Cardiac Transplantation and Surgery for Heart Failure

Post–Heart Transplant Survival Is Inferior at Low-Volume Centers Across All Risk Strata

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Background—Previous studies have demonstrated a relationship between increasing center volume and cardiac transplant outcomes. The purpose of this study was to confirm a relationship between post–heart transplant outcomes and center experience and to determine whether this relationship persists among low- and high-risk heart transplant recipient–donor pairs.

Methods and Results—The United Network for Organ Sharing (UNOS) provided deidentified patient-level data. Analysis included 8029 heart transplant recipients aged ≥18 years and transplanted between January 1, 2001 and December 31, 2006 with follow-up available through February 3, 2009. The primary outcome was observed 1-year posttransplant graft survival. Multivariable logistic regression was used to calculate expected 1-year survival for recipients. Threshold analysis identified 3 discrete risk groups of transplant recipients: high-risk, moderate-risk, and low-risk. Three discrete risk strata for center volume: low (<10.5 recipients/yr), intermediate (10.5 to 47 recipients/yr), and high (>47 recipients/yr) were also identified. χ² test was used to compare 1-year survival at low- and intermediate- with high-volume centers. In multivariable logistic regression analysis, annual center volume was significantly associated with posttransplant graft survival at 1 year (odds ratio [OR]=0.995, 0.992 to 0.999; P=0.010) and primary graft failure (OR=0.985, 0.972 to 0.997; P=0.015), but not stroke (OR=0.996, 0.990 to 1.003; P=0.295), infection (OR=1.001, 0.998 to 1.003; P=0.613), or dialysis (OR=1.001, 0.997 to 1.005; P=0.522). Log-rank test demonstrated significant difference in survival between volume groups with respect to high-risk (P=0.0032) and low-risk (P=0.00415), but not moderate-risk (P=0.128) patients.

Conclusions—A direct relationship existed between increasing center volume and improved graft survival. Across all recipient–donor pair risk strata, posttransplant graft survival at 1 year was significantly lower at low-volume centers. The volume–outcomes relationship was strongest in the highest-risk recipient–donor category. (Circulation. 2010;122[suppl 1]:S85–S91.)

Key Words: outcomes ■ heart transplantation ■ hospital volume ■ survival

Since the seminal report by Luft et al in 1979,¹ there has been mounting evidence that with increasing center volume, patient outcomes improve.²–⁵ This “volume–outcomes” relationship has been observed to be the strongest in outcomes of complex surgical procedures, including heart transplantation.⁶ ⁷

There are a number of potential explanations for the association between high center volume and improved clinical outcomes, including superior surgical technique, expertise of nonsurgical subspecialists, ancillary care personnel and infrastructure, and better recipient and donor selection.

The purpose of this study was to confirm a relationship between post–heart transplant outcomes and center experience, to determine whether this volume–outcomes relationship persists among both low- and high-risk heart transplant recipient–donor pairs and to describe the distribution of recipient–donor pair risk by center volume. Findings from this study may have important implications regarding referral patterns for transplant candidates, as well as the evaluation and certification of transplant centers.

We hypothesized that there was a direct relationship between increasing center volume and improved outcomes among heart transplant recipients and that this relationship was the strongest among higher risk recipient–donor pairs. We further hypothesized that higher-volume centers transplanted a higher percentage of high-risk recipient–donor pairs.

Methods

Data Collection

Use of data in this analysis is consistent with the regulations of the Institutional Review Board of our university and the United Network

From the Division of Cardiothoracic Surgery (M.J.R., A.I., R.E., A.N.I., R.D., Y.N.), Department of Surgery, College of Physicians and Surgeons, Columbia University; and International Center for Health Outcomes and Innovation Research (InCHOIR) (M.J.R., A.I., K.N.H., D.D.A., A.C.G.), Department of Health Policy and Evidence, Mount Sinai School of Medicine, New York.

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for Organ Sharing (UNOS) Data Use Agreement. The Standard Transplant Analysis and Research Dataset were provided by UNOS (data source no. 030309-8). The dataset contains information collected from the UNet database forms including the Transplant Candidate Registration form, the Transplant Recipient Registration form, and the Transplant Recipient Follow-up form. These data are the basis for the UNOS Thoracic Registry.

Study Population
UNOS provided deidentified data for all orthotopic heart transplant recipients in the United States aged 18 years and older between January 1, 2001 and December 31, 2006. Follow-up data were provided through February 3, 2009. Recipients were excluded if they underwent other simultaneous organ transplantation (n=256). Encrypted center identifiers were used to identify the center performing each transplant.

Survival Analysis
Kaplan–Meier analysis with log-rank test was used for time-to-event analysis for graft survival. For graft survival analysis, the outcome of interest was graft loss, defined as patient death or retransplantation. Other patients, including those lost to follow-up or alive at last follow-up, were censored on the date of last known follow-up.

Volume–Outcomes
Multivariable logistic regression analysis was used to determine the relationship between center volume and the outcome measures. The risk factors used in the multivariable analysis included the following: recipient age (<40 years, 40 to 54 years, 55 to 69 years, ≥70 years); recipient heart failure etiology (congenital, hypertrophic, ischemic, restrictive, sarcoidosis, valvular, other); recipient previous heart transplant within 90 days; recipient pulmonary vascular resistance (PVR) >4 Wood units (Wu); recipient estimated glomerular filtration rate (eGFR) (<33 mL/min, 33 to 53 mL/min, >53 mL/min); recipient total bilirubin >2.0 mg/dL; recipient diabetes mellitus; recipient peripheral vascular disease; recipient receiving steroids at transplant; recipient need for ventilator; recipient hypertension; recipient extracorporeal membrane oxygenation (ECMO) at transplant; recipient extracorporeal left ventricular assist device–only at transplant; recipient intracorporeal left ventricular assist device–only at transplant; recipient right ventricular assist device–only at transplant; recipient biventricular assist device at transplant; recipient extracorporeal ventricular assist device at transplant; recipient total artificial heart at transplant; recipient intraaortic balloon pump at transplant; recipient in intensive care unit at transplant; recipient hospitalized at transplant; donor age (20 to 29 years, 30 to 39 years, 40 to 50 years and >50 years); donor:recipient weight ratio of <0.8; donor:recipient weight ratio of >0.8; female donor to male recipient; female donor to female recipient; male donor to female recipient; kidney donor concurrently; lung donor concurrently; pancreas donor concurrently; ischemic time (<1 hour, 1 to 4 hours, and >4 hours); mean number of heart transplants per center per year; and year of transplant.

The primary outcomes measure was posttransplant graft survival at 1 year (PTGS1Y). Other outcomes of interest included morbidity during the transplant hospitalization measured by incidence of stroke, infection, and need for dialysis, as well as primary graft failure (PGF) during the first 30 days after transplant. Center volume was defined as the mean number of heart transplant recipients transplanted annually at a given center from 2001 to 2006. The odds ratio (OR) and 95% CI were reported for each factor.

In the logistic regression model, all patients within the same center by definition take the same value for the variable center volume, thus it has been suggested that the basic assumption of independence of observations may be violated. Therefore, as a sensitivity analysis to assess the effect of modeling structure, we repeated the final regression models (for posttransplant graft survival at 1 year, stroke, infection, need for dialysis, and primary graft failure) in a hierarchical structure including a random transplant center effect.

Volume strata were defined by threshold analysis, using receiver operating characteristic curves and stratum-specific likelihood ratios (SSLRs), and were then used to determine graft survival at 1 year at various thresholds for center volume. Receiver operating characteristic curves were generated by plotting sensitivity on the ordinate and 1- specificity on the abscissa with a risk stratification score as a continuous variable and 1-year mortality as a binary outcome. SSLRs and 95% CIs were generated using threshold values at regular intervals as previously described. Threshold values were determined by combining adjacent volume strata with other statistically indistinct strata based on the presence of SSLRs with overlapping 95% CIs. Threshold values occurred when 2 statistically distinct strata could be formed. This process was repeated until no additional threshold values were found.

Risk Stratification
As previously described, recipient–donor risk stratification score (RSS) was developed using multivariable logistic regression (back-
ward, remove (P>0.15) to assess the simultaneous effect of multiple variables on 1-year graft survival following heart transplantation. Recipients lost to follow-up at less than 1 year (n=77) were excluded from recipient risk stratification analysis. Using the odds ratio (OR) calculated in regression analysis, weights were assigned for each risk factor. Model discrimination between survivors and nonsurvivors was assessed by calculating the area under the receiver operating characteristic curve. Patient risk strata were calculated using threshold analysis as described above.

Data Analysis

All data were analyzed with a statistical software package, Stata 9 (Stata Corp, College Station, Tex). The nonparametric trends test developed by Cuzick13 for ordered data were used to determine the significance of trends in recipient–donor pair risk by center volume. The conventional analysis identified 3 discrete risk groups of transplant recipients (Table 3). In threshold analysis for center volume, 3 discrete risk strata were identified: low volume (<10.5 recipients per year), intermediate volume (10.5 to 47 recipients per year), and high volume (>47 recipients per year) with SSLRs of 1.37 (1.23 to 1.53), 0.96 (0.91 to 1.00), and 0.84 (0.74 to 0.95), respectively (Table 1).

Recipient Risk Stratification

The risk factor score model is summarized in Table 2. The outcome is graft loss 1 year after transplantation (area under the curve=0.665, 0.646 to 0.684; P=0.0098). Threshold analysis identified 3 discrete risk groups of transplant recipients (Table 3).

Center and Risk Strata

Survival stratified by center volume for all recipients: high, moderate, and low-risk is shown in Figure 2. Survival stratified by patient risk group across all centers: high, intermediate, and low volume is shown in Figure 3. Kaplan–Meier survival was then stratified by center volume for each of the 3 recipient risk groups (Figure 4A through 4C). Log-rank test demonstrated that there was a significant difference in survival between center volumes groups among high-risk (P=0.0032) and low-risk (P=0.00415), but not intermediate-risk (P=0.128), patients.

Results

Study Population

Analysis included 8029 recipients. The mean follow-up time was 3.53±2.066 years (0 to 8.11) with a median follow-up time of 3.26 years.

Graft Survival Analysis

Analysis included 37 798.77 patient-years at risk. For graft survival analysis, the outcome of interest was death (n=1932; 24.1%) or retransplantation (n=76, 0.96%). Other patients, including those lost to follow-up (n=231, 2.88%) or alive at last follow-up (n=5790; 72.1%), were censored on the date of last known follow-up. Among the study population, 979 recipients experienced graft loss at less than 1 year.

Center Volume

In multivariable logistic regression analysis, annual center volume was significantly associated with PTGS1Y (OR=0.995, 0.992 to 0.999; P=0.010) and primary graft failure (OR=0.985, 0.972 to 0.997; P=0.015), but not stroke (OR=0.996, 0.990 to 1.003; P=0.295), infection (OR=1.001, 0.998 to 1.003; P=0.613), or dialysis (OR=1.001, 0.997 to 1.005; P=0.522; Figure 1). In sensitivity analysis to assess the effect of modeling structure, odds ratio estimates obtained from hierarchical models were virtually identical to those obtained from binary logistic regression; therefore, binary regression models were presented and discussed.

In threshold analysis for center volume, 3 discrete risk strata were identified: low volume (<10.5 recipients per year), intermediate volume (10.5 to 47 recipients per year), and high volume (>47 recipients per year) with SSLRs of 1.37 (1.23 to 1.53), 0.96 (0.91 to 1.00), and 0.84 (0.74 to 0.95), respectively (Table 1).

Table 1. Risk Strata and Associated Stratum-Specific Likelihood Ratios for Center Volume

<table>
<thead>
<tr>
<th>Average Annual Volume</th>
<th>SSLR</th>
<th>95% CI</th>
<th>n (%)</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High &gt;47</td>
<td>0.84</td>
<td>0.74-0.95</td>
<td>1252 20.4</td>
<td>6 4.2</td>
</tr>
<tr>
<td>Intermediate 10.5-47</td>
<td>0.96</td>
<td>0.91-1</td>
<td>5396 62.6</td>
<td>61 42.7</td>
</tr>
<tr>
<td>Low &lt;10.5</td>
<td>1.37</td>
<td>1.23-1.53</td>
<td>1381 17.0</td>
<td>76 53.1</td>
</tr>
</tbody>
</table>

Table 2. Multivariable Model of Risk Factors for Graft Loss at One-Year After Transplant

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVAD-only</td>
<td>7.236</td>
<td>2.058-25.45</td>
<td>0.002</td>
</tr>
<tr>
<td>ECMO</td>
<td>5.374</td>
<td>1.479-19.524</td>
<td>0.011</td>
</tr>
<tr>
<td>Extracorporeal VAD</td>
<td>3.912</td>
<td>2.137-7.161</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Etiology:congenital</td>
<td>2.882</td>
<td>1.97-4.216</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>eGFR&lt;33 ml/min</td>
<td>2.744</td>
<td>2.196-3.43</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Recipient age &gt;65 yo</td>
<td>2.481</td>
<td>1.508-4.083</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total artificial heart</td>
<td>2.418</td>
<td>1.069-5.47</td>
<td>0.034</td>
</tr>
<tr>
<td>Total bilirubin &gt;2.0 mg/dL</td>
<td>1.653</td>
<td>1.366-2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Donor age &gt;50 yo</td>
<td>1.606</td>
<td>1.255-2.055</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intubated</td>
<td>1.577</td>
<td>1.042-2.387</td>
<td>0.031</td>
</tr>
<tr>
<td>Paracorporeal VAD</td>
<td>1.406</td>
<td>0.994-1.988</td>
<td>0.054</td>
</tr>
<tr>
<td>Ischemic time &gt;4 hours</td>
<td>1.378</td>
<td>1.157-1.641</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Donor age 40–49 yo</td>
<td>1.312</td>
<td>1.079-1.596</td>
<td>0.007</td>
</tr>
<tr>
<td>Recipient age 50–65 yo</td>
<td>1.312</td>
<td>1.116-1.542</td>
<td>0.001</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1.311</td>
<td>0.909-1.89</td>
<td>0.147</td>
</tr>
<tr>
<td>eGFR 33–53 ml/min</td>
<td>1.301</td>
<td>1.091-1.551</td>
<td>0.003</td>
</tr>
<tr>
<td>Female donor:Male recipient</td>
<td>1.274</td>
<td>1.024-1.585</td>
<td>0.03</td>
</tr>
</tbody>
</table>

ECMO indicates extracorporeal membrane oxygenation; eGFR, estimated glomerular filtration rate; RVAD, right ventricular assist device.

Table 3. Risk Group Strata Thresholds and Outcomes

<table>
<thead>
<tr>
<th>Risk Group</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>4628</td>
<td>2281</td>
<td>1120</td>
<td>8029</td>
</tr>
<tr>
<td>%</td>
<td>57.6</td>
<td>28.4</td>
<td>13.9</td>
<td></td>
</tr>
<tr>
<td>SSLR</td>
<td>2.8</td>
<td>1.13</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>LL-SSLR</td>
<td>2.5</td>
<td>1.02</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>UL-SSLR</td>
<td>3.13</td>
<td>1.25</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>Expected 1-year survival (%)</td>
<td>92.4</td>
<td>86.6</td>
<td>72.9</td>
<td>88.0</td>
</tr>
</tbody>
</table>

LL-SSLR, stratum-specific likelihood ratio, lower limit; UL-SSLR, stratum-specific likelihood ratio, upper limit.
Table 4 shows the distribution of recipient risk across center volume strata. Of note, low-volume centers transplanted a higher proportion (P<0.001) of higher-risk recipients (15.2%) compared with intermediate-volume (14.2%) and high-volume (11.7%) centers.

Discussion

This analysis supports findings by other investigators that there is a significant relationship in heart transplantation between increasing center volume and improved posttransplant outcomes, including survival. As expected, posttransplant 1-year graft survival was significantly diminished at centers with low heart transplant volume. In addition, center volume was strongly associated with primary graft failure at 30 days. Surprisingly, however, this relationship was not observed among in-hospital complications, including infection, stroke, and dialysis.

Over the past decade, there has been mounting evidence that patients undergoing complex medical treatments and surgical interventions have better outcomes at centers performing such procedures more frequently1–5; however, much remains to be understood regarding the causal relationship between volume and outcomes.

There are a number of possible explanations for this phenomenon. Hospital volume may, in fact, serve as an easily measured surrogate for a myriad of different clinical practices and processes of care that are true causal factors. That is, centers with higher volumes may possess a greater knowledge base among specialists and a more developed physical infrastructure for delivering care. In addition, for complex surgical procedures, some aspect of “practice makes perfect,” with volume as a more direct measure of technical expertise, may be important. In transplantation, where patients undergo complex operations and then require care from various
medical and surgical subspecialists, as well as social support from nonmedical disciplines, the causes of the volume–outcomes relationship are likely multifactorial.

This study further explored this “volume–outcomes” effect by determining whether the relationship persists across a broad range of recipient risk strata. Specifically, it examined whether superior outcomes observed in higher-volume heart transplant centers are at least, in part, explained by differences in center outcomes across various recipient–donor pair risk strata and/or differences in recipient–donor selection.

Threshold Analysis
Threshold analysis, using SSLRs and receiver operator curves, was performed to stratify centers by mean annual transplant volume and recipient–donor pairs by expected posttransplant survival risk. This analysis was not intended to define minimum requirements for centers or to exclude candidates from consideration for transplantation. Rather, in this study, threshold analysis was used as a method to objectively and rigorously stratify centers by volume and recipient–donor pairs risk for the purpose of determining if the volume–outcomes effect persisted among both low- and high-risk heart transplant recipient–donor pairs.

Nevertheless, it is interesting to note that for center strata, posttransplant graft survival was similar in the intermediate volume (10.5 to 47 transplants per year) and high-volume (>47 transplants per year) strata; therefore, extremely high volume did not appear to be associated with a proportional improvement in posttransplant outcomes compared with more moderate volume. Conversely, survival in the low-volume (<10.5 transplants per year) strata (a benchmark similar to the Center for Medicare and Medicaid Services [CMS] standard of >=10 transplants per year to obtain CMS approval14) had significantly worse posttransplant graft sur-

![Figure 4. A, Survival of high-risk recipients stratified by center volume. B, Survival of moderate-risk recipients stratified by center volume. C, Survival of low-risk recipients stratified by center volume.](image-url)
vival when compared with intermediate and high-volume centers. This suggests that some minimum level of provider experience and institutional infrastructure is needed to achieve better posttransplant outcomes.

Recipient Risk and Center Volume

Compared with low-volume centers, superior survival was observed in high- and intermediate-volume centers across all risk strata. The relationship was the strongest in the highest risk category. It should be noted that in this discussion “high volume” is used; however, our results demonstrate that survival is equivalent at high- and intermediate-volume centers (considered here as “higher-volume centers”) and inferior at low-volume centers across all patient categories. In the intermediate-risk stratum, there was a trend toward better survival at the centers with higher volume, but the relationship was not statistically significant. Although it was statistically significant in the lowest-risk stratum, the observed differences in survival may not be as clinically significant.

These findings support the concept that high-risk recipients should be referred to higher-volume centers. However, the need to refer low-risk recipients to higher-volume centers may be less important.

It has been suggested that low-volume centers do not list high-risk recipients because of concern that it would increase the center mortality and that by regionalizing performance of complex procedures, high-risk patients would have better access to resources. This analysis suggests that low-volume centers actually transplant a higher percentage of high-risk recipient–donor pairs than intermediate and high-volume centers. There are a number of explanations for this finding in low-volume centers, including more limited experience evaluating recipients and donors; more limited referral basis, leaving these centers with only the sickest patients; and an attempt by centers to increase volume by more aggressively transplanting higher risk recipients.

Implications

Findings from this analysis may have important policy implications. First, it appears that aggregate outcomes could be improved if high-risk recipients were referred to higher-volume centers, especially considering that low-volume centers transplanted a high proportion of high-risk recipients despite having inferior results with this group. Furthermore, it must be recognized that center volume is not the sole determinant of quality. In fact, in this analysis, intermediate- and high-volume centers had similar outcomes. All centers, regardless of volume, could benefit from quality initiatives that promote better sharing of knowledge among centers. The effectiveness of such consortiums has been demonstrated in other areas including cardiac surgery.

Limitations

Patient registries often suffer from data entry variability; however, fields contained within this database were generally well-populated, with a 90% to 99% data entry rate for the majority of

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**Table 4. Distribution of Recipient Risk Across Center Volume Strata**

<table>
<thead>
<tr>
<th>Center Volume</th>
<th>Low Risk</th>
<th>Moderate Risk</th>
<th>High Risk</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High volume</td>
<td>813</td>
<td>293</td>
<td>146</td>
<td>1252</td>
</tr>
<tr>
<td>n</td>
<td>64.94</td>
<td>23.4</td>
<td>11.66</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>3112</td>
<td>1520</td>
<td>764</td>
<td>5396</td>
</tr>
<tr>
<td>n</td>
<td>57.67</td>
<td>28.17</td>
<td>14.16</td>
<td></td>
</tr>
<tr>
<td>Low volume</td>
<td>703</td>
<td>468</td>
<td>210</td>
<td>1381</td>
</tr>
<tr>
<td>n</td>
<td>50.91</td>
<td>33.89</td>
<td>15.21</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4628</td>
<td>2281</td>
<td>1120</td>
<td>8029</td>
</tr>
<tr>
<td>n</td>
<td>57.64</td>
<td>28.41</td>
<td>13.95</td>
<td></td>
</tr>
</tbody>
</table>
variables. Although the UNOS reporting system provided variable definitions in data guidelines, definitions may still vary by center. Nevertheless, the major outcomes of this analysis, including morbidity and mortality, are likely not subject to significant variability in interpretation among sites. One limitation of the UNOS registry is the inability to determine the cause of death of recipients, which could potentially lead to a more in-depth analysis of risk factors for specific outcomes.

Although our regression model demonstrated moderate discrimination, significant variability remains unexplained. We speculate that some of the variability stems from functional status and clinical variables that were not captured by the UNOS dataset, as well as technical aspects of the procedures not apparent in the pretransplant dataset. Prospective validation of our model may alleviate some of these limitations. Derived volume and risk strata were not validated in a new dataset.

Differences in outcomes cannot be explained by this analysis. It is possible, as demonstrated in our previous analysis of the UNOS database to categorize the cause of death, including acute rejection, cardiovascular cause, pulmonary cause, cerebrovascular accident, hemorrhage, infection, or primary graft failure. However, additional analyses not presented here have shown that stratifying by center volume, recipient–donor risk, and cause of death, no significant relationships were identified. The fact that the greatest differences in posttransplant graft survival were observed within the first 3 months in this analysis suggests that the difference across volume strata described here are explained, at least in part, by patient selection and preparation, donor–patient matching, surgical technique, and early postoperative care, including immunosuppression. Unfortunately, because of limitations of this retrospective analysis, greater insight into these complex relationships is not possible. In addition, it should be noted that some low-volume centers had excellent outcomes comparable to high-volume centers. Although the portion of such low-volume centers was small, further research is necessary to determine the etiology of this underlying variability between low-volume centers. This is a challenge given the minimal number of transplants that these centers perform each year.

Finally, the mean number of heart recipients per year suffers from a number of limitations; most significantly, there is random variation in volume from year to year. However, this variation was relatively small in our analysis.

Conclusions

A direct relationship existed between increasing center volume and improved graft survival. Across all recipient–donor pair risk strata, posttransplant graft survival at 1 year was significantly diminished at centers with low heart transplant volume; outcomes were similar in the intermediate- and high-volume centers. The volume–outcomes relationship was strongest in the highest-risk recipient–donor pair category. Although statistically significant in the low-risk category, differences may not be clinically relevant.

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Disclosures

None.

References

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