Use of two recipient lists for adults requiring heart transplantation

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See related editorial on page 23

Objective: An alternate (second) adult recipient list was used to match excluded potential recipients with nonstandard donor hearts that would otherwise be unused.

Methods: The only absolute criterion for entering the alternate recipient list was age: 65 years old before 1998 and 70 years old after that. Group I consisted of alternates who underwent transplantation, and group II consisted of 401 contemporaneous recipients. Hearts were first offered to regularly listed patients. At least one of the following donor risks accounted for allocation to an alternate: coronary artery disease, reused transplanted heart, high-risk behavior, hepatitis seropositivity, decreased left ventricular ejection fraction, high inotropic requirement, left ventricular hypertrophy, age older than 55 years plus another risk, and small donor with no other matches.

Results: Of 102 alternates, 82 were listed were because of age. After a median wait of 107 days, 62 alternates underwent transplantation. Median alternate recipient age was 67 years (vs 54 years, $P < .001$). Median donor age was 45 years (vs 31 years, $P < .001$). Survival for alternates at 90 days was 82% (vs 91%, $P = .04$). Significant recipient predictors of early mortality on multivariable analysis ($n = 463$) were previous cardiac surgery (odds ratio 2.74, 95% confidence interval 1.37-5.48) and renal dysfunction (odds ratio 1.39, 1.10-176). Alternate listing did not independently predict early or late mortality. Late (>90 days) death rates per 1000 person-months were 4.3 and 3.6 for groups I and II (relative risk 1.2, 0.62-2.36).

Conclusions: Use of two adult recipient lists facilitated allocation of unused donor organs. Satisfactory long-term survival supports the use of an alternate recipient list.

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As wait times for heart transplant recipients increase, nonstandard donor hearts are being used for higher risk recipients and for status I (critically ill) patients, while older recipients are potentially not listed.¹⁻⁶ In such cases the risk/benefit ratio justifies such a donor while expanding the pool of available hearts. Despite this, as many as 40% of organs remain unused, prompting our program to create an alternate recipient list in 1992. Borderline recipients who otherwise would be excluded from transplantation were considered for the alternate list and,

once accepted, were educated as to the possible risk factors associated with the donor hearts that would be assigned to them.

Patients and Methods

Patients

This report includes all patients entered to December 1999. All those who have undergone transplantation have at least 1 year of follow-up. Age was the only absolute criterion for alternate recipient listing. Until 1998, age for placement on the alternate list was greater than 65 years. In 1998 this age was raised to 70 years. Since 1999, patients between 65 and 70 years have been offered the option of regular listing combined with alternate listing. Also included on the alternate list were patients with moderate renal insufficiency or peripheral vascular disease. Informed consent was obtained from all patients at the time of listing. The final consent to accept an organ was made after a discussion that included both the treating surgeon and the cardiologist. The use of two adult lists for heart transplantation was reviewed by our hospital ethics committee.

Comparison Group

Alternates who underwent transplantation (group I) were compared with 401 consecutive patients (≥ 12 years old) who could have accepted the donor hearts by virtue of size (group II). This contemporaneous cohort underwent heart transplantation according to the criteria delineated in the 24th Bethesda Conference.⁷ Urgent priority (status I) was not offered to alternate recipients so that they would not be competing for organs with regularly listed patients. Outpatient assist device placement was, however, permitted.

Donor Heart Allocation

Donor hearts were considered nonstandard as outlined in Appendix Table 1.⁸ These were first offered by third-party organ procurement organizations to regularly listed patients according to United Network for Organ Sharing geographic allocation guidelines. Nonstandard hearts were used by us or others for regularly listed patients, usually waiting as status I. If the heart was refused by us (for example, if it was hepatitis C seropositive and the recipient was young or refused such a donor), then we instructed the organ procurement organization to call us back if the heart remained unused. We then considered the organ for alternate recipients.³

Preservation

Preservation solution consisted of University of Wisconsin solution.⁹ Reperfusion consisted of leukocyte-depleted, aspartate- and glutamate-enriched, warm blood cardioplegia (Buckberg solution) for 3 to 4 minutes, followed by leukocyte-depleted blood (8 minutes). Separate anastomoses of the superior and inferior venae cavae were used for the right atrium.¹⁰

Immunosuppression and Prevention of Infection

Methylprednisolone (7 mg/kg) was given on reperfusion, on separation from cardiopulmonary bypass, and at a dose of 125 mg every 12 hours for three doses. Cyclosporine was administered

with the aim of achieving a level of 250 ng/mL. Azathioprine was administered at 2 mg/kg and at half dose for older recipients (unusually >65 years old) not exhibiting rejection. Prednisone was initiated at 1 mg/(kg $\times$ d) and tapered to 0.1 mg/(kg $\times$ d) during the course of 3 months.¹¹ For those patients with few rejections, complete weaning from steroids was attempted. Since July 1994, all patients have received pravastatin after the operation. Older recipients (>65 years old) showing absence of rejection were targeted for lower cyclosporine levels (by 10%-20%).

In case of cytomegalovirus positivity in either the donor or recipient, ganciclovir was administered intravenously for 2 weeks at a dose of 2.5 to 5.0 mg/(kg $\times$ d), adjusted for renal function. This was followed by per os administration for 3 months at a dose of 1 to 3 g/d. This was extended for an additional 3 months if rejection (and treatment) or chronic illness occurred. Double-strength trimethoprim-sulfamethoxazole tablets (160-800 mg) were administered twice daily 2 days per week for 6 months. An additional 6-months course was repeated if patients had been treated for rejection during the 6 months before planned cessation. Clotrimazole (10 mg) was administered as a lozenge three times daily for 3 months and extended in the case of treatment for rejection. Beyond 6 months after the operation, influenza vaccination was recommended for patients who exhibited a low risk of rejection.

Statistical Methods

Analysis was performed with Excel 97 (Microsoft Corp, Redmond, Wash), SPSS 8.0 (SPSS Inc, Chicago, Ill), and STATA (Stata Corporation, College Station, Tex). Averages were compared with the Student *t* test, and proportions were compared with the Pearson χ^2 . Kaplan-Meier analysis with log rank test was used for survival and freedom from graft coronary artery disease (CAD). *P* values were calculated with the Wilcoxon rank-sum test for continuous variables and the Fisher exact test for categorical variables.

Regression models were used to study covariates (Appendix Table 2A), including the designation of alternate recipient. Early and late mortality and graft CAD-free survival for all patients ($n = 463$) were analyzed; 95% confidence intervals (CIs) are shown when available. A separate analysis was used to study early mortality among alternate list patients only ($n = 62$). Selection models were used on a backward-stepping algorithm with P_{remove} of .15 and P_{enter} of .10. The global test of proportional hazard assumptions (for Cox regression analysis of long-term outcome) was based on Schoenfeld residuals. Plots of natural log of survival for categories of the selected independent variables versus natural log of time did not show gross violations regarding proportionality assumptions.

Results

Listed Patients

One hundred two alternate recipients aged 34 to 74 years were listed (Table 1). Of those listed, 82 were on the alternate list for advanced age alone. More than half had ischemic cardiomyopathy, and 84% were male. Median maximum oxygen consumption was 12.4 mL/(kg $\times$ min). Sixty-two alternates underwent heart transplantation to De-

TABLE 1. Reasons for listing as alternate recipient (n = 102)

Reason	No.
Age alone	82
Retransplantation in combination	
Renal insufficiency*	7
Age	2
Peripheral vascular disease	1
Obesity†	1
Other risk factors	
Obesity†	4
Peripheral vascular disease	2
Renal dysfunction	1
Jehovah's Witness	1
Chagas disease	1

*Renal insufficiency according to criterion of serum creatinine level greater than 2.2 mg/dL.

†Obesity considered to be body mass index greater than 30 kg/m².

cember 1999. Four patients were removed from the list for malignancy, and 10 died while waiting. Two patients received an electric HeartMate (Thoratec Corporation (Pleasanton, Calif.)) assist device; both were discharged. One has died, and 1 continues to wait. Neither was listed status I at any time.

Donors

From July 1992 to 1999, our institution accepted 182 non-standard donor hearts. Of these, 120 went to regular list patients and 62 were allocated to alternates. The median donor age for transplanted alternates was 45 years, compared with 31 among regularly listed transplant recipients ($P < .001$). Median donor/recipient height ratios were comparable for both groups (1.01 vs 1.01, $P = .64$). Donors allocated to alternate recipients more often had atraumatic intracranial bleeding (aICB) as a cause of death (50% vs 31%, $P = .006$). Of the 62 alternates, 25 came from local area, defined as a travel time of less than 60 minutes by any mode of transportation. Median graft ischemia time was significantly longer for alternates (197 minutes vs 181 minutes, $P = .003$). The most common donor risks for alternates were high inotrope requirement, left ventricular hypertrophy (LVH), CAD, or hepatitis C seropositivity (Table 2).

Recipients

Recipients for the alternate and comparison groups are summarized in Table 3. Alternates were older and more frequently had undergone previous cardiac surgery. They also had decreased renal function relative to the others. Alternate recipients had shorter waiting times than did status II regular list patients (107 vs 158 days, $P = .04$). Four alternates were 65 years old, and 6 were less than 60 years old. Thirty-seven were aged 65 to 70 years old, and 15 were

TABLE 2. Risk factors for nonstandard donor hearts initially refused by our program and other institutions and subsequently allocated to alternate recipients (n = 62)

Risk factor*	No.
High inotropic requirement	
Isolated	6
High inotropic requirement plus substance abuse	2
High inotropic requirement plus recent cardiac arrest	2
LVH	
Isolated	6
LVH plus high inotropic requirement	2
LVH plus hepatitis C	1
CAD	
Isolated	7
CAD plus high inotropic requirement	1
CAD plus LVH	5
CAD plus hepatitis C seropositivity	2
Hepatitis C seropositivity (isolated)	7
Chest trauma with myocardial contusion	5
Smaller donor, no other matches	4
Age > 45 y, coronary angiogram not available	4
Extensive intravenous drug abuse with seronegativity for HIV	3
Reused donor heart†	2
Older age, long ischemia (515 min)	1
Older age, hepatitis C-seropositive spouse	1
Hepatitis B, anti-hepatitis B core antigen (immunoglobulin G) positive (immunoglobulin M unknown)	1

*Definitions and abbreviations per Appendix Table 1.

†Perioperative massive cerebrovascular accident in recipient.

older than 70 years. The oldest recipient was 74 years old. During the study period, the number of alternate recipient transplants increased as much as 14 per year, shadowing an increase in the number of newly listed alternates (Figure 1). During the same period our program's volume increased from 60 to 70 patients/y to 90 to 1000 patients/y. In 1998, when age for inclusion on the alternate list was raised from 65 to 70, the number of newly listed alternates decreased by 39%, and we observed a parallel decrease in the number of transplantations among patients on the alternate list. In the comparison group, 229 of 401 recipients (57%) were status I. Of these 229 patients, 51% received non-standard donor hearts. One percent of those in the comparison group who were status II received a nonstandard heart. This was due to previous knowledge of borderline stability and virtually class IV symptoms but not requiring intravenous inotropes. Twenty-four patients (of 401) in the comparison group were on a ventricular assist device; 3 patients among the 62 alternates were receiving continuous intravenous inotropic infusions.

Survival

Three alternates who received hearts with LVH, CAD, and long distance (heart coming from outside our local area) died from graft failure. Five others died of recipient risk

TABLE 3. Transplanted recipient characteristics

Characteristic	Alternates (n = 62)	Regular (n = 401)	P value
Patient demographic variables			
Age (y, median and interquartile interval)	67 (3)	54 (17)	<.001
Gender (% male)	79%	72%	.28
Previous cardiac surgery	64%	47%	.01
Retransplantation	14%	4%	.004
Serum creatinine (mg/dL, median and interquartile interval)	1.5 (0.8)	1.3 (0.7)	.01
Diagnosis			
Ischemic cardiomyopathy	60%	45%	.04
Dilated cardiomyopathy	21%	33%	.08
Graft CAD	14%	3%	<.001
Congenital heart disease	0	3%	.99
Valvular cardiomyopathy	2%	4%	.71
Viral cardiomyopathy	2%	3%	.99
Postpartum cardiomyopathy	0	2%	.6
Other*	2%	8%	.11
Median wait (d, interquartile interval)			
Status 1 at time of transplant	-	29 (112)	
Status 2	107 (211)	158 (294)	.04
Overall	107 (211)	60 (228)	.11

P values were calculated with Wilcoxon rank-sum test for continuous variables and Fisher exact test for categorical variables.

*Other diagnoses included hypertrophic cardiomyopathy (n = 3), alcoholic cardiomyopathy (n = 2), doxorubicin-induced cardiomyopathy (n = 3), acute rejection (n = 1), restrictive cardiomyopathy (n = 1), and Marfan syndrome (n = 1).

factors: 2 from stroke and 3 from multisystem organ failure. There were 11 in-hospital deaths, translating into a 90-day survival of 82%. In contrast, the comparison group had survival of 91% ($P = .04$) at 90 days. Causes of death are listed in Appendix Table 3.

Median follow-up time for all 463 patients in this study was 3.25 years. As of June 2001, a total of 13 alternates had follow-up beyond 4 years; 12 are still alive. Death rates per 1000 person-mo were 9.0 for alternate recipients and 5.8 for the comparison group. Overall 4-year survival was 68% (vs 77%, relative risk 1.55, 95% CI 0.96-2.48, $P = .11$; Figure 2, left). Beyond 90 days, death rate per 1000 person-mo was 4.3 for alternates (vs 3.6, relative risk 1.2; 95% CI 0.62-2.36, $P = .77$; Figure 2, right).

Graft Coronary Artery Disease and Rejection

Eleven donor hearts required revascularization (average 1.8 vessels), 10 with bypass grafting and 1 with angioplasty. Patency of grafts at last follow-up was 63%. As stated previously, there were 3 early deaths among these patients. Four other donor hearts also had evidence of CAD but did not require revascularization. Including these 15 recipients, 4-year freedom from any CAD was 67% (vs 78% for others, relative risk 1.94; 95% CI 1.10-3.43, $P = .04$). Excluding them, freedom from graft CAD was 76% for both groups. Freedom from grade III rejection at 1 year was 90% (vs 70% for regularly listed transplant recipients, $P = .001$).¹¹ Eight alternates had one episode each of at least grade III or presumed rejection.¹¹ Freedom from rejection at 1 year was

90% (vs 70% for regularly listed transplant recipients, $P = .001$).

Multivariable Analyses

Survival at Less Than 90 Days (Groups I and II Combined, n = 463) Recipient previous cardiac surgery and poor renal function were risk factors for early mortality. Odds ratios were 2.74 (95% CI 1.37-5.48) and 1.39 (95% CI 1.10-1.76). Donor death from aICB was also found to be a risk factor (odds ratio 2.84, 95% CI 1.51-5.34). Goodness-of-fit χ^2 in the selection model had a P value of .54. Odds ratio for alternate listing was 1.36 (95% CI 0.53-3.5; Appendix Table 2B).

Late Survival Longer Than 90 Days (Groups I and II Combined, n = 463) Donor age and long graft ischemia time were slight but significant risks. Hazard ratios for these were 1.30 (95% CI 1.02-1.65) and 1.28 (95% CI 1.05-1.55). Global test of proportional hazards in this selection model had a P value of .84. Hazard ratio for alternate listing was 0.85 (95% CI 0.35-2.03). P value for the selection model was .003 (Appendix Table 2C).

Graft Coronary Artery Disease (Groups I and II Combined, n = 463) The only significant predictor of graft CAD was donor age both by linear (hazard ratio 1.58, 95% CI 1.23-2.04) and quadratic analyses (hazard ratio 1.43, 95% CI 1.15-1.77). P value for the global test of proportional hazards for this late-occurring event was .10. P value for the selection model was < .001 (Appendix Table 2D).

Figure 1. Listed and transplanted alternate recipients.

Early Mortality Among Alternate List Patients (Group I only, $n = 62$) Only donor cause of death as aICB was predictive of early mortality for alternate recipients (odds ratio 9.68; 95% CI 1.59-58.9). Goodness-of-fit χ^2 P value for this model was .24. None of the recipient risk factors tested were found to be significant (Appendix Table 2E).

Discussion

Bridging the gap between organ supply and demand in heart transplantation may involve limiting the number of listed recipients to maintain or reduce demand. As the number of older recipients increases disproportionately, another way is to limit a shift in the status quo by ensuring that younger organs are prioritized for younger recipients.²⁻⁴ Such strategies are currently applied at the two extremes of life; organs from donors younger than 19 years old are prioritized to those of similar age, whereas many programs set age limits for enrollment. These broad guidelines do not address the difference between a 20- and a 70-year-old recipient.

Increasing supply involves extending the margins of what is considered acceptable and has led to the widely used term *marginal donor*.^{5,6} Many extracardiac and cardiac factors may qualify a donor as marginal; this is constantly being updated. The term *nonstandard* seems appropriate, because the only donor criteria on which the transplant community generally agree are the ideal criteria. These are age of 45 to 55 years, normal cardiac anatomy and function, and negative results of serologic studies. Ischemia times longer than 300 minutes are also generally accepted, but few opportunities exist to go up to the 500-minute mark.¹²

Central to the use of nonstandard donors is allocation, defined as to apportion for a specific purpose or to particular persons.¹³ United Network for Organ Sharing guidelines have acknowledged the fact that not all needs are the same. Some recipients are listed on a more urgent basis than others, and this can change. Given the choice between an assist device and a hepatitis C-seropositive nonstandard donor, one might allocate such a potentially higher risk donor heart to a patient in whom the excess risk is justified (for example, an older patient with previous cardiac surgery). Nonstandard organs would not necessarily be allocated to a much younger recipient who is not in extremis.¹⁴ This also depends on the circumstances leading to the organs being nonstandard. Thus the concept of matching donor and recipient risk remains fluid and is adjusted for each individual.

What if there are no available recipients for a nonstandard donor? About a third of such donor organs offered to our program cannot be allocated, and therefore a strategy to offer these unused organs to patients who would otherwise not be offered transplantation (mostly because of age) was developed. The current single list system for adult recipients does not formalize this concept. We informed these patients about the risks involved in using such donor organs and explained that they are usually turned down or used only for certain status I patients. We observed that we could decrease the number of unallocated organs and use them for a specific group of the potential recipient pool. Median age for alternate recipients was 67 years, compared with 54 years for regular list patients. The comparison group comprised

Figure 2. Actuarial survivals of alternate and regular list heart transplant recipients.

all patients that could have potentially used the donor hearts allocated to the alternates by virtue of size.

We found that between 1992 and 1999 a third of non-standard organs accepted by our program went to alternates. This demonstrates that most are being used selectively in regularly listed recipients in whom the added risk is justified.^{8,15,16} Older donors allocated for the alternate list in this study were always associated with another risk, including no coronary angiogram available, CAD, or long distance. Among the 62 alternates, 6 received hearts from donors older than 45 years old. In this study older donor age slightly influenced late mortality, as did longer ischemia. The quadratic effect of donor age on graft CAD may be explained by a previous observation that early mortality is increased for the donor age range of 35 to 55 years, reflecting a more cautious selection bias when using older donors.¹⁷

Our preservation method was adapted to retrieve higher risk hearts from outside our local area. Alternate recipients had longer mean graft ischemia times. We also observed that the hearts used for alternates came from donors who more often had died of aICB. This was a risk factor on multivariable analysis of groups I and II combined and an even stronger risk when only the alternates were analyzed. This has been noted to be a sensitive but not specific marker for both short- and long-term mortalities and is probably a surrogate for undetected left ventricular hypertrophy.¹⁸

Alternates who underwent transplantation were older than regular list recipients and more frequently had ischemic cardiomyopathy. These findings suggest less end-organ reserve and higher risk. The significantly increased 90-day mortality for alternates was explained by the observation that the risk factors for early mortality in this study were previous cardiac surgery, poor renal function, and donor death from aICB. This increased risk (18% vs 9%) supports keeping these patients on a separate list with consent in advance. Alternates were able to benefit from the shorter waiting times relative to status II patients on the regular list (median 107 vs 158 days).

On the basis of our early results, the age for alternate listing was raised from 65 to 70 years in 1998, according to the reasoning that heart transplants in those older than 65 years was feasible and should not be withheld. The number of alternates newly listed and undergoing transplantation decreased, perhaps reflecting the fact that the current number of patients older than 70 years who require heart transplantation and are acceptable surgical candidates is low. Shorter waiting times were also noted. This led to our current policy of offering both alternate and regular listing for patients older than 65 years. Alternate listing only is offered to those older than 70 years.

Three of the early deaths were associated with donor CAD, LVH, and long distance from the center; we no longer consider organs with such a triple combination of risk

factors. Individually, donor hearts with these risk factors are allocated to status I or alternate recipients (CAD) and to smaller size status I or alternates (LVH). Long distance aggravates LVH.⁸ Other deaths were from multisystem organ failure related to recipient risk factors in combination with generally higher risk donors. Three had renal insufficiency as well as representing retransplantation. One patient who died of volvulus illustrates the pathologic features specific to aging. Multivariable analysis of the factors affecting early mortality specifically in alternates alone did not show any recipient trends. After 90 days the death rates for both groups were comparable. On the basis of preoperative maximal oxygen consumption, this current survival is better than that which would be expected if these patients did not undergo transplantation.¹⁹ A separate report on quality of life among these generally older recipients is needed to better define this benefit.

Freedom from rejection for alternates within the first year was 90%, versus 70% for those on the regular list. This lower rejection rate was probably due to immunosenescence in older patients, which permits a reduced immunosuppression in these patients. All recipients in our institution are started on cholesterol-lowering therapy.^{20,21} Alternate recipients did not have increased graft CAD, after those receiving hearts with preexisting disease were excluded. To date, the longest survival of a revascularized donor heart is more than 7 years. Donor CAD appeared to be a risk factor for early graft failure when combined with other factors that aggravated ischemic insult but not independently when selectively used.

Alternate recipients currently account for about 10% of our program's yearly transplants. This model may provide a partial solution for the current increased waiting times for heart transplantation and the growing number of older recipients. Such a strategy might be complemented by destination therapy with mechanical devices should these alternately listed patients require continuous inotropic support.

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Appendix TABLE 1. Nonstandard donor criteria

Risk factor	Nonstandard donors* (%)	Definition
Cardiac		
CAD	5	Any coronary artery stenosis evident on coronary angiogram or greater than mild calcified plaque
Age >45 y, coronary angiogram not available	2	Normal function on echocardiogram
LVH by electrocardiographic criteria	2	Abnormal R wave on electrocardiogram in V ₅ and V ₆
LVH by echocardiogram	15	Posterior wall thickness ≥ 14 mm (at least moderate)
Low left ventricular ejection fraction	9	<50% on echocardiogram
High-dose inotropic requirement	1	1 inotrope at maximal dose or 2 inotropes at greater than half maximal dose (dopamine and dobutamine maximal dose 20 $\mu\text{g}/[\text{kg} \cdot \text{min}]$)
Suspected myocardial contusion secondary to chest trauma	21	Significant anterior blunt chest injury with right ventricular or septal wall motion abnormality on echocardiogram
Recent cardiac arrest requiring advanced cardiac life support	15	Organ retrieved less than 24 h after cardiac arrest
Reused donor heart	1	Perioperative cerebrovascular accident in heart transplantation leading to brain death and organ donation
Noncardiac		
Older age	17	Age >55 y
Hepatitis B seropositivity	1	Immunoglobulin G core antibody positive; immunoglobulin M unknown
Hepatitis C seropositivity	11	Positive antibody titer

*Figures represent percentages of all nonstandard donors (1992-1999, n = 182); 62 of these were allocated to alternates.

Appendix TABLE 2A. Covariates used in the multivariable analysis

Covariate	Notes
Recipients	
Alternate list patient	As defined in this study
Recipient male	
Recipient age (standard units = 52 ± 15 y)	In years
Previous cardiac surgery	Any
Retransplantation	Retransplantation because of chronic graft CAD
Renal function (standard units = 1.5 ± 0.8 mg/dL)	Serum creatinine
Donors	
Donor male	
Donor age (standard units = 33 ± 14 y)	In years
Donor death from aICB	Atraumatic
Graft ischemia time (standard units = 193 ± 67)	In minutes
Donor history of CAD	See Appendix Table 1
Donor LVH	Electrocardiographic or echocardiographic criteria (Appendix Table 1)

Appendix TABLE 2B. Early mortality (n = 463)

Logistic regression covariate	Full model ($P < .001$)		Selection model ($P < .001$)	
	Odds ratio	95% CI	Odds ratio	95% CI
Alternate list patients	1.36	0.53-3.50		
Recipient male	0.67	0.30-1.48		
Recipient age	0.98	0.67-1.43		
Previous cardiac surgery	2.70	1.28-5.68	2.74	1.37-5.48
Retransplantation	1.63	0.53-5.00		
Renal function (serum creatinine, standard units = 1.5 ± 0.8 mg/dL)	1.39	1.08-1.79	1.39	1.10-1.76
Donor male	0.85	0.40-1.78		
Donor age (standard units = 33 ± 14 y)	1.06	0.71-1.59		
Donor death from aICB	2.42	1.08-5.40	2.84	1.51-5.34
Graft ischemia time (standard units = 193 ± 67 min)	1.20	0.90-1.59		
Donor history of CAD	0.88	0.15-5.13		
Donor LVH	1.52	0.58-3.95		
Goodness-of-fit χ^2 P value	.49		.54	

Appendix TABLE 2C. Late mortality (n = 463)

Cox regression covariate	Full model ($P = .04$)		Selection model ($P = .003$)	
	Hazard ratio	95% CI	Hazard ratio	95% CI
Alternate list patients	0.85	0.35-2.03		
Recipient male	1.33	0.70-2.53		
Recipient age (standard units = 52 ± 15 y)	0.82	0.63-1.07		
Previous cardiac surgery	1.19	0.70-2.01		
Retransplantation	1.74	0.66-4.59		
Renal function (serum creatinine, standard units = 1.5 ± 0.8 mg/dL)	1.14	0.91-1.43		
Donor male	0.80	0.45-1.43		
Donor age (standard units = 33 ± 14 y)	1.43	1.05-1.95	1.30	1.02-1.66
Donor death from aICB	0.81	0.44-1.50		
Graft ischemia time (standard units = 193 ± 67 min)	1.32	1.07-1.64	1.28	1.05-1.55
Donor history of CAD	1.11	0.27-4.50		
Donor LVH	0.56	0.21-1.52		
Global test of proportional hazards P value	.56		.84	

Appendix TABLE 2D. Graft CAD-free graft survival (n = 463)

Cox regression covariate	Full model ($P < .001$)		Selection model ($P < .001$)	
	Hazard ratio	95% CI	Hazard ratio	95% CI
Alternate list patients	1.45	0.65-3.26		
Recipient male	0.89	0.50-1.59		
Recipient age (standard units = 52 ± 15 y)	0.86	0.57-1.30		
Previous cardiac surgery	0.98	0.58-1.66		
Retransplantation	2.15	0.75-6.17		
Renal function (serum creatinine, standard units = 1.5 ± 0.8 mg/dL)	1.01	0.78-1.32		
Donor male	1.56	0.87-2.79		
Donor age (standard units = 33 ± 14 y)				
Linear	1.45	1.08-1.96	1.58	1.23-2.04
Quadratic	1.40	1.82-1.26	1.43	1.15-1.77
Donor death from aICB	1.26	0.71-2.24		
Graft ischemia time (standard units = 193 ± 67)	0.98	0.76-1.27		
Donor history of CAD	1.26	0.40-3.99		
Donor LVH	1.10	0.53-2.28		
Global test proportional hazards P value	.43		.1	

Appendix TABLE 2E. Early mortality among alternate list recipients (n = 62)

Logistic regression covariate	Full model ($P = .09$)		Selection model ($P = .002$)	
	Odds ratio	95% CI	Odds ratio	95% CI
Recipient age (standard units = 52 ± 15 y)	0.37	0.04-3.58		
Previous cardiac surgery	1.54	0.22-11.0		
Retransplantation	0.21	0.00-11.0		
Renal function (serum creatinine, standard units = 1.5 ± 0.8 mg/dL)	1.27	0.40-4.00		
Donor male	3.88	0.52-29.0		
Donor age (standard units = 33 ± 14 y)	0.82	0.28-2.36		
Donor death from aICB	8.22	0.93-72.8	9.68	1.59-58.9
Graft ischemia time (standard units = 193 ± 67)	1.76	0.85-3.63		
Donor history of CAD	1.47	0.16-13.6		
Donor LVH	1.46	0.22-9.67		
Goodness-of-fit χ^2 P value	.23		.24	

Appendix TABLE 3. Patient deaths

Cause of death	Alternates (n = 62)	Regular (n = 401)	P value
All deaths	21	93	
<90 d after operation			.97
Graft failure	3	7	
Infection	2	6	
Rejection	1	5	
Multisystem organ failure	3	12	
Cerebrovascular accident	2	4	
Other	0	2	
Total	11	36	
90-d actuarial survival	82%	91%	
90 d-1 y after operation			.88
Infection	0	2	
Rejection	1	6	
Graft CAD	0	4	
Multisystem organ failure	1*	4	
Cerebrovascular accident	0	2	
Other	0	1	
Not stated	0	2	
Total	3	21	
1-y actuarial survival	77%	86%	
>1 y after operation			.36
Graft failure	0	1	
Infection	0	4	
Rejection	0	4	
Graft CAD	2	7	
Multisystem organ failure	2	3	
Cerebrovascular accident	0	1	
Cancer	1	1	
Pulmonary embolism	1	1	
Other	0	7	
Not stated	1	7	
Total	7	36	

P values testing the equality of distributions of deaths between the two groups were calculated by Fisher exact test for categorical variables.

*Sigmoid volvulus.

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