Thank you for your interest in the Texas Children’s Heart Center Outcomes book, which highlights our leading cardiac program, important data about patient outcomes and the innovative work that took place at our center during calendar year 2012.

It has been an exciting and active year for Texas Children’s Heart Center. We were the lead center in a multi-institution study for the Berlin Heart EXCOR® Pediatric ventricular assist device, the only pediatric mechanical circulatory support device designed specifically for infants and small children. In late 2011, the Berlin Heart was granted humanitarian device exemption by the United States Food and Drug Administration.

In early 2013, Dr. Charles D. Fraser Jr., surgeon-in-chief and chief of Congenital Heart Surgery, performed the congenital heart surgery team’s 10,000th surgery since his arrival to Texas Children’s in 1995. Additionally, we designated a new space for our Cardiac Developmental Outcomes Clinic. This multidisciplinary clinic was founded on groundbreaking research from Texas Children’s Department of Anesthesia and is another example of how Texas Children’s Heart Center provides individualized care to each patient and strives to understand the long-term impact of our care on our patients’ growth and development.

For the fifth consecutive year, Texas Children’s Hospital was ranked in all ten subspecialties in U.S. News & World Report’s list of America’s Best Children’s Hospitals and was ranked #4 among top children’s hospitals in the nation. Texas Children’s Heart Center is also ranked #3 in the nation for pediatric cardiology and heart surgery. This achievement was made possible through the commitment and dedication of our Heart Center faculty and staff.

Even though our program ranks among the best in the nation, we continuously strive to improve. The Heart Center Outcomes book is a product of our ongoing effort to examine patient outcomes and thereby improve the quality of care that we provide to our cardiac patients. I hope you find it valuable and informative.

Sincerely,

Mark A. Wallace
President and CEO
Texas Children’s Hospital

Texas Children’s Heart Center referrals:

Congenital Heart Surgery
832-82-HEART (832-824-3278)

Heart Transplant Program
866-683-8032

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

Cardiovascular Anesthesia
832-826-5831

Cardiovascular Anesthesia
832-826-5831
Table of Contents

Welcome .................................................. 2

Texas Children’s Hospital and Baylor College of Medicine ...................... 3

Texas Children’s Heart Center Overview ........................................... 6

Congenital Heart Surgery Service .................................................. 7

Coronary Anomalies Program ....................................................... 14

Cardiac Developmental Outcomes Program ..................................... 17

Heart Failure and Transplant Program ........................................... 20

Interventional Cardiology ............................................................ 25

Electrophysiology ................................................................. 28

Diagnostic Testing and Cardiac Imaging ....................................... 30

Adult Congenital Heart Disease Program ....................................... 31

Cardiovascular Anesthesia ......................................................... 33

Cardiovascular Intensive Care Unit ................................................ 40

Quality, Innovation and Research ............................................... 43

Medical Staff Directory ............................................................ 46

Publications .............................................................................. 50

Referrals .................................................................................... 58

For access to Texas Children’s Heart Center outcomes, informative videos, physician profiles and more, visit texaschildrens.org/heartoutcomes.
Dear colleagues, parents and friends:

We are very pleased to offer you the 2012 Texas Children's Heart Center Outcomes Book. This information is also available in a multimedia format at texaschildrens.org/heartoutcomes. Our commitment is to provide accurate and timely information to aid referring physicians, patients and families in making informed decisions about the care of patients with pediatric and congenital cardiac disease.

This year’s edition further highlights our integrated, multidisciplinary Texas Children’s Heart Center team. A striking example of the strength and depth of our team is exemplified in the care provided for a child with an extremely rare congenital malformation known as ectopia cordis. The family lived in a remote area of Texas and was referred to Texas Children’s through one of our regional partnerships. A multidisciplinary team of surgeons, anesthesiologists, cardiologists, critical care physicians and others saved this baby girl’s life by reconstructing her chest cavity to make space for the one third of her heart that had developed outside of her body. Today she is a growing, healthy and happy little girl. We at Texas Children’s Hospital are proud of our heritage of collaborating with physicians both locally as well as outside the Houston area to provide premier pediatric health care. Our collective effort provides for the care of children from North America and around the world.

In this edition, you will also find information about our ongoing efforts to optimize neurologic outcomes for children who require cardiac interventions. Through the efforts of a combined basic science and clinical research program, our Congenital Cardiac Anesthesiology Department has patented a new technology to optimize cerebral oxygenation and brain blood flow. This phenomenon, known as cerebral autoregulation, is important in the complex relationship of brain physiology, particularly during critical cardiac surgery. Using this novel, highly specialized monitoring, anesthesiologists are able to discern whether blood pressure in the brain is at adequate levels. This methodology is both non-invasive and rapid enough to guide decisions about blood pressure in the brain during critical stages of surgery including the time on cardiopulmonary bypass.

Texas Children’s Heart Center strives to provide every procedure available for patients with critical congenital heart disease. Through our innovations in research and ongoing commitment to improving 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

Daniel J. Penny, M.D., Ph.D., M.H.A.
Chief of Cardiology, Texas Children’s Hospital
Professor of Pediatrics, Baylor College of Medicine

Emad B. Mossad, M.D.
Director of Pediatric Cardiovascular Anesthesiology, Texas Children’s Hospital
Professor of Anesthesiology and Pediatrics, Baylor College of Medicine

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, located in the Texas Medical Center, is committed to a community of healthy children by providing the finest pediatric patient care, education and research. Renowned worldwide for its 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 also ranked in all ten subspecialties in U.S. News & World Report’s list of America’s Best Children’s Hospitals. Texas Children’s operates the nation’s largest primary pediatric care network, with 48 offices throughout the greater Houston community and the Texas Children’s Health Plan, the nation’s first health maintenance organization (HMO) created just for children.

Texas Children’s Hospital is affiliated with Baylor College of Medicine (BCM), ranked by U.S. News & World Report as one of the nation’s top 25 medical schools for research. Texas Children’s Hospital serves as BCM’s primary pediatric training site, and BCM professors are the service chiefs and staff physicians of Texas Children’s patient care centers. The collaboration between Texas Children’s Hospital and BCM is one of the top 10 such partnerships for pediatric research funding from the National Institutes of Health. The hospital’s medical staff includes more than 1,500 board-certified, primary-care physicians, pediatric subspecialists, pediatric surgical subspecialists and dentists, offering the highest level of pediatric care in more than 40 subspecialties, programs and services and a support staff in excess of 8,500.
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.

**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** – 35-bed inpatient unit including six “step-down” beds for patients who are healthy enough to leave intensive care but still need close monitoring
Pioneers in Pediatric Cardiac Care

Texas Children's Hospital has been a leader in pediatric cardiac care since its inception more than fifty years ago and has pioneered many of the now standard procedures and therapies related to the diagnosis and treatment of children with cardiac problems. *U.S. News & World Report* recently ranked the Heart Center #3 in the nation for pediatric cardiology and heart surgery.

Comprised of several multidisciplinary teams working in conjunction with pediatric subspecialists throughout the hospital, Texas Children’s Heart Center provides 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.
## 2012 Texas Children’s Heart Center Overview

### Surgical procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac operations</td>
<td>703</td>
<td>767</td>
</tr>
<tr>
<td>Heart transplants</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Lung transplants</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Adult congenital heart disease operations</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

### Cardiac catheterizations

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic cardiac catheterizations</td>
<td>390</td>
<td>948</td>
</tr>
<tr>
<td>Interventional cardiac catheterizations</td>
<td>363</td>
<td></td>
</tr>
<tr>
<td>Electrophysiology studies and procedures</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>Pacemaker and defibrillator implants</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Diagnostic testing and cardiac imaging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiograms</td>
<td>20,717</td>
<td>58,800</td>
</tr>
<tr>
<td>Fetal echocardiograms</td>
<td>1,237</td>
<td></td>
</tr>
<tr>
<td>Electrocardiograms</td>
<td>30,817</td>
<td></td>
</tr>
<tr>
<td>Cardiac MRIs</td>
<td>459</td>
<td></td>
</tr>
<tr>
<td>Holter® monitors</td>
<td>4,384</td>
<td></td>
</tr>
<tr>
<td>Stress tests</td>
<td>1,186</td>
<td></td>
</tr>
</tbody>
</table>

### Cardiovascular anesthesia

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterizations and electrophysiology patients</td>
<td>924</td>
<td>2,219</td>
</tr>
<tr>
<td>Cardiovascular operating room patients</td>
<td>839</td>
<td></td>
</tr>
<tr>
<td>Interventional radiology patients</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>MRI patients</td>
<td>347</td>
<td></td>
</tr>
</tbody>
</table>

### Cardiovascular intensive care

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical admissions</td>
<td>548</td>
<td>812</td>
</tr>
<tr>
<td>Medical admissions</td>
<td>264</td>
<td></td>
</tr>
</tbody>
</table>

The outpatient clinic at Texas Children’s Heart Center had over 20,000 patient encounters in 2012.
Congenital Heart Surgery Service

The Congenital Heart Surgery Division strives to offer every procedure available for the treatment of pediatric heart disease and defects. We care for children of all ages, including preterm and low-birth-weight newborns, tailoring procedures and treatments to the needs of each individual child and his or her family. For more detailed information about Congenital Heart Surgery at Texas Children’s Heart Center, please visit texaschildrens.org/heartoutcomes.

Cardiovascular and thoracic surgery cases

Volume by year

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

As one of the largest pediatric congenital heart programs in the country, we offer one of only 11 Accreditation Council for Graduate Medical Education (ACGME) accredited fellowships in congenital cardiac surgery in the nation, which provides intense training in pediatric congenital heart disease. Many of its graduates have assumed leadership positions at institutions all over the world.
More than 60% of operations performed require the use of cardiopulmonary bypass. Our incidence of mechanical circulatory support postcardiotomy is less than 1%.

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.
### Mortalities by RACHS-1 classification in 2012

<table>
<thead>
<tr>
<th>Primary procedure</th>
<th>Number of procedures</th>
<th>Number of discharge mortalities</th>
<th>% mortality</th>
<th>STS national benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total for Risk Category 1</td>
<td>63</td>
<td>0</td>
<td>0.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Total for Risk Category 2</td>
<td>218</td>
<td>1</td>
<td>0.5%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Total for Risk Category 3</td>
<td>170</td>
<td>4</td>
<td>2.4%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Total for Risk Category 4</td>
<td>36</td>
<td>1</td>
<td>2.8%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Total for Risk Category 5-6</td>
<td>24</td>
<td>4</td>
<td>16.7%</td>
<td>15.8%</td>
</tr>
<tr>
<td>Grand total</td>
<td>511</td>
<td>10</td>
<td>2.0%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>

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 six representing congenital heart surgeries associated with the greatest risk.

Overall risk-adjusted hospital mortality rate for our program in 2012 was 2.0%\(^2\). Data collected by the Society of Thoracic Surgeons (STS) shows the national hospital discharge mortality rate at 3.1%\(^3\).

---


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

\(^3\) Society of Thoracic Surgeons Data Harvest Report, published May 2012.
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 = 511).
The Congenital Heart Surgery Division performs an average of 23 ASD closures annually. This includes patients with secundum, coronary, sinus and sinus venosus ASDs. Our hospital survival rate is 100%. Our service also offers a minimally invasive approach to ASD closure.

Ventricular septal defects are the most commonly diagnosed congenital heart defect, and surgical treatment remains the standard of care for children with this disease. These data include patients having perimembranous, supracristal, inlet or muscular VSDs. They also include patients with double chambered right ventricle. The Congenital Heart Surgery Division performs an average of 56 VSD closures each year and in 2012 had a survival rate of 100%.

---

*A* Hospital mortality is calculated over the last four years from 2009-2012.

*B* STS benchmark data from 2008-2011.
The Congenital Heart Surgery Division performs an average of 31 operations each year for partial, intermediate and complete atrioventricular canal defect. The survival rate in 2012 was 100%.

Our surgical approach to the repair of tetralogy of Fallot 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 30 TOF repairs each year.

---

6 Hospital mortality is calculated over the last four years from 2009-2012.
7 STS benchmark data from 2008-2011.
The arterial switch operation 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%.

The Congenital Heart Surgery Service performs an average of 19 Norwood operations per year for hypoplastic left heart syndrome and other single ventricle anomalies.
Coronary Anomalies Program

Congenital coronary anomalies are the second most common cause of sudden cardiac death in children and young adults. These anomalies are congenital defects in one or more of the coronary arteries of the heart and may relate to the origin, location, size or course of the coronary artery. In the past, the optimal management of these patients has been controversial and inconsistent. In December 2012, Texas Children’s Hospital established the Coronary Anomalies Program with the following mission:

• Treat patients with congenital coronary anomalies in an optimal and consistent way, based on the most current and reliable evidence available.

• Educate health care providers and the public about the current knowledge on risks, workup and treatment alternatives for patients with congenital coronary anomalies.

• Study the pathophysiology and outcomes related to congenital coronary anomalies to improve the management of patients with this disease.

The Coronary Anomalies Program includes a multidisciplinary core team of cardiologists, congenital heart surgeons, radiologists, pathologists and researchers working together to provide the best treatment to patients with congenital coronary anomalies, study their outcomes and educate health care providers and the public about this problem.

To refer patients to the Coronary Anomalies Program, please call 832-82-HEART.
Outcomes of patients with Anomalous Aortic Origin of a Coronary Artery (AAOCA)

<table>
<thead>
<tr>
<th>Date range</th>
<th>1995-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients</td>
<td>50</td>
</tr>
<tr>
<td>Patients managed medically</td>
<td>34 patients (68%)</td>
</tr>
<tr>
<td>Patients managed surgically</td>
<td>16 patients (32%)</td>
</tr>
<tr>
<td>Surgical interventions</td>
<td>Coronary unroofing in 12 patients (75%), coronary reimplantation in 3 patients (19%) and osteoplasty in 1 patient (6%).</td>
</tr>
<tr>
<td>Early reintervention after coronary reimplantation</td>
<td>1 patient</td>
</tr>
<tr>
<td>Morbidities</td>
<td>0%</td>
</tr>
<tr>
<td>Complete follow-up</td>
<td>80%</td>
</tr>
</tbody>
</table>

Since the creation of the Coronary Anomalies Program at Texas Children's Hospital in December 2012:

<table>
<thead>
<tr>
<th>Total patients</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery recommended</td>
<td>12 patients (48%)</td>
</tr>
<tr>
<td>Surgery completed</td>
<td>7 patients</td>
</tr>
<tr>
<td>Surgical interventions</td>
<td>Coronary unroofing in 6 patients (86%) and coronary translocation in 1 patients (14%).</td>
</tr>
<tr>
<td>Complications</td>
<td>0%</td>
</tr>
</tbody>
</table>

Texas Children’s looks forward to hosting a symposium on congenital coronary anomalies, the first of its kind, in December 2013.
Surgical pulmonary valve/conduit replacement outcomes

With the increasing application of percutaneous pulmonary valves, Texas Children’s Heart Center decided to evaluate our surgical results of pulmonary valve/conduit replacement in order to provide a reference point for examining outcomes of both modalities in the future. We reviewed our outcomes from 1995-2010. We have performed pulmonary valve (PV) replacements in 247 patients but to specifically examine the outcomes of patients who would be candidates for a percutaneous valve, we narrowed our study to include patients who were 5 years old or older and who weighed 30 kg or more.

| Total PV replacements | 148 All patients had undergone at least 1 previous intervention on their PV. |
| Total PV replacements | 148 All patients had undergone at least 1 previous intervention on their PV. |
| Most common fundamental diagnosis | Tetralogy of Fallot (53%) |
| Surgical indications for PV replacement | 60% PV insufficiency 26% PV stenosis 13% both PV insufficiency and stenosis |
| Valves used | 73% bioprosthetic valves 27% homografts |
| Median time to extubation following surgery | < 1 day |
| Median ICU length of stay | 2 days |
| Median hospital length of stay | 5 days |
| Hospital survival | 100% |
| Freedom from reintervention on the PV | 1 year = 99% 3 years = 99% 5 years = 94% |
| Survival at last follow-up\(^\text{18}\) | 99% |

\(^{18}\) Average length of follow-up five years +/- four years.
Cardiac Developmental Outcomes Program

The Cardiac Developmental Outcomes Program at Texas Children’s Hospital supports babies and children with congenital heart disease after surgery, during the early stages of life, with regular developmental assessments and coordination of ongoing care.

From as early as a child’s first admission to the hospital and throughout childhood, our interdisciplinary team brings together experts in cardiology, critical care, developmental pediatrics, clinical psychology, nursing, and occupational and physical therapy to identify early problems that may impair his or her development. These problems are often very subtle and not easy to recognize. Our thorough assessments can often pick up these problems very early in life at a time when intervention can make a difference.

Our program provides family-centered care, where parents or caregivers are directly consulted and involved in our assessment program. We also help families find resources that support their child’s development in their communities. The Cardiac Developmental Outcomes Program is committed to enhancing our patients’ opportunities in life by focusing on medical, social and developmental health in order to help them reach their maximum potential.

To refer patients to the Cardiac Developmental Outcomes Program, please call 832-82-HEART.
Audrina’s ectopia cordis: a case study

During a routine ultrasound 16 weeks into Ashley Cardenas’ pregnancy, her sonogram image indicated that part of Audrina’s heart was forming outside of her chest, also known as ectopia cordis. Only eight per one million babies are born with this rare congenital malformation, where the heart is abnormally located either partially or totally outside the chest. Of those eight, 90 percent are either stillborn or die within the first three days of life. On October 16, 2012, a multidisciplinary team of surgeons at Texas Children’s saved Audrina’s life during a miraculous six-hour open heart surgery where the team reconstructed her chest cavity to make space for the one third of her heart that was outside her body.

Texas Children’s Fetal Center received the referral for Ashley, who was first evaluated just weeks before she would be scheduled for delivery. Ashley’s initial evaluation included an ultrasound, fetal echocardiogram and fetal MRI (magnetic resonance imaging), which allowed the maternal fetal medicine (MFM) and Heart Center teams at Texas Children’s to develop a unique care plan for her delivery. Texas Children’s Pavilion for Women delivered Audrina by caesarean, and she was immediately attended to by a large team of neonatal specialists who took over her care.

Once the cardiac surgeons were finished operating on Audrina, the plastic surgery team played a pivotal role in completing this surgery as it was responsible for covering her heart beneath her skin and muscle. Audrina recovered in the cardiovascular intensive care unit at Texas Children’s. She will continue to be carefully followed by a multidisciplinary team and will require specialized care by a pediatric cardiologist for the rest of her life.
Heart Failure and Transplant Program

Since its inception in 1984, Texas Children’s Heart Center has performed more than 280 heart transplants, making it one of the largest and most successful programs in the nation. In 2012, over 400 cardiomyopathy patients were seen in our clinic. 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 for each child. For more information on the Heart Transplant Program, please visit texaschildrens.org/heartoutcomes.

Since 2011, Texas Children’s Heart Center has been an active member of the Pediatric Heart Transplant Study (PHTS), which is dedicated to the advancement of the science and treatment of children during listing for and following heart transplantation. The purposes of the group are 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.

VAD implantations

by device

<table>
<thead>
<tr>
<th>Device</th>
<th>CASES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoratec P-VAD®</td>
<td>11</td>
<td>10%</td>
</tr>
<tr>
<td>Bio-Medicus®</td>
<td>22</td>
<td>20%</td>
</tr>
<tr>
<td>Total Artificial Heart</td>
<td>36</td>
<td>32%</td>
</tr>
<tr>
<td>HeartWare®</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>Micromed®</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>TandemHeart®</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>SynCardia®</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>HeartMate II®</td>
<td>15</td>
<td>13%</td>
</tr>
<tr>
<td>Rotaflow®</td>
<td>18</td>
<td>16%</td>
</tr>
<tr>
<td>Berlin Heart EXCOR® Pediatric</td>
<td>1</td>
<td>1%</td>
</tr>
</tbody>
</table>

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 and a mortality rate while waiting of approximately 25 percent due to progressive organ system failure. Before this FDA ruling, physicians longed for a reliable circulatory support device so children could survive until an appropriate donor heart became available.

The journey for the FDA’s approval began with a multi-year, multi-institution study led by Texas Children’s Hospital. Starting in 2005, a trans-Atlantic dialogue was initiated between the Berlin Heart Corporation, clinicians in North America and the FDA to design and conduct the first ever prospective pediatric ventricular assist trial in the world. The study design addressed questions of safety and benefit of the Berlin Heart in supporting children with heart failure until they received a heart transplant. This extremely ambitious study involved detailed analysis and ongoing multicenter data collection 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 very encouraging. This groundbreaking trial has become part of the rich legacy of surgical advancements that have happened at Texas Children’s Hospital. Findings from this unprecedented study were published in the *New England Journal of Medicine* in August 2012. Outcomes for 48 children (infants – 16 years) who received the Berlin Heart from 2007 – 2010 were compared to patients supported by extracorporeal membrane oxygenation (ECMO).

---

<table>
<thead>
<tr>
<th>Smaller patients (body surface area &lt; 0.7 m²)</th>
<th>Berlin Heart EXCOR® Pediatric</th>
<th>ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median duration of support</td>
<td>28 days</td>
<td>5 days</td>
</tr>
<tr>
<td>Longest time a child was supported by the device</td>
<td>174 days</td>
<td>21 days</td>
</tr>
<tr>
<td>At 174 days, 88% of patients had been successfully transplanted</td>
<td>At 21 days, 25% of patients had died</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Larger patients (body surface area ≥ 0.7 m² but &lt; 1.5 m²)</th>
<th>Berlin Heart EXCOR® Pediatric</th>
<th>ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median duration of support</td>
<td>43 days</td>
<td>5 days</td>
</tr>
<tr>
<td>Longest time a child was supported by the device</td>
<td>192 days</td>
<td>28 days</td>
</tr>
<tr>
<td>At 192 days, 92% of patients had been successfully transplanted or weaned</td>
<td>At 30 days, 33% of patients had died</td>
<td></td>
</tr>
</tbody>
</table>

These data demonstrate that the Berlin Heart EXCOR® Pediatric improves the chances of survival for children of all ages as compared to ECMO support.

Over the course of the study, which included collaborating with leading pediatric academic institutions, patients did extremely well. The overall success of the device between the two cohorts was 90%.
Heart transplantations\textsuperscript{13}

Volume by year

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

Heart transplant patient survival rates\textsuperscript{14}

Pediatric age <18

<table>
<thead>
<tr>
<th>Survival Rate</th>
<th>1 Year After Transplant</th>
<th>3 Years After Transplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas Children's Heart Center</td>
<td>97%</td>
<td>82%</td>
</tr>
<tr>
<td>SRTR Expected</td>
<td>95%</td>
<td>86%</td>
</tr>
<tr>
<td>National</td>
<td>91%</td>
<td>83%</td>
</tr>
</tbody>
</table>

\textsuperscript{13} Data includes patients who received a heart and lung transplant simultaneously.

\textsuperscript{14} Scientific Registry of Transplant Recipients (SRTR). Program Specific Reports. Table 11 - srtr.org.
Pediatric Heart Failure Summit

In conjunction with Cincinnati Children’s®, SickKids® and Berlin Heart®, Texas Children’s Hospital and Baylor College of Medicine are hosting the Pediatric Heart Failure Summit on October 10 – 12, 2013. This summit, approved for AMA PRA Category 1 Credits™, will focus on the challenges of caring for patients with advanced pediatric heart failure. Program topics include management strategies of acute heart failure syndromes, methods of hemodynamic and physiologic monitoring, renal protective techniques and updates on mechanical circulatory support in children. Additionally, a Berlin Heart User’s Training Seminar will be held immediately before the summit on October 9 – 10, 2013. For more information, please visit texaschildrens.org/phfs2013.

The Heart Transplant Program earned a national certification from the Centers for Medicare & Medicaid Services (CMS) in 2012.
Interventional Cardiology

Texas Children’s Heart Center, the largest and most comprehensive facility in the region to offer interventional cardiac catheterization for infants, children, adolescents and adults, performed more than 750 cardiac catheterization procedures in 2012. To learn more about our Interventional Cardiology Program, please visit texaschildrens.org/heartoutcomes.

Cardiac catheterization laboratory complications
by rate

Of cases performed in the cardiac catheterization laboratories at Texas Children’s Heart Center in 2012, 97.8% occurred without complication, 1.8% occurred with minor complications including minor hematomas or minor arrhythmias, and only 0.4% occurred with major complications. Given that we are a quaternary referral center for some of the most complex cases in the region, these data represent an extremely low complication rate.
Ductal stenting for pulmonary flow

Since 2004, interventional cardiologists at Texas Children’s Hospital have offered a novel procedure to maintain pulmonary blood flow in critically ill children with congenital heart defects that are ductal-dependent. This minimally invasive procedure may avoid the need for surgery to place a Blalock–Taussig shunt in selected patients. Texas Children’s Hospital recently evaluated 15 patients who received ductal stenting for pulmonary flow from February 2004 to April 2012.

<table>
<thead>
<tr>
<th>Total patients</th>
<th>42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients who received stents</td>
<td>31</td>
</tr>
</tbody>
</table>
| Number of stents | 1 stent - 16 patients (52%)  
2 stents - 13 patients (42%)  
3 stents - 2 patients (6%) |
| Median age | 11 days (2-218) |
| Median weight | 3.2 kg (1.9-8.4) |
| Diameter of stents placed | Ranged from 3 – 4.5 mm |
| Completely occluded ductus requiring recanalization | 5 |
| Baseline minimum ductal diameter | Increased from 1.3 (0 - 3.4) mm to 3.5 (2.1 - 4.5) mm post stenting (p<0.0001) |
| Mean duration of palliation from ductal stenting (until surgical takedown or last follow-up) | 7.3 months  
6 patients still awaiting surgery |

86% of patients eligible for stent placement in ductus arteriosus successfully received stents. The overall survival for patients referred for ductal stenting on an intention-to-treat analysis was 86% with 7% mortality attributable to the ductal stenting catheterization procedure.

Justino H, Petit CJ, Crystal MA, Liou A, Ing FF. Beyond procedural results for stenting the ductus arteriosus: eight year retrospective review from a single large U.S. center. Data was presented at the 2012 Pediatric and Adult Interventional Cardiac Symposium (PICS & AICS 2012).
**Placement of stents in ductus arteriosus**

by volume

- Received stents: 31
- Not eligible: 6
- Unable to stent: 5

**Survival for patients referred for ductal stenting**

by volume

- Survived: 36
- Mortality not attributable to ductal stenting: 3
- Mortality attributable to ductal stenting: 3
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 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. To view a short video on our Electrophysiology Program, visit texaschildrens.org/heartoutcomes.

Supraventricular tachycardia ablation outcomes

<table>
<thead>
<tr>
<th>SUCCESS RATE</th>
<th>Texas Children’s Hospital</th>
<th>National benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>96.7%</td>
<td>95.2%</td>
</tr>
</tbody>
</table>

To expand patient access, we now offer dedicated electrophysiology outpatient clinics on a daily basis. Additionally, partnerships with community and referring providers from across the region have been established to provide on-site and telemedicine consultations, enabling Texas Children’s electrophysiology care closer to home.

Stereotaxis

Texas Children’s Hospital is the only freestanding children’s hospital with a remote magnetic navigation system (Stereotaxis) for catheter manipulation that was utilized for 37 ablation cases in 2012.

Magnetic navigation (MN) offers some theoretic advantages in the treatment of children. The catheter is more flexible and atraumatic than standard catheters, potentially eliminating risk of perforation. It can also be navigated with 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 retrospective review of prospectively gathered data in children undergoing radiofrequency ablation at our institution. The efficacy and safety between a 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.
Diagnostic Testing and Cardiac Imaging

The non-invasive imaging lab performs more than 21,000 echocardiograms each year for fetuses, infants and children 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, known as mission control, consists of 10 rooms with a four-bed sedation bay and state-of-the-art physician work area that houses four reading stations. For more on our Diagnostic Testing and Cardiac Imaging Program, visit texaschildrens.org/heartoutcomes.

Fetal cardiac interventions for HLHS

Texas Children’s Hospital has successfully completed in utero fetal cardiac interventions to treat hypoplastic left heart syndrome (HLHS). Texas Children’s Fetal Center at Texas Children’s Pavilion for Women is one of only a few centers in the world capable of performing this complex fetal intervention as it 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. Babies receiving this unique fetal procedure at Texas Children’s Fetal Center will continue treatment immediately after delivery at Texas Children’s Heart Center.

Following each procedure, physicians monitor the mother and baby through multiple fetal ultrasounds and echocardiograms so that the mother may carry the baby as close to full term as possible, giving the lungs, brain and other vital organs a chance to mature prior to birth, and allowing the child to be more stable before having to undergo his or her first heart surgery.
Adult Congenital Heart Disease Program

The Adult Congenital Heart Disease (ACHD) Program enables patients with congenital heart disease to receive a seamless continuation of care from birth to adulthood. Our program offers the full range of adult congenital heart disease services and specialties including surgery, diagnostic and interventional cardiac catheterization, non-invasive imaging (including cardiac MRIs and coronary CT angiography), transcranial doppler electrophysiology and arrhythmia services and more. For more information on the ACHD Program, visit texaschildrens.org/heartoutcomes.

In addition to treating patients with these diagnoses, the ACHD team sees a high number of pregnant patients with heart disease and general cardiology patients.

**ACHD clinic encounters**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tetralogy of Fallot</td>
<td>807</td>
</tr>
<tr>
<td>Ventricular septal defect</td>
<td>487</td>
</tr>
<tr>
<td>Coarctation</td>
<td>249</td>
</tr>
<tr>
<td>Transposition of the great vessels</td>
<td>144</td>
</tr>
</tbody>
</table>

**ACHD program volumes**

<table>
<thead>
<tr>
<th>Service</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiograms</td>
<td>2,800</td>
</tr>
<tr>
<td>Cardiac MRIs</td>
<td>96</td>
</tr>
<tr>
<td>Electrophysiology and interventional cardiac catheterizations</td>
<td>191</td>
</tr>
<tr>
<td>Surgical procedures</td>
<td>39</td>
</tr>
</tbody>
</table>
Adult patients treated in the cardiovascular intensive care unit by age

- > 18 years: 41 (36%)
- 13 to 18 years: 74 (64%)

Total cases: 115
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. Find out more about the Cardiovascular Anesthesia Division at texaschildrens.org/heartoutcomes.

Cardiovascular anesthesia cases
by location

The Pediatric Cardiovascular Anesthesia Division treated more than 2,000 patients in 2012. Beyond anesthetic care, the division actively participates in the daily care of patients in the Cardiovascular Intensive Care Unit.

Total cases include all congenital heart surgery operations as well as noncardiac procedures for children with heart disease.
Heart Center

2012

Cardiovascular anesthesia complications
by percentage

TOTAL CASES 2,219

Cases without complications 98.5%

1.5% Cases with complications

Of all procedures performed, only 1.5% occurred with complications. Of this 1.5%, 22% were airway or respiratory complications, 34% were cardiac, 16% were medication-related and 28% were categorized as other.
Heart Center

2012 35

The average duration of an MRI from October 2012 to May 2013 was 74 minutes. Cardiac MRI is becoming an integral imaging and diagnostic tool for children with congenital heart disease. These studies are lengthy and detailed and require careful perioperative monitoring and sedation.

Cardiovascular anesthesia complications by age

Cardiovascular anesthesia duration during MRI

The average duration of an MRI from October 2012 to May 2013 was 74 minutes. Cardiac MRI is becoming an integral imaging and diagnostic tool for children with congenital heart disease. These studies are lengthy and detailed and require careful perioperative monitoring and sedation.
Cerebral autoregulation monitoring

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

Cerebral autoregulation monitoring can show anesthesiologists if blood pressure in the brain is at adequate levels. Previously, autoregulation monitoring was a tool for neurosurgeons only: an invasive and slow process that cannot be performed on the brain during cardiopulmonary bypass. The new process is both non-invasive and rapid enough to guide decisions about blood pressure in the brain during bypass. The goal of this new monitoring is to help the brain regulate its own blood flow during bypass, perfusion and other procedures, by showing the range of blood pressure that allows for this to occur. By “helping the brain to help itself,” this method may prevent strokes in our most vulnerable patients. Monitoring of this kind has been successful in neurosurgery patients and appears promising for the cardiac arena. Our patented technology is currently being tested with the ultimate goal of incorporation into pediatric operating rooms.
Long-term neurodevelopmental outcomes

Improving the long-term neurologic outcomes of our patients remains the primary focus of our neurologic monitoring strategies.

<table>
<thead>
<tr>
<th>Incidence of new postoperative brain injury, as seen on MRI</th>
<th>Texas Children's Hospital</th>
<th>Comparable reports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36%^{19}</td>
<td>67%-73%^{20,21}</td>
</tr>
</tbody>
</table>

| Incidence of postoperative EEG seizures                     | 1.5%^{22}                | 14%-20%^{23,24}    |

Arterial switch operation neurodevelopmental assessments

<table>
<thead>
<tr>
<th>Cognitive scores at 12 months</th>
<th>&gt; population mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor and language scores at 12 months</td>
<td>&lt; population mean</td>
</tr>
<tr>
<td>Motor and language scores at 36 months</td>
<td>Comparable to children who had not undergone heart surgery</td>
</tr>
</tbody>
</table>

---


Leaders in cardiovascular anesthesia education

Transesophageal Echocardiography for Congenital Heart Disease, edited by Pierre C. Wong and Wanda C. Miller-Hance, is the only textbook of its kind that focuses specifically upon the applications of this imaging modality in patients with congenital heart disease. With an anticipated publication date of September 2013, this work provides practical and instructive information extensively supplemented with figures/illustrations and high quality videos and serves as a resource for clinicians and trainees who wish to obtain basic knowledge or advance their understanding of the field.

A major textbook in the field of pediatric anesthesia, 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, 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.

Edited by Dean B. Andropoulos, M.D., chief of anesthesiology as well as anesthesiologists Stephen A. Stayer, M.D., and Emad B. Mossad, M.D., Anesthesia for Congenital Heart Disease is the only and 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. The latest edition, forthcoming in 2014, will include a number of recent advances in the field as well as new online videos of cardiac anesthesia procedures.
Cardiovascular Intensive Care Unit

The Cardiovascular Intensive Care Unit (CVICU) admits newborns, infants, children and young adults with heart disease. The CVICU cares for children undergoing surgery for congenital heart disease, children and adolescents with end-stage heart failure before and after heart transplantation and children whose hearts can no longer adequately support them. For more information on the CVICU, please visit texaschildrens.org/heartoutcomes.

The CVICU at Texas Children’s Hospital is part of the Virtual Pediatric Intensive Care Unit (PICU) System known as VPS. This national pediatric critical care data registry applies a predicted mortality score – PIM 2 – for every critical care admission, including children who did not have heart surgery, based upon the child’s diagnosis and other indicators of illness on CVICU admission.

Cases with PIM 2 data

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cases</td>
<td>812</td>
</tr>
<tr>
<td>Mortalities</td>
<td>15</td>
</tr>
<tr>
<td>Actual mortality rate</td>
<td>1.85%</td>
</tr>
<tr>
<td>Predicted mortality rate</td>
<td>3.51%</td>
</tr>
<tr>
<td>Mortality ratio</td>
<td>0.53</td>
</tr>
</tbody>
</table>

67.5% of all patients admitted to the Cardiovascular Intensive Care Unit (CVICU) underwent at least one surgical procedure during their stay. The remainder were medical admissions.
Cardiovascular intensive care unit admissions by age

- **0 to < 1 month**: 113 admissions (14%)
- **1 month to < 2 years**: 341 admissions (42%)
- **2 years to < 6 years**: 128 admissions (16%)
- **6 years to < 13 years**: 115 admissions (14%)
- **13 years to < 19 years**: 74 admissions (9%)
- **≥ 19 years**: 41 admissions (5%)

**Total Admissions**: 812
**Extracorporeal life support (ECLS)**

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

At Texas Children’s Hospital, we use extracorporeal membrane oxygenation, or ECMO. With ECMO, blood is pumped through the cannulae and into the machine, which provides all the oxygen needed. The oxygenated blood is then returned through the circuit to the body. The process creates a continuous flow and does the work of the heart and/or lungs so they can heal.

**CVICU ECMO cases**

by year

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>14</td>
</tr>
<tr>
<td>2008</td>
<td>8</td>
</tr>
<tr>
<td>2009</td>
<td>8</td>
</tr>
<tr>
<td>2010</td>
<td>14</td>
</tr>
<tr>
<td>2011</td>
<td>18</td>
</tr>
<tr>
<td>2012</td>
<td>15</td>
</tr>
</tbody>
</table>

The ECMO program at Texas Children’s Hospital has received the Award for Excellence in Life Support from the Extracorporeal Life Support Organization and is a designated Center of Excellence.
Quality, Innovation and Research

Quality improvement

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

- American College of Cardiology IMPACT Registry™ (Improving Pediatric and Adult Congenital Treatment) for diagnostic and interventional catheterization procedures
- Society of Thoracic Surgeons’ National Quality and Outcomes program for congenital heart surgery
- Virtual Pediatric Intensive Care Unit (PICU) Performance System (VPS) including the cardiac intensive care unit program
- Congenital Cardiac Anesthesia Database (CCAS)

In-situ simulation program

As part of the Nursing Congress Exemplar, Texas Children’s Heart Center developed an in situ simulation program to ensure nurses on the acute care floor were prepared for patient emergencies and other nonstandard health care situations. 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. A space was dedicated to hands-on simulations using mannequins to create lifelike scenarios for training.

Texas Children’s Hospital Outcomes and Impact Service – Better data, better decisions

The Surgical Outcomes Center was established in 2011 to track, analyze and report the outcomes of procedures within Texas Children’s Hospital. It quickly became apparent that patients and families were requesting outcomes data for a variety of treatments and not just surgical procedures. Because of this, the Surgical Outcomes Center was rebranded as Texas Children’s Hospital Outcomes and Impact Service. Texas Children’s Hospital Outcomes and Impact Service is not just data; it’s a service we provide. It is the starting point for a conversation about choices affecting where people seek care or are referred to for care. As a hospital system, we believe that a critical component to offering outstanding clinical programs is tracking the outcomes of the care delivered through them. The service is comprised of a team of outcomes nurses, computer programmers, data architects and specialists and a statistician who work closely with the clinical teams to measure, share and improve our outcomes.
**Congenital Cardiac Anesthesia Society Database (CCAS)**

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

Texas Children’s and other participating institutions use the data collected to determine practice 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.

**Pediatric Heart Network**

The Pediatric Heart Network (PHN) was established in 2001 by the National Heart, Lung and Blood Institute (NHLBI) 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.

It consists of nine clinical sites comprised of experienced research teams at hospitals that specialize in the care of pediatric patients with heart disease as well as a data coordinating center (DCC). Texas Children’s Hospital/Baylor College of Medicine became a core site in September 2011.

Texas Children’s Hospital is committed to participation in all PHN studies, including four current and six approved future studies. The 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 whether one is better than the other 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.
• The 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 (HLHS) 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 other cardiac centers caring for infants with critical congenital heart disease.

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/heartoutcomes.

Intensive care monitoring
This research involves creating computer programs that look for early warning signs of impending 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.
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 Susan V. Clayton Chair in Surgery at Baylor College of Medicine 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 Cleveland Clinic, Dr. Fraser was recruited to Texas Children’s Hospital in July of 1995 to establish a dedicated pediatric congenital heart surgery program. Since that time, he and his team have performed corrective operations in more than 10,000 children and adults with congenital heart disease.

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 entitled “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 Greater 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, Cairo, Egypt. His medical degree is from University of Cairo Medical School, Cairo, Egypt. His residency and fellowship training in cardiac anesthesia took place at the Cleveland Clinic Foundation in Cleveland, Ohio. Dr. Mossad also completed a pediatric anesthesiology 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.

Lara S. Shekerdemian, M.D., M.R.C.P., F.R.C.P.C.H., F.R.A.C.P., F.J.F.I.C.M., M.H.A., is chief of Critical Care, co-director of Texas Children’s Heart Center and professor of Pediatrics at Baylor College of Medicine. She graduated in medicine from Birmingham University Medical School in 1990. She was awarded her postgraduate doctoral degree for her thesis entitled, “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/heartoutcomes.

**Congenital Heart Surgery**
Charles D. Fraser, Jr., M.D., *Chief*
Iki Adachi, M.D.
Jeffrey S. Heinle, M.D.
E. Dean McKenzie, M.D.
Carlos Mery, M.D.
Yuji Naito, M.D. *(Instructor)*
Yishay Orr, M.D. *(Instructor)*

**Coronary Anomalies Program**
Charles D. Fraser, Jr., M.D.
Rajesh Krishnamurthy, M.D. *(Radiology)*
Silvana M. Lawrence, M.D., Ph.D.
E. Dean McKenzie, M.D.
Carlos Mery, M.D.
S. Kristen Sexson Teitel, M.D., Ph.D.

**Heart Failure and Transplant**
William J. Dreyer, M.D., F.A.C.C., F.A.A.P., *Medical Director*
Jeffrey S. Heinle, M.D., *Surgical Director*
Jack F. Price, M.D., *Medical Director, MCS Program* *
Iki Adachi, M.D., *Co-Surgical Director, MCS Program* *
E. Dean McKenzie, M.D., *Co-Surgical Director, MCS Program* *
Antonio G. Cabrera, M.D.
Susan W. Denfield, M.D.
Aamir Jeewa, M.D.
Jeffrey J. Kim, M.D.

**Pediatric Cardiology**
Daniel J. Penny, M.D., Ph.D., M.H.A., *Chief*
Hugh Allen, M.D., Ph.D.
William Buck Kyle, M.D.
Silvana M. Lawrence, M.D., Ph.D.
Douglas S. Moodie, M.D., M.S.
Michael R. Nihill, M.D.
Subhash Chandra-Bose Reddy, M.D.
David W. Sapire, M.D.
Thomas J. Seery, M.D.
Thomas A. Vargo, M.D.
Steven B. Wolfe, M.D.

**Interventional Cardiology**
Henri Justino, M.D., C.M., F.R.C.P.C., F.A.C.C., F.S.C.A.I., *Director*
Asra Khan, M.D.
Aimee Liou, M.D.
Dhaval R. Parekh, M.D.

**Electrophysiology and Pacing**
Caridad De La Uz, M.D.
Jeffrey J. Kim, M.D.
Santiago O. Valdes, M.D.

**Cardiovascular Imaging**
Nancy A. Ayres, M.D., F.A.C.C., F.A.S.E., *Director*
Carolyn A. Altman, M.D., F.A.C.C., F.A.S.E.
Judith A. Becker, M.D.
Josh A. Kailin, M.D.
M. Regina Lantin-Hermoso, M.D.
Emily J. Lawrence, D.O.
Keila N. Lopez, M.D., M.P.H.
Shiraz A. Maskatia, M.D.

*Mechanical Circulatory Support (MCS)*
Adult Congenital Heart Disease
Wayne J. Franklin, M.D.,
Medical Director
Charles D. Fraser, Jr., M.D.,
Surgical Director
Douglas S. Moodie, M.D., M.S.
Dhaval R. Parekh, M.D.

Cardiovascular Anesthesia
Emad B. Mossad, M.D., Director
Dean B. Andropoulos, M.D.
Kenneth M. Brady, M.D.
Lisa A. Caplan, M.D.
R. Blaine Easley, M.D.
Erin A. Gottlieb, M.D.
Stuart R. Hall, M.D.
Douglas J. Miller, M.D.
Wanda C. Miller-Hance, M.D.
Pablo Motta, M.D.
David F. Vener, M.D.

Cardiac Intensivists
Lara S. Shekerdemian, M.D., M.R.C.P.,
F.R.C.P.C.H., F.R.A.C.P., F.I.F.C.M.,
M.H.A., Chief
Paul A. Checchia, M.D., F.A.A.P.,
F.C.C.M., F.A.C.C., Medical Director
Patricia Bastero, M.D.
Aarti Bavare, M.D., M.P.H.
Kenneth M. Brady, M.D.
Ronald A. Bronicki, M.D.
Antonio G. Cabrera, M.D.
Heather A. Dickerson, M.D.
R. Blaine Easley, M.D.
Stuart R. Hall, M.D.
Parag Jang, M.D.
Cesar Mella, M.D.
Elena C. Ocampo, M.D., F.A.A.P.,
F.A.C.C.
Joseph Philip, M.D.
Jack F. Price, M.D.
Sebastian Tume, M.D.
Eric A. Williams M.D., M.S

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, Texas Children’s Hospital
Outcomes and Impact Service
Heart Center Publications

This past year, Texas Children’s Heart Center physicians and staff were published in key journals such as The New England Journal of Medicine, The Journal of the American College of Cardiology, Pediatric Cardiology, Annals of Thoracic Surgery, Intensive Care Medicine, Anesthesia & Analgesia and more. To access copies of our 2012 publications, visit texaschildrens.org/heartoutcomes.


For more than 50 years, Texas Children’s Heart Center has been saving lives with the best possible pediatric cardiac care. Our multidisciplinary team of pediatric cardiologists, cardiovascular surgeons, cardiovascular anesthesiologists, perfusionists, adult congenital heart 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.
For more than 50 years, Texas Children’s Heart Center has been saving lives with the best possible pediatric cardiac care. Our multidisciplinary team of pediatric cardiologists, cardiovascular surgeons, cardiovascular anesthesiologists, perfusionists, adult congenital heart 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.
Thank you for your interest in the Texas Children’s Heart Center Outcomes book, which highlights our leading cardiac program, important data about patient outcomes and the innovative work that took place at our center during calendar year 2012.

It has been an exciting and active year for Texas Children’s Heart Center. We were the lead center in a multi-institution study for the Berlin Heart EXCOR® Pediatric ventricular assist device, the only pediatric mechanical circulatory support device designed specifically for infants and small children. In late 2011, the Berlin Heart was granted humanitarian device exemption by the United States Food and Drug Administration.

In early 2013, Dr. Charles D. Fraser Jr., surgeon-in-chief and chief of Congenital Heart Surgery, performed the congenital heart surgery team’s 10,000th surgery since his arrival to Texas Children’s in 1995. Additionally, we designated a new space for our Cardiac Developmental Outcomes Clinic. This multidisciplinary clinic was founded on groundbreaking research from Texas Children’s Department of Anesthesia and is another example of how Texas Children’s Heart Center provides individualized care to each patient and strives to understand the long-term impact of our care on our patients’ growth and development.

For the fifth consecutive year, Texas Children’s Hospital was ranked in all ten subspecialties in U.S. News & World Report’s list of America’s Best Children’s Hospitals and was ranked #4 among top children’s hospitals in the nation. Texas Children’s Heart Center is also ranked #3 in the nation for pediatric cardiology and heart surgery. This achievement was made possible through the commitment and dedication of our Heart Center faculty and staff.

Even though our program ranks among the best in the nation, we continuously strive to improve. The Heart Center Outcomes book is a product of our ongoing effort to examine patient outcomes and thereby improve the quality of care that we provide to our cardiac patients. I hope you find it valuable and informative.

Sincerely,

[Signature]

Mark A. Wallace
President and CEO
Texas Children’s Hospital

Texas Children’s Heart Center referrals:

- Congenital Heart Surgery
  832-826-1929

- Heart Transplant Program
  866-683-8032

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

- Cardiovascular Anesthesia
  832-826-5831