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Evaluating Predicted Heart Mass in Adolescent Heart Transplantation

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Abstract

Purpose—Predicted Heart Mass (PHM) has emerged as an attractive size matching metric in adult cardiac transplantation. However, since PHM was derived from a healthy adult cohort, its generalizability to the pediatric population is unclear. We hypothesize that PHM can be extended to older adolescents, and potentially broaden the donor pool available to this group.

Methods—The United Network for Organ Sharing database was retrospectively analyzed for patients aged 13–18 undergoing heart transplantation. Recipients were divided into quintiles (Q1-Q5) based on donor-to-recipient predicted heart mass ratios (PHMR). Primary endpoint was graft survival at five years.

Results—2061 adolescent heart transplant recipients between January 1994 and September 2019 were retrospectively analyzed. The median PHMR's for each quintile was 0.84 (0.59 to 0.92), 0.97 (0.92 to 1.02), 1.08 (1.02 to 1.14), 1.21 (1.14 to 1.30), and 1.44 (1.30 to 2.31). Kaplan-Meier survival curves demonstrated comparable survival across all quintiles of PHMR (p=0.9). Multivariate Cox regression showed no significant difference in graft failure of the outer quintiles when compared to the middle quintile (Q1: 1.04 HR, p=0.80; Q2: 1.02 HR, p= 0.89; Q4: 1.19 HR, p=0.28; Q5: 1.02 HR, p=0.89). Significant covariates included transplant year (HR: 0.95, p<0.0001), serum bilirubin (HR: 1.04, p=0.0004), ECMO at transplantation (HR: 2.85, p<0.0001), and underlying diagnosis of dilated cardiomyopathy (vs. congenital heart disease, HR: 0.66, p=0.0004).

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Author Contributions

JYL contributed to the design of the study, data analysis, interpretation of results, writing of the manuscript, and critical review of the manuscript. RSZ, SK contributed to the design of the study, data analysis, interpretation of results, and critical review of the manuscript. DNR, JCD, TN, MM contributed to the design of the study, interpretation of results, and critical review of the manuscript.

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Conclusion—Matching by PHM is not associated with survival or risk in adolescent heart transplant recipients. Our results underscore the ongoing need to develop an improved size-matching method in pediatric heart transplantation.

Introduction

Evaluating size-match continues to be a challenge in pediatric heart transplantation and hundreds of organs are declined for perceived size-mismatch each year [1]. Waitlist mortality is more than 12% in the pediatric population, yet over 30% of donor hearts are rejected due to perceived size mismatch [2]. The traditional method of size-matching is by donor-recipient weight ratio (DRWR), and it is the only metric reported to the United Network for Organ Sharing. Oversized grafts are generally preferred to undersized grafts and the current ISHLT guidelines do not recommend undersizing more than 30% by DRWR in pediatric cardiac transplantation. Despite this practice, the extent to which low DRWR is associated with adverse post-transplant outcomes in the pediatric population remains controversial [3–4].

Improved size-matching methods are needed, and several metrics have been evaluated in the aims of improving size-matching in pediatric cardiac transplantation. Some institutions have reported matching using height in order to mitigate the effects of failure to thrive and fluid retention in the pediatric transplant population [3–4]. Despite this rationale, size matching by height has not been associated with superior survival in retrospective analysis of the UNOS and ISHLT multi-institutional registries [5–6]. Additional analysis has been conducted using metrics that incorporate both weight and height to varying degrees, such as body mass index and body surface area, but these metrics have not proven to be superior for size matching in cardiac transplantation [7–9].

In recent years, predicted heart mass (PHM) has emerged as an attractive size matching metric in adult cardiac transplantation. Unlike other metrics, PHM was specifically derived to predict total myocardial mass based on patient weight, height, age, and sex. Previous multi-institutional studies have reported that PHM is a more appropriate metric for size matching and would have resulted in a 32% reduction in grafts rejected for size mismatch in the adult population [9]. Other studies demonstrate superior predictive power of survival when using PHM compared to weight matching, and it has become the preferred metric used by several institutions [10–11].

Because PHM was derived from a healthy adult cohort, its generalizability to the pediatric population is unclear. While the body proportions of young children are different compared to adults, measures of body proportionality such as sitting height and leg length begin to plateau in adolescents as young as 13 years old [12–14]. We hypothesize that PHM can be extended to patients 13–18 years old, and potentially broaden the donor group available to this patient population.

Methods

This study retrospectively reviews all adolescent cardiac transplantations (13–18 years old) reported to the United Network for Organ Sharing from 1994–2019. Exclusion criteria for

this study included patients undergoing combined heart and lung transplantation, patients undergoing retransplantation, or patients missing graft follow up data. Donors and patients with missing data for height, weight, or sex were also excluded from the analysis; these variables are necessary for the calculation of PHM. LV and RV volumes were estimated using weight, height, age, and sex as previously described [2]. Predicted heart mass was calculated by summing LV and RV mass estimates (Table 1). After calculating PHM, missing covariate data was handled using multiple imputation to avoid list-wise deletion in multivariate analyses. A regression switching approach with predictive mean matching was used. Regression coefficients from 20 imputations were pooled according to Rubin's rules. The final cohort of 2061 adolescent transplantations were split into five quintiles based on donor-to-recipient predicted heart mass ratios (PHMR).

The primary endpoint for this study was graft survival at 5-year post-transplantation. Graft survival event rates for each of the five quintiles was estimated using Kaplan-Meier survival curves and compared using the Mantel-Cox log-rank test. After multiple imputation, the effect of clinically relevant variables on graft survival was evaluated using univariate Cox proportional hazards regression. The effect of donor-recipient sex mismatch on 5-year graft survival and DRWR matching was also evaluated. A final multivariate Cox proportional hazards model was constructed to evaluate the independent effect of size-matching by PHMR on 5-year graft survival while controlling for confounding effects. Schoenfeld residuals were used to evaluate the proportional hazards assumption for each variable in the final model. Martingale residuals were used to evaluate the linearity assumption for continuous variables.

After this primary analysis, additional subanalysis of the bottom quintile was conducted to evaluate the effect of undersizing with a PHMR below 0.85. Inverse probability weighting via the propensity score was used to compare risk of 5-year graft failure in recipients with PHMR 0.59 to 0.85 to recipients with PHMR 0.85 to 0.92. Propensity scores were calculated across all imputed data sets (n=20) and combined using the across method of analysis for multiply imputed propensity scores. A sensitivity analysis that excluded recipients with a primary diagnosis of CHD (n=610) was also performed to evaluate the predictive ability of PHM in a non-CHD population. A sensitivity analysis of a CHD-only population was also performed.

A p-value <0.05 was considered statistically significant and hazard ratios are presented with 95 confidence intervals. Continuous variables are presented as medians with interquartile ranges and categorical variables are presented with percentages. Quintiles are presented with PHMR ranges in parenthesis. All analyses were conducted in R statistical software (version 4.0.4). The study was approved by the institutional review board and the need for patient consent was waived because the UNOS Standard Transplant Analysis and Research File includes no patient identifiers. The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy of or interpretation by the OPTN or the United States Government.

Results:

2061 adolescent heart transplant recipients between January 1994 and September 2019 were retrospectively analyzed. The primary diagnosis for transplantation was congenital heart disease (CHD) in 29.6% of transplants and dilated cardiomyopathy (DCM) in 54.8% of patients. 15.6% of patients received cardiac transplantation for a primary diagnosis that was not CHD or DCM. The 1-year graft survival rate was 93.0% and the 5-year graft survival rate was 76.7% (Figure 1). The median age at transplantation was 15.4 years and 65.0% of the cohort were males. At the time of transplantation, 27.0% of recipients were on mechanical circulatory support. The number of annual adolescent cardiac transplantations has steadily increased since 2003, and the median year of transplantation in the study cohort was 2010.

In univariate analysis, 9 of 14 variables were significant predictors of 5-year graft failure. Primary diagnosis of DCM was associated with a lower risk of 5-year graft failure compared to patients diagnosed with CHD (Table 3). Younger recipients and younger donors were associated with a lower risk of 5-year graft failure. The highest increase in risk of 5-year graft failure was associated with extracorporeal membrane oxygenation (ECMO) at the time of transplantation. Increased serum bilirubin levels at the time of transplantation were associated with an increased risk of 5-year graft failure but levels of serum creatinine at transplantation were not. Neither ischemic time nor mechanical circulatory support at transplantation were associated with risk of 5-year graft failure in univariate analyses (Table 3). Sex mismatch was not a significant risk factor for 5-year graft failure in univariate analysis and DRWR matching practices were not statistically different between sex matched and sex mismatched transplantations (Figure 2A).

The impact of PHMR on 5-year graft survival was evaluated by splitting adolescent transplantations into 5 quintiles. The distribution of transplantations by PHMR and the corresponding donor-to-recipient weight ratio is shown in Figure 2B. The median PHMR for each quintile was 0.84 (0.59 to 0.92), 0.97 (0.92 to 1.02), 1.08 (1.02 to 1.14), 1.21 (1.14 to 1.30), and 1.44 (1.30 to 2.31). There was no statistically significant difference in 1-year graft survival (p=0.7) or 5-year graft survival (p=0.9) between any of the five quintiles (Figure 1). Differences in baseline characteristics between each of the quintiles are summarized in Table 2. The bottom quintile featured recipients with older donor age and earlier era of transplantation. The top quintile was composed of recipients with longer ischemic times compared to the lower 4 quintiles. The primary diagnosis for transplantation varied between the quintiles, with higher proportions of DCM in the lower quintiles and higher proportions of CHD in the higher quintiles.

Multivariate Cox regression showed no significant difference in 5-year graft failure between any of the PHMR quintile groups. ECMO at transplantation and higher serum bilirubin levels were associated with increased risk of 5-year graft failure in the multivariate model. A primary diagnosis of DCM was associated with decreased risk of 5-year graft failure when compared to CHD recipients (Table 3). There was a significant increase in risk of 5-year graft failure associated with black ethnicity or individuals that identified in the “other ethnicities” category. The “other ethnicities” category was composed of

individuals identifying as Pacific Islander, Native American, or multiracial, and were grouped together due to small sample size. Ischemic time in hours and serum creatinine levels at transplantation were not significant risk factors in multivariate regression.

Further threshold analysis of the bottom quintile demonstrated equivalent survival between recipients undersized with PHMR below 0.85 (ranging from 0.59 to 0.85, n=241) when compared to the remaining adolescents in the bottom quintile (PHMR 0.85 to 0.92, n=185) (p=0.9) (Figure 3). There was no adverse effect associated with undersizing below a PHMR of 0.85, even after balancing covariates across the two groups using inverse probability weighting via the propensity score (95% Confidence Interval: 0.62 to 1.59; HR: 0.99; p=0.99) (Table 5). Additional sensitivity analysis did not reveal an association between PHMR and risk of graft failure when recipients were stratified by non-CHD or CHD primary diagnosis. There was no difference in unadjusted 5-year survival by PHMR quintiles in either of the analyses stratified by patient diagnosis (p=0.5, p=0.6).

Discussion

PHM is an attractive size matching metric in adult cardiac transplantation that has been shown to be more predictive of graft failure than weight, height, body mass index, or body surface area alone [9]. We hypothesized that body proportions of older adolescents would be sufficiently similar to adults to benefit from PHM matching. The benefits of utilizing PHM to predict myocardial mass are likely two-fold. First, PHM more precisely predicts myocardial mass from body proportions by combining weight, height, and age rather than any one of these measurements alone. Second, the PHM equation captures the impact of patient sex by utilizing different coefficients to estimate the myocardial mass of males and females. An external study validating the PHM equation found it to be more highly correlated to left ventricular mass than weight or height in the UK Biobank [15].

This study retrospectively evaluated PHM as a size-matching metric for cardiac transplantation in adolescents 13 to 18 years old. In a cohort of 2061 patients, PHM mismatch was not associated with adverse 1-year or 5-year graft survival rates. Baseline characteristics were largely comparable between each of the PHMR quintiles. The most undersized PHMR quintile featured older donors and an earlier era of transplantation. Interestingly, there was a trend in diagnosis where the lower PHMR quintiles featured a higher proportion of DCM patients while the higher PHMR quintiles featured a higher proportion of CHD patients.

The independent effect of PHM on graft failure was assessed by using a multivariate Cox proportional hazards regression to control for confounders. PHM was not a significant risk factor for 5-year graft failure in this multivariate analysis. The negative finding from this analysis raises several questions about the adolescent transplantation population. First, because the benefit of PHM in size matching is in part a result of correcting for sex dependent variations in myocardial mass in adults, it questions the significance of sex mismatch in adolescent heart transplantation. Second, it brings into question the extent to which myocardial mass estimations derived from adult body proportions can be generalized to older adolescents.

To investigate the impact of sex-dependent variations in myocardial mass in adolescent transplantation, we evaluated DRWR matching practices and graft failure rates in sex-mismatched recipients. Female-to-male transplantations were only modestly oversized by DRWR with a median DRWR of 1.14, the same as the overall median DRWR of 1.14 (Figure 2A). This indicates that, on average, female-to-male transplantations were not preferentially oversized by DRWR in this cohort. Moreover, univariate analysis did not reveal a statistically significant association between sex mismatch and 5-year graft failure. Previous analysis of the UNOS database has similarly found no difference in mortality attributable to sex mismatch in pediatric transplantation [16]. Infants compose the largest recipient group of heart transplantations per year of age in the pediatric population, and thus analyses are often overfitted towards younger, prepubescent patients. Our results suggests that sex mismatch does not have a deleterious effect, even in a subset of older adolescents that may have more significant sex-based differences.

Although PHMR quintile was not predictive of 5-year graft failure in this study, the most undersized quintile was composed of recipients better matched by PHMR compared to previous analysis of adults undersized by PHMR. Kransdorf et al. reported worse 1-year survival and increased risk of 1-year mortality in the bottom septile of adult recipients with PHMR ranging from 0.54 to 0.86, and hypothesized that a PHMR of 0.86 represents the minimum myocardial mass necessary to provide adequate circulatory support in adults. In contrast, the most undersized quintile in this study encompassed a PHMR from 0.59 to 0.92. To evaluate this lower PHMR threshold, we performed a subanalysis of the bottom quintile with a PHMR threshold of 0.85. There was no difference in graft failure rates or risk of graft failure for recipients undersized with PHMR below 0.85 compared to recipients with PHMR ranging from 0.85 to 0.92. Although this does not preclude an effect at some smaller ratio, these results demonstrate that the 241 most undersized adolescents by PHM do not suffer from discernibly worse outcomes compared to their counterparts that are better matched by PHMR.

To mitigate the possibility of systematic variations in myocardial mass caused by the inclusion of CHD recipients, we also performed a sensitivity analysis. Recipients with CHDs such as single ventricle physiology may have lower myocardial mass than suggested by their PHM (or weight). CHD composed 21.8% to 36.5% of primary diagnoses for each of the quintiles in our analysis and only accounts for a minority of cases in previous analysis of PHM in adult transplantation. To evaluate PHM in a non-CHD population, we repeated the main analysis in this study with CHD recipients excluded. After excluding 610 CHD recipients, PHM was not predictive of 5-year graft failure in 1451 transplantations, thereby demonstrating the robustness of this negative finding in a non-CHD population.

The limitations of PHM in this population may be partially explained by the study cohort from which it was derived. The PHM formula was derived from the Multi-Ethnic Study of Atherosclerosis (MESA) which excludes individuals younger than 45 or over 300lbs. Analysis by Kim et al. found that undersizing by PHM does not predict survival in obese patients and the authors attribute this to the exclusion of obese patients from the MESA study cohort [17]. Similarly, despite having body proportions approaching those of adults, PHMR mismatch was not associated with graft failure in this study. Collectively,

these findings indicate that caution should be exercised when utilizing PHM estimations of myocardial mass in populations that do not strictly meet the inclusion criteria for the MESA cohort. Deviations in body proportions attributable to younger age or obesity may significantly impair the association between PHM and true myocardial mass. Further investigation is needed to assess the applicability of PHM in such subpopulations.

This study has important limitations. The results should be interpreted within the limitations of a retrospective multi-institutional review. It therefore cannot establish causality, and it should be noted that most recipients in this study were likely matched using DRWR and not PHMR. Additionally, institutions currently utilizing PHMR as a metric for size-matching are unlikely to have accepted organs with large PHMR mismatches. The lack of granularity in such a registry-based study also precluded evaluation of risk factors such as warm ischemic time. Nonetheless, this review benefits from a large sample size and broad generalizability to the adolescent transplantation population.

The findings of this study have important implications for clinical care. Our results extend previous analysis of the UNOS database to suggest that sex matching is not associated with graft failure in adolescents. Additionally, despite having body proportions approaching those of adults, our results indicate that PHM mismatch is not associated with graft failure adolescent cardiac transplantation. Within the range of donors that were accepted, we did not identify an adverse impact of undersizing down to a PHMR of 0.85. This does not preclude an effect at some smaller ratio and these findings do not necessarily mean that PHM has no utility in pediatric transplantation. However, these results may reassure clinicians of the safety of using low PHMR in older adolescents. These findings underscore the ongoing need to develop an improved size-matching method in adolescents, and pediatric heart transplantation more broadly.

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Non-standard abbreviations

DRWR	Donor-Recipient Weight Ratio
PHMR	Donor-Recipient Predicted Heart Mass Ratio

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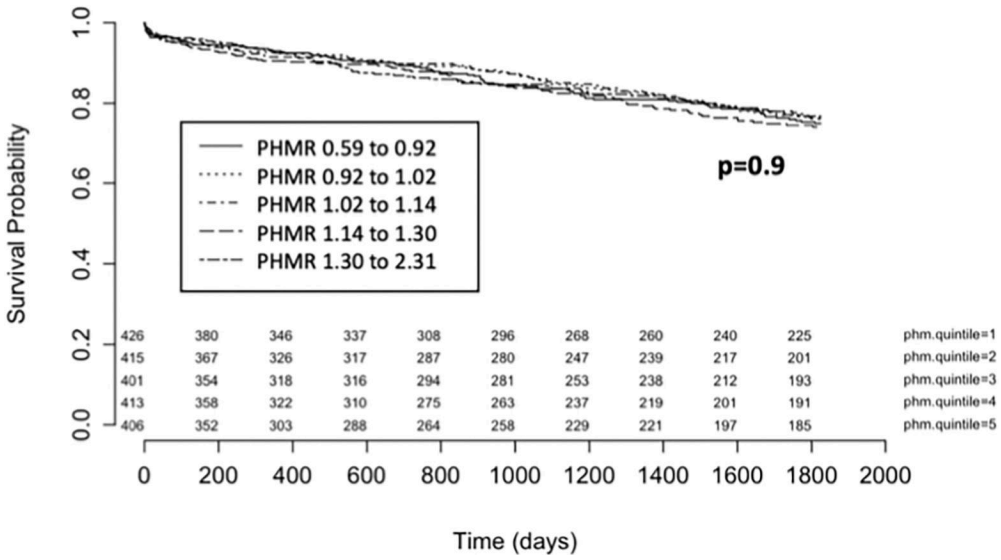

Figure 1:

Five-year Kaplan-Meier survival curves comparing survival by PHMR quintile in adolescents transplanted from 1994 to 2019 (n = 2061).

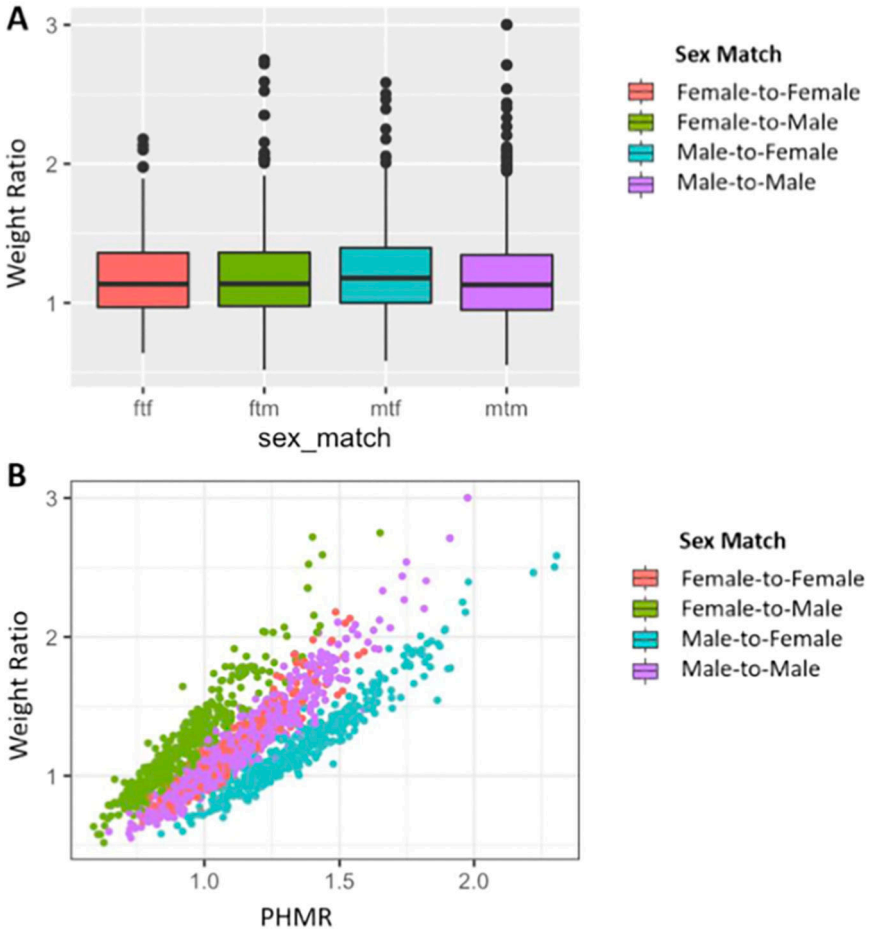

Figure 2:

(A) Weight ratio practices compared between varying donor-recipient sex match groups (p = 0.07). (B) Donor-recipient weight ratios compared to predicted heart mass ratio (PHMR) matching practices.

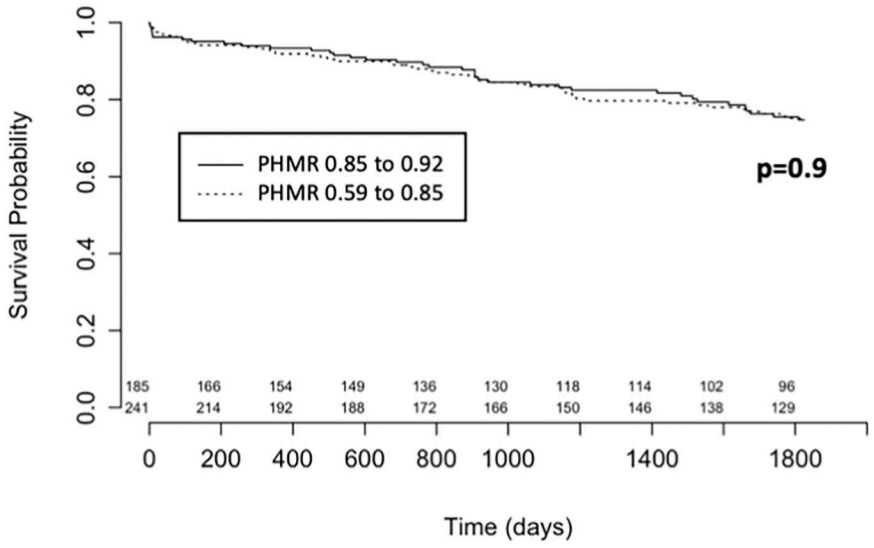

Figure 3:
Kaplan-Meier survival curves of PHMR 0.59 to 0.85 compared to PHMR 0.85 to 0.92 in the bottom quintile.

Table 1:

Predicted Heart Mass Equations

Predicted Left Ventricular Mass (g)	$a*Height^{0.54}(m)*Weight^{0.61}(kg)$ *Where a = 6.82 for women and 8.25 for men*
Predicted Right Ventricular Mass (g)	$a*Age^{-0.32}(years)*Height^{1.135}(m)*Weight^{0.315}(kg)$ *Where a = 10.59 for women and 11.25 for men*

Table 2:

Baseline characteristics by PHMR quintile

Variable (missing values, %)	Q1 (0.59 to 0.92) n=426	Q2 (0.92 to 1.02) n=415	Q3 (1.02 to 1.14) n=401	Q4 (1.14 to 1.30) n=413	Q5 (1.30 to 2.31) n=406
PHMR (0 missing)	0.84 (0.79–0.88)	0.97 (0.94–1.00)	1.08 (1.05–1.10)	1.21 (1.17–1.24)	1.44 (1.37–1.55)
Ischemic time (58 missing, 2.8%)	3.27 (2.63–4.00)	3.370 (2.73–3.95)	3.38 (2.75–4.05)	3.350 (2.6–4.0)	3.48 (2.83–3.98)
Serum Bilirubin (97 missing, 4.7%)	0.9 (0.5–1.5)	0.8 (0.5–1.4)	0.8 (0.5–1.2)	0.8 (0.5–1.5)	0.8 (0.5–1.5)
Serum Creatinine (34 missing, 1.6%)	0.8 (0.63–1.0)	0.79 (0.60–1.00)	0.70 (0.60–0.90)	0.7 (0.6–0.9)	0.7 (0.5–0.86)
Tx Year (0 missing)	2008 (2001–2015)	2010 (2002–2015)	2010 (2003–2015)	2011 (2004–2016)	2011 (2005–2015)
Recipient Age (years) (0 missing)	15.8 (14.6–16.9)	15.5 (14.4–16.8)	15.4 (14.2–16.6)	15.2 (14.1–16.4)	15.2 (14.1–16.7)
Donor Age (years) (0 missing)	18.4 (15.4–26.5)	17.4 (14.6–22.7)	17.4 (15.0–22.8)	17.3 (14.7–21.7)	17.4 (15.8–21.9)
Diagnosis DCM	64.3%	58.3%	52.9%	50.4%	47.8%
Diagnosis CHD	21.8%	26.7%	30.0%	33.7%	36.5%
Diagnosis Other (0 missing)	13.9%	14.9%	17.5%	16.0%	15.8%
ECMO at Transplant (0 missing)	3.1%	1.9%	1.7%	1.9%	1.7%
Transplant MCS (417 missing)	36.4%	34.3%	31.7%	32.7%	30.1%
Ethnicity White	55.8%	57.8%	52.9%	58.4%	59.4%
Ethnicity Asian	4.0%	3.9%	1.7%	2.4%	5.7%
Ethnicity Black	23.5%	22.4%	28.7%	21.8%	16.3%
Ethnicity Hispanic	14.8%	12.8%	12.7%	14.8%	14.8%
Ethnicity Other (0 missing)	1.9%	3.1%	4.0%	2.7%	3.9%

Table 3:

Univariate analysis

Variable	HR	95 CI	p-value
Recipient Gender (M reference)	1.303	1.069 – 1.588	0.0087
Donor Gender (M reference)	1.109	0.909 – 1.352	0.304
Recipient Age	1.10	1.026 –1.177	0.0066
Donor Age	1.03	1.02 – 1.04	<0.0001
Diagnosis (CHD reference)			
DCM	0.764	0.6169 – 0.946	0.0138
Other	0.737	0.542 – 1.002	0.0517
ECMO_TRR	2.8577	1.755 – 4.651	<0.0001
Tx Year	0.9515	0.938 – 0.965	<0.0001
Serum Bilirubin	1.063	1.041 – 1.086	<0.0001
Serum Creatinine	1.022	0.986 – 1.059	0.217
Ischemic time (hrs)	1.059	0.968 – 1.158	0.209
Transplant MCS	0.9138	0.707 – 1.180	0.487
PHMR Quintile (Q3 reference):			
Q1	1.059	0.782 – 1.434	0.709
Q2	1.001	0.732 – 1.367	0.994
Q4	1.128	0.831 – 1.532	0.436
Q5	0.998	0.727 – 1.371	0.993
Ethnicity (White reference):			
Asian	0.582	0.273 – 1.239	0.1600
Black	1.662	1.335 – 2.069	<0.0001
Hispanic	0.764	0.544 – 1.073	0.1205
Other	2.365	1.535 – 3.643	0.0001
Sex Match (Female-to-Female reference):			
Female-to-Male	0.776	0.570 – 1.058	0.1094
Male-to-Female	0.932	0.686 – 1.265	0.6513
Male-to-Male	0.719	0.547 – 0.944	0.0180

Table 4:

Multivariate analysis

Variable	HR	95 CI	p-value
Q3 reference:	-	-	-
Q1	1.04	0.75–1.45	0.798
Q2	1.02	0.74–1.41	0.889
Q4	1.19	0.87–1.62	0.275
Q5	1.02	0.73–1.44	0.893
Transplant Year	0.95	0.94–0.97	<0.0001
ECMO at Tx	2.85	1.72–4.71	<0.0001
Serum Bilirubin (mg/dL)	1.04	1.02–1.07	0.0004
Serum Creatinine (mg/dL)	0.99	0.95–1.04	0.82
Ischemic Time (hrs)	1.07	0.98–1.17	0.13
Recipient age (yrs)	1.13	1.05–1.21	0.001
Donor age (yrs)	1.02	1.01–1.03	0.003
Female reference:			
Recipient gender	0.72	0.57–0.91	0.007
Donor gender	0.96	0.76–1.22	0.768
CHD reference:			
DCM	0.66	0.53–0.83	0.0004
Other	0.71	0.52– 0.97	0.03
White ethnicity reference:			
Black	1.90	1.52–2.39	<0.0001
Hispanic	0.93	0.66–1.31	0.67
Asian	0.53	0.25–1.14	0.11
Other	1.93	1.23–3.05	0.005

Table 5:

Baseline Characteristics of Most Undersized Transplantations

	BEFORE MATCHING			AFTER MATCHING		
	PHMR 0.59 to 0.85 ***(n=241)***	**PHMR 0.85 to 0.92** ***(n=185)***	**SMD**	**PHMR 0.59 to 0.85 (n=189.7)**	**PHMR 0.85 to 0.92 (n=239.7)**	**SMD**
Ischemic time(hrs)	3.22 (1.03)	3.49 (1.12)	0.011	3.35 (1.02)	3.32 (1.12)	0.755
Serum Bilirubin	1.56 (3.08)	1.51 (2.37)	0.85	1.51 (2.87)	1.42 (2.29)	0.751
Serum Creatinine	1.19 (2.77)	0.93 (0.65)	0.22	1.07 (2.15)	0.99 (0.84)	0.540
ECMO at Tx(%)	7 (2.9)	6 (3.2)	0.99	6.9 (3.6)	8.2 (3.4)	0.926
Tx Year	2007 (8)	2009 (7)	0.009	2008 (8)	2007 (8)	0.649
Recipient Age	15.6 (1.4)	15.8 (1.4)	0.235	15.7 (1.3)	15.7 (1.4)	0.791
Donor Age	22.0 (9.7)	21.0 (9.1)	0.275	21.4 (9.1)	21.0 (9.1)	0.695
Diagnosis CHD (%)	51 (21.2)	42 (22.7)	0.86	42.5 (22.4)	55.3 (23.1)	0.985
Diagnosis DCM (%)	155 (64.3)	119 (64.3)		122.4 (64.5)	152.4 (63.6)	
Diagnosis Other (%)	35 (14.5)	24 (13.0)		24.9 (13.1)	31.9 (13.3)	
Ethnicity Asian (%)	8 (3.3)	9 (4.9)	0.33	7.4 (3.9)	10.6 (4.4)	0.978
Ethnicity Black (%)	61 (25.3)	39 (21.1)		44.0 (23.2)	58.7 (24.5)	
Ethnicity Hispanic (%)	30 (12.4)	33 (17.8)		30.1 (15.9)	36.8 (15.4)	
Ethnicity Other (%)	6 (2.5)	2 (1.1)		3.2 (1.7)	2.5 (1.0)	
Ethnicity White (%)	136 (56.4)	102 (55.1)		105.0 (55.3)	131.0 (54.7)	
Recipient Gender Male (%)	227 (94.2)	159 (85.9)	0.006	168.3 (88.7)	217.9 (90.9)	0.586
Donor Gender Male (%)	51 (21.2)	89 (48.1)	<0.001	66.5 (35.1)	78.1 (32.6)	0.654