositive liver transplant recipient. J Clin Pathol. 2002; 55: 637-637.
13. Barcan L, Dallurzo M, Clara L, Valledor A, Macias S, Zorkin E, et al. Toxoplasma gondii pneumonia in liver transplantation: Survival after a severe case of reactivation. Transpl Infect. 2002; 4: 93-96.
14. Botterel F, Ichai P, Feray C, Bouree P, Saliba F, Raspa RT, et al. Disseminated toxoplasmosis, resulting from infection of allograft, after orthotopic liver transplantation: Usefulness of quantitative PCR. J Clin Microbiol. 2002; 40: 1648-1650.
15. Hommann M, Schotte U, Voigt R, Glutig H, Grube T, Küpper B, et al. Cerebral toxoplasmosis after combined liver-pancreas-kidney and liver-pancreas transplantation. Transplant Proc; 2002; 34: 2294-2295.
16. Vaessen N, Verweij J, Spijkerman I. Fatal disseminated toxoplasmosis after liver transplantation: Improved and early diagnosis by PCR. Neth J Med. 2007; 65: 222-223.
17. Caner A, Döşkaya M, Karasu Z, Değirmenci A, Guy E, Kılıç M, et al. Incidence and diagnosis of active toxoplasma infection among liver transplant recipients in western turkey. Liver Transpl. 2008; 14: 1526-1532.
18. Miltgen G, Paillot J, Vanlemmens C, Di Martino V, Heyd B, Millon L, et al. Fatal acute respiratory distress by toxoplasma gondii in a toxoplasma seronegative liver transplant recipient. New Microbiol. 2016; 39: 160-162.
19. Webb G, Shah H, David M, Tiew S, Beare N, Hirschfield G. Post-prophylaxis toxoplasma chorioretinitis following donor–recipient mismatched liver transplantation. Transpl Infect Dis. 2016; 18: 805-808.
20. Bejjanki H, Olaoye OA, Santos AH, Koratala A. Liver transplant, toxoplasmosis and kidney stones: Connecting the dots. BMJ Case Rep. 2019; 12.
21. Puvanesuaran V, Nowroji K, Sreenivasan S, Noordin R, Balakrishnan V. Use of prednisolone to aid propagation of toxoplasma gondii in mice. Eur Rev Med Pharmacol Sci. 2012; 16: 1028-1032.
22. Schaffner A. Pretransplant evaluation for infections in donors and recipients of solid organs. Clin Infect Dis. 2001; 33: S9-S14.
23. Ison M, Grossi P, Practice AIDCo. Donor-derived infections in solid organ transplantation. Am J Transplant. 2013; 13: 22-30.
24. Schwartz B, Mawhorter S, Practice AIDCo. Parasitic infections in solid organ transplantation. Am J Transplant. 2013; 13: 280-303.
25. Patel R. Disseminated toxoplasmosis after liver transplantation. Clin Infect Dis. 1999; 29: 705-706.

26. Batista M, Pierrotti L, Abdala E, Clemente W, Girao E, Rosa D, et al. Endemic and opportunistic infections in brazilian solid organ transplant recipients. Trop Med Int Health. 2011; 16: 1134-1142.
27. Campbell AL, Goldberg CL, Magid MS, Gondolesi G, Rumbo C, Herold BC. First case of toxoplasmosis following small bowel transplantation and systematic review of tissue-invasive toxoplasmosis following noncardiac solid organ transplantation. Transplantation. 2006; 81: 408-417.