Waitlist Weight Changes Impact Survival Following Heart Transplantation

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Abstract

Background: This study investigated the impact of weight change in waitlisted candidates on posttransplant outcomes following orthotopic heart transplantation (OHT). Methods: The United Network for Organ Sharing database was queried to identify adult patients undergoing isolated, primary OHT from 1/1/2010 to 3/20/2020. Patients were stratified into 3 cohorts based on percent weight change from listing to OHT. The primary outcome was one-year survival, and multivariable modeling was used for risk-adjustment. A secondary analysis compared outcomes of recipients waitlisted [?]90 days. Results: A total of 22,360 patients were included, 18,826 (84.2%) with stable weight, 1,672 (7.5%) with [?]5% weight loss, and 1,862 (8.3%) with [?]5% weight gain. Median age was similar across cohorts. Waitlist time was longest in patients with weight gain and shortest in those with stable weight (417 vs 74 days, P<0.001). The weight loss cohort had higher rates of dialysis dependency, pacemaker, and drug-treated acute rejection at one year (all P<0.05). Ninety-day and one-year posttransplant survival was lowest in the weight loss cohort. Multivariable modeling identified both [?]5% weight loss (HR 1.26, 95% CI 1.07-1.48) and decreasing weight (per 1%, HR 1.02, 95% CI 1.01-1.03) as risk-adjusted predictors of one-year mortality. In sub-analysis of recipients waitlisted [?]90 days, [?]5% weight loss and decreasing weight remained significant independent predictors for mortality. Conclusion: Waitlisted OHT candidates with [?]5% weight loss comprised a small, but higher-risk population with increased rates of postoperative complications and decreased survival. Efforts focused on nutritional optimization and preventing weight loss while awaiting OHT appear warranted.

Introduction

Orthotopic heart transplantation (OHT) remains the gold standard treatment for advanced, end-stage heart failure[1]. As efforts have focused on improving outcomes following OHT, much research has aimed at identifying modifiable risk factors that impact posttransplant outcomes. Of these, recipient weight and body composition have become of interest. The relationship between weight and heart failure are complex, as obesity is simultaneously a risk factor for the development of heart failure and a favorable prognostic marker in patients with existing heart failure[2]. In the OHT population, general consensus has recommended candidates achieve a body mass index (BMI) of <35-38 to prevent worse outcomes[3,4]. In some instances, OHT candidates may even undergo bariatric surgery in order to meet this BMI goal and increase chances of transplantation[5,6]. Although higher pretransplant BMI may be associated with longer waitlist times, several studies have questioned whether increased BMI actually impacts posttransplant outcomes[7–9].

While the impact of pre-OHT BMI remains controversial, even less is understood about the significance of weight changes on these outcomes. Among lung transplant recipients, pretransplant weight loss and BMI reduction, regardless of initial weight, has been shown to be associated with improved outcomes and survival[10,11]. However, it is unknown if these findings are applicable in the heart failure population. In this study, we aim to investigate the impacts of pretransplant weight changes on posttransplant outcomes following OHT.

Materials and Methods

Data Source

The United Network for Organ Sharing (UNOS) database prospectively collected database of all thoracic transplants performed in the United States. We analyzed patients undergoing orthotopic heart transplantation (OHT) from January 1, 2010 to March 20, 2020. Patient and medical center identifiers were excluded from the analysis and manuscript. This study was approved by the Institutional Review Board at the University of Pittsburgh.

Study Design

In this study, we included adult patients ([?]18 years) who underwent isolated, primary OHT within the study period. Multi-visceral transplants and heterotopic heart transplants were excluded. Percent waitlist weight change was calculated from time of OHT waitlisting to time of transplant. Recipients were then divided into three cohorts, those with [?]5% weight loss while waitlisted, those with stable weight (<|5%| weight change), and those with [?]5% weight gain. Patient demographic and outcomes data were collected from the UNOS database.

The primary outcome of this study was one-year posttransplant survival. Other outcomes included postoperative complications, hospital length of stay, and rates of drug-treated one-year acute rejection. Predictors of posttransplant mortality and were modeled in multivariable analysis.

Because patients with short waitlist times are unlikely to experience significant fluctuations in weight, we performed a sub-analysis. In this analysis, we excluded patients with waitlist times <90 days. One-year survival was compared among cohorts, and multivariable modeling for mortality was performed in this population. Furthermore, as many transplanting centers focus on waitlisted candidates achieving a BMI less than 35 kg/m^2 prior to transplantation, we performed a separate sub-analysis to investigate outcomes of patients with initial waitlist BMI [?] 35 kg/m^2.

Statistical Analysis

Continuous, normally distributed data are presented as mean (± standard deviation), and continuous, nonparametric data are presented as median [interquartile range (IQR)]. Categorical data are displayed as a number (percentage). Preoperative baseline characteristics were compared between groups using Student's t-test for normally distributed continuous variables and Wilcoxon rank sum test for nonparametric variables. Categorical variables were compared using either chi square or Fisher's exact test when appropriate.

Kaplan Meier survival analysis was used to compare one-year survival among weight change cohorts. Multivariable Cox proportional hazards modeling was performed to evaluate the risk-adjusted predictors of one-year posttransplant mortality. B-spline regression was used to model effects of weight loss across initial waitlisting BMI. Statistical analysis was performed using Stata version 16.1 statistical software (StataCorp, College Station, TX, USA).

Results

Baseline Recipient and Transplant Characteristics

A total of 22,360 patients were included in this study, 18,826 (84.2%) with stable weight (<|5%| weight change), 1,672 (7.5%) with [?]5% weight loss, and 1,862 (8.3%) with [?]5% weight gain. Distributions of age, race, BMI, and heart failure etiology are presented in **Table 1** . Patients with stable weight had the lowest proportion of recipients with non-ischemic cardiomyopathy (52.0% vs 53.1% vs 55.7%, P<0.001). Patients with stable weight also had the lowest incidence of waitlist transfusion (19.3% vs 37.8% vs 37.5%, P<0.001). Recipients with [?]5% weight gain had the lowest incidence of pretransplant mechanical ventilation (1.3% vs

0.9% vs 0.5%, P=0.004), pretransplant inotrope requirement (37.6% vs 33.4% vs 17.2%, P<0.001), intra-aortic balloon pump (10.4% vs 9.2% vs 3.2%, P<0.001) and extracorporeal membrane oxygenation support (1.3% vs 1.3% vs 0.1%, P<0.001). Patients with [?]5% weight gain were also most frequently bridged to transplant with a left ventricular assist device (39.4% vs 46.6% vs 74.9%, P<0.001).

Recipients with [?]5% weight gain received donor hearts from the lowest median donor-to-recipient hospital distance (101 miles vs 102 miles vs 86 miles, P=0.004). This cohort also had the longest median waitlist time, and patients with stable weight had the shortest median waitlist time (74 days vs 220 days vs 417 days, P<0.001). Graft cold ischemic times were similar across cohorts (**Table 1**).

Posttransplant Complications and Survival

Following transplantation, patients with [?]5% weight loss experienced the highest rate of renal failure requiring dialysis, while those with [?]5% weight gain experienced the lowest (11.2% vs 14.1% vs 10.3%, P<0.001). The [?]5% weight loss cohort also experienced the highest incidence of pacemaker requirement (2.9% vs 3.7% vs 2.3%, P=0.044) and drug-treated acute rejection at one year (11.0% vs 13.4% vs 12.1%, P=0.005) (**Table 2**). Rates of stroke, hospital length of stay, and 30-day mortality were comparable.

Ninety-day and one-year survival were greatest in recipients with [?]5% weight gain and lowest in those with [?]5% weight loss (94.7% vs 92.8% vs 95.8%; and 91.6% vs 89.0% vs 92.3%, P=0.008) (**Figure 1**). In multivariable analysis controlling for both BMI and ventricular assist device, [?]5% weight loss was associated with 26% increased hazards for one-year mortality (HR 1.26, 95% CI 1.07 to 1.48, P=0.005) and [?]5% weight gain was associated with 17% decrease in mortality (HR 0.83, 95% CI 0.69 to 1.00, P=0.047) compared to the stable weight cohort (**Table 3**). Decreasing weight modeled as a continuous variable was also associated with increased hazards for mortality (per 1% lost, HR 1.02, 95% CI 1.01 to 1.03, P<0.001) (**Supplemental Table 1**). Other factors associated with increased hazards for mortality included increasing BMI, congenital heart disease, restrictive heart disease, increasing total bilirubin and serum creatinine, pretransplant mechanical ventilation and extracorporeal membrane oxygenation, increasing donor age, female donor, and increasing graft cold ischemia time.

To model the effects of weight loss across initial BMI at waitlisting, B-spline regression was performed. Probability of one-year posttransplant mortality was plotted across initial waitlist BMI in**Figure 2** . Weight loss [?] 5% is shown to have increasing probability of mortality in waitlist BMI levels below 24 kg/m^2. However, in patients with stable weight or weight gain, decreasing initial waitlist BMI did not appear to increase probability of one-year posttransplant mortality.

Sub-analysis

A sub-analysis was performed which included only patients that had been waitlisted [?]90 days prior to OHT. This resulted in a total of 11,623 patients, 8,669 (74.6%) with stable weight, 1,262 (10.9%) with [?]5% weight loss, and 1,692 (14.6%) with [?]5% weight gain. Ninety-day (94.5% vs 92.9% vs 95.6%) and one-year (91.4% vs 88.9% vs 92.3%) mortality were lowest in patients with [?]5% weight loss (**Figure 3**) (P =0.0044). In multivariable model, [?]5% weight loss was associated with 33% increased hazards for posttransplant mortality (HR 1.33, 95% CI 1.11 to 1.61, P=0.003). [?]5% weight gain was not found to have significant impact on mortality (HR 0.87, 95% CI 0.72 to 1.06, P=0.173) (**Supplemental Table 2**). When examined as a continuous variable, decreasing weight was associated with increased hazards for mortality (per 1% weight lost, HR 1.02, 95% CI 1.01 to 1.03, P<0.001) (**Supplemental Table 3**). Other factors associated with increased hazards for mortality included increasing BMI, congenital heart disease, increasing total bilirubin and serum creatinine, pretransplant mechanical ventilation, extracorporeal membrane oxygenation, increasing donor age, and increasing graft cold ischemia time.

Additional sub-analysis investigated the outcomes of patients with initial waitlist BMI [?]35 kg/m^2. This subgroup was comprised of 1,470 patients, 1,205 (82.0%) who were transplanted with a BMI [?] 35 kg/m^2, and 265 (18.0%) who dropped to a BMI < 35 kg/m^2 prior to OHT. Comparison of baseline characteristics are shown in **SupplementalTable 4** . Patients who were transplanted at a BMI < 35 kg/m^2 had a higher utilization of left ventricular assist device as a bridge to OHT (66.9% vs 56.9%, P<0.001), and also had a longer median waitlist time (397 days [IQR 172 to 727] vs 111 days [IQR 31 to 343], P<0.001) compared those who were transplanted with a BMI [?] 35 kg/m^2.**Figure 4a** displays Kaplan Meier posttransplant survival between groups. Additionally, recipients with waitlist BMI [?] 35 kg/m^2 were stratified into weight change while on waitlist (stable weight, [?]5% weight loss, [?]5% weight), and Kaplan Meier survival comparisons are shown in **Figure 4b** . In both comparisons, there were no differences in one-year survival among groups.

Discussion

The relationship between weight and pathophysiology of heart failure are complex and remain poorly understood. Obesity is a known risk factor for the development of cardiovascular disease, and alike, heart failure[12]. Paradoxically, in patients with preexisting heart failure, a higher weight and BMI appears to be a protective when assessing outcomes such as hospital readmission and/or mortality[13,14]. Such findings have been coined the "obesity paradox". While this phenomenon may exist within non-transplant patients, less is understood regarding the transplant populations.

The current consensus guidelines recommend that heart transplantation should not be performed in patients with BMI [?]35 kg/m^{2,} and that weight loss should be pursued prior to listing[4]. Prior analysis has suggested BMI [?]35 kg/m^2 is associated with increased mortality, infection, and/or graft rejection following OHT[8,15,16]. Additionally, post-OHT obesity has been associated with development of cardiac allograft vasculopathy[3]. However, these findings are controversial, and have been challenged[7,9]. An analysis of the UNOS database (1998-2007) performed by Weiss et al demonstrated that candidates with BMI [?]35 kg.m^2 were half as likely to receive a donor heart (risk-adjusted HR 0.54, 95% CI 0.49 to 0.60, P<0.001). However, following OHT, this cohort did not demonstrate increased one-year mortality[7]. In our own analysis, we did observe an association between increasing BMI at time of transplant with increased hazards for mortality (HR 1.03, 95% CI 1.02-1.04, P<0.001). Furthermore, this relationship was still observed in our sub-analysis of recipients who were waitlisted at least 90 days prior to OHT (HR 1.03, 95% CI 1.02-1.05, P<0.001).

In light of conflicting evidence regarding the impact of pretransplant BMI on posttransplant outcomes, it is possible that perhaps pretransplant weight change is a better predictor than a static pretransplant measurement. However, it appears that trends in weight change are not uniform across all solid organ transplant recipients. For example, several prior studies have shown that weight loss, regardless of starting weight/BMI, is associated with favorable outcomes and improved survival in the lung transplant population[6,10]. To our knowledge, this study is the first to examine the effects of pretransplant weight change in the OHT population. In our own analysis of OHT recipients, we found the relationship between pretransplant weight loss and posttransplant outcomes to be opposite that found in lung transplant recipients. In our analysis, we found OHT recipients with [?]5% pretransplant weight loss to have the highest incidence of posttransplant renal failure, drug-treated acute allograft rejection, and one-year mortality. Similar to our findings, weight loss has been associated with worse prognosis in the non-transplant heart failure population. Okuhara *et al* analyzed a cohort of 242 patients with mild congestive heart failure. In this study, patients with [?]5% weight loss over the course of one year were found to have higher rates of renal failure, and weight loss was an independent predictor of cardiovascular death and/or re-hospitalization (HR 3.22, 95% CI 1.10-8.41, P=0.034)[17]. While weight loss was found to have these associations, underweight status was not. As a result, changes in weight may offer more prognostic insight into the heart failure population than static BMI or weight measurements.

Although we found pretransplant weight loss to be an independent predictor of worse outcomes following OHT, it is likely these effects are not uniform across patients with different initial BMIs at time of waitlisting. As demonstrated in **Figure 2** , the probability of one-year mortality was shown to increase in recipients with >5% weight loss as initial waitlist BMI decreased. However, decreasing initial BMI did not seem to increase probability of mortality in patients with stable weight or weight gain. It also appears the effects of weight loss are less impactful in patients with higher initial BMIs. In our sub-analysis, we did not demonstrate a significant decrease in survival in patients with initial BMI [?]35 who lost weight on the waitlist. It is not uncommon that weight loss in this cohort is intentional, whether through diet, exercise, or bariatric surgery programs, in order to reach a target goal set by providers or increase likelihood of transplant candidacy. For these reasons, it is less likely that reductions in weight in this higher-BMI subpopulation have significant negative impacts on posttransplant outcomes.

Study Implications

This study findings add to the growing knowledge regarding the complex relationship between weight and heart failure. This study and others have demonstrated higher pretransplant BMI to be associated with higher risk of posttransplant mortality. However, we suggest that perhaps examination of weight changes in the pretransplant period may offer better prognostic potential than weight measurements alone. In this study, we found an inverse relationship between pretransplant weight loss and posttransplant mortality, with a 2% increase in risk-adjusted hazards for mortality for every 1% of initial weight lost. Furthermore, the impacts of pretransplant weight loss are likely the highest in patients with lower initial BMI. Patients with [?]5% weight loss account for 7.5% of all OHT recipients, and 11% of recipients who are waitlisted for 90 or more days and represent a vulnerable and high-risk subset. Further efforts are needed to identify these patients and investigate the underlying mechanisms by which weight loss impact long-term outcomes. Such understanding of these mechanism may help promote future interventions such as patient-tailored nutritional optimization prior to OHT.

Limitations

This study was subject to limitations. First, this was a retrospective study and thus subject to selection bias that true randomization would eliminate. It is possible that pretransplant weight loss may serve as a surrogate for other disease processes and illness that influence posttransplant outcomes. In order to adjust for these possible confounding variables, we performed a multivariable analysis to adjust for pretransplant risk factors that were found to have influence on posttransplant mortality. However, it is possible that further unmeasured variables exist and may influence the findings of this study. Additionally, we recognize that weight changes are gradual, and patients who are transplanted after short waitlisting times are not likely to experience significant weight change. To address this, we performed a secondary analysis and included only patients who were waitlisted at least 90 days prior transplantation. Finally, we cannot determine from this analysis if weight loss was intentional or unintentional, or how volume overload and subsequent diuresis may have impacted our categorization.

Conclusions

In this analysis of 22,360 adult patients undergoing isolated OHT, we identified significant impacts of pre-transplant weight changes on posttransplant outcomes. Patients with [?]5% loss in weight from time of OHT listing were found to have higher incidence of renal failure requiring dialysis and drug-treated acute rejection at one year. Furthermore, one-year survival was significantly reduced in comparison to recipients with stable pretransplant weight, and the negative effects of pretransplant weight loss are likely higher in patients with lower initial waitlist BMI levels. This cohort represents a small (7.5%), but high-risk subset of OHT recipients. As a result, efforts should be made to identify these at-risk patients and focus on nutritional optimization and weight loss prevention prior to OHT.

Disclosures

None of the following disclosures are in direct conflict with this manuscript

AK: advisory board for Medtronic, Inc.

RT: consulting, Medtronic, Abbott, Aria CV Inc., Arena Pharmaceuticals, Acceleron, Eidos Therapeutics, Gradient and United Therapeutics.

-steering committee for Medtronic, Acceleron, Itamar and Abbott

-research advisory board for Abiomed

-hemodynamic core lab work for Actelion and Merck

BH: received research grant funding from and is on the medical advisory board for Medtronic, Inc.

MK: consulting for Abbott, Boston Scientific, Edwards, and Medtronic.

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Table 1 . Baseline recipient and transplant characteristics of OHT recipients stratified by waitlist weight change

	Stable Weight	**[?]5% Weight Loss**	**[?]5% Weight Gain**
	N=18,826	**N=1,672**	**N=1,862**
Recipient Characteristics			
Recipient Age (years)	57 (47-63)	56 (46-63)	56 (45-62)
Female	5,142 (27.3%)	397 (23.7%)	413 (22.2%)
Race			
White	12,427 (66.4%)	1,122 (67.5%)	1,124 (60.8%)
Black	3,930 (21.0%)	371 (22.3%)	505 (27.3%)
Hispanic	1,557 (8.3%)	132 (7.9%)	158 (8.5%)
Asian	693 (3.7%)	29 (1.7%)	50 (2.7%)
Other	115 (0.6%)	8 (0.5%)	12 (0.6%)
BMI at Waitlisting (kg/m^2)	27.32 (4.82)	30.02 (5.24)	26.01 (4.39)
BMI at Transplant (kg/m^2)	27.32 (4.81)	26.76 (4.64)	29.39 (4.84)
Recipient Blood Type			
A	7,747 (41.2%)	595 (35.6%)	662 (35.6%)
AB	1,156 (6.1%)	67 (4.0%)	58 (3.1%)
B	2,878 (15.3%)	231 (13.8%)	240 (12.9%)
O	7,045 (37.4%)	779 (46.6%)	902 (48.4%)
Heart Failure Etiology			
Non-Ischemic	9,775 (52.0%)	887 (53.1%)	1,037 (55.7%)
Ischemic	6,450 (34.3%)	528 (31.6%)	665 (35.7%)
Congenital	559 (3.0%)	50 (3.0%)	50 (2.7%)
Restrictive	695 (3.7%)	69 (4.1%)	31 (1.7%)
Valvular	257 (1.4%)	22 (1.3%)	16 (0.9%)
Hypertrophic	512 (2.7%)	57 (3.4%)	27 (1.5%)
Other	30 (0.2%)	5 (0.3%)	1 (0.1%)
Diabetes Mellitus	5,172 (27.6%)	503 (30.2%)	514 (27.6%)
Total Bilirubin (mg/dL)	0.98 (1.62)	0.99 (1.48)	0.86 (1.12)
Serum Creatinine (mg/dL)	1.23 (0.61)	1.24 (0.48)	1.24 (0.40)
Positive CMV Serology	10,514 (55.8%)	899 (53.8%)	1,072 (57.6%)
Transfusion on Waitlist	3,527 (19.3%)	608 (37.8%)	675 (37.5%)
Pretransplant Mechanical Ventilation	245 (1.3%)	15 (0.9%)	9 (0.5%)
Pretransplant Intensive Care Unit	6,148 (32.7%)	555 (33.2%)	235 (12.6%)
Intravenous Inotropes	7,078 (37.6%)	559 (33.4%)	320 (17.2%)
Pretransplant Intra-Aortic Balloon Pump	1,954 (10.4%)	154 (9.2%)	60 (3.2%)
Pretransplant Extracorporeal Membrane Oxygenation	253 (1.3%)	21 (1.3%)	1 (0.1%)
Ventricular Assist			
None	10,729 (57.7%)	747 (45.2%)	413 (22.4%)
LVAD	7,329 (39.4%)	770 (46.6%)	1,379 (74.9%)

	Stable Weight	[?]5% Weight Loss	[?]5% Weight Gain
RVAD	35 (0.2%)	4 (0.2%)	3 (0.2%)
TAH	159 (0.9%)	58 (3.5%)	16 (0.9%)
LVAD + RVAD	330 (1.8%)	74 (4.5%)	31 (1.7%)
Transplant Characteristics			
Sex Matched	14,267 (75.8%)	1,314 (78.6%)	1,468 (78.8%)
Race Matched	9,696 (51.5%)	861 (51.5%)	920 (49.4%)
HLA Matched	2,428 (12.9%)	231 (13.8%)	239 (12.8%)
ABO Matched	15,761 (83.7%)	1,448 (86.6%)	1,688 (90.7%)
CMV Matched	9,946 (53.1%)	857 (51.4%)	989 (53.5%)
Donor Distance (nautical miles)	101 (14-303)	102 (15-289)	86 (12-271)
Cold Ischemic Time (hours)	3.2 (2.4-3.8)	3.2 (2.5-3.8)	3.1 (2.4-3.8)
Days Listed	74 (21-230)	220 (91-504)	417 (212-758)

BMI, body mass index, CMV, cytomegalovirus; HLA, human leukocyte antigen; LVAD, left ventricular assist device; RVAD, right ventricular assist device; TAH, total artificial heart; VAD, ventricular assist device

Table 2 . Post-transplant outcomes stratified by waitlist weight change

	Stable Weight N=18,826	**[?]5% Weight Loss N=1,672**	**[?]5% Weight Gain N=1,862**	**P-Value**
Renal Failure Requiring Dialysis	2,061 (11.2%)	232 (14.1%)	189 (10.3%)	<0.001
Stroke	532 (2.9%)	44 (2.7%)	59 (3.2%)	0.61
Pacemaker	532 (2.9%)	61 (3.7%)	42 (2.3%)	0.044
Hospital Length of Stay (days)	15 (11-22)	16 (11-25)	16 (11-23)	<0.001
Drug-Treated Acute Rejection at One Year	2,034 (11.0%)	222 (13.4%)	222 (12.1%)	0.005
30-Day Mortality	651 (4.3%)	59 (4.5%)	48 (3.2%)	0.102

Table 3 . Multivariable Cox Proportional Hazards model for one-year mortality.

	Hazard Ratio	**95% Confidence Interval**	**P-Value**
Recipient Age (increasing, per year)	1.02	1.02, 1.03	<0.001
Weight Change			
Stable Weight	Reference	Reference	Reference?>?
5% Weight Loss	1.26	1.07, 1.48	0.005?>?
5% Weight Gain	0.83	0.69, 1.00	0.047
Body Mass Index (increasing, per kg/m^2)	1.03	1.02, 1.04	<0.001
Heart Failure Etiology			
Non-Ischemic	Reference	Reference	Reference
Ischemic	1.08	0.97, 1.20	0.172
Congenital	2.74	2.14, 3.51	<0.001
Restrictive	1.45	1.14, 1.83	0.002
Valvular	0.90	0.58, 1.42	0.661
Hypertrophic	1.07	0.77, 1.47	0.699
Other	4.79	2.38, 9.63	<0.001
Diabetes Mellitus	1.10	0.99, 1.22	0.084
Total Bilirubin (increasing, per mg/dL)	1.06	1.05, 1.07	<0.001
Serum Creatinine (increasing, per mg/dL)	1.10	1.07, 1.14	<0.001
Pretransplant Mechanical Ventilation	2.37	1.75, 3.23	<0.001

	Hazard Ratio	95% Confidence Interval	P-Value
Pretransplant Intensive Care Unit	1.16	1.04, 1.30	0.010
Pretransplant Extracorporeal Membrane Oxygenation	1.78	1.26, 2.52	0.001
Ventricular Assist			
None	Reference	Reference	Reference
LVAD	1.33	1.19, 1.49	<0.001
RVAD	1.89	0.94, 3.81	0.076
TAH	3.41	2.50, 4.65	<0.001
LVAD + RVAD	1.71	1.28, 2.30	<0.001
Heartmate III	1.64	1.05, 2.55	0.030
Donor Age (increasing, per year)	1.01	1.01, 1.01	<0.001
Female Donor	1.21	1.10, 1.35	<0.001
Graft Cold Ischemic Time (increasing, per hours)	1.13	1.08, 1.18	<0.001
Waitlist Time (increasing, per day)	1.00	1.00 1.00	0.016

LVAD, left ventricular assist device; RVAD, right ventricular assist device; TAH, total artificial heart

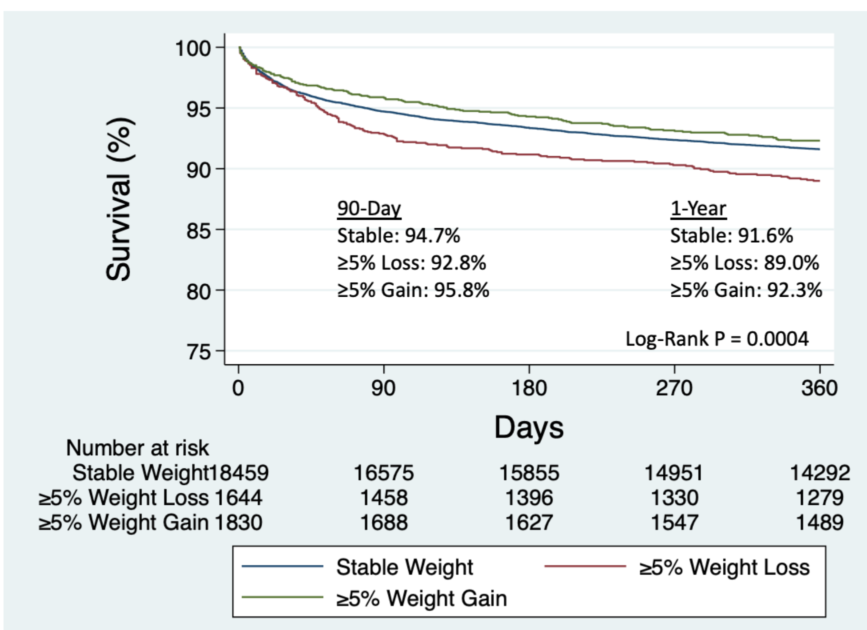
Figure Legend

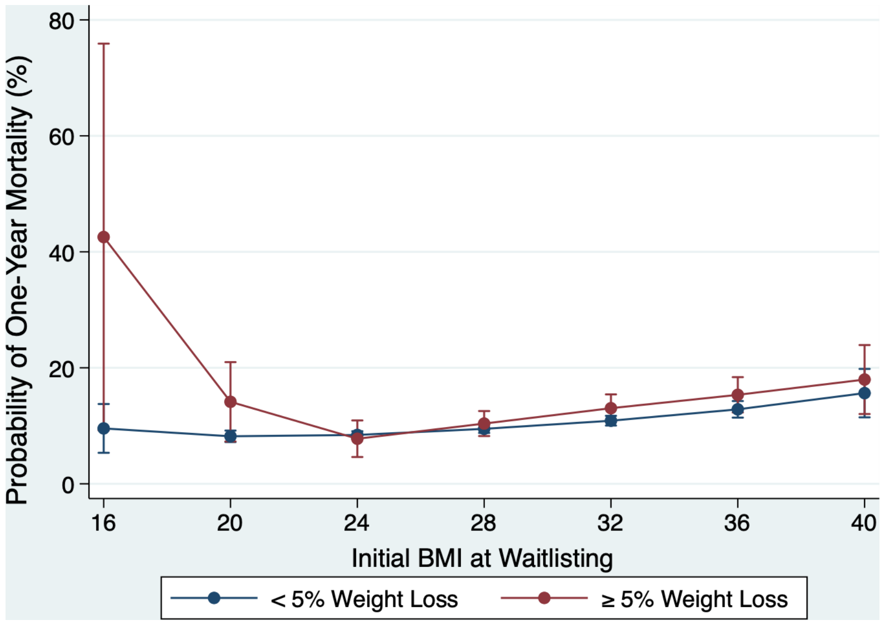
Figure 1. Kaplan Meier survival analysis of primary, isolated orthotopic heart transplant recipients. Patients stratified by percent change in weight from time of waitlisting to transplantation.

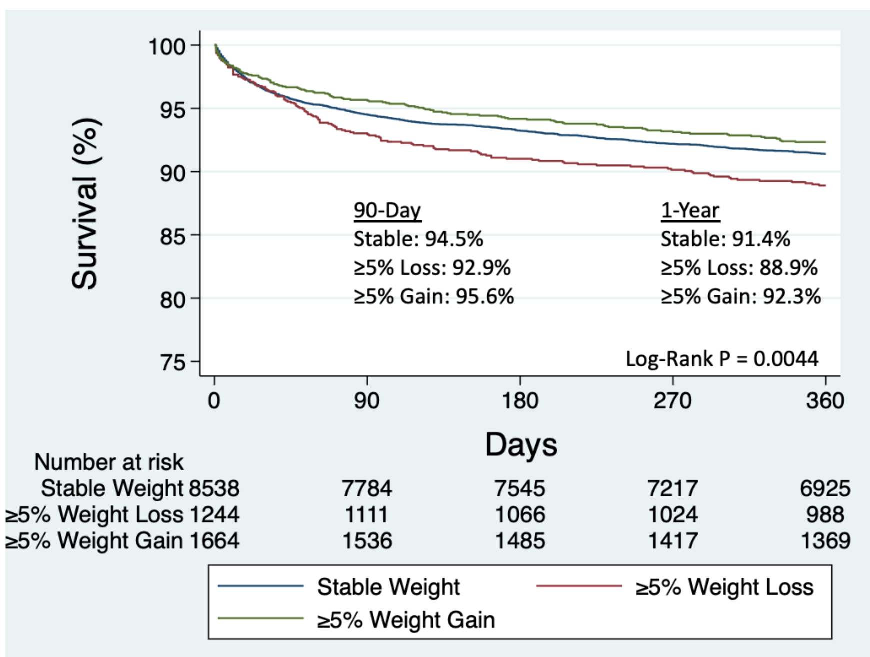
Figure 2. Probability of one-year mortality modeled across initial body mass index at time of waitlisting. Comparison of [?] 5% weight loss and less than 5% weight loss.

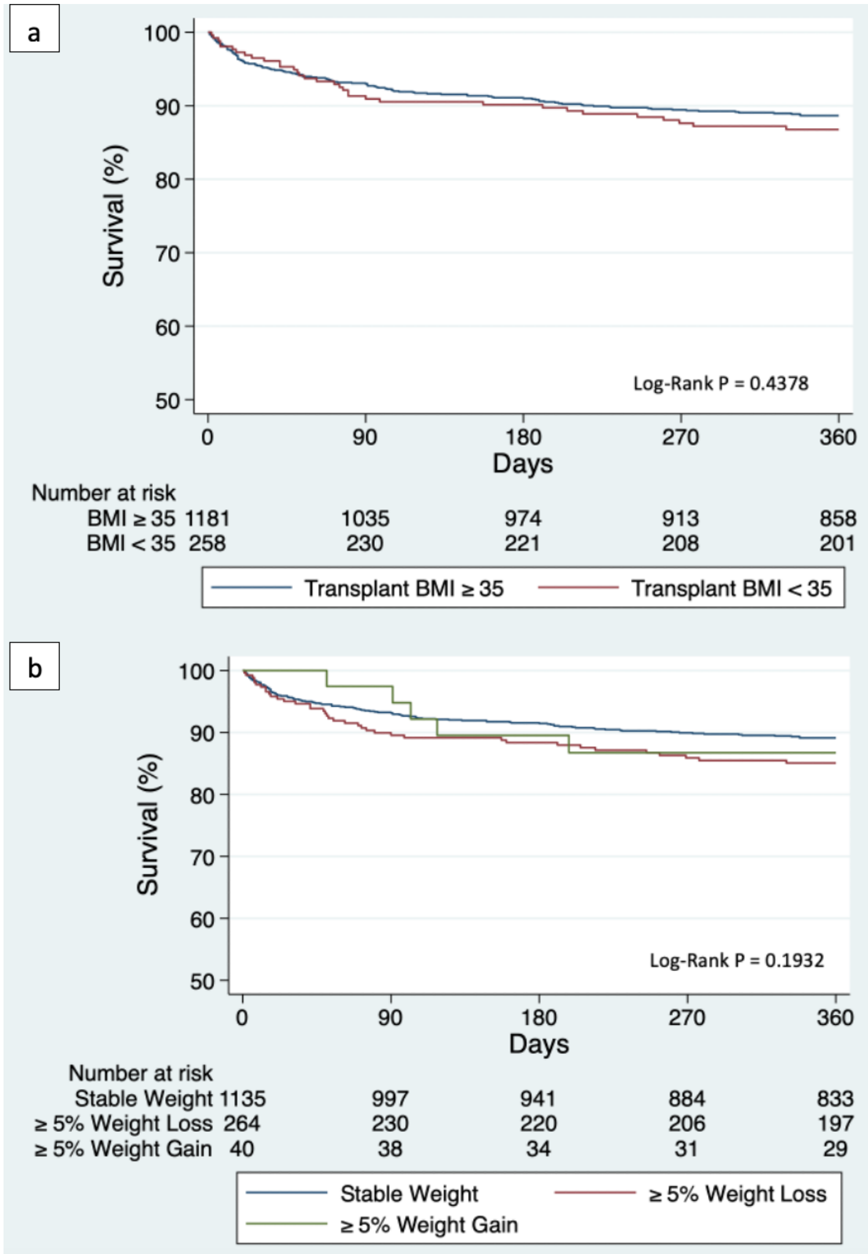
Figure 3. Sub-analysis**.** Kaplan Meier survival analysis of primary, isolated orthotopic heart transplant recipients who were waitlisted [?]90 days. Patients stratified by percent change in weight from time of waitlisting to transplantation.

Figure 4. Sub-analysis**.** Kaplan Meier one-year survival of OHT recipients with initial waitlisting BMI [?] 35 kg/m^2. **Figure 4a** compares recipients with a BMI lower than 35 kg/m^2 at time of transplant with those with BMI [?]35 kg/m^2. **Figure 4b** compares recipients based on weight change while on transplant waitlist.




Probability of One-Year Mortality (%)
0
20
40
60
80
16
20
24
28
32
36
40
Initial BMI at Waitlisting
< 5% Weight Loss
≥ 5% Weight Loss


Survival (%)
75
80
85
90
95
100
90-Day
Stable: 94.5%
≥5% Loss: 92.9%
≥5% Gain: 95.6%
1-Year
Stable: 91.4%
≥5% Loss: 88.9%
≥5% Gain: 92.3%
Log-Rank P = 0.0044
0
90
180
270
360
Days
Number at risk
Stable Weight 8538 7784 7545 7217 6925
≥5% Weight Loss 1244 1111 1066 1024 988
≥5% Weight Gain 1664 1536 1485 1417 1369
Stable Weight
≥5% Weight Loss
≥5% Weight Gain


a
100
90
80
70
60
50
Survival (%)
Log-Rank P = 0.4378
0
90
180
270
360
Days
Number at risk
BMI ≥ 35 1181 1035 974 913 858
BMI < 35 258 230 221 208 201
Transplant BMI ≥ 35
Transplant BMI < 35
b
100
90
80
70
60
50
Survival (%)
Log-Rank P = 0.1932
0
90
180
270
360
Days
Number at risk
Stable Weight 1135 997 941 884 833
≥ 5% Weight Loss 264 230 220 206 197
≥ 5% Weight Gain 40 38 34 31 29
Stable Weight
≥ 5% Weight Loss
≥ 5% Weight Gain