DR. DAVID A BARAN (Orcid ID : 0000-0002-7754-9953)

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REPORT FROM THE AMERICAN SOCIETY OF TRANSPLANTATION CONFERENCE ON DONOR HEART SELECTION IN ADULT CARDIAC TRANSPLANTATION IN THE U.S.

J. Kobashigawa, MD[1], K. Khush, MD, MAS[2], M. Colvin, MD[3], M. Acker, MD[4], A. Van Bakel, MD, PhD[5], H. Eisen, MD[6], Y. Naka, MD, PhD[7], J. Patel, MD, PhD[1], D.A. Baran, MD[8], T. Daun, RN[1], M. Luu, MBBS[1], M. Olymbios, MBBS[1], J. Rogers, MD[9], V. Jeevanandam, MD[10], F. Esmailian, MD[1], F.D. Pagani, MD, PhD[3], B. Lima, MD[11], J. Stehlik, MD[12]

[1]Cedars-Sinai Heart Institute, Los Angeles, California; [2]Stanford University, Stanford, California; [3]University of Michigan, Ann Arbor, Michigan; [4]University of Pennsylvania, Philadelphia, Pennsylvania; [5]Medical University of South Carolina, Charleston, South Carolina; [6]Drexel University, Philadelphia, Pennsylvania; [7]Columbia University, New York, New York; [8]Newark Beth Israel Medical Center, Newark, New Jersey; [9]Duke University, Durham, North Carolina; [10]University of Chicago, Chicago, Illinois, [11]Baylor University Medical Center, Dallas, Texas; [12]University of Utah, Salt Lake City, Utah

Running Title: Donor heart selection conference

Reprint requests and correspondence:

Jon A. Kobashigawa, MD

Cedars-Sinai Heart Institute

127 S. San Vicente Blvd

Los Angeles, CA 90048, USA

Phone: (310) 248-8310

Fax: (310) 248-8333

Email: Kobashigawaj@cshs.org

Abbreviations

AL	Amyloid Light-Chain
CAV	Cardiac Allograft Vasculopathy
CPR	Cardiopulmonary Resuscitation
cPRA	Calculated Panel Reactive Antibodies
ECD	Extended Criteria Donor
ECMO	Extracorporeal Membrane Oxygenation
HLA	Human Leukocyte Antigen
ISHLT	International Society of Heart and Lung Transplantation
LV	Left Ventricular
LVEF	Left Ventricular Ejection Fraction
MCS	Mechanical Circulatory Support
MFI	Mean Fluorescence Intensity
OE	Observed to Expected
OPO	Organ Procurement Organization
PGD	Primary Graft Dysfunction
PRA	Panel Reactive Antibodies
SRTR	Scientific Registry of Transplant Recipients

RR Relative Risk

RVAD Right Ventricular Assist Device

UNOS United Network for Organ Sharing

US United States

VAD Ventricular Assist Device

Abstract

Cardiac transplantation remains the only definitive treatment for end-stage heart failure. Transplantation rates are limited by a shortage of donor hearts. This shortage is magnified because many hearts are discarded due to strict selection criteria and concern for regulatory reprimand for less than optimal post-transplant outcomes. There is no standardized approach to donor selection despite proposals to liberalize acceptance criteria. A donor heart selection conference was organized to facilitate discussion, and generate ideas for future research. The event was attended by 66 participants from 41 centers with considerable experience in cardiac donor selection. There were state-of-the-art presentations on donor selection, with subsequent break-out sessions on standardizing the process and increasing utilization of donor hearts. Participants debated misconceptions and established agreement on donor and recipient risk factors for donor selection, and identified the components necessary for a future donor risk score. Ideas for future initiatives include modification of regulatory practices to consider extended criteria donors when evaluating outcomes, and prospective studies aimed at identifying the factors leading to non-acceptance of available donor hearts. With agreement on the most important donor and recipient risk factors, it is anticipated that a consistent approach to donor selection will improve rates of heart transplantation.

Introduction

A conference took place on May 1, 2015 at the American Transplant Congress in Philadelphia, Pennsylvania, to provide a forum for in-depth expert discussion regarding donor management and donor heart selection for transplantation. The conference, which was endorsed by the American Society of Transplantation, was attended by 66 participants, many of whom had published on the topic and possessed vast clinical experience in heart transplantation (including cardiologists, cardiac surgeons, transplant coordinators and organ procurement professionals, see Appendix A). Participants came from 41 heart transplant centers across the United States.

Prior to the conference, opinions regarding current donor selection and management practices were solicited from transplant centers via an online survey. This survey included questions about donor management protocols, perceived donor and recipient risk factors, selection criteria and general clinical practice regarding donor selection. Important survey results include: most respondents believe that oversized donors are needed for recipients with pulmonary hypertension, place most importance on height for donor matching, and view undersizing a same-sex donor heart to recipient by >30% as a contraindication. The most common criteria that would cause turndown of a donor heart include: left ventricular ejection fraction (LVEF) $\leq$ 50%, cold ischemia time >4 hours, left ventricular hypertrophy >1.3 cm and donor age >55 years. All responses received from 47 transplant centers (more centers responded to the survey than attended the meeting) are summarized in Table 1.

Currently, donor heart selection is based on several factors including echocardiographic parameters, hemodynamics, catheterization results, pressor requirements, intraoperative anatomic considerations, multiorgan procurement, and post-procurement function (as in ex vivo perfusion). However, there exists no standardized approach towards management and weighing of donor and recipient risk factors, resulting in considerable variability between transplant centers in clinical practice. As a result, between-center comparisons and research collaborations have been difficult to implement. Therefore, the purpose of this conference was to initiate the process of standardization of donor selection for heart transplantation, to optimize overall outcomes and enable future collaborative research.

Current Understanding of Donor Heart Selection

Donor Risk Factors: What's Important?

Donor characteristics do influence post-transplant outcomes but there is contention as to the degree of risk that many of these factors represent. Traditionally the prevailing opinion (supported by ISHLT registry data (1)) has been that increasing donor age is a risk factor for mortality after cardiac transplantation. Currently, the median donor age for utilized hearts is 35 years in the US (1) and 43 years in Europe

(Eurotransplant annual report, 2013). The combination of older donor and older recipient portends a higher risk of mortality and development of cardiac allograft vasculopathy (CAV) (1). In addition, use of hearts from older donors for critically ill Status 1A candidates results in higher mortality than use of younger donor hearts, but post-transplant survival remains better than if these patients were not to receive a transplant. Two recent European retrospective studies demonstrated similar survival outcomes between recipients of younger and older donor hearts, but increased risk of CAV in recipients of the older hearts (2, 3).

The issue of left ventricular hypertrophy in donor selection is controversial, with no clear accepted boundaries on acceptable level of wall thickness. While a single-center study at Stanford found LV wall thickness of greater than 1.4 cm to be significantly associated with reduced survival (4), others have found that mild and moderate LVH (up to 1.7cm) has no adverse effect on survival (5). A subsequent analysis of UNOS data showed no difference in survival between groups with no LVH, mild (1.1-1.3cm), and moderate to severe (>=1.4cm) LVH (6). However, the combination of older age (>55 years) and the presence of LVH, as well as ischemic time >4hr in the presence of LVH was found to negatively impact survival (6).

Examination of interactions between factors may provide important insights that explain some of the conflicting results from studies describing individual risk factors. Multiple studies reveal increasing donor age as a predictor of mortality, but the combination of older age and longer ischemic time, as well as age and gender mismatch (female to male) appears particularly detrimental to long term outcomes. A multi-institutional study by Stehlik et al. (7) employed multivariable logistic regression analysis to identify donor-associated risk predictors and important interactions between these donor characteristics. The study found that a history of hypertension and diabetes mellitus were risk factors for early recipient mortality in male donors, but not in female donors. There was also a significant interaction between donor age and donor-recipient weight difference, with increased risk of death in those with increasing weight difference (undersized donor heart). Donor and recipient gender further modified the degree of risk with a higher risk in female donors when recipients were male.

As a result of these observations, the use of a validated donor risk score taking these interactions into account may provide the best risk prediction in the future. Two studies, Smits et al. (8) using a European database and Weiss et al. (9) using the UNOS database designed and validated donor heart scores that accurately reflected the likelihood of donor heart acceptance and predicted long-term patient mortality. A major criticism of both studies is that recipients supported with MCS were not included in their models. A recent study by Johnston et al. (10) used a transplant risk score specifically for patients on mechanical circulatory support. A 75-point scoring system encompassing 9 recipient and 4 donor variables was used

to predict the 1-year mortality of MCS patients if they were to undergo transplantation. The study found that several variables, such as renal function, recipient age, recent infection, total bilirubin and preoperative ventilatory support, are consistent with non-MCS patient risk factors. Variables unique to MCS patients include BMI, intensive care admission, and MCS type. Such a risk score may be useful for determining organ allocation in MCS patients but requires further validation.

Recipient Risk Factors in the Context of Donor Heart Selection

Like donor risk factors, recipient factors in donor selection need to be considered. Traditionally, the following recipient factors have influenced donor heart selection: age of the patient, size/weight ratio, pulmonary vascular resistance, presence and/or type of circulatory support and antibody sensitization. In every case, these factors are considered relative to the prospective donor.

The presence of pre-transplant renal dysfunction in the recipient has been reported as a risk factor. ISHLT registry data demonstrates an increased post-transplant 5 and 10-year mortality in recipients with increased pre-transplant creatinine (1).

Additional factors resulting in a high-risk recipient are presence of a total artificial heart, biventricular/right ventricular assist device (VAD), those on temporary circulatory support or ventilator prior to transplant, and those with a recent history of dialysis (1).

Balancing Donor and Recipient Risk in Donor Selection

Individual donor and recipient risk factors do not determine post-transplant outcome. It is the complex interactions among risk factors that play a critical role in the outcome of heart transplantation.

Donor/recipient gender mismatch is of great interest since an ISHLT registry study showed that male recipients of female donor hearts had the lowest 5-year actuarial survival and highest risk of CAV, whereas 5-year actuarial survival in female recipients was not affected by donor gender (11). Interestingly, a study that combined gender and age found that donor gender had no effect on survival in female or male recipients less than 45 years of age, but that female donors conferred a higher risk of mortality to male recipients who were over 45 years old (12).

In regard to donor/recipient matching, oversizing of donors for recipients with pulmonary hypertension is controversial. An analysis of UNOS data involving 15,284 transplants revealed no significant effect of smaller weight ratio (<0.8) on the risk of short or long term mortality after transplantation (13). However, recipients with elevated pulmonary vascular resistance who received undersized hearts had worse

survival. Furthermore, in the setting of high pulmonary vascular resistance, male recipients who received hearts from female donors had worse survival than those who received hearts from male donors. A retrospective cohort study of 31,634 patients from the UNOS registry found that donor weight alone did not predict recipient post-transplant survival; instead, predicted total donor heart mass was a better discriminator (14). In that study, a mismatch greater than 10-15% below the recipient's predicted donor heart mass was associated with reduced survival.

Intraoperative Risk Factors

There are many intraoperative risk factors that relate to donor management prior to implantation in the recipient including ischemic time, reperfusion, cardioplegia solution, and whether an MCS device is present. These intraoperative risk factors may increase the risk of primary graft dysfunction (PGD) which remains a significant cause of post-transplant morbidity and mortality, as it is associated with up to two-thirds of deaths in the first 30-days post-transplant.

Other intraoperative risk factor that has been linked with post-transplant outcome is the presence of an MCS device at the time of transplantation. Patients bridged to transplant with MCS also require increased cardiopulmonary bypass time, and increased inotrope use, which are known risk factors for adverse postoperative outcomes (15). In addition, more blood products for a coagulopathy are generally required in these cases, and there is an increased risk of vasoplegia. With increased blood products, the right ventricle of the donor heart may dilate and fail; thus, many programs may desire a younger donor heart that can accommodate right ventricular stress.

Other Specialty Considerations

Immunologic Risk Factors: Avoiding Hyperacute Rejection

Although overall rejection rates have declined substantially over the years with the advent of more effective immunosuppression, almost 5% of patients still experience either cellular or antibody-mediated rejection within the first 30 days of transplant. Hyperacute rejection, although infrequent, remains a concern due to its devastating consequences (16). Pre-transplant sensitization is a major risk factor for early rejection. With the emergence of MCS as an effective bridge to transplantation, the number of sensitized patients awaiting heart transplant is on the rise with a third of the patients now demonstrating positive panel reactive antibodies at transplant (16). The challenge of these patients is that sensitization limits the donor pool (due to incompatible donors), prolongs time on the wait-list, and increases wait-list

mortality. After transplantation, increased rejection may lead to graft loss or development of allograft vasculopathy (17-19).

Extended Criteria Donor Hearts- Standardizing Definitions and Criteria for Use

The Extended Criteria Donor (ECD) heart, while lacking a unified, formal definition, has traditionally been defined by several risk factors. These risk factors include one or more of the following: donor age greater than 40 years, a history of chest trauma, prolonged hospitalization, prolonged CPR or downtime, a history of diabetes/tobacco/illicit drug use, transient reversible hypotension, short-term high dose catecholamine administration, and a substantially smaller weight donor compared to the recipient. In 2001, a consensus-led donor management algorithm specifying suitable hemodynamic and echocardiographic parameters for donor hearts was devised, and was incorporated into the UNOS critical pathway (20).

There is considerable evidence that ECD hearts that may result in favorable post-transplant survival continue to be discarded. A retrospective review of 1,872 potential organ donors in California from 2001 to 2008 showed predictors of non-use to be age >50 years, female sex, death attributable to cerebrovascular accident, hypertension, diabetes mellitus, a positive troponin assay, left-ventricular dysfunction (left ventricular ejection fraction <50%), regional wall motion abnormalities and left-ventricular hypertrophy (20). However, these characteristics seemed to have little effect on recipient outcomes when some of these hearts were transplanted.

Breakout Sessions from the Donor Selection Conference

Each break-out session group included a balanced mix of cardiologists, cardiac surgeons, pathologists, transplant coordinators, and organ procurement professionals. All points of consensus, as well as notable points of contention, were recorded and presented to a reconvened session of all conference participants.

Discussions took place under four main themes:

- Identifying best practices regarding donor selection and management
- Consideration of risk in donor selection
- Donor scoring system: what to include
- Areas for further study

Theme 1: Identifying best practices regarding donor selection and management

There was considerable discussion on common practices in donor heart selection. These practices include the use of oversized donor hearts for pulmonary hypertension/female donor to male recipient, duration of resuscitation and amount of inotropic support offset by normal cardiac function and the use of a young male donor that outweighs all other risk factors for donor acceptance in most scenarios. These and other key points from this discussion are summarized in Table 2.

Theme 2: Consideration of risk in donor selection

Donor and recipient risk factors

Donor age was universally viewed as the most important risk factor to consider in a heart offer, along with left ventricular function (defined as ejection fraction below 50% that failed to improve after donor resuscitation) and the presence of left ventricular hypertrophy. The distance from a transplant center was also considered to be very important, as longer distances would increase the cold ischemic time, which is associated with poorer outcomes after transplantation (21).

For most participants, recipient age was again one of the most important risk factors to consider, given the worse outcomes demonstrated in recipients >60 years (22). Other high priority recipient risk factors included the presence of pulmonary hypertension, congenital heart disease, and/or MCS, as well as redo heart transplantation. Some participants also felt that the severity of end-organ dysfunction in the recipient (i.e. serum bilirubin, creatinine) and whether the patient was on mechanical ventilation pre-transplant should also be considered as high risk. Amyloid patients were also an area of contention, as there is on-going debate on whether AL amyloid patients should be transplanted, due to the systemic nature of the disease.

Overall, it was agreed that these prioritizations of both donor and recipient risk factors were necessary for standardizing the approach to donor selection, and that these discussions would be referred to the SRTR, in the hope of contributing towards a donor selection risk score that incorporates these factors and helps to increase donor acceptance rates. A summary of donor and recipient risk factors and their level of importance, can be found in Table 3.

Regulatory oversight in donor selection

There was concern regarding the issue of regulatory oversight and how it impacts donor selection. As Khush et al. demonstrated in a recent paper, there has been a decrease over the last 20 years in the use of available donor hearts (23). This may be related to increased scrutiny of post-transplant outcomes by

national regulatory bodies (i.e. UNOS Membership Professional Standards Committee). If there is a reduced observed to expected (OE) survival ratio, a transplant center may be warned/reprimanded, placed on probation, or even closed. In addition, this could result in loss of Medicare certification, and could also adversely affect a transplant center's contracts with medical insurance.

The group was concerned that the statistical models used for risk adjustment may not fully adjust for all donor and recipient characteristics (e.g. highly sensitized patient, different forms of MCS, pre-existing coronary artery disease). Centers that perform a disproportionate number of high-risk transplants may be penalized unfairly for "low" performance. Therefore, there is a disincentive for centers to transplant riskier donors or recipients, especially in smaller centers where survival ratios can be greatly affected by just one or two deaths. Participants at this forum strongly felt that more data (for these unmeasured characteristics, such as sensitization level, MCS use) should be incorporated into the risk adjustment models. There could be additional incentives for using higher risk donors to counteract the conservative approach that results in high discard rates.

Theme 3: Working towards a useful donor risk score

The donor heart selection process of matching the donor heart to the ideal recipient involves meticulous review of both donor and recipient characteristics, as well as consideration of factors such as ischemic time and problems in special recipient populations, such as the risk of bleeding and prolonged operations in candidates with durable mechanical circulatory support devices. Therefore, there was agreement that a donor selection risk scoring system would be an extremely useful tool that would provide a standardized approach to the practice of donor selection.

Participants agreed that for such a score to be practical, the score would have to be calculated in real time and displayed in Unet/Donor net, the U.S organ allocation platform. A potential issue was the continually evolving use of MCS devices and improving survival in waitlist patients; therefore, such a score would have to be continually updated with new data.

In addition to donor and recipient factors, a donor risk score might include waitlist mortality, risk of primary graft dysfunction (PGD), post-transplant mortality (30 days, 1 and 3 years), as well as longer-term outcomes such as incidence of CAV. Waitlist mortality, and the relative risk of not taking the heart was also felt to be important to assess the relative benefit of transplantation, but the majority felt that the score should be weighted towards the risks of donor use over the relative risk of donor non-use. Additionally, projected quality of life post-transplant was proposed as a factor, but the majority felt that it was too difficult to incorporate. Everyone agreed that prospective validation of the score would have to

occur based on observed outcomes. In implementing its use, it was agreed that decision guidelines based on score ranges would be needed. The score would also be valuable in clarifying criteria for ECD based on the quantified expected risk associated with the donor characteristics.

There were regulatory concerns regarding the implementation of the score: there was a fear that transplant centers with higher risk scores might be penalized. Some participants suggested excluding high risk transplants from outcome measures, or allowing a percentage of high risk transplants. Overall, a scoring system has great potential to become a vital tool for providing a standardized approach to the practice of donor selection, while also potentially reducing the number of hearts discarded.

Theme 4: Suggestions for further action/ studies in donor selection

Further action and research revolve around more refined donor heart functional studies, factors leading to donor heart non-use, utilization of donor biomarkers of outcome, donor management and optimal strategies for the use of extended criteria donor hearts. These further actions are summarized in Table 4.

Summary of Donor Heart Selection Conference

The increasing success of cardiac transplantation as a treatment for heart failure is currently mitigated by the relative unavailability of donor organs, limiting transplantation rates. Despite a long waitlist, a high percentage of donor hearts are discarded due to strict yet non-standardized selection criteria. This donor heart selection conference was therefore an attempt to discuss the current process of donor selection, with the eventual aim of standardizing the process across transplant centers and increasing utilization of available donor hearts. Through discussion, the participants debunked common misconceptions, established an agreement on a practical approach to the most important donor and recipient risk factors during donor selection, and to identify the components necessary for a future donor selection risk score. Furthermore, ideas for future work were raised, including modifying regulatory practices to include consideration of high-risk donors and candidates when evaluating transplant center outcomes, as well as future prospective studies to identify the factors behind donor heart non-use.

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Disclosure

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APPENDIX A: CONFERENCE PARTICIPANTS

Keith Aronson, MD, University of Michigan Medical Center; Michael Acker, MD, University of Pennsylvania; Luis Arroyo, MD, Tampa General Hospital; David A. Baran, MD, Newark Beth Israel Medical Center; John Belcher, BS, CCEMT-P, CPTC, New England Organ Bank; Gheeta Bhat, MD, Advocate Christ Medical Center; Arvind Bhimaraj, MD, The Methodist Hospital; Joseph Cleveland, MD, University of Colorado; Monica Colvin, MD, University of Michigan Medical Center; Michael Cooper, BSN, MBA, LifeGift; Gregory Couper, MD, Brigham and Women's Hospital; Lawrence Czer, MD, Cedars-Sinai Heart Institute; David D'Alessandro, MD, Montefiore Medical Center; Richard Daly, MD, St. Mary's Hospital (Mayo Clinic); Todd Dardas, MD, MS, University of Washington; Teresa DeMarco, MD, University of California, San Francisco; Eugene DePasquale, MD, University of California, Los Angeles; Shashank Desai, MD, Inova Fairfax Hospital; Michael Dickinson, MD, Spectrum Health; Ioana Dumitru, MD, Memorial Regional Hospital; Leah Edwards, PhD, United Network for Organ Sharing; Howard Eisen, MD, Drexel University; Fardad Esmailian, MD, PhD, Cedars-Sinai Heart Institute; Jerry Estep, MD, The Methodist Hospital; MaryJane Farr, MD, New York-Presbyterian/Columbia; Dan Fishbein, MD, University of Washington; Michael Givertz, MD, Brigham and Women's Hospital; Richard Ha, MD, Stanford University; Alain Heroux, MD, Loyola University Medical Center; Valluvan Jeevanandam, MD, University of Chicago Medical Center; Mariell Jessup, MD, University of Pennsylvania; David Joyce, MD, St. Mary's Hospital (Mayo Clinic); Andrew Kao, MD, St. Luke's Hospital of Kansas City; Kiran Khush, MD, Stanford University; James Kirklin, MD, University of Alabama; Jon Kobashigawa, MD, Cedars-Sinai Heart Institute; Takushi Kohmoto, MD, PhD, University of Wisconsin; Evan Kransdorf, MD, Mayo Clinic Arizona; Brian Lima, MD, Baylor University Medical Center; Darren Malinoski, MD, Oregon Health and Science University; Donna Mancini, MD, Columbia University; Cindy Martin, MD, University of Minnesota; Kelly McCants, MD, Piedmont Atlanta Hospital; Thomas Mone, MS, OneLegacy; James Mudd, MD, Oregon Health and Science University; Yoshifumi Naka, MD, PhD, Columbia University; Sriram Nathan, MD, Memorial Hermann Hospital; David Nelson, MD, Integris Baptist Medical Center; Francis D. Pagani, MD, PhD, University of Michigan Medical Center; Jignesh Patel, MD, PhD, Cedars-Sinai Heart Institute; Michael Pham, MD, Stanford University; Si Pham, MD, University of Maryland; Sean Pinney, MD, Mount Sinai Medical Center; Joseph Rogers, MD, Duke University; Brooke Simones, PA, LifeSource; Melissa Skeans, MS, Scientific Registry of Transplant Recipients; Jason Smith, MD, University of Washington; Josef Stehlik, MD, MPH, University of Utah; Lynne Stevenson, MD, Brigham and Women's Hospital; Jeffrey Teuteberg, MD, University of Pittsburgh; Adrian Van Bakel, MD, PhD, University of South Carolina; J David Vega, MD, Emory University; Amanda Vest, MD, Tufts Medical Center; Georg Wieselthaler, MD, University of California, San Francisco; Mark Wigger, MD, Vanderbilt University; Charles Wright, MD, LifeLink Florida.

Table 1. Results of Pre-Conference Online Survey: 47 centers participating. Survey conducted January 2015- April 2015.

Survey respondent demographics:

- 47 different heart transplant centers represented
- 11 UNOS regions represented roughly equally
- Distribution between small (1-19/year), medium (20-39/year) and large (40+/year) centers in transplant volume: 36%, 38%, 23% respectively
- Distribution between small (1-19/year), medium (20-39/year) and large (40+/year) centers in MCS implant volume: 9%, 36%, 53% respectively

On the issue of sizing donor/recipient

- 58% believed that oversize donors are needed for recipients with pulmonary hypertension, 42% disagree.
- Among those who use oversize donors in this scenario, 46% prefer to oversize 10% by body weight, and 54% prefer to oversize 20% by body weight
- 57% of respondents place most importance on height in donor to recipient ratio, while 43% place most importance on weight
- 69% of respondents view undersizing a same sex donor heart to recipient by >30% as a contraindication to heart transplant, 31% do not view it as such.
- 30% of respondents view oversizing a same sex donor heart to recipient by >30% as a contraindication to heart transplant, 70% do not view it as such.
- For female donor heart to male recipient, 46% would oversize the donor, 48% believe no oversizing is necessary and 6% would accept an undersized heart.

On risk factors and their importance

- Asked to rank donor risk factors in order of their perceived importance, the 5 most important were heart function (LVEF), presence of LV wall motion abnormality, presence of hypertrophy, cold ischemic time and donor age.
- Asked what level of left ventricular hypertrophy would cause them to reject a heart, assuming no other mitigating circumstances, 21% chose >1.2cm, 45% chose >1.3cm, 21% chose >1.4cm and 13% chose >1.5cm.
- Asked what expected ischemia time would cause them to reject a heart, assuming no other mitigating circumstances, 34% said >4 hours, 34% said >5 hours, 30% said >6 hours and 2% said >7 hours.
- Asked what LVEF level would cause them to reject a heart, assuming no other mitigating circumstances, 21% said ≤40%, 30% said ≤45%, and 49% said ≤50%.

- Asked what an unacceptable downtime (administration of CPR duration) would be for acceptance of a donor heart, 20% said >20minutes, 38% said >30 minutes, 23% said >40 minutes, and 20% said >60 minutes.
- Asked to determine the threshold for acceptable right atrial pressure (RAP) (after donor optimization) to proceed to transplantation, 30% said <10 mmHg, 59% said <15 mmHg, and 11% said <20 mmHg.
- 34% of respondents require donor hearts to be off inotropes to proceed to transplant, 66% do not require this.
- Asked to specify the level of dependence on inotropes that would still result in acceptance of a donor heart, 15% specified "no inotropes", 34% specified a "minimal level of inotropes", 47% specified a "mild level of inotropes" and 4% specified a "moderate level of inotropes".
- Asked to specify an upper donor age limit that respondents would consider accepting, 2% said age 45, 23% said age 50, 42% said age 55, 19% said age 60, 9% said age 65, 2% said age 69 and 2% said age 70.
- Asked to specify the acceptable age differential threshold for transplanting older donors into younger recipients, 33% said >10 years, 50% said >20 years, 13% said >30 years, and 4% said >40 years.
- 38% of respondents routinely use older donors (>50 years) for older recipients (>60 years) at their program, 62% do not.
- Asked to rank recipient risk factors in order of their perceived importance, the 5 most important were high sensitization level, presence of complications associated with VAD, presence of temporary circulatory support, mechanical ventilation pre-transplant, and congenital heart disease.

On donor management strategies

- 53% of respondents normally request the use of thyroid hormone to optimize donor heart function, 47% do not.
- 22% of respondents normally request the use of corticosteroids to optimize donor heart function, 78% do not.

Abbreviations

UNOS- United Network for Organ Sharing

LVEF- Left Ventricular Ejection Fraction

LV- Left Ventricular

CPR- Cardiopulmonary Resuscitation

VAD- Ventricular Assist Device

Table 2. Key points for donor selection: debunking myths.

- Oversizing is not necessarily needed for recipients with pulmonary hypertension, but undersizing should be avoided.[24]
- Oversizing is not necessarily needed for female donors to male recipients, and should be assessed on case-by-case basis.[12, 14]
- LV mass index should be considered in conjunction with height and weight.[4-6]
- Younger donor age and good graft function should be prioritized above all other risk factors.[1-3]
- There is no unacceptable length of CPR ('downtime') if echocardiographic function of the donor heart and other donor factors are favorable.[20]
- Low dose inotrope use and use of vasopressors on the donor heart is acceptable to proceed to transplant. Use of norepinephrine, epinephrine and/or multiple inotropes should be viewed with caution.[25]

Table 3. Risk Factors to be considered in donor selection- by tier of importance.

Donor Risk Factors	Recipient Risk Factors
MOST IMPORTANT	MOST IMPORTANT
Older Age	Older age
Left ventricular function	Congenital heart disease as etiology of heart failure
Presence of LVH	Severe organ dysfunction (as reflected by elevated creatinine or total bilirubin)
Cold Ischemic time/Distance from transplanting center	Pulmonary Hypertension
High inotrope use	Temporary circulatory support (RVAD, Impella, ECMO), especially if complicated
IMPORTANT	IMPORTANT
Sex mismatch (female to male)	Redo heart transplant
Pre-existing coronary artery disease	Sensitization level of patient
Malignancy as cause of death	

List of abbreviations:
LVH- Left Ventricular Hypertrophy; RVAD- Right Ventricular Assist Device; ECMO- Extra-corporeal Membrane Oxygenation

Table 4. Priorities for further action and research.

Prospective study to identify clinical correlates of cardiac function in potential donors being evaluated for heart transplantation, with view to developing real-time scoring system
Additional analysis of factors leading to donor heart non-use, including specific analyses with regard to hearts refused by multiple programs that have a high Potential Transplant Recipient (PTR) sequence number (In Progress-
Survey studies to better understand clinicians' decision making regarding non-use, including considerations of program staff availability and concern for competition from other programs
Discussions with UNOS regarding potential interventions that would allow programs to utilize higher-risk donors without penalization in the case of an adverse outcome (e.g. allowance for a certain number of high-risk transplants
Translational research on donor biomarkers of outcomes
Studies to further understand the use of thyroid hormone supplementation of the donor heart- e.g. retrospective study of the specifics of use by OPOs
Standardization of anti-HLA antibody reporting: CPRA, MFI
Cost-effectiveness analyses to determine optimal strategy in older patients; e.g. extended criteria donor heart transplant vs. VAD as destination therapy
Development of a standard definition of an extended criteria donor
Further studies involving Hepatitis C positive donors with negative nucleic acid testing for either naïve or infected recipients in the era of curative therapies
List of abbreviations: UNOS- United Network for Organ Sharing SRTR- Scientific Registry of Transplant Recipients OPO- Organ Procurement Organization HLA- Human Leukocyte Antigen CPRA- calculated Panel Reactive Antibody