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To access Texas Children's Heart Center outcomes information online, please visit texaschildrens.org/heartoutcomes.





TEXAS CHILDREN'S HEART CENTER®

Texas Children's Hospital has been a leader in pediatric heart care for more than 60 years. Led by Denton Cooley, M.D., and Dan McNamara, M.D., the hospital started performing heart surgery for children in 1956. Dr. McNamara, a patriarch of pediatric cardiology, and Dr. Cooley, a pioneer heart surgeon, were among the first to demonstrate that small children could safely undergo heart surgery.

Today, Texas Children's Heart Center is a global leader in pediatric cardiac care, treating some of the rarest and most complex heart cases. With several multidisciplinary teams working in conjunction with pediatric subspecialists throughout the hospital, the Heart Center strives to provide unparalleled care at every point from diagnosis through treatment and follow-up, in order to achieve the best possible result for each patient.



In 2017, Texas Children's Hospital was proudly selected as the best place for children to receive cardiology and heart surgery care in the nation by U.S. News & World Report in their 2017-18 edition of Best Children's Hospitals. Consistently ranked among the top institutions for pediatric cardiac care, Texas Children's Heart Center is committed to consistently achieving outcomes that are among the best in the nation.



TEXAS CHILDREN'S HOSPITAL®

Texas Children's Hospital is one of the nation's largest and most comprehensive specialty pediatric hospitals, with more than 3.7 million patient encounters in 2017. With a staff of more than 13,500 employees and 2,000 physicians, pediatric subspecialists, pediatric surgical subspecialists and dentists, Texas Children's offers more than 40 subspecialties, programs and services.

The 2017-18 edition of Best Children's Hospitals by *U.S. News & World Report* ranked Texas Children's Hospital fourth in the country among nearly 200 pediatric centers. For the ninth straight year, Texas Children's Hospital was placed on the Best Children's Hospital Honor Roll of best pediatric institutions, one of only 10 hospitals nationally and the only hospital in Texas awarded this distinction.

Texas Children's Hospital is located near downtown Houston in the Texas Medical Center, the largest medical center in the world. This campus includes nearly 600 licensed inpatient beds; the Mark A. Wallace Tower for outpatient visits; the Feigin Tower for pediatric research; Texas Children's® Pavilion for Women, a comprehensive OB/GYN facility with a focus on high-risk births; and Texas Children's Hospital® Jan and Dan Duncan Neurological Research Institute®, a basic research institute dedicated to solving childhood neurological diseases. Additionally, two community hospitals, Texas Children's Hospital® West Campus and Texas Children's Hospital® The Woodlands, bring specialty pediatric care — including acute care and critical care beds, 24/7 pediatric emergency centers, surgical suites and more than 20 subspecialty clinics — to a rapidly expanding population of children across the west and north of Houston.

Texas Children's also operates Texas Children's® Health Plan, the nation's first health maintenance organization created just for children, and Texas Children's® Pediatrics, the nation's largest pediatric primary care network, with over 50 locations across Houston. Texas Children's Health Centers®, Specialty Care and Urgent Care locations provide additional enhanced access to care throughout the Greater Houston community.

In 2018, we expanded our care even further, all the way to the capital city of Austin. The first Texas Children's® Urgent Care opened in March 2018 to bring convenient, affordable, high quality after-hours pediatric care to Austin area families. Additional plans for 2018 include the opening of Texas Children's Pediatrics practices and a Texas Children's® Specialty Care location staffed by Texas Children's board-certified physicians, therapists and clinical staff.

Texas Children's Hospital is affiliated with Baylor College of Medicine® in the areas of pediatrics, pediatric surgery and obstetrics and gynecology. Baylor is ranked by U.S. News & World Report as one of the nation's top 10 medical schools for pediatrics. Currently and throughout our partnership, Texas Children's Hospital serves as Baylor's primary pediatric training site. The collaboration between Texas Children's Hospital and Baylor is one of the top five such partnerships for pediatric research funding from the National Institutes of Health.

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



Affiliated with

Baylor College of Medicine

HEART CENTER VOLUME OVERVIEW

In 2017

Outpatient Clinic Patient Encounters				
Total	28,892			

Surgical Procedures				
Cardiac operations	843			
Heart transplants	28			
Lung transplants	10			
Adult congenital heart disease operations	45			
Total	926			

Cardiac Catheterizations				
Diagnostic	522			
Interventions	484			
Electrophysiology studies and ablations	152			
Pacemaker implants	49			
Therapeutic	34			
Total	1,241			





Diagnostic Testing and Cardiac Imaging				
Echocardiograms	27,119			
Fetal echocardiograms	2,335			
Cardiac MRIs	846			
Cardiac CTs	908			
Cardiac Stress MRIs	95			
Total	31,303			

Cardiovascular Anesthesiology				
Catheterizations and electrophysiology patients	I,177			
Cardiovascular operating room patients	1,017			
Interventional radiology patients	340			
MRI patients	436			
Total	2,970			

Cardiovascular Intensive Care			
Patient admissions	1,138		

HEART CENTER MOVES TO NEW LEGACY TOWER

Texas Children's Hospital is known for providing highly specialized care that often cannot be obtained elsewhere. Our multidisciplinary team of experts care for the most critically ill children, those with the most complex medical needs – children who simply would not have survived just a few years ago.

The physical spaces where we have cared for these children for more than 20 years have served us well, but we have outgrown them. This is one of the biggest challenges Texas Children's has ever faced – and we have addressed these needs by reinvesting in core clinical services at our Texas Medical Center campus, to provide greater access to the children and families who need us most.

Through this vertical expansion, named Legacy Tower, Texas Children's has added 640,000 square feet of space. The building houses six new and expanded high acuity operating rooms, including a state-of-the-art neurosurgical operating room with an integrated MRI scanner. The tower also includes a new 84-bed pediatric intensive care unit (ICU) spanning four floors, which includes a dedicated neuro-ICU, a surgical ICU and a transitional ICU.

Legacy Tower will also be the new home of Texas Children's Heart Center. The eight Heart Center floors include an outpatient clinic, four cardiac catheterization labs including a dedicated MRI scanner, a 48-bed cardiovascular ICU, four cardiovascular operating rooms and 42 cardiology acute care beds.

The tower will also have a helistop, allowing even greater access to Texas Children's for the most critically-ill patients.

To learn more, please visit legacytower.org.











ADULT CONGENITAL HEART DISEASE

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

PROGRAM EARNS NATIONAL ACCREDITATION

In September of 2017, Texas Children's ACHD program earned Comprehensive Care Center accreditation from the Adult Congenital Heart Association (ACHA). Texas Children's was the first in Texas to receive this esteemed designation.

The program achieved accreditation by meeting ACHA's criteria – which includes medical and surgical services and personnel requirements – and by going through a rigorous accreditation process developed over a number of years through a collaboration with doctors, physician assistants, nurse practitioners, nurses and adult congenital heart disease patients.



ACHD CLINIC ENCOUNTERS

Volume by year

Year	2013	2014	2015	2016	2017
Clinic visits	1,793	2,054	2,423	2,322	2,320
Patients	I,373	1,529	1,782	1,805	I,847

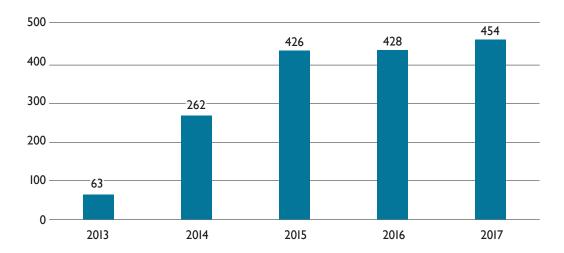


CARDIAC DEVELOPMENTAL OUTCOMES

The Cardiac Developmental Outcomes program (CDOP) provides routine longitudinal neurodevelopmental follow up by board-certified developmental-behavioral pediatricians, neurodevelopmental disability pediatricians and child psychologists for all children who undergo surgery for congenital heart disease during the first three months of life. The CDOP team also provides longitudinal monitoring for children and adolescents with congenital heart disease and neurodevelopmental concerns who are referred by pediatric cardiologists and other providers. Our program is the most mature and comprehensive developmental outcomes program in Texas, and we see not only Texas Children's Hospital patients, but also children from other programs across the state. Over the past year, our clinic has continued to grow, as has our clinic team and the number of clinic days. We welcomed a new research coordinator who has worked with the clinicians to further develop our state-of-the-art database. In addition to providing an outstanding clinical service, we are participating in national quality initiatives and increasing our research platform with multiple current and upcoming projects. These projects will evaluate outcomes for our patients as well as interventions taking place and resources being provided as part of their routine care within the CDOP clinic.

CARDIAC DEVELOPMENTAL OUTCOMES PROGRAM CLINIC VISITS

Volume by year



CARDIAC IMAGING

Our noninvasive imaging lab performs more than 27,000 echocardiograms annually for fetuses, infants, children and adults with congenital or acquired heart disease. We provide transesophageal, epicardial, intracardiac and transthoracic echocardiographic support in the catheterization labs, operating rooms and intensive care units on a daily basis.

The main echocardiography lab consists of 10 rooms with a four-bed sedation bay.

Our state-of-the-art "Mission Control"

multi-physician reading lab was designed with input from NASA. We also have ancillary imaging centers at Texas Children's Hospital West Campus and Texas Children's Hospital The Woodlands to support our services in the community. Our imaging team now consists of 45 sonographers and more than 30 faculty members across our campuses, along with a dedicated advanced practice provider for sedation as well as nurses, medical assistants and clerical staff.

ECHOCARDIOGRAMS

Volume by location

Location	Volume
Texas Children's Hospital	18,595
Texas Children's Hospital West Campus	2,745
Texas Children's Hospital The Woodlands	1,833
Texas Children's Health Centers/Specialty Care	3,946

CARDIAC MRI & CT

The diagnostic imaging capabilities of cardiac MRI and CT provide an excellent complement to the primary imaging modality, echocardiography. With advances in technology that allow rapid imaging with minimal radiation, cardiac CT has become vital in the diagnosis and surgical planning for many of our patients with congenital heart disease. For neonates with complex congenital heart disease, we use cardiac CT to provide rapid and excellent diagnostic information, typically without the need for sedation. For our single ventricle patients, we often employ cardiac CT prior to each

surgical endeavor to supply information about the extracardiac anatomy to our surgeons.

Our cardiac MRI program continues to grow and is currently one of the largest in North America. This modality provides a wealth of information in multiple areas, including anatomy, morphology, volumetric and function data, as well as physiologic information regarding blood flow. This imaging modality is frequently used on our teenage and adult congenital populations because of the valuable information it provides and the limitations of transthoracic echocardiography among this population.

CARDIAC MRI & CT PROCEDURES

Volume by year

Y ear	2014	2015	2016	2017
Cardiac MRI	650	662	799	846
Cardiac CT	502	458	601	908

PHARMACOLOGIC CARDIAC STRESS MRI

At Texas Children's Hospital, we are proud to have one of the busiest pediatric stress MRI programs in the world. There are many different pediatric cardiac diseases that may be a cause of myocardial ischemia. Cardiac MRI is an excellent diagnostic tool to examine the cardiac function, perfusion and viability in these unique populations. Most patients in our Coronary Artery Anomalies program undergo a dobutamine stress MRI as part of their diagnostic work-up. For patients at risk of coronary ischemia, including those who recently had an arterial switch operation or were diagnosed with Kawasaki disease, we are one of only a few pediatric centers in the U.S. to offer regadenoson as a pharmacologic stress agent. These tests require a dedicated, coordinated effort from a team of experts including a pediatric cardiologist, pediatric radiologist, cardiac nurse, cardiac MRI technologist and MRI physicist. In 2017, our program performed 95 cardiac stress MRI examinations.

ADVANCES IN CARDIAC IMAGING

 Hypoplastic left heart syndrome (HLHS) is a complex cyanotic heart defect requiring three surgical palliations in the first three years of life. To better assess for changes in function of the single right ventricle in these patients over time, we have instituted an imaging protocol

- using cardiac strain technology, which assesses deformation of the cardiac muscle. Using cardiac strain, we are investigating the potential to predict outcomes which could then improve management strategies to optimize ventricular function. Prospective gathering of data will continue through the end of summer 2018.
- With industry support, we have started to evaluate
 the clinical utility of blood speckle imaging (BSI).
 Blood cells traveling through a heart chamber or
 valve produce flow variations such as vortices and
 helix formations. New software improvements
 provide the rare opportunity to ascertain normal
 and abnormal intracardiac flow patterns without
 using injected contrast or invasive methods.
- The impact of chemotherapy on ventricular function in children is being increasingly recognized. As part of our cardio-oncology initiative, we have adopted strict standards for detailed ventricular functional analysis, including myocardial strain, in an effort to minimize interstudy variability. Our goal is to provide better and earlier identification of cancer therapy-related cardiac dysfunction and determine best practices for coordinating care with our hematology-oncology colleagues.



CARDIOVASCULAR ANESTHESIOLOGY

The Cardiovascular Anesthesiology program at Texas Children's Hospital, the largest of its kind in the country, provides sedation and anesthesia services for all congenital cardiac operations and for children with congenital heart disease undergoing various noncardiac procedures.

Our team of more than 15 board-certified pediatric anesthesiologists and 10 nurse anesthetists also provides anesthesia services for catheterization and electrophysiology procedures as well as imaging studies in MRI, CT and interventional radiology.

CARDIOVASCULAR ANESTHESIOLOGY CASES

Volume by year

Year	Catheterizations and Electrophysiology Patients	Cardiovascular Operating Room Patients	Interventional Radiology Patients	MRI Patients
2013	927	969	130	434
2014	1,094	1,002	152	430
2015	1,129	982	252	428
2016	1,226	1,051	264	394
2017	1,177	1,017	340	436

PAIN MANAGEMENT AND THE ROLE OF PECTORALIS BLOCKS

Regional techniques may hold particular value in children and young adults with congenital heart disease, particularly given the minimal hemodynamic effects of peripheral nerve and fascial plane blocks. At Texas Children's Hospital, pectoralis plane blocks, particularly PECS I and PECS 2 blocks in combination, are now placed for children and adults undergoing placement or replacement of intracardiac devices in the chest.

Briefly, using an echogenic needle, and with ultrasound guidance, we deposit a local anesthetic, such as ropivicaine, within the fascial plane between the two pectoralis muscles, as well as between the pectoralis minor muscle and the serratus anterior muscle (Figure 1). This local anesthetic spreads to bathe most of the thoracic nerves that supply sensation to the chest wall, particularly the second through the ninth thoracic nerves. This leads to a numbing of the chest on the side where the device will be placed that lasts until well after the procedure is completed.



Figure 1. (A) PECS 2 block with the needle advanced within the plane between the pectoralis minor and serratus anterior muscles on the lateral chest. (B) PECS 1 block with the needle pulled back into the plane between the pectoralis major and the pectoralis minor muscles. Thin arrow = needle tip with hydrodissection between the pectoralis minor and serratus anterior muscles; dotted arrow = needle tip with hydrodissection between the pectoralis minor muscles; thick arrows = pleura; "X" = fourth rib.

In our patient population, patients receiving these blocks before placement of a device in the chest have required less opioid pain medications, such as morphine, and have been discharged earlier from the hospital (Table I). Additionally, no negative effects to blood pressure and heart rate were seen, which holds particular importance when caring for patients with congenital heart disease. While this data is preliminary, we are encouraged that adopting this practice has improved the care of our patients.

	Control (n = 24)	Pecs I and II Block (n = 8)	P-Value
Intraoperative morphine equivalence (mg/kg)	0.26 [0.21 – 0.31]	0.20 [0.13 – 0.26]	<0.04*
Hospital stay morphine equivalence (mg/kg)	0.89 [0.73 – 1.15]	0.75 [0.38 – 0.77]	<0.03*
Discharge from PACU (h)	3 [2.1 – 4.2]	4.4 [3.0 – 6.1]	0.12
Discharge from hospital (h)	24 [18 – 27]	9.3 [4.9 – 19.3]	0.05*
Post-operative pain score (0-10)=	4.3 [4 – 4.5]	0.9 [0 – 3]	<0.03*

Table 1: Median outcome measures between control and study groups. Values are median [IQR25 – IQR75] or frequency. *Statistical significance defined as p < 0.05. bpm = beats per minute. =Retrospective pain data limited by missing pain scores with only a pain reporting compliance rate of 18.8%.

PROTECTING THE INFANT BRAIN DURING CARDIOPULMONARY BYPASS

Newborns who require heart surgery may suffer a brain injury and experience side effects later in life, including developmental delays, difficulties in school and other hurdles that could interfere with their quality of life. Texas Children's Anesthesiology department has contributed significantly to identifying these injuries, determining their causes and finding potential solutions to mitigate against them. One promising modality developed by our team is a new kind of monitor that can delineate

safe from harmful blood pressure goals for patients supported on cardiopulmonary bypass. This method measures and optimizes the natural ability of the brain to regulate its own blood flow by a process called autoregulation. Our monitor is part of an NIH-sponsored study of adult patients, where preliminary results have shown a reduction in both mortality and delirium after surgery. We are working with Medtronic to bring this new technology to the FDA for approved use in pediatric patients who require cardiopulmonary bypass.

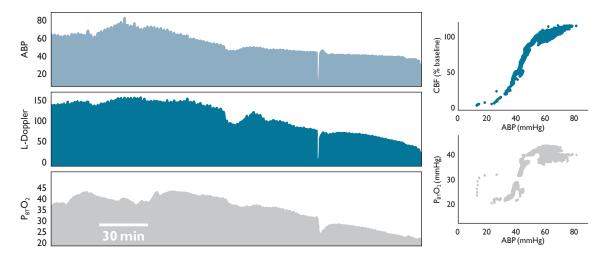


Figure I: Autoregulation and brain oxygenation: During cardiopulmonary bypass, when arterial blood pressure (light blue tracing) is adequate, cerebral blood flow is constant (dark blue tracings) and oxygenation in the brain is maintained (gray tracings). When arterial blood pressure falls below a critical level, blood flow to the brain falls and oxygenation is no longer maintained. Finding the critical blood pressure where autoregulation fails is the goal of autoregulation monitoring. When this limit is known, providers can manage patients in the safe blood pressure range, which is different for each person.

ULTRASOUND-GUIDED VASCULAR ACCESS

Children undergoing cardiac surgical and interventional catheterization procedures require invasive monitoring for safe management. Vascular access of peripheral veins, arteries and central veins can be very challenging, especially in small babies and children undergoing multiple repeat procedures.

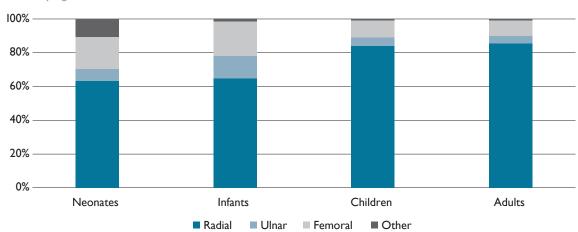
The use of ultrasound guidance has become standard practice in the Cardiovascular

Anesthesiology division. This has enhanced efficiency as well as safety for our patients. Compared to the Society of Thoracic Surgeons reported national practices, our team is able to safely establish access for these patients with a significantly lower incidence of complications or need for surgical cut downs.

The use of ultrasound guidance has also enabled us to use vascular access sites that are not routinely used in centers not applying this technology.

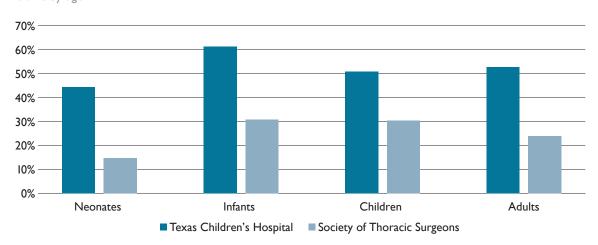
SITE OF ARTERIAL LINE ACCESS (2013-2017)





ULTRASOUND GUIDED VASCULAR ACCESS (2013-2017)

Volume by age



CARDIOVASCULAR INTENSIVE CARE UNIT

The Cardiovascular Intensive Care Unit (CVICU) team of cardiac intensivists, advanced practice providers, nurses, respiratory therapists, social workers, dietitians, pharmacists and support staff provides intensive care to newborns, infants, children and young adults with congenital and acquired heart disease. With a total of 33 beds, the CVICU cares for patients undergoing surgery for congenital and acquired heart disease, as well as

those with end-stage heart failure before and after heart transplantation.

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

CVICU PATIENT ADMISSIONS

Volume by year

Year	Patient Admissions
2015	1,045
2016	1,159
2017	1,138

RENOWNED FACULTY AND TRAINING PROGRAMS

The CVICU faculty includes leaders in pediatric cardiac intensive care who have certification in pediatric critical care medicine, pediatric cardiology and pediatric anesthesiology. Texas Children's Hospital also has the largest dedicated cardiac critical care advanced training program in the country. The Pediatric Cardiac Critical Care Instructorship is a 12-month didactic and clinical training program for physicians who have completed fellowships in pediatric critical care medicine or pediatric cardiology and wish to pursue an additional year of training in pediatric cardiac intensive care. This training program provides a unique interface among critical care medicine, cardiology, cardiothoracic surgery and cardiac anesthesia. We also offer a fourth year of specialized training in neonatal cardiac critical care. The first of its kind in the nation.

this program provides an opportunity for neonatologists who desire additional training in newborn critical heart disease.

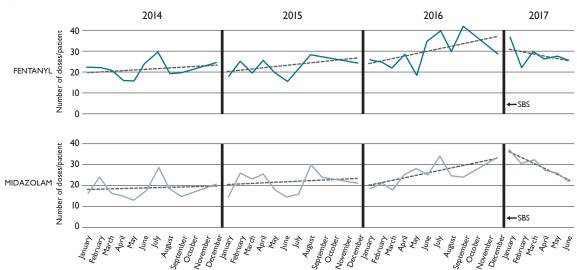
SEDATION IN THE CVICU

Children admitted to the CVICU after surgery or as a result of acquired heart disease often receive sedatives to facilitate mechanical ventilation and recovery. However, despite their widespread use, data supporting appropriate dosing, safety and optimal regimens for sedation are lacking. At Texas Children's Hospital, we have developed and implemented clinical guidelines using validated objective scoring for sedation and analgesia management in the CVICU and continually collect data to evaluate the impact, feasibility and acceptability of these guidelines. We believe that the use of clinical sedation guidelines and optimizing sedation practices can lead to decreased complications for our patients.

Early findings show that our use of weightbased and age-based sedation guidelines have impacted a historically upward trending use of medications, improving the duration and dosage of sedation medications without any apparent impact on ventilation duration or safety. The use of protocolized sedation guidelines have laid the foundation for guidelines for weaning or withdrawal from sedation medications, which will be implemented in 2018. Longitudinal studies of sedation practices are ongoing and we are continually assessing and refining the sedation practices for an individualized approach for the patients cared for in the CVICU.

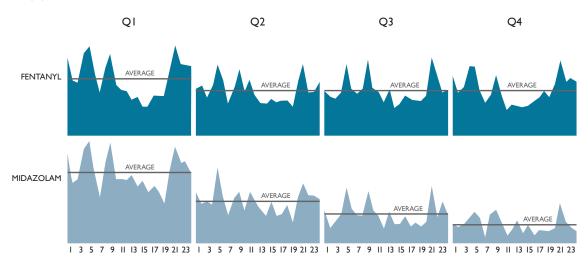
BOLUS DOSING FREQUENCY PER PATIENT

By month



BOLUS DOSES

In 2017



CONGENITAL HEART SURGERY

The Congenital Heart Surgery team provides individualized and comprehensive surgical care for all aspects of pediatric and adult congenital heart disease. We are experienced in the rarest and most common cases and perform more than 900 surgical procedures annually, with outcomes among the best in the country. We treat patients of all ages, from preterm and low-birth-weight newborns to adults with congenital heart disease, and we personalize treatments and procedures to best suit the situation of each patient and family. This tailored approach includes cardiopulmonary bypass and neuroprotection strategies focused on the patient's condition and needs, helping to achieve optimal functional outcomes. The center's Heart, Lung and Heart-Lung Transplant programs, among the largest and most successful pediatric programs in the U.S., are also part of the Congenital Heart Surgery division.

PROGRAM EARNS TOP RATING FROM THE SOCIETY OF THORACIC SURGEONS FOR SECOND CONSECUTIVE YEAR

For the second straight year, the Congenital Heart Surgery program earned a three-star rating from the Society of Thoracic Surgeons (STS) — the highest possible distinction. Star ratings are calculated based on overall risk-adjusted operative mortality for all patients undergoing pediatric and/or congenital heart surgery performed by an STS Congenital Heart Surgery Database (CHSD) participant. The latest analysis of data covers a four year period, from January 2013 to December 2016, and includes I16 participants. Texas Children's Hospital is one of only I1 CHSD participant hospitals to earn a three-star rating.

CARDIOVASCULAR AND THORACIC SURGERY CASES

Volume by year

Year	Cases
2013	889
2014	928
2015	914
2016	1,001
2017	926

CARDIOVASCULAR AND THORACIC SURGERY CASES

Percent by age

Year	Neonate	Infant	Child	Adult
2013	19.9%	27.7%	47.4%	5%
2014	18.6%	32.9%	44.5%	4%
2015	17.1%	31.4%	44.6%	6.9%
2016	19.3%	30%	44.4%	6.4%
2017	18.8%	31.1%	45.2%	4.9%

TOTAL CARDIOPULMONARY BYPASS OPERATIONS

Volume by year

Year	СРВ	Non-CPB	Total
2013	549	340	889
2014	597	331	928
2015	609	305	914
2016	654	347	1,001
2017	608	318	926

MORTALITIES BY STAT CLASSIFICATION¹

In 2017

Primary Procedure	Number of Procedures	Number of Discharge Mortalities	Percent Mortality	STS National Benchmark
STAT I	196	0	0%	0.4%
STAT 2	189	I	0.5%	1.5%
STAT 3	73	0	0%	2.4%
STAT 4	177	5	2.8%	6%
STAT 5	25	3	12%	14.4%
Total	660	9	1.4%	3%

¹Source for STS National Benchmark is Table 1 of the Society of Thoracic Surgeons Data Harvest Report Jan. 2016 to Dec. 2016.

MORTALITIES BY AGE AND OPERATION TYPE²

In 2017

Age	CPB Cases	Non-CPB Cases	CPB Discharge Mortalities	Non-CPB Discharge Mortalities	Discharge Mortality	Percent Mortality	STS National Benchmark
Neonate (0d - 30d)	86	25	5	1	6/111	5.4%	8.1%
Infant (31d - 1y)	176	31	I	I	2/207	1%	2.6%
Child (>1y - <18y)	276	31	I	0	1/307	0.3%	1%
Adult (18y+)	29	6	0	0	0/35	0%	1.3%
Total	567	93	7	2	9/660	1.4%	3%

²Patient grand total combines CPB and non-Cases (N = 660).

The source for the overall hospital data is STAT Index Surg CHD Volume; Data pulled 1/16/2018.

The source for the STS National Benchmark is Table 7 of the Society Thoracic Surgeons Data Harvest Report Jan. to Dec. 2016.

The source for the overall hospital data is STAT Index Surg CHD Volume; Data pulled 1/16/2018.

ARTERIAL SWITCH OPERATION

Volume by year

Year	2013	2014	2015	2016	2017
Cases	19	18	29	18	17

Overall hospital discharge mortality rate³: **0%** STS national benchmark⁴: **4.1%**

ATRIAL SEPTAL DEFECT REPAIR

Volume by year

Year	2013	2014	2015	2016	2017
Cases	35	42	39	37	33

Overall hospital discharge mortality rate³: **0%** STS national benchmark⁴: **< 1%**

ATRIOVENTRICULAR CANAL REPAIR

Volume by year

Year	2013	2014	2015	2016	2017
Cases	19	31	32	36	29

Overall hospital discharge mortality rate³: **0%** STS national benchmark⁴: **2%**

NORWOOD OPERATION

Volume by year

Year	2013	2014	2015	2016	2017
Cases	17	17	10	20	27

Overall hospital discharge mortality rate³: 9.7% STS national benchmark⁴: 14.7%

TETRALOGY OF FALLOT REPAIR

Volume by year

Year	2013	2014	2015	2016	2017
Cases	23	24	31	37	33

Overall hospital discharge mortality rate³: **0.8%** STS national benchmark⁴: **1.7%**

VENTRICULAR SEPTAL DEFECT REPAIR

Volume by year

Year	2013	2014	2015	2016	2017
Cases	86	59	70	79	85

Overall hospital discharge mortality rate³: **0**% STS national benchmark⁴: **< |**%

³Hospital mortality is calculated over the last four years from 2013-2016; Data pulled 4/14/2017.

⁴Source for STS national benchmark is the Society of Thoracic Surgeons Data Harvest Report January 2012 to December 2015.

CORONARY ARTERY ANOMALIES

In 2012, Texas Children's Hospital created the Coronary Artery Anomalies program, a multidisciplinary team to care for patients with rare congenital heart defects associated with coronary ischemia, myocardial infarction and sudden death. Coronary artery anomalies are the second-leading cause of sudden cardiac death in children and young adults. Diagnosing these anomalies can be challenging because many individuals with the conditions have no symptoms, and their first manifestation can be sudden cardiac arrest or death. Those who do have symptoms complain most often of chest pain, palpitations, dizziness or fainting during or just after exercise.

How to best treat children and young adults with coronary artery anomalies is a subject of debate

in the medical community. Most physicians agree that surgery is necessary for patients who show evidence of decreased blood flow to the heart muscle, but how to treat patients who have no physical complaints and show no evidence of reduced blood flow to the heart is unclear.

In December 2018, Texas Children's Hospital will partner with Children's Hospital of Philadelphia to host the 4th Symposium on Coronary Artery Anomalies. During the conference, speakers from leading heart institutions across the country provide a dedicated forum to discuss the diagnosis and management of patients with coronary artery anomalies.



ELECTROPHYSIOLOGY

The Electrophysiology program at Texas Children's Hospital offers cutting-edge treatment for patients with heart rhythm abnormalities. Most of these abnormalities cause the heart to beat either too fast or too slow and can be dangerous if they cause a significant decrease in the heart's ability to pump blood. There are many causes of arrhythmias including congenital heart disease and heart muscle disease including cardiomyopathies, genetic disorders, abnormalities of electrical conduction, electrolyte disturbances, infections and others.

At Texas Children's Heart Center, we offer a broad complement of diagnostic and therapeutic options to evaluate and manage heart rhythm abnormalities. We are one of the highest volume pediatric centers in the country for invasive electrophysiology studies and pacemaker/defibrillator implantations, and we maintain success rates for ablations that exceed the national average. Additionally, Texas Children's Heart Center is one of the leading centers in the world for the diagnosis and treatment of arrhythmias in children and adults with congenital heart disease.

TREATMENT OF ARRHYTHMIAS AND SUDDEN DEATH IN CHILDREN

Electrophysiology has developed a multipronged approach to tackle and study arrhythmias and sudden death in children in the Houston community. First, educating the public and potential responders regarding arrhythmias and sudden cardiac arrest is paramount. As such, we have embarked on an ambitious campaign to educate and prepare the community and schools in the Houston area. The campaign's goal is to certify all schools as "heart safe."

Our team is at the forefront of ongoing research to gain insight into the molecular mechanisms of these arrhythmias and develop new diagnostic approaches and therapies. Using novel technologies, we are able to convert blood samples from patients into their own stem cells and subsequently into their own cardiac cells. When coupled with experimental platforms that allow for measurement of electrical changes and ion flow, we can explore the molecular causes of sudden death-predisposing arrhythmias in an unprecedented fashion. This also allows us to test pharmacologic agents to treat their arrhythmias on what is effectively their own individualized heart tissue. This may open the door for truly individualized, precision medicine that is custom tailored to these children.

SUPRAVENTRICULAR TACHYCARDIA ABLATION OUTCOMES In 2017

Acute Success Rate			
Texas Children's Hospital	98.9%		
National benchmark ⁵	95.2%		

⁵Based on data from the Pediatric Radiofrequency Catheter Ablation Registry. Kugler JD, Danford DA, Houston KA, et al. Pediatric radiofrequency catheter ablation registry success, fluoroscopy time, and complication rate for supraventricular tachycardia: comparison of early and recent eras. J Cardiovasc Electrophysiol. 2002 Apr; 13(4):336-41.

STEREOTAXIS

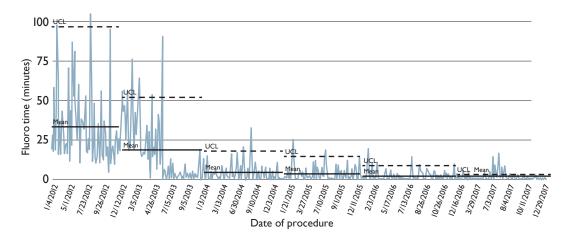
As one of only a few pediatric hospitals in the U.S. with a remote magnetic navigation system for catheter manipulation, we have used stereotaxis on over 200 ablation cases in recent years with excellent results. Magnetic navigation offers several theoretic advantages in the treatment of children. The catheter is more flexible and atraumatic than standard catheters, potentially eliminating the risk of heart perforation. It can also be navigated with more precision, allowing for movements as small as one millimeter or deflections as small as one

degree. This may result in enhanced accuracy and safety during mapping and ablation of certain arrhythmias in this patient population.

RADIATION REDUCTION

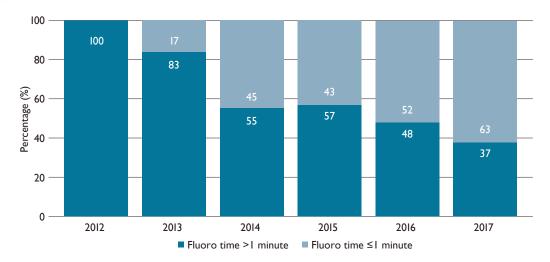
In order to decrease morbidity associated with radiation exposure during ablation cases, the Electrophysiology team has established protocols using nonfluoroscopic mapping techniques to minimize radiation. This has resulted in a nearly 20-fold reduction in fluoroscopy times, with over 200 procedures being performed with minimal radiation (<1 minute) over the past two years.

CHANGES IN FLUOROSCOPY TIME FOR ABLATION PROCEDURESBy month



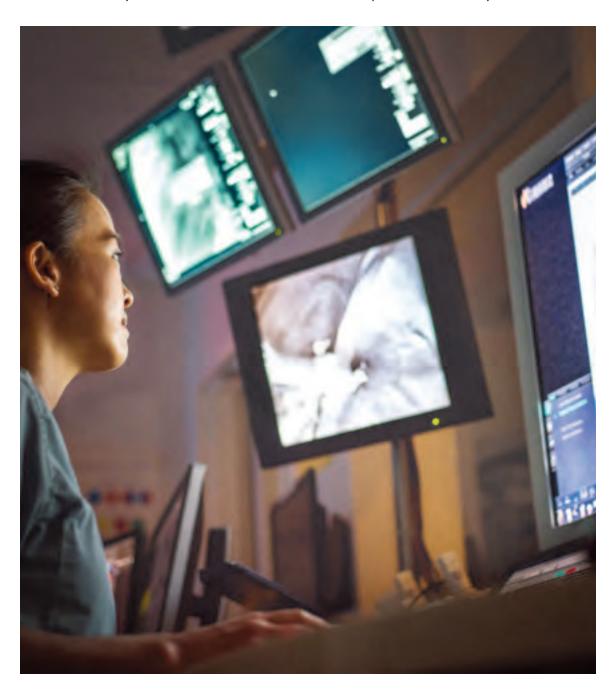
PROPORTION OF FLUOROSCOPY TIME

By year



AWARDS & GRANTS

- Three Electrophysiology team members received Baylor College of Medicine's Fulbright Educational Excellence Award in Leadership and Teaching
- National Institutes of Health K08 Grant for study of Junctophilin type 2 in cardiac nodal automaticity
- Pediatric Pilot Grant Award for study of Junctophilin type 2 and cardiac nodal dysfunction
- The Pediatric and Congenital Electrophysiology Society Paul C. Gillette Award for research on nodal automaticity and conduction
- American Heart Association Early Career Investigator Award for the study of the genetic basis of pediatric sudden arrhythmic death



FETAL CARDIOLOGY

Since the 1980s, Texas Children's Fetal Cardiology program has provided comprehensive fetal cardiac care to expecting families when there is a concern for or risk of heart disease in the fetus. In partnership with Texas Children's Fetal Center, this care includes diagnosis, counseling, delivery planning and then transition to treatment at Texas Children's Heart Center after birth. Our collaborative model allows patients to receive the best care from a team of specialists, all in one location.

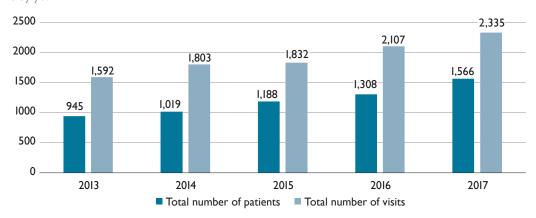
We have immense expertise and experience in fetal cardiology given our long history and high volume of cases. We currently have 16 fetal cardiology providers highly trained in fetal cardiac imaging.

Our vast experience following fetuses through gestation, delivery, infancy and adulthood gives us unique insight and ability to make accurate diagnoses and formulate the best care plans.

We strive to develop new cutting-edge treatments and therapies for fetal cardiac anomalies and have many promising clinical trials and research efforts in progress. Our program is heavily involved with the Fetal Heart Society, which is an international fetal cardiology research organization. We are leading and contributing to multiple fetal studies through this collaboration. We are also members of the International Fetal Cardiac Intervention Registry, which studies techniques and outcomes of fetal cardiac intervention across the world.

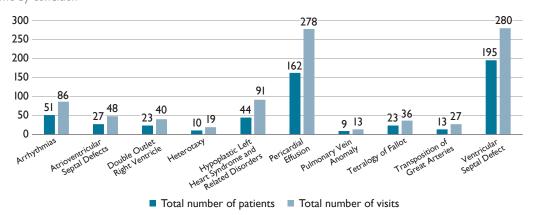
FETAL ECHOCARDIOGRAMS

Volume by year



FETAL ECHOCARDIOGRAMS IN 2017

Volume by condition



FETAL CARDIAC INTERVENTIONS

For fetuses with some cardiovascular conditions, fetal cardiac intervention is available at Texas Children's Hospital to try to improve the physiology of the heart before birth. Texas Children's Fetal Center is one of only a few centers in the world capable of providing the full array of fetal cardiac interventions, which involves a coordinated effort among a large, multidisciplinary team of fetal cardiologists, interventional pediatric cardiologists, congenital heart surgeons, maternal-fetal medicine specialists, maternal and fetal anesthesiologists and other clinical specialists.

We offer the following fetal cardiac interventions:

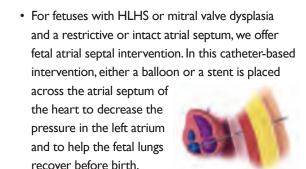
Fetal arrhythmia evaluation and treatment -

While some abnormal fetal rhythm problems are benign, others may result in fetal heart failure and thus pose a risk to the fetus and mother. Medical therapy is customized for each fetus and mother. We collaborate closely with adult cardiologists to protect the safety of both fetus and mother during treatment.

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

 For the most severe form of fetal aortic valve stenosis, which may progress to HLHS, we offer a catheter-based intervention called aortic valvuloplasty. Performed by a multidisciplinary team, this procedure consists of placing a small balloon

across the fetal aortic valve to enlarge it and to promote blood flow through and growth of the left side of the heart.



 For fetuses with small left-sided structures who may need neonatal heart surgery but do not meet the criteria for the above procedures, we are conducting an experimental study protocol called chronic maternal hyperoxygenation. This treatment involves

providing daily home oxygen for expectant mothers to promote fetal left heart growth. From 2014-2017, 13 patients have undergone this procedure.

Total evaluations for catheter- based interventions (2012-2017)	35
Total catheter-based fetal cardiac interventions (2012-2017)	15

HEART FAILURE

As the number of diagnoses for pediatric heart failure increases, so has our experience in treating patients. Each year, our dedicated team of physicians, nurse coordinators and administrative personnel cares for hundreds of cardiomyopathy and heart failure patients.

In most hospitals, the only option for pediatric heart failure patients is extracorporeal membrane oxygenation (ECMO). Although ECMO is a necessary intervention in some cases – and one with which we have particular expertise – it is not a long-term solution for heart failure. At Texas Children's Heart Center, we offer a full range of treatment options from medication to heart transplantation and beyond.

Treatment is tailored to the individual needs of each patient. The majority of cardiomyopathy and

heart failure patients are managed with medication. A small percentage of patients will go on to require a heart transplant. Since its inception in 1984, Texas Children's Heart Center has become one of the largest and most successful heart transplant programs in the nation.

Some patients awaiting a heart transplant may require mechanical circulatory support with a ventricular assist device (VAD) as a bridge to transplantation. Since we implanted our first VAD in 1985, we have become one of the largest, most comprehensive pediatric VAD programs in the world, implanting 20-30 VADs annually. Texas Children's Hospital offers a comprehensive range of both short- and long-term mechanical devices for children of all ages and sizes. Our program is also leading the way in using a VAD as a bridge to recovery.



HEART TRANSPLANT

The Heart Transplant program at Texas Children's Hospital provides complex, multifaceted medical and surgical care for patients from newborns to young adults in need of heart transplants. Since 1984, our team has performed more than 400 pediatric heart transplants.

We provide a comprehensive, interdisciplinary team approach through all aspects of the transplant process, from initial referral to hospitalization and outpatient management. Our heart transplant team works closely with patients, families and referring physicians to help make the evaluation process as convenient and efficient as possible.

HEART TRANSPLANTS

Volume by year

Year	Transplants
2013	15
2014	32
2015	21
2016	25
2017	28

HEART TRANSPLANTS IN 2017

By patient age

Age Range	Count	Percentage
<i td="" year<=""><td>5</td><td>18%</td></i>	5	18%
I-5 years	7	25%
6-10 years	4	14%
II-I7 years	9	32%
18-34 years	3	11%

HEARTTRANSPLANT GRAFT SURVIVAL RATES

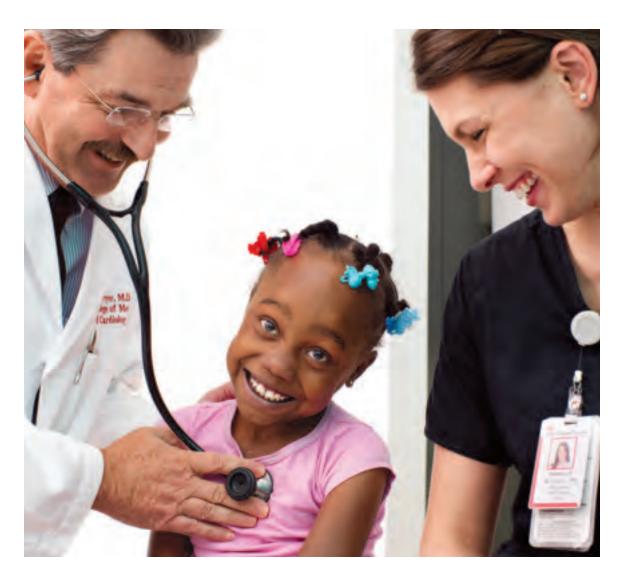
Pediatric age < 18

One Year after Transplant ^{6,7}			
Texas Children's Heart Center (N=61)	92%		
SRTR expected	92.7%		

Three Years after Transplant ^{6,8}			
Texas Children's Heart Center (N=42)	88.1%		
SRTR expected	87.9%		

 $^{{}^{6}\}text{Scientific Registry of Transplant Recipients (SRTR)}. \textit{Program Specific Reports.} \textit{Table II} - \textit{srtr.org}.$

 $^{^8 \}text{Based}$ on transplants performed from January 1, 2012 through June 30, 2014.



⁷Based on transplants performed from July 1, 2014 through December 31, 2016.

INTERVENTIONAL CARDIOLOGY

Interventional pediatric cardiology is a rapidly advancing field, with an increasing number of heart conditions able to be treated through minimally invasive, catheter-based interventions. Interventional Cardiology at Texas Children's Hospital is the largest program of its kind in the region, performing more than 1,200 cardiac catheterization procedures in 2017. The full-service Charles E. Mullins Cardiac Catheterization Laboratories, which includes three dedicated labs, provides routine interventions including:

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

Beyond these relatively common procedures, the Interventional Cardiology team has developed cutting-edge treatment strategies for rare and debilitating conditions such as:

- · Pulmonary vein stenosis
- Venous and arterial thrombosis
- Multiple muscular ventricular septal defects ("Swiss cheese" septum)
- Congenital portosystemic shunts (Abernethy malformation)
- Pulmonary arteriovenous malformations (congenital and acquired)
- · Pulmonary hypertension
- Renal artery stenosis
- Mid-aortic syndrome
- Critical aortic stenosis and hypoplastic left heart syndrome

In addition, we have the largest volume of experience with pediatric ventricular assist device placement for heart failure using the Impella® devices.





The Interventional Cardiology program is actively involved in many clinical trials to advance the care of children and adults with congenital heart disease, including:

- Clinical trial of closure of patent ductus arteriosus using the new Amplatzer® Duct Occluder II Additional Sizes (ADO-II AS)
- Clinical trial of closure of atrial septal defects with the new Gore Cardioform device (ASSURED trial)
- Clinical trial of transcatheter implantation of the new Medtronic Harmony® valve in patients with pulmonary insufficiency after repair of tetralogy of Fallot or after treatment of pulmonary valve stenosis
- Clinical trial of transcatheter implantation of the new Edwards Alterra® pre-stent system in patients with pulmonary insufficiency after repair of tetralogy of Fallot

- Post-approval study of transcatheter closure of muscular ventricular septal defects using the Amplatzer® Muscular Septal Defect Occluder (the highest enrolling site in the country)
- Humanitarian device exemption (HDE) for use of the Impella® RP to treat right heart failure

Despite being a regional and national referral center for the most complex forms of acquired and congenital heart disease, our team has an extraordinarily low complication rate from cardiac catheterizations. In addition, we have a strong culture of attention to radiation safety and continuous quality improvement, and we strive to promote these concepts locally and nationally. Our team is actively involved in research into new treatment strategies for congenital heart disease and is invited to lecture on these topics nationally and internationally.

CARDIAC CATHETERIZATION LABORATORY COMPLICATIONSBy rate

Description	Percentage
Cases without complications	93.8%
Cases with minor complications	1.3%
Cases with major complications	4.9%

⁹Calculated according to Jayaram N. et al. Modeling Major Adverse Outcomes of Pediatric and Adult Patients With Congenital Heart Disease Undergoing Cardiac Catheterization: Observations From the NCDR IMPACT Registry (National Cardiovascular Data Registry Improving Pediatric and Adult Congenital Treatment). Circulation. 2017;136:2009-2019.

PREVENTIVE CARDIOLOGY

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

REASONS FOR EARLY INTERVENTION

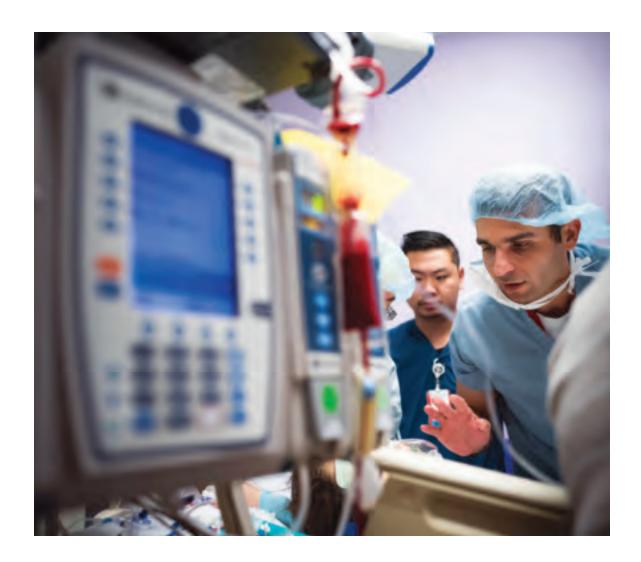
Abnormal cholesterol and high blood pressure are well recognized conditions in adults. It surprises many people that these conditions can also arise in childhood, and that they lay the foundation for heart disease in adulthood.

Research shows that normalizing cholesterol values and lowering blood pressure in children may help prevent or slow the development of heart disease as they reach adulthood.

Some patients have conditions such as liver disease, diabetes or metabolic syndrome that directly cause the cholesterol or blood pressure abnormalities. Others may be at a higher risk for cardiac disease and on an early pathway to acquired heart disease in adulthood due to childhood obesity and lifestyle factors.

The Preventive Cardiology program uses a collaborative approach to treating patients, drawing on the expertise of a multidisciplinary team of specialists, including experts in pediatric cardiology, heart disease prevention, physical activity, nephrology, endocrinology and nutrition.





SINGLE VENTRICLE PROGRAM

The Single Ventricle program at Texas Children's Hospital is a multidisciplinary team dedicated to caring for infants with single ventricle congenital heart defects such as hypoplastic left heart syndrome (HLHS), unbalanced atrioventricular septal defects, complex heterotaxy syndrome and related conditions. Our dedicated clinic provides specialized care to each patient.

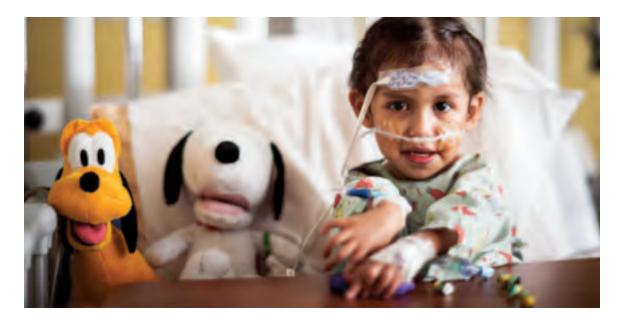
During the critical interstage period – the months between the first operation (Norwood procedure) and the second operation (bidirectional Glenn) – the baby is able to go home but is still at risk of certain problems and conditions. Parents and

caregivers are required to actively participate in monitoring and addressing these issues when they arise. Our home monitoring program provides support, resources and clinical care to help families transition successfully to the second surgery.

We are also actively involved with the National Pediatric Cardiology Quality Improvement Collaborative with the main goal of improving overall outcomes in infants with single ventricle heart disease. We are expanding our focus to begin at the time of diagnosis as a fetus, up to the infant's first birthday.







OUTCOMES & IMPACT SERVICE

The Outcomes & Impact Service at Texas Children's Hospital measures important clinical outcomes and the impact of care on the quality of life and functional status of our patients over time. Our team's goal is to deliver the highest value of health care to the patient.

By tracking outcomes, we learn about what happens to our patients, and we also learn about our performance as a health care delivery organization, as we constantly strive to improve.

Our team includes dedicated outcomes nurses in several clinical specialties, computer programmers, data architects and specialists and a statistician who works closely with clinical and administrative

teams to measure, improve and share our outcomes. The goals of our service are to:

- Track and improve our clinical outcomes
- Understand the impact of those outcomes on the lives of our patients and families over time
- Make our outcomes data available in a form accessible by the general public
- Partner with patients and families in understanding outcomes data
- Help patients and families know what questions to ask when seeking medical treatment

For more information, please visit texaschildrens.org/outcomes-and-impact-service.

REFERRALS

To refer a patient to Texas Children's Heart Center, please visit **texaschildrens.org/refer** or contact us directly.

Texas Children's Hospital 6621 Fannin St. Houston, TX 77030 832-824-3278 texaschildrens.org/heart



texaschildrens.org/heart

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