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Minireview

An Update on Heart Transplantation in Human Immunodeficiency Virus–Infected Patients

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Cardiovascular diseases have become a significant cause of morbidity in patients with human immunodeficiency virus (HIV) infection. Heart transplantation (HT) is a well-established treatment of end-stage heart failure (ESHF) and is performed in selected HIV-infected patients in developed countries. Few data are available on the prognosis of HIV-infected patients undergoing HT in the era of combined antiretroviral therapy (cART) because current evidence is limited to small retrospective cohorts, case series, and case reports. Many HT centers consider HIV infection to be a contraindication for HT; however, in the era of cART, HT recipients with HIV infection seem to achieve satisfactory outcomes without developing HIV-related events. Consequently, selected HIV-infected patients with ESHF who are taking effective cART should be considered candidates for HT. The present review provides epidemiological data on ESHF in HIV-infected patients from all published experience on HT in HIV-infected patients since the beginning of the epidemic. The practical management of these patients is discussed, with emphasis on the challenging issues that must be addressed in the pretransplant (including HIV criteria) and posttransplant periods. Finally, proposals are made for future management and research priorities.

Abbreviations: ADE, AIDS-defining event; ART, antiretroviral therapy; ARV, antiretroviral; ATG, anti-thymocyte globulin; cART, combined antiretroviral therapy; CM, cardiomyopathy; CVD, cardiovascular disease; CyA, cyclosporine; CYP3A4, cytochrome P450 3A4; CYP450, cytochrome P450; DDI, drug–drug interaction; ESHF, end-stage heart failure; EVR, everolimus; FK, tacrolimus; HBV, hepatitis B virus; HCV, hepatitis C virus; HF, heart failure; HIV, human immunodeficiency virus; HT, heart transplantation; IS, immunosuppression; LVAD, left ventricular assist device; MCS, mechanical circulatory support; MMF, mycophenolate mofetil; MOF, multiorgan failure; NA, not applicable; NR, not reported; OI, opportunistic infection; P, prednisone; PCP, *Pneumocystis jirovecii* pneumonia; PI, protease inhibitor; SOT, solid organ transplantation; UNOS, United Network for Organ Sharing; USA, United States; YOT, year of transplantation

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Introduction

The widespread use of combined antiretroviral therapy (cART) has dramatically reduced mortality associated with infection by the human immunodeficiency virus (HIV) and improved survival rates among patients with HIV infection. In this context, survival of HIV-infected patients depends on other comorbidities and end-stage failure of organs such as liver, kidney and heart. In fact, patients with HIV infection have a significantly higher risk of cardiovascular disease (CVD) than non-HIV-infected patients (1), and the prevalence of heart failure (HF) is significantly higher in HIV-infected patients than in non-HIV-infected persons (1); however, the prevalence of end-stage heart failure (ESHF) in HIV-infected patients is unknown. Heart transplantation (HT) is currently the most established long-term approach for suitable candidates with no other options for therapy, but even in high-volume HT centers, HIV-infected patients are rarely considered candidates for HT (2). Current evidence from small retrospective cohort studies and case series indicates that HT is safe in carefully selected HIV-infected patients and that its outcomes are similar to those seen in non-HIV-infected patients (2–5). Nevertheless, more information is needed to accurately establish the long-term safety and efficacy of HT in the setting of HIV infection.

The present review presents a general overview of HT and provides epidemiological data on CVD and ESHF in the

setting of HIV infection. All cases, case series and cohorts of HT in patients with HIV infection since the beginning of the epidemic are reviewed. The implications of the existing body of knowledge are discussed, and future directions and research priorities are addressed.

Epidemiology of HF Leading to HT in HIV-Infected Patients

Cardiovascular manifestations of HIV infection comprise a wide range of clinical conditions including coronary artery disease, ischemic and nonischemic dilated cardiomyopathy, arrhythmias resulting from conduction abnormalities, and sudden death. Although the possible link between antiretroviral (ARV) agents (mainly abacavir) and the development of CVD remains to be elucidated, the introduction of cART seems to have caused a shift from dilated cardiomyopathy with severely reduced ejection fraction to mildly reduced left ventricular function; however, patients with HIV infection are still at increased risk of HF after adjustment for traditional risk factors (1,2). In the cART era, the frequency of systolic and diastolic left ventricular dysfunction has been reported to be 8% and 43%, respectively (6), and the prevalence of heart failure is reportedly ≈3%, that is, twofold higher than in the non-HIV-infected cohort (1).

Data on the prevalence of ESHF in HIV-infected patients in the cART era are scant. A recent report estimates that around 2400 HIV-infected patients in the United States have advanced HF and that, of those, 20 will need a left ventricular assist device (LVAD) or HT annually (2). Interestingly, the number of patients referred for evaluation was dramatically lower than that of patients expected to need advanced HF therapy, indicating that access to care is not equal in this group of patients (2).

Experience With HT in HIV-Infected Patients

Knowledge of the efficacy and safety of kidney and liver transplantation in the setting of HIV infection is increasing (2,4,7–10) (Table 1). HIV-infected kidney recipients achieve 5- and 10-year outcomes similar to those of non-HIV-infected patients. Similar good outcomes are seen in HIV and hepatitis B virus–coinfected liver recipients. Conversely, 5-year outcomes of HIV and hepatitis C virus (HCV)–coinfected liver transplant recipients are poorer than those of HCV-monoinfected recipients, although the results are still acceptable. Published experience with HT in the setting of HIV infection is scant. The present review includes data from small retrospective cohort studies, case series, and cases published in indexed journals (2–5,11–30). The data presented comprise reports of patients who acquired HIV infection before, during and after HT.

Published Data on HT in the Pre-cART Era (1982–1996)

The 11 published cases of HT in HIV-infected patients in the pre-cART era are summarized in Table S1 (3,16,17,19,20,22,25–28). In all but one case, HIV infection was acquired through the donor graft, blood transfusion or blood products received in the perioperative period or shortly after HT. Five patients developed AIDS, and six patients died. Only three of the five recipients who remained alive had normal graft function at the end of follow-up.

Published Data on HT in the cART Era (1997–2014)

In 2001, the United Network for Organ Sharing (UNOS) stated that asymptomatic HIV-positive patients ''should

Table 1: Patient survival rates in the main cohorts of kidney, liver, heart, and LVAD recipients

			Years, %						
Type of SOT/Country	Period	Number of patients	1	2	3	4	5	10	p-value
Kidney/USA (1)*	2002–2011	HIV+ (n = 362)	96	–	92	–	89	63%	0.096
		HIV− (n = 3620)	97	–	94	–	89	78%	
Liver/Spain (2)	2002–2006	HIV+/HCV+ (n = 84)	88	71	62	60	54	–	0.008
		HIV−/HCV+ (n = 252)	90	81	76	73	71	–	
Liver/USA (3)	2003–2010	HIV+/HCV+ (n = 89)	76	–	60	–	–	–	0.001
		HIV+/HCV− (n = 235)	92	–	79	–	–	–	
Liver/USA (4)	2001–2007	HIV+/HBV+ (n = 22)	85	–	85	–	85	–	0.09
		HIV−/HBV+ (n = 20)	100	–	100	–	100	–	
Heart/USA (5)	1999–2004	HIV+ (n = 20)	90	–	90	–	–	–	0.950
		HIV− (n = 9174)	86	–	79	–	–	–	
Heart/USA (6)	NR	HIV+ (n = 18)	100	100	–	–	63	–	
		HIV− (unknown)	84	81	–	–	72	–	
LVAD/USA (6)	NR	HIV+ (n = 22)	80	72	–	–	–	–	

HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; LVAD, left ventricular assist device; NR, not reported; SOT, solid organ transplantation; USA, United States.
*All patients were HCV negative.

not necessarily be excluded from candidacy for organ transplantation.'' Since then, 12 HTs in HIV-infected patients have been reported worldwide, and three patients acquired HIV infection after HT (Table 2) (3,5,11–15,18,21,23,24,29,30). Most patients were aged <50 years (14 of 15, 93%) and were on cART. All patients had $CD4^+$ cell counts >200 cells/mm^3.

Although rejection was reported in 11 of 15 patients, outcome was satisfactory in the majority, and 13 were alive with normal graft function at the end of follow-up. One of the two remaining patients had suboptimal adherence to treatment and died of multiorgan failure (24). The cause of death in the other patient was not reported (29). The mortality rate of patients undergoing HT in the cART era was much lower than that of patients who underwent HT in the pre-cART era (2 of 15 [13%] vs. 6 of 11 [55%], respectively).

HIV infection was adequately controlled (HIV viral load was undetectable in 11 patients after HT; in four patients, this parameter was not reported), and none of the patients developed AIDS after HT. These findings are consistent with those of previous reports, with encouraging 1-, 2-, and 5-year patient survival rates (90–100%, 90–100%, and 63%, respectively), which were similar to those of non-HIV-infected patients (84%, 81%, and 72%, respectively) (2,4). After a median follow-up of 47 months, three of 18 patients died, two of rejection episodes and one of sepsis. Of note, no HIV-infected patient progressed to AIDS after HT (2). Moreover, in the study by Pelletier et al (4), the survival rates of HIV-infected patients were similar to those of non-HIV-infected patients, even though their medical conditions were worse (stay in intensive care unit: 65% vs. 36%, respectively; $p = 0.02$).

The largest data set for HIV-infected patients bridged to HT with mechanical circulatory support (MCS) is that of Uriel et al (2), who reported that the results for 22 patients from a multicenter cohort bridged with an LVAD were similar to those of non-HIV-infected patients (Table 1) (2). The same group had previously reported four patients on LVAD support as bridged to HT, of whom one was successfully transplanted (Table 2, patient 12), another died on support, and the remaining patients were still on the waiting list after 542 and 426 days (4). The incidence of infectious complications was not greater than in non-HIV-infected patients (11). Finally, patient 11 (18) and patient 14 (12) in Table 2 were also bridged to HT under percutaneous MCS and LVAD, respectively. All three patients with LVAD (11,12,18) were alive at the end of follow-up.

Criteria for Including HIV-Infected Patients on the HT Waiting List

The indications for HT in HIV-infected patients are the same as in non-HIV-infected patients (31). The most common etiology of HT in HIV-infected patients is HF secondary to dilated cardiomyopathy (4).

Most national transplantation programs use similar clinical, immunological, and virological HIV criteria for HT (Table S2) (32,33). A CD4 cell count >200 cells/mm^3 is the most commonly used cutoff (32,33). Furthermore, absence of active AIDS-defining opportunistic infection (OI) or malignancy is mandatory (32,33); however, patients with OIs that can be treated efficaciously or prevented, such as *Pneumocystis jirovecii* pneumonia (PCP), can be included on the HT waiting list (32,33). In the present report, only one of the HIV-infected patients who underwent HT in the cART era had a history of OIs (PCP, disseminated *Mycobacterium avium* complex and cytomegalovirus infection) (14,29). This patient was one of the two who died after HT (Table 2).

The essential virological criterion for HT is that patients tolerate cART and achieve undetectable HIV viral load by ultrasensitive techniques (<50 copies/mL) before transplant. Patients with detectable HIV viral load due to diagnosis of HIV infection immediately before HT, for example, and/or inability to take oral drugs could be included on the waiting list but must be able to follow effective, safe and long-lasting cART during the posttransplant period (32,33). Given the number of currently available ARV agents, exclusion for this reason would be exceptional.

Management of Patients With HIV Infection in the Pretransplant Period

As a general rule, HIV-infected candidates for HT should be managed as non-HIV-infected patients (Figure 1).

Access to care, provision of expanded criteria (marginal) donor organs and ethical issues

Most HT centers in the United States and Canada currently consider HIV infection to be a contraindication for HT in patients with ESHF (2). The most common concerns are the distribution of limited organs to ''high-risk'' patients, progression to AIDS due to immunosuppression, drug–drug interactions (DDIs) and increased susceptibility to infection (2). Moreover, in some cases, HIV-infected patients are considered unsuitable for HT by traditional criteria but could receive organs that had been rejected by first-tier candidates; therefore, they are placed on an alternative HT waiting list (11,12).

Efficacy, urgency and equity are the main ethical factors in the allocation policies of the UNOS and other national transplantation networks (32,34). Efficacy is fundamental for determining the candidacy of patients with HIV infection. To date, accumulated evidence from small retrospective cohort studies and case series indicates that HIV infection does not affect outcomes and that survival rates for HIV-infected HT recipients are similar to those seen in non-HIV-infected recipients (2–5). Consequently, HIV-infected patients derive the same benefit from HT as non-HIV-infected patients (even those receiving suboptimal grafts and/or more critically ill patients) (4,11,12), thus the equity principle drives the need

Table 2: Baseline characteristics and clinical outcomes of patients with HIV infection undergoing HT in the cART era (1997–2014)

Patient (reference)	Country	YOT	Sex	Age at HT	HIV status at HT	cART before HT	CD4 cells/mm^3 at HT	Etiology of heart disease	Initial IS	Follow-up after HT (months)	Rejection/grade	Graft function at end of follow-up	Status	Cause of death
1 (23)	USA	1997	Female	>40	Negative	NA	NA	Nonischemic CM	CyA/MMF/P	120	Yes/3A	Normal	Alive	–
2 (3,15)	USA	2001	Male	42	Positive	Yes	637	Dilated CM	CyA/MMF/P/ daclizumab	88	Yes/NR	Normal	Alive	–
3 (14,29)	USA	2001	Male	39	Positive	Yes	>250	Anthracycline-associated CM	CyA/MMF/P	43	Yes/3A	Normal	Dead	NR
4 (3)	USA	2005	Male	47	Positive	Yes	443	Dilated CM	CyA/MMF/P/ daclizumab	40	Yes/NR	Normal	Alive	–
5 (3)	USA	2005	Male	19	Negative	NA	NA	Dilated CM	CyA/MMf/P/ daclizumab	36	Yes/NR	Normal	Alive	–
6 (3)	USA	2007	Male	29	Positive	No	536	Dilated CM	CyA/MMF/ P/daclizumab	14	Yes/NR	Normal	Alive	–
7 (5,13)	Spain	2007	Male	39	Positive	Yes	>500	Ischemic CM	FK/MMF/P	84	Yes/3A	Normal	Alive	–
8 (24)	USA	2007	Male	>60	Negative	NA	NA	Ischemic CM	FK/MMF/P/ basiliximab/ATG	34	Yes/moderate	Impaired	Dead	MOF
9 (3)	USA	2008	Male	48	Positive	Yes	360	Dilated CM	CyA/MMF/P/ daclizumab	6	No	Normal	Alive	–
10 (3)	USA	2008	Female	43	Positive	Yes	793	Dilated CM	CyA/MMF/P/ daclizumab	3	No	Normal	Alive	–
11 (18)*	France	2008	Male	32	Positive	Yes	700	Dilated CM	NR	30	Yes/2R	Normal	Alive	–
12 (11)**	USA	2008	Male	47	Positive	Yes	360	Nonischemic dilated CM	NR	31	No	Normal	Alive	–
13 (21)	Italy	2009	Male	36	Positive	Yes	NR	Nonischemic dilated CM	CyA/EVR/ P/ATG	36	Yes/2R	Normal	Alive	–
14 (12)**	USA	2009	Female	42	Positive	Yes	>450	Nonischemic dilated CM	FK/MMF/P	24	Yes/NR	Normal	Alive	–
15 (30)	Italy	2011	Male	42	Positive	Yes	NR	Dilated CM	FK/P	19	No	Normal	Alive	–

ATG, antithymocyte globulin; cART, combined antiretroviral therapy; CM, cardiomyopathy; CyA, cyclosporine; EVR, everolimus; FK, tacrolimus; HIV, human immunodeficiency virus; HT, heart transplantation; IS, immunosuppression; MMF, mycophenolate mofetil; MOF, multiorgan failure; NA, not applicable; NR, not reported; P, prednisone; USA, United States; YOT, year of transplantation.

*Percutaneous extracorporeal life support.

**Patient with left ventricular assist device implanted before HT.

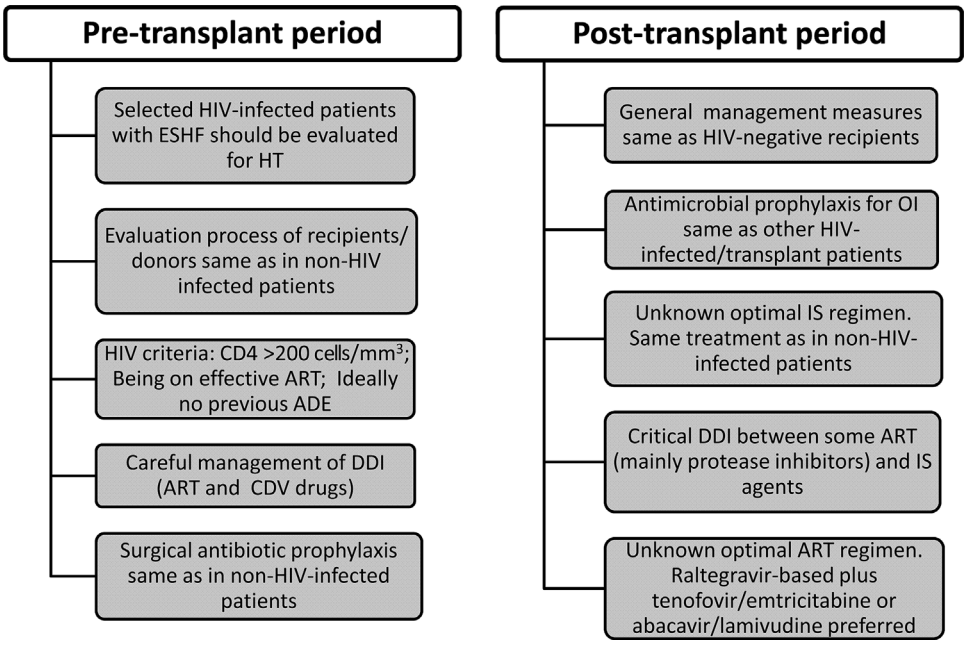

Figure 1: Main messages regarding the management of HIV-infected HT recipients. ADE, AIDS-defining event; ART, antiretroviral therapy; CVD, cardiovascular disease; DDI, drug–drug interaction; ESHF, end-stage heart failure; HIV, human immunodeficiency virus; HT, heart transplantation; IS, immunosuppression; OI, opportunistic infection.

to include appropriate HIV-infected candidates with ESHF on the standard HT waiting list (2,15,21,31,34). The absence of more robust evidence of favorable outcomes among HIV-infected patients in the setting of HT is not a valid justification for penalizing this group of patients. Consequently, considering HIV infection as a contraindication for HT or as an indication to use marginal organs is not an evidence-based approach. Such limitations are clearly arbitrary.

Pharmacological interactions between ARV drugs and drugs used to treat CVD

Effective cART is the prerequisite for inclusion on the waiting list, and HIV-infected candidates for HT should follow general recommendations (35). Interactions can occur between ARV agents and the drugs used concomitantly for the treatment of hyperlipidemia, hypertension and arrhythmia as well as with antithrombotic or anticoagulant agents. Because some interactions are potentially severe (e.g. ritonavir-boosted protease inhibitors [PIs] plus simvastatin), coadministration of these drugs must be avoided. PIs boosted with ritonavir (lopinavir, atazanavir, darunavir) or cobicistat (darunavir) inhibit cytochrome P450 3A4 (CYP3A4) (36) and could induce a rapid and enduring increase in plasma levels of drugs using the same pathway. In contrast, non-nucleoside reverse transcriptase inhibitors (mainly efavirenz) induce cytochrome P450 (CYP450), producing a consistent decrease in the concentrations of drugs metabolized by these enzymes. Nucleoside reverse transcriptase inhibitors (tenofovir, abacavir, lamivudine, emtricitabine) do not usually present clinically relevant pharmacokinetic interactions with the medications used to treat CVD. Similarly, interactions with integrase inhibitors (raltegravir, dolutegravir) or the CCR5 inhibitor maraviroc are not expected because these agents are neither inhibitors nor inducers of CYP450. Nonetheless, antacids and other compounds that contain cationic metals (i.e. calcium, magnesium, aluminum and iron) may decrease levels of integrase inhibitors if taken close in time to each other. This interaction must be avoided if integrase inhibitors are administered 2 hours before or 6 hours after intake of compounds containing cationic metals. Some interactions may also involve other enzymes of CYP450, glucuronosyltransferase and transporters.

Finally, given the speed with which new drugs appear and new interactions are detected, it is recommended that physicians visit specific websites with updated databases on all proven interactions with ARV agents (37).

Management of Patients With HIV Infection in the Posttransplant Period

As a general principle, medical care for HIV-infected HT recipients should be the same as for non-HIV-infected patients (Figure 1).

cART

The objectives of cART are to maintain an acceptable immunological status and plasma HIV viral load below the detection limit. Because the optimal cART regimen after HT has not been established, patients generally follow their

pretransplant regimens (35). Nonetheless, these regimens can be changed after transplantation on an individual basis after considering the ARV safety profile and potential toxicity, pharmacokinetic DDIs and adherence to treatment. Interestingly, there is a growing body of knowledge on the appropriateness of a cART regimen comprising raltegravir (the first integrase inhibitor) plus two nucleoside reverse transcriptase inhibitors (tenofovir/emtricitabine or abacavir/lamivudine) (38). Raltegravir and, probably, dolutegravir have no significant interactions with calcineurin inhibitors (37,38), thus enabling simplified management of immunosuppressive treatments as in HIV-negative recipients. In addition, in patients undergoing liver and kidney transplant treated with raltegravir-based cART, tolerability was excellent, and no rejection episodes were recorded (38). Consequently, raltegravir inhibitor–based cART regimens containing two nucleoside reverse transcriptase inhibitors are recommended in the posttransplant period.

Immunosuppression and rejection

Patients who undergo HT need extensive immunosuppressive therapy to prevent graft rejection. The optimal immunosuppression regimen for HIV-infected patients is unknown, and centers use the same regimens as for non-HIV-infected HT recipients. In our center, patients receive induction with basiliximab at the time of HT and corticosteroids and mycophenolate mofetil before surgery. Tacrolimus or cyclosporine is started on the fourth day after surgery, with target drug levels of 10–15 mg/mL and 250–300 mg/mL, respectively, during the first year. Endomyocardial biopsies are performed as in every other transplant patient following local protocols, with a minimum of six biopsies during the first 6 months after transplant and subsequently if clinically indicated. Findings from liver and kidney transplant cohorts seem to confirm that HIV-infected persons are significantly more likely to develop acute rejection than recipients without HIV infection (8,9,33). In fact, most HT recipients with HIV infection listed in Table 2 had rejection episodes. Given these findings, it is considered unwise to reduce immunosuppressive drug doses in the long-term follow-up of heart recipients. In addition, some immunosuppressive drugs (especially cyclosporine and mycophenolate mofetil) might even have beneficial effects (i.e. contributing to the control of HIV replication) for these patients, although the clinical significance of this issue is unknown (33).

Pharmacological interactions between ARV drugs and immunosuppressive agents

Given their effect on CYP3A4 (described earlier), some ARV drugs are subject to formidable pharmacological interactions, many of which are clinically relevant, when coadministered with immunosuppressive agents (36). In the case of non-nucleoside reverse transcriptase inhibitors, efavirenz can decrease calcineurin inhibitor levels. Consequently, doses of these agents should be increased (36,37). Data on the effect of etravirine are lacking, although rilpivirine does not seem to affect clearance of calcineurin inhibitors (33). Conversely, all ritonavir-boosted PIs dramatically increase the levels of immunosuppressive drugs. Patients receiving PIs boosted with ritonavir could require 0.5 mg (or less) of tacrolimus every 10–15 days, whereas those on cyclosporine could require 50 mg/day as a maintenance dose (33). Elvitegravir/cobicistat can behave as PIs, but scarce information is available with immunosuppressive drugs. In contrast, no clinically important interactions are expected between immunosuppressive drugs and nucleoside reverse transcriptase inhibitors, entry inhibitors (enfuvirtide/maraviroc) or nonboosted integrase inhibitors (raltegravir/dolutegravir). In any case, monitoring of both immunosuppressive and ARV agents is critical after HT, and treatment should be optimized bearing in mind the rapid change in plasma levels secondary to unpredictable interactions between ARVs and immunosuppressive agents (36).

Many other drugs (e.g. antimicrobial and antihypertensive drugs, especially calcium channel blockers) can interact with immunosuppressive agents and ARVs (37); therefore, changes in medication must be carefully managed to avoid graft rejection and toxicity.

OIs and de novo *tumors*

Specific prophylaxis guidelines for OIs in the setting of HIV-infected HT recipients are currently lacking; however, general measures for prevention of OIs in HIV-infected patients (33) and those used for all HT recipients (e.g. vaccination) are recommended (39,40). Of note, the ideal duration of posttransplant PCP prophylaxis is unknown. The combination of effective cART and adherence to recommendations for prophylaxis has led to a decrease in the incidence of OIs in HIV-infected patients, and consistent data show that this population is at no greater risk of developing OIs after transplantation (33).

Data on the development of *de novo* tumors in the posttransplant period in the setting of HIV infection are scarce. Nevertheless, HIV infection did not increase susceptibility to *de novo* tumors (33).

Conclusions and Future Lines of Research

The life expectancy of patients with HIV infection enables them to benefit from therapies for ESHF (mainly LVAD and HT). Present evidence, although not robust, indicates that HIV-infected patients undergoing HT have outcomes similar to those seen in non-HIV-infected patients, thus HT is a feasible treatment option for HIV-infected patients with ESHF; however, candidates must be selected carefully according to strict criteria. HT should be reserved only for those HIV-infected patients who fulfill established HT criteria (being on effective cART; >200 $CD4^+$ cells/mm^3; and, ideally, no history of OI).

Medical management in the post-HT period is challenging, and measures for HT recipients with HIV infection should be the same as for non-HIV-infected patients. cART is safe and effective in the posttransplant period, and no significant adverse events attributed to HIV infection are expected. DDIs play a key role in this complex scenario, and multidisciplinary teams are needed to address the diverse factors involved in the care of HIV-infected patients.

Regarding the future research lines, studies of HIV-infected HT recipients with larger sample sizes and longer follow-up periods are mandatory to improve the quality of currently available evidence. The following questions should be addressed in the near future: (1) What are the roles of HIV infection and donor variables in the prognosis of these patients? (2) Which is the best immunosuppressive regimen for HIV-infected heart recipients? (3) What are the rates of acute rejection, OIs, and *de novo* tumors? (4) What is the efficacy and safety of dolutegravir in this setting? (5) Does abacavir have any deleterious effect on heart allografts? (6) Does maraviroc have a role as an antirejection agent? To answer these questions, we strongly advocate the creation of a multinational registry of HT in HIV-infected patients. Meanwhile, it is reasonable to continue evaluating HIV-infected patients for HT because this seems to be an appropriate long-term therapeutic option for suitable candidates with ESHF.

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Disclosure

The authors of this manuscript have no conflicts of interest to disclose as described by the *American Journal of Transplantation*.

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Table S1: Baseline characteristics and clinical outcomes of patients with human immunodeficiency virus infection undergoing heart transplant in the pre–combined antiretroviral therapy era (1982–1996).

Table S2: Human immunodeficiency virus criteria for heart transplant in Spain and the United States.