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For access to Texas Children’s Heart Center outcomes information, visit texaschildrens.org/heartoutcomes.
Dear colleagues, parents and friends:

We are pleased to present the 2014 Texas Children's Heart Center Outcomes Book. Here you will find highlights from our Heart Center programs and important data about patient outcomes and innovative research programs.

We care for children of every age, and we are beginning to care for patients earlier than ever before. Texas Children's Heart Center works hand in hand with physicians in Texas Children's Fetal Center™ to identify and choose the best treatment plans for patients and their families. Surgery completed while the fetus is still in the womb is a cutting-edge treatment that gives the patient additional developmental time in the uterus, setting the stage for a healthier entry into the world.

Texas Children’s Hospital continues to have one of the largest pediatric solid organ transplant programs in the country. In 2014, our team performed 95 transplants, including 32 heart transplants, a record number for the hospital.

One of the joys of our work is seeing children thrive. In this year’s edition, we check in on two congenital heart patients who have become part of our extended family. These young people have not let heart disease hold them back from living full and active lives. As our patients enter adulthood, many of them continue into our adult congenital heart program where our cardiologists are experienced in treating patients with mended hearts.

Texas Children’s Heart Center strives to provide every procedure available for patients with pediatric and congenital heart disease. Through our innovations in research and commitment to improve all aspects of patient care, our goal is the very best possible treatment for every patient.

We hope you find this information useful. Thank you for your interest in our center.

Sincerely,

Charles D. Fraser, Jr., M.D.
Surgeon-in-Chief, Texas Children’s Hospital
Donovan Chair and Chief of Congenital Heart Surgery, Texas Children’s Hospital
Susan V. Clayton Chair in Surgery, Baylor College of Medicine
Professor of Surgery and Pediatrics, Baylor College of Medicine

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Professor of Anesthesiology and Pediatrics, Baylor College of Medicine

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Chief of Critical Care, Texas Children’s Hospital
Professor of Pediatrics, Baylor College of Medicine
Texas Children’s Hospital and Baylor College of Medicine

Texas Children’s operates Texas Children’s Hospital, Texas Children’s Health Plan, the nation’s first health maintenance organization (HMO) created just for children, and Texas Children’s Pediatrics, the nation’s largest primary pediatric care network with 50 practices throughout the greater Houston community.

Texas Children’s Hospital’s main campus is located near downtown Houston in the Texas Medical Center, the largest medical center in the world. The main campus includes 650 inpatient beds, the Clinical Care Center for outpatient visits, the Feigin Center for pediatric research and Texas Children’s Pavilion for Women. To serve the rapidly growing population in West Houston, Texas Children’s Hospital West Campus opened in 2011 as a community hospital and clinic and contains ICU beds, inpatient beds, an emergency center, surgical suites and more than 20 subspecialty clinics. In 2017, we will open our second community hospital, Texas Children’s Hospital The Woodlands.

Texas Children’s mission is to create a healthier future for children and women throughout our global community by leading in patient care, education and research. Renowned worldwide for our expertise and breakthrough developments in clinical care and research, Texas Children’s Hospital was recently ranked #4 among top children’s hospitals in the nation and was ranked in all 10 pediatric subspecialties in U.S. News & World Report’s list of America’s Best Children’s Hospitals.

Texas Children’s Hospital is affiliated with Baylor College of Medicine in the areas of pediatrics, pediatric surgery, and obstetrics and gynecology. Baylor is ranked by U.S. News & World Report as one of the nation’s top 25 medical schools for research. Currently and throughout our 60-year partnership, Texas Children’s Hospital serves as Baylor’s primary pediatric training site, and Baylor faculty are the division chiefs and staff physicians of Texas Children’s patient care centers. The collaboration between Texas Children’s Hospital and Baylor is one of the top 10 such partnerships for pediatric research funding from the National Institutes of Health.

More than 1,500 board-certified pediatricians, pediatric subspecialists, pediatric surgical subspecialists and dentists – offering the highest level of pediatric care in more than 40 subspecialties, programs and services – practice at Texas Children’s with a support staff in excess of 10,500.
Texas Children’s Heart Center is located in the hospital’s main inpatient building, the West Tower, on floors 15 and 17 through 20. The close proximity of the Heart Center’s treatment and administrative areas, perhaps unique in pediatric cardiac care, enables team members to respond quickly to patient and family needs or emergencies and promotes collaboration among our multidisciplinary team.

Most recently, Texas Children’s Board of Trustees approved expansion plans for the hospital’s main campus that includes a 19-story addition to the top of an existing building, adding 640,000 square feet and resulting in a 25-floor tower. Slated to be completed in 2018, the new tower will house 130 beds for pediatric and cardiovascular intensive care, new operating rooms with the latest technology and will be the new home to Texas Children’s Heart Center, including the outpatient clinic, cardiovascular operating rooms and catheterization labs.
Pioneers in Pediatric Cardiac Care

Texas Children’s Hospital has been a leader in pediatric heart care for more than 50 years. Led by Denton Cooley, M.D., and Dan McNamara, M.D., the hospital started performing heart surgery in children in 1956. Dr. McNamara, a patriarch of pediatric cardiology, and Dr. Cooley, a pioneer heart surgeon, were among the first to demonstrate that small children could safely undergo heart surgery.

Today, Texas Children’s Heart Center is one of the nation’s leading providers of pediatric cardiac care. In 2014, U.S. News & World Report ranked Texas Children’s Heart Center #2 in the nation for pediatric cardiology and heart surgery. Comprised of several multidisciplinary teams working in conjunction with pediatric subspecialists throughout the hospital, the Heart Center provides unparalleled care at every point from diagnosis through treatment and follow-up.
National and International Reach

Texas Children’s commitment to caring for children reaches around the globe. Our Heart Center cares for patients from over 15 countries around the world and more than 35 states in the United States. We are dedicated to creating a healthier future for children throughout the global community.
## 2014 Texas Children’s Heart Center Overview

### Surgical procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac operations</td>
<td>843</td>
</tr>
<tr>
<td>Heart transplants</td>
<td>32</td>
</tr>
<tr>
<td>Lung transplants</td>
<td>16</td>
</tr>
<tr>
<td>Adult congenital heart disease operations</td>
<td>37</td>
</tr>
</tbody>
</table>

**Total:** 928

### Cardiac catheterizations

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic cardiac catheterizations</td>
<td>503</td>
</tr>
<tr>
<td>Interventions</td>
<td>446</td>
</tr>
<tr>
<td>Electrophysiology studies and ablations</td>
<td>141</td>
</tr>
<tr>
<td>Pacemaker and defibrillator implants</td>
<td>60</td>
</tr>
</tbody>
</table>

**Total:** 1,150

### Diagnostic testing and cardiac imaging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>Echocardiograms</td>
<td>24,832</td>
</tr>
<tr>
<td>Fetal echocardiograms</td>
<td>1,781</td>
</tr>
<tr>
<td>Electrocardiograms</td>
<td>35,341</td>
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<tr>
<td>Cardiac MRIs</td>
<td>515</td>
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<tr>
<td>Stress MRIs</td>
<td>24</td>
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<tr>
<td>Holter® monitors</td>
<td>4,988</td>
</tr>
<tr>
<td>Stress tests</td>
<td>1,215</td>
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</table>

**Total:** 68,696

### Cardiovascular anesthesia

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterizations and electrophysiology patients</td>
<td>1,094</td>
</tr>
<tr>
<td>Cardiovascular operating room patients</td>
<td>1,002</td>
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<tr>
<td>Interventional radiology patients</td>
<td>152</td>
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<tr>
<td>MRI patients</td>
<td>430</td>
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</table>

**Total:** 2,678

### Cardiovascular intensive care

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical admissions</td>
<td>616</td>
</tr>
<tr>
<td>Medical admissions</td>
<td>420</td>
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</tbody>
</table>

**Total:** 1,036

The outpatient clinic at Texas Children's Heart Center had more than 23,000 patient encounters in 2014.
Congenital Heart Surgery Service

The Congenital Heart Surgery Division provides individualized and comprehensive surgical care for all aspects of pediatric and adult congenital heart disease. We are experienced in the rarest of cases such as ectopia cordis and other infrequently seen conditions. Texas Children’s Heart Center performs more than 900 surgical procedures annually with outcomes among the best in the country.

We treat children of all ages, including preterm and low-birth-weight newborns, and we personalize treatments and procedures to best suit the situation of each child and family. This tailored approach includes cardiopulmonary bypass and neuroprotection strategies focused on the patient’s condition and needs, helping to achieve optimal functional outcomes. The center’s Heart, Lung and Heart-Lung Transplant Programs, among the largest and most successful in the United States, are also part of the Congenital Heart Surgery Division.

Cardiovascular and thoracic surgery cases

According to the Society of Thoracic Surgeons National Database Program, congenital heart surgery programs are considered high-volume programs if they perform more than 250 index operations per year on average.

Since 1995, Charles D. Fraser, Jr., M.D., and the Congenital Heart Team have performed more than 13,600 operations on children and adults with congenital heart disease.
Total cardiopulmonary bypass operations
Volume by year

More than 64 percent of operations performed require the use of cardiopulmonary bypass (CPB). Our incidence of mechanical circulatory support postcardiotomy is less than 1 percent.

Cardiovascular and thoracic surgery cases
Percent by age

Our patients include children of all ages as well as adults who have been treated since infancy or who have been diagnosed with a congenital heart defect later in life.
The Risk Adjustment in Congenital Heart Surgery (RACHS-1) categorization is a widely used risk stratification model that analyzes outcomes in congenital heart surgery. The most common surgeries for congenital heart defects are stratified into six risk categories. Surgeries with higher risk are placed in higher categories with Category 6 representing congenital heart surgeries associated with the greatest risk.

Overall risk-adjusted hospital mortality rate for our program in 2014 was less than 1.0%. Data collected by the Society of Thoracic Surgeons (STS) shows the national hospital discharge mortality rate at 3.2%.

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2. 007-RACHS-1 Index Surg CHD Volume.
Age-appropriate surgical planning and management allows for outcomes in patients of all ages to be better than the national benchmarks. Patient grand total combines CPB and non-CPB cases (N=609).
Atrial septal defect repair
Volume by year

The Congenital Heart Surgery Division performs an average of 26 atrial septal defect (ASD) closures annually. This includes patients with secundum, coronary, sinus and sinus venosus ASDs. Our hospital survival rate is 100 percent. Our service also offers a minimally invasive approach to ASD closure.

Ventricular septal defect repair
Volume by year

Ventricular septal defects (VSD) are the most commonly diagnosed congenital heart defects, and surgical treatment remains the standard of care for children with this condition. This data includes patients having perimembranous, supraventricular, inlet or muscular VSDs. They also include patients with double-chambered right ventricle. The Congenital Heart Surgery Division performs an average of 59 VSD closures each year and in 2014 had a survival rate of 100 percent.
The Congenital Heart Surgery Division performs an average of 28 operations each year for partial, intermediate and complete atrioventricular (AV) canal defect.

Our surgical approach to the repair of tetralogy of Fallot (TOF) is individualized for each patient based on age, anatomy and symptoms. This allows us to repair the defect and preserve critical parts of the cardiac anatomy, thereby optimizing the patient’s cardiac function over the long term. The Congenital Heart Surgery Division performs an average of 27 TOF repairs each year.

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6 Hospital mortality is calculated over the last five years from 2010-2014.
7 STS benchmark data is from 2010-2013.
The arterial switch operation (ASO) is offered to patients with simple transposition of the great arteries, complex transposition of the great arteries and Taussig-Bing anomaly. Historically, this operation has not been viewed as a viable treatment option for some children due to their size, complex coronary anatomy and associated cardiac malformations. Our outcomes have demonstrated that these characteristics are not associated with increased operative risk. Our hospital survival rate is 100 percent.

The Congenital Heart Surgery Service performs an average of 20 Norwood operations per year for hypoplastic left heart syndrome and other single ventricle anomalies.
The gift that keeps giving

Kathy and Anthony tried for years to have a baby. So when an ultrasound revealed that the daughter Kathy was carrying had a dangerous heart defect, they immediately kicked into crisis mode. The condition, dextro transposition of the great arteries, or dTGA, meant the two main arteries leading out of the baby’s heart were switched or transposed. Surgery would be needed soon after birth.

After extensive homework, the couple booked several appointments with top pediatric cardiovascular surgeons close to their home in Cleveland, Ohio. Then a physician told them about Texas Children’s, and they found themselves traveling more than a thousand miles to take a look.

“Dr. Fraser was warm, knowledgeable and took the time to answer all our questions,” Kathy says.

“It was a difficult decision to be so far from home, and Texas was the least convenient option,” Anthony says. “But the results Dr. Fraser has had with dTGA and the confidence we have in him speak for themselves.”

The couple moved into an apartment in Houston a couple of weeks before Olive was born at Texas Children’s Pavilion for Women. Immediately after birth, she was whisked away to the CVICU. At two days old, she had a catheter procedure called a septostomy. When Olive was eight days old, Dr. Fraser performed a complex 13-hour surgery called an arterial switch to restore regular blood flow through the heart and to the rest of the body.

“The next two weeks were really tough,” Anthony says. “It’s scary enough to be a new parent, and it was hard to see her on a breathing machine and connected to so many monitors. But it was extraordinary how much attention she got. Dr. Fraser came in every day, even on Sunday.”

Three weeks later, Olive was healthy enough to go home. Today she is an active 2-year-old, and she has achieved every developmental and physical milestone expected for her age. She sees a cardiologist in Cleveland, and Dr. Fraser reviews her scans. Olive will have to have another surgery, and when she does, she will be back at Texas Children’s.

“She is our miracle,” Kathy says. “She has taught us to love every moment. Not a day goes by that I don’t thank Dr. Fraser. You would think gratitude would fade, but it just grows.”
Single Ventricle Program

The Single Ventricle Program (SVP) at Texas Children’s Hospital is a multidisciplinary team that includes pediatric cardiologists, nurse practitioners, neurodevelopmental specialists, dietitians and social workers. Patients have a variety of diagnoses such as hypoplastic left heart syndrome (HLHS) or tricuspid atresia, but no matter the diagnosis, the program offers specialized medical care, education and support. The SVP team strives to ensure the best possible outcomes for this specialized patient population.

Many of the patients who enter the program are identified before delivery during their fetal ultrasound and are seen at Texas Children’s Fetal Center™ at Texas Children’s Pavilion for Women. We know that having a prenatal diagnosis is important for the family and for the infant during the critical newborn period.10

One unique prenatal offering, “Parenting Your High-Risk Baby,” focuses on preparing for delivery and parenting skills needed while in the hospital. The class is presented by multidisciplinary teams from both the Pavilion for Women and Texas Children’s Heart Center. In the final session, parents meet with other families who have already gone through the same experience.

After delivery, the newborn is transferred to the Cardiovascular Intensive Care Unit for further care. The SVP team works collaboratively with other teams at Texas Children’s Hospital during the transition from newborn care to open heart surgery to recovery. Many of the infants will be able to go home, but some patients, identified for a variety of reasons, will need to stay in the hospital until after their second surgery, which is usually a Bi-Directional Glenn.

As the infant recovers and progresses, the SVP team members educate and prepare the family for the transition home. Since these infants are at risk for a number of medical complications, parents are critical members of the team. Before discharge, parents receive education on the Single Ventricle Home Monitoring Program. Parents learn how to keep track of their baby’s daily progress by measuring daily weights, oxygen saturations, feeding information and heart rate.

Once parents learn and become comfortable with daily care, the baby is discharged from the hospital. We support them at home through phone consultations and frequent outpatient clinic follow-up visits. The SVP monitors for symptoms referred to as “red flags.” When these symptoms are noted, the patient is brought in for evaluation and sometimes readmitted to the hospital. The family has 24-hour access to a member of the team for questions or concerns.

The SVP is also an active member of the National Pediatric Cardiology Quality Improvement Collaborative, a multi-hospital collaborative focused on improving quality and outcomes for children with HLHS.

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Coronary Anomalies Program

In December 2014, Texas Children’s Hospital hosted its second national conference on coronary artery anomalies. A group of rare congenital heart defects, coronary artery anomalies are associated with coronary ischemia, myocardial infarction and sudden death. The condition is the second-leading cause of sudden cardiac death in children and young adults.

Diagnosing these anomalies can be challenging because many individuals with the condition have no symptoms. Those who do have symptoms complain most often of chest pain, palpitations, dizziness or fainting during or just after exercise.

How to best treat a child or young adult with coronary artery anomalies is a subject of debate in the medical community. Most physicians agree that surgery is necessary for patients who show evidence of decreased blood flow to the heart tissue, but how to treat patients who have no physical complaints – and who show no evidence of reduced blood flow to the heart – is unclear.

During the conference, speakers from 16 leading heart institutions provided a dedicated forum to discuss the diagnosis and management of patients with coronary artery anomalies. A panel discussion with families affected by the condition brought special attention to the psycho-social needs of patients with cardiac anomalies as well as their parents and siblings. Other talks focused on the most appropriate imaging modalities, identification of risk factors, different management strategies based on best available evidence, surgical techniques, and counseling of patients and families regarding treatment and exercise recommendations.

Outcomes of patients with Anomalous Aortic Origin of a Coronary Artery (AAOCA)

The program began tracking outcomes in December 2012 and as of February 2015 has recorded:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients</td>
<td>90</td>
</tr>
<tr>
<td>Surgery treatment</td>
<td>29</td>
</tr>
<tr>
<td>Mortality</td>
<td>0</td>
</tr>
<tr>
<td>Complications</td>
<td>2</td>
</tr>
</tbody>
</table>

(Data as of January 31, 2014.)
Heart Failure and Transplant Program

Since its inception in 1984, Texas Children’s Heart Center has performed more than 315 heart transplants, making it one of the largest and most successful programs in the nation. As the number of diagnoses for pediatric heart failure increases, so has our depth and breadth of experience in treating patients, as has our ability to offer the right mechanical circulatory device to support each child in heart failure. For more information on the Heart Transplant Program, please visit texaschildrens.org/transplant.

Since 2011, Texas Children’s Heart Center has been an active member of the Pediatric Heart Transplant Study, which is dedicated to the advancement of the science and treatment of children during listing for and following heart transplantation. The purpose of the group is to establish and maintain an international, prospective, event-driven database for heart transplantation, to use the database to encourage and stimulate basic and clinical research in the field of pediatric heart transplantation, and to promote new therapeutic strategies.

Mechanical circulatory support is often used as a bridge to transplantation in children. At Texas Children’s Heart Center, we select a ventricular assist device (VAD) from a variety of options to best meet the needs of the individual patient.

VAD implantations

by device

- Thoratec P-VAD®
- Berlin Heart EXCOR® Pediatric
- Impella®
- Micromed®
- HeartWare®
- Total Artificial Heart
- SynCardia®
- HeartMate II®
- Rotaflo®
- Bio-Medicus®

TOTAL CASES 138

**VADs placed from 1995-2014.**
Extracorporeal life support

Extracorporeal life support (ECLS) is a treatment that helps support children when their heart and/or lungs are unable to supply enough blood flow or oxygen to the body. This support may be necessary after heart surgery or in some children with heart or lung disease. ECLS is provided in the Pediatric Intensive Care Unit (PICU), Cardiovascular Intensive Care Unit (CVICU) or Neonatal Intensive Care Unit (NICU) based on each child’s underlying problem. Our specially trained team of cardiac intensivists, surgeons, critical care nurses and ECLS specialists carefully monitors each child’s condition while on ECLS.

To provide ECLS, we use extracorporeal membrane oxygenation, or ECMO. With ECMO, blood is pumped through the cannulae and into the machine oxygenating the patient’s blood. The oxygenated blood is then returned through the circuit to the body, creating a continuous flow and doing the work of the heart and/or lungs so the patient’s body can heal.

The ECMO program at Texas Children’s Hospital received the Award for Excellence in Life Support from the Extracorporeal Life Support Organization and is a designated Center of Excellence.
Berlin Heart EXCOR® Pediatric Ventricular Assist Device

In 2012, the United States Food and Drug Administration (FDA) granted humanitarian device exemption for the Berlin Heart EXCOR® Pediatric Ventricular Assist Device, the only pediatric mechanical circulatory support device designed specifically for infants and small children. This was a landmark day for physicians who treat children dying of heart failure whose only hope is a heart transplant. Small children awaiting heart transplantation face a long time on the waiting list due to limited availability of donor organs. Mortality rate while waiting is approximately 25 percent due to progressive system organ failure.

FDA approval began with a multi-year, multi-institution study, led in part by Texas Children’s Hospital. In 2005, a trans-Atlantic dialogue was initiated among the Berlin Heart Corporation, clinicians in North America and the FDA to design and conduct the first prospective pediatric ventricular assist trial in the world. The study design addressed questions of safety and benefit of the Berlin Heart in bridging children with heart failure until they received a heart transplant. This study involved detailed analysis and ongoing multicenter data collection and coordination in critically ill children with rapidly progressive heart disease.

During the course of the study, Texas Children’s implanted 27 Berlin Hearts – more than any other center in the U.S. – and our results were encouraging. Findings from this study were published in the New England Journal of Medicine in August 2012. Outcomes for 48 children (infants through 16 years) who received the Berlin Heart from 2007-2010 were compared to those of patients supported by extracorporeal membrane oxygenation.

Data includes patients who received heart-and-lung transplants simultaneously.
Heart transplants

Volume by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Heart Transplants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>11</td>
</tr>
<tr>
<td>2008</td>
<td>16</td>
</tr>
<tr>
<td>2009</td>
<td>18</td>
</tr>
<tr>
<td>2010</td>
<td>13</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
</tr>
<tr>
<td>2012</td>
<td>14</td>
</tr>
<tr>
<td>2013</td>
<td>15</td>
</tr>
<tr>
<td>2014</td>
<td>32</td>
</tr>
</tbody>
</table>

Heart transplant patient survival rates

Pediatric age <18

<table>
<thead>
<tr>
<th>Period</th>
<th>Texas Children’s Heart Center</th>
<th>SRTR Expected</th>
<th>National</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Year After Transplant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/1/11 TO 12/31/13 N=31</td>
<td>92.38%</td>
<td>94.37%</td>
<td>92.47%</td>
</tr>
<tr>
<td>3 Years After Transplant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/1/09 TO 6/30/11 N=31</td>
<td>90.32%</td>
<td>91.59%</td>
<td>85.87%</td>
</tr>
</tbody>
</table>

13 Data includes patients who received heart-and-lung transplants simultaneously.
14 Scientific Registry of Transplant Recipients (SRTR). Program Specific Reports. Table I I – srtr.org.
Heart transplant survival curves
The following graphs show the survival rates for patients by the number of years after heart transplantation. The lines show the expected survival rates for our patients a number of years after their transplant. Because these are estimates, the shaded areas show the 95 percent confidence limits of the expected survival rates.

Survival curves by era

Texas Children’s data: 1984-2014, 275 Txs on 286 patients, Age between 0 and 22 years.
UNOS data: 1987-2013, 7437 Txs on 6487 patients (3 observations missing data), Age between 0 and 17 years.

Survival curve vs. UNOS\textsuperscript{16}
Era III (2005-2014)

Texas Children’s data: 1984-2014, 275 Txs on 286 patients, Age between 0 and 22 years.
UNOS data: 1987-2013, 7437 Txs on 6487 patients (3 observations missing data), Age between 0 and 17 years.
Interventional Cardiology

Increasing numbers of heart conditions can be treated with minimally-invasive catheter-based interventions. Texas Children’s Heart Center, the largest program in the region to offer interventional cardiac catheterization for infants, children and adolescents, performed 1,150 cardiac catheterization procedures in 2014. The full-service cardiac catheterization laboratory performs every possible intervention, including:

- Balloon valvuloplasty
- Balloon angioplasty (using standard as well as “cutting” balloons)
- Stent placement (e.g. for pulmonary artery stenosis, coarctation of the aorta, etc.)
- Device closure of atrial septal defects, arterial and venous collaterals, coronary fistulae, etc.
- Device closure of patent ductus arteriosus, including in low birth weight and premature babies
- Transcatheter pulmonary valve replacement using the Melody® valve

In addition to these relatively common procedures, the interventional cardiology team at Texas Children’s Hospital has developed cutting-edge treatment strategies for some rare and debilitating conditions such as:

- Pulmonary vein stenosis
- Venous thrombosis
- Multiple muscular ventricular septal defects (“Swiss cheese” septum)
- Congenital portosystemic shunts (Abernethy malformation)
- Pulmonary arteriovenous malformations (congenital and acquired)
- Pulmonary hypertension
- Renal artery stenosis
- Mid-aortic syndrome
- Percutaneous ventricular assist device placement for heart failure (Impella® device)
- Fetal cardiac interventions for conditions such as critical aortic stenosis and hypoplastic left heart syndrome

Despite being a regional and national referral center for the most complex forms of acquired and congenital heart disease, our team has an extraordinarily low complication rate from cardiac catheterizations (see chart on following page). We have a strong culture of attention to radiation safety and continuous quality improvement, and we strive to promote these concepts locally and nationally. Dr. Henri Justino, medical director of the Charles E. Mullins Cardiac Catheterization Laboratories, serves as the national chair for the Pediatric Quality Improvement Committee of the Society for Cardiovascular Angiography and Interventions. Our interventional team is actively involved in research into new treatment strategies for congenital heart disease, and is invited to lecture on these topics nationally and internationally.
Cardiac catheterization laboratory complications
by rate

- Cases without complications: 98.22%
- Cases with major complications: 0.68%
- Cases with minor complications: 1.10%
Pioneering procedure gives baby healthy start
When Kaylin made medical history, she weighed just over two pounds and had a heart the size of a nickel. Born at 28 weeks gestation, Kaylin had critical aortic valve stenosis and critical coarctation of the aorta, two areas of narrowing on the left side of the heart which forced it to work too hard to deliver blood throughout her body. Without intervention, she would die – but the procedure she needed had never been performed on a baby so small.

Texas Children’s Hospital, only 200 miles from the family’s home in Austin, had the expertise to try the intervention. It was their best chance. Within a day, Texas Children’s Kangaroo Crew flew mother and baby to Houston. The next day, physicians gathered to discuss the options.

“It felt like all the best minds were on the scene,” says Kaylin’s mother, Nancy. “I instantly knew we were in the right place and that we had found a hospital that could help her.”

But she and her husband, Chris, were nervous nonetheless. After almost six hours, Nancy and Chris got the good news that the procedure was a success. Interventional cardiologist Dr. Henri Justino made an incision about the size of a pinprick to perform a balloon aortic valvuloplasty and snaked a catheter through the carotid artery to repair the aortic valve and the narrowed aorta with a tiny balloon and stent.

Kaylin spent a few days in the CVICU and then was flown back to Austin, where she stayed several weeks in the NICU. Due to her rapid growth, she required two more catheterization procedures through the femoral artery to redilate the aortic valve and the stent in her first year of life. Another procedure at 2½ years was performed to intentionally fracture the stent, which Kaylin had outgrown.

Now 8, Kaylin visits Texas Children’s annually. She will require additional procedures someday, but for now, Kaylin is an active child who has never had any restrictions. She plays competitive soccer and is above her grade level in math and reading.

“It’s amazing,” Nancy says. “You would never be able to tell by looking at her that she had such a revolutionary minimally-invasive cardiac catheterization procedure as a baby. We owe so much to Texas Children’s.”
Electrophysiology

The Arrhythmia and Pacing Service at Texas Children’s Heart Center offers the full complement of diagnostic and therapeutic options to evaluate and manage any heart rhythm abnormality. We have one of the highest volume pediatric centers in the country for invasive electrophysiology studies and pacemaker/defibrillator implantations, and we maintain success rates for ablations that exceed the national average. Innovation, research and experience have made Texas Children’s Heart Center one of the leading centers in the world for the diagnosis and treatment of arrhythmias in children and adults with congenital heart disease.

Supraventricular tachycardia ablation outcomes

<table>
<thead>
<tr>
<th>2014 ACUTE SUCCESS RATE</th>
<th>Texas Children’s Hospital</th>
<th>National benchmark17</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>98.3%</td>
<td>95.2%</td>
</tr>
</tbody>
</table>

Stereotaxis

Texas Children’s Hospital is the only freestanding children’s hospital in the U.S. with a remote magnetic navigation (MN) system called stereotaxis for catheter manipulation. Stereotaxis has been utilized for 63 ablation cases over the last three years.

MN offers theoretic advantages in the treatment of children. The catheter is more flexible and atraumatic than standard catheters, potentially eliminating risk of heart perforation. It can also be navigated with more precision, allowing for movements as small as one millimeter or deflections as small as one degree. This may result in enhanced accuracy and safety during mapping and ablation of certain arrhythmias in this patient population.

We performed a review of data in children undergoing radiofrequency ablation at our institution.18 The efficacy and safety of an MN-guided approach and standard manual techniques for mapping and ablation of AP-mediated tachycardia were compared. Acute success rates and recurrence rates were equivalent (p=NS). There was also no difference in total procedure time. However, fluoroscopy time was significantly reduced in the MN group when compared to the manual group (p < 0.001). There were no complications in either group.

Additionally, in order to decrease morbidity associated with radiation exposure during ablation cases, the Arrhythmia and Pacing Service has established protocols utilizing non-fluoroscopic mapping techniques to minimize radiation. This has resulted in a three-fold reduction in fluoroscopy times with 97 procedures being performed with minimal radiation (<1 minute) over the past two years.

**Changes in fluoroscopy time for ablation procedures**

by year

![Fluoroscopy time graph]

**Average fluoro time for ablations**

<table>
<thead>
<tr>
<th>AVERAGE FLUORO TIME</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.9 minutes</td>
<td>4.2 minutes</td>
</tr>
</tbody>
</table>
Diagnostic Testing and Cardiac Imaging

Each year, our non-invasive imaging lab performs more than 24,000 echocardiograms for fetuses, infants, children and adults with congenital or acquired heart disease. The imaging lab provides transesophageal, epicardial, intracardiac and transthoracic echocardiogram support in the catheterization labs and operating rooms on a daily basis. The main echocardiography lab consists of 10 rooms with a four-bed sedation bay and a state-of-the-art physician work area that houses five reading stations.

Fetal echocardiograms

Volume by year

Fetal cardiac interventions

For some fetuses with cardiovascular conditions, fetal cardiac intervention is available at Texas Children's Hospital to try to improve the physiology, even before birth. Texas Children’s Fetal Center™ at Texas Children’s Pavilion for Women is one of only a few centers in the world capable of providing the full array of fetal cardiac interventions, which involves a coordinated effort among a large, multidisciplinary team of fetal cardiologists, obstetricians and gynecologists, interventional cardiologists, congenital heart surgeons, fetal imaging experts, maternal and fetal anesthesiologists and other clinical specialists. We offer the following fetal cardiac interventions:

- Fetal arrhythmia evaluation and treatment – While some abnormal fetal rhythm problems are benign, some may result in fetal heart failure and can pose a risk to the fetus and mother. We offer a variety of therapies that are customized for both the fetus and mother. We collaborate closely with our adult cardiologists to ensure both fetus and mother are safe during treatment.

- Fetal hypoplastic left heart syndrome (HLHS) and related conditions – We offer three fetal cardiac interventions where the left heart structures are small, and the type of therapy depends on the fetal heart anatomy. For fetal aortic stenosis, which progresses to HLHS, we offer aortic valvuloplasty. This procedure is performed by a multidisciplinary team and consists
of placing a small balloon across the fetal aortic valve to enlarge it and to promote blood flow through the left side of the heart.

- Fetal atrial septal intervention – We offer this procedure for fetuses with hypoplastic left heart syndrome or mitral valve dysplasia and a restrictive or intact atrial septum. For this procedure, either a balloon or stent is placed across the atrial septum of the heart to decrease the pressure in the left atrium, and to help the fetal lungs recover before birth.

Some fetuses have small left-sided structures and without intervention will need neonatal heart surgery, but do not meet the criteria for the above procedures. We are currently conducting an experimental study protocol in which we provide daily home oxygen to mothers, also known as maternal hyperoxygenation, to promote fetal left heart growth.

**Stress MRI**

There is a growing need within pediatrics for the accurate assessment of myocardial perfusion due to both acquired and congenital heart defects. At Texas Children’s Hospital, we are one of the few pediatric centers in the country to offer stress MRI by multiple pharmacologic stress agents. This technology has been shown to be superior to many other non-invasive modalities in the adult population, and Texas Children’s Hospital is adopting many of these same principles and applying them to the pediatric population. These examinations involve the dedicated and coordinated efforts of a pediatric cardiologist, pediatric radiologist, cardiac pharmacologist, cardiac MRI technician and MRI physicist.

We have performed nearly 25 of these examinations over the last academic year with excellent results and no adverse effects. Some of the different pathology types include D-transposition of the great arteries after arterial switch procedure, aortic valve replacement by the Ross procedure, repaired anomalous origin of the coronary arteries, Kawasaki disease and myocardial bridge. The possible pharmacologic agents include either regadenoson, adenosine or dobutamine, and the decision making is dependent upon the patient’s disease type and their size.
Adult Congenital Heart Disease Program

The Adult Congenital Heart Disease (ACHD) Program offers a single point of care for patients with congenital heart disease from birth to adulthood. Our program offers the full range of ACHD services and specialties including surgery, diagnostic and interventional cardiac catheterization, noninvasive imaging (including cardiac MRIs and coronary CT angiography), arrhythmia services, and more.

ACHD clinic encounters

in 2014

- Clinic visits: 1,606
- Unique patients: 1,186

ACHD program volumes

by procedure

- Cardiac MRI = 117
- Echocardiograms = 2,092
- EP & Interventional Procedures = 215

Volumes reflect patients age 18 years or older.
Despite the growing population of adults with congenital heart disease, a gap remains in published information looking at the care these patients receive at pediatric institutions. With this in mind, a group of cardiologists at Texas Children’s Hospital recently evaluated the experience and resource utilization these adult patients had at our institution from January 2006 through December 2010.

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Number</th>
<th>Minor adverse events</th>
<th>Major adverse events</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterization lab</td>
<td>525</td>
<td>4.8%</td>
<td>0.7%</td>
<td>0%</td>
</tr>
<tr>
<td>Surgical procedures</td>
<td>104</td>
<td>6.7%</td>
<td>1.9%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visits</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinic</td>
<td>5,489</td>
</tr>
<tr>
<td>Emergency department</td>
<td>162</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnoses (most common)</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetralogy of Fallot</td>
<td>228</td>
<td>13%</td>
</tr>
<tr>
<td>D-transposition of the great arteries</td>
<td>208</td>
<td>11.9%</td>
</tr>
<tr>
<td>Single ventricle physiology</td>
<td>187</td>
<td>10.7%</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>128</td>
<td>7.3%</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>117</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

**Complexity of congenital heart disease**

- Simple: 41%
- Severe: 22%
- Moderate: 37%

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Cardiovascular Anesthesia

Pediatric Cardiovascular Anesthesia at Texas Children’s Hospital provides sedation and anesthesia services for all congenital cardiac operations and for children with congenital heart disease undergoing various non-cardiac procedures. Services are also provided for catheterization and electrophysiology procedures as well as imaging studies in MRI, CT and interventional radiology.

Cardiovascular anesthesia cases
by location

The Pediatric Cardiovascular Anesthesia Division treated more than 2,600 patients in 2014. Beyond anesthetic care, the division actively participates in the daily care of patients in the Cardiovascular Intensive Care Unit.
Cardiovascular anesthesia use during MRI by age

- 18 years or older: 6%
- 0-30 days: 8%
- 31 days-1 year: 4%
- 1-6 years: 44%
- 7-13 years: 28%
- 0-30 days: 8%

Cardiovascular anesthesia duration during MRI

- Less than 1 hour: 74%
- 1-2 hours: 19%
- 2-3 hours: 6%
- More than 3 hours: 1%
Leaders in cardiovascular anesthesia education

Transesophageal Echocardiography for Congenital Heart Disease, edited by Texas Children’s physicians Pierre C. Wong, M.D., and Wanda C. Miller-Hance, M.D., focuses on the application of imaging modality in patients with congenital heart disease. Published in early 2014, this work provides practical and instructive information, supplemented with figures/illustrations and high-quality videos. It is a resource for clinicians and trainees who wish to obtain basic knowledge or advance their understanding of the field.

Gregory’s Textbook of Pediatric Anesthesia introduces the basics of the field and explains how they are applied to contemporary practice both in and out of the operating room. Co-edited by Dean B. Andropoulos, M.D., chief of Anesthesiology at Texas Children’s Hospital, the book uses an evidence-based approach and is supplemented by in-depth case studies that spotlight best practice in action across all the major subspecialties. It also contains extensive information on anesthesia care for patients with congenital heart disease.

Anesthesia for Congenital Heart Disease, edited by Dean B. Andropoulos, M.D., chief of Anesthesiology, as well as Texas Children’s Hospital anesthesiologists Stephen A. Stayer, M.D., and Emad B. Mossad, M.D., is the leading textbook in the field of pediatric cardiac anesthesia. This textbook contains information on the rapid advances in surgery and anesthesia for congenital heart disease that have occurred in recent years, including neonatal cardiac surgery and anesthesia, treatment of single ventricle patients, new diagnostic modalities, and developments in the catheterization laboratory. It also addresses mechanical support of circulation, embryology and quality/outcomes management.

Following the inaugural American Board of Anesthesiology Pediatric Anesthesiology subspecialty board exam, Texas Children’s Hospital is now home to more than 60 subspecialty board-certified pediatric anesthesiologists.
Developmental Outcomes

Texas Children’s Heart Center strives to offer the best neurodevelopmental outcomes for our patients. As leaders in the field, we are focused on improving our patients’ long term developmental outcomes through state-of-the-art monitoring, focused research and routine neurodevelopmental follow-up of our highest risk patients.

Cerebral autoregulation monitoring

During surgery, our pediatric cardiovascular anesthesiologists work closely with surgeons and perfusionists to provide consistent care for cardiopulmonary bypass and anesthetic management. In an effort to continue improvement of cardiac outcomes, research teams are investigating a method to optimize cerebral oxygenation and brain blood flow through a new method of monitoring called cerebral autoregulation.

This unique, non-invasive approach has been designed by our cardiovascular anesthesiologists to monitor in real time the adequacy of blood flow to the brain during the highest risk parts of open heart surgery. We aim to be able to individualize cardiac bypass to provide ideal conditions to every patient at every moment during their heart operations. Our patented technology is being tested with the ultimate goal of incorporation into pediatric operating rooms across the world.

Long-term neurodevelopmental outcomes

Heart Center investigators have extensive experience in prospective outcomes research in infants undergoing heart surgery. We have published extensively on this topic in high-impact cardiac journals, and have presented our findings at many national and international meetings. Our teams have already uncovered important factors that contribute to developmental outcome, including brain immaturity, early brain injury and anesthetic drug exposure. The long-term impact of early brain injury will be better understood as we continue to follow patients throughout childhood. This will also form the basis of research aimed at providing early interventions to minimize the risk of brain injury and impaired development.

Cardiac Developmental Outcomes Program

Until recently, most neurodevelopmental follow-up has been in the context of research studies.

Texas Children’s Heart Center’s Cardiac Developmental Outcomes Program focuses on medical, social and developmental health in order to help children reach their maximum potential.

Launched in April 2013, the outcomes program was created to provide routine neurodevelopmental assessments and referrals to babies and children with congenital heart disease who have undergone early surgery. During its first year of operation, the team assessed more than 100 babies and children and provided referrals to a variety of specialists including speech and language, hearing, neurology and behavioral experts. Previously, these early interventions would not have been readily available.

The outcomes team includes developmental specialists and psychologists who work with the Heart Center to identify any problems at the earliest possible stage. This provides an opportunity for early intervention in order to minimize the impact of issues during childhood.

The program provides family-centered care, where the child’s parents or caregivers are directly consulted and involved in their child’s assessment and interventions for developmental progress. We also help families find resources that support their child’s development in their communities.
Cardiovascular Intensive Care Unit

The Cardiovascular Intensive Care Unit (CVICU) team of cardiac intensivists, nurses, respiratory therapists, social workers, dietitians and support staff provide intensive care to newborns, infants, children and young adults with heart disease. One of the largest of its kind in the country, the 21-bed CVICU cares for patients undergoing surgery for congenital heart disease, as well as those with end-stage heart failure before and after heart transplantation. In 2014, our CVICU medical team welcomed five new faculty members and continues to expand to support our growing patient population and increasing patient complexity.

Education in the CVICU

The faculty of the CVICU represent a multidisciplinary team focused on the care of the most critically ill patients with cardiac disease. Paul A. Checchia, M.D., serves as president of the Pediatric Cardiac Intensive Care Society (PCICS), the largest international society of its kind. Dr. Checchia and Ronald Bronicki, M.D., have led the international symposium for the PCICS for the past eight years. Faculty also serve as editors of the leading textbooks and journals in the field, including the journal *Pediatric Critical Care Medicine* and the *Rogers’ Textbook of Pediatric Intensive Care*, 5th Edition.

The CVICU prepares future leaders in the field through a subspecialty training program in Cardiovascular Critical Care Medicine. With four positions open every year, this is the largest program of its kind in the world. Texas Children’s Hospital also developed the first subspecialty training program in Neonatal Cardiovascular Medicine.

Nursing care in the Cardiovascular Intensive Care Unit

The CVICU at Texas Children’s Hospital has 106 specialized pediatric intensive care registered nurses on staff. The hours per patient day equivalent in the CVICU are 22.43 compared to the national benchmark of 22.1. Benchmark data is pulled from Children’s Hospital Association of like units. All newly admitted surgical cases receive a minimum ratio of 1:1 nursing care. Ninety-two percent of the CVICU registered nurses have a bachelor’s degree in nursing with a 35 percent rate of attainment of Certification in Critical Care Nursing.
Cardiovascular Intensive Care Unit admissions by age

- 0-1 month: 14%
- 1 month-2 years: 41%
- 2-6 years: 14%
- 6-13 years: 15%
- 13-19 years: 11%
- ≥ 19 years: 5%
Quality, Innovation and Research

Texas Children’s Heart Center is committed to examining the quality of care we provide to patients and helping them understand our performance compared to national standards. We are active participants in the following national quality programs:

• American College of Cardiology IMPACT (Improving Pediatric and Adult Congenital Treatment) Registry™ for diagnostic and interventional catheterization procedures
• National Cardiovascular Data Registry’s ICD Registry measuring and improving care for patients receiving implantable cardioverter defibrillators (ICDs)
• Society of Thoracic Surgeon’s National Quality and Outcomes program for congenital heart surgery

Outcomes and Impact Service
The focus of the work in the Outcomes and Impact Service at Texas Children’s Hospital is to measure clinical outcomes that matter to patients and the impact of care on the quality of life and functional status of our patients over time. Our ultimate goal is to deliver the highest value of health care to the patient.

By tracking outcomes, we learn about what happens to our patients, and we also learn about our performance as a health care delivery organization. We know we must continue to strive toward excellence in care delivery. In addition to providing statistics, we strive to engage patients and families in a conversation about the choices they face that will impact their health.

Our team includes outcomes nurses dedicated to different clinical specialties, computer programmers, data architects and specialists, and a statistician who works closely with clinical and administrative teams to measure, improve and share our outcomes. The goals of our service are to:
• Track and improve our clinical outcomes
• Understand the impact of those outcomes on the lives of our patients and families over time
• Make our outcomes data available in a form accessible by the general public
• Partner with patients and families in understanding outcomes data
• Help patients and families know what questions to ask when seeking medical treatment

Congenital Cardiac Anesthesia Society Database
Formed in January 2010 in coordination with the Society of Thoracic Surgeons Congenital Heart Database, the Congenital Cardiac Anesthesia Society (CCAS) Database captures and reports data concerning anesthesia monitoring and management, as well as adverse outcomes for congenital heart disease patients. This population is significantly more likely to suffer adverse events and cardiac arrest than patients without congenital heart disease.

Texas Children’s Hospital and other participating institutions use the data collected to determine patterns and to track adverse outcomes relative to the national experience. Local data has been used to determine the frequency of need for reintubation following in-OR extubation after congenital heart surgery and to identify unfavorable outcomes associated with the use of transesophageal echocardiography.
Cardiovascular Simulation Program
This in situ simulation program was developed to ensure our staff is prepared for patient emergencies and other high-risk clinical scenarios. The goals of the program are to improve patient safety through early identification of patient issues and to improve crisis resource management and teamwork skills. Program leaders established a curriculum and learning matrix in order to track objectives and progress. In addition to the “just-in-time” simulations done in the new, in situ simulation room on the cardiology ward, ECMO simulations are scheduled in the hospital’s state-of-the-art Simulation Center. In these scenarios, a large multidisciplinary team consisting of a surgeon, perfusionist and medical team with nurses and physicians gathers for four hours to simulate these time-sensitive, highly critical and technical events.

Pediatric Heart Network
The Pediatric Heart Network (PHN) was established in 2001 by the National Heart, Lung and Blood Institute to improve health outcomes in patients with pediatric acquired and congenital heart disease; to disseminate collaborative findings as the basis for improved evidence-based treatment options and standards of care; to train and educate new investigators; and to provide support and advocacy for families during the conduct of excellent, ethical clinical research.

The network of nine clinical sites is comprised of experienced research teams at hospitals that specialize in the care of pediatric patients with heart disease and have a data coordinating center. Texas Children’s Hospital and Baylor College of Medicine became a core site in September 2011. Texas Children’s is committed to participation in all PHN studies, including five current and six approved future studies. Current studies include the following:

• A study comparing two drug therapies (Beta Blocker Therapy (Atenolol) versus Angiotensin II Receptor Blocker Therapy (Losartan)) on Marfan syndrome patients to see which is better at slowing the speed of aortic enlargement. It will also compare side effects. The study began in February 2007 and will take approximately seven years.
• A study on Marfan syndrome patients to see if circulating TGF Beta levels correlate with treatment arm (atenolol versus losartan) and/or clinical outcomes in the PHN Trial of Beta Blocker Therapy (Atenolol) versus Angiotensin II Receptor Blocker Therapy (Losartan). By measuring the circulating TGF Beta levels after achieving steady-state optimal dosing in this trial cohort, we will be able to determine if there is a differential effect on TGF Beta levels in the two treatment arms, and if circulating TGF Beta levels correlate with clinical response in tissues where TGF Beta has a demonstrated (aorta, mitral valve) or proposed (left ventricle, skeleton) contribution to disease pathogenesis.

• An ECHO Z-score study will develop normal reference values for echocardiogram measurements obtained from multiple centers and geographic locations and adjusted for body size, age, gender and race that currently do not exist.

• The inter-stage monitoring project will develop predictive models of impending cardiorespiratory deterioration that will reduce morbidity and mortality in children with hypoplastic left heart syndrome and related cardiac lesions. Using sophisticated computational algorithms, we will develop multivariable predictive risk models that will analyze the physiological data that are routinely available in our patients in real time, providing clinical staff with early warning that a life-threatening event is imminent. This predictive risk model will ultimately be applicable to other patient populations, and across PHN institutions and in other cardiac centers caring for infants with critical congenital heart disease.

• Residual Lesion Score (RLS Main Study): a multi-center prospective study will validate the RLS as a tool to predict early and mid-term outcomes for five common congenital cardiac operations. The RLS study will develop the first validated tool for measurement of residual lesions following congenital heart surgery. The proposed project will also lay the groundwork for future projects, facilitating continuous quality improvement in congenital heart surgery. Approximately 250 subjects per procedural category will be enrolled at each institution over a two-year period. The study will last five years.
Preventive Cardiology Program
Focused on medically managing the risk factors of acquired heart disease in pediatric patients, the Preventive Cardiology Program cares for patients who have abnormal lipid levels or blood pressure results or who have been diagnosed with Kawasaki disease. The clinic’s goals are to prevent future cardiac disease and events such as heart attack and stroke through early and timely interventions and to learn how to better care for children with these issues.

Research
Texas Children’s Heart Center is expanding the boundaries of pediatric cardiac care through novel research. To learn more about how we are translating research into clinically relevant and beneficial solutions for our patients, visit texaschildrens.org/heart.

Real-time predictive monitoring in ICU settings
This research involves creating computer programs that look for early warning signs of deterioration in intensive care unit patients. The programs process the physiological data recorded from patient monitoring equipment in real time. The goal is to create a system that provides advanced warning that a life-threatening event is likely to occur within the next 12-24 hours. Care providers can use this information to proactively decide how to intervene before a situation becomes life threatening, thus improving patient outcomes.

Genomic analysis of cardiac ICU patients
This research aims to develop predictive outcome models in the unique patient population of children with complex cardiac disease using novel genomic technology. The goal is to tailor medical and surgical therapies, developmental therapy services, and even sedation strategies for each individual child based on their own genetic profile.
Meet Our Leaders

Charles D. Fraser, Jr., M.D., is surgeon-in-chief, co-director of Texas Children’s Heart Center and chief of the Division of Congenital Heart Surgery at Texas Children’s Hospital. His academic appointments include professor of Surgery in the Michael E. DeBakey Department of Surgery (tenured) at Baylor College of Medicine, professor of Pediatrics at Baylor College of Medicine and adjunct professor of Bioengineering at Rice University. Dr. Fraser holds the Clayton Chair in Surgery and the Donovan Chair in Congenital Heart Surgery at Texas Children’s Hospital. Dr. Fraser has a clinical appointment at the Texas Heart Institute, where he serves as director of the Adult Congenital Heart Surgery Program.

Dr. Fraser’s extensive education began as an undergraduate at The University of Texas at Austin, where he graduated with honors in mathematics. He received his medical degree with honors from The University of Texas Medical Branch at Galveston. His residency and fellowship training took place at The John Hopkins Hospital in Maryland. He completed additional fellowship training in congenital heart surgery at the Royal Children’s Hospital in Melbourne, Australia. After joining the faculty at the Cleveland Clinic, Dr. Fraser was recruited to Texas Children’s Hospital in July of 1995 to establish a dedicated pediatric congenital heart surgery program.

Daniel J. Penny, M.D., Ph.D., M.H.A., is chief of Cardiology at Texas Children’s Hospital, co-director of Texas Children’s Heart Center and professor of Pediatrics at Baylor College of Medicine. Dr. Penny obtained his medical degree from the National University of Ireland and received a doctoral degree for his thesis “Functional Analysis of Fontan Circulation” from the University of London. He completed fellowship training in pediatric cardiology at the Royal Children’s Hospital in Melbourne and received a second doctoral degree at Monash University, Australia for his studies on neonatal circulation. Dr. Penny worked as a pediatric cardiologist at the Royal Brompton Hospital in London and at Great Ormond Street Hospital in London. Before coming to Texas Children’s Hospital, he was the chief of Cardiology at the Royal Children’s Hospital of Melbourne and a professor in the Department of Pediatrics within the University of Melbourne.
Emad B. Mossad, M.D., is director of Pediatric Cardiovascular Anesthesiology at Texas Children’s Hospital and co-director of Texas Children’s Heart Center. He is also a professor of Anesthesiology and Pediatrics at Baylor College of Medicine. Dr. Mossad’s training began as an undergraduate at Cairo University, Egypt. His medical degree is from University of Cairo Medical School, and his residency and fellowship training in cardiac anesthesia took place at the Cleveland Clinic Foundation. Dr. Mossad also completed a pediatric anesthesia fellowship at Children’s National Medical Center of George Washington University and an echocardiography fellowship at the Cleveland Clinic. Dr. Mossad was the director of Congenital Cardiac Anesthesia at Cleveland Clinic for 13 years before he joined the Cardiovascular Anesthesiology team at Texas Children’s Hospital in 2008. Dr. Mossad is a founding board member and currently serves as President of the Congenital Cardiac Anesthesia Society.

Lara S. Shekerdemian, M.D., F.R.A.C.P., M.H.A., is chief of Critical Care and co-director of Texas Children’s Heart Center. She also serves as the vice chair of Clinical Affairs for the Department of Pediatrics and professor of Pediatrics at Baylor College of Medicine. She graduated from Birmingham University Medical School in 1990. She was awarded her postgraduate doctoral degree for her thesis, “Cardiopulmonary Interactions in Congenital Heart Disease” from the University of Birmingham in 1997. Dr. Shekerdemian trained in pediatrics and pediatric cardiology and undertook postgraduate research in London. She trained in critical care in London and Toronto. She was previously on faculty at Great Ormond Street Hospital in London and was most recently the chief of Critical Care at The Royal Children’s Hospital in Melbourne. Her research and clinical interests include extracorporeal life support, brain injury in infants and children with heart disease, and outcomes in children after admission to the intensive care unit.
Texas Children’s Heart Center Medical Staff

To view online profiles for each of our physicians, visit texaschildrens.org/heart.

Congenital Heart Surgery
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Iki Adachi, M.D.
Jeffrey S. Heinle, M.D.
Lauren Kane, M.D.
E. Dean McKenzie, M.D.
Carlos Mery, M.D.

Pediatric Cardiology
Daniel J. Penny, M.D., Ph.D., M.H.A., Chief
Hugh Allen, M.D., Ph.D.
Carolyn A. Altman, M.D., F.A.C.C., F.A.S.E.
Rachel Arnold, PA-C.
Nancy A. Ayres, M.D., F.A.C.C., F.A.S.E.
Manish Bansal, M.D.
Judith A. Becker, M.D.
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