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CARDIAC TRANSPLANTATION FOR OLDER PATIENTS: CHARACTERISTICS AND OUTCOMES IN THE SEPTUAGENARIAN POPULATION

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Abstract

Introduction—With increasing age of the heart failure population, it is important to understand the potential role for orthotopic heart transplant (OHT) in the elderly. We examined recipient and donor characteristics and long-term outcomes of older OHT recipients in the US.

Methods—Using the United Network for Organ Sharing (UNOS) database, we identified OHT recipients from 1987–2014 and stratified them by age 18–59, 60–69, and ≥70. We compared baseline characteristics of recipients and donors, and assessed outcomes across groups.

Results—During this period, 50,432 patients underwent OHT; 71.8% (N=36,190) were 18–59yo, 26.8% (N=13,527) were 60–69yo, and 1.4% (N=715) were ≥70yo. Comparing the ≥70yo and 60–69yo groups, older patients had higher rates of ischemic etiology (53.6% vs 44.9%) and baseline renal dysfunction (61.4% vs 56.4%), and at the time of OHT were less likely to be currently hospitalized (45.0% vs. 50.9%) or supported with LVAD therapy (21.0% vs. 28.3%). Older recipients received organs from older donors (median age 36 vs. 30) who were more likely to have diabetes and substance use. After OHT, the median length of stay was similar between groups. At one year, of patients alive, those ≥70yo had fewer rejection episodes (17.8%) compared to those 60–69yo (29.5%). Five-year mortality was 26.9% for recipients age 18–59, 29.3% for age 60–69, and 30.8% for age ≥70.

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Conclusions—Despite advanced age and less ideal donors, OHT recipients in their seventies had similar outcomes to recipients in their sixties and selected older should not routinely be excluded from consideration for OHT.

Introduction

The risk of heart failure increases with age.¹ As the prevalence of older patients with heart failure grows, the potential role for orthotopic heart transplant (OHT) in elderly patients requires further evaluation. Historically, heart transplant was only offered to younger patients without significant comorbidities. Prior guidelines suggested that while patients older than age 50 could be considered for transplantation, the risk of adverse outcomes could be higher with increasing age.² While patients in their sixties were routinely evaluated for transplant, until recently septuagenarian patients were considered too old for transplant.

In 2006, however, the International Society for Heart and Lung Transplant (ISHLT) issued updated guidelines on patient selection for heart transplantation which included consideration of adults into their seventies.³ In the United States, transplantation of older adults is increasingly performed, but limited contemporary data exist regarding outcomes for elderly patients.⁴⁻⁸ To evaluate transplantation in older adults, we used data from the United Network for Organ Sharing (UNOS) to analyze the demographics and outcomes of patients 70 years of age compared with patients 60-69 years of age and 18-59 years of age at the time of cardiac transplant.

Methods

Data collection and Study population

This was a retrospective cohort study utilizing transplant data from the Organ Procurement and Transplant Network (OPTN) Standard Transplant Analysis and Research database provided by UNOS. This is a comprehensive database that includes information on all patients who underwent cardiac transplantation in the United States, and the donors whose organs were received by those recipients.⁹⁻¹¹ The study population consisted of adult patients (≥ 18 years old) who underwent a primary or re-do heart transplantation between January 1, 1987 and March 31, 2014. Patients who underwent combined heart-lung transplant were excluded from this analysis. The Duke University Institutional Review Board approved this study.

Outcomes

The primary outcome was 5-year mortality. Other outcomes of interest included length of hospital stay after transplant, episodes of graft rejection, and hospitalizations in the first post-transplant year, and 1-year and 5-year renal dysfunction, stroke, and lymphoproliferative disease. Graft rejection was defined as an episode of rejection requiring medical treatment.¹² Renal dysfunction was defined as the need for chronic dialysis.

Statistical analyses

We identified all adult patients who underwent OHT from January 1, 1987 through March 31, 2014, and stratified them into three groups based on age at the time of transplant: 18-59 years old, 60-69 years old, and ≥70 years old. These age groups have been used in prior analyses, and mirror the changes in ISHLT recommendations over time.^{2,3,5-9} We calculated the frequency of heart transplants by age group for each year. Baseline characteristics of transplant recipients were described using means and standard deviations or medians and interquartile ranges for continuous variables and frequencies and percentages for categorical variables. Variables were compared across groups using the Kruskal-Wallis test for continuous variables and Pearson's chi-square or Fisher's exact test for categorical variables. Donor characteristics were described and compared using similar methods. In addition, 1 and 5 year outcomes were measured and differences in groups were calculated using the chi-square rank based group means score statistics. Kaplan-Meier methods were used to estimate survival. Survival was compared across groups using the log-rank test.

Multivariable proportional hazards regression models were used to estimate the association between age groups and 5-year mortality among heart transplant patients. Outcomes were adjusted for select baseline characteristics of transplant recipient and donor, chosen a priori based on prior studies and clinical relevance.^{8-10,13,14} Single imputation was used for missing values. Missing values for continuous variables were imputed to the median, and missing values for categorical variables were imputed to the most frequent category. Two models were created, one using the study period from 1995 to 2014, and the other using a more recent cohort from 2004 through 2014 to account for variables not collected prior to 2004, specifically left ventricular assist device (LVAD) use and Centers for Disease Control (CDC) high risk donor status.

Results

Based on OPTN data as of June 6, 2014, from January 1987 through March 2014, 50,432 patients underwent OHT in the United States, of which 71.8% (N=36,190) were 18-59 years old, 26.8% (N=13,527) were 60-69 years old, and 1.4% (N=715) were ≥70 years old. The median age of heart transplant recipients in the oldest cohort was 71 years old and the maximum age was 79 years old. While the total number of heart transplants performed each year has remained relatively stable over time, the number of heart transplant recipients in their seventies has increased, most notably after 2006 (Figure 1a/1b). Table 1 shows the baseline characteristic of heart transplant recipients by age group. Across all ages, the majority of patients were White and male. Comparing the ≥70 year old group to the 60-69 year old and 18-59 year old group, the oldest group had highest rates of type II diabetes (16.3% vs. 14.9% vs. 8.1%) and chronic kidney disease (CKD) stage ≥3 (61.4% vs 56.4% vs 35.1%). More than half (52.4%) of recipients in their seventies had a history of CABG. At the time of OHT, the oldest patient group was the least likely to be currently hospitalized (≥70 yo: 45.0% vs. 60-69 yo: 50.9% vs. 18-59 yo: 54.5%) or supported with an LVAD (21.0% vs 28.3% vs 28.6%).

Table 2 reports characteristics of organ donors. Recipients aged ≥70 received organs from older donors (median donor age 36 [25th, 75th: 23, 48]) compared with recipients aged 60-69

(median donor age 30 [21, 43]) and those aged 18-59 (median donor age 28 [20, 39]). Recipients aged ≥ 70 were the most likely to receive organs from donors considered high risk for transmission of disease, as defined by the CDC, due to history of hemophilia, high-risk sexual behaviors, intravenous drug use, or incarceration. Furthermore, donors for older recipients were more likely have a history of tobacco, alcohol, and cocaine use. Across all groups, donors most commonly died from head trauma, but donors for the oldest recipients were comparatively more likely to die from stroke vs. donors for the 60-69 year old age group and the 18-59 year old age group (30.9% vs 27.5% vs 24.6%). Donors for older recipients also had longer ischemic times (3.2 hours [25th, 75th: 2.5, 3.9]) than donors for younger recipients (3.0 hours [2.3, 3.7] for those 60-69 yo and 2.9 [2.2, 3.6] for those 18-59 yo).

After OHT, the median length of stay was 15 days (25th, 75th: 10, 23) for both the ≥ 70 and 60-69 year old groups, and 14 days (10, 21) for the <60 year old group (Table 3). Of patients alive at one year, patients ≥ 70 years old had lower rates of rejection episodes in the first year (17.8%) compared to patients 60-69 years old (29.5%) and <60 years old (38.2%). The oldest age group also had the fewest hospitalizations in the first year. Of patients alive at five years, rates of dialysis, stroke, and post-transplant lymphoproliferative disease were similar between groups.

Figure 2 presents 5-year mortality based on age group. Five year Kaplan-Meier estimated mortality rates were 30.8% (95% CI: 27.0-35.0%) in patients ≥ 70 years old, 29.3% (95% CI: 28.5-30.2%) in patients 60-69 years old, and 26.9% (95% CI: 26.4-27.4%) in adults < 60 years old. Overall, these three groups had different rates of survival ($p < 0.001$), but survival between the ≥ 70 year old group and the 60-69 year old group was not significantly different ($p = 0.48$).

Table 4a/4b presents unadjusted and adjusted association between age group and 5-year mortality for heart transplant recipients. Table 4a evaluates the association for the time period from April 1, 1995 to March 27, 2014, whereas Table 4b displays the association for the time period from June 30, 2004 to March 27, 2014. Adjusting for donor, recipient, and transplant procedure characteristics, for both time periods, compared to age 18-59, those age 60-69 and age ≥ 70 at the time of transplant had increased 5-year mortality. In adjusted analysis, for the 1995-2014 time period, patients age ≥ 70 had a higher risk of death compared to patients age 60-69 (HR 1.2, 95% CI 1.03, 1.41); however in the more recent time period, there was no difference in risk of mortality between the groups (HR 1.13, 95% CI 0.90, 1.41).

Discussion

We used data from the United Network for Organ Sharing to examine characteristics of heart transplant donors and recipients and post-transplant outcomes, stratified by transplant recipient age. The update of the ISHLT guidelines on heart transplantation ushered in an era of cardiac transplantation of older adults, including those age 70 and above. Over time, the frequency of transplantation in older adults has increased, and in 2013 almost 40% of heart transplants occurred in recipients aged 60 and older with over 4% of heart transplants

occurring in recipients age 70 and older. Almost 300 septuagenarians have been transplanted since 2010 when this population was last examined.⁶

Despite their advanced age, transplant recipients in their seventies had few chronic comorbidities, with the exception of CKD. Moreover, they were less acutely ill at the time of transplantation compared to younger transplant recipients as they were least likely to be hospitalized prior to transplantation. Furthermore, fewer patients in the oldest group were supported with LVAD therapy prior to transplantation. It has been shown that LVAD recipients age 70 and above have worse short-term and midterm survival, and higher rates of stroke and gastrointestinal bleeding after LVAD implantation.¹⁵ Despite these risks, the rate of LVAD as a bridge-to-transplant is increasing in this older population.⁶ Moreover, recent data suggest that transplant outcomes are worse in patients previously supported with either temporary or durable mechanical circulatory support devices compared to patients supported with inotropes only or with no circulatory support prior to transplant.^{9,13} This is particularly true when device-related complications require emergent transplantation to mitigate the ongoing risk of device support.¹⁶ Therefore, our findings highlight that appropriate patient selection is paramount when considering older patients for cardiac transplantation. It appears that current recipient selection strategies at centers that offer transplantation in this population exclude certain high risk groups, such as those with a prior LVAD.

To counter ethical concerns over the distribution of limited donor organs to an older population, transplant guidelines propose allocating organs through alternate donor programs. This practice involves utilization of organs that would traditionally not be accepted for donation or have been turned down by other centers due to donor or organ related factors.^{3,17} The criteria used for determining an alternate (or extended criteria) donor varies by transplant center, but have shown to effectively maximize the use of donor organs that otherwise would remain unused and therefore extend the option of transplantation to recipients who otherwise may not have been offered this treatment option.¹⁸⁻²⁴ Alternate donor use is not captured in the UNOS database, but our results show that older recipients receive organs from donors with older age, more comorbidities, and other high risk features, such as substance abuse. Furthermore, donors from older recipients had longer ischemic times, suggesting that transplant programs may accept donor organs from a greater distance for these patients.

Despite receiving organs from older and sicker donors and having longer ischemic times, transplant recipients in their seventies had comparable outcomes after transplant compared with younger recipients. Among patients alive at one year, they did not require longer post-transplant hospitalizations, and had fewer rejection episodes and rehospitalizations in the first year. While 5-year survival was lower in the oldest age group, in a contemporary cohort survival in the 70 year old group was not significantly different from survival in the 60-69 year old group. Our study shows comparable outcomes for patients in their sixties and seventies. Given that it is an increasingly common practice for sexagenarians to be considered for transplantation, our data suggest that older patients should not be routinely excluded from transplantation based on age alone. Select patients in their seventies, specifically those with few co-morbidities, may be appropriate candidates for this therapy.

Limitations

Our study has several limitations. This was a retrospective cohort study, so there is a possibility of unmeasured confounders. In addition, there was likely a selection bias in the study population that influenced the results, such that sicker older patients may not have been offered heart transplantation. Furthermore, we only included patients who underwent heart transplantation, so we did not assess survival and outcomes of patients on the heart transplant waiting list. In addition, as this study used data collected in a national registry, we are limited by the data available. Certain data elements were not collected for the entire study period, and there is a high degree of missingness for several outcome variables. In addition, we are limited by the quality, accuracy, and completeness of the data entered into the database. Furthermore, our study was unable to account for regional or center-specific variation in the care of patients before and after transplantation.

Future Research

Appropriate patient selection is a key for success in heart transplantation, and this may be especially true in older patients. Further studies should focus on identifying factors associated with favorable outcomes in older patients and ways to select the right patients to be offered this therapy. Furthermore, with the increase in destination-therapy LVAD in an older population, identifying which patients would be better suited for transplantation versus LVAD therapy could help inform clinical decision-making in the future. In addition, as transplantation of older adults becomes more common, future studies should examine longer-term outcomes in these patients.

Conclusions

Patients 70 years old selected for OHT were less acutely ill at the time of transplant and tended to receive organs from older donors with high-risk behaviors. Despite advanced age, these patients had comparatively similar outcomes to younger age groups. Select patients in their seventies should not routinely be excluded from consideration for OHT.

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Figure 1.

Frequency of Heart Transplantation from 1988 to 2013

Panel A shows the frequency of heart transplantation by age group from 1988 to 2013.

Panel B shows the frequency of heart transplantation for recipients ≥ 70 years of age from 1988 to 2013.

Figure 2.
Mortality Rates from Kaplan-Meier Estimates Among Heart Transplant Recipients by Age Group

Table 1
Baseline Characteristics of Heart Transplant Recipients

Variable	N	Age 18-59	N	Age 60-69	N	Age 70	P-value ¹
Characteristic							
Gender, Male, No (%)	36,190	27,030 (74.7)	13,527	11,178 (82.6)	715	644 (90.1)	<.001
Race, White, No (%)	36,163	26,860 (74.3)	13,522	11,359 (84.0)	715	623 (87.1)	<.001
Ischemic etiology, No (%)	36,189	8,449 (23.4)	13,526	6,067 (44.9)	715	383 (53.6)	<.001
Creatinine (mg/dL), median (25 th , 75 th) ²	24,866	1.2 (0.9, 1.5)	10,682	1.3 (1.0, 1.6)	665	1.3 (1.1, 1.6)	<.001
eGFR (ml/min per 1.73 m ²), median (25 th , 75 th) ²	24,864	68.4 (52.0, 88.0)	10,681	58.9 (45.0, 72.3)	665	56.9 (45.1, 69.6)	<.001
CKD stage 3, No (%) ²	24,864	8,714 (35.1)	10,681	6,022 (56.4)	665	408 (61.4)	<.001
Condition at time of transplant, No (%)	36,081		13,483		709		<.001
Not hospitalized		16,409 (45.5)		6,619 (49.1)		390 (55.0)	
Hospitalized, not in intensive care unit		5,187 (14.4)		1,884 (14.0)		96 (13.5)	
In intensive care unit		14,485 (40.2)		4,980 (36.9)		223 (31.5)	
History, No (%)							
Diabetes ²	25,788		11,100		688		<.001
Type II		2,085 (8.1)		1,650 (14.9)		112 (16.3)	
Type I		353 (1.4)		190 (1.7)		10 (1.5)	
Type Unknown		2,543 (9.9)		1,245 (11.2)		37 (5.4)	
Type Other		36 (0.1)		16 (0.1)		0	
Diabetes status unknown		335 (1.4)		142 (1.3)		12 (1.7)	
No		20,416 (79.2)		7,857 (70.8)		517 (75.2)	
Hypertension ³	16,787	5,871 (36.2)	6,502	2,729 (43.9)	279	110 (40.7)	<.001
Cerebrovascular disease ³	16,888	609 (3.6)	6,533	279 (4.3)	282	11 (3.9)	0.02
Peripheral vascular disease ³	16,833	509 (3.1)	6,524	297 (4.8)	280	11 (4.1)	<.001
Chronic obstructive pulmonary disease ³	16,913	454 (2.8)	6,548	286 (4.6)	281	7 (2.6)	<.001
Any prior malignancy ²	25,186	1,053 (4.2)	10,859	801 (7.4)	673	59 (8.8)	<.001
Prior cardiac surgery ⁴	2,606		1,341		105		
Coronary artery bypass grafting only		390 (15.0)		447 (33.3)		55 (52.4)	<.001
Valve replacement/repair only		164 (6.3)		84 (6.3)		5 (4.8)	
Other (including multiple surgeries)		2,052 (78.7)		810 (60.4)		45 (42.9)	
Life Support at time of transplant, No (%)							
Extra corporeal membrane oxygenation ⁵	24,301	143 (0.6)	10,592	39 (0.4)	681	3 (0.4)	0.01
Intra-aortic balloon pump	36,190	2,087 (5.8)	13,527	757 (5.6)	715	44 (6.2)	0.57
Prostaglandins ⁵	24,301	49 (0.2)	10,592	15 (0.1)	681	0	0.14
Intravenous inotropes ²	25,832	12,093 (46.8)	11,118	5,214 (46.9)	688	304 (44.2)	0.80
Inhaled Nitric Oxide	36,190	45 (0.1)	13,527	17 (0.1)	715	0	0.83

Variable	N	Age 18-59	N	Age 60-69	N	Age 70	P-value ¹
Ventilator	36,190	1,017 (2.8)	13,527	357 (2.6)	715	22 (3.1)	0.39
Ventricular assist device at time of transplant ⁴	11,557		5,623		461		<.001
Left ventricular assist device		3,302 (28.6)		1,593 (28.3)		97 (21.0)	
Right ventricular assist device		34 (0.3)		16 (0.3)		1 (0.2)	
Left + Right ventricular assist devices		489 (4.2)		109 (1.9)		7 (1.5)	
Total artificial heart		153 (1.3)		45 (0.8)		1 (0.2)	
None		7,579 (65.6)		3,860 (68.7)		355 (77.0)	

¹ P-values are based on chi-square rank based group means score statistics for all categorical row variables and chi-square 1 df rank correlation statistics for all continuous/ordinal row variables.

² Excludes patients registered before Apr 1, 1994

³ Excludes patients registered before Apr 1, 1994 and after Jan 1, 2007

⁴ Excludes patients registered before Jun 30, 2004

⁵ Excludes patients registered before Apr 1, 1995

Table 2
Characteristics of Organ Donors by Age Group of Transplant Recipients

Variable	No avail	Age 18-59	No avail	Age 60-69	No avail	Age 70	P-value ¹
Donor Characteristic							
Gender, Male, No (%)	36,190	25,647 (70.9)	13,527	9,498 (70.2)	715	479 (67.0)	0.05
Age (years), Median (25 th , 75 th)	36,190	28 (20, 39)	13,525	30 (21, 43)	715	36 (23, 48)	<.001
Age 35, No (%)	36,190	12,535 (34.6)	13,525	5,607 (41.5)	715	382 (53.4)	<.001
Age 45, No (%)	36,190	5,302 (14.7)	13,525	2,882 (21.3)	715	222 (31.1)	<.001
CDC high risk, No (%) ^{2,3}	9,294	971 (10.5)	4,750	476 (10.0)	409	65 (15.9)	0.61
Tattoos present, No (%) ⁴	9,277	3,955 (42.6)	4,757	2,029 (42.7)	408	166 (40.7)	0.80
Donor History							
History of diabetes, No (%) ⁵	9,287	277 (3.0)	4,745	162 (3.4)	408	27 (6.6)	0.01
Insulin dependence, No (%) ⁵	276	117 (42.4)	162	69 (42.6)	27	16 (59.3)	0.40
History of cigarette use, No (%) ⁵	9,233	1,280 (13.9)	4,709	760 (16.1)	407	83 (20.4)	<.001
Cigarette use in last 6 months, No (%) ⁵	1,275	1,157 (90.8)	755	689 (91.3)	83	74 (89.2)	0.89
Heavy alcohol use, No (%) ³	9,161	1,359 (14.8)	4,696	757 (16.1)	404	82 (20.3)	0.005
History of cocaine use, No (%) ⁴	9,117	1,302 (14.3)	4,659	698 (15.0)	402	77 (19.2)	0.05
Cocaine use in last 6 months, No (%) ⁴	1,116	558 (50.0)	587	284 (48.4)	69	37 (53.6)	0.75
History of other drug use, No (%) ⁵	9,193	3,761 (40.9)	4,690	1,995 (42.5)	405	170 (42.0)	0.07
Other drug use in last 6 months, No (%) ⁵	3,316	2,354 (71.0)	1,768	1,234 (69.8)	155	114 (73.6)	0.58
Combo smoking, alcohol, cocaine, other drugs, No (%) ³	9,304	117 (1.3)	4,764	78 (1.6)	409	8 (2.0)	0.04
Donor Transplant Variables							
Cardiac arrest with downtime, No (%) ⁴	9,305	611 (6.6)	4,766	319 (6.7)	409	35 (8.6)	0.42
LVEF (%), Median (25 th , 75 th) ⁴	9,258	60 (55, 65)	4,754	60 (55, 65)	404	60 (55, 65)	0.82
Cause of death, No (%)	36,114		13,500		715		<.001
Head trauma		19,633 (54.4)		7,269 (53.8)		333 (46.6)	
Cerebrovascular/Stroke		8,875 (24.6)		3,718 (27.5)		221 (30.9)	
Anoxia		3,365 (9.3)		1,423 (10.5)		130 (18.2)	
CNS tumor		272 (0.8)		118 (0.9)		8 (1.1)	
Other		3,969 (11.0)		972 (7.2)		23 (3.2)	
Ischemic time (hours), Median (25 th , 75 th)	34,458	2.9 (2.2, 3.6)	12,849	3.0 (2.3, 3.7)	675	3.2 (2.5, 3.9)	<.001
Gender mismatch between donor and recipient, No (%)	36,190	10,559 (29.2)	13,527	3,780 (27.9)	715	213 (29.8)	0.01

¹ P-values are based on chi-square rank based group means score statistics for all categorical row variables and chi-square 1 df rank correlation statistics for all continuous/ordinal row variables.

² High risk defined as history of hemophilia, IV drug use, prostitution, high risk sexual activity, HIV exposure, or jail sentencing.

³Excludes donors admitted before Jun 30, 2004

⁴Excludes donors admitted before Oct 25, 1999

⁵Excludes donors admitted before Apr 1, 1994

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Table 3
Observed Outcomes of Transplant Recipients by Age Group

Variable	No avail	Age 18-59	No avail	Age 60-69	No avail	Age 70+
Follow Up Outcomes						
Length of Stay Transplant to Discharge, Median (25th, 75th) ¹	17,229	14 (10, 21)	7,764	15 (10, 23)	555	15 (10, 23)
Treated for Rejection within 1 year, No (%)	16,905	6,464 (38.2)	7,151	2,106 (29.5)	427	76 (17.8)
Rehospitalizations in the First Year, No (%) ²	14,558		5,869		298	
2		25 (0.2)		14 (0.2)		1 (0.3)
1		5,969 (41.0)		2,292 (39.1)		111 (37.3)
0		8,564 (58.8)		3,563 (60.7)		186 (62.4)
If Renal Dysfunction, Chronic Dialysis at 1 year, No (%) ²	3,149	97 (3.1)	1,501	33 (2.2)	78	1 (1.3)
If Renal Dysfunction, Chronic Dialysis at 5 years, No (%) ³	2,311	182 (7.9)	939	51 (5.4)	35	6 (17.1)
Stroke at 1 year, No (%) ²	9,445	95 (1.0)	3,369	38 (1.1)	124	3 (2.4)
Stroke at 5 year, No (%) ³	6,257	66 (1.1)	2,005	31 (1.5)	61	0
Post-Transplant Lymphoproliferative Disease at 1 Year, No (%) ²	187	33 (17.7)	211	10 (4.7)	18	2 (11.1)
Post-Transplant Lymphoproliferative Disease at 5 Years, No (%) ³	355	18 (5.1)	265	9 (3.4)	11	0

¹ Excludes patients listed before Oct 25, 1999

² Among patients alive at 1 year

³ Among patients alive at 5 years

Table 4a
Association between Age Groups and 5-Year Mortality among Transplant Recipients
from April 1, 1995 to March 27, 2014

Outcome	Variable	Unadjusted		Adjusted ^a	
		HR (95% CI)	P-value	HR (95% CI)	P-value
5-Year Mortality	Age (60-69) vs. Age (18-59)	1.12 (1.07, 1.18)	<.001	1.13 (1.07, 1.18)	<.001
	Age (70+) vs. Age (18-59)	1.29 (1.10, 1.51)	0.001	1.35 (1.16, 1.58)	<.001
	Age (70+) vs. Age (60-69)	1.15 (0.98, 1.34)	0.09	1.20 (1.03, 1.41)	0.02

^a Adjustment variables: Recipient: gender, race, ischemic etiology, creatinine, condition at transplant, mechanical support (ECMO, IABP, ventilator, or other), pharmacological support (prostaglandins, inotropes, or inhaled NO), diabetes. Donor: ischemic time, age, diabetes, smoking history, cause of death (head trauma, stroke, anoxia, other). Gender mismatch. Year of transplant.

Table 4b
Association between Age Groups and 5-Year Mortality among Transplant Recipients
from June 30, 2004 to March 27, 2014

Outcome	Variable	Unadjusted		Adjusted ^a	
		HR (95% CI)	P-value	HR (95% CI)	P-value
5-Year Mortality	Age (60-69) vs. Age (18-59)	1.09 (1.02, 1.18)	0.02	1.10 (1.02, 1.19)	0.02
	Age (70+) vs. Age (18-59)	1.23 (0.99, 1.52)	0.06	1.24 (1.00, 1.54)	0.05
	Age (70+) vs. Age (60-69)	1.12 (0.90, 1.40)	0.30	1.13 (0.90, 1.41)	0.28

^a Adjustment variables: Recipient: VAD (Yes/No), gender, race, ischemic etiology, creatinine, condition at transplant, mechanical support (ECMO, IABP, ventilator, or other), pharmacological support (prostaglandins, inotropes, or inhaled NO), diabetes. Donor: CDC high risk, ischemic time, age, diabetes, smoking history, cause of death (head trauma, stroke, anoxia, other). Gender mismatch. Year of transplant.