Reoperative Sternotomy Is Associated With Increased Mortality After Heart Transplantation

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Background. **Although several studies have examined factors affecting survival after orthotopic heart transplantation (OHT), few have evaluated the impact of reoperative sternotomy. We undertook this study to examine the incidence and impact of repeat sternotomies on OHT outcomes.**

Methods. **We conducted a retrospective review of all adult OHT from 2 institutions. Primary stratification was by the number of prior sternotomies. The primary outcome was survival. Secondary outcomes included blood product utilization and commonly encountered postoperative complications. Multivariable Cox proportional hazards regression models examined mortality while linear regression models examined blood utilization.**

Results. **From January 1995 to October 2011, 631 OHT were performed. Of these, 25 (4.0%) were redo OHT and 182 (28.8%) were bridged to transplant with a ventricular assist device; 356 (56.4%) had undergone at least 1 prior sternotomy. On unadjusted analysis, reoperative sternotomy was associated with decreased 90-day (98.5% vs 90.2%, $p < 0.001$), 1-year (93.1% vs 79.6%, $p < 0.001$), and 5-year (80.4% vs 70.1%, $p = 0.002$) survival. This difference persisted on multivariable analysis at 90 days (hazard ratio [HR] 2.99, $p = 0.01$), 1 year (HR 2.98, $p = 0.002$), and 5 years (HR 1.62, $p = 0.049$). The impact of an increasing number of prior sternotomies was negligible. On multivariable analysis, an increasing number of prior sternotomies was associated with increased intraoperative blood product utilization. Increasing blood utilization was associated with decreased 90-day, 1-year, and 5-year survival.**

Conclusions. **Reoperative sternotomy is associated with increased mortality and blood utilization after OHT. Patients with more than 1 prior sternotomy do not experience additional increased mortality. Carefully selected patients with multiple prior sternotomies have decreased but acceptable outcomes.**

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Orthotopic heart transplantation (OHT) is the gold-standard for the treatment of end-stage heart failure [1]. As outcomes have improved, the indications for OHT, and thus the number of potential recipients, have continued to increase [2,3]. Unfortunately, because of the relatively stagnant donor pool, the number of OHT performed annually has not changed in almost 2 decades [1, 3]. Thus, given the relative shortage of donor hearts available for OHT, appropriate recipient risk stratification is paramount to ensure optimal allocation of this scarce resource [3].

As the waiting list grows, and mechanical circulatory support technology improves, an increasing number of patients are being bridged to transplantation (BTT) with a ventricular assist device (VAD) [4]. Moreover, an increasing number of patients with heart failure are undergoing nontransplant cardiac surgery to optimize cardiac function before progressing to heart failure requiring VAD or OHT [3, 5, 6]. Thus an increasing number of potential recipients are presenting for OHT having undergone 1 or more prior sternotomies [3,6]. Therefore, it is incumbent on surgeons to understand the impact of reoperative sternotomy on outcomes after OHT. Although reoperative sternotomy is a known risk factor for morbidity and mortality after coronary bypass surgery, its impact on OHT outcomes is unclear [2, 3, 6–13]. Moreover, most previous studies represent single-center experiences of limited sample size. Additionally, most current OHT risk scores do not incorporate reoperative sternotomy because these data are not adequately captured by existing registries [14, 15]. Therefore we undertook this multiinstitutional study to characterize the incidence and impact of reoperative sternotomy on outcomes after OHT.

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Abbreviations and Acronyms

ANOVA = analysis of variance
BMI = body mass index
BTT = bridge to transplantation
CI = confidence intervals
CPB = cardiopulmonary bypass
HR = hazard ratio
IABP = intraaortic balloon pump
ICU = intensive care unit
IQR = interquartile ranges
OHT = orthotopic heart transplantation
PA = pulmonary artery
VAD = ventricular assist device

Material and Methods

Study Design

We conducted a retrospective review of the cardiac surgery databases at both the Johns Hopkins and the Barnes-Jewish Hospitals. Our study included all adult (≥18 years) OHT from 1995 to 2011. Patients undergoing combined heart and lung transplantation were excluded. Each hospital's Institutional Review Board approved this study. We examined pertinent variables in our data set, including the following: recipient demographics and comorbidities; hemodynamics, measures of acuity, and need for support; donor demographics and comorbidities; and transplant variables.

Patient records were reviewed for the number of previous sternotomies prior to OHT. Primary stratification was according to the number of prior sternotomies; 0, 1, or 2 or greater. Subgroup analysis focused on BTT patients. Secondary stratification was by intraoperative blood product utilization. The primary outcomes were 90-day, 1-year, and 5-year survival. Secondary outcomes included common postoperative complications, blood product utilization, and predictors of blood product use.

Statistical Analysis

We compared baseline characteristics stratified by the number of prior sternotomies using analysis of variance for continuous variables and the χ^2 or Fisher exact test for categoric variables as appropriate. For associations found to be significant according to preliminary analysis, post hoc pairwise comparisons were performed using the Tukey-Kramer method for continuous variables and by univariate logistic regression for categoric variables.

Survival was calculated by the Kaplan-Meier method and survival comparisons were performed using the log-rank test. To further analyze mortality, multivariable Cox proportional hazards regression models were constructed. Blood product utilization was analyzed with multivariable linear regression. To construct the multivariable models, all independent covariates were tested in univariate fashion. Variables associated with the outcome measure on exploratory analysis ($p < 0.20$), those with previous literature support, and those with biologic plausibility were incorporated in a forward and backward stepwise fashion into the multivariable model. The likelihood ratio test and Akaike information criterion were utilized in a nested model approach to identify which model had the greatest explanatory power. This method favors a more parsimonious model.

For all analyses, values of p less than 0.05 (2-tailed) were considered statistically significant. Mean values are displayed with standard deviations and median values are displayed with their interquartile ranges. Hazard ratios (HR) and linear regression coefficients are presented with their 95% confidence intervals (CI). Statistical analysis was performed using Stata 12.0 (StataCorp, College Station, TX).

Results

Cohort Statistics

From 1995 to 2011, 631 patients underwent OHT. The mean age was 50 (±12) years and 425 (67.4%) of the patients were male. The most common pre-OHT diagnosis was idiopathic dilated cardiomyopathy (n = 252, 39.9%) followed by ischemic cardiomyopathy (n = 222, 35.2%). Fourteen (2.2%) patients had congenital heart disease.

In this cohort, 25 (4.0%) patients were redo-OHT and 356 (56.4%) had undergone at least 1 prior sternotomy (number of prior sternotomies – 0: 275 (43.6%); 1: 295(46.8%); 2: 47(7.5%); 3: 10 (1.6%); ≥ 4: 4 (0.6%). A total of 182 (28.8%) patients were bridged to OHT with a left ventricle assist device LVAD, 61(9.7%) with a continuous flow device, and 121 (19.2%) with either a pulsatile or temporary support device.

In the study period, 223 (37.4%) patients died with a median follow-up of 5.2 [interquartile range 1.6 to 9.1] years. Overall 90-day, 1-year, and 5-year survival were 90.1%, 85.5%, and 74.6%, respectively.

Baseline Characteristics

When stratified by the number of prior sternotomies (0, 1, or ≥2), most baseline characteristics were well matched between the groups (Table 1). Patients with no prior sternotomies were more likely to be female. As expected, patients with multiple prior sternotomies were more likely to have been bridged to OHT with a VAD, more likely to have undergone a previous OHT, and more likely to have congenital heart disease. Additionally, as the number of prior sternotomies increased, patients required increasing cardiopulmonary bypass durations. Although several other variables were statistically different, most of the absolute differences were small and unlikely clinically relevant.

Sternotomy Outcomes

On unadjusted analysis, reoperative sternotomy was associated with a decreased 90-day (98.5% vs 90.2%, $p < 0.001$), 1-year (93.1% vs 79.6%, $p < 0.001$), and 5-year (80.4% vs 70.1%, p = 0.002; Fig 1A) survival. Most of this increased mortality appears to be the result of early, perioperative mortality. Although those who survive to 90 days still have slightly lower 1-year survival ($p = 0.04$),