Pediatric Heart Transplant: What, Why, When, and How

Chad Y. Mao, MD, FACC
Medical Director – Advanced Cardiac Therapies Program
Pediatric Electrophysiology and Device Therapies
Assistant Professor of Pediatrics
Sibley Heart Center Cardiology
Emory University – School of Medicine
What is a pediatric heart transplant?

- Physical translocation of a human heart to another human
  - Reserved for end-stage, advanced heart failure
- Christiaan Barnard successfully performed the first human heart transplant in 1967 in South Africa
- Dr. Norman Shumway performed the first human heart transplant in the US (Stanford) in 1968
- The 1st successful pediatric heart transplant in the US was performed in 1984 (Columbia)
- The 1st pediatric heart transplant in Atlanta in July 1988
Pediatric Heart Transplants
Recipient Age (in Years) Distribution by Year of Transplant

NOTE: This figure includes only the heart transplants that are reported to the ISHLT Transplant Registry. As such, this should not be construed as evidence that the number of hearts transplanted worldwide has increased and/or decreased in recent years.
Pediatric Heart Transplants
Number of Centers by Center Volume
(Transplants: January 2004 – June 2017)

Average number of heart transplants per year

Children's Healthcare of Atlanta

CHOA Transplant Numbers

Transplant Referrals

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Transplant Evaluations

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Transplant Listings

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Transplants

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What is Heart Failure?

- Heart Failure: structural or functional cardiac disorder resulting in inadequate perfusion and/or collection of fluid resulting in organ dysfunction - “Heart doesn't squeeze and/or relax normally”
- Congenital and Non-congenital heart disease

- Feeding difficulties
- Difficulty breathing / coughing
- Fatigue / Exercise Intolerance
- Abnormal heart rhythms
- Swelling
- Electrolyte abnormalities
- Abnormalities of the liver and kidneys
Causes of Heart Failure

Structural Heart Disease
- Left-to-right shunt
- Valvar regurgitation
- Pressure overload
- Single ventricle

Cardiomyopathy
- Dilated
- Hypertrophic
- Restrictive
- Arrhythmogenic
- Noncompaction
- Metabolic/Genetic

Other
- Arrhythmia
- Ischemic
- Inflammatory
- Infiltrative
- Toxic
When does someone need a heart transplant?

- Inoperable complex congenital heart disease
- Congenital heart disease that has failed surgical management
- Symptomatic heart failure (structural heart disease / cardiomyopathy)
- Significant, uncontrollable rhythm abnormalities
- Heart disease that is causing potentially irreversible damage to other organs (e.g. liver or lungs)
Recipient Age Distribution
January 2004 – June 2016

Number of Transplants

Recipient Age (Years)
CHOA Transplant Information (By Age)

- < 2 years
- 2 - 11 years
- 12-17 years
- > 18 years

(2018)

Scientific Registry of Transplant Recipients (SRTR) Program-Specific Report. July 2019
Pediatric Heart Transplants
Recipient Diagnosis

Age < 1 year 2009-2016
- CHD: 55%
- DCM: 37%
- Other: 7%
- Other: 0.3%

Age 1-5 years 2009-2016
- CHD: 41%
- DCM: 44%
- Other: 12%
- Other: 2.8%

Age 6-10 years 2009-2016
- CHD: 35%
- DCM: 43%
- Other: 16%
- Other: 7%

Age 11-17 years 2009-2016
- CHD: 23%
- DCM: 54%
- Other: 16%
- Other: 8%
CHOA Transplant Information
Primary Disease

- Cardiomyopathy, 83.3%
- Congenital Heart Disease, 16.7%
- Retransplant, 0.0%
- Other, 0.0%

(2018)
Scientific Registry of Transplant Recipients (SRTR) Program-Specific Report. July 2019
CHOA Transplant Information
By Ethnicity

- African-American, 58.3%
- White, 16.7%
- Hispanic/Latino, 8.3%
- Asian/Other, 8.3%
- Other, 8.3%

(2018)

Scientific Registry of Transplant Recipients (SRTR) Program-Specific Report. July 2019
CHOA Transplant Information
By Location

- CSU, 41.7%
- CICU, 25.0%
- Not Hospitalized, 33.3%

(2018)

Scientific Registry of Transplant Recipients (SRTR) Program-Specific Report. July 2019
Heart Transplant Life Cycle

- Confirm Candidate meets indications for transplantation
- Confirm no absolute contraindications for transplant
- Determine relative contraindications/risk factors for transplantation
- Identify ways to optimize pre-transplant care
  - Vaccinations
  - Rehabilitation
  - Nutrition
  - Psychological (swallowing pills)
  - Social support
- Informed consent for evaluation and listing (Education)
Transplant Evaluation Team

- Medical Evaluation
  - Cardiology (MD/NP)
  - CT Surgery
  - Infectious Disease
  - Medical Genetics

- Social Work
- Pharmacy
- Psychology
- Financial / Insurance
- Nutrition
- Physical Therapy
- Palliative Care
Listing for Transplant

- Pediatric rules differ from adult
- Patient listed prior to their 18\textsuperscript{th} birthday continue to qualify under pediatric guidelines
- Status 1A, 1B, 2, 7

**Waitlist Factors**
- Status, Blood Type, Size, Time
Current Ventricular Assist Device (VAD) Platforms

- Berlin EXCOR
- Thoratec® CentriMag® and PediMag®
- Abiomed Impella®
- Medtronic Heartware HVAD
- Jarvik 2015 (PumpKIN)
Pediatric Heart Transplants
% of Patients Bridged with Mechanical Circulatory Support*
by Year (Transplants: January 2005 – December 2016)

% of Patients

VAD or TAH  VAD + ECMO  ECMO

2005  20.6  22.5  21.4
2006  22.2  22.2  20.6
2007  29.2  25.4  22.5
2008  28.8  28.8  29.2
2009  30.9  30.9  28.8
2010  34.7  34.7  30.9
2011  32.4  32.4  34.7
2012  27.8  27.8  32.4
2013  15.0  15.0  27.8
2014  31.0  31.0  32.4
2015  29.3  29.3  31.0
2016  36.0  36.0  29.3
2017  67.0  67.0  36.0
2018  67.0  67.0  36.0

* LVAD, RVAD, TAH, ECMO
Pediatric Heart Transplants

ECMO, no VAD or TAH vs. VAD or TAH, no ECMO: p <0.0001
ECMO, no VAD or TAH vs. No ECMO/VAD/TAH: p<0.0001
VAD or TAH, no ECMO vs. No ECMO/VAD/TAH: p=0.9007

ECMO, no VAD or TAH (N=134)  VAD or TAH, no ECMO (N=889)
No ECMO/VAD/TAH (N=2,457)
Time of Transplant

- Referral
- Evaluation
- Listing
- Transplant
- Post-Transplant Care
Biatrial Anastomosis
Bicaval Anastomosis

B Orthotopic Cardiac Transplantation with Bicaval Technique

- Brachiocephpalic trunk
- Left common carotid artery
- Left subclavian artery
- Superior vena cava
- Arch of aorta
- Pulmonary artery trunk
- Right atrium
- Inferior vena cava
- Left atrium

Completed transplantation
Post-Transplant Care

Referral

Evaluation

Listing

Transplant

Post-Transplant Care
Post-Transplant Schedule (> 12 mo)

Post-transplant graft surveillance and follow-up schedule for children >12 months of age at the time of transplant (may vary if necessary to meet individual needs):

Week 1 - ECHO visit
Week 2 – endomyocardial biopsy, RHC
Week 3 - ECHO visit
Week 4 - endomyocardial biopsy, RHC
Week 6 - ECHO visit
Week 8 - endomyocardial biopsy, RHC
Months 3, 4 & 5 – ECHO visit
Month 6 – endomyocardial biopsy, RHC
Months 8 & 10 - ECHO visit
Month 12 – endomyocardial biopsy,
  echocardiogram, RHC, LHC

1-3 years- endomyocardial biopsy, RHC every 6 months; ECHO visit every 3 months; LHC annually
>3 years- endomyocardial biopsy, RHC every 6 months; May have annual biopsy (RHC, LHC) with an echocardiogram every 4 months if ...
  a) no previous rejection episodes (defined as 2R or 3R between post-op years 1-3) or
  b) has been at least 3 years from cellular rejection episode.

- Patient may be seen for an additional visit weekly for the first two weeks following hospital discharge for physical exam, review of medications, and lab work.
- The following will be performed at all post-transplant visits: review of medications, physical exam, laboratory tests, echocardiogram, review of postoperative care and additional diagnostics if indicated.
Life with a Heart Transplant

• Immunosuppression
  – 2-3 medications, once or twice daily
  – Regular blood work to monitor immunosuppression

• Complications
  – Infections
  – Cancers:
    • Post-transplant lymphoproliferative disease (PTLD)
  – Rejection
    • Cellular, Antibody-mediation,
    • Coronary allograft vasculopathy
  – Graft Failure
Pediatric Heart Transplants
Kaplan-Meier Survival (Transplants: January 1982 – June 2016)

Median survival (years)
- <1 = 22.3
- 1-5 = 19.3
- 6-10 = 14.6
- 11-17 = 13.3

Survival (%)

Years
Pediatric Heart Transplants
Kaplan-Meier Survival by Era
(Transplants: January 1982 – June 2016)

Median survival (years)
1982-1989= 9.7
1990-2003=14.5
2004-2008=NA
2009-6/2016=NA

All p-values were significant at p < 0.05.
Pediatric Heart Transplants
Functional Status of Surviving Recipients
(Follow-ups: January 2009 – June 2017)
Pediatric Heart Transplants
Rehospitalization Post-transplant of Surviving Recipients
(Follow-ups: January 2009 – June 2017)

Bar chart showing rehospitalization rates for 1, 3, and 5 years post-transplant.

- No Hospitalization
- Hospitalized, Not Rejection/Not Infection
- Hospitalized, Rejection
- Hospitalized, Infection Only
- Hospitalized, Rejection + Infection
Advanced Cardiac Therapies Program

Advanced Heart Failure and Cardiomyopathy Program

Ventricular Assist Device (VAD) Program

Heart Transplant