

Donor Ethnicity Influences Outcomes following Deceased-Donor Kidney Transplantation in Black Recipients

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ABSTRACT

Although the majority of deceased-donor kidneys are donated after brain death, increased recovery of kidneys donated after cardiac death could reduce the organ shortage and is now a national priority. Racial disparities in donations after brain death have been well described for renal transplantation, but it is unknown whether similar disparities occur in donations after cardiac death. In this study, outcomes of adult deceased-donor renal transplant recipients included in the United Network for Organ Sharing database (1993 through 2006) were analyzed. Among black recipients of kidneys obtained after cardiac death, those who received kidneys from black donors had better long-term graft and patient survival than those who received kidneys from white donors. In addition, compared with standard-criteria kidneys from white donors after brain death, kidneys from black donors after cardiac death conferred a 70% reduction in the risk for graft loss (adjusted hazard ratio 0.30; 95% confidence interval 0.14 to 0.65; $P = 0.002$) and a 59% reduction in risk for death (adjusted hazard ratio 0.41; 95% confidence interval 0.2 to 0.87; $P = 0.02$) among black recipients. These findings suggest that kidneys obtained from black donors after cardiac death may afford the best long-term survival for black recipients.

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Persistent disparities have been recognized in virtually all aspects of health care in the United States, including ESRD and renal transplantation. US Renal Data System data indicate that 32% of Americans with ESRD are black, yet black individuals represent only 12% of the US population.¹ Currently, black patients with ESRD compose 34.9% of the kidney transplant waiting list but are 2 times less likely to receive a kidney transplant than their white counterparts, with only 30.7% of deceased-donor and 13.8% of living-donor kidneys going to black recipients (based on Organ Procurement and Transplantation Network [OPTN] data as of June 10, 2008). Numerous studies have also demonstrated that black renal transplant recipients are more likely to experience kidney allograft failure compared with their white counterparts and, furthermore, that this disparity in outcome exists even after controlling for multiple socioeconomic fac-

tors.^{2–14} In addition, kidneys from black deceased donors have a 1.64-fold higher risk for graft loss compared with those from white donors.¹⁵

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Despite the well-documented disparities, renal transplantation is recognized as the optimal treatment for all patients with ESRD. Moreover, as advances in immunosuppression have contributed to improvements in overall graft and patient survival, the demand for transplantation has steadily increased. Unfortunately, organ donation rates have not kept pace with the increased demand, and there are currently more than 75,000 Americans awaiting renal transplantation (based on OPTN data as of June 10, 2008). In response to the growing shortage of organs, many members of the transplant community, as well as the Institute of Medicine and the Society of Critical Care Medicine, advocate for increased recovery and use of organs donated after cardiac death (DCD).^{16,17} Since the establishment of brain death criteria in the mid-1970s, the vast majority of deceased-donor transplants have used organs donated after brain death (DBD); therefore, increased recovery and use of DCD organs would constitute a significant change in current clinical practice. In support of such a change, several studies have demonstrated that nationwide optimization of DCD recovery could increase the donor pool by as much as 350%.^{18–20} More important and despite the increased rates of delayed graft function (DGF) associated with DCD transplantation,²¹ Doshi and Hunsicker²² and Rudich *et al.*²³ separately demonstrated that the 5-yr patient and graft survivals of DCD kidneys are equivalent to those of DBD kidneys. In addition, we recently provided evidence that (1) DCD kidneys from donors who are younger than 50 yr have equivalent graft survival

to standard-criteria DBD donor kidneys, (2) limiting cold ischemic time (CIT) in DCD kidneys to <12 h reduces the rate of DGF by 15%, and (3) DGF is associated with a smaller reduction in graft survival for DCD kidneys compared with DBD kidneys.²⁴ Although these studies indicate that increased use of DCD kidneys will not decrease overall graft survival after renal transplantation, they do not address the potential of DCD kidneys to exacerbate or mitigate the well-established racial disparities in DBD renal transplantation.

Here we provide evidence that, among black recipients, DCD kidney transplantation is potentially more beneficial than standard-criteria DBD kidney transplantation. More specific, we found that black recipients of DCD kidneys from black donors have higher graft and better patient survival than black recipients of other donor subgroups. These findings indicate that increased use of DCD kidneys has the potential not only to reduce the organ shortage but also to mitigate the existing disparities in graft function and survival for black renal transplant recipients.

RESULTS

Demographics

A total of 25,251 black recipients met criteria for inclusion in these analyses. Black DCD donors were younger and more likely to be male compared with all other donor subgroups. Recipient age was similar for black recipients of the various

Table 1. Demographic characteristics of black recipients by donor ethnicity and subtype

Black Recipients	SCD		Donor Type ECD		DCD	
	White	Black	White	Black	White	Black
No. who underwent transplantation	14,925	5015	3380	777	1012	142
Age (yr; median [range])						
donor	36 (<1 to 59)	29 (<1 to 59)	61 (50 to 84)	57 (50 to 79)	41 (1 to 72)	25 (<1 to 66)
recipient	46 (18 to 84)	46 (18 to 80)	54 (18 to 85)	52 (18 to 79)	49 (18 to 80)	51 (18 to 75)
Gender (% female)						
donor	40.20	34.40	52.80	55.70	34.80	23.90
recipient	39.10	39.90	39.80	39.00	37.20	40.10
HLA mismatch (%)						
0	5.77	8.77	3.18	3.48	2.67	2.11
1	1.63	2.68	1.36	1.29	0.49	3.52
2	5.58	8.07	5.07	8.00	3.66	7.04
3	17.16	21.50	15.52	17.55	14.94	25.35
4	27.87	27.19	27.66	28.26	28.68	31.69
5	27.93	22.20	29.02	25.81	33.93	23.94
6	14.05	9.59	18.19	15.6	15.63	6.34
PRA (%)						
≤15	73.25	70.80	78.62	78.50	75.15	75.89
>15	26.75	29.20	21.38	21.50	24.85	24.11
Diabetes (%)						
donor	3.00	2.91	9.54	13.33	5.84	3.52
recipient	26.30	25.94	38.17	32.37	28.82	30.66
Donor hypertension (%)	12.44	19.90	65.77	82.61	19.44	12.68
CIT (h)						
≤20	59.38	57.64	54.08	54.51	53.84	59.69
>20	40.62	42.36	45.92	45.49	46.16	40.31

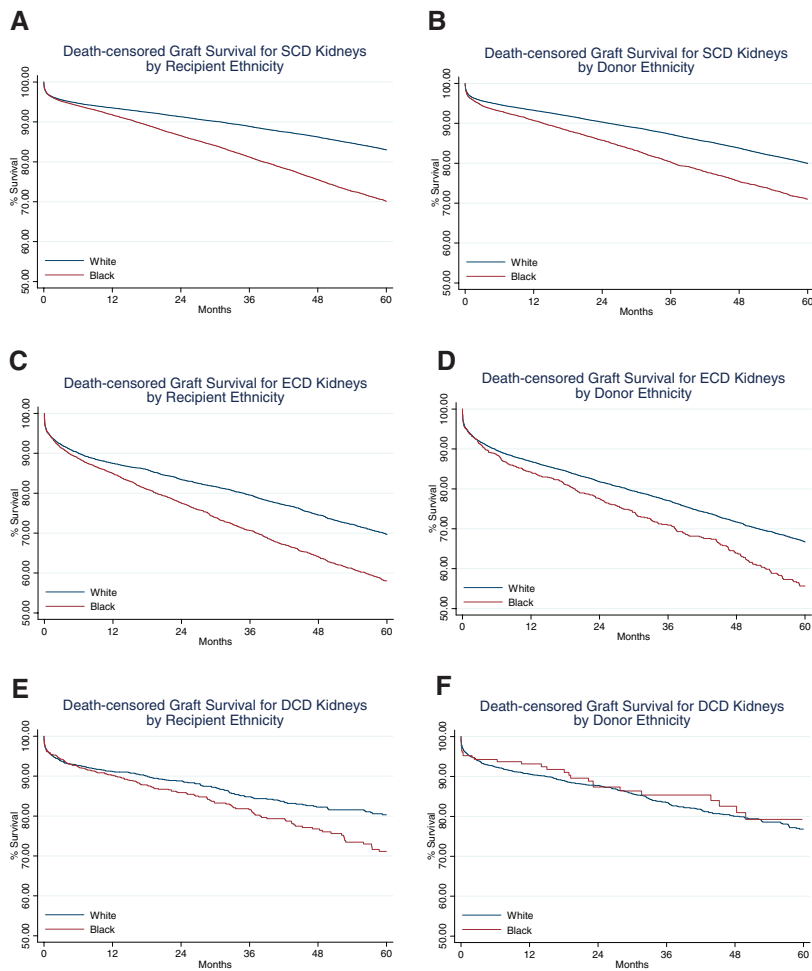


Figure 1. (A through F) Graft survival after SCD (A and B), ECD (C and D), and DCD (E and F) renal transplantation by donor and recipient ethnicity. Compared with SCD and ECD renal transplantation, outcomes after DCD renal transplantation seem to be less racially disparate. Each panel contains a graphic representation of the Kaplan-Meier survival function for DCGS.

donor subgroups. Furthermore, black recipients of DCD kidneys from black donors were less likely to have a zero-antigen-mismatch transplant (Table 1).

Graft Survival by Recipient and Donor Ethnicity and Donor Subtype

Black recipients of standard-criteria-donor (SCD; 70.1 versus 83%; $P < 0.001$) or expanded-criteria-donor (ECD; 58 versus 69.6%; $P < 0.001$) kidneys donated after brain death have significantly lower death-censored graft survival (DCGS) compared with their white counterparts (Figure 1, A and C). Furthermore, SCD and ECD kidneys from black donors have a significantly lower DCGS compared with SCD and ECD kidneys from white donors (SCD 71.1 versus 79.4% [$P < 0.001$]; ECD 55.7 versus 66.7% [$P < 0.001$]; Figure 1, B and D). Although still significant, the difference in 5-yr DCGS between black and white recipients of DCD kidneys is smaller than that of black and white recipients of DBD kidneys (71.2 versus

80.3%; $P < 0.001$; Figure 1E). The 5-yr DCGS of DCD kidneys from black donors is not significantly different from that of DCD kidneys from white donors (79.3 versus 76.8%; $P = 0.59$; Figure 1F).

Regression Analyses for Survival among Black Recipients by Donor Ethnicity and Subtype

Both unadjusted and adjusted analyses provide strong evidence that, among black recipients, DCD kidneys from black donors have significantly higher graft survival than all other donor subgroups (5-yr DCGS 83.8%; $P < 0.001$; Figure 2). After having adjusted for differences between recipient and donor characteristics, we found that black recipients of DCD kidneys from black donors have a 57% reduction in risk for graft loss (adjusted hazard ratio [AHR] 0.43; 95% confidence interval [CI] 0.22 to 0.82) compared with black recipients of SCD kidneys from white donors, the donor subgroup with the next highest DCGS (Table 2). As expected compared with SCD kidneys from white donors, other donor subgroups, including white DCD, black SCD, and black and white ECD, have lower rates of graft survival in black recipients (Figure 2, Table 2). A similar trend in outcomes among black recipients was noted with regard to patient survival. More specific, DCD kidneys from black donors afforded black recipients improved patient survival compared with SCD kidneys from white donors (87.6 versus 81.6%; AHR 0.55; 95% CI 0.29 to 1.06; Table 3).

Sensitivity Analyses for Survival among Black Recipients by Donor Ethnicity and Subtype

To account for potential alternative explanations of these surprising results, additional models were constructed. The initial clinical judgment models were stratified by time period to account for the relatively recent increase in DCD transplantation and for changes in immunosuppression regimen over time. A comprehensive model controlling for all statistically significant recipient, donor, and graft covariates as well as transplant year and preservation method (pump versus cold storage) was also constructed. In addition to the covariates included in the clinical judgment model, the comprehensive model adjusted for recipient gender, cause of ESRD, time on dialysis, functional status at transplantation, and history of previous kidney transplant; donor gender, blood urea nitrogen, and cause of death; preservation method; and transplantation year. To exclude the potential influence of differences in the rate of death with a functioning graft among various subgroups, non-

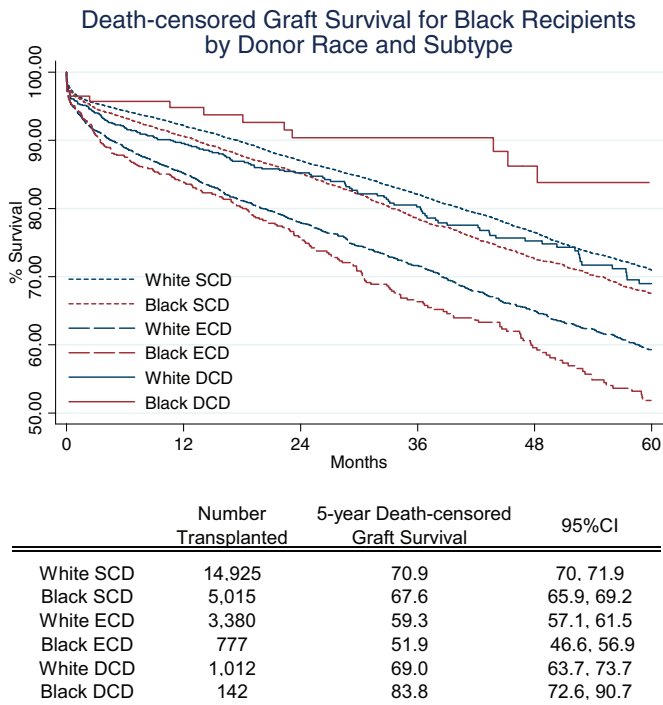


Figure 2. Graft survival for black recipients by donor ethnicity and subtype. The panel contains a graphic representation of the Kaplan-Meier survival function for DCGS. The 95% CI for 5-yr DCGS are presented in parentheses.

death-censored graft survival was evaluated using all previously described models. All of the adjusted results for risk for graft loss and patient death were robust to alternative approaches for covariate adjustment (data not shown).

Table 2. Multivariate regression model for the risk for graft loss among black recipients by donor ethnicity and subtype

Parameter	Risk for Graft Loss (HR)	95% CI	P
Donor type			
white SCD	1.00	–	–
black SCD	1.12	1.03 to 1.21	0.005
white ECD	1.10	0.97 to 1.25	0.140
black ECD	1.34	1.12 to 1.62	0.002
white DCD	1.24	1.04 to 1.47	0.010
black DCD	0.43	0.22 to 0.82	0.010
Donor characteristics			
age >50	1.42	1.29 to 1.57	<0.001
hypertension	1.22	1.12 to 1.32	<0.001
diabetes	1.17	1.01 to 1.36	0.030
BMI	1.00	0.99 to 1.00	0.230
Recipient characteristics			
age ≥39	0.71	0.66 to 0.75	<0.001
PRA ≥15	1.20	1.11 to 1.28	<0.001
diabetes	0.89	0.82 to 0.95	0.001
BMI	1.01	1.00 to 1.01	0.008
HLA mismatch ≥3	1.19	1.11 to 1.27	<0.001
CIT ≥20 h	1.12	1.06 to 1.19	<0.001

Table 3. Multivariate regression model for the risk of patient death among black recipients by donor ethnicity and subtype

Parameter	Risk for Death (HR)	95% CI	P
Donor type			
white SCD	1.00	–	–
black SCD	1.01	0.92 to 1.10	0.870
white ECD	1.18	1.03 to 1.36	0.020
black ECD	1.51	1.24 to 1.84	<0.001
white DCD	1.15	0.94 to 1.40	0.180
black DCD	0.55	0.29 to 1.06	0.070
Donor characteristics			
age >50	1.14	1.02 to 1.27	0.020
hypertension	1.12	1.02 to 1.22	0.020
diabetes	1.15	0.98 to 1.34	0.090
BMI	1.00	0.99 to 1.01	0.910
Recipient characteristics			
age ≥39	2.18	1.98 to 2.38	<0.001
PRA ≥15	1.19	1.10 to 1.28	<0.001
diabetes	1.90	1.78 to 2.04	<0.001
BMI	0.99	0.99 to 1.00	0.030
HLA mismatch ≥3	1.13	1.05 to 1.21	0.001
CIT ≥20 h	1.03	0.96 to 1.09	0.450

Matched Control Analyses for Survival among Black Recipients by Donor Ethnicity and Subtype

Although the results of our clinical judgment models were robust to multiple sensitivity analyses, we acknowledge the potential influence of selection bias and confounders on the model design for and analysis of small sample sizes (142 black recipients of DCD kidneys from black donors). To account for these influences and differences in donor demographics, we performed a matched control analysis of outcomes among black recipients receiving either an SCD kidney from a white donor or a DCD kidney from a black donor. Specifically, matched control analyses allow for the comparison of groups that have similar distributions of comorbid conditions and demographic backgrounds and as such more precisely isolate the effect of donor subtype on outcome. Case patients and control subjects were matched for donor factors, including age (±3 yr), gender, and history of diabetes and/or hypertension. Results from the matched control analysis support our initial findings. Specifically, black recipients of DCD kidneys from black donors conferred a 70% reduction in the risk for graft loss compared with black recipients of SCD kidneys from white donors (AHR 0.30; 95% CI 0.14 to 0.65; P = 0.002; Figure 3A). In addition, matched control analysis demonstrated that black recipients of a DCD kidney from a black donor had a 59% lower risk for death (AHR 0.41; 95% CI 0.20 to 0.87; P = 0.02; Figure 3B).

Survival among White Recipients by Donor Ethnicity and Subtype

Identical analyses were performed for white recipients. As expected, SCD kidneys from white donors afforded white recip-

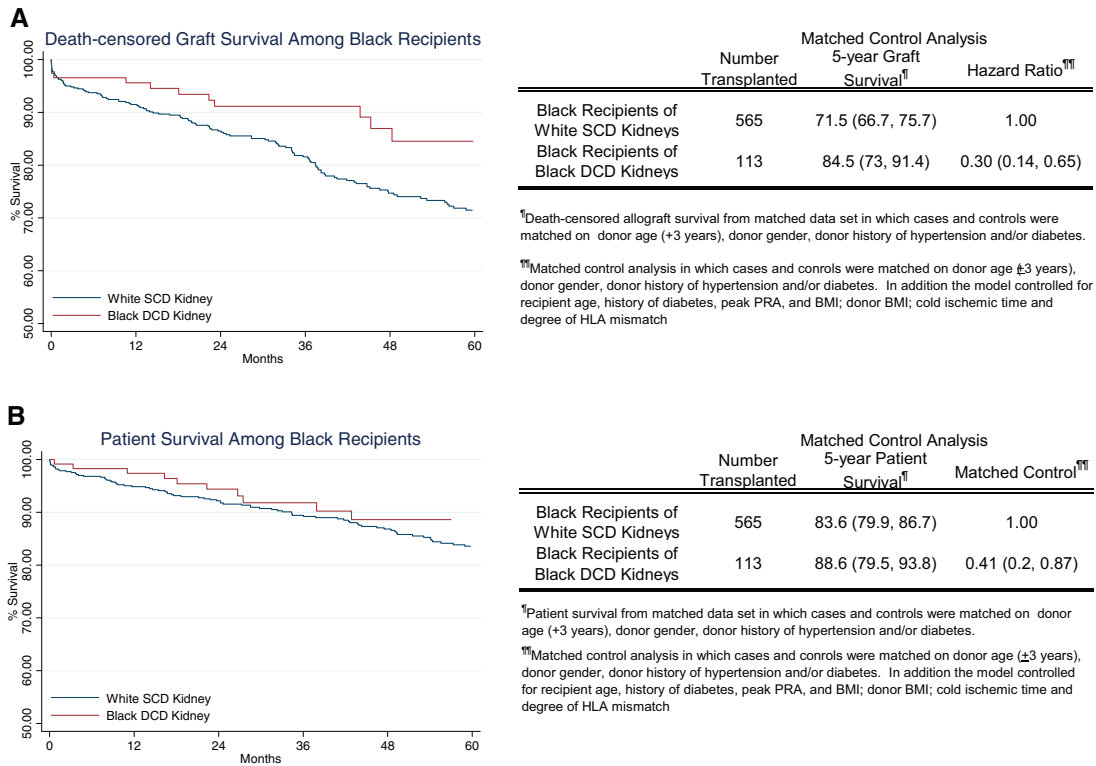


Figure 3. Matched control analysis of graft and patient survival among black recipients. Each panel contains a graphic representation of the Kaplan-Meier survival function and a table of the adjusted hazard for DCGS (A) and patient survival (B). The 95% CI are presented in parentheses.

ients the best long-term graft and patient survival (see supplemental data).

DISCUSSION

It is well established that black Americans are disproportionately affected by ESRD and have worse outcomes after transplantation with DBD kidneys than do white patients.²⁻¹⁴ The use of organs from cardiac death donors has recently gained momentum, and we describe here the first comprehensive analysis of the influence of donor ethnicity on graft and patient survival after DCD kidney transplantation among black recipients. Our analysis of all of the available and potentially informative data from the United Network for Organ Sharing (UNOS)/OPTN Transplant Registry revealed several new findings. We found that compared with DBD kidney transplantation, outcomes after DCD kidney transplantation are less racially disparate. More specific, both unadjusted and adjusted analyses demonstrated that, compared with other donor subgroups, DCD kidneys from black donors provided the highest graft and patient survival for black recipients. These data suggest that among black recipients, DCD kidney transplantation may be more beneficial than DBD kidney transplantation.

Given the current understanding of deceased-donor kidney transplantation, we performed several analyses to investigate the sensitivity of the results to covariate adjustments. For ex-

ample, black DCD donors on average were younger and had significantly lower incidences of hypertension and diabetes compared with other deceased donors. Furthermore, the number of DCD kidney transplants has increased significantly only in the past several years, and thus the DCD subgroup may be advantaged compared with the DBD subgroups as the result of improvements in immunosuppression and of kidney transplantation in general. It is also feasible that the results are merely a statistical aberration found in a small subgroup, because there are only 142 black recipients of black DCD kidneys; however, multiple sensitivity analyses supported our initial findings that DCD kidneys from black donors provide black recipients with the highest overall graft survival. Sample size calculations revealed that only 112 DCD kidneys from black donors were needed to power the comparison adequately between black recipients of either a black DCD kidney or a white SCD kidney. Analyses using matched control subjects, in which white SCD and black DCD donors were matched on the basis of age (± 3 yr), gender, and history of hypertension and diabetes, also demonstrated a significant reduction in risk for graft loss for black recipients of DCD kidneys from a black donor compared with black recipients of SCD kidneys from a white donor ($P \leq 0.05$). Finally, our results were robust to adjustments for transplant year and transplant era, suggesting that the recent increase in DCD kidney transplantation is not responsible for the observed superior survival.

Although our results are intriguing and suggest that the physiologic response to brain and cardiac death may differ across ethnic backgrounds, we do not advocate for changes in allocation policy at this time but, rather, view our results as additional support for the increased recovery and use of DCD kidneys. Furthermore, kidney transplantation continues to be a superior alternative to remaining on dialysis, and we caution against overinterpretation of these data for directing patient-level decisions; however, these findings are also encouraging and suggest that despite the lower socioeconomic status, higher rates of noncompliance, greater MHC polymorphism, and immune hyperactivity associated with black recipients,^{25–31} DCD kidney transplantation provides a potential opportunity to improve the existing racial disparity in deceased-donor renal transplantation. Although the exact mechanisms responsible for racial differences in graft survival are not known, that black recipients of DCD kidneys from black donors have better outcomes than black recipients of DCD and DBD kidneys from white donors suggests that the physiologic consequences of brain death and cardiac death on the donor organ and the subsequent recipient immune response may be influenced by ethnicity. Studies in rat and human transplant models have demonstrated the presence of an early-phase inflammatory process in response to brain death that is characterized by upregulation of adhesion molecules, cytokines, chemokines, and heat-shock proteins (HSP).^{32,33} Recently, Smith *et al.*³⁴ demonstrated the presence of HSP polymorphisms between white and black populations that are associated with altered mRNA and protein levels. Given the ability of HSP to protect against cell damage, some of these polymorphisms may reduce an individual's tolerance to the cellular insults associated with brain death. In addition, a study by Glauser *et al.*³⁵ documented enhanced free radical scavenging enzyme activity in black individuals, which might improve an individual's tolerance of the increased generation of reactive oxygen species that occurs during the warm ischemia that is unique to DCD kidney transplantation.

Because of the small sample size, we must acknowledge and address the susceptibility of our results to both type I (α) and type II errors (β). We attempted to account for the increased risk for α error by performing thorough model diagnostics and matched control analyses. Ensuring that the proportional hazards assumption was met allowed for the identification of interaction terms and significantly reduced the risk for type I error, particularly in analyses involving small sample sizes; however even in the context of well-designed standard multivariate regression modeling, retrospective analysis of small patient groups may still be susceptible to type I error. In other words, standard modeling may not adequately control for differences between subgroups, making results overly susceptible to selection bias and confounding. In an effort to avoid the majority of these biases and to account for the inherent differences between various ethnic subgroups and donor types, we performed matched control analyses. Matched control analyses allow for the comparison of groups that have similar distri-

butions of comorbid conditions and demographic backgrounds and as such more precisely isolate the effect of donor subtype on outcome. Finally, the 5-yr DCGS for black recipients of a DCD kidney from a black donor was associated with a wide CI, which is suggestive of a result with great variability and susceptibility to a type II error. In an effort to account for this potential error, we performed a power calculation that demonstrated that we have 89.8% (0.898) power to detect the reported difference. This means that the probability of the reported result having a type II error (false negative or β) is approximately 10%. This is more than adequate given that in research in which the power is calculated *a priori*, a β of 0.2 (20%) is considered standard. Although statistical testing cannot eliminate the potential error associated with taking a large registry and parsing data into smaller and smaller subsets, the results from this study were generated from the largest available renal transplantation data set and provide provocative new insight into the evolving role of DCD renal transplantation.

Independent of recipient ethnicity, fewer than 4000 DCD kidney transplants have ever been performed, and fewer than 600 are performed annually. Unfortunately, only 142 black recipients have ever received the benefit of the 83.8% 5-yr DCGS apparently afforded by a black DCD kidney transplant, whereas more than 25,000 black patients with ESRD have received an SCD, an ECD, or a white DCD kidney transplant with much lower 5-yr DCGS, ranging from 51.9 to 70.9%. Although DCD kidneys seem to be in short supply, the number of potential DCD donors is not. According to an Institute of Medicine Report *Organ Donation, Opportunities for Action*, at least 22,000 potential donors die each year of cardiac arrest.¹⁶ Optimization of this untapped donor source could dramatically increase the number of kidneys available for transplantation each year, and increased recovery of DCD kidneys from black donors may also mitigate existing racial disparities and improve outcomes for black renal transplant recipients.

CONCISE METHODS

Study Design and Population

We retrospectively analyzed a prospective cohort study of deceased-donor renal transplant recipients included in the UNOS Standard Transplant Analysis and Research (STAR) files. Our study population initially included 191,781 recipients who underwent renal transplantation between January 1993 and June 2007. We then excluded (1) pediatric recipients (<18 yr of age; $n = 10,572$); (2) adult recipients who underwent multiorgan transplantation ($n = 2829$); (3) adult live-donor renal transplant recipients ($n = 66,307$); (4) because of limited follow-up information, adult recipients who underwent transplantation after 2006 ($n = 1634$); and (5) adult recipients with missing information on donor kidney subgroup received ($n = 10,056$). Approximately 5.2% of information on donor kidney subgroup received was missing. Data analysis indicated that charac-

teristics of recipients with missing donor kidney subgroup information were not significantly different from the characteristics of recipients with recorded donor kidney subgroup information; therefore, we assumed that the information was missing at random. Deceased-donor recipients with a history of a previous renal transplant ($n = 13,100$) and *en bloc* and dual kidney transplants were not excluded ($n = 2995$).

We stratified the recipients according to the subgroup of donor kidney received (ECD, SCD, and DCD). ECD were defined as having been DBD with donor age >60 yr or age 50 to 59 yr and two of the following three characteristics: Donor hypertension, donor creatinine ≥ 1.5 mg/dl, or donor cause of death as a result of intracranial hemorrhage ($n = 15,816$). SCD were defined as DBD not meeting ECD criteria ($n = 80,720$). DCD donor subgroup was identified on the basis of the UNOS designation of non-heart-beating donation, specifically the recovery of organs from a donor whose heart has irreversibly stopped beating ($n = 3847$).

Donor (D) and recipients (R) were further classified by ethnicity: White (white and/or Caucasian; D = 75,993, R = 53,878), black (black and/or African American; D = 11,364, R = 29,252), Hispanic (D = 11,524, R = 11,915), Asian (D = 1916, R = 4675), and other (American Indian, Alaskan Native, Native Hawaiian or other Pacific Islander, and/or multiracial; D = 3098, R = 2297). Kaplan-Meier estimates of graft survival demonstrated that black recipients and kidneys from black donors have the largest disparity compared with all other ethnic subgroups (data not shown); therefore, the analyses were limited to a comparison between black and white deceased-donor kidneys among black recipients. Hispanic, Asian, and other recipient and donor ethnic groups were excluded from further analysis.

Five-year DCGS was the primary outcome, and 5-yr patient survival was the secondary outcome. Information on the time of graft loss was not missing. DCGS times for patients who died with a functioning graft were defined as the day of death, and these observations were censored.

Regression Model Development

Among black recipients, unadjusted DCGS was estimated using Kaplan-Meier method and was compared across donor subgroups (white and black ECD, white and black SCD, white and black DCD) with the log-rank test. We developed Cox proportional hazards models for estimating AHR for graft loss among black recipients using indicator variables for each donor subgroup. The models based on clinical judgment were adjusted for recipient, donor, and graft characteristics that are known predictors of long-term outcomes, including recipient age, diabetes, panel reactive antibody (PRA), and body mass index (BMI); donor age, hypertension, diabetes, and BMI; and CIT and degree of HLA mismatch. Before inclusion in the multivariate models, exploratory data analysis was used to identify interactions between model covariates and to determine the appropriate functional forms of model covariates.

Model Diagnostics and Sensitivity Analyses

Assumptions of proportional hazards were met as determined by examination of Schoenfeld residuals.³⁶ The goodness-of-fit of the models were evaluated using graphic representations of the sums of

weighted Martingale-transform residuals. The predicted probabilities of graft loss and mortality generated by the adjusted models were compared with the observed graft loss and mortality using the Hosmer-Lemeshow χ^2 ,³⁷ and the goodness-of-fit of each Cox model was adequate ($\chi^2, P > 0.05$).

To assess the sensitivity of our results, we performed the following additional analyses: (1) Stratified analyses by time period (1993 through 2006 *versus* 2000 through 2006) to account for changes in immunosuppression regimen over time; (2) stratified analyses by recipient ethnicity for each combination of donor subgroup (no indicator variable); (3) identification of all covariates with $P < 0.05$ on univariate analyses and construction of a stepwise model using forward and backward procedures for covariate adjustment on the basis of a reduction in Akaike's Information Criterion—the stepwise model adjusted for recipient factors (age, gender, cause of ESRD, time on dialysis, functional status at transplantation, peak PRA, history of diabetes or previous kidney transplantation, and BMI), donor factors (age, gender, BMI, blood urea nitrogen, cause of death, and history of diabetes or hypertension), and transplant factors (cold ischemic time [hours] and degree of HLA mismatch); (4) construction of a comprehensive model adjusted for covariates described in the stepwise model as well as other clinically relevant variables, including transplantation year and preservation method (pump *versus* cold storage); (5) construction of an additional comprehensive model adjusted for covariates described in the stepwise model as well as other clinically relevant variables, including hepatitis C and HIV status; and (6) evaluation of non-death-censored graft survival using all models previously described. Results from these sensitivity analyses were robust and consistent with the findings from our initial model.

Sample Size and Power Calculations

Sample size calculations were performed to determine whether an appropriate number of black recipients of a DCD kidney from a black donor were available for analysis. Specifically, among black recipients of either a white SCD kidney or a black DCD kidney, a two-sided comparison of proportions, 0.709 and 0.838, assuming a power of 0.8, α of 0.05, and a ratio of 1:5, demonstrated a need for 112 black DCD kidneys and 559 white SCD kidneys.

Because the DCGS for black recipients of a DCD kidney from a black donor has a wide CI, suggesting great variability and increased risk for a type II error, we performed power calculations. Power calculations among this subgroup demonstrated that we had 89.8% (0.898) power to detect the observed difference. This means that the probability of our results' having a type II error (false negative or β) is approximately 10%. This is more than adequate given that in research in which the power is calculated *a priori*, a β of 0.2 (20%) is considered standard.

Matched Control Analyses

Among black recipients, a matched control analysis was performed to examine outcomes further by donor subtype and ethnicity and to limit the impact of selection bias and confounders on reported outcomes. Controls were defined as SCD kidneys from white donors, and cases were defined as DCD kidneys from black donors. The matched control analysis used a ratio of five controls ($n = 565$) to one case ($n =$

113). Our matched control analyses used the same variables as the clinical judgment model. Controls (white SCD kidneys) were matched to cases (black DCD kidneys) on the basis of the donor factors included in the clinical judgment model: Age (± 3 yr), gender, and history of hypertension and/or diabetes. The matched control model was further adjusted for the remaining factors in the clinical judgment model: Recipient age, peak PRA, history of diabetes, BMI, and degree of HLA mismatch; donor BMI; and graft CIT.

To account for potential latent matched group effects, such as intragroup correlation, we performed a sensitivity analysis. Specifically, we used a cluster variance estimator, which is robust to misspecification and within cluster specification, and found a reduction in the SE, suggesting that the intragroup correlations are negative. Results from this sensitivity analysis were robust and consistent with the findings from our initial model.

Statistical Analysis

All tests were two-sided with statistical significance set at the $\alpha = 0.05$ level. All analyses were performed using STATA 10.0 for Linux (Stata Corp., College Station, TX).

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DISCLOSURES

None.

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