



[doi:10.1016/j.athoracsur.2007.02.013](https://doi.org/10.1016/j.athoracsur.2007.02.013)

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Original article

Comparison of Survival in Primary and Repeat Heart Transplantation From 1987 Through 2004 in the United States

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Accepted 2 February 2007.

Available online 25 May 2007.

Background

The purpose of this study was to identify predictors for survival after primary and repeat heart transplantations, and to compare their survival.

Methods

The United Network for Organ Sharing database provided 20,787 primary heart transplants and 594 repeat heart transplants (for those patients who had previously

undergone a primary heart transplant). Cox regression models were used to separately determine predictors of survival in primary and retransplant patients and to compare their survival distributions. Propensity score matching was then used to compare the survival between primary and retransplant patients adjusted for potential confounders.

Results

Similar predictors of survival were found for primary and retransplant patients. The overall increased risk of death was 71% higher for retransplant versus primary transplant patients. Propensity score analysis showed that, in patients with characteristics most similar to primary transplant patients, the increased risk of death was 133%; however, for patients with characteristics most like retransplant patients, the increased risk of death was only 34%.

Conclusions

Survival after retransplantation is significantly reduced relative to survival after primary transplantation. The difference in survival between primary and repeat transplants is smallest among recipients who fit the profile of the typical repeat transplant patient. In general, these are younger patients with better functional status prior to listing, who received an organ from a younger donor.

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Cardiac retransplantation is a controversial procedure due to the disparity between donor heart demand and supply. It has been performed at a steady number of 40 to 60 per year.

To determine which patients benefit most from repeat transplantation is key to our advancement in the field of transplantation and sharing of thoracic organs. To date, one- year survival for repeat heart transplantation has ranged from 48% to 95% [1]. The data indicate that chronic rejection, longer intervals between transplant, lack of preoperative mechanical assistance, and repeat transplantation after 1985 were predictors of survival [2]. These facts make it imperative to restrict the option of transplantation (and more so for retransplantation) to those patients with the greatest need and who are likely to derive the maximum benefit.

Rigorous analysis of an official registry such as the United Network for Organ Sharing (UNOS) databank is needed in order to address the clinical practice of repeat heart transplantation in the face of improving medical and therapeutic care of patients with heart failure. This has important implications for both the direction of research in the laboratory as well as in organ allocation and sharing.

The objectives of this study were the following: (1) to identify predictors for survival for each of the primary and the repeat heart transplantation patient groups; (2) to test whether there is a difference in the predictors between the two groups; and (3) to compare survival outcomes of primary and repeat heart transplants using propensity score matching.

Material and Methods

The UNOS Thoracic Registry database was the basis for our analysis. The database includes heart, lung, and heart lung transplants from October 1987 through June 2004. The Institutional Review Board at Loyola University and University of Illinois at Chicago waived the need for patient consent as this was an independent registry and identity of

individual patients was not identified. Subjects undergoing combined heart and lung transplantation were not included in this analysis. For the purpose of our study, the following variables were extracted from this database. UNOS heart transplant status (status 1, 1a, or 1b), recipient race, recipient ethnicity, organ ischemic time, employment status at time of transplant (not working due to disease versus other), limited functional status at time of transplant, donor and recipient age, donor and recipient sex, ABO blood type match (identical versus other), life support at time of transplant (intraaortic balloon pump), hospitalization, human leukocyte antigen (HLA) mismatch (0–6), ventilation status (ventilated or not), cause of donor death (anoxia or cerebrovascular-stroke), and cytomegalovirus (CMV) viral infection. There were 20,787 primary heart transplants and 594 repeat heart transplants with complete data on variables utilized for the analysis.

Statistically, this is a naturalistic study and comparison of primary and repeat transplant survival is complicated by differences in case mix between the two populations, and possible selection effects. For example, patients who undergo a repeat transplant may be more chronically or acutely ill than primary transplants because they are selected on the basis of a failed primary transplant. Conversely, these patients may be less acutely ill than at least some primary transplants, because they were able to survive long enough for a repeat organ(s) to become available.

We adopted two approaches to the analysis of our data. The first approach involves simple covariate adjustment for those variables that would potentially confound the comparison of survival between primary and repeat transplants. For the purpose of this study, we used a Cox regression model to examine predictors of survival in primary transplants, predictors of survival in repeat transplants, and to compare survival between primary and repeat transplant patients adjusted for potential confounders.

The second approach compared survival after primary versus repeat transplants using propensity score matching [\[3\]](#), [\[4\]](#) and [\[5\]](#). The propensity score described the likelihood of repeat transplantation conditional on potential confounders. A propensity score is computed for each subject (ie, the propensity to receive a second transplant,

regardless of whether or not the subject actually did receive a second transplant) and the sample is stratified into quintiles (Q1–Q5) on the basis of the propensity score. Q1 consists of patients most similar to those that had a single transplant (based on the potential confounders alone), and Q5 consists of patients most similar to those patients that had a repeat transplant (regardless of actual transplant status).

Comparison of primary and repeat transplants within quintiles are then unconfounded, assuming that the correct confounders have been included in the analysis. The proportional hazards assumption of the Cox regression model can be tested by including transplant type (primary versus repeat) by time interactions in the model.

Results

[Table 1](#) presents a simple univariate comparison of baseline characteristics between primary and repeat transplant patients. Overall, repeat transplant patients were more likely to be female, less likely to be in status 1, less likely to be unemployed due to disease, less likely to have functional limitations with daily living, more likely to be on a ventilator when hospitalized, younger, have a younger donor, and receive organs with increased ischemic time.

Table 1.

Characteristics of Primary and Repeat Transplants

Variable	Transplant		p Value
	Primary (n = 20787)	Repeat (n = 594)	
% Female (recipient)	24.1	30.0	0.001
% Female (donor)	31.5	31.5	1.000
% Transplant Status 1	65.3	59.3	0.003
% Hispanic or Latino	6.8	6.1	0.509

Variable	Transplant		p Value
	Primary (n = 20787)	Repeat (n = 594)	
% Not Working due to disease	49.2	42.8	0.002
% Functional status (limitations with ADI)	89.9	82.5	<0.001
% ABO match (not identical)	15.4	17.7	0.134
% Patient on life support at Tx	4.9	5.7	0.387
% Medical condition (hospitalized)	59.4	56.4	0.138
% Ventilator support	4.9	8.4	<0.001
% White	87.8	86.9	0.485
% CMV positive	62.9	66.8	0.052
% Donor cause of death (Anoxia)	7.2	8.1	0.422
% Donor cause of death (Cerebrovascular/stroke)	25.6	23.4	0.233
Mean (STD) HLA mismatch	4.53 (1.10)	4.54 (1.01)	0.710
Mean (STD) recipient age in years	47.1 (17.5)	40.4 (18.9)	<0.001
Mean (STD) donor age in years	28.2 (13.9)	26.5 (13.3)	0.003
Mean (STD) ischemic time in hours	2.97 (1.08)	3.12 (1.14)	0.001

[Full-size table](#)

ABO = blood type; CMV = cytomegalovirus; CVA = cerebrovascular accident; HLA = human leukocyte antigen; Tx = transplantation.

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Comparison of Primary and Repeat Transplants Using Cox Models

Estimation results of the Cox regression models for primary, repeat, and the comparison of primary and repeat transplants are provided in [Appendix Table 1](#). The significant predictors of survival for the primary transplantation patient group are the following: female, ethnicity, race, ischemic time, employment, functional status, age, donor age, life support, HLA mismatch level, and ventilator. Estimates of the coefficients of the above variables imply that female recipients have a 7% higher mortality than male recipients, being Hispanic increases mortality by 12%, African Americans have 47% higher mortality, ischemic time increases mortality by 9% per hour, being unemployed due to illness decreases mortality by 12%, needing assistance with daily living increases mortality by 13%, recipient age increases mortality by 0.2% per year, donor age increases mortality by 0.9% per year, being on life support (intraaortic balloon pump) increases mortality by 18%, having an HLA mismatch increases mortality by 3% per mismatch level, and being on a ventilator increases mortality by 58%.

Predictors of survival for repeat transplants were in general quite similar to the results for primary transplants (see [Appendix Table 1](#)). Out of 18 estimates of coefficients for predictors, 15 have identical signs between the two groups although many of the coefficients for the repeat transplantation group were not statistically significant due to the decreased sample size. The significant predictors of survival for the repeat transplantation patient group were the following: ischemic time, employment, age, and ventilator dependency at time of transplantation. Estimates of the coefficients of these variables imply that ischemic time increases mortality by 19% per hour, being unemployed due to illness decreases mortality by 33%, recipient age increases mortality by 1.8% per year, and being on a ventilator increases mortality by 215%. A statistical test for the differential effects of predictors between primary and repeat transplants was not significant ($p < 0.07$).

Comparison of survival between primary and repeat transplant patients was significant ($p < 0.001$), indicating that the repeat transplants are 70.8% more likely to die, adjusted for the potential confounders included in the analysis (see [Appendix Table 1](#)). No evidence for nonproportionality in hazard rates over time was found for either time in years ($p < 0.92$) or log time ($p < 0.49$).

Propensity Score Analysis

The potential confounder variables that were, or approached, statistical significance individually were the following: (1) donor characteristics (sex, age, and donor cause of death [anoxia or stroke]); (2) recipient characteristics (sex, age, ethnicity, race, blood group, human leukocyte antigen [HLA], ventilation, cytomegalovirus [CMV] status, intraaortic balloon pump, UNOS heart transplant status [Status 1, 1a, or 1b], employment status at time of transplant [not working due to disease vs other], limited functional status at time of transplant); and (3) procedure characteristics (ischemic time). Breakdown of characteristics (percentages or means and standard deviations) by propensity score quintile are presented in [Appendix Table 2](#). In general, the higher quintiles were populated with patients who had better functional status prior to listing, were less likely to be in status 1 upon listing, had increased likelihood of being on respiratory and mechanical life support at the time of transplantation, had an increased likelihood of being on a ventilator, and had increased CMV infection. The Q5 patients were also more likely to be younger and female, and more likely to have received an organ from a younger donor. The indications for primary as well as repeat heart transplantation are presented in [Table 2](#).

Table 2.

Indications for Primary and Repeat Transplantation

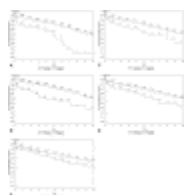
Diagnosis Category	Primary	Repeat	p Value	Total
Cardiomyopathy	14915 (71.8)	12 (2.0)	<0.0001	14927 (70.0)
Coronary artery disease	3707 (17.8)	13 (2.2)	<0.0001	3720 (17.4)
Retransplant/graft failure	23 (0.1)	567 (95.5)	<0.0001	590 (2.8)
Valvular heart disease	522 (2.5)	1 (0.2)	0.0003	523 (2.5)
Congenital heart disease	1412 (6.8)	0 (0)	<0.0001	1412 (6.6)
Other cardiac disease	12 (0.1)	0 (0)	0.56	12 (0.1)
Not reported or unknown	196 (0.9)	1 (0.2)	0.05	197 (0.9)

Diagnosis Category	Primary	Repeat	<i>p</i> Value	Total
Total	20787 (100)	594 (100)		21381 (100)

[Full-size table](#)

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In terms of risk ratios, the increased risk was 133% in Q1, 118% in Q2, 72% in Q3, 55% in Q4, and 34% in Q5 for a repeat transplant. All results were statistically significant ($p < 0.001$ for Q1 to Q4 and $p < 0.01$ for Q5). Overall, the increased risk was 65% for a repeat transplant. These results indicate that repeat transplants that were more characteristic of primary transplants sustained more than double the risk of death relative to a primary transplant, but in recipients more characteristic of repeat transplants, the increased risk of mortality was only 34%. The differences between first and second transplants by quintile are displayed graphically in [Figures 1A to 1E](#) for each of the five quintiles. [Figure 1](#) also provides the number of patients at risk for primary and repeat transplant groups for each year.



[Full-size image](#) (67K)

Fig 1. (A) Survival probability for primary and repeat transplants in quintile 1. (B) Survival probability for primary and repeat transplants in quintile 2. (C) Survival probability for primary and repeat transplants in quintile 3. (D) Survival probability for primary and repeat transplants in quintile 4. (E) Survival probability for primary and repeat transplants in quintile 5.

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Comment

The data from the Registry for the International Society for Heart and Lung Transplantation (ISHLT) states that retransplantation accounts for about 2% of adult cardiac transplants and nearly 3% of pediatric cardiac transplants (3). In contrast to previous years, retransplantation according to a recent ISHLT report from 2004 [6] was no longer a risk factor for increased mortality, with the odds ratio for increased risk having dropped from 1.76 in 1995 to 1998 to 1.08 in 1999 to 2002. However, their survival rates were calculated at the first year only. More importantly, other reports with five-year follow-up survival rates have shown a lower survival ranging from 33% to 37% [7] and [8]. The improved outcome reported by others may be due to more stringent guidelines for retransplantation and alternative strategies for acute graft failure including mechanical assist devices [6] and [9].

The transplant community is fully aware that retransplantation also raises ethical and financial considerations. Many patients do not survive on the waiting list long enough to receive their primary cardiac transplant [10] and [11]. The supply of donor organs does not meet the current demand and this lag will continue to increase as more patients are diagnosed with heart failure. The focus of our analysis was on this contemporary cohort of heart retransplants from the UNOS registry.

Our findings reveal that the determinants of survival in primary and repeat heart transplants are statistically indistinguishable. Overall, being female, Hispanic, African American, having longer ischemic time, needing assistance with daily living, being an older recipient, having an older donor, being on life support, having more HLA mismatches, and being on a ventilator increased mortality, whereas being unemployed due to illness decreased mortality. Based on simple adjustment for these covariates, significantly increased risk was found for retransplants relative to primary transplants with an increased estimated risk of mortality of 70.8%. Using propensity score matching, the overall estimated increased risk of a retransplant relative to a primary transplant was 65%; however, the effect was as high as 133% for patients who fit the profile for primary transplants (Q1) and as low as 34% for patients who fit the profile for

retransplants (Q5). From a policy perspective, this implies that overall, retransplantations are associated with a decreased survival relative to primary transplants; however, the smallest differential is for subjects with characteristics that characterize Q5 (see [Appendix Table 2](#)). In general, these are younger patients with better functional status prior to listing, who received an organ from a younger donor. For more severely impaired patients, these data indicate that organs should be allocated for primary transplantation, whenever possible.

An extensive number of recipient and donor factors that affect survival after heart retransplantation was identified. In reality, the need for retransplantation can be grouped into two general situations; emergent retransplantation and elective retransplantation. Patients with emergent retransplantation are nearly always desperately ill in cardiogenic shock from either acute graft failure or acute rejection. These patients do far worse than those with late graft failure undergoing elective retransplantation [[7](#)] and [[11](#)]. Given this, some centers [[8](#)] have restricted their donor pool for retransplantation to early graft arteriosclerosis and have experienced outcomes similar to primary transplantation. Similar risk factors were found for survival, including older recipient age, female gender, Hispanic or African American, HLA mismatch, mismatch in ABO blood group, donor age, and ischemic time. Interestingly, such factors were not predictors in the analysis reported by Srivastava and colleagues [[1](#)] in their analysis of 514 cardiac retransplants from the UNOS registry from October 1987 to August 1998. These investigators did not find any significant demographic predictors. In our study, those recipients who had maximal benefit from repeat transplantation (approaching primary transplant survival) were patients who were more likely to be female, with chronic heart failure, who did not meet the criteria for status 1A or 1B. Quintile 5 also included repeat heart transplant patients who were on a ventilator and (or) requiring circulatory support (15% and 7% of cohort, respectively). This suggests that there exists a portion of patients who are in a “favorable retransplant zone” that still benefit from repeat transplantation. A plausible reason for this could be that their estimated life expectancy was not deemed short enough for them to be listed status 1 at that institution and their clinical condition could be sustained temporarily with mechanical ventilation or circulatory life support.

Work-up for retransplantation is very similar to that for primary transplantation. Special attention to sensitization, if present, would necessitate a cross match at the time of retransplantation. The incidence of rejection after retransplantation is not different from that after primary transplantation [[12](#)] and [[13](#)].

Our study has several limitations; it is retrospective and nonrandomized. Although we attempted to minimize bias by propensity score matching, there could be additional hidden bias due to other confounding variables including serum creatinine, plasma reactive antibody, and dialysis, that were not available to us in sufficient frequency for our analysis. Potential earlier retransplantation for patients with ventricular assisted devices could introduce some bias given that less time is spent on the device and hence potentially fewer complications are sustained. Given that no standardized immunosuppressive regimen has been applied to patients after retransplantation, we did not control for this potential risk factor. The data used in our analysis were more limited with respect to rejection rates and intertransplant interval. We hope that future randomized prospective studies will be conducted to alleviate these potential biases.

In conclusion, retransplantation results in reasonable survival for chronic allograft failure patients who are refractory to medical therapy. Survival after retransplantation is significantly reduced relative to survival after primary transplantation. The magnitude of this difference is proportional to the severity of illness of the patient (ie, the difference in survival between primary and repeat transplants is smallest among recipients who are not in status 1). As such, when heart retransplantation is needed for late graft failure, we recommend that those patients who attain maximal benefit from repeat transplantation be considered. This can further maximize the efficiency of organ sharing in the near future from a limited donor pool, in the light of even a greater demand for organs.

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Appendix

Statistical Details of the Analysis

In this Appendix, we provide a nontechnical overview of the statistical methodology and present intermediate statistical details of the analysis in tabular form. First, Cox proportional hazards models were used to identify significant predictors of mortality separately for primary and repeat heart transplant patients. Second, data for primary and repeat transplants were combined and the difference between the two groups in terms of survival was computed, after adjustment for the effects of potential confounders. These analyses assume linearity between the predictors and risk of mortality, and do not alert us to the possibility of confounding (ie, lack of overlap in the distribution of potential confounders between primary and repeat transplant patient samples). These analyses also assume proportional hazards across the range of the covariates. To test this assumption, interactions between covariates and time were included in the model, but were not statistically significant, indicating that the proportional hazards assumption is reasonable for these data. Third, to provide a more sensitive analysis that is free from bias (given the covariates used in the model) we performed a propensity score analysis. The propensity score is a linear combination of potential confounders that is computed under the constraint that it maximally differentiates primary and repeat transplant patients. The linear combination is typically

computed using logistic regression analysis. In this case, the binary outcome was primary versus repeat transplant and the predictors were the potential confounders (ie, donor and recipient characteristics). By stratifying the sample into quintiles based on the estimated propensity score, the primary and repeat transplant groups within each quintile are balanced in probability with respect to all of the measured confounders. Kaplan-Meier survival analyses are then performed within each quintile, and a pooled analysis combining the survival curves across quintiles is also performed. Quintile 1 represents subjects that have characteristics that are most similar to primary transplant patients, whereas quintile 5 represents subjects that have characteristics most similar to repeat transplant patients. In this way, the potential effects of selection bias, based on observed subject characteristics, can be directly evaluated. A limitation of the analysis is that it only accounts for bias that is produced by measured confounders. If important confounders are not included in the propensity score, residual bias may still be present. Note that if the unmeasured confounders are highly correlated with the measured confounders, unbiased between-group comparisons can still be made.

[Appendix Table 1](#) presents maximum likelihood estimates, standard errors, probability values, and hazard ratios for all predictors, transplant type (primary versus repeat), and interactions between transplant type and predictors. Significant interactions imply that the effect of the predictor is different for primary and repeat transplant patients.

[Appendix Table 2](#) presents proportions or means and standard deviations of the potential confounders by quintile. Sample sizes for primary and repeat transplants by quintile are provided at the bottom of [Appendix Table 2](#).

Appendix Table 1.

Maximum Likelihood Estimates, Standard Errors, Probability Values, and Hazard Ratios (HR)

Variable	1 st TX (model 1)	2 nd TX (model 2)	1 st & 2 nd TX (model 3)
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	Est	St Er	p-val	HR	Est	St Er	p-val	HR	Est	St Er	p-val
Female	0.068	0.029	0.018	1.071	0.248	0.158	0.1152	1.283	0.028	0.012	0.019
Fem (don)	0.028	0.027	0.293	1.029	0.045	0.147	0.7595	1.046	0.012	0.012	0.308
Tx status 1	-0.029	0.037	0.434	0.971	0.203	0.182	0.2639	1.226	-0.023	0.017	0.168
CMV statatus	-0.018	0.025	0.469	0.982	-0.062	0.133	0.6378	0.939	-0.013	0.012	0.269
Ethnicity	0.115	0.049	0.019	1.122	0.527	0.290	0.0697	1.695	0.032	0.012	0.009
Race	0.383	0.035	<.000	1.467	0.197	0.202	0.3296	1.218	0.122	0.011	<.000
Ischemic time	0.082	0.011	<.000	1.086	0.173	0.055	0.0016	1.190	0.084	0.012	<.000
Employment	-0.121	0.027	<.000	0.885	-0.395	0.153	0.0099	0.673	-0.081	0.013	<.000
Functional status	0.125	0.050	0.012	1.133	0.190	0.229	0.4066	1.209	0.048	0.014	0.001
Age	0.002	0.000	0.022	1.002	0.018	0.004	<.0001	1.018	0.041	0.015	0.005
Age (don)	0.009	0.001	<.000	1.009	0.004	0.006	0.4614	1.005	0.121	0.015	<.000
ABO match	-0.017	0.033	0.602	0.983	-0.090	0.173	0.6017	0.914	-0.006	0.011	0.586
Life support	0.168	0.052	0.001	1.183	0.296	0.240	0.2177	1.345	0.038	0.011	0.000
Med condition	0.070	0.037	0.061	1.073	0.121	0.192	0.5297	1.129	0.044	0.018	0.014
HLA mismatch	0.027	0.011	0.012	1.028	-0.053	0.065	0.4097	0.948	0.026	0.011	0.025
Ventilator	0.45	0.0	<.0	1.5	1.14	0.2	<.00	3.1	0.08	0.0	<.0

Variable	1 st TX (model 1)				2 nd TX (model 2)				1 st & 2 nd TX (model 3)		
	Est	St Er	p-val	HR	Est	St Er	p-val	HR	Est	St Er	p-val
	4	67	00	76	7	57	01	49	4	14	00
Anoxia	0.00 0	0.0 51	0.9 90	1.0 01	0.00 1	0.2 75	0.99 45	1.0 02	-0.0 03	0.0 13	0.8 01
Cerebrovascular/stroke	0.05 0	0.0 32	0.1 17	1.0 52	-0.1 03	0.1 77	0.56 01	0.9 02	0.02 1	0.0 13	0.1 29
Transplant									0.08 8	0.0 11	<.0 00
Female*transplant									0.00 8	0.0 11	0.4 49
Fem (don)*transplant									0.00 0	0.0 11	0.9 92
Tx status 1*transplant									0.01 8	0.0 14	0.1 82
CMV status*transplant									-0.0 05	0.0 10	0.5 83
Ethnicity*transplant									0.02 1	0.0 12	0.0 83
Race*transplant									-0.0 12	0.0 11	0.2 69
Ischemic time*transplant									0.01 5	0.0 09	0.1 22
Employment*transplant									-0.0 30	0.0 12	0.0 12
Functional status*transplant									0.00 8	0.0 11	0.4 32
Age*transplant									0.05 0	0.0 13	0.0 00
Age									-0.0	0.0	0.3

Variable	1 st TX (model 1)				2 nd TX (model 2)				1 st & 2 nd TX (model 3)		
	Est	St Er	p-val	HR	Est	St Er	p-val	HR	Est	St Er	p-val
(don)*transplant									12	14	94
ABO match*transplant									-0.06	0.10	0.517
Life support*transplant									0.004	0.08	0.579
Med condition*transplant									0.006	0.15	0.674
HLA mismatch*transplant									-0.13	0.11	0.250
Ventilator*transplant									0.015	0.08	0.072
Anoxia*transplant									-0.02	0.11	0.827
Cerebrovascular*transplant									-0.10	0.12	0.427

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Appendix Table 2.

Characteristics of Patients in Propensity Score Quintiles

Variable	Q1 (n = 4277)	Q2 (n = 4276)	Q3 (n = 4276)	Q4 (n = 4276)	Q5 (n = 4276)
% Female (recipient)	12.7	16.7	22.8	28.6	40.4
% Female (donor)	36.3	30.1	28.2	30.1	32.9

Variable	Q1 (n = 4277)	Q2 (n = 4276)	Q3 (n = 4276)	Q4 (n = 4276)	Q5 (n = 4276)
% Transplant status 1	83.6	72.9	61.9	56.3	50.9
% Hispanic or Latino	13.3	4.5	4.5	6.2	5.8
% Not working due to disease	62.5	55.7	49.6	45.1	32.2
% Functional status (limitations with ADI)	99.3	98.6	95.8	86.9	67.9
% ABO match (not identical)	9.5	12.8	15.2	18.4	21.4
% Patient on life support at TX	1.0	2.8	5.4	8.5	7.0
% Medical condition (hospitalized)	62.3	66.5	59.6	57.0	51.3
% Ventilator support	0.2	0.8	2.4	6.6	15.0
% White	90.6	88.6	88.5	86.0	85.2
% CMV positive	42.4	63.6	71.0	68.3	69.7
% Donor cause of death (anoxia)	8.4	6.0	5.0	6.1	10.6
% Donor cause of death (cerebrovascular/stroke)	28.9	28.3	26.4	24.4	19.6
Mean (STD) HLA (D, R Q), Mismatch	4.50 (1.11)	4.50 (1.12)	4.51 (1.11)	4.55 (1.08)	4.57 (1.07)
Mean (STD) ischemic yime in hours	2.73 (0.93)	2.84 (0.94)	2.92 (0.98)	2.97 (1.08)	3.41 (1.32)
Mean (STD) donor age in years	27.8 (11.8)	30.1 (12.2)	30.7 (12.6)	29.8 (14.0)	22.4 (16.7)
Mean (STD) recipient age in years	58.1 (7.0)	54.9 (8.5)	51.0 (10.7)	43.4 (16.1)	27.3 (21.2)
# of 1st transplant	4220	4196	4175	4139	4057
# of 2nd transplant	57	80	101	137	219
% of 2nd transplant	1.3	1.9	2.4	3.2	5.1

[Full-size table](#)

Note: Quintile 5 patients are most likely to receive the repeat transplant.

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