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Longer-term outcomes after kidney transplantation from seronegative deceased donors at increased risk for blood-borne viral infection 1 – ,17

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Abstract

Background—Transmission of human immunodeficiency virus (HIV) and hepatitis C to transplant recipients has drawn attention to the use of allografts from seronegative donors at increased risk for viral infection (DIRVI).

Methods—We performed a cohort study of 7,803 kidney transplant recipients whose kidneys were recovered through one of two organ procurement organizations (OPO) from 1996 to 2007. Detailed OPO data on donor risk factors were linked to recipient data from the Organ Procurement and Transplantation Network.

Results—Median recipient follow-up was 3.9 years. 368 (5%) patients received DIRVI kidneys, a third of which were procured from donors with a history of injection drug use or commercial sex work. Compared to standard criteria kidney recipients, DIRVI kidney recipients were more likely to be HIV-positive or Black. In multivariable Cox regression, using DIRVI recipients as the reference, recipients of standard criteria donor kidneys had lower mortality (HR 0.71, $p<0.01$) and no difference in death-censored allograft failure (HR 1.09, $p=0.62$), whereas recipients of expanded criteria donor kidneys had no significant difference in mortality (HR 0.98, $p=0.83$), but a higher allograft failure rate (HR 1.93, $p<0.01$). High-quality data on post-transplant recipient viral testing were not available.

Conclusions—DIRVI kidney recipients experienced higher mortality than standard criteria kidney recipients. This finding could be explained if sicker patients received DIRVI kidneys (i.e., residual confounding) or the less likely possibility of undetected transmission of viral infections. Given the limitations of registry data used in this analysis, prospective studies are needed to further elucidate these findings.

Keywords

Kidney transplantation; Viral transmission; Human immunodeficiency virus; High Risk Donor

Introduction

The lengthy wait for a kidney transplant has driven interest in expanding the criteria for acceptable donor kidneys. Efforts to enlarge the pool of kidney allografts have included the increased use of expanded criteria donor (ECD) kidneys, which are recovered from older donors, as well as kidneys donated after cardiac death (DCD). Compared to so-called standard criteria donor (SCD) kidneys, ECD kidneys have shorter allograft survival, while DCD kidneys have high rates of delayed graft function.(1, 2) Also within the enlarged pool are kidneys from donors at increased risk of blood-borne viral infection (DIRVI)(3, 4)—

donors with negative viral serologic tests, but behavioral and clinical risk factors suggesting greater likelihood of undetected infection. Some DIRVIs could be in a “window period” when serologies have not yet become positive, or their viral serologies might be falsely negative due to hemodilution. Limited data about recipient outcomes are available to guide the use of kidneys from these donors.(5–7)

A 1994 report from the Centers for Disease Control and Public Health Service (CDC/PHS) defined criteria for deceased donors at increased risk for infection with human immunodeficiency virus (HIV) (Table 1).(8) The report recommended that organs from donors meeting these criteria should be discarded unless the risk to the recipient of not undergoing transplantation is considered greater than the risk of transplantation and infection.(8) Since 1994, these criteria have also been used to identify donors at increased risk of hepatitis B (HBV) and C (HCV). The precise risk of viral infection with acceptance of a DIRVI organ is uncertain. However, the transmission of HIV and HCV to four patients undergoing solid organ transplantation from a DIRVI in 2007 drew public attention to the possible negative consequences of accepting organs from these donors.(9–11)

Because of concerns about viral transmission or the stigma associated with HIV, kidneys from DIRVIs may be not be recovered, or may be declined by centers. The short-term nature of outcome data for DIRVI kidney recipients and the lack of detailed information about donor risk factors have made it difficult to contextualize the potential hazards of accepting DIRVI organs within the framework of other transplant-related risks – such as accepting an ECD kidney or remaining on dialysis.(5, 12).

We sought to better characterize DIRVIs and their recipients and to compare longer-term outcomes for recipients of DIRVI, SCD, ECD, and DCD kidneys. We hypothesized that recipients of DIRVI kidneys would have similar rates of mortality compared to SCD recipients, and lower rates of allograft failure and mortality compared to ECD recipients.

Results

The cohort comprised 7,803 kidney transplant recipients from 1996 – 2007, among whom 5,484 (70%) received kidneys recovered by the Gift of Life Donor Program (GOL) in Philadelphia, Pennsylvania, and 2,319 (30%) received kidneys recovered by the New Jersey Sharing Network (NJSN) in Springfield, New Jersey. In the cohort, 5,228 individuals (67%) received kidneys from SCDs, 1,621 (21%) from ECDs, 586 (8%) from DCDs, and 368 (5%) from DIRVIs. DIRVI allografts were transplanted at 57 centers; the majority (56%) were used by six centers in Pennsylvania and New Jersey. Median follow-up was 1,430 days.

The mean age of DIRVI kidney recipients was 48.7 years versus 47.7 years for SCD recipients. A higher proportion of DIRVI kidney recipients were black and HIV-infected compared to SCD recipients. Median waiting time was slightly greater for DIRVI recipients (645 days) versus SCD recipients (578 days) (Table 2).

In multivariable logistic regression for the outcome of receiving a DIRVI versus a SCD kidney, recipient HIV infection (OR 7.72, OR 3.95 – 15.1, $p<0.01$) and transplantation in the most recent era (OR 2.25, CI 1.64 – 3.10, $p<0.01$ for the years 2004 – 2007, and OR 2.11, CI 1.65 – 2.70, $p<0.01$ for the years 2000 – 2003, compared to the reference years 1996 – 1999) were strongly associated with DIRVI kidney use. Among the 26 HIV-infected recipients, DIRVI kidney use (31% of recipients) was nearly as common as SCD kidney use (35% of recipients).

The mean age of DIRVIs (32.9 years) was similar to that of SCDs (33.9 years) and DCD donors (33.7 years), but much lower than the mean age of ECDs (62.1 years). Compared to

SCD kidneys, DIRVI kidneys were more likely to be from black (p<0.01) and male (p<0.01) donors (Table 3).

We also examined patterns of kidney usage. DIRVI kidneys were less likely to be shared outside the local geographic area (12% for DIRVI versus 19% for SCDs, p<0.01). In multivariable logistic regression, DIRVIs were no less likely to have 1 versus 2 kidneys used for transplantation (OR 0.90, CI 0.51 – 1.60, p=0.73).

Kidneys were most likely to have been characterized as from a DIRVI due to donor history of incarceration (59%). The next most common reasons were injection drug use (26%), exchanging sex for drugs or money (10%), having a partner with a DIRVI risk factor (10%), and being a male with a history of sex with another male (5%) (Table 4).

Recipient infections

In this cohort, no donor-to-recipient transmissions of HIV, HCV, or HBV were reported to either organ procurement organization (OPO).

Multivariable analyses of mortality and allograft failure (Table 5)

Among DIRVI kidney recipients, 86 (23%) individuals died, compared with 1,032 (20%) SCD kidney recipients, 500 (31%) ECD kidney recipients, and 93 (16%) DCD recipients. In Cox regression, compared to DIRVI recipients, SCD (HR 0.71, CI 0.58 – 0.87, p<0.01) and DCD kidney recipients (HR 0.67, CI 0.54 – 0.83, p<0.01) had a lower mortality rate, while ECD recipients (HR 0.98, CI 0.83 – 1.17, p=0.83) had no significant difference in mortality.

Sixty-one (17%) DIRVI kidney recipients experienced death-censored allograft failure, compared with 1,103 (21%) SCD kidney recipients, 504 (31%) ECD kidney recipients, and 121 (21%) DCD kidney recipients. In Cox regression, compared to DIRVI recipients, SCD (HR 1.09, CI 0.78 – 1.51, p=0.62) and DCD recipients (HR 1.19, CI 0.82 – 1.73, p=0.36) had no statistically significant difference in allograft failure, while ECD recipients had a higher rate of allograft failure (HR 1.93, CI 1.33 – 2.81, p<0.01).

Additional analyses

Sensitivity analyses revealed results consistent with the primary analyses.

Secondary analyses of two subgroups of DIRVI kidneys showed that, compared to SCD kidney recipients, recipients of kidneys from DIRVIs with only an incarceration history had no difference in mortality (HR 1.25, CI 0.92 – 1.71, p=0.15), while recipients of kidneys from DIRVIs with other risk factors had elevated mortality (HR 1.46, CI 1.10 – 1.94, p<0.01).

We also examined Organ Procurement and Transplantation Network (OPTN) cause of death data. Compared to SCD recipients, DIRVI recipients were more likely to have died of infectious (OR 1.99, CI 1.23 – 3.21, p<0.01) or cardiovascular causes (OR 1.60, CI 1.04 – 2.48, p=0.03), but not of malignancy (OR 1.64, CI 0.78 – 3.46, p=0.19).

Discussion

The lengthening waiting list for kidney transplants has motivated efforts to maximize the use of good quality donor organs. We found that DIRVI kidney recipients had rates of patient survival lower than among SCD and DCD recipients, but similar to ECD recipients. DIRVI kidney recipients had allograft survival that was similar to SCD and DCD recipients and better than for ECD recipients. The higher mortality among DIRVI kidney recipients suggests that DIRVI kidney allografts are received by transplant candidates who are sicker

than SCD recipients. A less likely possibility is that these findings are attributable to undetected, donor-derived transmission of viral infections.

The DIRVIs in this study were a heterogeneous group. Most had an incarceration history, whereas a third had used injection drugs and/or engaged in commercial sex work—behaviors associated with the highest risk for HIV infection. The risk of viral transmission from a DIRVI depends on the risk factor, the testing modality, and the accuracy of the donor's history. In a decision model that employed data from non-organ donor populations, Schweitzer et al. calculated that, if nucleic acid testing (NAT) and antibody testing were used, the chance of HIV and/or HCV infection would be approximately 1 in 107 if a donor was a commercial sex worker or as low as 1 in 10,000 if the donor was an inmate. The risks would be higher if only antibody testing was used, as was the case during most years of our study.(3) These estimates, and data from the OPTN/UNOS Disease Transmission Advisory Committee (DTAC), indicate that viral transmission should be a rare event.(7)

Recipients of DIRVI kidneys had excellent allograft survival, but contrary to our hypothesis, they had higher mortality compared to SCD kidney recipients. The proportion who died over 4 years was 3.7% higher among DIRVI recipients compared to SCD recipients, a small but clinically important difference. This finding would be explained if sicker patients received these organs; unfortunately, their co-morbidities were not fully captured by our data. For instance, during the study period, OPTN data on cardiovascular disease, vascular access, and functional status lacked granularity and were not included in our multivariable models. Additionally, our analyses of cause of death revealed that, compared to SCD kidney recipients, recipients of DIRVI kidneys were more likely to die of infectious *as well as* cardiovascular causes, which is consistent with the hypothesis that DIRVI kidney recipients were a sicker group.

HIV-positive patients were much more likely to receive DIRVI organs, suggesting that they were more willing to accept DIRVI organs or that transplant staff directed kidneys to this group due to concerns about their outcomes while receiving chronic dialysis. The acceptance of organs from DIRVIs requires that patients overcome the stigma associated with the possibility of an HIV-infected donor, and this stigma may be less important to candidates who already have HIV. Another strong possibility is that HIV-positive patients go to centers where the transplant clinicians are comfortable with more clinically complex recipients and are, therefore, willing to accept kidneys from higher risk donors such as DIRVIs.

The explanation of greater rates of viral transmission among DIRVI recipients must also be considered. The risk of donor transmission of infections has received far greater scrutiny over the past several years, whereas our cohort spans an earlier period from 1996 – 2007. Recipient infections with hepatitis or HIV might not have been diagnosed. For instance, opportunistic infections such as *Pneumocystis* pneumonia could have been attributed to immunosuppression rather than HIV, and antibody serologies to diagnose viral infection (the standard of care during much of the study) can produce false negative results in immunosuppressed patients or those with renal disease. We acknowledge the limitation that we were not able to report post-transplant viral testing outcomes for recipients at over 200 centers. Nonetheless, given the low rate of viral transmission expected from DIRVIs and the lack of reports to the OPOs of viral transmission, donor-derived infections are unlikely to explain our results.(3, 7)

These findings of higher mortality among recipients of kidneys from DIRVIs versus SCDs contrast with two earlier studies (one from our group).(5, 6) These previous studies reported outcomes from a national cohort with shorter follow-up, whereas the current study reports outcomes related to kidneys from two OPOs and the majority of transplants took place at six

transplant centers in northeastern US, where waiting times are long. It is plausible that in this region (compared to others), sicker patients are more willing to accept DIRVI kidneys, and that a slightly higher rate of mortality only became evident after four years.

For transplant candidates considering the acceptance of a DIRVI kidney, the risks of viral transmission must be weighed against the substantial risks and diminished quality of life with end-stage renal disease.(13) Accepting a DIRVI kidney may provide a way to decrease waiting time. Since 2007, many OPOs have also adopted NAT, which narrows the window period of seronegative infections and could reassure patients. On the other hand, even with NAT, viral transmission will remain a small risk regardless of donor type, and informed consent of recipients remains an essential ethical precondition to transplantation.(14) Further study is needed about the most effective methods for informing transplant candidates about DIRVI organs, particularly since HIV and hepatitis are also associated with social stigma.(4, 15)

Conclusion

In a cohort of kidney transplant recipients over a decade, recipients of kidneys from DIRVIs experienced higher rates of mortality and similar allograft survival compared to SCD kidney recipients, but similar mortality and better allograft survival compared to ECD kidney recipients. With the registry data used in this study, we were unable to determine conclusively if our findings were due to the allocation of DIRVI kidneys to sicker patients versus the consequences of viral transmissions to recipients. Prospective studies are needed to resolve the mechanisms driving these findings.

Methods

Data on donor and recipient characteristics and recipient outcomes came from the OPTN. However, because the OPTN has only recorded DIRVI status since 2004, and has only coded this variable as present or absent, we also obtained information about specific viral infection risk factors and donor testing for HIV, HCV, and HBV from GOL and the NJSN – two geographically contiguous OPOs. We linked these data and performed a non-concurrent cohort study of adult (age≥18 years) kidney transplant recipients from 1996 – 2007 whose allografts were recovered through either OPO. The University of Pennsylvania Institutional Review Board approved the study.

The primary outcome was mortality and the primary exposure was donor type. We defined a DIRVI as any deceased donor with negative test results for HIV, HCV, and HBV, and who was classified as having a risk factor for infection due to social/medical history (Table 1).(8) Although the conventional definition of a DIRVI encompasses donors infected with HCV or HBV, we excluded recipients of kidneys from these donors (n=375) because of the belief that the decision-making by centers and patients about acceptance of organs with known infections is different from acceptance of organs from seronegative donors with only risk factors for infection.

NJSN and GOL employed slightly different criteria to categorize donors as “inmates of correctional systems” (a DIRVI category). The NJSN categorized individuals as DIRVIs if they had ever been incarcerated for >72 hours. GOL categorized donors as increased risk if they had been incarcerated for >72 hours in the last 12 months.

All donors underwent ELISA testing for HIV and measurement of HCV antibody and HBV surface antigen. The NJSN additionally measured HBV core IgM, and since 2004, performed nucleic acid testing for HIV, HCV, and HBV for all donors using Roche Cobas Ampliscreen.

As per OPTN definitions, we defined an ECD as a deceased donor ≥60 years old, or ≥50 years with two of the following: hypertension, terminal serum creatinine>1.5mg/dL, or death by cerebrovascular accident. A DCD was a donor for whom cardiac death was diagnosed prior to kidney recovery.(16) For simplicity, the 180 recipients of kidneys categorized as any combination of ECD, DCD, and DIRVI were excluded.

Recipient viral infections

Surveillance to detect viral transmissions to recipients was not mandated during the study period. However, several recommendations were in place to encourage the detection of such events. First, the CDC/PHS recommended that solid organ transplant recipients undergo HIV testing at 3, 6, and 12 months after transplantation. Second, the CDC/PHS recommended that if a transplant recipient was diagnosed with HIV, “the transplant center or health-care provider should, consistent with state law, immediately notify the state health department and the organization from which the tissue was obtained.”(8)

Notably, during this period, the OPTN did not obtain comprehensive data on infections after transplantation. Specifically, only 33.2% of the recipients in the study cohort ever had any HIV serologic testing results reported to the OPTN after transplantation. Even among DIRVI kidney recipients, only 35.8% had any HIV serologic data reported.

Statistical analysis

We conducted analyses using Stata (Stata 11.0, Stata Corporation, College Station, Texas). We used ANOVA to compare the means of normally distributed continuous variables across donor types, and the Kruskal-Wallis test to compare the medians of non-normally distributed variables. For categorical variables, we used the chi-square test or Fisher’s exact as appropriate.

We fit multivariable Cox regression models for the outcomes of mortality and allograft failure, adjusted for recipient center. We inspected log-log plots and other graphical displays to confirm model selection. Based on prior studies and clinical judgment, we identified independent variables for these models.(2, 17, 18) Recipient variables included age (defined as <30, ≥30 and <50, ≥50 and <70, and ≥70 years), gender, race (black or non-black), diabetes, history of dialysis, prior kidney transplant, multi-organ transplant, waiting time (<1000 versus ≥1000 days), and high peak panel reactive antibody (PRA, defined by OPTN convention as <80% versus ≥80%), HCV seropositivity, HIV seropositivity, and HBV seropositivity. HCV and HIV are reported as positive, negative or unknown “serostatus” to OPTN. We categorized individuals with hepatitis B surface antigen positive as HBV seropositive. Induction antibody therapy was categorized as lymphocyte-depleting or non-depleting. Initial immunosuppression was a categorical variable (FK-506 with neither cyclosporine nor rapamycin, cyclosporine with neither FK-506 nor rapamycin, Rapamycin used alone or with other agents, and other regimens).

Allograft variables included cold ischemia (<12, ≥12 and <24, ≥24 hours), antigen mismatch (zero mismatch or not), transplant era (the years 1996–1998, 1999–2002, 2003–2007), and share type. Share type, the geographical relationship between the donor service areas where the organ was recovered and accepted, was categorized as local/non-local. Donor characteristics that define ECD status (e.g., age) were not included in multivariable analyses.

A multivariable logistic model was fit for the outcome of receiving a DIRVI kidney; recipient independent variables used in the mortality model were used for this model. Lastly, to assess the willingness of centers to accept DIRVI kidneys, we fit a multivariable logistic model for the outcome of having both donor kidneys used for transplantation using donor independent variables included in the mortality model.

Missing data

A minority of recipients had missing data on variables of interest, including HIV serostatus (n=1,045, 13%), cold ischemia (n=841, 11%), hepatitis C serostatus (n=488, 6%), and peak PRA (n=478, 6%). In our primary multivariable analyses, we employed multiple imputation. (19) Additionally, we performed sensitivity analyses for mortality in which extreme values were assigned to individuals with missing data.

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Abbreviations

CDC/PHS	Centers for Disease Control and Public Health Service
DCD	Donation after cardiac death
DIRVI	Seronegative donors at increased risk of viral infection
DATC	Disease Transmission Advisory Committee
ECD	Expanded criteria donor
GOL	Gift of Life Donor Program
HBV	Hepatitis B virus
HCV	Hepatitis C virus
HIV	Human immunodeficiency virus
NAT	Nucleic acid testing
NJSN	New Jersey Sharing Network
OPO	Organ Procurement Organization
OPTN	Organ Procurement and Transplantation Network
PRA	Panel reactive antibody
SCD	Standard criteria donor
UNOS	United Network for Organ Sharing

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Table 1

Criteria for a seronegative Centers for Disease Control/Public Health Service high behavioral risk adult organ donor

1	Men who have had sex with another man in the preceding 5 years
2	Persons who report non-medical intravenous, intramuscular or subcutaneous injection of drugs in the preceding 5 years
3	Persons with hemophilia or related clotting disorders who have received human-derived clotting factor concentrates
4	Men and women who have engaged in sex in exchange for money or drugs in the preceding 5 years
5	Persons who have had sex in the preceding 12 months with any person described in items 1–4 above or with a person known or suspected to have HIV infection
6	Persons who have been exposed in the preceding 12 months to known or suspected HIV-infected blood through percutaneous inoculation or through contact with an open wound, non-intact skin or mucous membrane
7	Inmates of correctional systems

Table 2

Clinical and demographic characteristics of kidney transplant recipients *

	DIRVI kidney recipient (n=368)	SCD kidney recipient (n=5228)	ECD kidney recipient (n=1621)	DCD kidney recipient (n=586)	p-value
Mean age in yrs (s.e.)	48.7 (0.6)	47.7 (0.2)	57.2 (0.3)	49.9 (0.5)	<0.01
Male gender (%)	223 (60.6)	3151 (60.3)	1003 (61.9)	348 (59.4)	0.64
Race (%)					<0.01
White	198 (53.8)	3095 (59.2)	838 (51.7)	278 (47.4)	
Black	125 (34.0)	1524 (29.2)	591 (36.5)	234 (39.9)	
Hispanic	33 (9.0)	388 (7.4)	92 (5.7)	40 (6.8)	
Asian	6 (1.6)	168 (3.2)	77 (4.8)	26 (4.4)	
Other	6 (1.6)	53 (1.0)	23 (1.4)	8 (1.3)	
Dialysis prior to transplant (%)	323 (87.8)	4594 (87.9)	1494 (92.2)	533 (91.0)	<0.01
Hepatitis C seropositive (%)	27 (7.7)	287 (5.8)	85 (5.6)	32 (5.9)	0.52
CMV seropositive	167 (45.4)	1991 (38.1)	724 (44.7)	273 (46.6)	<0.01
Education					0.50
High school or less	170 (46.2)	2162 (41.4)	698 (43.1)	259 (44.2)	
Some college	53 (14.4)	781 (14.9)	232 (14.3)	76 (13.0)	
Bachelor's degree or higher	54 (14.7)	811 (15.5)	238 (14.7)	79 (13.5)	
Unknown	91 (24.7)	1474 (28.2)	453 (27.9)	171 (29.3)	
Primary payor					<0.01
Private insurance	117 (31.8)	1760 (33.7)	480 (29.6)	207 (35.3)	
Medicare	222 (60.3)	3129 (59.9)	1058 (65.3)	340 (58.0)	
Medicaid	17 (4.6)	241 (4.6)	55 (3.4)	31 (5.3)	
Other	12 (3.3)	98 (1.9)	28 (1.7)	8 (1.4)	
HIV seropositive (%)	8 (2.4)	9 (0.2)	4 (0.3)	5 (1.0)	<0.01
Hepatitis B seropositive	6 (1.6)	74 (1.4)	22 (1.4)	16 (2.7)	0.09
Median days on the wait-list	645	578	640	751	<0.01
Prior kidney transplant	48 (13.0)	707 (13.5)	148 (9.1)	77 (13.1)	<0.01

	DIRVI kidney recipient (n=368)	SCD kidney recipient (n=5228)	ECD kidney recipient (n=1621)	DCD kidney recipient (n=586)	p-value
Multi-organ transplant	64 (17.4)	791 (15.1)	18 (1.1)	10 (1.7)	<0.01
Pancreas	51	621	6	8	
Liver	10	117	9	2	
Heart	3	52	3	0	
Intestine	0	1	0	0	
Lung	0	0	0	0	
Diabetes	135 (36.7)	1742 (33.3)	579 (35.7)	168 (28.7)	0.01
Mean percent peak panel reactive antibody	14.3 (1.5)	15.1 (0.4)	9.6 (0.6)	10.4 (1.0)	<0.01
High peak panel reactive antibody (%) **	30 (8.9)	462 (9.6)	80 (5.1)	39 (6.8)	<0.01
Blood group (%)					0.77
A	130 (35.3)	1967 (37.6)	585 (36.1)	215 (36.7)	
B	52 (14.1)	681 (13.0)	217 (13.4)	70 (12.0)	
AB	24 (6.5)	314 (6.0)	83 (5.1)	35 (6.0)	
O	162 (44.0)	2266 (43.3)	736 (45.4)	266 (45.4)	

DIRVI: donor at increased risk for viral infection according to the Centers for Disease Control categorization; SCD: Standard criteria donor; ECD: Expanded criteria donor; DCD: donation after cardiac death; HIV: human immunodeficiency virus

*Recipients of live donor kidneys, recipients of kidneys from deceased donors seropositive for hepatitis C or hepatitis B, and recipients of kidneys from deceased donors that met criteria as ECD-DCD, ECD-DIRVI, DCD-DIRVI, or ECD-DCD-DIRVI were excluded. P-values represent comparisons across all groups. Percentages were calculated among individuals without missing data for that variable.

**Defined as peak panel reactive antibody >80%

Table 3

Characteristics of HIV seronegative donor allografts classified as increased risk for viral infection, standard criteria, expanded criteria, and donation after cardiac death

	DIRVI (n=368)	SCD (n=5228)	ECD (n=1621)	DCD (n=586)	p-value
Donor age (s.e.)	32.9 (0.6)	33.9 (0.2)	62.1 (0.2)	33.7 (0.6)	<0.01
Donor male gender (%)	297 (80.7)	3141 (60.1)	788 (48.6)	396 (67.6)	<0.01
Donor race (%)					<0.01
White	224 (60.9)	3768 (72.1)	1271 (78.4)	451 (77.0)	
Black	92 (25.0)	750 (14.4)	185 (11.4)	92 (15.7)	
Hispanic	48 (13.0)	556 (10.6)	128 (7.9)	32 (5.5)	
Asian	2 (0.5)	100 (1.9)	30 (1.9)	9 (1.5)	
Other	2 (0.5)	54 (1.0)	7 (0.4)	2 (0.3)	
Median cold ischemia in hours	16	17	18	17	<0.01
Zero antigen mismatch (%)	32 (8.7)	636 (12.2)	92 (5.7)	43 (7.3)	<0.01
Share type non-local (%)	45 (12.2%)	970 (18.6)	128 (7.9)	43 (7.3)	<0.01
CMV donor	226 (61.4)	3134 (60.0)	1093 (67.4)	312 (53.2)	<0.01

SCD: Standard criteria donor; DIRVI: designation of donor as increased risk for viral infection according to the Centers for Disease Control categorization; ECD: Expanded criteria donor; DCD: donation after cardiac death

Table 4

Among DIRVI kidney recipients: reasons why donors were categorized as elevated risk for blood-borne viral infection *

DIRVI criterion	Total (n=368)	Number from GOL (n=257)	Number from NJSN (n=111)
Inmates of correctional systems (%) **	218 (59.2)	143 (55.6)	75 (67.6)
Injection drug use (%) **	95 (25.8)	79 (30.7)	16 (14.4)
Commercial sex work (i.e. history of exchanging sex for money or drugs) (%)	37 (10.1)	22 (8.6)	15 (13.5)
Donor partner had DIRVI risk factor (%)	35 (9.5)	23 (9.0)	12 (10.8)
Man who had sex with another man (%) **	19 (5.2)	19 (7.4)	0 (0.0)
Persons with hemophilia or related clotting disorders (%)	8 (2.2)	6 (2.3)	2 (1.8)
Exposure to HIV infected blood (%) **	8 (2.2)	0 (0.0)	8 (7.2)

DIRVI: designation of donor as increased risk for viral infection according to the Centers for Disease Control/Public Health Service categorization; HIV: human immunodeficiency virus

* Columns do not sum to total because some donors had met multiple criteria for increased risk for viral infection

** Indicated difference between proportions across the two organ procurement organizations ($p<0.05$).

Table 5

Multivariable Cox analyses of patient mortality and death-censored allograft failure

	Mortality			Allograft failure		
	HR	**CI**	**p-value**	**HR**	**CI**	**p-value**
Recipient of:						
DIRVI kidney	*Reference*			*Reference*		
SCD kidney	0.71	0.58–0.87	<0.01	1.09	0.78–1.51	0.62
ECD kidney	0.98	0.83–1.17	0.83	1.93	1.33–2.81	<0.01
DCD kidney	0.67	0.54–0.83	<0.01	1.19	0.82–1.73	0.36
Recipient age (years)						
Age<40	Reference			*Reference*		
40≤age<50	1.34	1.16–1.55	<0.01	0.83	0.70–0.98	0.03
50≤age<60	2.44	2.12–2.81	<0.01	0.76	0.64–0.89	<0.01
60≤age<70	3.23	2.65–3.92	<0.01	0.79	0.64–0.98	0.03
Age≥70	5.69	4.41–7.35	<0.01	0.60	0.46–0.78	<0.01
Recipient black race	0.94	0.84–1.04	0.21	1.56	1.36–1.78	<0.01
Recipient male	1.13	1.05–1.23	<0.01	1.06	0.96–1.16	0.24
Recipient prior kidney transplant	1.20	0.99–1.45	0.06	1.29	1.12–1.47	<0.01
Recipient on dialysis	1.30	1.09–1.56	<0.01	1.16	0.96–1.42	0.13
Recipient diabetes	1.74	1.54–1.96	<0.01	0.98	0.88–1.08	0.67
Recipient hepatitis C sero-positive	1.63	1.37–1.94	<0.01	1.40	1.22–1.61	<0.01
Recipient HIV sero-positive	1.24	0.69–2.21	0.46	1.39	0.95–2.03	0.09
Recipient high PRA *	1.53	1.25–1.88	<0.01	1.30	1.08–1.55	<0.01
CMV positive recipient	1.01	0.91–1.11	0.87	0.95	0.87–1.03	0.20
CMV positive donor	1.09	1.00–1.20	0.05	1.15	1.07–1.24	<0.01
Wait-list time>1000 days	1.13	0.97–1.32	0.11	0.99	0.89–1.11	0.89
Dual organ transplant	1.16	0.89–1.50	0.28	0.72	0.57–0.91	<0.01
Donor black race	1.12	0.96–1.29	0.15	1.10	0.95–1.29	0.21
Donor male	0.92	0.84–1.01	0.07	0.95	0.84–1.06	0.36
Allograft cold ischemia (hours)						

	Mortality			Allograft failure		
	HR	**CI**	**p-value**	**HR**	**CI**	**p-value**
<12	*Reference*			*Reference*		
12≤time<24	1.04	0.91–1.18	0.59	1.09	0.94–1.26	0.28
≥24	0.96	0.81–1.14	0.63	1.12	0.91–1.37	0.30
Non-local transplant	0.93	0.76–1.14	0.50	1.00	0.81–1.23	0.99
Zero mismatch	0.89	0.73–1.07	0.22	0.71	0.57–0.89	<0.01
Steroid induction	1.08	0.96–1.20	0.19	1.12	0.96–1.30	0.17
Antibody induction	*Reference*			*Reference*		
Lymphocyte depleting	1.08	0.96–1.22	0.22	1.09	0.95–1.23	0.21
Non- Lymphocyte depleting	1.14	0.97–1.33	0.11	1.08	0.92–1.27	0.37
Initial immuno-suppression						
Tacrolimus based	*Reference*			*Reference*		
Cyclosporine based	1.19	0.98–1.44	0.09	1.12	0.98–1.49	0.08
Rapamycin based	1.27	1.05–1.52	0.01	1.54	1.22–1.93	<0.01
Other	1.92	1.59–2.32	<0.01	2.81	2.39–3.31	<0.01
Transplant era						
1996 – 1998	*Reference*			*Reference*		
1999 – 2002	0.94	0.79–1.12	0.48	1.09	0.98–1.23	0.12
2003 – 2006	0.87	0.73–1.05	0.15	1.05	0.83–1.34	0.68

* Defined as ≥80% peak panel reactive antigen

DIRVI: donor at increased risk for viral infection according to the Centers for Disease Control categorization; SCD: Standard criteria donor; ECD: Expanded criteria donor; DCD: donation after cardiac death; HIV: human immunodeficiency virus