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Cardiac Donor Risk Factors Predictive of Short-Term Heart Transplant Recipient Mortality: An Analysis of the United Network For Organ Sharing Database

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Abstract

Background—To address the shortage of donor hearts for transplant, there is significant interest in liberalizing donor acceptance criteria. Therefore, the aim of this study is to evaluate cardiac donor characteristics from the United Network for Organ Sharing (UNOS) database to determine their impact on post-transplant recipient outcomes.

Methods—Adult (≥ 18 years) patients undergoing heart transplant from July 1, 2004 to December 31, 2012 in the UNOS Standard Transplant Analysis and Research (STAR) database were reviewed. Patients were stratified by 1-year post-transplant status; survivors (Group S, n=13,643) and patients who died or underwent cardiac re-transplant at 1-year follow-up (Group NS/R=1,785). Thirty-three specific donor variables were collected for each recipient, and independent donor predictors of recipient death or re-transplant at 1 year were determined using multivariable logistic regression analysis.

Results—Overall 1-year survival for the entire cohort was 88.4%. Mean donor age was 31.5 ± 11.9 years and 72% were male. On multivariable logistic regression analysis, donor age > 40 years (OR 1.44, 95% CI 1.27-1.64), graft ischemic time > 3 hours (OR 1.32, 1.16-1.51), and the use of cardioplege (OR 1.17, 1.01-1.35) or Celsior (OR 1.21, 1.06-1.38) preservative solution were significant predictors of recipient death or re-transplant at 1 year post-transplant. Male donor gender (OR 0.83, 0.74-0.93) and the use of antihypertensives (OR 0.88, 0.77-1.00) or insulin (OR 0.84, 0.76-0.94) were protective from adverse outcomes at 1-year.

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Conclusions—These data suggest that donors who are older, female, or have a long projected ischemic time pose greater risk to heart transplant recipients in the short-term. Additionally, certain components of donor management protocols, including antihypertensive and insulin administration, may be protective to recipients.

Keywords

Heart Transplantation; Donor Selection; Donor Management; Outcomes

INTRODUCTION

Heart failure affects approximately 6 million people in the United States and poses a significant burden to the health care system (1). While heart transplantation is the optimal therapy for the treatment of end-stage heart failure, the number of transplants performed annually is approximately half the number of active waitlist candidates, representing a persistent shortage of donor organs. There is increasing interest in maximizing the total number of usable donor hearts through liberalization of donor acceptance criteria (2-5).

Several studies to date have evaluated specific donor characteristics including age (4, 6), cause of death (7, 8), sex mismatch (9), social risk factors (10, 11), medical history (12, 13), hemodynamic support requirements (14, 15), and their impact on post-transplant recipient survival. However, many of these studies were single-center reports with small sample sizes and evaluated only a limited number of donor variables. Therefore, the aim of this study is to utilize the United Network for Organ Sharing (UNOS) Standard Transplant Analysis and Research (STAR) database in order to evaluate a broad number of donor characteristics and their impact on the short-term survival of patients undergoing cardiac transplant. Insight from this analysis may help to refine the criteria for “high-risk” donors, thereby enhancing our ability to maximize the donor pool, as well as obtain useful information on beneficial donor management practices.

METHODS

Data Source

All data used in the analysis was provided by UNOS through the STAR database. The database is a de-identified, patient-level data source that contains donor, waitlist, and transplant recipient variables derived from UNet forms for any transplant in the United States after October 1, 1987. Data were provided by UNOS through June 6, 2014. The Columbia University Institutional Review Board reviewed the current study and an exemption was granted for approval given the de-identified nature of the dataset.

Study Design

All adult (≥ 18 years) heart transplant recipients undergoing transplant between July 1, 2004 and December 31, 2012 were reviewed for inclusion in the study (n=16,037). Patients who were lost to follow-up within 1 year post-transplant were excluded from the study (n=609). Remaining patients were stratified by their status 1 year after transplant; patients who were alive at 1-year (Group S, n=13,643) and patients who died or underwent cardiac re-

transplant by 1-year follow-up (Group NS/R=1,785). Mean follow-up time for the entire cohort was 3.9 ± 2.6 years.

Recipient variables collected included baseline demographics, heart failure etiology, comorbidities, and clinical status at transplant. Donor variables included baseline demographics, graft ischemic time, cause of death, medical and social history, terminal laboratory values, and donor hospital course including hemodynamic support, medications, transfusion status, presence of infection, and initial graft flush solution at procurement. The primary outcome of interest was the influence of donor characteristics on 1-year recipient survival. Ninety-day predictors of adverse outcomes were a secondary outcome.

Statistical Analysis

Analyses were conducted using SPSS version 22 (IBM corporation, Armonk, NY). All donor variables included in the analysis had greater than 97% population rate in the STAR dataset. Continuous variables are presented as mean ± standard deviation and compared using independent samples t-tests or median and interquartile range and compared using Mann-Whitney U test where appropriate. Categorical variables are presented as total count and percentage of the group and compared using Pearson's chi-square test or Fisher's exact test where applicable. A total of 33 donor covariates were screened for significant correlation with 1-year recipient death or re-transplantation using univariable logistic regression analysis. Any covariate with a univariable p-value ≤ 0.2 was entered into a multivariable logistic regression model to determine independent predictors of 1-year death or re-transplant. Results are presented as odds ratios (OR) and 95% confidence intervals (CI). All p-values ≤ 0.05 were considered statistically significant.

RESULTS

Recipient Characteristics and Post-Transplant Outcomes

Recipient characteristics stratified by study group are presented in Table 1. Overall 1-year survival was 88.4%. Of patients in Group NS/R, 1,735 (97.2%) patients died and 50 (2.8%) patients underwent re-transplant. Mean age of the entire cohort was 52.1 ± 12.7 years, 75.5% were male, and mean body mass index was 26.9 ± 4.9 kg/m^2. Dilated cardiomyopathy was significantly more common in Group S and ischemic cardiomyopathy and congenital heart disease were more common in Group NS/R. Patients who died or underwent re-transplant at 1-year were more likely to have had prior, non-transplant cardiac surgery at listing. Finally, patients in NS/R had significantly higher rates of need for mechanical ventilation (7.1% NS/R vs. 1.9% S), intra-aortic balloon pump (6.4% NS/R vs. 5.0% S), ventricular assist device (26.2% NS/R vs. 23.0% S), and extracorporeal membrane oxygenation (3.1% NS/R vs. 0.5% S) at the time of transplant.

Donor Characteristics

All donor characteristics evaluated in this study are listed in Table 2 according to recipient study group. Mean age of all donors was 31.5 ± 11.9 years and 72% were male. Mean age of donors for Group NS/R was significantly higher than Group S ($p < 0.001$) and the percentage of donors > 40 years of age was higher for Group NS/R (35.7% NS/R vs. 26.8%

S, $p < 0.001$). Significantly more donors in Group S were male than NS/R. Mean left ventricular ejection fraction (EF) was not significantly different between groups, and 27.4% of all donors had an EF < 55%. With respect to donor cause of death, there were significantly more donors who died of cerebrovascular accident (CVA) in Group NS/R and more donors who died of head trauma in Group S. Overall, 1.7% of donors had a history of cancer, 13.7% had a history of hypertension, and 3.1% were diabetic. Donor management protocol within 24 hours of procurement included antihypertensives, arginine vasopressin, insulin, vasodilators (distinct variable from antihypertensives), diuretics, steroids, thyroxine and inotropes, however, only the rate of insulin usage differed between groups. Transfusion of blood products occurred in 60.9% of donors and was equivalent across groups. There were no differences in rates of pulmonary, urine, or bloodstream infections between groups. The distance from donor hospital to recipient transplant center was greater than 100 miles in 49.3% of transplants with a mean distance of 179.9 ± 212.3 miles, and significantly more transports > 100 miles occurred in NS/R (51.5% NS/R vs. 49.0% S). A graft ischemic time > 3 hours was also more common in NS/R (63.4% NS/R vs. 58.0% S). Overall, 37.1% of donor hearts were flushed with University of Wisconsin solution, 26.2% with Celsior, 4.9%, Custodiol, 18.2% cardioplege, and 13.6% other solutions. Celsior and cardioplege were used more commonly in Group NS/R and University of Wisconsin solution was used more commonly in Group S.

Donor Predictors of Adverse Outcomes

Donor characteristics predictive of 90-day death or re-transplant are shown in Table 3. Donor age > 40 years (OR 1.51), donor BMI < 20 kg/m^2 (OR 1.30), ischemic time > 3 hours (OR 1.54), and the use of Celsior (OR 1.30) or cardioplege (OR 1.25) as initial flush solution were found to be independent predictors of adverse recipient outcomes at 90 days. Male gender (OR 0.75) and the use of insulin (OR 0.84) or vasodilators (OR 0.81) within 24 hours of procurement were protective. Donor cause of death, EF, and social historical variables were not significant.

Univariable and multivariable logistic regression analysis for donor variables predictive of 1-year recipient death or re-transplant are shown in Table 4. On univariable analysis, there was a significant correlation with 1-year recipient outcomes for donor age > 40 years, male donor gender, donor BMI < 20 kg/m^2, ischemic time > 3 hours, donor hospital > 100 miles from transplant center, CVA as cause of death, smoking history, other drug history, hypertension, cancer, insulin administration with 24 hours of procurement, and use of Celsior or cardioplege as preservative solutions. On multivariable analysis, only donor age > 40 (OR 1.44), ischemic time > 3 hours (OR 1.32), and use of Celsior (OR 1.21) or cardioplege flush (OR 1.17) remained independent predictors of 1-year death or re-transplant. There was a trend towards underweight donor BMI being predictive of adverse events at 1 year (OR 1.22, $p = 0.07$). Male gender (OR 0.83), insulin therapy prior to procurement (OR 0.84), and antihypertensive use prior to procurement (OR 0.88) were protective from adverse outcomes at 1 year.

DISCUSSION

The number of patients listed for heart transplant in the United States each year far surpasses the annual transplant rate, which has been attributed to a shortage of usable donor organs and a high donor organ rejection rate (16). In order to maximize the number of allografts for transplant, several studies have suggested a liberalization of the donor acceptance criteria (3-6). In order to ensure that criteria modification does not adversely affect transplant outcomes, large national studies are needed to determine which donor variables are safe to liberalize and which characteristics should continue to influence rejection of donor organs. Therefore, our aim in this study is to utilize the UNOS database to analyze the characteristics of a national cohort of cardiac donors from the present era and determine their respective influence on short-term recipient survival after heart transplantation.

Through analysis of 33 specific donor characteristics including demographic information, ischemic time, medical and social histories, and donor hospital course, we have found that only advanced donor age greater than 40 years, ischemic time greater than 3 hours, female gender, and graft preservation with Celsior or cardioplege are independent predictors of recipient death or re-transplant at 1 year. Conversely, insulin therapy and antihypertensives prior to procurement proved to be protective to recipient survival at 1 year. Equally as important in this study are the factors that did not show significant influence on post-transplant outcomes: donor cause of death, medical or social historical variables, donor ventricular function, or donor hospital course other than insulin and antihypertensive therapy. These findings do suggest that further liberalization of donor acceptance criteria may be warranted in order to increase the relatively stagnant annual transplant rate. To our knowledge, this is the largest and most inclusive evaluation of donor characteristics' influence on heart transplant recipient survival in the current era.

It is worth noting that the term "donor acceptance criteria" is a broad, non-specific term with no standardization across transplant centers. While two groups have attempted to create donor risk scoring systems, the use of such scores in clinical practice while directly evaluating a donor are fairly infrequent (17, 18). The final decision to accept or reject an organ is generally made after visualizing the heart at the donor hospital. Thus, while risk scoring systems may prevent a procurement team from going to evaluate a donor heart, the final decision is based on multiple sources of data, including both on-site (visualization of heart function, gross hemodynamic parameters, etc.) and recipient factors (urgency or stability). It is generally believed that on-site factors are heavily influenced by parameters of EF, right ventricular function, and hemodynamic support at procurement, and play a significant role in the short-term outcome of the recipient. Our study findings indicate that these immediate, peri-operative factors do not have as strong an influence on recipient outcomes as one might predict, and that poor ventricular function or worsened hemodynamics at the time of procurement may reflect a peri-operative state or temporary alteration due to the absence of neural input after brain death rather than inherently poor myocardial function (19). Our data suggests that the "make or break" rule of visualization of heart function at procurement may carry undue weight and requires further study.

Donor age remains an important predictive factor for post-transplant survival and one that deserves special consideration. In our study, recipients who were allocated organs from donors over 40 years old had a 44% greater risk of death or re-transplant than recipients of younger organs in the first year after transplant, which represents a significant increase in risk for a fairly young donor age cutoff of 40 years old. Overall, in the UNOS deceased donor database (166,559 donors since 1987), 48.7% of donors were over 40 years old. Thus, if we avoid this increased risk completely, the available donor pool will be significantly reduced, which will cause a significant impact on waitlist candidates. In practice, this increased risk appears to support the use of an alternate waitlist strategy and highlights the importance of individualized approaches to the consideration of using older donor hearts.

While many studies have addressed donor characteristics, few have evaluated the specific donor management protocols used. Interestingly, our study identified that the use of insulin and antihypertensive therapy in the peri-procurement period is protective to recipient survival. Although possible that this is related to a confounding variable that we have not analyzed, it is also possible that this finding reflects altered metabolic needs for myocardium in the presence of brain death. In an interesting study by Berman et al. in 2010, the authors show that ventricular dysfunction after brain death is mechanically and histologically similar to stress-induced cardiomyopathy (Takotsubo cardiomyopathy) and may be induced by a catecholamine surge experienced near the time of death (20). Thus, while some donor factors are not modifiable, such as age and gender, further research into the biochemical and metabolic changes to myocardial cells induced by brain death may uncover potentially reversible or “conditionable” donor factors that could influence donor management protocols.

One easily modifiable factor we have identified in this study is the choice of preservative solution used during procurement. Although there may be some variability in the composition of individual centers’ solutions, the use of Celsior or cardioplege were both significant predictors of adverse recipient outcomes in our analysis compared to preservation with University of Wisconsin solution. Other studies have found similar interactions suggesting that the use of these solutions should be questioned during cardiac procurement (21, 22). Given that myocardial protection is paramount in the field of heart transplantation, further study into the biochemical interactions associated with each preservative solution as well as the development of new solutions will further delineate the optimal preservation strategy in order to minimize myocardial injury during organ transport.

There were several limitations to this study. The provided data was from a national database compiled by UNOS and it is possible that definitions varied between transplant centers and organ procurement organizations. The main focus of our report is the influence of donor characteristics on 1-year recipient mortality, however, specific recipient characteristics certainly contribute to 1-year mortality as well, and those have not been included in our analysis. Several recipient characteristics showed statistically significant correlations with adverse post-transplant outcomes in univariable analysis and suggest that those recipients that died within the first year were sicker candidates, but the interaction of recipient and donor characteristics was beyond the scope of our study. Finally, we only included donors whose hearts were accepted for transplant. Thus, there may be additional characteristics that

are responsible for high rates of donor organ rejection, and those factors would not be accounted for in this analysis. The topic of rate and predictors of organ “non-use” is the subject of a different study and was not addressed here.

In conclusion, we have found that increased donor age, female donor gender, longer ischemic times, and the use of Celsior or cardioplege as preservative solutions are independent donor predictors of short-term adverse recipient outcomes for adults undergoing heart transplantation in the United States. Additionally, the use of insulin and antihypertensive medications prior to procurement confers a protective effect. This suggests that transplant centers should use caution when evaluating older donors and those with a prolonged period of predicted ischemic time. Given that these factors confer, at worst, moderately worsened recipient outcomes, they should not be considered absolute contraindications to donor organ acceptance, but rather they should be evaluated on an individual basis with consideration of alternate waitlist allocation. Additionally, further research is required in the field of myocardial metabolic demands following brain death in order to optimize donor medical management which may help condition donor hearts for transplant, specifically focusing on glucose regulation and optimal preservative solution.

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Abbreviations

BMI	body mass index
CVA	cerebrovascular accident
EF	ejection fraction
STAR	Standard Transplant Analysis and Research
UNOS	United Network for Organ Sharing

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Manuscript Highlights

- We examine the effect of donor characteristics on heart transplant outcomes
- We utilize the United Network for Organ Sharing Database
- Donor age, graft ischemic time, and preservative solution are risk factors
- Male gender and peri-procurement management factors are protective

Table 1

Recipient Characteristics stratified by 1-year post-transplant survival

	Group S	Group NS/R	*p*-value
Demographics			
Total, n	13,643	1,785	---
Age, years (mean ± SD)	52.0 ± 12.6	53.0 ± 13.1	0.003
Male, n (%)	10,337 (75.8)	1,316 (73.7)	0.06
BMI, kg/m^2 (mean ± SD)	26.9 ± 4.8	27.2 ± 5.0	0.01
Ethnicity, n (%)			< 0.001
White	9,557 (70.1)	1191 (66.7)	
Black	2,500 (18.3)	402 (22.5)	
Hispanic	1,073 (7.9)	128 (7.2)	
Other	513 (3.8	64 (3.6)	
Blood Group, n (%)			0.18
A	5,684 (41.7%)	725 (40.6)	
B	1,964 (14.4)	255 (14.3)	
O	5,263 (38.6)	726 (40.7)	
AB	732 (5.4)	79 (4.4)	
Etiology of Heart Failure, n (%)			< 0.001
Dilated CM	6,257 (45.9)	706 (39.6)	
Ischemic CM	5,382 (39.4)	745 (41.7)	
Restrictive CM	322 (2.4)	63 (3.5)	
Congenital heart disease	338 (2.5)	77 (4.3)	
Other	1,344 (9.9)	194 (10.9)	
Co-morbidities, n (%)			
Diabetes	3,534 (26.0)	488 (27.5)	0.18
Cerebrovascular disease	612 (4.5)	88 (5.0)	0.38
Prior cardiac surgery at listing	4,727 (36.8)	746 (45.2)	<0.001
Hemodynamics at Transplant			
Cardiac output, L/min (mean ± SD)	4.5 ± 1.5	4.5 ± 1.6	0.29
mPAP, mmHg (mean ± SD)	28.4 ± 10.1	29.6 ± 10.2	< 0.001
PCWP, mmHg (mean ± SD)	19.0 ± 8.8	19.5 ± 8.6	0.02
Clinical Status at Transplant, n (%)			
Intubated	257 (1.9)	126 (7.1)	< 0.001
Inotropic support	5,574 (40.9)	724 (40.6)	0.81
IABP	686 (5.0)	115 (6.4)	0.01
LVAD	3,141 (23.0)	468 (26.2)	0.003
ECMO	64 (0.5)	56 (3.1)	< 0.001

Abbreviations: BMI=body mass index, CM=cardiomyopathy, ECMO=extracorporeal membrane oxygenation, IABP=intra-aortic balloon pump, LVAD=left ventricular assist device, mPAP=mean pulmonary artery pressure, PCWP=pulmonary capillary wedge pressure

Table 2

Donor characteristics stratified by recipient 1-year post-transplant outcomes

	Group S	Group NS/R	*p*-value
Demographics			
Age, years (mean ± SD)	31.2 ± 11.8	33.7 ± 12.6	< 0.001
Age > 40 years, n (%)	3,659 (26.8)	638 (35.7)	< 0.001
Male, n (%)	9,902 (72.6)	1,208 (67.7)	< 0.001
BMI, kg/m^2 (mean ± SD)	26.9 ± 5.5	26.8 ± 5.5	0.70
BMI < 20 kg/m^2, n (%)	763 (5.6)	124 (7.0)	0.02
BMI > 30 kg/m^2, n (%)	3,228 (23.7)	412 (23.1)	0.60
LVEF, % (mean ± SD)	61.5 ± 7.3	61.9 ± 7.4	0.06
LVEF < 55%, n (%)	3,726 (27.6)	457 (25.8)	0.12
Ischemic time > 3 hrs, n (%)	7,741 (58.0)	1,085 (63.4)	< 0.001
Donor hospital > 100 miles from transplant center, n (%)	6,687 (49.0)	919 (51.5)	0.05
Cause of Death, n (%)			0.001
Anoxia	2,077 (15.2)	272 (15.2)	
CVA	3,043 (22.3)	468 (26.2)	
Head Trauma	8,133 (59.6)	986 (55.3)	
CNS Tumor	113 (0.8)	23 (1.3)	
Other	276 (2.0)	35 (2.0)	
Social History, n (%)			
CDC high-risk donor	1,275 (9.4)	151 (8.5)	0.24
Smoking (> 20 pack*years)	2,335 (17.2)	349 (19.8)	0.007
Heavy alcohol use (> 2 drinks/day)	2,022 (15.0)	280 (16.0)	0.31
Cocaine use	1,924 (14.4)	231 (13.3)	0.21
Other drug use	5,184 (38.5)	619 (35.2)	0.007
Medical History, n (%)			
Diabetes	405 (3.0)	65 (3.7)	0.11
Hypertension	1,808 (13.3)	291 (16.5)	< 0.001
Cancer	215 (1.6)	42 (2.4)	0.02
Terminal Laboratory Values, n (%)			
Creatinine > 2.0 mg/dL	1,351 (9.9)	176 (9.9)	0.96
Total bilirubin > 1.5 mg/dL	2,569 (18.9)	331 (18.6)	0.79
Donor Hospital Course, n (%)			
Anticonvulsants[a]	567 (4.2)	79 (4.5)	0.58
Antihypertensives[a]	3,307 (24.3)	401 (22.5)	0.10
Vasopressin[a]	8,143 (59.9)	1,050 (59.1)	0.50
Vasodilators[a]	2,042 (15.0)	244 (13.7)	0.16
Insulin[a]	9,009 (66.2)	1,126 (63.2)	0.01
Diuretics[a]	8,848 (65.0)	1,152 (64.8)	0.88

	Group S	Group NS/R	*p*-value
Steroids[a]	10,869 (79.9)	1,425 (80.1)	0.84
T4[a]	9,476 (69.6)	1,214 (68.2)	0.24
Any blood transfusion	8,302 (60.9)	1,083 (60.8)	0.94
Inotrope at procurement	7,240 (53.3)	952 (53.7)	0.73
Heparin	12,760 (93.6)	1,649 (92.7)	0.13
Pulmonary artery catheter	2,685 (19.7)	368 (20.7)	0.34
Pulmonary infection	5,541 (40.6)	724 (40.6)	0.97
Bloodstream infection	928 (6.8)	131 (7.3)	0.40
Urinary infection	1,048 (7.7)	134 (7.5)	0.79
Preservative Solution, n (%)			0.02
University of Wisconsin Solution	5,110 (37.5)	622 (34.9)	
cardioplege	2,503 (18.4)	356 (20.0)	
Celsior	3,545 (26.0)	508 (28.5)	
Custodiol	640 (4.7)	85 (4.8)	
Other	1,836 (13.5)	211 (11.8)	

Abbreviations: BMI=body mass index, CDC=Center for Disease Control, CNS=central nervous system, CVA=cerebrovascular accident, LVEF=left ventricular ejection fraction, T4=thyroxine

[a]within 24 hours of procurement

Table 3

Multivariable logistic regression analysis for donor characteristics predictive of 90-day post-transplant mortality or re-transplantation

	OR (95% CI)	*p* - value
Donor age > 40 years	1.51 (1.28-1.78)	< 0.001
Male gender	0.75 (0.65-0.87)	0.001
Donor BMI < 20 kg/m^2	1.30 (1.00-1.69)	0.05
LVEF < 55%	0.92 (0.79-1.07)	0.27
Ischemic time > 3hrs	1.54 (1.31-1.82)	< 0.001
Donor hospital > 100 miles from transplant center	0.90 (0.76-1.05)	0.17
Donor cause of death		
Anoxia	reference	
CVA	0.95 (0.76-1.18)	0.62
Head trauma	0.95 (0.79-1.16)	0.63
CNS tumor	1.28 (0.69-2.36)	0.43
Other	1.00 (0.61-1.62)	0.99
Smoking (> 20 pack*years)	0.95 (0.79-1.14)	0.60
Cocaine use	0.84 (0.68-1.04)	0.11
Other drug use	1.02 (0.88-1.18)	0.81
Heavy alcohol use (> 2 drinks/day)	1.16 (0.96-1.40)	0.12
CDC high risk donor	0.91 (0.70-1.17)	0.45
Hypertension	1.07 (0.88-1.30)	0.50
Cancer	1.51 (0.98-2.30)	0.06
T4[a]	0.99 (0.85-1.14)	0.86
Vasodilators[a]	0.81 (0.66-0.98)	0.03
Insulin[a]	0.84 (0.73-0.96)	0.01
Heparin	0.87 (0.68-1.13)	0.30
Preservative Solution		
University of Wisconsin Solution	reference	
cardioplege	1.25 (1.04-1.50)	0.02
Celsior	1.30 (1.10-1.54)	0.002
Custodiol	1.02 (0.74-1.42)	0.89
Other	0.87 (0.70-1.09)	0.23

Abbreviations: BMI=body mass index, CDC=Center for Disease Controla, CNS=central nervous system, CVA=cerebrovascular accident, LVEF=left ventricular ejection fraction, T4=thyroxine

[a]within 24 hours of procurement

Table 4

Logistic regression analysis for donor characteristics predictive of 1-year post-transplant recipient mortality or re-transplantation

	Univariable		Multivariable	
	OR (95% CI)	***p* - value**	**OR (95% CI)**	***p* value**
Donor age > 40 years	1.52 (1.37-1.68)	< 0.001	1.44 (1.27-1.64)	< 0.001
Male gender	0.79 (0.71-0.88)	< 0.001	0.83 (0.74-0.93)	0.002
Donor BMI < 20 kg/m^2	1.26 (1.04-1.54)	0.02	1.22 (0.98-1.50)	0.07
LVEF < 55%	0.91 (0.82-1.02)	0.12	0.92 (0.82-1.04)	0.16
Ischemic time > 3hrs	1.26 (1.13-1.40)	< 0.001	1.32 (1.16-1.51)	< 0.001
Donor hospital > 100 miles from transplant center	1.10 (1.00-1.22)	0.05	0.94 (0.83-1.06)	0.31
Donor cause of death				
Anoxia	reference		reference	
CVA	1.17 (1.00-1.38)	0.05	0.92 (0.77-1.10)	0.34
Head trauma	0.93 (0.80-1.07)	0.29	0.95 (0.82-1.11)	0.52
CNS tumor	1.55 (0.98-2.48)	0.06	1.25 (0.75-2.10)	0.39
Other	0.97 (0.67-1.41)	0.87	0.95 (0.64-1.40)	0.79
Smoking (> 20 pack*years)	1.19 (1.05-1.35)	0.007	1.02 (0.89-1.17)	0.81
Other drug use	0.86 (0.78-0.96)	0.007	0.94 (0.84-1.05)	0.26
Diabetes	1.24 (0.95-1.62)	0.11	1.04 (0.78-1.38)	0.81
Hypertension	1.28 (1.12-1.47)	< 0.001	1.09 (0.94-1.28)	0.26
Cancer	1.51 (1.08-2.11)	0.02	1.20 (0.83-1.74)	0.34
Antihypertensives[a]	0.91 (0.81-1.02)	0.10	0.88 (0.77-1.00)	0.05
Vasodilators[a]	0.90 (0.78-1.04)	0.16	0.94 (0.81-1.10)	0.46
Insulin[a]	0.88 (0.79-0.98)	0.01	0.84 (0.76-0.94)	0.002
Heparin	0.86 (0.71-1.04)	0.13	0.85 (0.70-1.04)	0.12
Preservative Solution				
University of Wisconsin Solution	reference		reference	
cardioplege	1.17 (1.02-1.34)	0.03	1.17 (1.01-1.35)	0.04
Celsior	1.18 (1.04-1.33)	0.01	1.21 (1.06-1.38)	0.004
Custodiol	1.09 (0.86-1.39)	0.48	1.15 (0.90-1.48)	0.27
Other	0.94 (0.80-1.11)	0.50	0.95 (0.80-1.13)	0.57

Abbreviations: BMI=body mass index, CNS=central nervous system, CVA=cerebrovascular accident, LVEF=left ventricular ejection fraction

[a] within 24 hours of procurement