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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 share with you the 2015 Texas Children’s Heart Center Outcomes Book. With more than 900 operating room cases and over 25,600 patient encounters, this year has been full of activity and growth. This report covers highlights from our Heart Center programs, including incredible patient stories and important programmatic developments.

We continue to develop all of our Heart Center teams to better meet the needs of our patients and families. In 2015, we welcomed several new physicians to our center, bringing the combined Heart Center staff to over 125 providers.

Our facilities also continue to grow. We opened our first-of-its-kind Pediatric Heart Failure Intensive Care Unit in 2015, aimed at providing highly specialized care for children with heart failure, as well as those requiring intensive care before and after heart transplant, and those on mechanical cardiac support.

Texas Children’s Hospital The Woodlands is in its final construction stages and remains on target to open in 2017. We are actively recruiting a team to meet the specific needs of this community. This will be Texas Children’s second community hospital and third pediatric hospital.

The main campus of Texas Children’s Hospital is also undergoing a $575 million expansion to improve care and the patient/family experience in high-acuity areas such as surgery and intensive care. In 2015, construction began on a pediatric tower that will be the new home to Texas Children’s Heart Center, including the outpatient clinic, cardiovascular operating rooms and catheterization labs. Slated for completion in 2018, the 25-floor tower will feature state-of-the-art technology and 130 beds for pediatric and cardiovascular intensive care.

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

We hope you enjoy reading about our outstanding team and their activities. Thank you for your interest in our center.

Sincerely,

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

Daniel J. Penny, M.D., Ph.D., M.H.A.
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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 Hospital is one of the nation’s largest and most comprehensive specialty pediatric hospitals, with more than 3.5 million patient encounters in 2015. Texas Children’s also operates 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 more than 50 practices throughout the greater Houston community.

The main campus of Texas Children’s Hospital is located near downtown Houston in the Texas Medical Center, the largest medical center in the world. The main campus includes nearly 500 licensed inpatient beds; the Clinical Care Center for outpatient visits; the Feigin Center for pediatric research; and Texas Children’s Pavilion for Women, a comprehensive OB/GYN facility with a focus on high-risk births. Located nearby is the Texas Children’s Hospital Jan and Dan Duncan Neurological Research Institute, a basic research institute dedicated to solving childhood neurological diseases. To serve the rapidly growing population in West Houston, Texas Children’s Hospital West Campus opened in 2011 with acute care and critical care beds, an emergency center, surgical suites and more than 20 subspecialty clinics. In 2017, a second community hospital, Texas Children’s Hospital The Woodlands, will open.

The mission of Texas Children’s 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 ranked #4 among top children’s hospitals in the nation and 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 10 medical schools for pediatrics. Currently and throughout our 61-year partnership, Texas Children’s Hospital serves as Baylor’s primary pediatric training site. The collaboration between Texas Children’s Hospital and Baylor is one of the top five such partnerships for pediatric research funding from the National Institutes of Health.

With a staff of more than 11,000 employees and more than 2,000 board-certified physicians, pediatric subspecialists, pediatric surgical subspecialists and dentists, Texas Children’s offers more than 40 subspecialties, programs and services.

Physicians are employees of Baylor College of Medicine, not Texas Children’s Hospital. Because they practice at Texas Children’s Hospital, they may be referred to as “our team” or “Texas Children’s physicians” throughout this report.
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 the multidisciplinary team.

**20th Floor** – Heart Center clinics and diagnostic facilities, including the echocardiography lab and cardiovascular clinical research core

**19th Floor** – Heart Center administrative offices and conference rooms

**18th Floor** – 21-bed Cardiovascular Intensive Care Unit; dedicated Heart Center pharmacy; three state-of-the-art cardiovascular operating rooms; three state-of-the-art cardiac catheterization labs; eight-bed holding/catheterization recovery unit

**17th Floor** – Cardiovascular Anesthesiology administrative offices; Ronald McDonald® Family Waiting Room with additional private rooms for families to consult with their child’s physicians or to wait during procedures; support services, including social work and child life staff

**15th Floor** – 22-bed inpatient unit including six “step-down” beds for patients who are healthy enough to leave intensive care but still need close monitoring; 12-bed dedicated Heart Failure Intensive Care Unit
Pioneers in Pediatric Cardiac Care

Texas Children’s Hospital has been a leader in pediatric heart care for 60 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 2015, U.S. News & World Report ranked Texas Children’s Heart Center #2 in the nation for pediatric cardiology and heart surgery. Comprising several multidisciplinary teams working in conjunction with pediatric subspecialists throughout the hospital, the Heart Center strives to provide unparalleled care at every point from diagnosis through treatment and follow-up.

Texas Children’s Heart Center is part of the OptumHealth Pediatric Transplant Centers of Excellence Network and is recognized by Aetna as a Pediatric Congenital Heart Surgery Institute of Excellence.
National and International Reach

Texas Children’s commitment to caring for children reaches around the globe. In 2015, our Heart Center cared for patients from more than 30 states and over 15 countries (shown below). We are dedicated to creating a healthier future for children throughout the global community.
2015 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>822</td>
</tr>
<tr>
<td>Heart transplants</td>
<td>21</td>
</tr>
<tr>
<td>Lung transplants</td>
<td>8</td>
</tr>
<tr>
<td>Adult congenital heart disease operations</td>
<td>63</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>914</strong></td>
</tr>
</tbody>
</table>

### Cardiac catheterizations

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic cardiac catheterizations</td>
<td>544</td>
</tr>
<tr>
<td>Interventions</td>
<td>454</td>
</tr>
<tr>
<td>Electrophysiology studies and ablations</td>
<td>132</td>
</tr>
<tr>
<td>Pacemaker and defibrillator implants</td>
<td>59</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,189</strong></td>
</tr>
</tbody>
</table>

### Diagnostic testing and cardiac imaging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiograms</td>
<td>25,915</td>
</tr>
<tr>
<td>Fetal echocardiograms</td>
<td>1,831</td>
</tr>
<tr>
<td>Electrocardiograms</td>
<td>37,138</td>
</tr>
<tr>
<td>Cardiac MRIs</td>
<td>509</td>
</tr>
<tr>
<td>Stress MRIs</td>
<td>41</td>
</tr>
<tr>
<td>Holter® monitors</td>
<td>5,118</td>
</tr>
<tr>
<td>Stress tests</td>
<td>931</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>71,483</strong></td>
</tr>
</tbody>
</table>

### Cardiovascular anesthesia

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterizations and electrophysiology patients</td>
<td>1,129</td>
</tr>
<tr>
<td>Cardiovascular operating room patients</td>
<td>982</td>
</tr>
<tr>
<td>Interventional radiology patients</td>
<td>252</td>
</tr>
<tr>
<td>MRI patients</td>
<td>428</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,791</strong></td>
</tr>
</tbody>
</table>

The outpatient clinic at Texas Children’s Heart Center had more than 25,600 patient encounters in 2015.
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 Surgery team have performed more than 14,500 operations on children and adults with congenital heart disease.
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.

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)\(^1\) 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 2015 was 1.6%\(^2\). Data collected by the Society of Thoracic Surgeons (STS) shows the national hospital discharge mortality rate at 2.9%\(^3\).

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\(\text{\(^2\) 007-RACHS-1 Index Surg CHD Volume.}\)

\(\text{\(^3\) Society of Thoracic Surgeons Data Harvest Report, published June 2015.}\)
Age-appropriate surgical planning and management allows for outcomes in patients of all ages to be better than the national benchmarks. Patient total combines CPB and non-CPB cases (N=632).

### Mortalities by age and operation type in 2015

<table>
<thead>
<tr>
<th>Age</th>
<th>CPB cases</th>
<th>Non-CPB cases</th>
<th>CPB discharge mortalities</th>
<th>Non-CPB discharge mortalities</th>
<th>Discharge mortality</th>
<th>Percent mortality</th>
<th>STS national benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonate</strong> (0d - 30d)</td>
<td>68</td>
<td>39</td>
<td>2</td>
<td>3</td>
<td>5/107</td>
<td>4.7%</td>
<td>7.9%</td>
</tr>
<tr>
<td><strong>Infant</strong> (31d - 1y)</td>
<td>175</td>
<td>30</td>
<td>2</td>
<td>0</td>
<td>2/205</td>
<td>1.0%</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>Child</strong> (&gt;1y - &lt;18y)</td>
<td>262</td>
<td>20</td>
<td>3</td>
<td>0</td>
<td>3/282</td>
<td>1.1%</td>
<td>1.1%</td>
</tr>
<tr>
<td><strong>Adult</strong> (18y+)</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0/38</td>
<td>0.0%</td>
<td>1.6%</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td><strong>543</strong></td>
<td><strong>89</strong></td>
<td><strong>7</strong></td>
<td><strong>3</strong></td>
<td><strong>10/632</strong></td>
<td><strong>1.6%</strong></td>
<td><strong>2.9%</strong></td>
</tr>
</tbody>
</table>
The Congenital Heart Surgery Division performs an average of 27 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 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 with perimembranous, supracristal, inlet or muscular VSDs, and patients with double-chambered right ventricle. The Congenital Heart Surgery Division performs an average of 59 VSD closures each year and in 2015 had a survival rate of 100 percent.

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4 Hospital mortality is calculated over the last four years from 2012-2015.
5 STS benchmark data is from 2011-2014.
Atrioventricular canal repair
Volume by year

The Congenital Heart Surgery Division performs an average of 30 operations each year for partial, intermediate and complete atrioventricular (AV) canal defects.

Tetralogy of Fallot repair
Volume by year

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 attempt repair of the defect while preserving 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 29 TOF repairs each year.

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OVERALL HOSPITAL DISCHARGE MORTALITY RATE

<table>
<thead>
<tr>
<th>Year</th>
<th>Atrioventricular canal repair</th>
<th>Tetralogy of Fallot repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td>2007</td>
<td>30</td>
<td>21</td>
</tr>
<tr>
<td>2008</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>2009</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>2010</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>2011</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>2012</td>
<td>20</td>
<td>27</td>
</tr>
<tr>
<td>2013</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>2014</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>2015</td>
<td>32</td>
<td>31</td>
</tr>
</tbody>
</table>

6 Hospital mortality is calculated over the last four years from 2012-2015.

7 STS benchmark data is from 2011-2014.
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 19 Norwood operations per year for hypoplastic left heart syndrome and other single ventricle anomalies.
Single Ventricle Program

The Single Ventricle Home Monitoring Program and Outpatient Clinic at Texas Children’s Heart Center is focused on the care of infants with single ventricle congenital heart defects, which include hypoplastic left heart syndrome (HLHS) and variants, unbalanced atrioventricular septal defects, complex single ventricle and heterotaxy syndrome, among others. Most of these infants will require at least two or three operations within the first few years of life. The goals of these operations are to: (1) allow free flow of blood from the heart out to the body; (2) protect the lungs from high pressure and too much blood flow; and (3) create separate paths for blood to flow to the lungs and out to the body. Infants will typically undergo placement of a shunt or conduit to provide blood flow to the lungs within the first few days of life. For infants with HLHS, reconstruction of the vessel that allows blood to flow to the body (the Norwood operation) is typically performed within the first week of life. The second stage (bidirectional Glenn shunt) is performed at around 3-6 months of age. The period between these operations is called interstage period.

The importance of a home monitoring program

The interstage period is an important phase in the infant’s well-being and outcome. It is common for infants with single ventricle congenital heart defects to have poor oral intake and weight gain, which may affect their well-being. They may require multiple daily medications, modified feeding and interstage interventions. Common childhood illnesses, such as a cold or diarrhea, can be life-threatening. Early recognition of signs and symptoms is thus necessary to be able to obtain immediate evaluation and intervention. The home monitoring program allows parents and caregivers to actively participate in the care of their babies outside of the hospital by watching for and addressing many of the problems that can be seen in the interstage period. Our program provides support, resources and clinical care to help transition successfully to the second surgery.

A team approach to treatment

Texas Children’s Congenital Heart Surgery team performs an average of 19 Norwood operations a year for patients with HLHS and other single ventricle heart defects. We take a collaborative approach to the post-surgical care of these infants drawing on the expertise of a multidisciplinary team including Pediatric Cardiology, Congenital Heart Surgery, Interventional Cardiology, Electrophysiology, Cardiac Imaging, Cardiovascular Anesthesia, Genetics and Nutrition Services.

Research and quality improvement

We are leaders in research involving the many aspects of care of infants with single ventricle heart disease, encompassing genetics, critical care, nutrition and epidemiology. We are part of several studies with the Pediatric Heart Network aiming to further understand and address clinical questions.

Our program is also an active member of the National Pediatric Cardiology Quality Improvement Collaborative, a multicenter group focused on improving quality and outcomes for children with single ventricle heart defects who have undergone a Norwood operation.
Patient thrives after complex surgeries for congenital condition

Three surgeries and four years after a lifesaving open heart surgery, Stockton Watson is a tenacious and energetic preschooler who recharges at naptime and takes only one medication—a baby aspirin.

When his mother, Brittany, had a routine ultrasound at 14 weeks gestation, she learned Stockton’s heart was abnormally shaped. An echocardiogram provided a diagnosis: hypoplastic left heart syndrome (HLHS), a dangerous defect that stunts development of the left ventricle, mitral valve and aortic valve, causing the left ventricle to be too small to function.

“The doctors told us HLHS was very serious and life-threatening for our baby,” she said. “It was frightening, but we knew he would have to have surgery to correct the problem.”

Immediately, Brittany and her husband, Seth, began to research hospitals and surgical success rates. To their surprise, that wasn’t as easy as they thought it would be.

“Most hospitals don’t give out figures, but Texas Children’s shared all the statistics,” she said. “It confirmed that’s where we needed to be.”

HLHS typically requires a series of surgeries over the first several years of life. Between surgeries, patients are monitored closely by the Single Ventricle Program.

Stockton weighed almost 8 pounds when he was born, and his first surgery was four days later. He spent 11 days in the Cardiovascular Intensive Care Unit and 40 days as an inpatient.

“Those first few months were difficult, I have to admit,” Brittany said. “We would get over one hurdle and another would pop up. But he was growing, and everything was progressing toward his second surgery.”

Five months later, Stockton had the second procedure.

“This surgery gave us a whole new outlook,” Brittany said. “It really changed him, and he started growing more quickly, crawling and talking.”

In 2015, when Stockton was 4, his doctors said he was ready for the next surgery. It too was a success, and now the family returns for follow-ups only once a year.

Brittany says Stockton brings a great deal of love and happiness to their family, which includes an older sister and younger brother and sister. He enjoys learning and is hitting—often exceeding—developmental milestones.

Although it is likely Stockton will need a heart transplant as a young adult, he starts kindergarten next fall with no restrictions except to avoid contact sports. Brittany has become an advocate for people who are affected by HLHS as a member of the National Pediatric Cardiology Quality Improvement Collaboration.

“We’re so grateful, and we know Texas Children’s was the right choice,” she said. “They have so much experience and knew exactly what they were doing every step of the way.”
Coronary Anomalies Program

In December 2012, Texas Children’s Hospital created the Coronary Anomalies Program, a multidisciplinary team to care for patients with rare congenital heart defects associated with coronary ischemia, myocardial infarction and sudden death. Coronary artery anomalies are the second-leading cause of sudden cardiac death in children and young adults.

Diagnosing these anomalies can be challenging because many individuals with the conditions have no symptoms, and their first manifestations can be sudden cardiac arrest or death. Those who do have symptoms complain most often of chest pain, palpitations, dizziness or fainting during or just after exercise.

How to best treat children or young adults 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 show no evidence of reduced blood flow to the heart is unclear.

Texas Children’s Hospital has hosted two conferences focused on this topic and is partnering with the Children’s Hospital of Philadelphia to host the 3rd Symposium on Coronary Artery Anomalies, which will be held in Philadelphia in 2016. During the conferences, speakers from leading heart institutions across the country provide a dedicated forum to discuss the diagnosis and management of patients with coronary artery anomalies.

Outcomes of patients with anomalous aortic origin of a coronary artery

Texas Children’s Coronary Anomalies Program began tracking outcomes in December 2012 and as of April 2016 has recorded:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients</td>
<td>134</td>
</tr>
<tr>
<td>Surgery treatment</td>
<td>38</td>
</tr>
<tr>
<td>Surgical mortality</td>
<td>0</td>
</tr>
<tr>
<td>Complications</td>
<td>3</td>
</tr>
</tbody>
</table>
Heart Failure and Transplant Program

Since its inception in 1984, Texas Children’s Heart Center has performed more than 335 heart transplants, making it one of the largest and most successful programs in the nation. As the number of diagnoses for pediatric heart failure has increased, 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](http://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 meet the needs of the individual patient.

VAD implantations

By device

- Thoratec P-VAD®: 11
- Impella®: 7
- Micromed®: 3
- HeartWare®: 17
- TandemHeart®: 3
- SynCardia® Total Artificial Heart: 1
- HeartMate II®: 17
- Rotaflow®: 26
- Berlin Heart EXCOR® Pediatric: 46
- Bio-Medicus®: 22
- Micromed®: 3

**TOTAL CASES 153**

**10 VADs placed from 1995-2015.**
Advancing the field of pediatric ventricular assist devices

In 2012, the United States Food and Drug Administration (FDA) granted humanitarian device exemption for the Berlin Heart EXCOR Pediatric Ventricular Assist Device (VAD). This approval was the successful result of a multi-year, multi-institution study led by Texas Children’s Hospital. This landmark event has opened the era of pediatric VAD support in North America. The Berlin Heart EXCOR is the only FDA-approved pediatric VAD.

Today, Texas Children’s Hospital continues to advance the field of pediatric ventricular assist devices. Because there are significantly more adult patients with heart failure than pediatric patients, device development is far more advanced in the adult world. Texas Children’s VAD program strives to achieve improved outcomes by finding ways to utilize adult VADs in children. These VADs include the HeartWare HVAD and Impella catheter VAD. Since HeartWare is implantable, children on this device can live at home and even attend school. This has significantly improved quality of life of patients compared to the Berlin Heart, which requires inpatient management. Since 2012, Texas Children’s Heart Center has implanted 20 HeartWare and 11 Impella devices – more than any other pediatric center in North America. Our positive results are widely recognized nationally and internationally, resulting in multiple publications.11,12,13

Texas Children’s Hospital is also working on the development of a new-generation miniaturized implantable VAD specifically designed for small children, known as the Jarvik Infant VAD. With the support of the federal government through the National Heart, Lung and Blood Institute, this AA-battery-size device is undergoing pre-clinical testing in a chronic animal model, with the anticipation of FDA approval for a human trial within 2016. This will further expand the use of implantable VADs in small children, including babies.

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, Cardiovascular Intensive Care Unit or Neonatal Intensive Care Unit based on each child’s underlying problem. A specially trained team of cardiac intensivists, surgeons, critical care nurses and ECLS specialists carefully monitors each child’s condition.

To provide ECLS, we use extracorporeal membrane oxygenation (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.

Heart transplants

Volume by year

Heart transplant patient survival rates

Pediatric age <18

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14 Data includes patients who received heart-and-lung transplants simultaneously.
15 Scientific Registry of Transplant Recipients (SRTR). Program Specific Reports. Table 11 – 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

<table>
<thead>
<tr>
<th>Era</th>
<th>Years post transplant</th>
<th>Survival probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERA I</td>
<td>0</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>36</td>
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<tr>
<td></td>
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<td>16</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>ERA II</td>
<td>0</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>41</td>
</tr>
<tr>
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<td></td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0</td>
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<tr>
<td>ERA III</td>
<td>0</td>
<td>172</td>
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<td></td>
<td>5</td>
<td>45</td>
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<td>10</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>


Texas Children’s data: 1984-2015, 318 Txs on 318 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{17}

One family fights breast cancer and heart failure

To say Riki Graves’ pregnancy was full of ups and downs would be a vast understatement. On her 38th birthday, just a few weeks after finding out that she and her husband, Chris, were expecting their second child, Riki was diagnosed with breast cancer.

After consulting with doctors at MD Anderson Cancer Center, Riki made the deeply personal decision to forego cancer treatments until after her baby was born. “I wanted to provide my daughter with the strongest pregnancy and healthiest beginning to life possible,” she said.

Soon after that, during her 20-week ultrasound, the Graves family was dealt a second blow. They found out that their unborn baby, a little girl whom they would name Juliana, had a serious heart condition. Juliana was diagnosed with an unbalanced atrioventricular septal defect with severe biventricular dysfunction, a small aortic arch and severe atrioventricular valve regurgitation.

Although the terminology meant little to her, Riki understood Juliana would likely need several heart surgeries, and even then she might not survive. “Hearing those words sent a panic through me that, even now, is hard to describe.”

Riki was referred to Texas Children’s Fetal Center.™ Nancy Ayres, M.D., director of Noninvasive Imaging and Fetal Cardiology, and a multidisciplinary team provided care for mother and baby during the pregnancy.

On April 9, 2014, Juliana was born weighing 6 pounds, 14 ounces. Charles D. Fraser, Jr., M.D., Texas Children’s surgeon-in-chief and chief of Congenital Heart Surgery, determined that Juliana’s heart was too structurally abnormal and not strong enough for surgery. Juliana was placed on the transplant list on April 21. On April 26, at just 17 days old, she received a new heart.

“It is rare to find an organ for her size and age,” said Diana Orosco, R.N., a nurse coordinator assigned to the Graves. “Historically, our center has not performed transplants on babies this young.”

Jeffrey Heinle, M.D., surgical director of Texas Children’s Heart and Lung Transplant Program, led the successful transplant surgery on Texas Children’s youngest heart transplant patient to date.

“We feel so fortunate that Juliana was cared for by Texas Children’s Hospital,” Riki said. “All the doctors, fellows and nurses who provided extraordinary care and helped us get through – we can’t thank them enough.”

Since her heart transplant, Juliana is doing fantastic. She recently celebrated her second birthday and is developing typically.

After Juliana was born, Riki received radiation treatment at MD Anderson for her breast cancer and has been in remission since July 2014.
Interventional Cardiology

Thanks to advances in the field, an increasing number 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 1,189 cardiac catheterization procedures in 2015. The full-service cardiac catheterization laboratory performs interventions 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 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
• Critical aortic stenosis and hypoplastic left heart syndrome

In addition, we provide percutaneous ventricular assist device placement for heart failure (using the Impella® device).

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 the following page). In addition, we have a strong culture of attention to radiation safety and continuous quality improvement, and we strive to promote these concepts locally and nationally. 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

96.20%

0.55%
Cases with major complications

3.25%
Cases with minor complications
Electrophysiology

The Arrhythmia and Pacing Service at Texas Children’s Heart Center offers a broad complement of diagnostic and therapeutic options to evaluate and manage heart rhythm abnormalities. 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.

The Electrophysiology team runs a robust Genetic Arrhythmia Clinic. In 2015, there were more than 500 patient visits for assessment of inherited arrhythmia syndromes, and the team is actively involved in research to improve the management and outcomes of these patients. In collaboration with the Cardiovascular Research Institute, work is underway to identify novel genes and the molecular mechanisms that underlie arrhythmias and sudden death syndromes. Over the past year, our group has discovered new insights into Wolff-Parkinson-White syndrome, catecholaminergic polymorphic ventricular tachycardia, SCN5A overlap syndromes, Long QT syndrome and the muscular dystrophies. Our research spans both the clinical and basic sciences, encompassing a “bed to benchside” approach that strives to improve the overall care of our patients.

Supraventricular tachycardia ablation outcomes

<table>
<thead>
<tr>
<th></th>
<th>2015 ACUTE SUCCESS RATE</th>
<th>Texas Children’s Hospital</th>
<th>National benchmark(^{18})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>99%</td>
<td>95.2%</td>
</tr>
</tbody>
</table>

Stereotaxis

Texas Children’s Hospital is one of only a few hospitals in the U.S. with a remote magnetic navigation (MN) system called Stereotaxis for catheter manipulation. Stereotaxis has been utilized for over 150 ablation cases at Texas Children’s Hospital over the past several years.

MN offers theoretic advantages in the treatment of children. The catheter is more flexible and atraumatic than standard catheters, potentially eliminating the 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.

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 over 100 procedures being performed with minimal radiation (<1 minute) over the past two years (see graphs on the following page).

Changes in fluoroscopy time for ablation procedures
By month

Mean and median of fluoroscopy time
By year
Diagnostic Testing and Cardiac Imaging

Each year, our noninvasive imaging lab performs more than 25,000 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 of the heart 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, others 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 adult cardiologists to protect the safety of both fetus and mother during treatment.

• Fetal hypoplastic left heart syndrome (HLHS) and related conditions – We offer three fetal cardiac interventions for babies with small left heart structures, with the type of therapy depending 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.

- For fetuses with HLHS or mitral valve dysplasia and a restrictive or intact atrial septum, we offer fetal atrial septal intervention. 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.

- For fetuses with small left-sided structures who may need neonatal heart surgery but do not meet the criteria for the above procedures, we are 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 noninvasive 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.
Adult Congenital Heart Disease Program

The Adult Congenital Heart Disease (ACHD) Program at Texas Children’s Hospital 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**

**Volume by year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Clinic Visits</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1,217</td>
<td>1,556</td>
</tr>
<tr>
<td>2013</td>
<td>1,373</td>
<td>1,793</td>
</tr>
<tr>
<td>2014</td>
<td>2,054</td>
<td>1,529</td>
</tr>
<tr>
<td>2015</td>
<td>2,423</td>
<td>1,782</td>
</tr>
</tbody>
</table>

2014 volumes reflect patients age 18 years or older.

**Congenital heart disease diagnoses of ACHD patients**

In 2015

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetralogy of Fallot</td>
<td>20%</td>
</tr>
<tr>
<td>Transposition of the great arteries</td>
<td>18%</td>
</tr>
<tr>
<td>Single ventricle</td>
<td>15%</td>
</tr>
<tr>
<td>Coarctation of the aorta</td>
<td>9%</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>9%</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>6%</td>
</tr>
<tr>
<td>Atroventricular septal defect</td>
<td>12%</td>
</tr>
<tr>
<td>Other</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Living life to the fullest, despite congenital heart condition

Falon Wiesner-Jones has spent 33 years defying the odds, including giving birth to two healthy babies after she was told her chances to get pregnant were slim to none.

Diagnosed at 6 weeks old with transposition of the great arteries, a life-threatening heart defect, Falon has had more than 15 procedures, including three open-chest surgeries at Texas Children's.

At age 4, Falon had her first open heart surgery, performed by Denton Cooley, M.D., at Texas Children's. At 5, she received a pacemaker.

Although she couldn’t participate in contact sports, she did everything else – band, 4-H, ballet, gymnastics, skiing – even cheerleading.

“My parents never babied me; they only encouraged me,” she said. “My mom always told me I should go and live my life rather than watch it pass me by.”

When she was 16, Falon learned she had Stage II heart failure. Although she feels healthy most of the time, it is a condition that requires a lifetime of careful maintenance.

During college at Texas A&M University, Falon fell in love with her husband, Chad. Following graduation, they moved to New York and then Dallas. Falon has had two major complications and surgeries in adulthood.

At 28 years old, Falon transitioned to Texas Children’s Adult Congenital Heart Disease (ACHD) Program for specialized follow-up care for her condition.

“I’ve been at Texas Children’s since day one, and they really know me and my entire history,” Falon said. “It is so reassuring to be able to continue my care here, and to have all the resources I need in one spot.”

When Falon became pregnant with her first child, the ACHD team and Texas Children’s Pavilion for Women maternal-fetal medicine specialists worked hand-in-hand and closely monitored the condition of both mother and child.

“In the past, we used to tell women who had grown up with congenital heart disease not to get pregnant,” said Wayne Franklin, M.D., director of Texas Children’s Adult Congenital Heart Disease Program. “But we have since found that with excellent cardiology care and maternal-fetal medicine, these patients can have good outcomes with their pregnancies.”

After delivering a healthy baby girl in 2011, Falon went on to have a healthy son in late 2015.

“I have been very fortunate, and there isn’t a day that goes by I don’t thank God for my blessings,” she said. “I may still have many obstacles to face in the future, but with the help of Texas Children’s I am looking forward to seeing my children grow up and accomplish their dreams.”
Preventive Cardiology Program

The Preventive Cardiology Program at Texas Children’s Heart Center is part of our mission to provide the best possible care and outcomes for our patients. Focused on medically managing the risk factors of acquired heart disease in children, the Preventive Cardiology Program cares for patients with a strong personal or family history of cardiac disease, elevated cholesterol, high blood pressure or Kawasaki disease. Our goal is to prevent future cardiac disease and events such as heart attack and stroke through early detection and intervention and by educating children and families on how to better care for themselves.

Abnormal cholesterol and high blood pressure are well recognized conditions in adults. It surprises many people that these conditions can also arise in childhood, and that they lay the foundation for heart disease in adulthood. Research shows that normalizing cholesterol values and reducing high blood pressure in children may help prevent or slow the development of heart disease as they reach adulthood.

The goal of the Preventive Cardiology Program is to prevent heart attack, stroke and other acute cardiac events later in life, to decrease mortality and to increase a child’s future quality of life. Typically, our patients have abnormal cholesterol levels or high blood pressure or have been diagnosed with Kawasaki Disease, which can increase the risk of cardiac disease in adulthood.

Our patients may have other conditions such as liver disease, obesity, diabetes or metabolic syndrome that directly cause cholesterol or blood pressure abnormalities. Others, perhaps through a poor diet, lack of physical activity or other lifestyle factors, may be at a higher risk for cardiac disease and on an early pathway to acquired heart disease in adulthood.

With more than half a century of leadership in the care of patients with congenital heart disease, Texas Children’s has pioneered many of the now-standard procedures and therapies in pediatric cardiovascular care. The Preventive Cardiology Program uses a collaborative approach to treating patients, drawing on the expertise of a multidisciplinary team of specialists, including experts in pediatric cardiology, heart disease prevention, physical activity, nephrology, endocrinology and nutrition.
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 2,700 patients in 2015. Beyond anesthetic care, the division actively participates in the daily care of patients in the Cardiovascular Intensive Care Unit.
Reduction in cryoprecipitate waste in the pediatric cardiovascular operating room: A goal-directed transfusion pathway

In the United States, although the volume of blood and blood products needed for surgeries continues to increase annually, the amount of blood donated annually remains the same. Thus, it is important for health care organizations to responsibly manage blood/blood products and reduce the amount wasted in the OR due to over-ordering or over-estimating need. Texas Children’s Pediatric Cardiovascular Anesthesia Division recently embarked on a quality improvement project led by Erin Gottlieb, M.D., to introduce a goal-directed transfusion pathway based on results from rotational thromboelastometry (ROTEM®) and to limit the waste of cryoprecipitate, a blood product used to treat coagulation abnormalities in congenital heart surgery that was identified as highly vulnerable to waste.

The graphs below show a sustained decrease in cryoprecipitate waste after education and implementation of the transfusion pathway, along with a corresponding increase in the use of ROTEM® and fibrinogen concentrate (substitute for cryoprecipitate). The results were recently presented at the Congenital Cardiac Anesthesia Society and Society for Pediatric Anesthesia meetings and since then, multiple peer institutions have implemented similar measures in their CVORs. Texas Children’s Heart Center has found this pathway to be effective at reducing wasted blood as well as cryoprecipitate and is using it in cardiovascular surgeries.

Cryoprecipitate waste in the CVOR

By month

ROTEM® and fibrinogen concentrate trends

In 2015
Early extubation in the pediatric cardiac operating rooms

Early extubation in the cardiac operating rooms can have a positive impact on patient outcomes, including reducing the risk of pneumonia, infections and other complications and improving patient comfort. Texas Children’s Hospital participated in a multicenter quality improvement project to create clinical practice guidelines (CPG) to try to shorten the length of time patients spend on a ventilator following two types of surgeries: tetralogy of Fallot and coarctation repair. Teams from five leading pediatric heart centers looked into the factors that contribute to longer ventilation periods and created guidelines to help address these issues. The centers then adopted standardized guidelines and evaluated the changes in outcomes in the OR and the ICU. At Texas Children’s, the anesthesia portion of the project was led by David F. Vener, M.D., and included teams from Cardiovascular Anesthesia, the Cardiovascular Intensive Care Unit, Cardiovascular Surgery and Nursing, among others. The guidelines resulted in a significant reduction in time to extubation and ICU length of stay at all participating centers. At Texas Children’s, the mean hours of ventilation went from 66 hours to 5.5 hours following adoption of the CPG for patients with tetralogy of Fallot, and the mean length of stay in the CVICU went from 6.2 to 4.2 days. For coarctation, the mean hours of ventilation went from 21.2 hours to 12 hours following adoption of the CPG, and the mean length of stay in the CVICU went from 5 days to 4.8 days.

Tetralogy of Fallot

![Graph showing changes in post-op ventilation (hours) and ICU length of stay (days) pre- and post-CPG adoption for tetralogy of Fallot](image-url)
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 book 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 practices 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., Stephen A. Stayer, M.D., Emad B. Mossad, M.D., and Wanda C. Miller-Hance, M.D., is the leading textbook in the field of pediatric cardiac anesthesia. Now in its 3rd edition, 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.
Cardiovascular Intensive Care Unit

The Cardiovascular Intensive Care Unit (CVICU) includes cardiac intensivists, advanced practice providers, nurses, respiratory therapists, social workers, dietitians and support staff who provide intensive care to newborns, infants, children and young adults with congenital and acquired heart disease. With a total of 33 beds, the CVICU cares for patients undergoing surgery for congenital and acquired heart disease, as well as those with end-stage heart failure before and after heart transplantation. This year, in partnership with Cardiovascular Surgery, Heart Failure and Interventional Cardiology, we expanded our mechanical support program to include the largest pediatric utilization of a novel device, the Impella®.

New Heart Failure Intensive Care Unit

In July 2015, the CVICU launched the Heart Failure Intensive Care Unit, the first of its kind in the nation. This highly specialized 12-bed unit focuses on the treatment of children with heart failure, as well as those requiring intensive care before and after heart transplant, and those on mechanical cardiac support.

Renowned faculty and training programs

CVICU faculty includes leaders in pediatric cardiac intensive care, with certification in pediatric critical care, pediatric cardiology and pediatric anesthesiology. Texas Children’s also has the largest dedicated CVICU advanced training program in the country. The Pediatric Cardiac Critical Care Instructorship is a 12-month didactic and clinical training program for individuals who have completed fellowships in pediatric critical care medicine or pediatric cardiology and wish to pursue an additional year of training in pediatric cardiac intensive care. This training program provides a unique interface among critical care medicine, cardiology, cardiothoracic surgery and cardiac anesthesia. Texas Children’s also offers a fourth year of specialized training in neonatal cardiac critical care. The first of its kind in the nation, this program provides one position each year to neonatologists who desire additional training in newborn critical heart disease.
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 22.52 compared to the national benchmark of 26.16. 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. More than 95 percent of the CVICU registered nurses have a bachelor’s degree in nursing with a 22 percent rate of attainment of certification in critical care nursing.

Cardiology Patient Care Unit
The Cardiology Patient Care Unit is a 22-bed mixed intermediate and acute care unit caring for newborns, infants, children and young adults with heart disease. The unit is staffed by pediatric cardiologists, as well as a team of cardiology fellows, cardiac advanced practice providers, medical residents and cardiac trained registered nurses. In 2015, there were 1,222 patient encounters in this unit.

Nursing care in the Cardiology Patient Care Unit
The Cardiology Patient Care Unit at Texas Children’s Hospital has 54 registered nurses on staff. The hours per patient day equivalent in the acute care unit are 13.7, compared to the national benchmark of 15.9. The unit has a 65 percent rate of attainment for certification in pediatric nursing. Almost 90 percent of the cardiology acute care registered nurses have a bachelor’s degree in nursing, with the remaining 11 percent currently pursuing their bachelor’s degree in nursing.

Cardiovascular Simulation Program
Texas Children’s Heart Center developed an in-situ simulation program in 2012 to ensure nurses are 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 2015, the in-situ simulation room provided over 300 learning opportunities on the cardiology floor.
Cardiac Developmental Outcomes Program

Until recently, most neurodevelopmental follow-up of congenital heart disease patients 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 program was created to provide routine neurodevelopmental assessments and referrals for babies and children with congenital heart disease who have undergone early surgery. Since the program’s creation, the team has assessed 375 babies and children and provided referrals to a variety of specialists including speech and language, hearing, neurology and behavioral experts.

The team includes developmental pediatricians 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, in which 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 in their communities that support their child’s development.
Outcomes & Impact Service

The Outcomes & Impact Service at Texas Children’s Hospital measures important clinical outcomes and the impact of care on the quality of life and functional status of our patients over time. The team’s 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

For more information, please visit texaschildrens.org/outcomes-and-impact-service.
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 Congenital Heart Surgery Division 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 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 Johns Hopkins Hospital. He completed additional fellowship training in congenital heart surgery at the Royal Children’s Hospital in Melbourne, Australia. After joining the faculty at Cleveland Clinic, Dr. Fraser was recruited to Texas Children’s Hospital in July 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 and 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 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. He completed a pediatric anesthesia fellowship at Children’s National Medical Center of George Washington University and an echocardiography fellowship at the Cleveland Clinic. Prior to joining Texas Children’s Hospital in 2008, Dr. Mossad served as section head for Congenital Cardiac Anesthesia at the Cleveland Clinic from 1997-2008.

Dr. Mossad is actively involved in several professional societies, including service on committees for the Society of Cardiovascular Anesthesiologists and Society for Pediatric Anesthesia. He is also a founding board member and currently serves as president of the Congenital Cardiac Anesthesia Society. Additionally, Dr. Mossad has 38 peer-reviewed publications and eight book chapters, mostly in his field of interest of coagulation management and perioperative care of children and adults with congenital heart disease. He also has a strong interest in the training and education of fellows and residents in the disciplines of pediatric and cardiac anesthesia.

Lara S. Shekerdemian, M.D., F.R.A.C.P., M.H.A., is chief of Critical Care at Texas Children’s Hospital 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 and was awarded a postgraduate doctoral degree for her thesis, “Cardiopulmonary Interactions in Congenital Heart Disease,” from the University of Birmingham. 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 the 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.

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<th>Congenital Heart Surgery</th>
<th>Pediatric Cardiology</th>
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<td>Charles D. Fraser, Jr., M.D., Chief</td>
<td>Daniel J. Penny, M.D., Ph.D., M.H.A., Chief</td>
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<td>Iki Adachi, M.D.</td>
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<td>Cardiovascular Anesthesia</td>
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<td>Emad B. Mossad, M.D., Director</td>
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<td>Tamra Baker, C.R.N.A.</td>
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<td>Blaine Esley, M.D.</td>
<td>Jennifer Esplana, C.R.N.A.</td>
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Margaret Whitehead, R.N., Outcomes Research Coordinator

Quality
Eric A. Williams, M.D., M.S., M.M.M., F.A.A.P., Medical Director
Kathleen E. Carberry, R.N., M.P.H., Director, Outcomes & Impact Service
Texas Children's Heart Center Publications


Maskatia SA, Morris SA, Spinner JA, Krishnamurthy R, Altman CA. Echocardiographic parameters of right ventricular diastolic function in repaired tetralogy of fallot are associated with important findings on magnetic resonance imaging. Congenit Heart Dis. 2015;10:E113-122.


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With six decades of experience in caring for children’s hearts, Texas Children’s Heart Center combines leading, world-class technology with a compassionate, family-centered approach to pediatric cardiac care. Our multidisciplinary team of pediatric cardiologists, cardiovascular surgeons, cardiovascular anesthesiologists, perfusionists, adult congenital heart disease specialists, cardiac intensivists, nurses, child life specialists and support staff work together to surround patients with expertise at every point from diagnosis through treatment in order to provide the best possible results.

Meet the Texas Children’s Heart Center team.

Referrals

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The Congenital Heart Surgery Service at Texas Children’s Hospital offers same-day surgical consultation appointments. To make an appointment for a same-day consultation, call 832-TCH-APPT (832-824-2778). For additional appointment information or to speak with a division administrator, please call 832-826-2030.

Heart Transplant Program
866-683-8032

Cardiology, Adult Congenital Heart Disease and Cardiovascular Intensive Care Unit
832-82-HEART (832-824-3278)

Cardiovascular Anesthesia
832-826-5831

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Visit texaschildrens.org/refer for more information about referring a patient or learn more about Texas Children’s Heart Center at texaschildrens.org/heart.
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