ELSEVIER

The Journal of Heart and Lung Transplantation

http://www.jhltonline.org

The International Thoracic Organ Transplant Registry of the International Society for Heart and Lung Transplantation: Twenty-first pediatric heart transplantation report—2018; Focus theme: Multiorgan Transplantation

Joseph W. Rossano, MD, Wida S. Cherikh, PhD, Daniel C. Chambers, MD, FRACP, Samuel Goldfarb, MD, Don Hayes, Jr, MD, Kiran K. Khush, MD, MAS, Anna Y. Kucheryavaya, MS, Alice E. Toll, BA, Bronwyn J. Levvey, RN, Bruno Meiser, MD, and Josef Stehlik, MD, MPH

From the International Society for Heart and Lung Transplantation International Thoracic Organ Transplant Registry, Dallas, Texas.

This is an exciting time for pediatric thoracic organ transplantation. At the end of last year, we celebrated the 50th anniversary of the first orthotopic heart transplantation. Since then, the field of pediatric heart transplantation has grown dramatically, and heart transplantation in children is now performed routinely at many centers throughout the world. The International Thoracic Organ Transplant Registry of the International Society for Heart and Lung Transplantation (ISHLT) is the largest source of worldwide heart transplant data, with more than 14,000 transplants in children reported. This report examines important trends over time as well as contemporary data on volumes, management, and outcomes of pediatric heart transplant recipients.

Statistical methods

Data collection, analytical conventions, and statistical methods

National and multinational organ/data exchange organizations and individual centers submit data to the ISHLT International Thoracic Organ Transplant Registry. Since the Registry's inception, 477 heart transplant centers, 258 lung transplant centers, and 181 heart-lung transplant centers have reported data to the registry. We estimate the data submitted to the registry represent approximately 80% of worldwide transplant activity.

An overview of donor and recipient characteristics and outcomes is presented throughout this report. The data are supplemented with additional and extended analyses presented in the online slide sets (3 separate slide sets, named "Introduction," "Heart Overall," and "Heart Pediatric," available online at https://ishltregistries.org/registries/slides.asp). Slide sets for previous annual reports are also available on this site. The study refers to specific online e-slides when particular data are discussed but not shown in the report due to space limitations; e-slide numbers refer to the online pediatric heart transplant slide set (eSlide H(p)).

The Registry website (http://ishlt.org/registries/ttx-registry) provides detailed spreadsheets of data elements collected in the Registry. The Registry requires submission of core donor, recipient, and transplant procedure variables at baseline (before and at time of transplantation) and at yearly follow-up, and these variables therefore have low rates of missingness. Nevertheless, data quality depends on accuracy and completeness of reporting. Rates of missingness may significantly increase for Registry variables that depend on voluntary reporting. The Registry uses various quality control measures to

Reprint requests: Josef Stehlik, MD, MPH, University of Utah Health, Division of Cardiovascular Medicine, U.T.A.H. Cardiac Transplant Program, 50 N Medical Dr, 4A100 SOM, Salt Lake City, UT 84132. Telephone: 801-585-2340. Fax: 801-581-7735.

E-mail address: josef.stehlik@hsc.utah.edu

1053-2498/$ - see front matter
https://doi.org/10.1016/j.healun.2018.07.018

ensure acceptable data quality and completeness before including data for analyses.

Analytical conventions

Unless otherwise specified, heart-lung transplants are not included in analyses of heart transplants or lung transplants. Retransplant includes those with a previously reported transplant of the same organ type, same organ type in combination, or with a retransplant diagnosis. Because identification of all transplants for an individual may not be complete, the number of retransplant events may be slightly underestimated. The Registry does not capture the exact occurrence date for most secondary outcomes (e.g., renal dysfunction), but it does capture the window of occurrence (i.e., the event occurred between the first-year and the second-year annual follow-up visits). For the annual report, the midpoint between annual follow-up assessments is used as a surrogate for the event date. There is some bias in reporting secondary outcomes and other information on the follow-up where a death is reported. To reduce the possibility of underestimating event rates or other outcomes, some analyses are limited to surviving patients.

For time-to-event rates and cumulative morbidity rates, follow-up of recipients not experiencing the event of interest was censored at the last time the recipient was reported not to have had the event, either the most recent annual follow-up or the time of retransplantation. Time-to-event graphs (e.g., survival graphs) are truncated when the number of individuals still at risk was $<$ 10. Additional information regarding the general statistical methods used for analyses and data interpretation is included in the Supplementary Material available online (www.jhltonline.org).

Focus theme methods: Multiorgan transplant

The Registry Steering Committee selected multiorgan transplantation as the theme topic for the 2018 Report because numbers of multiorgan transplants have been increasing over time. Multiorgan transplant is less frequently performed in the pediatric population, and the goal of this theme is to help facilitate decisions in rare cases of multiorgan failure that may present to transplant centers across the world.

Because numbers are small for these infrequently performed procedures, largely descriptive statistics have been used, and multivariable analyses were not performed. The Registry Steering Committee hence recommends cautious interpretation of the focus theme data. In the current heart focus theme report, multiorgan transplants do not include combined heart-lung transplantation because they are included in the lung report.

Pediatric heart transplant: Overview of donor and recipient demographics, survival, and morbidity outcomes

Centers and activity

A total of 128 centers reported data to the Registry in 2016, which represents the greatest number of centers reporting to the Registry to date. Most of the centers are from North America and Europe (Figure 1, eSlide H(p) 4). Although most centers that report to the Registry are low-volume centers (center averages 1−4 transplants per year; eSlide H(p) 5), nearly 50% of the transplants are performed at large-volume centers (centers average $\geq$ 10 transplants per year; Figure 2, eSlide H(p) 6).

Recipient characteristics

Infants (aged $<$ 1 year at transplant) account for the greatest number of transplant recipients per 1 year of life, with more than 1,700 infant transplants performed from January 2004 to June 2017 (eSlide H(p) 9). For age groups, children aged 11 to 17 years account for the greatest number of transplants compared with younger age groups (eSlide H(p) 10). The underlying diseases leading to transplantation differ by

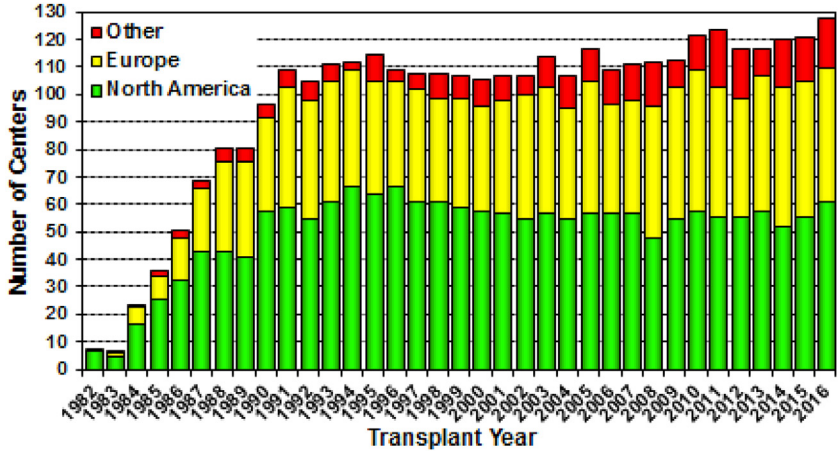

Figure 1 Number of centers reporting pediatric heart transplants (January 1982−December 2016).