Time for evidence-based, standardized donor size matching for pediatric heart transplantation

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ABSTRACT

Background: Accurately predicting cardiac size by other body parameters has long been problematic to determine whether a donor heart will serve a given waitlist candidate, yet hundreds of heart donors are turned down annually for size mismatch.

Objectives: We sought to describe how donor body weight parameters are currently utilized in cardiac transplantation and its influence on waitlist outcomes.

Methods: From the United Network for Organ Sharing database, pediatric (age <18 years) heart transplant candidates were divided into lower quartile, interquartile, and upper quartile categories based on final maximum acceptable donor-candidate weight ratio (DCW), expressed as percentage. Baseline characteristics and waitlist outcomes, including monthly offers/candidate and survival were compared.

Results: Overall median DCW was 200% (range, 159%-241%). Patients with congenital heart disease had higher DCW than those with cardiomyopathy (223% vs 203%; $P < .001$). Number of monthly offers/candidate (5.0, 5.6, and 7.2, respectively; $P < .001$) increased with quartile of DCW. Posttransplant survival was similar amongst the groups (log-rank $P > .05$). Subgroup analysis of critically ill children showed a waitlist survival advantage in those listed with a DCW $\geq 200\%$ ($P < .001$).

Conclusions: Despite substantial practice variation in acceptable donor weight in pediatric heart transplantation, patients listed with variable DCW had similar posttransplant survival. However, in critically ill patients, higher DCW was associated with greater waitlist survival. Better understanding of the importance of donor weight could reduce practice variability and improve organ use and waitlist outcomes for pediatric cardiac transplant candidates. (J Thorac Cardiovasc Surg 2019;158:1652-60)

Acceptable maximal donor weight varies greatly across the United States.

Central Message

There is great variation of acceptable donor-to-candidate weight ratio in pediatric heart transplant. A higher ratio benefits critically ill children but uniformity in listing practices should be sought.

Perspective

Significant variation in pediatric heart transplantation listing practices influences organ allocation and time on waitlists. There appears to be no nationwide standard for acceptable weight. With better justification and measurements for donor-to-recipient size matching, a more equal system could improve waitlist and posttransplant outcomes.

See Commentaries on pages 1661 and 1663.

Physicians have long sought to estimate the size of the human heart based on other anthropometric factors, even before heart transplantation was feasible.¹ Although the vast majority of studies come from adults, no sufficient correlating factor has been found between heart size and

other measurements.^{2,3} In pediatrics, estimating heart size is further confounded by a growing patient and a variety of pathologies (dilated cardiomyopathy vs single-ventricle congenital heart disease [CHD]). Despite the lack of validation of a correlation between heart size and anthropometric factors, transplant centers continue to mostly use patient weight when determining whether a donor heart is of suitable size for an individual heart transplant candidate, and

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Received for publication Jan 22, 2019; revisions received June 10, 2019; accepted for publication June 14, 2019; available ahead of print July 26, 2019.

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0022-5223/\$36.00

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<https://doi.org/10.1016/j.jtcvs.2019.06.037>

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Abbreviations and Acronyms

CHD	= congenital heart disease
DCW	= donor–candidate weight ratio
ECMO	= extracorporeal membranous oxygenation
UNOS	= United Network for Organ Sharing
VAD	= ventricular assist device

this measure is what is reported to United Network for Organ Sharing (UNOS). Several studies have shown that oversizing or undersizing a donor heart does not adversely affect survival if the donor heart can be made to appropriately fit in the chest cavity. Despite this, there continues to be significant practice variation in how US transplant centers utilize weight criteria for recipient candidate waitlisting.^{4,5} Prior studies have used <80% of the transplant candidate's weight for undersizing and more than 250% of the transplant candidate's weight for oversizing, with very few patients being listed outside of that range.^{6,7} Although waitlist parameters can influence on the number of offers a transplant candidate receives, it has not been shown to affect posttransplant survival. However, the belief among transplant teams that a size mismatch may be associated with poorer outcomes is suggested by the large number of donor refusals (34%) for weight mismatch.⁸ Along with other reasons one may refuse an organ offer, only 42% of pediatric donor hearts were used from 2005 to 2014.⁹ This seems problematic and an area for focused improvement in donor utilization. Therefore, this study aimed to identify the practice variation in transplant waitlisting across the United States and quantify the influence on waitlist outcomes and posttransplant survival, especially in critically ill heart transplant candidates.

PATIENTS AND METHODS

Patient Selection

After obtaining approval for the study from the Cincinnati Children's Hospital Institutional Review Board, the UNOS database was searched for pediatric patients (age <18 years) listed for heart transplantation from 2000 to 2015. Their most recent maximum acceptable donor weight and candidate weight on the waitlist were identified. Patients with missing weight data were excluded from the study ($n = 118$ [1.6%]). Minimum acceptable weight was clustered around the candidates' actual weight so maximum acceptable weight was analyzed as a percentage of the patient's weight (donor–candidate weight ratio [DCW]). This was used rather than absolute weight difference to account for patients of differing size. Patients were then grouped based on their maximal DCW as lower quartile, interquartile, and upper quartile. Patient indication for transplantation was classified as congenital heart disease, cardiomyopathy, retransplantation, or other. Estimated glomerular filtration rate was by the Schwartz method with <60 mL/min/1.73 m² or pretransplant dialysis classified as renal dysfunction.

Statistical Analysis

Data are presented as median (interquartile range) when distributed nonnormally and with mean $\pm$ standard deviation when normally

distributed. Categorical variables are presented as frequency (%). Variables with missing data report the n for that category. Baseline variables at listing and time of transplant and outcomes were compared amongst the groups. An adverse event on the waitlist was defined as removal from the waitlist due to death or decline in health resulting in removal from the waitlist. Fisher exact and χ^2 tests were used for categorical variables. Nonparametric tests were used to compare nonnormally distributed data. Kaplan-Meier survival curves with log-rank comparison were recorded for waitlist and posttransplant survival. Cox-regression was used for multi-variable analysis of waitlist survival, adjusting for DCW category, patient diagnosis, mechanical ventilation, extracorporeal membranous oxygenation (ECMO), renal dysfunction, and ventricular assist device (VAD) support, all at listing.

Center Data

The median patient DCW of centers who performed more than 20 transplants within the timeframe of the study was analyzed. The listing DCW and actual transplant DCW are described.

To assess the influence of changes in weight criteria on waitlist outcomes, we created a linear model of the number of changes in weight criteria on the number of days on the waitlist. A change in weight criteria was any absolute change in the maximum weight criteria.

A subgroup analysis focused on mortality in critically ill patients who had CHD, renal dysfunction, and mechanical ventilation, all of which are known risk factors for mortality.¹⁰ Due to smaller numbers and less variation in listing variables, these patients were divided ad hoc into a Strict DCW and a Liberal DCW group. The Strict group was defined as a DCW $\leq 200\%$ of the candidate's weight. The Liberal group was defined as a DCW $>200\%$ of the candidate's weight. Baseline characteristics and outcomes were then compared between these 2 groups. A competing risk analysis, as well as a Kaplan-Meier survival curve were also performed for these groups.

RESULTS

Overall

A total of 7067 patients were included in the study. Minimum acceptable weight was normally distributed just below the candidate's actual weight with a mean of $81.1\% \pm 17.2\%$ of the patient's weight. Maximum acceptable DCW was right skewed and varied greatly with a median of 200% (range, 159.7%-241.4%) of the candidate's weight. Furthermore, the fifth and 95th percentiles were 129% and 329% of the candidate's weight. The lowest acceptable DCW was reported to be 75% of the candidate's weight and the highest acceptable DCW was at 7400% of the candidate's weight. [Figure E1](#) shows the maximum acceptable weight categorized by the candidate's actual weight. The maximum acceptable DCW decreased significantly with increasing candidate weight ($P < .001$).

The baseline characteristics for the patient cohort are described in [Table 1](#). Compared with the interquartile group, patients in the lower quartile were older (9 years; range, 3-15 years; $P < .001$), with more VAD support (243 [19.9%]; $P = .001$) and less ECMO support (54 [4.4%]; $P < .001$) at transplant. They also were less frequently mechanically ventilated (124 [10.2%]; $P < .001$) with better renal function (190 [15.9%]; $P < .001$) at transplant and were more likely to have a diagnosis of cardiomyopathy

TABLE 1. Patient characteristics and outcomes by donor to candidate weight ratio group (Group A: Lower 25%, Group B: 25%-75%, Group C: Upper 75%)

Variable*	Group B (n = 3529)	Group A (n = 1763)	A vs B P value	Group C (n = 1775)	B vs C P value
Age (y)	5 (0-11)	9 (3-15)	<.001	3 (0-6)	<.001
Female gender	45.2 (1595)	42.9 (755)	.109	46.1 (819)	.517
Weight (kg)	23 (6-36)	40 (14-60)	<.001	14 (4-18)	<.001
Listing max weight of patient weight (%)	145 (130-151)	200 (185-204)	<.001	288 (259-313)	<.001
Diagnosis					
Cardiomyopathy	44.6 (1574)	50.9 (898)	<.001	38.2 (678)	<.001
CHD	46.8 (1653)	35.7 (629)	<.001	54.6 (969)	<.001
Retransplant	6.0 (211)	10.2 (179)	<.001	4.5 (79)	.021
Other	2.3 (91)	3.2 (57)	.152	2.8 (49)	.590
Race					
White	55.4 (1956)	51.3 (904)	.004	56.7 (1007)	.049
African American	20.6 (728)	23.5 (414)	.017	18.3 (324)	.041
Hispanic	17.7 (625)	18.9 (334)	.271	18.0 (319)	.729
Other	6.3 (219)	6.3 (111)	.888	7.1 (125)	.244
VAD at listing	7.0 (247)	9.5 (168)	.001	4.8 (85)	.002
VAD at transplant	16.5 (386/2335)†	19.9 (243/1219)†	.003	12.8 (163/1273)†	.048
Mechanical ventilation at listing	25.9 (914)	17.1 (301)	<.001	27.8 (494)	.133
Mechanical ventilation at transplant	19.0 (441/1320)†	10.2 (124/1214)†	<.001	23.8 (301/1267)†	<.001
ECMO at listing	11.7 (414)	8.3 (147)	<.001	11.5 (204)	.798
ECMO at transplant	6.0 (139/2320)†	4.4 (54/1148)†	.050	8.4 (107/1267)†	.006
eGFR <60 mL/min/1.73 m ² at listing	28.6 (947/3315)†	19.9 (340/1705)†	<.001	33.6 (548/1632)†	<.001
eGFR <60 mL/min/1.73 m ² at transplant	19.9 (457/2294)†	15.9 (190/1194)†	.004	25.8 (324/1254)†	<.001
PRA >10%	18.2 (642/1979)†	20.4 (360/1094)†	.792	16.9 (301/1013)†	.129
Ischemic time (h)	3.5 (2.9-4.2)	3.5 (2.8-4.2)	.377	3.7 (3.1-4.5)	<.001
Days on waitlist	39 (14-97)	52 (16-147)	<.001	38 (13-87)	.118
Offers/candidate/month	5.6 (1.3-6.4)	5.0 (0.9-5.9)	<.001	7.2 (2.0-8.3)	<.001
Transplant rate	66.2 (2335)	69.1 (1219)	.030	71.7 (1273)	<.001
Adverse outcome on waitlist	20.5 (729)	15.0 (266)	<.001	18.5 (328)	.061
Actual donor-to-recipient weight (%)	132 (107-161)	110 (95-125)	<.001	161 (121-207)	<.001

Values are presented as median (interquartile range) or % (n). CHD, Congenital heart disease; VAD, ventricular assist device; ECMO, extracorporeal membranous oxygenation; eGFR, estimated glomerular filtration rate; PRA, panel reactive antibody. *For at-transplant variables: Group A: n = 1219, Group B: n = 2335, Group C: n = 1273. †Missing data, so totals are reported in parentheses.

(898 [50.9%]; $P < .001$). Conversely, the upper quartile group was younger compared with the interquartile group (3 years [range, 0-6 years]; $P < .001$) and more frequently had a diagnosis of CHD (969 [54.6%]; $P < .001$). They were also more frequently mechanically ventilated (301 [23.8%]; $P < .001$) with more renal impairment (324 [25.8%]; $P < .001$) and ECMO support (107 [8.4%]; $P = .006$) at transplant.

Figure 1 shows how median DCW varies by different institutions across the United States. for those centers that performed 20 or more transplants during the study period. Despite large differences in listing habits, the transplanted DCW was tightly clustered around 130%.

Waitlist outcomes and posttransplant outcomes are described in Table 1. The transplant rate of both the upper quartile (1273 [71.7%]; $P < .001$) and lower quartile (1219 [69.1%]; $P = .030$) was significantly greater than the interquartile group (2335 [66.2%]). The lower quartile group had the best waitlist survival (Figure 2), despite having longer waitlist times (52 days [range, 16-147 days]; $P < .001$) with the fewest adverse events (266 [15.0%]; $P < .001$). The number of organ offers each candidate received per month increased from 5.0 in the lower quartile to 5.6 in the interquartile to 7.2 for the upper quartile (all P values $< .001$). Accordingly, actual transplant DCW also increased from 110% in the

FIGURE 1. Median institutional maximal acceptable listing donor-candidate weight ratio (DCW) (red) and accepted donor-to-recipient transplants ratios (blue) and median transplanted patient weight (green). Despite maximal listing DCW ranging from 141% to 298%, most centers match to donors between 110% and 140% of the patient's weight.

lower quartile to 132% in the middle quartile to 161% in the upper quartile.

On multivariable analysis controlling for known risk factors, DCW (hazard ratio [HR], 0.939; 95% confidence interval [CI], 0.820-1.073; $P = .365$) was not associated with waitlist survival (Table 2). ECMO at listing was the strongest predictor of an adverse event (HR, 3.614, 95% CI, 3.109-4.201; $P < .001$), whereas VAD at listing was the only protective factor (HR, 0.732; 95% CI, 0.580-0.922; $P = .008$) on the waitlist.

While on the waitlist, 37.2% of patients had their maximal acceptable DCW altered, and 29.9% had it altered by $>10\%$ of their starting weight. Changes in acceptable donor weight while listed more frequently occurred in infants (44.8% vs 33.1%; $P < .001$) and those who were on the waitlist for longer periods of time ($P < .001$) (Figure E2). This ranged from 0 to 14 changes in acceptable weight. When examining all changes, the median change was an increase of 25.0% (range, 13.5%-47.9%) from the previous listing.

Of 4827 patients undergoing transplant, the median accepted DCW was 127% (range, 105%-161%). The largest actual DCW was 408% of recipient weight and the smallest was 50%. Posttransplant survival was similar for the 3 categories (Figure E3). The lower quartile group had the shortest median posttransplant length of stay at 16 days (range, 11-28 days) compared with the interquartile group (18 days [range, 12-31 days]; $P < .001$) and upper quartile group (19 days [range,

12-34 days]; $P < .001$). The upper and interquartile groups were similar ($P = .740$).

Critically Ill Children

In the subgroup analysis of critically ill children who received mechanical ventilation, had renal dysfunction, and had CHD, the overall median maximum acceptable DCW for the whole group was 205% (range, 190%-275%) with similar baseline characteristics (Table 3). The Liberal group received more offers per month and was associated with more patients being transplanted and fewer adverse events while on the waitlist. They had better waitlist survival by Kaplan-Meier (Figure 3) curve analysis ($P = .005$), which was further evaluated by a competing outcomes analysis. Competing outcomes demonstrated that most of the events took place during the first 2 months after listing for transplant (Figure 4). The Liberal group had 42% of patients undergo transplant, whereas only 36% died waiting, compared with 30% transplanted with 53% dying on the waitlist in the Strict group. The 2 groups experienced similar posttransplant survival regardless of maximum listing weight criteria (Figure E4).

DISCUSSION

We identified significant practice variability in the weight range criteria used when listing a pediatric patient for heart transplantation. This is suspected to be due to the lack of accessible methods for accurately assessing heart size, as well as a paucity of studies demonstrating heart size

FIGURE 2. Waitlist survival of patients grouped by their maximal acceptable donor–candidate weight ratio. Patients in the lower quartile demonstrated superior weight list survival to the interquartile and upper quartile groups. *n/a*, Not available.

mismatch affecting survival after pediatric heart transplant. Despite this practice variability, there was no difference in posttransplant survival between groups listed with different weight ranges—even when they accepted organs from donors of significantly different sizes. Prior studies have revealed conflicting results regarding the influence of donor-to-recipient weight ratio on survival. Literature

from adult cardiac transplantation suggests donor undersizing helps increase the donor pool,¹¹ and a UNOS database review showed that weight ratio did not affect survival.² Although limited, most pediatric studies discourage donor undersizing and show a survival benefit to oversizing¹²⁻¹⁴ or no difference in posttransplant outcomes,⁷ which is similar to our analysis. Unfortunately, these studies are mostly single-center experiences and do not expand on many other factors that could account for their findings, leaving uncertainty and skepticism amongst transplant centers.

In our large, multicenter analysis, listing patients with different maximal DCW did not affect waitlist or posttransplant survival, except in the critically ill subset. In addition, factors that one may surmise would influence waitlist DCW in children, such as diagnosis, did not seem to have an effect. For example, one might expect a patient with dilated cardiomyopathy to have a thoracic cavity capable of accommodating a heart from a much larger donor. For this reason, dilated cardiomyopathy candidates were excluded from prior studies examining weight ratios in transplant.^{7,14} Our analysis paradoxically showed that greater maximal acceptable weight is actually used in patients with CHD

TABLE 2. Multivariable analysis of waitlist survival

Variable	Hazard ratio (95% confidence interval)	P value
DCW 25%-75% compared with <25%	0.939 (0.820-1.076)	.365
DCW >75% compared with <25%	1.013 (0.873-1.175)	.866
Diagnosis of CHD	1.902 (1.688-2.143)	<.001
Mechanical ventilation at listing	2.228 (1.948-2.547)	<.001
ECMO at listing	3.614 (3.109-4.201)	<.001
eGFR <60 mL/min/1.73 m ² at listing	2.199 (1.947-2.482)	<.001
VAD at listing	0.732 (0.580-0.922)	.008

DCW, Donor to candidate weight ratio; CHD, congenital heart disease; ECMO, extracorporeal membranous oxygenation; eGFR, estimated glomerular filtration rate; VAD, ventricular assist device.

TABLE 3. Baseline demographic characteristics and outcome data for subanalysis of critically ill children

Variable	Strict weight group DCW <200% (n = 215)	Liberal weight group DCW ≥200% (n = 247)	P value
Baseline			
Age at listing (mo)	0 (0-4)	0 (0-3)	.146
Female gender	37 (80)	39 (95)	.077
African American race	13 (27)	21 (51)	.021
Weight (kg)	4.0 (3.2-6.0)	3.8 (3.2-5.5)	.174
ECMO at transplant	25 (21)	24 (31)	.861
VAD at transplant	1.9 (4)	1.6 (4)	.843
Listing max DCW (%)	188 (165-199)	259 (222-300)	<.001
Outcomes			
Offers per month	2.31 (0-4.4)	3.21 (1.5-6.7)	<.001
Days on waitlist	25 (10-61)	23 (9-51)	.203
Adverse events	53 (113)	39 (96)	.003
Received transplant	40 (85)	53 (131)	.003
Donor age (mo)	4 (2-11)	5 (2-20)	.579
Donor to recipient weight ratio (%)	142 (117-166)	164 (125-215)	.153

Values are presented as median (interquartile range) or % (n). DCW, Donor-candidate weight ratio; ECMO, extracorporeal membranous oxygenation; VAD, ventricular assist device.

compared with cardiomyopathy. Therefore, transplant teams may be adjusting waitlist criteria to increase offers in patients who are more ill or at higher risk. In line with that thought process, a maximal acceptable weight closer to a patients’ actual weight was more commonly seen when patients were less ill. This is supported by the decreased incidence of ECMO, mechanical ventilation, and renal dysfunction both at listing and transplant in the lower quartile. Their overall lower burden of illness appeared to contribute to their superior waitlist survival on multivariable analysis, and their listing DCW ratio was not found to be significant. All this is despite the lower quartile having longer waitlist times and a lower proportion of the group being transplanted at the end of the study period. The lower quartile had the greatest percentage of cardiomyopathy diagnoses that may represent the greatest potential for recovery or lower acuity. Accordingly, the upper quartile had the most CHD diagnoses as well as the smallest children. Additionally, it was associated with more mechanical ventilation at transplant and worse renal function at listing and at transplant. This perhaps represents a group with more growth potential, a willingness to accept a larger organ, and an increased urgency to find a suitable donor.

While only one third of patients had their maximum DCW change while on the waitlist, this occurred more often in smaller patients and those on the waitlist longer. This may represent growth in these patients while listed or potentially a need to elicit more offers. In all, we were surprised to

find such considerable differences between the groups of patients listed with different acceptable DCWs. It may be that certain centers use differing acceptable DCWs for different patient populations in addition to having differences in practice preferences among centers. Although our main focus was on patient-level outcomes, it is also possible that higher volume centers would have more high-risk children. That fact, along with their greater experience, may affect listing patterns.

The primary differences in outcomes between the groups were the number of offers per month, the amount of time spent on a waitlist, and the actual DCW at transplant. The upper quartile received the most offers, whereas the lower quartile had the longest wait times. Logically, the actual transplanted DCW increased with higher quartiles. These are key findings of this study because prior works only focused on posttransplant outcomes. It is important to note that waitlist attrition can be high and represents an important time where patients may either be optimized for transplant or deteriorate into Interagency Registry for Mechanically Assisted Circulatory Support level I status. However, we found that DCW does not affect this survival. Whether or not the differences in listing habits across the country are influencing the quality of care patients receive on a center-by-center basis is unclear. Yet, there is certainly a degree of disparity generated if a patient who would have been listed with a higher acceptable weight at 1 center is listed at another center with a lower limit and, therefore, receives fewer offers. A multitude of variables and clinical decision making ultimately result in the listing patterns, yet further emphasis on waitlist outcomes and donor offer acceptance patterns may help improve outcomes for all patients. Davies and colleagues¹⁵ recently demonstrated the mortality risk of refusing even 1 offer on the waitlist is 15%.

Despite the heterogeneity among the groups, these practices led to posttransplant survival that was remarkably similar amongst the groups. This finding raises the question of how the upper quartile, a group of patients with more CHD, mechanical ventilation, and renal dysfunction, can have comparable survival to members of the lower quartile, which was composed of older patients who more commonly had cardiomyopathy, had more VAD use, and had fewer other risk factors for posttransplant mortality. Perhaps the beneficial result of using a larger organ (161% vs 110% of a patient’s weight) is masked by the apparent need to expand the weight range criteria in sicker patients in an attempt to find a suitable donor sooner.

With this in mind, we identified a group of 462 critically ill patients who were at high risk for mortality. A very liberal listing criteria weight range (>200% recipient weight) was associated with fewer adverse events while on the waitlist, more offers, and a higher rate of transplant. However, post-transplant survival was comparable. Although posttransplant survival did not differ, the more liberal weight group

FIGURE 3. Kaplan-Meier curve showing superior waitlist survival for critically ill children listed in the Liberal weight group.

benefited by having superior waitlist survival, even with similar risk factors for mortality. Therefore, they experienced an overall better survival from day of listing. From this, we conclude that these critically ill infants who have not been separately analyzed before may be an exception to the rest, in which case utilizing what many may consider an excessively large weight range may lead to superior outcomes.

Lastly, these data suggest that we reassess the criteria upon which we have been turning down pediatric cardiac donors because donor-to-recipient weight ratio only appeared to influence waitlist time with no difference in survival after transplant. If 34% of donor hearts do not get utilized due to size or weight mismatch,⁸ our findings may represent an opportunity to broaden the donor pool. This could increase the number of pediatric heart transplants performed annually while decreasing wait time without increasing morbidity or mortality. A single-center study from the United Kingdom reported comparable outcomes in patients of all weight ratios with a policy of accepting up to 300% of their candidates' weight to help maximize donor organ use.¹⁴ A technology that may help alleviate some of the angst associated with weight mismatch is the use of virtual transplantation, whereby

using computed tomography or magnetic resonance imaging data cardiac volume can be estimated for both the donor and the candidate to determine the exact fit. This technology has already helped to expand use of mechanical circulatory support devices and is currently being evaluated in transplantation.^{16,17} Even with this technology, there would be a range of sizes that could be made to fit within a candidate's thoracic cavity. This could allow a potentially greater pool of donors to be identified for each candidate on the waitlist with a sound, reproducible, scientific basis and reduced disparity. This would also allow for the investigation of the influence of predicted heart mass because this metric has been recently advocated for in the adult literature.¹⁸

Limitations

Limitations of our study are those typical of a retrospective review because we used the UNOS database. Although associations are present, no causal effects can be defined among listing weights and patient outcomes. The primary issue is that we cannot discern the actual complex decision-making process that led to the selected weight ranges for each patient. Also, with a limited number of pre-defined variables collected at specific times, we may be

FIGURE 4. Competing outcomes analysis of waitlist survival. A, Strict weight group. B, Liberal weight group. Indicators of 1- and 2-month outcomes show that in both groups, >77% of patients have either received transplanted (Tx) or died within the first 2 months, making the acceptance of early offers critical to avoiding waitlist mortality.

missing a key factor that affected the maximum weight chosen. Lastly, it must be kept in mind that patients with CHD, and to some degree dilated cardiomyopathy, are a heterogeneous group that is not further well classified within this dataset.

CONCLUSIONS

In all, we found large variation in the weight range set forth for individual patients. Furthermore, there was vast intercenter variation in median acceptable donor weight, despite finding no influence on waitlist or posttransplant survival. Therefore, the utility of waitlist weight criteria

in pediatric cardiac transplantation should be reconsidered, as well as possibly normalizing the criteria programs use, or including supplemental methods to size-match analysis. Although a more liberal weight range criteria was found to benefit select critically ill patients, arbitrarily acceptable weight range restrictions seem unjustified in most pediatric candidates based on our data. If better consensus among programs was achieved, we could potentially improve equality of organ allocation, and the overall pediatric cardiac transplant candidate pool could prosper from better donor organ use.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: pediatric, heart failure, cardiac transplantation, waitlist, weight

FIGURE E1. The proportion of patients in 4 different ranges of maximum acceptable donor-candidate weight ratio. There is a trend toward accepting a larger donor in smaller children, whereas a candidate closer to the patient’s size is more desirable in children >50 kg. Candidates are grouped by their final weight.

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FIGURE E2. Box and whiskers plot showing that as the number of changes in maximal donor–candidate weight ratio (DCW) increase, so does number of days on the waitlist such that patients waiting for an organ longer are likely to have more changes in their acceptable DCW. The upper and lower borders of the box represent the upper and lower quartiles. The middle horizontal line represents the median. The upper and lower whiskers represent the maximum and minimum values of nonoutliers. Extra dots represent outliers. If the number of subjects or measurements is <15, then each data point is plotted individually as a dot.

FIGURE E3. Posttransplant survival of patients grouped by their maximal acceptable donor–candidate weight ratio. There is no difference in posttransplant survival among the groups. *n/a*, Not available.

FIGURE E4. Kaplan-Meier curve showing similar posttransplant survival for Liberal and Strict weight groups.