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 2011.

Texas Children’s Hospital® was ranked #4 among top children’s hospitals in the nation as well as in all ten subspecialties in the 2012 U.S. News & World Report list of America’s Best Children’s Hospitals. Additionally, Texas Children’s Heart Center was 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.

This year we marked the completion of our $1.5 billion expansion, Vision 2010, with the opening of Texas Children’s Pavilion for Women®. This 1.3 million-square-foot facility provides comprehensive obstetrics and gynecology care using the most advanced technologies and treatments available, beginning before conception and continuing after delivery, as well as throughout a woman’s lifetime. The Pavilion for Women enables us to provide seamless care across the perinatal period for children with critical heart diseases and develop one of the few fetal intervention programs in the country.

We also continued to expand our cardiac services at Texas Children’s Hospital West Campus®, the first pediatric community hospital in suburban West Houston. This growth has reduced patient wait-times and increased community access to state-of-the-art cardiac diagnostic services and treatment.

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 Chief Executive Officer, Texas Children’s Hospital

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 pleased to offer you the Texas Children’s Heart Center Outcomes book. This year we launched a new multimedia format that includes informative videos about our key cardiac programs, updated metrics by division, physician profiles, access to a list of publications and more. We invite you to view our newly enhanced site at texaschildrens.org/heartoutcomes. By providing accurate and timely information online, we aim to help referring physicians, patients and families make the most informed decisions about their patient care.

It was a busy year for Texas Children’s Heart Center as we extended cardiac services to the newly opened Texas Children’s Pavilion for Women. Expectant mothers now have access to a full spectrum of fetal therapies, and the new facility offers the highest level of newborn intensive care. Our fetal cardiology team continues to build collaborations with fetal medicine specialists to diagnose heart conditions in utero and provide state-of-the-art fetal diagnostic interventions.

Texas Children’s Heart Center is able to provide every procedure available, and through our innovations in research and ongoing commitment to improving all aspects of patient care, we strive for the very best possible treatment for our cardiac patients.

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

Lara S. Shekerdemian, M.D., F.R.A.C.P., F.A.A.P., M.H.A.
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 is nationally ranked in all ten subspecialties in U.S. News & World Report’s list of America’s Best Children’s Hospitals, and was one of only twelve hospitals in the nation to make its Honor Roll in 2012. Texas Children’s also operates Texas Children’s Pediatrics, the nation’s largest primary pediatric care network, with more than 45 offices throughout the greater Houston community and 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 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. The Heart Center was recently ranked #3 in the U.S. for pediatric cardiology and heart surgery by U.S. News & World Report.

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.

The outpatient clinic at Texas Children’s Heart Center had over 18,700 patient encounters in 2011.
# 2011 Texas Children’s Heart Center Overview

## Surgical Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac operations</td>
<td>746</td>
</tr>
<tr>
<td>Heart transplants</td>
<td>15</td>
</tr>
<tr>
<td>Lung transplants</td>
<td>13</td>
</tr>
<tr>
<td>Adult congenital heart disease operations</td>
<td>63</td>
</tr>
</tbody>
</table>

## Cardiac Catheterizations

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic cardiac catheterizations</td>
<td>486</td>
</tr>
<tr>
<td>Interventional cardiac catheterizations</td>
<td>312</td>
</tr>
<tr>
<td>Therapeutic cardiac catheterizations</td>
<td>21</td>
</tr>
</tbody>
</table>

## Electrophysiology

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ablations</td>
<td>163</td>
</tr>
<tr>
<td>Pacemaker and defibrillator implants</td>
<td>60</td>
</tr>
</tbody>
</table>

## Diagnostic Testing and Cardiac Imaging

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiograms</td>
<td>18,973</td>
</tr>
<tr>
<td>Fetal echocardiograms</td>
<td>930</td>
</tr>
<tr>
<td>Electrocardiograms</td>
<td>24,785</td>
</tr>
<tr>
<td>Cardiac MRIs</td>
<td>481</td>
</tr>
<tr>
<td>Holter® monitors</td>
<td>3,912</td>
</tr>
<tr>
<td>Stress tests</td>
<td>1,061</td>
</tr>
</tbody>
</table>

## Cardiovascular Anesthesia

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterizations and electrophysiology patients</td>
<td>955</td>
</tr>
<tr>
<td>Cardiovascular operating room patients</td>
<td>855</td>
</tr>
<tr>
<td>Interventional radiology patients</td>
<td>125</td>
</tr>
<tr>
<td>MRI patients</td>
<td>375</td>
</tr>
</tbody>
</table>

## Cardiovascular Intensive Care*

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical admissions</td>
<td>644</td>
</tr>
<tr>
<td>Medical admissions</td>
<td>228</td>
</tr>
</tbody>
</table>

*74% 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, in which the most common reason for admission was medical management of heart failure.

## Congenital Heart Surgery Service

The Congenital Heart Surgery Division offers 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](http://www.texaschildrens.org/heartoutcomes).

## Cardiovascular and Thoracic Surgery Cases

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>837</td>
</tr>
</tbody>
</table>

The Congenital Heart Surgery Division performs a high volume and variety of surgical procedures. Multiple studies have shown a clear link between high case volumes and improved outcomes.
More than 60% of operations performed require the use of cardiopulmonary bypass. Our incidence of mechanical circulatory support post-cardiotomy 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.
The Risk Adjustment in Congenital Heart Surgery (RACHS-1) categorization is a widely used risk stratification model used to analyze 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 2011 was 1.5%. Data collected by the Society of Thoracic Surgeons (STS) shows the national hospital discharge mortality rate at 3.0%.

Mortalities by RACHS-1 Classification in 2011

<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>58</td>
<td>0</td>
<td>0.0%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Total for Risk Category 2</td>
<td>233</td>
<td>2</td>
<td>0.9%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Total for Risk Category 3</td>
<td>185</td>
<td>2</td>
<td>1.1%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Total for Risk Category 4</td>
<td>44</td>
<td>2</td>
<td>4.5%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Total for Risk Category 5-6</td>
<td>25</td>
<td>2</td>
<td>8.0%</td>
<td>15.5%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>545</td>
<td>8</td>
<td>1.5%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

Mortalities by Age and Operation Type in 2011

<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>% Mortality</th>
<th>STS National Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate (0 - 30d)</td>
<td>70</td>
<td>22</td>
<td>5</td>
<td>1</td>
<td>6/92</td>
<td>6.5%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Infant (31d - 1y)</td>
<td>166</td>
<td>16</td>
<td>2</td>
<td>0</td>
<td>2/182</td>
<td>1.1%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Child (&gt;1y - &lt;18y)</td>
<td>226</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0/244</td>
<td>0.0%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Adult (18y+)</td>
<td>26</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0/27</td>
<td>0.0%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>488</td>
<td>57</td>
<td>7</td>
<td>1</td>
<td>8/545</td>
<td>1.5%</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

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 = 545).
The Congenital Heart Surgery Division performs an average of 22 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 54 VSD closures each year and in 2011 had a survival rate of 100%.

* Hospital mortality is calculated over the last 4 years from 2008-2011.
  1 STS benchmark data from 2007-2010.

OVERALL HOSPITAL DISCHARGE MORTALITY RATE*
0%

STS NATIONAL BENCHMARK* <1%
The Congenital Heart Surgery Division performs an average of 32 operations each year for partial, intermediate and complete atrioventricular canal defect. The survival rate in 2011 was 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.

Our surgical approach to the repair of Tetrology 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.

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.

* Hospital mortality is calculated over the last 4 years from 2008-2011.
* STS benchmark data from 2007-2010.
Palliative Arterial Switch Outcomes

Newborns with single ventricle anatomy, transposition of the great arteries and systemic outflow obstruction are challenging patients most often managed with a Norwood or Damus-Kaye-Stansel procedure. The palliative arterial switch operation (pASO) is less frequently used, but in certain patients affords a more favorable anatomic arrangement for long-term palliation. Below are the outcomes of all newborns undergoing a pASO at our institution from July 1995 to February 2011.

<table>
<thead>
<tr>
<th>Total Cases</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Age at Operation</td>
<td>7 days (range: 2 to 16 days)</td>
</tr>
</tbody>
</table>
| Primary Diagnoses    | Double-inlet left ventricle = 6  
                        | Tricuspid atresia = 4  
                        | Other = 4 |
| Concomitant Procedures at Initial Operation | Aortic arch reconstruction = 13  
                                              | Pulmonary artery banding (PAB) = 6  
                                              | Systemic-to-pulmonary-artery shunt = 1 |
| Median ICU Length of Stay | 11 days (range: 4 to 60 days) |
| Median Hospital Length of Stay | 21 days (range: 9 to 84 days) |
| Hospital Survival    | 100% |
| Intervention Between pASO and Second Stage Operation | Systemic-to-pulmonary-artery shunt = 3  
                                                          | PAB revision = 1 |
| Patients Achieving Fontan Completion | 10 (4 are candidates awaiting repair) |
| Survival at Last Follow-up | 100% |
| Echocardiogram Findings at Last Follow-up | Normal ventricular function  
                                              | Trivial-mild neoaortic insufficiency  
                                              | No left ventricular outflow obstruction |

In patients with single ventricle variations involving a hypoplastic subaortic outlet chamber and a diminutive, anterior and leftward ascending aorta, the goal of achieving an unobstructed systemic outlet using either a classic Norwood or modified Damus Kaye-Stansel connection may be suboptimal. An alternative that has proven highly effective is a palliative arterial switch.

This series of illustrations highlights the important features including alignment of the dominant semilunar valve (pulmonary) directly with the reconstructed ascending aorta and arch, protection of the pulmonary arteries by bringing them anterior to the reconstructed aorta (which facilitates subsequent palliation) and alignment of the obstructed outlet with the pulmonary arteries in the initial palliation.

The degree of neo-subpulmonary obstruction is variable in individuals and may need to be dealt with through either pulmonary artery banding or a systemic-to-pulmonary artery shunt. In many cases, however, the degree of obstruction allows for a balance circulation.

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10 Abstract accepted for oral presentation at the Southern Thoracic Surgical Association (STSA) 58th Annual Meeting held November 9-12, 2011 in San Antonio, Texas.
11 Last follow-up occurred at a median of 4 years (range: 3 months to 1 year.)
Outcomes Following Aortic Valve Repair and Replacement in Children

Surgical treatment of aortic valve (AV) diseases in childhood involves complex decisions, particularly in very small patients, and there is no consensus regarding the optimum surgical option. We recently reviewed our outcomes following aortic valve repair and replacement in children.

| Total Operations | 97 AV repairs  
188 AV replacements  
68 autograft  
74 homograft  
36 mechanical  
10 bioprosthetic |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Age at First Operation</td>
<td>7 years (range: 1 day to 18 years)</td>
</tr>
<tr>
<td>Gender</td>
<td>Males = 154 (64%)</td>
</tr>
<tr>
<td>Immediate Failure of Valve Repair (within 24 hours) Requiring Replacement</td>
<td>2 (2%) patients</td>
</tr>
</tbody>
</table>
| Survival | 98% for AV repairs  
97% for AV replacements |
| Reoperations at Last Follow-up | 17% for AV repairs  
16% for AV replacements |
| Survival at Last Follow-up | 97% for AV repairs  
96% for AV replacements |

Depictions of modes of aortic valve dysfunction that may be surgically correctable including cusp restriction and prolapse.

\[1\] Average follow-up time was 4 years (range: 8 days to 5 years.)

In the setting of a subaortic ventricular septal defect, the associated aortic valve cusp may be subject to distortion and prolapse related to turbulent flow. The corresponding cusp elongation and prolapse may progress to significant aortic valve incompetence.

In the setting of severe aortic valve cusp distortion, symmetric leaflet reduction may be required as noted in this illustration. Subcommissural sutures also aid in improving the zone of coaptation with adjacent cusps.
Heart Failure and Transplant Program

Since its inception in 1984, Texas Children’s Heart Center has performed over 260 heart transplants, making it one of the largest and most successful programs in the nation. In 2011, more than 600 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 well as our ability to offer the right device for each child.

Texas Children’s Heart Center has one of the busiest pediatric Ventricular Assist Device (VAD) Programs in the world. Part of our VAD therapy strategy includes using long-term VADs to bridge eligible patients to myocardial recovery instead of transplant. Of the patients who received a long-term VAD for bridge-to-transplant or bridge-to-recovery, the survival rate to transplant, explant or transfer to another device was 88%.13

13 One patient is still currently being supported with a device.

In May, 2011, Texas Children’s Hospital became the first pediatric hospital in the nation to implant a SynCardia® Total Artificial Heart, a pulsatile blood pump that mimics the pumping action of the native heart, into the chest of a 17-year-old patient as the only option to save his life. The history-making patient underwent a rare 15-hour operation and is one of three congenital heart patients in the nation to get such a device.

The artificial heart was powered by a portable battery pack called the Freedom® portable driver. The patient used the artificial heart until he underwent a 12-hour transplant operation to receive a donor heart in October, 2011.

Today, the patient is doing well. He spends times volunteering for LifeGift, a Texas non-profit group that works to connect patients waiting for organ donations with potential donors, and is looking forward to attending college this fall.
In the past five years, Texas Children’s Heart Center has placed 59 VADs in patients with acquired and congenital heart disease.

### VAD Implantations by Device
- **Berlin Heart EXCOR® Pediatric**: 27 (46%)
- **Bio-Medicus®**: 6 (10%)
- **TandemHeart®**: 9 (15%)
- **Rotaflow®**: 11 (18%)
- **HeartMate II®**: 2 (2%)
- **Thoratec P-VAD®**: 1 (2%)
- **Syncardia®**: 5 (2%)
- **Total Artificial Heart**: 2 (2%)

**TOTAL CASES**: 59

### Berlin Heart EXCOR® Pediatric

Recently, 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.

Over the course of the study, which included collaborating investigators from Harvard, Stanford and other prestigious institutions, patients did extremely well. In the primary cohort, more than 90 percent of children were successfully bridged to transplantation or recovery. At Texas Children’s, where we implanted 27 Berlin Hearts – more than any other center in the U.S. – our results were very encouraging. This groundbreaking trial now becomes part of the rich legacy of cardiac surgical advances that have happened at Texas Children’s Hospital and at the Texas Medical Center. At last, babies and children have a lifesaving device available while waiting for a donor heart or recovery.
Heart Transplant

Volume by Year

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21</td>
<td>16</td>
<td>18</td>
<td>13</td>
<td>18</td>
<td>16</td>
</tr>
</tbody>
</table>

Primary Disease Leading to Heart Transplantation

- **Congenital Heart Disease**: 23.5%
- **Re-transplant/Graft Failure**: 5.9%
- **Cardiomyopathy**: 70.6%

Heart Transplant Patient Survival Rates

(Pediatric Age <18)

- **1 Year After Transplant**:
  - Texas Children’s Heart Center: 96.88%
  - National: 95.19%
- **3 Years After Transplant**:
  - Texas Children’s Heart Center: 82.35%
  - National: 86.04%

Texas Children’s heart transplant outcomes are in line with national performance metrics.

- **Primary disease at time of listing for heart transplantation at Texas Children’s Hospital, January-December 2011.**
- **Scientific Registry of Transplant Recipients (SRTR), Program-Specific Reports, Table II.**
  - www.srtr.org
Interventional Cardiology

Our team of interventional cardiologists performs more than 1,000 procedures each year using three state-of-the-art laboratories. To learn more about our Interventional Cardiology Program, please visit texaschildrens.org/heartoutcomes.

Electrophysiology and Cardiac Catheterizations by Age:

- > 5 Years: 594 (59%)
- 1 Month to 1 Year: 145 (14%)
- 1 to 5 Years: 238 (24%)
- < 1 Month: 27 (3%)

Total Cases: 1,004

Cardiac Catheterization Laboratory Complications by Rate:

- Cases without Complications: 94%
- Cases with Minor Complications: 3.5%
- Cases with Significant Complications: 2.5%
- Cases with Major Complications: 0.5%

Of cases performed in the Cardiac Catheterization Laboratory at Texas Children’s Heart Center in 2011, 94.0% occurred without complication. Of all procedures performed, only 3.5% occurred with minor complications, including minor hematomas or minor arrhythmias.

In two instances, an interventional catheterization case and electrophysiology case were completed on the same patient.
Stent Implantation for Coarctation of the Aorta (CoA)

Interventional cardiologists at Texas Children’s Hospital have performed numerous percutaneous therapeutic procedures for discrete coarctation of the aorta and recently evaluated the outcomes on all patients receiving a stent from 1996-2011. Patients ranged in age from less than one year to 51 years.

Outcomes for Stent Implantation for Coarctation of the Aorta

<table>
<thead>
<tr>
<th>Total Cases</th>
<th>69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Weight at Procedure</td>
<td>Median weight 49.3kg (range: 10.5 to 100kg)</td>
</tr>
<tr>
<td>Gender</td>
<td>Males = 41 (59%)</td>
</tr>
<tr>
<td>Prior CoA Surgery</td>
<td>Patients = 27 (39%)</td>
</tr>
<tr>
<td>Prior Catheterization Procedure Including Balloon Angioplasty</td>
<td>Patients = 18 (26%)</td>
</tr>
<tr>
<td>Gradient Pre-stent</td>
<td>30.1 ± 16.3mmHg</td>
</tr>
<tr>
<td>Gradient Post-stent</td>
<td>1.3 ± 14.2mmHg</td>
</tr>
<tr>
<td>Minimum Diameter Pre-stent</td>
<td>6.8 ± 3.6mm</td>
</tr>
<tr>
<td>Minimum Diameter Post-stent</td>
<td>12.7 ± 3.4mm</td>
</tr>
<tr>
<td>Major Complications</td>
<td>Patients = 1 (1.4%) - stroke</td>
</tr>
</tbody>
</table>

Outcomes at Late Follow-Up

Mean follow-up = 3.4 ± 2.7 years

One death due to non-cardiac related causes

One patient developed significant aneurysm formation after angioplasty, prior to stent implantation without sufficient containment with bare metal stent implant and required surgical resection

No dissections or aneurysms related to stent implantation

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Electrophysiology

Electrophysiology at Texas Children’s Heart Center offers cutting-edge arrhythmia and pacing services for patients with heart rhythm abnormalities. More than 24,000 electrocardiograms, 3,900 Holter monitors and 1,000 exercise treadmill tests are completed annually. To view a short video on our Electrophysiology Program, visit texaschildrens.org/heartoutcomes.

2011 Ablation Procedure Outcomes

<table>
<thead>
<tr>
<th>SUCCESS RATE</th>
<th>Texas Children’s Hospital</th>
<th>National Benchmark</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>98.9%</td>
<td>95.2%</td>
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Stereotaxis

Texas Children’s Hospital is the only freestanding children’s hospital with a remote magnetic navigation system (Stereotaxis) for catheter manipulation which has been utilized for ablations in more than 100 patients to date.

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 mm 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.

Recently 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.


Cardiac Imaging

The non-invasive imaging lab performs approximately 20,000 echocardiograms each year for 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. For more on our Cardiac Imaging Program, visit texaschildrens.org/heartoutcomes.

Fetal Cardiology

Texas Children’s Hospital has successfully completed in utero fetal cardiac interventions to treat hypoplastic left heart syndrome (HLHS). The Fetal Center at Texas Children’s Pavilion 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, OB/GYNs, 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. This allows the child to become more stable before undergoing his or her first heart surgery.

240 prenatal echocardiograms were performed on fetuses with Congenital Diaphragmatic Hernia (CDH) this past year. CDH is a defect in the formation of the diaphragm, resulting in a hole in the diaphragm that allows passage of abdominal organs into the chest.

Cardiologists at Texas Children’s Heart Center evaluated 89 twin-twin transfusion syndrome (TTTS) cases in 2011. TTTS is a complication seen in approximately 10-15 percent of twins who share a common placenta (monochorionic) where there is unbalanced blood flow from one twin (donor) to the other (recipient).
Hypoplastic Left Heart Syndrome

Infant Cyanosis
Due to the inability of blue blood (deoxygenated) and red blood (oxygenated) to mix when the atrial septal defect is very small or absent in HLHS, the majority of blood pumped to the baby’s body is lacking oxygen, resulting in a blue cyanotic skin discoloration and rapid deterioration of the baby. When there is an atrial septal defect in HLHS, the red blood can pass from the left atrium into the rest of the heart and result in a much more stable, less cyanotic baby.

Fetal Intervention for HLHS
While imaging the fetus by ultrasound guidance on a mother’s abdomen, a needle is inserted through the abdominal wall, through the uterus, through the fetus’ chest wall and into the fetal heart. The needle is passed from the right atrium to the left atrium. A very fine wire is passed through the needle, and this wire is used to pass a small balloon or stent over a balloon that is subsequently inflated across the atrial septum. The balloon is then deflated and a new atrial septal defect remains.

HLHS Circulation After Birth with and without an Atrial Septal Defect

NO ATRIAL SEPTAL DEFECT: Blue (deoxygenated) blood enters the right atrium from the rest of the body. This blue blood is then pumped primarily to the lungs to collect oxygen. The red (oxygenated) blood returns to the heart from the lungs into the left atrium. When the mitral valve is small and there is no atrial septal defect, the red blood has no way of getting out of the heart and delivering oxygen to the other organs. Blue blood is then instead pumped to the body via a residual fetal structure, the patent ductus arteriosus. This results in rapid deterioration of the newborn.

ATRIAL SEPTAL DEFECT PRESENT: As above, red blood enters the left atrium from the lungs. When an atrial septal defect is present, the oxygenated blood can then escape the left atrium and mix with the other blood to increase the oxygen content of the blood. This mixed blood is pumped to the other organs via the patent ductus arteriosus and has adequate oxygen content for the baby to be stable until surgery several days later.

Texas Children’s Pavilion for Women

Fully opened in March 2012, Texas Children’s Pavilion for Women offers the most advanced technologies and treatments available, beginning before conception and continuing after delivery, as well as throughout a woman’s lifetime. Expectant mothers now have access to a full spectrum of fetal therapies, and the facility offers the highest level of newborn intensive care. Our fetal cardiology team continues to build collaborations with fetal medicine specialists to diagnose heart conditions in utero and provide state-of-the-art fetal diagnostic interventions. The Pavilion for Women enables us to provide seamless care across the perinatal period for children with critical heart diseases and develop one of the few fetal intervention programs in the country.

The Pavilion for Women has many family-friendly amenities including electronic medical records for the mother and baby that are linked in a common system, beginning even before birth. Children’s records can follow them within the entire Texas Children’s Hospital system throughout their development.
Adult Congenital Heart Disease Program

The Adult Congenital Heart Disease 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, noninvasive imaging (including cardiac MRIs), transcranial doppler electrophysiology and more. The program completed 63 surgical operations and more than 1,700 clinic visits in 2011. For a deeper look into the Adult Congenital Heart Disease Program, visit texaschildrens.org/heartoutcomes.

Since January, 2010 the Adult Congenital Heart Disease Program has completed 5,478 clinic visits.

Since 2009, the Adult Congenital Heart Disease Program has seen more than 100 expectant mothers with congenital heart disease. 136 babies have been born to mothers with congenital heart disease, and 92% of these babies were born without congenital heart disease.
Cardiovascular Anesthesia

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 noncardiac 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](http://texaschildrens.org/heartoutcomes).

Cardiovascular Anesthesia Cases
by Location

On average, the Cardiovascular Anesthesia Division treats more than 2,300 patients each year. Beyond anesthetic care, the division actively participates in the daily care of patients in the Cardiovascular Intensive Care Unit.
Cardiovascular Anesthesia Complications by Volume

Only 3% of total pediatric cardiovascular anesthesia cases in 2011 could be categorized as complicated cases. Of this 3%, 45% were airway or respiratory complications, 32% were cardiac, 13% were medication-related and 9% were categorized as other.

Developmental Outcomes

Children treated for congenital heart disease have been found to be at greater risk and have higher rates of motor delays, language and visual difficulties, and attention and behavioral problems. The recently developed Cardiac Developmental Outcomes Program at Texas Children’s Hospital supports patients with congenital heart disease who have survived surgery during the first month of life by providing developmental assessments and coordinating any appropriate care needed.

Our experts in cardiology, critical care, developmental pediatrics, clinical psychology, nursing and other professions work together to screen children for issues at identified and developmental milestones. These thorough assessments can recognize subtle but significant delays where early intervention can make a difference.

The program provides family-centered care, where the child’s parents or caregivers are directly consulted and involved in assessments and interventions in their child’s best interest for developmental progress. The Cardiac Developmental Outcomes Program is focused on a patient’s medical, social and developmental health in order to help them reach their maximum potential.

Neurodevelopmental Outcomes Research

Led by Dean Andropoulos, M.D., Chief of Anesthesiology at Texas Children’s Hospital and Professor of Anesthesiology and Pediatrics at Baylor College of Medicine, a multidisciplinary team from Pediatric Cardiovascular Anesthesiology, Congenital Heart Surgery, Pediatric Cardiology, Pediatric Intensive Care, Pediatric Radiology, Pediatric Neurology and Developmental Pediatrics has enrolled a cohort of 97 neonates undergoing complex cardiac surgery for long-term follow-up of neurological events and neurodevelopmental outcomes.

Two major papers were written about this study and will soon be published in Annals of Thoracic Surgery. The first \(^{23}\) won the J. Maxwell Chamberlain Award for the best paper in Congenital Heart Surgery at the 2012 Society of Thoracic Surgeons’ Annual Meeting. This study found that the 20 patients with transposition of the great arteries undergoing the arterial switch operation had a mean cognitive score on the Bayley Scales of Infant Development III of 104.8 ± 15.0, significantly above the reference population mean normal value.

In addition, for the very first time, these Texas Children’s Hospital investigators demonstrated an association between preoperative MRI brain injury and later neurodevelopmental outcomes.

In the second paper, they demonstrated excellent cognitive outcomes at age 12 months in 35 patients undergoing a special cardiopulmonary bypass technique with a protocol for brain monitoring developed by Dean B. Andropoulos, M.D., Charles D. Fraser, Jr., M.D., and E. Dean McKenzie, M.D. in the early 2000s. The cognitive score on the Bayley Scales of Infant Development III was 100.1 ± 14.6 for this group, equal to the population norm.

In addition, the investigators demonstrated that longer duration of regional cerebral perfusion was not associated with worse outcomes. This is the largest outcome study ever published in regional cerebral perfusion patients. It demonstrates the safety and efficacy of this technique and the neurorunning protocol pioneered at Texas Children’s Hospital.

Neurologic Monitoring

During surgery, our cardiovascular anesthesiologists work in close concert with surgeons and perfusionists to provide a consistent approach for cardiopulmonary bypass and anesthetic management. Our strategy is to optimize cerebral oxygenation and brain blood flow during surgery. These neurologic monitoring techniques include continuous cerebral oxygenation monitoring for each procedure complemented with transcranial Doppler (TCD) and/or electroencephalographic (EEG) monitoring. Our goal is to improve the long-term developmental outcomes of our patients.

We are currently developing new bedside monitoring techniques to improve our detection of adequate blood flow to the brain. This includes laboratory research and a clinical prospective study of our brain monitoring techniques to determine if we can improve our brain protection strategies in the operating room and afterwards in the intensive care unit.

Long-term Neurodevelopmental Outcomes

Improving the long-term neurologic outcomes of our patients remains the primary focus of our neurologic monitoring strategies. Recent findings demonstrate that the incidence of new postoperative brain injury, as seen on MRI, was 36% in Texas Children’s patients, which is similar to one report, but considerably lower than 67%-73% from other comparable reports. We have also analyzed the incidence of postoperative EEG detected seizures in our newborns undergoing complex congenital heart surgery. EEG seizures are an important sign of acute brain injury and are associated with adverse long-term neurodevelopmental outcomes.

The overall incidence of postoperative EEG seizures in our patients was 1.5%, compared to the reported incidence of 14%-20%.

In a recent prospective study of long-term neurodevelopmental outcomes, infants undergoing the arterial switch operation at Texas Children’s Hospital underwent comprehensive neurodevelopmental assessments at 12 and 36 months. We found at 12 months, these children had cognitive scores above the population mean, though motor and language were below the mean. By 36 months, language and motor scores had improved significantly and were comparable to other children who had not undergone heart surgery.

These findings support the continued application of our surgical, perfusion and anesthetic management strategies, as well as the need for neurodevelopmental outcomes in studies of infants and children undergoing corrective heart surgery.

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 Cardiovascular Intensive Care Unit at Texas Children’s Hospital joined the Virtual Pediatric Intensive Care Unit (PICU) System known as VPS in 2010. This is a national pediatric critical care data registry, to which all of Texas Children’s critical care units now submit data. The 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. Our first complete year of data collection was 2011.

Cases with PIM 2 Data

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<tbody>
<tr>
<td><strong>Total Cases</strong></td>
<td>872</td>
</tr>
<tr>
<td><strong>Mortalities</strong></td>
<td>22</td>
</tr>
<tr>
<td><strong>Actual Mortality Rate</strong></td>
<td>2.52%</td>
</tr>
<tr>
<td><strong>Predicted Mortality Rate</strong></td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Mortality Ratio</strong></td>
<td>0.45</td>
</tr>
</tbody>
</table>

The CVICU performed much better than predicted. The CVICU’s actual mortality rate was only 45% of the predicted rate.
Quality, Innovations 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

Texas Children’s Hospital and the Department of Anesthesia have been charter members in the establishment of a national quality program to collect outcomes data for pediatric cardiac anesthesia. The Congenital Cardiac Anesthesia Society with the Society of Thoracic Surgeons collect data from participating hospitals throughout the country with the goal of establishing benchmarks in patient management and safety for pediatric cardiac anesthesia programs throughout the United States and worldwide.

The Surgical Outcomes Center was recently established to track, analyze and report the outcomes of procedures within Texas Children’s Hospital. The center works closely with physicians to collect data on procedures, complications and outcomes, analyze trends in data, establish hospital and national benchmarks, assimilate outcomes information into improving bedside care, report long-term functional outcomes and more. The concept for a department-wide approach to examining and reporting patient outcomes was derived from the vision of Charles D. Fraser, Jr., M.D., Surgeon-in-Chief at Texas Children’s Hospital. The center’s team of research nurses, computer programmers, data architects and specialists, outcome analysts and research statisticians will work closely with physicians throughout the entire Department of Surgery to reach its goals.

Innovations and 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.
Meet Our Leaders

Charles D. Fraser, Jr., M.D., is Surgeon-in-Chief 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 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 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 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. 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. His residency and fellowship training in cardiac anesthesia took place at the Cleveland Clinic Foundation in Cleveland, Ohio. Dr. Mossad also completed a pediatric anesthesia fellowship at Children’s National Medical Center of George Washington University and an echocardiography fellowship at the Cleveland Clinic. Dr. Mossad was the Director of Congenital Cardiac Anesthesia at Cleveland Clinic for 13 years before he joined the Cardiovascular Anesthesiology team at Texas Children’s Hospital in 2008.

Lara S. Shekerdemian, M.D., F.F.A.C.P., F.A.A.P., M.H.A., is Chief of Critical Care and Professor of Pediatrics at Baylor College of Medicine. She graduated in medicine from Birmingham University Medical School in 1990. She was awarded her post-graduate 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. Henle, M.D.
E. Dean McKenzie, M.D.
Carlos Mery, M.D.
Yuji Naito, M.D. (Instructor)

**Heart Failure and Transplant**
William J. Dreyer, M.D., Medical Director
Jeffrey S. Henle, 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*
Susan W. Denfield, M.D.
Aamir Jeewa, M.D.

**Pediatric Cardiology**
Daniel J. Penny, M.D., Ph.D., M.H.A., Chief
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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**
Frank F. Ing, M.D., Director
Henri Justino, M.D.
Aimee Liou, M.D.

**Electrophysiology and Pacing**
Jeffrey J. Kim, M.D.
Scott L. Macicek, M.D.
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**Cardiovascular Imaging**
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M. Regina Lantin-Hermoso, M.D.
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Shaine A. Morris, M.D.
Cory V. Noel, M.D.
Ricardo H. Pignatelli, M.D.
Shannon M. Rivenes, M.D.
Alexia B. Santos, M.D.
S. Kristen Sexson Tejtel, M.D., Ph.D.
Giles W. Vick III, M.D., Ph.D.

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Dhaval R. Parekh, M.D.

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Eric A. Williams, M.D., M.S., Medical Director of Quality
Patricia Bastero, M.D.
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Antonio G. Cabrera, M.D.
Heather A. Dickerson, M.D.
Bena C. Ocampo, M.D.
Jack F. Price, M.D.

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Kenneth M. Brady, M.D.
Carlos J. Campos Lopez, M.D.
Lisa A. Caplan, M.D.
R. Blaine Easley, M.D.
Erin A. Gottlieb, M.D.
Stuart R. Hall, M.D.
Javier E. Joglar, M.D.
Douglas J. Miller, M.D.
Wanda C. Miller-Hance, M.D.
Pablo Motta, M.D.
Stephen A. Stayer, M.D.
David F. Vener, M.D.

*Mechanical Circulatory Support (MCS)
Heart Center Publications

This past year, Texas Children’s Heart Center physicians were published in key journals such as Pediatric Anesthesia, Pediatric Cardiology, Pediatric Critical Care Medicine, The American Journal of Cardiology, The Annals of Thoracic Surgery, The Journal of Pediatric Surgery, The Journal of Thoracic and Cardiovascular Surgery and more. To access our full list of our 2011 publications, visit texaschildrens.org/heartoutcomes.

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Cardiovascular Imaging


**Adult Congenital Heart Disease**


**Cardiovascular Anesthesia**


**Cardiac Intensivists**


