National Decline in Donor Heart Utilization With Regional Variability: 1995–2010

K. K. Khush1,*, J. G. Zaroff2, J. Nguyen3, R. Menza4 and B. A. Goldstein5

1Division of Cardiovascular Medicine, Department of Medicine, Stanford University School of Medicine, Palo Alto, CA
2Kaiser Northern California Division of Research, Oakland, CA
3California Transplant Donor Network, Oakland, CA
4Graduate School of Nursing, Midwifery, and Health, Victoria University of Wellington, Wellington, New Zealand
5Department of Biostatistics and Bioinformatics, Duke University School of Medicine, Durham, NC
*Corresponding author: Kiran K. Khush, kiran@stanford.edu

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

The severe shortage of donor hearts limits the availability of transplantation for the growing population of patients with end-stage heart disease. We examined national trends in donor heart acceptance for transplant. OPTN data were analyzed for all potential adult cardiac organ donors between 1995 and 2010. Donor heart disposition was categorized as transplanted, declined for transplant or other. We studied changes in the probability of donor heart acceptance according to demographic and clinical characteristics, nationwide and by UNOS region. Of 82,053 potential donor hearts, 34% were accepted and 48% were declined (18% used for other purposes). There was a significant decrease in donor heart acceptance from 44% in 1995 to 29% in 2006, and subsequent increase to 32% in 2010. Older donor age, female sex and medical co-morbidities predicted non-acceptance. Donor age and co-morbidities increased during the study period, with a concomitant decrease in acceptance of hearts from donors with undesirable characteristics. Overall, predictors of heart non-use were similar across UNOS regions, although utilization varied between regions. Regional variation suggests a potential to improve heart acceptance rates in under-performing regions, and supports research and policy efforts aimed at establishing evidence-based criteria for donor heart evaluation and acceptance for transplantation.

Abbreviations: INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; LVEF, left ventricular ejection fraction; MPSC, Membership Professional Standards Committee; OE, observed to expected; OPTN, Organ Procurement and Transplantation Network; UNOS, United Network for Organ Sharing

Received 31 August 2014, revised 09 October 2014 and accepted for publication 13 October 2014

Introduction

Heart transplantation remains the best therapeutic option for patients with end-stage heart disease, with current median survival reported at 11 years overall and 13 years for those surviving the first year (1). Despite estimates showing that more than 20,000 patients could benefit from this life-saving procedure each year, only 1949 heart transplants were performed in the United States in 2011, with a concurrent waiting list mortality of 12.4 per 100 waitlist years (2).

The severe and persistent shortage of donor organs considerably limits the availability of heart transplantation. Despite this donor organ shortage, only one in three available donor hearts is currently accepted for transplantation, which greatly limits heart transplant rates nationwide. Many reasons exist for discarding donor hearts, including demographic and clinical factors (e.g. older age, small size), co-morbidities (hypertension, diabetes) and cardiac findings (left ventricular hypertrophy, left ventricular dysfunction) (3).

Currently, criteria for acceptance of donor hearts for transplantation remain poorly studied and even less well standardized. We therefore aimed to closely examine national trends in donor heart acceptance and variation across geographical regions of the United States, over the past two decades. Through an examination of current predictors of donor heart non-use, we hope to inform future research and policy efforts aimed at judiciously increasing utilization rates, thereby making heart transplantation available to a greater number of patients dying from end-stage heart failure.
Materials and Methods

Study population
This study used transplant donor, adult heart transplant waiting list, and postheart transplant survival data obtained from the Organ Procurement and Transplantation Network (OPTN) database, by way of Standard Transplant Analysis and Research files. The OPTN database includes demographic and clinical information on all organ donors and transplant recipients in the United States, submitted by their transplant centers, and is provided to investigators as de-identified data. The Health Resources and Services Administration, US Department of Health and Human Services, provides oversight of the activities of the OPTN contractor, the United Network for Organ Sharing (UNOS).

All potential organ donors after neurologic determination of death who were between 18 and 70 years of age and were managed between January 1, 1995 and December 31, 2010 were included. Posttransplant recipient follow-up extended through March 2, 2012.

Study definitions and endpoints
The OPTN database recorded donor heart disposition according to six categories: (1) authorized but not recovered for transplant (37% of hearts in the study population), (2) no authorization for heart recovery given by living next-of-kin (4%), (3) no request for heart donation was made to living next-of-kin (8%), (4) recovered-not for transplant (13%), (5) recovered-not transplanted (1%) and (6) transplanted (36%). We grouped these categories into three mutually exclusive groups: Transplanted (6), Declined for Transplant (1 and 3) and Other (2, 4 and 5). We focused our analyses on the differences between donor hearts that were accepted (Transplanted) and those that were not accepted (Declined) for transplantation.

Donor characteristics and recipient outcomes
To investigate regional differences in donor heart acceptance, we considered a series of donor characteristics. These included demographic factors (age, sex) and clinical factors (hypertension, diabetes, cause of death and left ventricular ejection fraction [LVEF]). For some variables, for example LVEF, OPTN reporting has improved over time, and missing values were set to unknown. We dichotomized age at 50 years, LVEF at 50%, and cause of death as cerebrovascular versus other, based on prior studies (3).

Heart transplant recipients were included if they were between 14 and 70 years old at the time of transplantation, in order to capture potential recipients of adult donor hearts. Multi-organ transplant recipients were excluded. We assessed 30-day and 1-year graft survival and overall survival.

Statistical analysis
We investigated changes in the probability of donor heart acceptance over the 15-year study period for the demographic and clinical characteristics of interest. To assess regional variation in donor heart acceptance in the United States, we studied differences between the 11 UNOS regions into which the country has been divided to facilitate transplant-related activities. For each region we fit a logistic regression model, regressing whether or not a graft was accepted for transplantation onto demographic and clinical variables, and calculated the odds ratio of donor heart acceptance for each characteristic of interest. We used a cubic polynomial for year to allow for nonlinearity over time. To assess regional differences we fit an overall model and assessed the differences in the fixed effect between regions.

Results

Donor characteristics
A total of 82,053 potential donors met study inclusion criteria; of these, hearts from 28,098 (34%) were accepted and 39,529 (48%) were declined for transplantation. Three-quarters of the remaining 18% of donor hearts were recovered for uses other than transplantation, such as for heart valve procurement or research purposes.

The characteristics of all potential donors who met study inclusion criteria are presented in Table 1. As demonstrated, donors whose hearts were declined for transplantation were significantly more likely to be female, older, have hypertension or diabetes, died from cerebrovascular causes, were of Asian race, or had reduced left ventricular systolic function (ejection fraction <50%).

National donor heart utilization
As shown in Figure 1, the fraction of available donor hearts that were accepted for transplantation declined steadily over the study period, with a high of 44% in 1995 and a nadir of 29% in 2006; utilization increased slightly to 32% by 2010. Conversely, the percentage of available donor hearts that were declined for transplant rose steadily from 37% in 1995 to 52% in 2010. These trends toward greater avoidance of “marginal” donor hearts occurred despite national efforts aimed at increasing the use of available donor organs for transplantation, as shown in Figure 1, including the Crystal City recommendations (2001) (4) and the Organ Donation Breakthrough Collaborative (2003) (5). Other relevant milestones that may have been expected to improve national organ utilization rates include the change in the allocation algorithm to allow broader regional sharing of donor hearts (2006) (6) and the Centers for Disease Control high risk designation, implemented in 2008, which required special informed consent from recipients of organs from donors considered to be at increased risk of undetected human immunodeficiency virus infection (7). Special informed consent has been previously shown to be associated with higher utilization of donor livers and kidneys (8).

We then examined changes in national donor characteristics over time, focusing on characteristics that have been previously shown to predict non-acceptance of donor hearts (3). Figure 2A demonstrates an increase in donor age and an increase in the prevalence of hypertension and diabetes over the time period studied, among available donor hearts. Between 1995 and 2010, mean donor age increased from 40.3 to 43.2 years, prevalence of diabetes increased from 3.5% to 13.7%, and prevalence of hypertension increased from 23.3% to 38.9%. Of note, data on left ventricular systolic function were missing for most donors in the OPTN database prior to 2005. The proportion of female donors remained relatively constant and the proportions of donors with cerebrovascular causes of death declined slightly during this period.
We next examined the percentage of hearts accepted for transplantation, by donor characteristics, again focusing on characteristics that predict non-acceptance. As demonstrated in Figure 2B, there was a steady decrease in the percent of hearts accepted for transplant from female donors, from donors over 50 years of age, and from donors who died from cerebrovascular causes. The corresponding 30-day and 1-year survival for heart transplant recipients during the study time period is shown in Figure 2C.

**Donor heart utilization, by UNOS region**

Figure 3 demonstrates the proportion of available donor hearts accepted for transplantation, by UNOS region (Figure 3A), during three time periods: 1995–1999 (Figure 3B), 2000–2005 (Figure 3C) and 2006–2010 (Figure 3D). Geographic variation in donor heart acceptance is apparent, with relatively high utilization in regions 1, 4, and 11 and relatively low utilization in regions 3, 6 and 9 in 1995–1999. Regions 1 and 11 continued to demonstrate above-average utilization in 2000–2005, with relatively low utilization in regions 3, 6, 7 and 8. Relative improvement was seen in donor heart utilization in regions 5 and 9 in this era, compared to other regions, while a relative decline in utilization was seen in regions 2, 4 and 10. In the most recent era (2006–2010), above-average donor heart utilization was seen in regions 1 and 5, and below-average in regions 2, 3, 4, 6 and 9. Note a decrease in median national donor heart utilization from 41% in 1995–1999 to 30% in 2006–2010.

**Donor heart utilization, by UNOS region**

Table 3 demonstrates the proportion of available donor hearts accepted for transplantation, by UNOS region (Figure 3A), during three time periods: 1995–1999 (Figure 3B), 2000–2005 (Figure 3C) and 2006–2010 (Figure 3D). Geographic variation in donor heart acceptance is apparent, with relatively high utilization in regions 1, 4, and 11 and relatively low utilization in regions 3, 6 and 9 in 1995–1999. Regions 1 and 11 continued to demonstrate above-average utilization in 2000–2005, with relatively low utilization in regions 3, 6, 7 and 8. Relative improvement was seen in donor heart utilization in regions 5 and 9 in this era, compared to other regions, while a relative decline in utilization was seen in regions 2, 4 and 10. In the most recent era (2006–2010), above-average donor heart utilization was seen in regions 1 and 5, and below-average in regions 2, 3, 4, 6 and 9. Note a decrease in median national donor heart utilization from 41% in 1995–1999 to 30% in 2006–2010.

**Donor heart utilization, by UNOS region**

We next examined the odds of donor heart acceptance for transplantation in the 11 UNOS regions, focusing on donor characteristics that have previously been shown to predict non-acceptance (3): older age (defined as age >50 years), female sex, hypertension, diabetes, cerebrovascular cause of death and left ventricular dysfunction (ejection fraction <50%). As demonstrated in Figure 4, all six donor characteristics were significantly associated with heart non-acceptance, and this finding was consistent across UNOS regions.

| Table 1: Donor characteristics |
|--------------------------------|
| **Overall** (N = 82,053) | **Transplanted<sup>1</sup>, N = 28,098 (34%) | **Declined<sup>2</sup>, N = 39,529 (48%) | **Other<sup>3</sup>, N = 14,426 (18%) | **p-Value** |
| Female | 34,024 (41%) | 8,741 (31%) | 18,346 (46%) | 6,937 (48%) | <0.001 |
| Age >50 years | 39,381 (36%) | 2,982 (11%) | 20,729 (52%) | 5,670 (39%) | <0.001 |
| Height (cm) | 173 (165, 180) | 175 (168, 183) | 170 (163, 178) | 170 (163, 178) | <0.001 |
| Weight (kg) | 77 (67, 90) | 78 (68, 90) | 77 (66, 91) | 77 (65, 91) | <0.001 |
| Race | | | | | |
| White | 57,793 (70%) | 19,996 (71%) | 27,553 (70%) | 10,244 (71%) | <0.001 |
| Black | 11,407 (14%) | 3,472 (12%) | 5,838 (15%) | 2,097 (15%) | <0.001 |
| Asian | 1,805 (2%) | 416 (1%) | 1,036 (3%) | 353 (2%) | <0.001 |
| Hispanic | 10,081 (12%) | 3,906 (14%) | 4,613 (12%) | 1,562 (11%) | <0.001 |
| Other | 967 (1%) | 308 (1%) | 489 (1%) | 170 (1%) | <0.001 |
| Cause of death | | | | | |
| Anoxia | 10,485 (13%) | 2,675 (10%) | 5,919 (15%) | 1,891 (13%) | <0.001 |
| Cerebrovascular | 38,995 (48%) | 8,291 (30%) | 22,741 (58%) | 7,963 (55%) | <0.001 |
| Head trauma | 30,352 (37%) | 16,335 (58%) | 9,809 (25%) | 4,208 (29%) | <0.001 |
| CNS tumor | 679 (1%) | 313 (1%) | 271 (1%) | 95 (1%) | <0.001 |
| Unknown | 1,542 (2%) | 484 (2%) | 789 (2%) | 269 (2%) | <0.001 |
| Hypertension | | | | | |
| Yes | 26,553 (32%) | 3,727 (13%) | 17,375 (44%) | 5,451 (38%) | <0.001 |
| No | 54,654 (67%) | 24,154 (86%) | 21,670 (55%) | 8,830 (61%) | <0.001 |
| Unknown | 846 (1%) | 217 (1%) | 484 (1%) | 145 (1%) | <0.001 |
| Diabetes | | | | | |
| Yes | 7,376 (9%) | 676 (2%) | 5,271 (13%) | 1,429 (10%) | <0.001 |
| No | 74,156 (90%) | 27,279 (97%) | 33,944 (86%) | 12,933 (90%) | <0.001 |
| Unknown | 521 (1%) | 143 (1%) | 314 (1%) | 64 (<1%) | <0.001 |
| LVEF | | | | | |
| <50% | 5,827 (7%) | 477 (2%) | 3,312 (8%) | 2,038 (14%) | <0.001 |
| >50% | 29,845 (36%) | 18,759 (67%) | 7,479 (19%) | 3,607 (25%) | <0.001 |
| Unknown | 46,381 (57%) | 8,862 (32%) | 28,738 (72%) | 8,781 (61%) | <0.001 |

CNS, central nervous system; LVEF, left ventricular ejection fraction.

1Recovered and accepted for transplant.
2Authorized but not recovered for transplant; or no request made for heart donation.
3Authorization not received; recovered, not for transplant; or recovered, not transplanted.

Khush et al American Journal of Transplantation 2015; 15: 642–649
Probability of donor heart acceptance, by UNOS region

An overall model of the probability of donor heart acceptance, by year and UNOS region, is shown in Figure 5A. This unadjusted model once again demonstrates an overall national decline in donor heart acceptance from 1995 to 2008, with an increase in the probability of acceptance for most regions between 2008 and 2010. We did note significant differences between geographical areas. Regions 1, 2 and 11, for example have a higher probability of donor heart acceptance compared to regions 3 and 6. Figure 5B shows the probability of donor heart acceptance after adjusting for donor characteristics that predict non-use. Regional variation persists, with a consistently higher likelihood of donor heart utilization in regions 1, 2 and 11, compared with other regions, for much of the past decade.

Discussion

Approximately 50% of people diagnosed with heart failure will die within 5 years (9,10). This sobering fact, combined with the rising incidence of heart failure in the United States, underscores the urgent need for donor hearts for transplantation. The severe and persistent shortage of
donor organs, however, considerably limits the availability of heart transplantation, and highlights the importance of using all available organs, when deemed safe and feasible. Unfortunately, there are no standard guidelines for donor heart evaluation and acceptance, resulting in considerable inconsistencies in the types of donor hearts that are accepted by different transplant centers, and likely resulting in non-recovery of potentially useful organs. We therefore leveraged the UNOS database to closely examine characteristics of all potential heart transplant donors in the United States over the past two decades. We focused on donor predictors of heart non-use for transplant, and variations in acceptance patterns nationwide and by UNOS region.

We found a striking decline in use of available donor hearts for transplantation between 1995 and 2006, from 44% to 29% nationwide. This decline occurred despite a steady growth of the heart transplant waiting list, and has likely contributed to increasingly long waiting times for transplantation (2). The adoption of mechanical circulatory support devices (such as left ventricular assist devices or LVADs) to stabilize critically ill patients may, in part, contribute to lower utilization rates. The option of stabilizing a patient with mechanical support as a bridge to transplant may make donor hearts with one or more undesirable features less likely to be accepted for transplantation. Moreover, once an LVAD is implanted, centers may be reluctant to transplant a “marginal” donor heart into a stable device recipient. Recent reports from the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) highlight actuarial survival of 80% at 1 year.
after implantation of continuous-flow pumps, with significantly improved quality of life. Since June 2006, 141 hospitals in the United States have contributed data on over 10,500 device implants to INTERMACS, over half of which were implanted as a bridge to transplantation (11). As shown in Figure 2B, however, the decline in acceptance of donor hearts with undesirable features largely predated the implantation of mechanical circulatory support devices.

Donors have, in general, become older with a greater burden of co-morbidities, as demonstrated in Figure 2A. Mean donor age has increased over the past two decades, as has the prevalence of hypertension and diabetes. Despite the increase in the proportion of donors with these characteristics, however, a smaller proportion of these donors are being accepted for transplantation (Figure 2B).

It is possible that more conservative donor heart acceptance practices may be related to increased scrutiny of posttransplant outcomes by national regulatory bodies, such as the US Centers for Medicare and Medicaid Services, which oversees the nation’s federally approved transplant centers. Furthermore, the Membership Professional Standards Committee (MPSC) of UNOS has been charged with investigating and monitoring programs with reduced performance metrics, such as reduced observed to expected (OE) outcomes ratios. Based on MPSC findings, transplant centers may be warned, reprimanded, placed on probation, or closed, either temporarily or permanently. These actions can result in loss of Medicare certification, and may affect a transplant center’s contracts with managed care companies and loss of designation as a center of excellence. Thus, federal oversight may have had the unintended consequence of increased risk aversion in donor heart acceptance decisions, thereby reducing heart transplant rates. It is worth noting that the OE method has several limitations. This method of assessing transplant center outcomes captures only one of the two important sources of data variation: random variation across patient outcomes, but not variations across transplant centers. It might also overestimate the number of centers considered to be outliers and therefore exaggerates differences between the centers with the best and worst outcomes (12). Other methods of assessing outcomes, such as generalized mixed-effects models that capture variation across transplant centers and avoid exaggerated estimates that result in classification of centers as outliers, may improve accuracy but have not been adopted in transplantation (12).

One may expect posttransplant recipient survival to improve with adoption of more conservative donor heart acceptance practices. Figure 2C reveals a 3% increase in 30-day and 1-year recipient survival over the study period; however, it is unclear whether this small improvement can
Khush et al

be attributed to use of higher-quality donor hearts, or to improvements in postoperative care or immunosuppression. Indeed, there is a paucity of data demonstrating significant associations between donor characteristics and posttransplant adverse events (3,13,14). The potential improvement in posttransplant survival must therefore be carefully weighed against the risk of dying while awaiting heart transplantation in the setting of a donor organ shortage. Indeed, in-hospital mortality is as high as 20% in patients admitted with acutely decompensated heart failure (15).

An examination of regional changes in donor heart acceptance patterns (Figures 3 and 5) show consistently above-average donor heart acceptance rates in regions 1, 2 and 11, with below average use in regions 3, 4, 6 and 9, even after adjusting for donor characteristics, that may vary between geographical areas. These regional discrepancies in utilization rates may reflect differences between transplant centers’ willingness to accept “higher risk” donor hearts, differences in organ procurement organizations’ cardiac evaluation and allocation practices, or a combination of both. It is notable that regions 1, 2, 9 and 11 have several high volume transplant centers located within close geographic proximity; in contrast, regions 6 and 8 have relatively few transplant centers that are geographically dispersed. This factor may play a role in transplant centers’ decisions regarding donor heart acceptance. These regional differences underscore the need for updated consensus guidelines on donor heart acceptance, and evidence-based research supporting these criteria. Furthermore, these results support the development of novel and improved methods of donor heart resuscitation and preservation (16).

This study has significant strengths and limitations. By using the UNOS database, we were able to study a nationally representative sample of potential heart transplant donors in the current era. The large sample size (>80,000 potential donors) enabled us to examine differences in donor characteristics, over time and by region, and to assess for changes in recipient posttransplant survival. While data on some donor characteristics, such as age, sex and cause of death are likely robust, there was a large amount of missing data on other characteristics that likely affect donor heart selection—especially echocardiographic findings. This lack of data on donor heart function (as measured by left ventricular ejection fraction) and wall thickness, as well as levels of serum markers such as cardiac troponin, limits our ability to fully study predictors of donor heart acceptance. Furthermore, we are reluctant to make any causal statements about the relationship between donor characteristics and heart acceptance for transplant. The reason/s for donor heart discard are not well captured in current UNOS database, and variables other than donor characteristics (lack of a suitable recipient, time considerations, donor family preference) may have accounted for some cases of nonuse.

In conclusion, we have demonstrated a national decline in the use of available donor hearts for transplantation in the face of a severe organ-donor shortage and a growing number of patients with end-stage heart disease who are awaiting transplantation. An examination of regional variations in donor heart utilization revealed differences in acceptance patterns by geographic area, suggesting the potential to improve utilization rates in under-performing regions. These results therefore lend support to research and policy efforts aimed at establishing evidence-based criteria for donor heart evaluation and acceptance.

Acknowledgments

We thank the California Transplant Donor Network and the United Network for Organ Sharing for access to the donor data required for this study. The content is the responsibility of the authors alone and does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the US Government. This study was supported by the National Heart, Lung, and Blood Institute (K23HL091143, K.K.K.) and the National Institute of Diabetes and Digestive and Kidney Diseases (K25DK097279, B.A.G.). The data reported here have been supplied by the United Network for Organ Sharing as the contractor for the Organ Procurement and Transplantation Network, and was supported in part by Health Resources and Services Administration contract 234-2005-370011C.

Disclosure

The authors of this manuscript have no conflicts of interest to disclose as described by the American Journal of Transplantation.

References

1. Lund LH, Edwards LB, Kucheryavaya AY, et al. The Registry of the International Society for Heart and Lung Transplantation: Thirtieth official adult heart transplant report—2013; focus theme: Age. J Heart Lung Transplant 2013; 32: 951–964.
2. Colvin-Adams M, Smithy JM, Heubner BM, et al. OPTN/SRTR 2012 Annual Data Report: Heart. Am J Transplant 2014; 14: 113–138.
3. Khush KK, Menza R, Nguyen J, Zaroff JG, Goldstein BA. Donor predictors of allograft use and recipient outcomes after heart transplantation. Circ Heart Fail 2013; 6: 300–309.
4. Zaroff JG, Rosengard BR, Armstrong WF, et al. Consensus conference report: Maximizing use of organs recovered from the cadaver donor: Cardiac recommendations, March 28–29, 2001, Crystal City, VA. Circulation 2002; 106: 836–841.
5. Shafer TJ, Wagner D, Chessare J, Zampiello FA, McBride V, Perdue J. Organ donation breakthrough collaborative: Increasing organ donation through system redesign. Crit Care Nurse 2006; 26: 33–42, 44-38; quiz 49.
6. Nativi JN, Kloury AG, Myrick C, et al. Effects of the 2006 U.S. thoracic organ allocation change: Analysis of local impact on organ procurement and heart transplantation. J Heart Lung Transplant 2010; 29: 235–239.
7. Rogers MF, Simonds RJ, Lawton KE, Moseley RR, Jones WK. Guidelines for preventing transmission of human immunodeficiency virus through transplantation of human tissue and organs. MMWR 1994; 43: 1–17.
8. Kucirka LM, Namuyinga R, Hanrahan C, Montgomery RA, Segev DL. Formal policies and special informed consent are associated with higher provider utilization of CDC high-risk donor organs. Am J Transplant 2009; 9: 629–635.
9. Levy D, Kenchaiah S, Larson MG, et al. Long-term trends in the incidence of and survival with heart failure. N Engl J Med 2002; 347: 1397–1402.
10. Roger VL, Weston SA, Redfield MM, et al. Trends in heart failure incidence and survival in a community-based population. JAMA 2004; 292: 344–350.
11. Kirklin JK, Naftel DC, Pagani FD, et al. Sixth INTERMACS annual report: A 10,000-patient database. J Heart Lung Transplant 2014; 33: 555–564.
12. Zenios S, Atias G, McCulloch C, Petrou C. Outcome differences across transplant centers: Comparison of two methods for public reporting. Clin J Am Soc Nephrol 2011; 6: 2838–2845.
13. Jeevanandam V, Furukawa S, Prendergast TW, Todd BA, Eisen HJ, McClurken JB. Standard criteria for an acceptable donor heart are restricting heart transplantation. Ann Thorac Surg 1996; 62: 1268–1275.
14. Wittwer T, Wahlers T. Marginal donor grafts in heart transplantation: Lessons learned from 25 years of experience. Transpl Int 2008; 21: 113–125.
15. Fonarow GC, Adams KF Jr, Abraham WT, et al. Risk stratification for in-hospital mortality in acutely decompensated heart failure: Classification and regression tree analysis. JAMA 2005; 293: 572–580.
16. Lowalekar SK, Cao H, Lu XG, Treanor PR, Thatte HS. Subnormothermic preservation in somah: A novel approach for enhanced functional resuscitation of donor hearts for transplant. Am J Transplant 2014; 14: 2253–2262.