



# Implications and outcomes of cardiac grafts refused by pediatric centers but transplanted by adult centers

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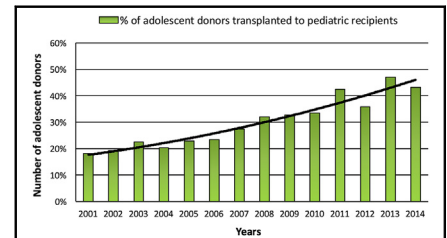
## ABSTRACT

**Background:** According to Organ Procurement Transplant Network policy, hearts from donors age <18 years are offered to pediatric recipients before being offered to adults of the same health status. We aimed to analyze differences in the use of adolescent donor hearts between adult and pediatric candidates and also to analyze the outcomes of pediatric candidates in which an adolescent donor heart was refused and later used in an adult recipient.

**Methods:** All adolescent donors (age 12-17 years) for 2000 to 2015 were identified using the standard United Network of Organ Sharing dataset and matched against the Potential Transplant Recipient dataset.

**Results:** Of the 2457 adults who received an adolescent heart, 855 (35%) received it after at least 1 refusal by a pediatric candidate (n = 844). Of the 844 pediatric candidates, 643 (76%) subsequently underwent transplantation (designated PCTs) and 201 (24%) never underwent transplantation (designated PCNTs). Among the latter group, 87 patients (43%) died or became too ill for transplantation. These 87 PCNTs refused 256 hearts that were later accepted by adult recipients. Donor quality was the most common reason for refusal. Overall, adult recipients had similar post-transplantation survival compared with PCTs, all pediatric transplants, and all adult transplants ( $P > .10$ ). A breakdown of adolescent heart donors by year shows a trend toward increased use in pediatric candidates.

**Conclusions:** A significant number of adolescent donor hearts that are refused by pediatric centers result in excellent post-transplantation outcomes in adult recipients. One in 10 pediatric candidates died on the waitlist after refusal of these hearts used by adult recipients. This warrants careful evaluation of the refusal criteria used by pediatric centers. Encouragingly, there now appears to be a trend toward an increased use of adolescent donor hearts by pediatric centers. (*J Thorac Cardiovasc Surg* 2017;154:528-36)



Proportional use of adolescent donor hearts by pediatric recipients over time.

### Central Message

Pediatric centers should carefully consider their refusal criteria for adolescent donor hearts, because some of the refused hearts are being used successfully by adult centers.

### Perspective

Pediatric transplant centers refuse a significant number of pediatric donor hearts that are successfully used by adult centers. This negatively impacts the outcomes of pediatric candidates for heart transplantation. This situation warrants careful evaluation of refusal criteria by pediatric centers. Encouragingly, there appears to be a recent trend by pediatric centers toward an increased use of these donors.

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Recently, the number of pediatric heart transplantations performed annually has increased to more than 500; however, at the same time there has been a larger increase in pediatric candidates awaiting a suitable transplant.<sup>1,2</sup> The size of the active waitlist for pediatric patients increased by >20%

between 2010 and 2014; therefore, the transplantation rate among active pediatric candidates decreased in that period across all pediatric age groups.<sup>2</sup> The increase in the waitlist is commonly attributed to stagnant donor pool, but in fact only 32% of all available donors and approximately 50% of pediatric donors were used for heart transplantation in 2014.<sup>3</sup> To meet the increasing demand, donor selection criteria and special groups of donors need to be

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### Abbreviations and Acronyms

OPTN	= Organ Procurement and Transplant Network
PCNT	= pediatric candidate (age $\leq 17$ years at listing) who refused adolescent donors and never underwent transplantation
PCT	= pediatric candidate (age $\leq 17$ years at listing) who refused adolescent donors before undergoing subsequent transplantation
PTR	= Potential Transplant Recipient
STAR	= Standard Transplant Analysis and Research
UNOS	= United Network of Organ Sharing

examined to improve organ utilization without compromising outcomes. In response to this need, several recent studies have demonstrated the use of extended donor criteria for pediatric heart transplantations that did not adversely affect post-transplantation outcomes.<sup>4-6</sup>

Adolescents are a particular group of donors being shared between adult and pediatric heart transplantations, but with a preference for pediatric candidates. Organ Procurement and Transplantation Network (OPTN) policy requires that a heart from a donor age  $< 18$  years be allocated to a pediatric candidate before being offered to an adult in the same United Network of Organ Sharing (UNOS) status.<sup>7</sup> This gives pediatric candidates an advantage over adult candidates for pediatric age donors. Although many pediatric age donors are directly offered to an adult in the highest UNOS status because of a lack of pediatric candidates in the same status at the time, there remain a significant number of adolescent grafts that are offered and accepted by adult candidates that were not accepted for pediatric candidates. This presents a unique opportunity to examine the outcomes of some of the eligible donors that were refused by pediatric centers and were later used for transplants. In the present study, we aimed to compare the use of adolescent donor hearts between adult and pediatric heart transplant programs, and to analyze the outcomes of pediatric candidates for whom donor hearts were refused but then used for transplantation into adult recipients, as well as the outcomes in these adult recipients.

## METHODS

### Data Source, Study Cohort, and Definitions

This is a retrospective analysis of the UNOS database. UNOS is a private, nonprofit organization that administers the OPTN under a federal contract. OPTN is a unified transplant network established by the US Congress under the National Organ Transplant Act of 1982, which requires submission of data on all solid-organ transplants in the United States and is internally audited. UNOS Standard Transplant Analysis and Research (STAR)

files provide data on donors, candidates, transplanted organs, and follow-ups. The UNOS Potential Transplant Recipient (PTR) file provides data on match runs. Each time a deceased donor organ becomes available, a computer program compares donor information with transplantation candidate characteristics stored on the waitlist and creates a list of potential donor-recipient combinations. For each donor organ, computerized matching algorithms are used to produce rank-ordered lists of potential recipients. The matching algorithms used are based on organ allocation policies, transplant center acceptance criteria, and local variances.

Once a deceased donor organ is allocated, the donor Organ Procurement Organization initiates completion of a Potential Recipient Form. Included on the form is a partial rank-ordered listing of potential organ recipients indicated by the match run. For each individual on the list with a higher priority than the actual recipient, a refusal code is entered indicating the reason why the organ was not accepted for transplantation.

All adolescent donors (age 12-17 years) used for heart transplantation between July 2000 and June 2015 were identified from the STAR files. These donors were identified against their respective match runs in the PTR file. Candidates in the match runs for each of the adolescent donors from the PTR file were then identified in the waitlist (STAR) file. Three main groups of candidates were identified for this study: (1) adult candidates (age  $\geq 18$  years at listing) who accepted adolescent donors (adult recipients) who were previously refused for pediatric candidates; (2) pediatric candidates (age  $\leq 17$  years at listing) who refused adolescent donors before undergoing transplantation at a later time (PCTs); and (3) pediatric candidates (age  $\leq 17$  years at listing) who refused adolescent donors and did not undergo transplantation (PCNTs). Overall pediatric and adult heart transplant populations were also used as controls to compare post-transplantation outcomes. No center-specific data were analyzed for this study; thus, "pediatric centers" and "adult centers" refer to centers caring for pediatric and adult candidates, respectively.

The populations were selected with 100% complete data on survival. The key donor and recipient characteristic variables used in the analysis had  $< 5\%$  data missing. The two variables functional status and PRA had between 27% and 30% missing data. Only available data were analyzed; no imputations were made for missing data. Donor ejection fraction was reported as 1 data point in the dataset and does not account for situations in which multiple echocardiograms were performed in a donor. Comparison of donor ejection fraction between refused and accepted donor hearts is a comparison between the aggregates and not between refusals and acceptance by each pediatric recipient.

### Statistical Analysis

Candidate characteristics, donor characteristics, waitlist outcomes, and post-transplantation survival were analyzed. Summary statistics are presented as median (interquartile range) or number (percentage). For baseline characteristics, continuous data were compared using the *t* test and analysis of variance with Tukey's method for normally distributed data and nonparametric tests (Mann-Whitney *U* test for 2 samples and Kruskal-Wallis analysis of variance for multiple samples) for data with a nonnormal distribution. Categorical data were compared using the  $\chi^2$  test. Survival curves were estimated using the Kaplan-Meier method; equality of survival curves was tested using a log-rank test. All analyses were performed using SPSS version 21 (IBM, Armonk, NY).

## RESULTS

### Cohorts

A total of 3473 adolescent hearts were used during the study period, 1016 (29%) by the pediatric recipients. Of the remaining 2457 adolescent hearts used by adult recipients, 855 were adult recipients, composing 25% of all adolescent donors. These 855 hearts were refused at least

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