Infections Transmitted by Transplantation

Michele I. Morris, MDa, Staci A. Fischer, MDb, Michael G. Ison, MDMSc,*

Infections are frequently transmitted through solid-organ and, to a lesser extent, stem cell transplantation. There are 2 major types of donor-derived infections that are transmitted: those that would be expected secondary to donor and recipient screening (ie, transmission of cytomegalovirus [CMV], Epstein-Barr virus [EBV], or toxoplasmosis from a seropositive donor to a seronegative recipient) and those that are unexpected despite routine donor screening (ie, human immunodeficiency virus [HIV] and hepatitis C virus [HCV] transmitted from a seronegative donor). Expected transmissions occur frequently and screening and prophylaxis strategies are applied to at-risk individuals in nearly all transplant centers globally. Several high profile donor-derived infectious disease transmissions have been recognized1–9; these reports have raised awareness of this rare complication of transplantation. Issues related to the epidemiology of, screening for, and management of proven or probable donor-derived infections are reviewed in this article.

EPIDEMIOLOGY AND SIGNIFICANCE OF INFECTIONS TRANSMITTED BY TRANSPLANTATION

Currently, the epidemiology of donor-derived infections has been extrapolated from reports made in the medical literature, to the Centers for Disease Control and Prevention, and to the Organ Procurement Transplantation Network (OPTN). OPTN Policy 4.7, which was enacted in November 2004, requires reporting by a transplant center of a confirmed or suspected donor-derived disease transmission to the organ.

KEYWORDS
- Organ transplant • Donor-derived infection • Transmission
- Donor screening

a Division of Infectious Diseases, University of Miami Miller School of Medicine, Miami, FL, USA
b Division of Infectious Diseases, The Warren Alpert Medical School of Brown University, Providence, RI, USA
c Divisions of Infectious Diseases & Organ Transplantation, Northwestern University Feinberg School of Medicine, Chicago, IL, USA
* Corresponding author. 645 North Michigan Avenue, Suite 900, Chicago, IL 60611. E-mail address: mgison@northwestern.edu

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procurement organization (OPO) who must then report the transmission to the OPTN. Since the policy was enacted, the number of reports of proven or potential donor-derived disease transmission has increased significantly from 7 reports in 2005 to 102 reports in 2008. From this exponential increase, it is clear that the current system is only capturing a fraction of the true donor-derived infections.

The methodology used by the OPTN, through its Ad Hoc Disease Transmission Advisory Committee, to identify, evaluate, and classify donor-derived disease transmissions has recently been published. A wide range of infectious diseases have been reported to the OPTN (Table 1). From these data, it is clear that several key features can be summarized:

1. Unexpected donor-derived infectious disease transmissions are rare. Despite current limitations of the systems to recognize these transmissions, they likely occur in less than 1% of all transplant procedures.
2. Unexpected donor-derived infectious diseases transmissions cause significant morbidity and mortality.
3. Nonreproducible (ie, false-positive) molecular diagnostics for viral infectious diseases occur and may result in discarding of organs.
4. Bacterial contamination of organs or bacterial infections and colonization in the donor occurs frequently but rarely results in transmission of infection.

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. of Donor Reports</th>
<th>No. of Recipients with Confirmed Transmission</th>
<th>No. of Recipient Deaths Attributable to Donor-Derived Disease</th>
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<tbody>
<tr>
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<tr>
<td>Viral&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>Expected transmissions&lt;sup&gt;e&lt;/sup&gt;</td>
<td>14</td>
<td>–</td>
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</tr>
</tbody>
</table>


<sup>b</sup> *Aspergillus* spp, *Candida* spp, histoplasmosis, zygomycetes.

<sup>c</sup> Babesia, Chagas, schistosomiasis, strongyloides.

<sup>d</sup> This includes 4 patients with both HIV and HCV transmission. All but 3 reports represent nonreproducible nucleic acid test (NAT) results except for 1 report of HCV with 3 transmissions, 1 report of HCV/HIV with 4 transmissions and 1 death, and 1 patient with HIV infection acquired after transplant.

<sup>e</sup> 14 expected transmissions: CMV, toxoplasmosis, and EBV.

Unfortunately, when a transmission occurs, there is usually significant associated organ loss, morbidity, and mortality.

5. Communication remains a significant hindrance to early identification of cases and may contribute to morbidity and mortality. This is clearly highlighted with the recent transmission of tuberculosis.\textsuperscript{12} Although a potential solution to this system was piloted (the Transplantation Transmission Sentinel Network), it has not been funded or implemented fully.\textsuperscript{13}

Interest in donor-derived disease transmission is growing globally. Although the US OPTN/United Network for Organ Sharing (UNOS) Disease transmission Advisory Committee (DTAC) is a national system for biovigilence of organ recipients, many other countries have nascent systems in place or have systems under development. A proposed system in Australia would have the advantage of combining a national prospective monitoring system with a biobank of specimens from all organ donors and recipients that would facilitate identification and evaluation of potential donor-derived disease transmissions. A group of global leaders has begun to meet to develop common definitions and evaluate plans to identify and manage proven donor-derived disease transmissions.

**CURRENT SCREENING REQUIREMENTS AND LIMITATIONS**

Organ donor screening in the United States is regulated by the OPTN to help ensure a uniform standard of testing through the activities of the nation’s OPOs (Table 2). OPTN policy 2.0 outlines recommended donor screening tests to identify organisms that are potentially transmissible to transplant recipients; OPTN policy 4.0 documents what diseases, if known to be present in the donor, should be disclosed to the recipient centers.\textsuperscript{14,15} Despite this minimum standard, testing practices vary among individual OPOs, depending in part on laboratory availability and geographic limitations. Screening requirements for human tissues and cellular products are regulated by the US Food and Drug Administration (FDA; see Table 2).

All potential donors are screened for transmissible infectious diseases using an FDA-licensed, -approved, or -cleared screening test if such a test is commercially available.

<table>
<thead>
<tr>
<th>Test</th>
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<tr>
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<tr>
<td>HCV NAT</td>
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\textsuperscript{a} Testing must be done only on human cellular tissue/products that are viable and leukocyte rich.
available (Table 3)\textsuperscript{15}; the use of FDA-approved diagnostic tests is permitted if no screening test is commercially available by current policy. There are important differences between the sensitivity and specificity of diagnostic and screening tests. Diagnostic tests are designed for maximum specificity, to be used to evaluate a patient with some pretest probability of infection. There is no requirement that diagnostic tests be performed according to the test manufacturer’s instructions; modifications of the test are allowed if the testing laboratory validates any changes they make. Such flexibility is not permitted with donor screening tests, which are standardized for maximum sensitivity to be used in testing a low-prevalence population. Screening tests optimized for sensitivity may have a higher incidence of false-positive results relative to diagnostic tests, but this has been acceptable to applications such as blood bank screening, although it might be problematic in a clinical setting in which such results might lead to an incorrect patient diagnosis. Differences also exist between tests approved for use in living versus cadaveric donors. The FDA defines cadaveric donors as those whose heartbeat has ceased; all organ donors have a heartbeat when screening tests are collected, so FDA-licensed living donor screening tests must be used.

Although testing for HIV, hepatitis B virus (HBV), and HCV is currently required for all donors, transmission may occur despite negative serology. The dynamics of viremia during primary infection with HIV, HCV, and HBV share some basic commonalities, although they differ in predictable virus-specific detection capability because of variations in the pattern of host response to each pathogen. All 3 viruses share a sequence of initial infection followed by a pre–ramp-up phase of early viremia. Circulating virus is currently not measurable during this pre–ramp-up phase using any of the available assays. The limit of detectability for most viruses is approximately 1 copy per 20 mL or 0.05 copies per mL, the viral concentration that might be present in a unit of red blood cells (RBC) containing a single HCV copy.\textsuperscript{16} Viral replication proceeds logarithmically during the ramp-up phase until it reaches a plateau level. Ramp-up and plateau phases for each virus have been studied and can be characterized relative to the typical appearance of clinical symptoms (Fig. 1).\textsuperscript{16–18}

Viral infections such as HIV, HCV, and HBV are potentially infectious to others exposed to the initial host through sharing of blood and body fluids or organs. Once primary infection occurs, there is a period of time, known as the eclipse phase, during which virus is replicating within the host in a localized fashion such that the levels circulating in the bloodstream are neither measurable by current methods nor transmissible by transfusion, but transmission through organ transplantation could occur. This is followed by a window period of viremia during which infection from bodily fluids can occur but detection by the most sensitive assays currently available is not possible. This results in a predictable residual risk of infection, the probability of infectious exposure despite laboratory screening. Newer screening assays are evaluated for their infection yield, the number of new infections detected through the enhanced sensitivity provided by such tests in comparison to previous screening methods.\textsuperscript{19} The incidence window period model was formulated to assess the residual risk of infection in a given population screened with a specific test for which the infection window period has been previously established.\textsuperscript{20–22} Testing focused on the identification of early infection is particularly important for the organ transplant recipient, as viral replication may occur at higher levels in donor organs than in the bloodstream, as in the case of occult viral hepatitis in a potential liver donor.

Much of the recent effort in assay development for blood and organ donor screening has been targeted at methods that provide earlier detection of infection, narrowing the
infectious window period to decrease the residual risk of donor infection. Most serologic tests can diagnose prevalent infection, donors with exposure to a pathogen at a time period in the past who have developed a predictable and complete host response. Additional work has focused on the diagnosis of incident infection, new cases recently exposed to virus in which previous screening assays would fail to detect virus. Mathematical modeling largely based on seroconversion rates in repeat blood donors has been used to help predict the rate of incident infection in a given population. Mandatory nucleic acid testing (NAT) for HIV and HCV in tissue donors has helped achieve a better understanding of incident infection rates in organ donors, many of whom are also tissue donors, but data specific to the organ donor population are still lacking. The available literature does suggest a higher rate of incident infection in organ donors compared with blood donors.

**HIV Screening Tests**

HIV serologic tests have been available since 1985 and current assays are more sensitive in early infection, as well as in the detection of HIV-2 and type O strains. Fourth generation assays available outside the United States combine antibody and antigen screening to shorten the infectious window period. Such tests are more sensitive than third-generation assays, but retain specificity and are significantly less expensive than NAT.

NAT for HIV requires sophisticated laboratory personnel, specialized equipment, and more time than serologic assays. It is the most sensitive assay for the detection of incident HIV infection, but is less specific. Individual donor NAT (ID-NAT) can be more sensitive in detecting very early seroconversion. Although ID-NAT is used by some OPOs for screening organ donors, specimens obtained from donors with low-level viremia may only intermittently contain detectable virus and likewise false-positive results have been described.

Commercial testing platforms vary in sensitivity and specificity. Multiplex NAT assays exist that detect HIV-1 and HCV RNA simultaneously. When multiplex NAT results are positive, a discriminatory NAT must be used containing primers specific to HIV and HCV, to distinguish the type of RNA present in the donor specimen; if the assay for either virus is positive, a positive screen is reported. If the individual NATs are negative, typically the multiplex is repeated to help identify initial false-positive results. Test platforms are also available that test for single virus and have no FDA-approved method for detecting a false-positive result; no standardized testing algorithm exists for the purposes of organ donor screening.

**HCV Screening Tests**

Serologic testing for HCV has improved in sensitivity since first becoming available in 1990, resulting in a shorter window period for the newer assays. Combination antigen-antibody fourth generation assays are not yet licensed in the United States, although their sensitivity may approach that of HCV MP-NAT. Because of the long window period inherent to infection with hepatitis C, NAT significantly improves the sensitivity of HCV screening compared with second- and third-generation serologic testing.

**HBV Screening Tests**

Hepatitis B screening is slightly more complex because of the existence of multiple serologic tests that allow the identification of early and established infection by using HBsAg and HbcAb, total immunoglobulin, and IgM. It seems that currently available and highly sensitive testing for HBsAg is able to identify virtually all blood donors
<table>
<thead>
<tr>
<th>Test</th>
<th>Format</th>
<th>Approved Indications</th>
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| **Abbreviations:** ChLIA, chemiluminescent immunoassay; EIA, enzyme immunoassay; EP, EDTA plasma; NAT, nucleic acid test; P, plasma; PCR, polymerase chain reaction; S, serum; TMA, transcription-mediated amplification; U, urine. |

undergoing seroconversion at a time when the level of circulating virus is low, making serology a comparable screening tool to NAT for the detection of early HBV infection.\textsuperscript{18,36}

HTLV-1/-2

Prospective testing for HTLV-1/-2 has been mandated for potential blood, organ, and tissue donors, but because of a change in the availability of the most commonly used FDA-licensed screening assay for individual organ donors, the requirement for screening all organ donors has been removed.\textsuperscript{14} The only FDA-approved screening test available in the United States after December 31, 2009 will be the Abbott Prism HTLV I/HTLV II assay, a high-throughput and expensive testing system that is not optimized for use in screening organ donors.

THE CHALLENGES OF INFECTIOUS DISEASE TESTING IN THE ORGAN DONOR

Deceased organ donors often require intensive medical care before becoming organ donor candidates. Such care often includes the transfusion of large volumes of blood products and crystalloid, which can potentially result in plasma dilution significant enough to produce false-negative results. Careful evaluation of the total volume of fluid infused before specimen collection must occur to determine if the degree of plasma dilution has the potential to affect infection screening tests.\textsuperscript{37}

Deceased organ donor infection screening is also challenged by timing constraints. Unstable donors must be supported medically while tests are being processed. Such medical care, if timing is prolonged, may be unsuccessful in maintaining organ perfusion and viability. This support may consume limited hospital resources and potentially increase the stress on the donor family facing the loss of a loved one. Specimens collected after cessation of blood flow may not provide accurate results on infection screen tests because of interference from products of decomposition. When organs are procured before the confirmation of final test results, maintaining...
such organs before implantation can result in increased cold ischemia time and poorer organ function after transplant.

Most of the newer assays developed for donor screening are high-throughput multiplex tests that were developed to conform to the needs of the blood-banking industry. Such assays require specialized equipment and personnel, and are best suited to scheduled runs during daytime hours. Most organ donor testing is done outside of the normal daytime hours. The ideal testing platform for organ donor screening would permit individual donor testing for the major viral pathogens with a well-defined and rapid confirmatory test algorithm. Development of such assays for the relatively small transplant market may not be economically attractive to industry without financial or regulatory incentives from governmental agencies involved in safety monitoring and laboratory oversight. Until specialized transplant screening platforms are more widely available, organ procurement agencies will face the challenges of changing testing availability and limited alternative platforms designed for use in transplant screening.

With all of the challenges faced by organ recipients, transplant waiting lists continue to increase. In 2006, 95,000 patients were waiting for organs, and 6300 died while on the transplant waiting list. Advances in transplantation have increased the demand for surgery, and improvements in medical care have allowed more people to survive with critical organ failure to become candidates. In this context, improving screening accuracy and timing is critically important to avoid further limiting access to organ transplant.

One of the major challenges of organ donor screening is the lack of availability of detailed historical information regarding the lifetime risk of pathogen exposure. Blood donor and population studies may allow the OPO to predict what optional screening tests might be most useful to optimize recipient safety, however additional testing increases the likelihood of false-positive results with the potential for unnecessary organ loss. Defining the at-risk population of donors for targeted testing remains a challenge as new assays become available and are incorporated into practice.

**NEWER AND OPTIONAL ASSAYS FOR TARGETED USE IN ORGAN DONOR SCREENING**

The decision to screen organ donors for specific pathogens must be based on the frequency of infection in the donor population, the availability of licensed screening tests, and the potential severity of donor-transmitted illness. Screening decisions may be modulated by the availability of therapeutic options if infection is found.

**Chagas Disease**

Case reports of Chagas disease transmission through solid-organ and stem cell transplantation seem to support screening. However prospective testing with results available before organ implantation may not be available at many centers. Given the frequency of false-positive results of preliminary testing and the lack of access to preemptive therapy in the United States, management of test results remain a major challenge. Follow-up monitoring after transplant is necessary and may require assistance from the Centers for Disease Control (CDC). Benznidazole and nifurtimox are not commercially available; these medications must be requested directly from the CDC when infection is confirmed. Chagas disease testing may be used in a more targeted fashion in organ donation if donor screening can be optimized; this is currently being done at several OPOs. It is estimated that more than 100,000 people in the United States are chronically infected with this parasite; occult parasitemia has been confirmed in a significant percentage of blood donors identified by the presence of
antibody on serologic screening tests. Efforts to predict infection risk with screening questionnaires have been validated in the blood donor population but may be impossible in deceased donor screening because of potential limitations in the historical information that can be obtained from living contacts. Time spent living in the Central and South American countries where the disease is endemic seems to correlate best with positive serology results, predicting a higher incidence in some blood donor populations containing a large population of immigrants from these areas. Testing in some areas of the country may not be useful, given the extremely low incidence of infection. Even when screening indicates the possibility of infection, none of the currently available screening assays can provide 100% sensitivity in disease detection.

**West Nile Virus**

Epidemiologic data are particularly important when screening is used to identify potential donors infected with West Nile virus (WNV). Although transmission through blood and organ donation has occurred and blood donor screening is currently mandated in the United States, no single test is sufficiently sensitive to capture many cases during early infection. Even NAT, generally regarded as the most sensitive assay for viral pathogens, may miss a substantial number of infections with low-level viremia. NAT testing and sophisticated serologic assays may allow the identification of infectious donors.

**Mycobacterium Tuberculosis**

Screening of potential transplant recipients using purified protein derivative skin testing has been a standard part of the pretransplant evaluation. Donor screening for *Mycobacterium tuberculosis* has been limited to historical data regarding risk factors, previous skin test findings, and exposure history. In lung donors, who are at highest risk for donor-derived mycobacterial infection, bronchoscopic sampling for acid-fast smear and culture can be used to supplement the required sputum Gram stain, but results from testing at the time of organ procurement may be delayed if traditional nonmolecular studies are used. A recent widely publicized case of donor-derived tuberculosis (TB) that resulted in the infection of 2 of the 3 transplant recipients and resulted in 1 death, combined with the availability of new blood tests to measure for previous exposure to the TB bacillus, have led to discussions regarding donor TB screening in the organ procurement community. Until such testing has been validated in other settings, including the organ recipient population, OPOs will continue to rely on historical information and donor physical examination to guide TB risk assessment.

**Strongyloides Stercoralis**

Hyperinfection strongyloidiasis is a life-threatening infection that can present a diagnostic challenge after transplant. Subclinical infection may persist in an asymptomatic host for decades, reactivating in the face of immunosuppression. Most cases of hyperinfection syndrome stem from previous infection of the transplant recipient, however cases of probable donor origin have been reported. Infection should be suspected in donors and recipients with a history of residence in tropical or subtropical areas, although infection can occur in more temperate areas with poor sanitation, including parts of the southeastern United States. Although it is estimated that approximately 90 million people worldwide may be infected with *Strongyloides stercoralis*, screening of donors has a limited role, except possibly for intestinal donors.
Donor infection with *Toxoplasma gondii* can cause significant disease, which may be particularly severe in the nonimmune recipient. Heart transplant patients are at highest risk because of the parasite’s propensity to encyst in myocardial tissue. Disease can occur in noncardiac transplant as well, leading to a nonspecific presentation with multisystem organ failure that is often diagnosed at autopsy. Routine prophylaxis with trimethoprim/sulfamethoxazole may decrease the incidence of severe disease, but screening to identify the seronegative recipient of a seropositive donor may help identify patients at risk for fulminant disease and promote early initiation of posttransplant prophylaxis.

*Coccidioides Immitis, Histoplasma Capsulatum, and Other Endemic Fungi*

Identification of risk factors for exposure to endemic fungi is relatively straightforward, as infection is associated with previous residence in specific locations. Screening donors and recipients who are at risk for latent infection is more challenging, as serologic tests may be negative even with widespread organ involvement. Awareness of risk factors present in a donor history may assist in the early recognition and successful diagnosis and treatment of infected recipients. Well-documented cases of donor-transmitted coccidioidomycosis have been reported, although the risk of transmission from seropositive donors in endemic areas seems to be low. This may be a result of the use of prolonged fluconazole prophylaxis after transplant, a practice that may decrease the incidence of donor-derived disease in addition to preventing reactivation or new infection in some recipients. Further study is needed to determine the best screening modality for donor-derived endemic fungal infection.

**MANAGEMENT OF RECIPIENTS OF ORGANS FROM INCREASED RISK DONORS**

Because of the shortage of donor organs, some recipients receive organs from donors with identified risk factors and/or screening tests that are positive for several infections. HIV infection in the donor remains a contraindication to transplantation, but many centers use donors with positive screening serology for hepatitis B or C in selected patient populations.

Hepatitis B may be transmitted from HBsAg-positive donors, with transmission rates as high as 80% to 100% without intervention, or HBsAg-negative, HBCab-positive donors, with a significantly lower risk of transmission. Pretransplant vaccination of the recipient helps to minimize the risk of transmission, although seroconversion may be limited in the patient with end-stage organ disease. Posttransplant prophylaxis with hepatitis B immune globulin (HBlg) and antiviral therapy may be helpful, but increasing viral resistance and the effect of immunosuppressive therapy on viral replication may limit the efficacy of posttransplant prophylaxis. Some transplant programs decline HBsAg(+) or HBsAg(−)/HBCab(+) donors although most use organs from these donors in previously vaccinated patients or in patients willing to take posttransplant prophylaxis. A recent trial demonstrated that kidneys from HBsAg(+) donors may be safely used in HBsAb(+) recipients, with posttransplant HBlg and lamivudine prophylaxis. The use of hepatitis C seropositive donors is more controversial. Organs from donors with active hepatitis C transmit infection at a high rate. Several studies have demonstrated the short-term safety of transplantation of HCV(+) donor organs.
into HCV(+)-recipients,\textsuperscript{88,89} although use of HCV(+) organs in HCV(−)-recipients is typically avoided because of the risk of liver disease and sepsis in such circumstances, as well as the risk of acute rejection in posttransplant treatment of hepatitis C with interferon-based therapies. The use of HCV(+) donor organs in life-threatening situations is commonplace, however, as there is a shortage of organ donors and mortality on the waiting list is often greater than that in patients with posttransplant hepatitis C.

Unfortunately, infections can be transmitted despite negative screening serology. Although there is significant controversy on how accurate the high-risk criteria are at identifying donors who have an infection that is missed using current serologic methods,\textsuperscript{90} these criteria have been incorporated into OPTN policy, which requires that the transplant centers obtain consent from the potential recipients to use organs from high-risk donors.\textsuperscript{15} The effect of the requirement to obtain special consent when using organs from increased risk donors has not been well studied and patients may inadvertently turn down an organ without understanding the potential higher risk of adverse outcomes by remaining on the waitlist. A recent consensus conference addressing testing methods for HIV, HBV and HCV in organ donors recommended that donors no longer be labeled high risk but instead be referred to as increased risk donors and that they should be tested by HIV and HCV NAT in an attempt to increase the safety and utilization of these organs (personal communication, Atul Humar, MD, 2009). Management of recipients of organs from increased risk donors is unclear, with no controlled trials available to dictate effective follow-up evaluation and care. The 1994 guidelines for preventing transmission of HIV through transplantation and the experts at this recent consensus conference recommended that recipients of organs from increased risk donors be tested for HIV, HCV, and HBV at periodic intervals after transplant (1, 3, and 12 months). Immunosuppressive therapy alters serologic responses to infection and as a result, infection can be transmitted and only detected by viral load assessments of the recipients. In most cases of donor-to-recipient HCV transmission, serology has remained negative after transplant despite active viral replication and increased liver function tests. Likewise, in the recent HIV/HCV cotransmission event, 1 of the 4 recipients had an indeterminant HIV serology but detectable virus 9 months after transplant.\textsuperscript{1,91} Any posttransplant testing of recipients for viral infections should include serologic and NAT/viral load assessments.

**MANAGEMENT OF RECIPIENTS WITH DONOR-DERIVED INFECTIONS**

Guidelines for the management of expected donor-derived infections, such as CMV and toxoplasmosis, are well established and are frequently incorporated into routine posttransplant care at most transplant centers. Although unexpected donor-derived infections are rare, it is critical to consider the donor as the source of any posttransplant infection. Failure to consider that an infection is potentially donor-derived will undoubtedly result in missed recognition. Recipients are typically cared for in several hospitals which will, in turn, limit the recognition of the infection as there are no robust mechanisms to identify complications in multiple recipients of the same donor. The clearest example of this occurred with 1 of the recent lymphocytic choriomeningitis virus transmission in which all of the recipients developed altered mental status, sepsis, and hepatitis but recognition of the cluster was not made initially because the patients were cared for by 3 separate hospitals.\textsuperscript{4} As soon as a single organ recipient presents with an atypical course or concern for an infection that may have been of donor origin, the local OPO should be contacted immediately. The OPO should have
a mechanism in place to rapidly assess the status of all other recipients of organs, tissues, or vessels from the same donor and report the concern to the OPTN as required by current policy. If a potential infection is considered, an infectious disease physician should be consulted to help guide antimicrobial treatment and microbiologic investigations.

SUMMARY AND FURTHER RESEARCH

Donor-derived infectious diseases are a rare but clinically significant complication of solid-organ transplantation. The actual incidence of unexpected donor-derived infectious diseases is not known but has been estimated to complicate about 1% of organ transplants. It is critical to consider donor origin for all early posttransplant infections as there are currently no standardized biovigilence systems to allow early recognition of a potential donor-derived disease transmission. Research is desperately needed to advance our understanding of the risk factors associated with disease transmission, optimal screening of donors for infectious diseases, and mechanisms to facilitate recognition and management of transmitted infections. Further, improved platforms for screening that are appropriate for the needs of the transplant community are needed, and sensitivity and specificity of existing testing needs to be improved to decrease the risk of disease transmission and minimize loss of organs through false-positive testing.

REFERENCES


29. Louie B, Pandori MW, Wong E, et al. Use of an acute seroconversion panel to evaluate a third-generation enzyme-linked immunoassay for detection of human


