

**Congenital Heart Center
Best Outcomes**

35% better outcomes
than established
national benchmarks

85% survival at one year for
Norwood procedure after first
and second single-ventricle
palliation

Over 750 pediatric and
adult congenital **heart**
surgeries annually



**Weill Cornell
Medicine**

**NewYork-
Presbyterian**



**COLUMBIA UNIVERSITY
MEDICAL CENTER**

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We consistently rank as the best in pediatric care in the New York Tri-State region, with the lowest mortality for pediatric heart surgery in the state.



Ralf J. Holzer, MD, Julie A. Vincent, MD and
Emile A. Bacha, MD

Message from the Directors

Dear Colleague:

Each year, pediatric cardiac surgeons and interventional cardiologists at the NewYork-Presbyterian Congenital Heart Center perform more than 750 pediatric and congenital heart defect operations, including some 25 heart transplants, 175 newborn heart repairs, 1,500 interventional and diagnostic transcatheter procedures, and 100 adult congenital heart repairs.

We have been performing pediatric heart surgery at a high volume since the early 1970s, creating a culture of clinical excellence and demanding the best outcome for every patient. We are proud to point to the fact that for seventeen years in a row, we have achieved significantly better outcomes than our peers in New York State. We performed the first successful pediatric heart transplant in the United States in 1984. We use 3-D printed heart models as part of pre-op management, allowing careful study of complex congenital heart disease lesions prior to surgical or transcatheter interventions. Our interventional cardiologists perform highly complex cardiac catheterization procedures in state-of-the-art cardiac catheterization laboratories with excellent outcomes.

The seamless integration of our Pediatric Cardiology and Cardiac Surgery Divisions begins prior to birth of the fetus, at the first consultation with a NewYork-Presbyterian surgeon or interventional cardiologist. Patients who require intervention receive continuity of care throughout their treatment and recovery. As a major national and international referral center for children and adults with congenital heart disease, NewYork-Presbyterian offers a physician access transfer program – 1-800-NYP-STAT – to coordinate patient transfers when tertiary and quaternary care are required.

On behalf of NewYork-Presbyterian Congenital Heart Center, we are pleased to provide a summary of outcomes for some of our most often performed pediatric and adult cardiac congenital surgical and catheterization procedures for the years 2013-2016, the most recent period for which complete data are available. Data are presented in accordance with the Society of Thoracic Surgeons (STS) congenital cardiac surgery database guidelines.

We hope you will find the information in this brochure valuable as you make informed decisions as to where to refer your pediatric cardiac patients for surgery.

Sincerely,

Emile A. Bacha, MD

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About NewYork-Presbyterian & Our Congenital Heart Center

We are comprised of two renowned medical centers:

Morgan Stanley Children's Hospital at NewYork-Presbyterian/
Columbia University Medical Center and Komansky Children's
Hospital at NewYork-Presbyterian/Weill Cornell Medical Center.

We have built a national reputation for outstanding care devoted to children. The hospital ranks in the top ten in the nation in pediatric cardiology and heart surgery, according to the 2017-2018 *U.S. News & World Report* "Best Children's Hospitals" rankings. We have the lowest mortality rate in New York State for pediatric heart surgery, and one of the lowest nationwide – even though our surgeons routinely treat some of the most complex cases, many referred from other institutions.

Our integrated Congenital Heart Center is one of the largest and most preeminent pediatric cardiology and cardiac surgery centers in the nation and one of the nation's major pediatric transplant centers. We have a distinguished roster of highly-skilled and experienced cardiovascular surgeons, including four national leaders specializing in complex neonatal surgery, hybrid minimally invasive surgery and transplant/assist devices. A team of five highly skilled interventional cardiologists provide a full range of transcatheter interventions at both NewYork-Presbyterian locations — Morgan Stanley Children's Hospital and Komansky Children's Hospital. We offer our young patients cardiovascular expertise together with all sub-specialties that may be needed when treating a complex heart problem — from fetal diagnosis and therapies to neonatal pediatric cardiac intensive care, minimally invasive electrophysiology studies, non-invasive imaging, and specialized pediatric cardiac anesthesia.

Our patients come to us from across the country and around the world to seek the most advanced, safest, and proven treatments for congenital heart conditions and for the revision of previous surgery when that treatment fails. We provide both adult and pediatric patients with congenital heart defects treatment options never thought possible just a short time ago.

The **most important measure** of a center's experience & expertise in pediatric cardiovascular surgery is the **quality of its outcomes**



Center Overview 2013-2016



Our outcomes are **35%** better than national benchmarks

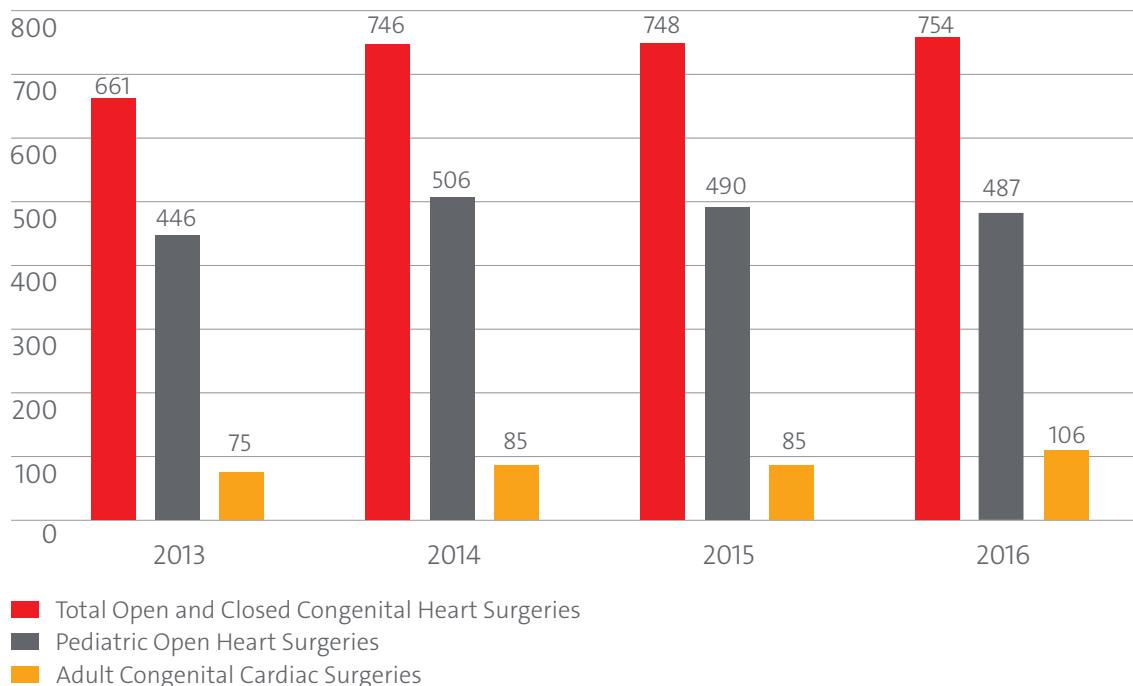
Our average hospital mortality for the most complex neonatal procedures was **11.9 %** compared to **17.0 %** globally

While we treat some of the most complex cases, our outcomes are well above established national benchmarks.

It has been demonstrated that improved clinical outcomes are closely linked to centers with high surgical volumes. As a center's activity increases, cardiothoracic surgeons, cardiologists, anesthesiologists, critical care specialists, nurses, perfusionists and other cardiac team members become more experienced caring for patients with congenital heart disease.

We Perform More Than 750 Pediatric and Adult Congenital Heart Surgeries

NewYork-Presbyterian Pediatric & Adult Congenital Cardiac Surgeries 2013-2016



Neonatal Volume 2013-2016

	2013	2014	2015	2016
Surgical Procedures (neonate <30 days)	103	146	127	153

NewYork-Presbyterian Survival Statistics 2013-2016

Number of Cases | Survival

Procedure

	2013	2014	2015	2016
Aortic Valve/Ross	9 100%	12 100%	10 100%	12 100%
Arterial Switch Operation (ASO)	13 100%	25 96%	17 100%	25 100%
Atrial Septal Defect Repair (ASD)	62 100%	38 100%	41 100%	55 100%
Atrioventricular Canal Defect (AV Canal)	29 97%	35 94%	16 100%	20 100%
Fontan	21 91%	22 95%	25 100%	27 100%
Glenn	16 100%	21 95%	26 96%	22 100%
Norwood	16 82%	18 100%	14 86%	19 89%
Tetralogy of Fallot Repair (TOF)	33 100%	50 100%	34 100%	35 97%
Total Anomalous Pulmonary Venous Return (TAPVR)	4 100%	16 94%	9 100%	14 100%
Transplant	30 93%	22 100%	26 100%	22 95%
Ventricular Septal Defect (VSD)	37 100%	48 98%	50 100%	43 100%

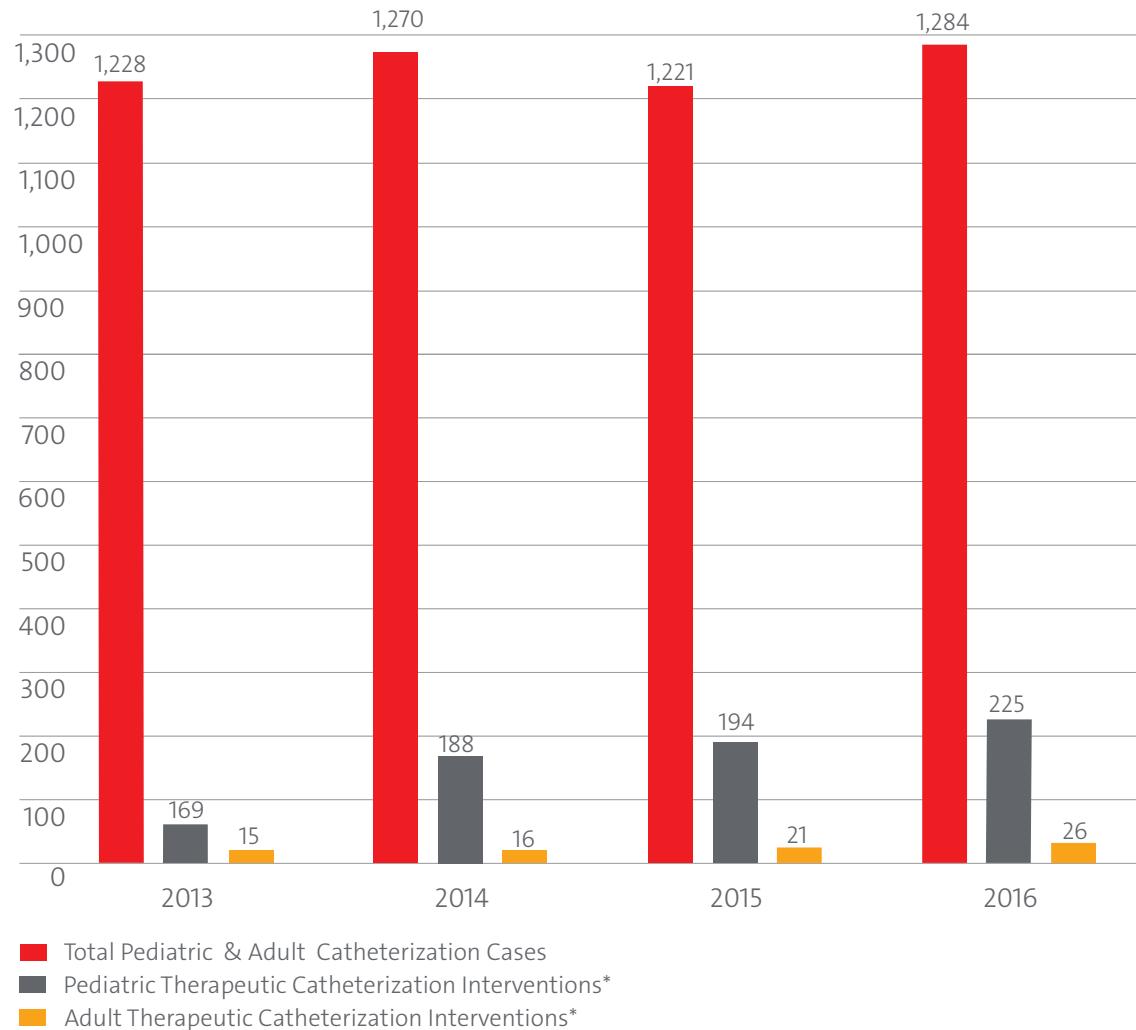
Overall Hospital Discharge Mortality Rate 2013-2016

NewYork-Presbyterian STS National Benchmark

2013	3.0%	3.2%
2014	2.5%	2.9%
2015	1.9%	3.1%
2016	2.8%	2.8%

We Perform More Than 1,300 Pediatric Cardiac Catheterization Procedures Annually

NewYork-Presbyterian Pediatric & Adult Cardiac Catheterization Procedures 2013-2016



* Because biopsies are considered NON-INTERVENTIONAL, numbers for pediatric and adult interventions in the chart above do not include biopsies.

Experience & Expertise Translate to Better Outcomes

In 2017, *U.S. News & World Report* ranked NewYork-Presbyterian as one of the top pediatric heart and heart surgery programs nationally, reflecting our reputation and surgical outcomes, the expertise of our surgical teams, our volume of cases, and other patient-care related data.

Under the direction of pediatric cardiovascular surgeon Dr. Emile Bacha and pediatric cardiologists, Dr. Julie A. Vincent and Dr. Ralf J. Holzer, NewYork-Presbyterian provides all therapies a newborn, young child or adolescent with congenital heart disease may need – from evaluating heart function and anatomy in utero to pediatric heart transplant and extended heart/lung support via Extracorporeal Membrane Oxygenation (ECMO) and other devices. We are widely recognized for neonatal heart surgery and many of the procedures we perform are in low birthweight premature newborns and in infants under the age of one month.

Dr. Bacha is known for developing novel techniques to perform hybrid surgical-interventional catheter-based procedures for many complex congenital heart defects, including hypoplastic left heart syndrome. He specializes in minimally invasive approaches to pediatric cardiac surgery and cardiac surgery in low birthweight infants and has pioneered methods of improving surgical safety. He has developed a method of pediatric cardiac surgical performance metrics that is now an accepted method of surgical monitoring for pediatric cardiac surgeons.

Dr. Vincent's clinical expertise includes transcatheter therapies for congenital heart disease (CHD) including all types of device closure techniques for atrial and ventricular septal defects, the patent ductus arteriosus, and abnormal vascular connections or collaterals. She is internationally recognized as an expert in transcatheter pulmonary valve replacement techniques.

Dr. Holzer is an internationally recognized expert in all types of transcatheter interventions, including device closure of ventricular septal defects, pulmonary artery stenting, and transcatheter pulmonary valve implantation. His academic interest is focused on improving outcomes and quality of care, as well as risk adjustment for transcatheter intervention.

Collaborative, Multi-Disciplinary Care

Bringing our pediatric surgical, medical, anesthesiology, perfusionist, critical care and cardiovascular support specialists together into an integrated care team helps us to optimize patient outcomes. This integrated care model enables us to provide seamless interaction with all sub-specialties, resulting in the best and safest treatment for our youngest patients. A family referred to the Center can be assured that they will be in the expert hands of a medical team renowned for excellence in pediatric cardiology and cardiac surgery and committed to a shared goal of providing our patients with the safest, most advanced surgical techniques available.

Our pediatric heart and heart surgery program has consistently been recognized as one of the top ten in the country



Dedicated Pediatric Catheterization Laboratory

A great number of congenital heart defects can now be treated in the cath lab, requiring only a single day of hospitalization, and eliminating the need for open heart surgical repair. NewYork-Presbyterian has particular expertise in pediatric interventional cardiology, a unique specialty that involves the non-surgical treatment of congenital and acquired cardiovascular disorders.

The Congenital Heart Center's pediatric catheterization laboratories offer diagnostic and therapeutic interventions, defibrillator and pacemaker implantations, arrhythmia studies, ablation, and evaluation of patients with pulmonary hypertension. Many of the pediatric interventional procedures that have become standard of care worldwide have been developed by interventional cardiologists at the children's hospitals of NewYork-Presbyterian.

Catheter-Based Interventions We Perform Regularly

- Balloon valvuloplasty of the aortic and pulmonary valves
- Angioplasty, including dilation and stent implantation to open narrowed arteries and systemic and pulmonary veins, pulmonary arteries, and coarct of aorta conduits
- Balloon atrial septostomy to improve mixing of oxygen-rich and oxygen-poor blood to ensure that the body's oxygen saturation remains in a safe range
- Atrial septoplasty and stenting for patients with severe pulmonary hypertension
- Coil or device closure for ductuses and unwanted vessels
- All types of device closures for atrial and ventricular septal defects
- Ablation for arrhythmias
- Defibrillator and pacemaker implantations

Each year, we perform more than **1,500 diagnostic and interventional transcatheter procedures**

Electrophysiology (EP) Procedures We Perform Regularly

- Electrophysiology testing
- Radiofrequency ablation of supraventricular tachycardia
- Cryoablation of supraventricular tachycardia
- Ablation of ventricular tachycardia
- Ablation in congenital heart disease patients
- Procainamide challenge test
- Pacemaker implantation
- ICD implantation
- Placement of implantable loop monitors
- Electrical cardioversion



Pediatric Cardiac Catheterization team

Minimally Invasive or Hybrid Options

Hybrid heart surgery refers to procedures that use conventional surgical methods in conjunction with minimally invasive, catheter-based interventional approaches. Hybrid techniques are performed in a combined procedure with a cardiothoracic surgeon and an interventional cardiologist working side-by-side in the same operating room. These less invasive alternatives use a much smaller incision through the breast bone or right chest, with the advantage of less pain, avoidance of cardiopulmonary bypass, faster return to normal activities and definite cosmetic advantages.

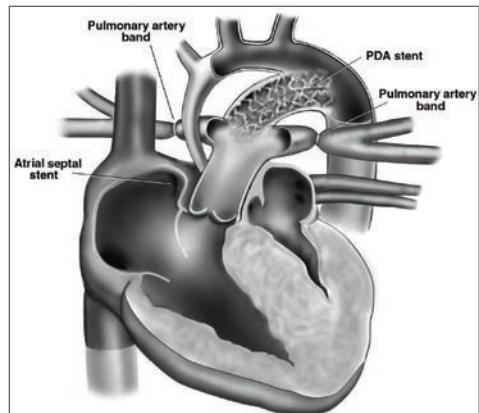
At NewYork-Presbyterian Congenital Heart Center, each patient is evaluated for less invasive treatment options first. In some cases, a hybrid approach may enable the team to treat a condition with a single operation rather than a series of surgeries or to treat conditions that would otherwise be inoperable. The Congenital Heart Center is one of just a few U.S. centers to offer hybrid heart operations to infants and children. Our surgeons and interventional cardiologists have extensive experience performing hybrid procedures and we have published many scientific papers on this topic.

Hybrid Therapy for Hypoplastic Left Heart Syndrome

Center surgeons and interventionalists are successfully using a less invasive hybrid technique for a difficult-to-treat defect in newborns known as hypoplastic left heart syndrome (HLHS). To survive, babies born with this anomaly must undergo surgery in the first week of life. Until recently, the only treatment available was the Norwood procedure, which requires three difficult standard open operations and carries a 10-20% or greater risk of mortality.*

The Stage 1 hybrid procedure removes dependence on the heart-lung machine. At approximately six months, when the baby is better able to handle major open-heart surgery, the second stage operation is performed. The hybrid procedure is thought to be safer in high-risk patients such as low birthweight or premature babies because it avoids use of the heart-lung machine. Hybrid techniques are not applied universally and they are not appropriate for every child. Some babies still do better with the Norwood procedure and we decide on a case-by-case basis, in a multidisciplinary fashion, whether a child will benefit most from one procedure or the other.

We are one of just a few Centers in the U.S. to have a formal pediatric hybrid program—and the only one in the New York area



Stage 1 Hybrid

*Source: Society of Thoracic Surgeons Congenital Heart Surgery Database 2012-2015 Report — mortality for all participating centers: 14.8%

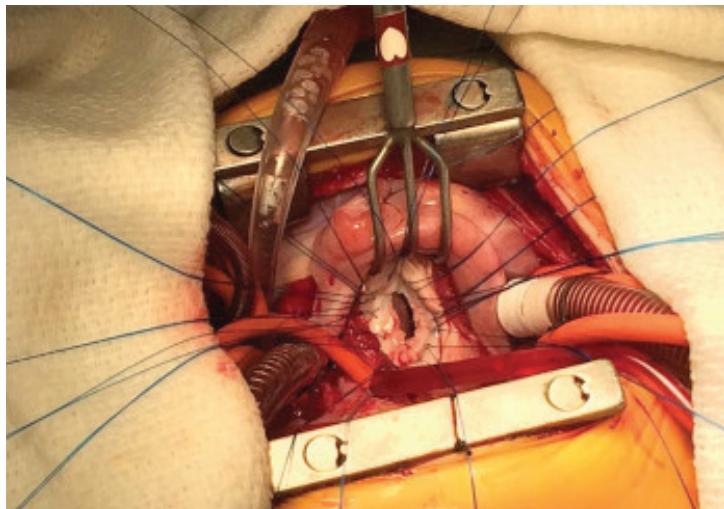
Minimally Invasive or Hybrid Options

Hybrid Therapy for Ventricular Septal Defect Repairs (VSDs) or Valve Implantation

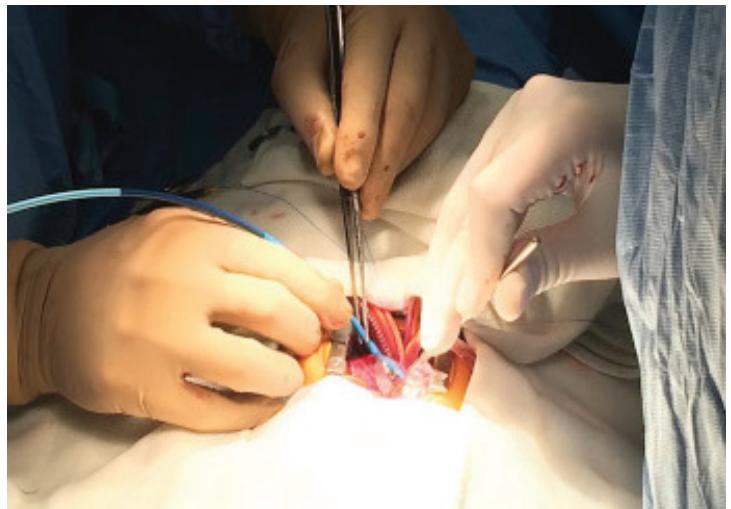
Center physicians are expanding applications of minimally invasive hybrid techniques to include closing ventricular septal defects or holes in the heart tissue with excellent results.

Typically, holes in the heart are closed by suturing a patch on the hole during open-heart surgery. The hybrid technique allows surgeons to go through the chest and deliver a device to close holes and prevent the need for multiple surgeries. We have developed special instruments that allow us to make these repairs using much smaller incisions than previously possible, resulting in markedly improved cosmetic results.

We have also implanted valves using a hybrid approach, resulting in less need for anticoagulation. Typically, valves are sutured inside the heart and often require anticoagulation with Coumadin. By using stented valves, we can implant biological valves that do not require anticoagulation. Biological valves can also be dilated and enlarged to keep up with the child's growth, unlike traditional "surgical" valves that cannot be enlarged and must be exchanged surgically.



Sutures are placed around the mitral valve annulus on the atrial side.



The valve is positioned through the mitral annulus before balloon expansion.

Center for Single Ventricle Care

A normal heart has two ventricles which pump blood out of the heart. In children with single ventricle defects, one of these chambers is missing or is too small to function properly. Examples include hypoplastic left heart syndrome, tricuspid atresia, pulmonary atresia, and double-outlet right ventricle. Babies born with this condition require urgent open-heart surgery within the first week of life.

The Center for Single Ventricle Care at NewYork-Presbyterian is the only center of its kind in New York, features a multidisciplinary team of specialists to:

- Manage single ventricle defects, even before birth, using advanced technologies to accurately assess a child's heart anatomy and function.
- Create a roadmap outlining a staged program of care, including a series of corrective surgeries that begin shortly after birth.
- Assess each child for neurodevelopmental delays or concerns and optimize neurodevelopmental progress.
- Monitor children to support health and optimal development until adulthood.

Subsequent operations are staged to re-route the circulatory system to eventually allow the single ventricle to pump red oxygenated blood to the body while the blue blood is channeled to flow passively directly to the lungs. A key component of the Center for Single Ventricle Care is our interstage surveillance program, created to track a child's health between the first two surgeries. A team of nurse practitioners dedicated to this specific program call home weekly to get updates on a child's health status. The nurses answer any questions and also coordinate visits to our clinic.

nyp.org/morganstanley/clinical-services/heart/center-for-single-ventricle-care

85% survival for high-risk neonates following single ventricle palliation is achievable because of the coordination and expertise of our highly-specialized multidisciplinary cardiovascular team



3-D Printed Heart Models Give Surgeons Vital Information About a Heart's Anatomy

Pediatric heart surgeons and interventionalists at NewYork-Presbyterian are using advanced 3-D printed pre-surgical planning models to guide surgery in children born with complex heart lesions, with the goal of improving accuracy and outcomes.

Based on patient cardiac MRI and CT scans, the printer can produce an exact replica of the baby's heart, allowing physicians to look at the inside of the heart in advance of surgery, providing them with more accurate information to precisely plan the surgery and allowing more time in the operating room to repair the child's cardiac defects. Typically, surgeons must wait until they are in the operating room to see the extent of a heart's congenital defect, and then execute the surgical procedure in a limited amount of time.

With the aid of a 3-D model, printed to scale, doctors are often able to repair all of a heart's defects in a single procedure. Usually, babies born with complex defects require three or more life-threatening surgeries to make repairs.



Thanks to this 3-D heart model, cardiac surgeons at NewYork-Presbyterian Congenital Heart Center could plan an infant's operation before stepping into the OR.

One of the Nation's Largest Heart Transplant Programs

NewYork-Presbyterian has a rich history of developing innovative surgical treatments that set the standard in pediatric cardiac surgery. In 1984, our surgeons performed the world's first successful pediatric heart transplant in a 4-year-old boy. In the intervening years, more than 500 children have received new hearts at NewYork-Presbyterian Morgan Stanley Children's Hospital. Today, NewYork-Presbyterian is one of the largest and most successful pediatric heart transplant centers in North America and the world – largely due to the dedication and expertise of our heart transplant team, the use of ventricular assist devices (VADs) in managing heart failure, and the application of novel immunosuppression protocols. Notably, we have the most pediatric experience in the U.S. with the PediMag (Levitronix) device. Our use of pediatric VADs has increased year after year.

Extracorporeal Membrane Oxygenation (ECMO)

ECMO is a short-term cardiac assist device for the very young, or for children whose anatomy will not permit a ventricular assist device (VAD). The Center's physicians participated in the earliest development of ECMO, making our facility one of the first in the world to use this life-saving technology successfully in neonates and children. We are an ELSO (Extracorporeal Life Support Organization) Center of Excellence, and have an ECMO transport program to move patients from outside hospitals into ours.

Blood Conservation Techniques

For the vast majority of procedures in neonates or small infants, transfusion-free cardiac surgery is unrealistic. However, we have made considerable progress in limiting the need for blood products with simple and safe techniques that involve a decrease in cardiopulmonary bypass prime volume, such as making the heart-lung machine smaller and less injurious.

Every participant in our program, including cardiologists, anesthesiologists, perfusionists, surgeons, intensivists and laboratory technicians, is committed to blood conservation in pediatric cardiac surgery.

Our cardiovascular surgeons perform 25 pediatric heart transplants every year



NewYork-Presbyterian Morgan Stanley Children's Hospital multidisciplinary transplant team.

Prenatal Diagnosis and Intervention

We have one of the largest and most experienced maternal-fetal medicine teams in the country, with over half of all deliveries designated high-risk or increased risk. The Maternal Fetal Medicine Program at NewYork-Presbyterian Morgan Stanley Children's Hospital is under the direction of Dr. Lynn Simpson. Fetal Cardiology is under the direction of Dr. Stephanie Levasseur. At NewYork-Presbyterian Komansky Children's Hospital, the Clinical Maternal-Fetal Medicine Program is directed by Robin Kalish, MD. Sheila Carroll, MD, directs the Weill Cornell Fetal Cardiology Program.

Our Carmen and John Thain Center for Prenatal Pediatrics at NewYork-Presbyterian Morgan Stanley Children's Hospital and our Fetal Cardiology Program at NewYork-Presbyterian Komansky Children's Hospital are the only facilities of this kind in the New York area offering comprehensive, multidisciplinary prenatal diagnosis and therapy in conjunction with pediatric subspecialty consultation. We communicate all test results, diagnoses, and specific treatment options with the referring obstetrical team in a timely manner and coordinate a care plan for the patient.

Fetal Cardiac Therapy

In 2018, our fetal cardiology team began providing fetal cardiac intervention, the first in New York to provide this therapy. When a heart defect is suspected in utero, we bring together a core team of high-risk obstetricians, neonatologists, interventional cardiologists, fetal cardiology specialists, pediatric congenital heart surgeons, and other cardiac specialists. Working jointly with our colleagues in maternal-fetal medicine, we precisely diagnose the anomaly, develop a plan for close surveillance, and prepare for surgical intervention and the proper level of care at delivery, ultimately leading to improved outcomes. In cases where fetal therapy is possible, such as for cardiac arrhythmia, collaboration with pediatric cardiologists can maximize our ability to improve fetal health while avoiding complications in the mother.

Twin-Twin Transfusion Therapies

As the number of women having twins has increased, so have the chances of developing a serious pregnancy complication called Twin-Twin Transfusion Syndrome (TTTS). This disorder affects as many as 15 percent of identical twin pregnancies and results from uneven blood flow between the fetuses. Successful treatment of this complex condition requires advanced training and experience available at only a few specialized perinatal centers in the United States. In more than 70 percent of cases, both twins will die if this syndrome is not treated early in pregnancy.

During the years 2015, 2016, and 2017 our Maternal-Fetal Medicine specialists performed more than 60 laser photocoagulation procedures, a minimally invasive laser treatment which involves coagulating unnecessary and harmful blood connections between the two fetuses. NewYork-Presbyterian is currently the only center in Manhattan that performs the laser photocoagulation procedure.

Twin-Twin Transfusion Syndrome can have a significant impact on the cardiovascular system in twins. It is important that twins with TTTS are thoroughly evaluated for heart problems in utero. An obstetrician may refer a patient for further evaluation and fetal echocardiogram by our maternal-fetal medicine cardiovascular team.



Only Dedicated Infant Cardiac Intensive Care Unit in the United States



By focusing exclusively on neonates with cardiac disease, we feel we have developed unsurpassed expertise in the care of low birthweight and premature babies

Many babies require surgery within hours of birth. The Vivian and Seymour Milstein Family Infant Cardiac Intensive Care Unit (ICICU), a state-of-the-art unit dedicated solely to infant cardiac care (0-3 months), is the first-of-its-kind facility in the United States.

These patients, primarily premature or low birthweight newborns, not only need expert surgeons able to operate on such tiny patients, but also require specialized life support technology, tiny tools, and a multidisciplinary team prepared to handle these intricate and complex challenges. From beds to medical and surgical equipment, all resources are designed for the smallest of patients. This includes specialized machines and assist devices that replace the function of the heart and lungs, such as the Berlin Heart and the ECMO (extracorporeal membrane oxygenation) machine, and 3-D printing to help guide surgery. We are one of the few institutions in the world offering such technology to the smallest patients.

Pediatric Cardiac Critical Care Medicine

Our Pediatric Cardiac Intensive Care Unit (PCICU) is a separate unit that serves the needs of critically ill infants, children and adolescents. This specialized unit for older babies and children is staffed by a highly skilled team of intensivists working together with multiple subspecialties including anesthesiology, pediatric cardiology, pediatric cardiovascular surgery, critical care, and pulmonology.

The care of patients in the PCICU is directed by both pediatric critical care physicians and pediatric cardiologists, with surgical patients managed in close consultation with our cardiothoracic surgical staff and a team of critical care nurses with advanced training. This unit also manages the perioperative care of patients undergoing heart and lung transplants. The PCICU staff are experts in the management of the most advanced support technology: ECMO, high-frequency oscillatory ventilation, inhaled nitric oxide, continuous renal replacement therapies such as continuous veno-venous hemofiltration (CVVH), and neurologic monitoring including continuous EEG and ventricular assist devices.

Metropolitan New York's First & Largest Adult Congenital Heart Program

With the success of cardiac surgery in childhood, the number of young adults with congenital heart defects represents a unique and growing population and more than 30 different forms of congenital heart disease. Because these adults present a unique challenge for the cardiology community, the American Heart Association recently recognized Adult Congenital Heart Disease as a subspecialty of cardiology.

Our adult congenital heart program, the first and largest of its kind in the Tri-State area, includes a team of board-certified pediatric and adult cardiologists, cardiothoracic surgeons, and intensive care experts specifically trained in adult congenital heart disease. They assist in managing young and older adults who present with primary or post-repair congenital heart disease.

Our physicians have expertise in echocardiography, interventional cardiac catheterization, interventional electrophysiology, pulmonary hypertension, complex congenital heart surgery, and cardiac transplantation.



Emphasis on Patient Safety & Quality

Our surgeons and interventional cardiologists are held to a rigorous standard. We hold monthly multi-disciplinary risk-adjusted mortality and morbidity conferences, where we review data on every patient. Additionally, every six months we review surgeon-specific mortality and complications with regard to several specific areas:

- post-operative infection
- unplanned re-operation or re-intervention
- unplanned need for mechanical support
- new post-operative neurological findings
- re-operation for bleeding
- post-operative cardiac arrest
- major technical problems during surgery

Twice a year, each surgeon receives a surgeon-specific performance metric. The result: we are able to maintain the highest quality by identifying and correcting potential problems early, which ultimately makes our patients safer.

Open Communication with Referring Physicians

We consider referring physicians an integral part of our cardiac team and are committed to keeping them updated about a patient's medical status, major treatment recommendations and progress during hospitalization. Within hours after patients leave the hospital, we provide a detailed discharge summary to all referring physicians for their reference and continuum of patient care.



Pioneers in Research

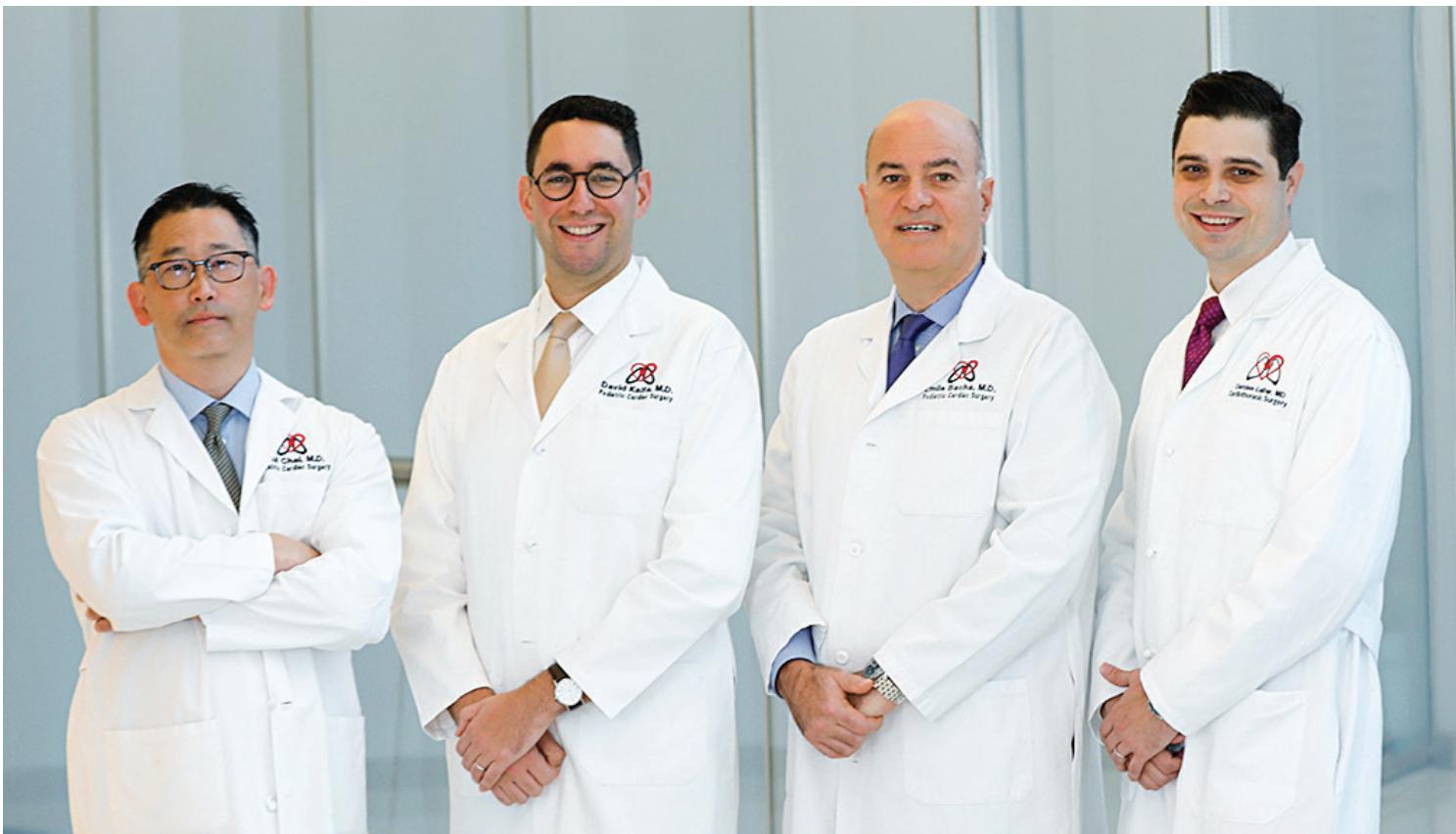
Following are a few examples of our ongoing efforts to expand our knowledge and develop new treatment options:

- **Pulmonary Hypertension** NewYork-Presbyterian Congenital Heart Center is a participant in a national multicenter trial funded by the National Heart, Lung and Blood Institute (NHLBI) of the National Institutes of Health (NIH) to redefine pulmonary hypertension through Pulmonary Vascular Disease Phenomics. (NHLBI U01). We are a participant in a NHLBI U01-funded Pediatric Pulmonary Hypertension Network Informatics (PPHNet) Registry on Data Fusion, to explore and compare electronic data capture options using a national pediatric pulmonary hypertension registry.
- **Tissue-and Mechanically-Engineered-Based Technologies** NewYork-Presbyterian surgeon-scientists are working to develop tissue-engineered-based and mechanically-engineered-based innovative technologies to offer personalized treatment modalities to children with congenital heart defects, applying the concepts of regenerative medicine and precision medicine to the field of pediatric cardiac surgery. The group is focusing on developing a heart valve having a growth potential to avoid multiple reoperations in children and developing electrically-active clinical-scale tissue-engineered cardiac constructs.
- **Reducing Pulmonary Vein Restenosis** NewYork-Presbyterian physician-scientists are working to overcome restenosis, the primary limitation of conventional angioplasty. Our researchers are investigating intervention with drug-eluting technologies to determine if this intervention will reduce pulmonary vein restenosis rates in children.
- **Role of Somatic Mutations in Congenital Heart Disease** Collaborations between the Department of Pediatric Cardiac Surgery, Pediatric Cardiology and Genetics enhanced the development of multidisciplinary multicentric projects of precision medicine adapted to the treatment of congenital heart disease. One of these collaborations, based on whole exome sequencing studies and using DNAs and RNAs extracted from cardiac tissues harvested in the operating room, aims to explore the role played by somatic mutations in the pathogenesis of congenital heart diseases.
- **Flow Dynamics, Biventricular Pacing & Hypercoagulability Research** Important clinical research projects also include Computer Modeling of flow dynamics after shunt operations; investigation of biventricular pacing for acute heart failure after cardiac surgery; and the use of TEG (thromboelastography) to evaluate hypercoagulability in single ventricle patients pre- and post-Fontan completion.

- **Quality Measures & Best Practices** We are active participants in a consortium of major children's hospitals charged with defining quality measures and best practices in pediatric cardiac surgery and in clinical studies led by the Congenital Heart Surgeon Society (CHSS)
- **Neurodevelopmental Outcomes** A new NIH-supported study evaluates the in utero effects of congenital heart disease on neurodevelopmental outcomes in childhood.
- **Cardiac Catheterization Initiatives** NewYork-Presbyterian interventional cardiologists participate in multi-center quality improvement initiatives, new device trials, and development of risk adjustment methods for congenital cardiac catheterization procedures.
- **Genetic Cardiac Diseases** Our researchers are using human pluripotent stem cell and rodent models to investigate the molecular and cellular mechanisms underlying genetic cardiac diseases like cardiomyopathy.
- **Cost, Outcomes, Value for Children With CHD** Other NewYork-Presbyterian physician researchers are focused on the integration of national datasets and the application of transdisciplinary methodology to the study of cost, outcomes, and value for children with congenital heart disease. In recent work, we have examined the effects of surgeon age and experience on patient outcomes and the effects of neighborhood disparities on both outcomes and resource utilization.
- **Zebrafish Studies—Molecular & Cellular Etiologies of CHDs** Other active projects in our laboratories include investigation of developmental genetics of the zebrafish embryo to address fundamental questions about the molecular and cellular etiologies of congenital heart defects (CHDs). By using the zebrafish model, we have discovered a prominent role of nkx genes in maintaining ventricular identity. We have also made substantial progress in describing the roles of nkx genes in the developing cardiac conduction system and in identifying key downstream effectors in the nkx pathway. Our physician-scientists translate insights back to fetal, neonatal, and pediatric patients with CHDs for risk stratification and improvement of prognosis and also to adult patients in need of ventricular cardiomyocyte regeneration.
- **Drug Study for Prevention of Shunt Thrombosis** A Phase I PK/PD study involving an anti-platelet agent for the prevention of shunt thrombosis in post-operative neonates with single ventricle physiology is underway.



Outcomes 2013-2016



From left: Dr. Chai, Dr. Kalfa, Dr. Bacha, and Dr. LaPar

While we treat some of the most complex cases, our survival rates surpass the national average, with children routinely returning to normal levels of activity and living into adulthood. The observed mortality is lower than expected, given the disease burden of our patients.

Our pediatric surgeons perform more than 750 surgeries for congenital heart disease every year and offer the best possible surgical outcomes. Our participation in the Society of Thoracic Surgeons (STS) congenital heart surgery database allows us to compare our performance with other pediatric and adult congenital heart surgery programs throughout the country.

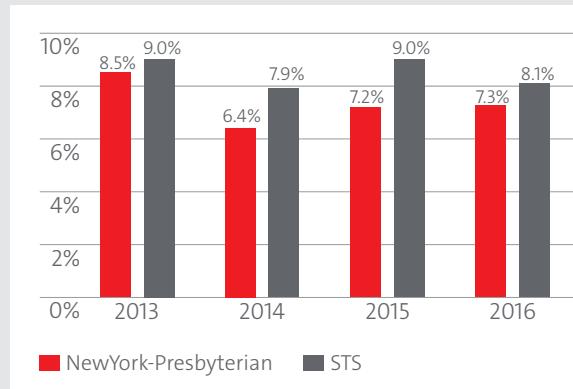
Neonatal Cardiac Surgery Age < 30 days

Early repair of congenital heart defects in neonates can minimize the need for future surgeries. For decades, our comprehensive Neonatal Cardiac Surgery program has been performing neonatal repairs of congenital defects – such as transposition of the great arteries, coarctation of the aorta, tricus arteriosus, and hypoplastic left heart syndrome – with outstanding results. Columbia-Presbyterian surgeons James R. Malm and Frederick O. Bowman Jr. pioneered many of the early cardiac repair techniques used today, including Tetralogy of Fallot repair and the use of the heart-lung machine in children.

Our mortality rate for neonates is among the lowest in the nation **7.4%**

Neonatal Cardiac Surgery Mortality

NewYork-Presbyterian 2013 -2016



The most recent STS report cites an overall neonatal mortality of 7.4% for NewYork-Presbyterian. STS predicted mortality was 8.1% based on the complexity of our cases.

Volume: 200 Annual Admissions

The Tri-State area's largest referral center for babies born with congenital heart disease, we admit approximately 200 babies every year. Not all of these infants require surgery.

Complexity-Adjusted Performance Measurement

Mortality is the most common performance metric used in following outcomes of congenital heart surgery. However, many variables can affect patient care outcomes.

To compare performance of congenital heart surgery centers, the Society of Thoracic Surgeons (STS) assigned scores for each surgical procedure based on the potential for mortality, the potential for morbidity, and surgical difficulty – from a risk of 1 to 5, with 5 the most difficult.

Performance Excellence	NewYork-Presbyterian Mortality	STS Benchmark
Overall	7.4%	8.6%
Difficulty 1	0%	1.7%
Difficulty 2	5.7%	3.4%
Difficulty 3	3.1%	3.2%
Difficulty 4	8.5%	8.8%
Difficulty 5	11.9%	17.0 %

Neonatal Cardiac Surgery Age < 30 days

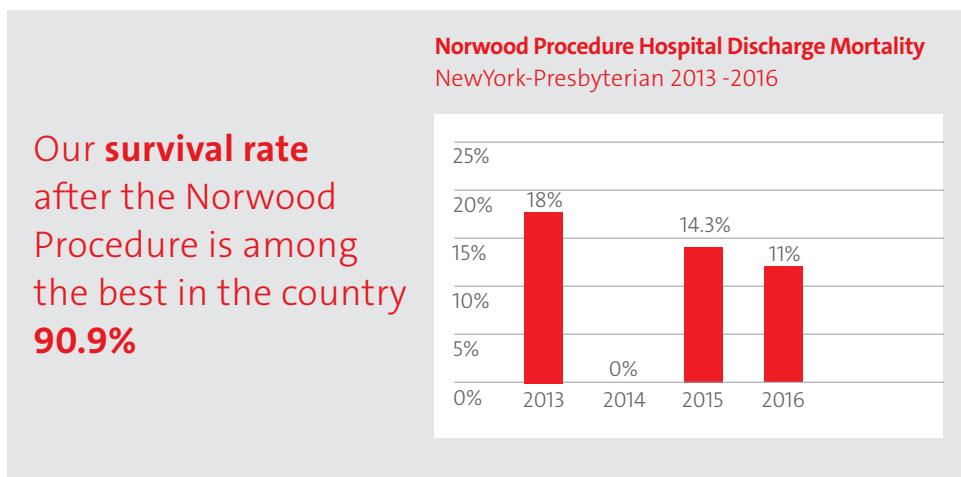
Norwood Procedure

Infants with Hypoplastic Left Heart Syndrome (HLHS) have an incompletely formed left ventricle. Since the early 1980s, a three-step serial procedure designed to create normal blood flow in and out of the heart has extended the life of infants born with HLHS. The Norwood procedure, the first of the three procedures, has the highest risk-adjusted mortality rate among all neonatal and pediatric heart surgeries.

We have decades of experience with the Norwood procedure and stage palliation for HLHS, having performed it since 1985. Our outcomes for this type of repair rank among the best in the country. We are currently involved in a major multi-institutional study evaluating this and other innovative procedures for the treatment of HLHS.

Survival following the Norwood procedure continues to be a challenge. On average, about 80% survive. Hospital mortality after the Norwood procedure is more than 14% in the Society of Thoracic Surgeons (STS) database for 2013-2016.

The Congenital Heart Center mortality rate following the Norwood Procedure has declined substantially since 2005, with survival now more than 90%. Notably, there was no mortality in 2014 for infants undergoing the first stage operation.



Total Norwood Procedure Volume = 67
2013-2016

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

9.1%

14.7%

Arterial Switch Operation (ASO)

The arterial switch operation corrects transposition of the great arteries, a condition in which anatomical positions of the pulmonary artery and the aorta are switched, so that the aorta rises from the right ventricle and the pulmonary artery arises from the left ventricle. This anomaly causes oxygen-poor blood, a life-threatening medical emergency requiring immediate treatment.

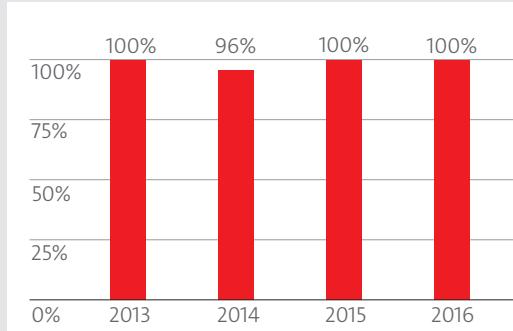
In the 1980s and 1990s, NewYork-Presbyterian's Dr. Jan Quaegebeur, one of the nation's top pediatric heart surgeons, pioneered this innovative procedure which re-establishes normal anatomy and function, while seeking to avoid complications associated with other surgical approaches. We have performed more than 460 arterial switch procedures since 1990 and our surgeons have been at the forefront of a series of evolutionary operations.

As a quaternary, or subspecialty referral center, a large proportion of the babies transferred to us either pre- or post-natally have complex transposition forms, involving transposition of the great arteries and either a Ventricular Septal Defect (VSD) or aortic arch problems such as aortic coarctation or Taussig-Bing anomaly. We also see an unusually large proportion of low birthweight babies with transposition.



Survival Following Arterial Switch Operation

Our survival rates following the Arterial Switch Operation set **world-class standards** – most notably, in 2013, 2015 and 2016 **100%**



**Total Arterial Switch Operation Volume = 81
2013-2016**

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

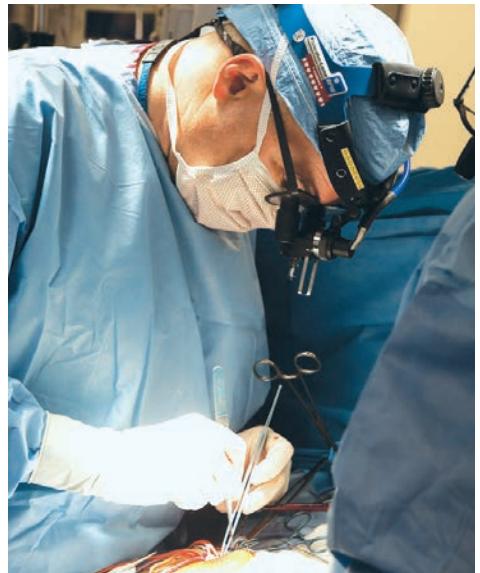
1.2%

4.0%

Tetralogy of Fallot

Tetralogy of Fallot is marked by a hole between the right and left ventricles (VSD) in conjunction with an obstruction between the right ventricle and the pulmonary artery (pulmonary stenosis).

As a result of these two abnormalities, unoxygenated blood can bypass the lungs, enter the aorta and produce cyanosis. Most children with this defect have open heart surgery to close the ventricular septal defect and remove the obstructing muscle. The procedure is individualized for each child, depending on age, anatomy and clinical symptoms.*



**Total Tetralogy of Fallot Volume = 152
2013-2016**

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

0.65%

1.8%

*We also actively attempt preservation of the pulmonary valve in all participants, resulting in a very low ratio of chronic pulmonary regurgitation.

Atrial Septal Defect Repair (ASD)

ASD is characterized by a hole between the atria (upper chambers of the heart). The majority of straightforward ASDs are closed percutaneously in the cath lab, without the need for surgery. Our interventional cardiologists are particularly adept at this procedure. However, a minority of patients will still require surgery. Typically, these patients have larger holes, or the position of the hole in the heart makes it difficult to close with a device.

When a child requires surgery for an ASD, we always will perform minimally-invasive surgery. Specialized instruments allow us to close these defects through tiny incisions. While cardiopulmonary bypass is still needed, it is more simplified than what we typically use in the repair of more serious defects. In most cases, patients do not require blood transfusions.



Total Atrial Septal Defect Repair Volume = 196
2013-2016

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

0%

0.29%

Ventricular Septal Defect Repair (VSD)

Unlike ASDs, most VSDs still require surgical repair. At the NYP Congenital Heart Center, our pediatric cardiac surgeons provide minimally invasive cardiac surgery and hybrid surgery for the treatment of ventricular septal defects, with the goal of small incisions and transfusion-free surgery.



Close to **100% of babies**
survive Ventricular
Septal Defect Repair,
even in premature and
very low birthweight
babies

Total Ventricular Septal Defect Repair Volume = 178
2013-2016

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

0.6%

0.6%

Atrioventricular Canal Defect (AV Canal)

AV Canal defects are complicated lesions where the center of the septum (the wall that separates the left and right heart) is missing. The mitral and tricuspid valves are fused in this malformation and extremely abnormal. AV Canal defect surgery requires highly specialized and technical expertise. As with other complex cardiac defects, the more often you do them, the better your results are.



Total Atrioventricular Canal Defect Volume = 100
2013-2016

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

3.0%* **2.0%**

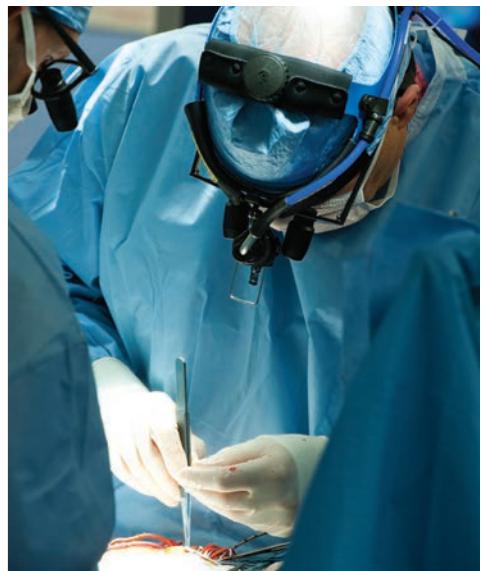
*This number is higher because of a high proportion of premature infants that needed the operation.

Aortic Valve/Ross Procedure (Pulmonary Autograft)

When the aortic valve is so abnormal that it cannot be effectively repaired, a valve replacement operation may be recommended. Our surgeons perform a technically demanding surgery called the Ross procedure, in which the patient's own normal pulmonary valve is used to replace the damaged aortic valve. The pulmonary valve itself is then replaced with a homograft (human tissue) valve. The homograft valve can be large enough to allow for growth and because it is not subjected to high pressure, it can last much longer in the position of the low pressure pulmonary valve. However, it is likely that it will eventually need to be replaced.

Once the homograft valve deteriorates (which takes years), it can often be dilated in the cath lab. And today, our interventional cardiologists can implant a new valve percutaneously into the homograft, avoiding another surgery.

The Ross operation is more complicated than aortic valve replacement with a tissue valve or mechanical valve. However, data have consistently shown excellent durability and long-term function of the pulmonary valve in the aortic position. Studies point to a 10-15% incidence of reoperation for pulmonary homograft degeneration over 10-15 years and a smaller incidence of reoperation on the new aortic valve.



Total Aortic Valve/Ross Procedure Volume = 43
2013-2016

NewYork-Presbyterian STS National Benchmark

Overall Hospital Discharge Mortality Rate

Ross & Ross-Konno

0%

Ross & Ross-Konno

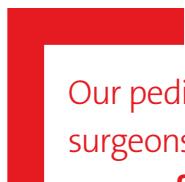
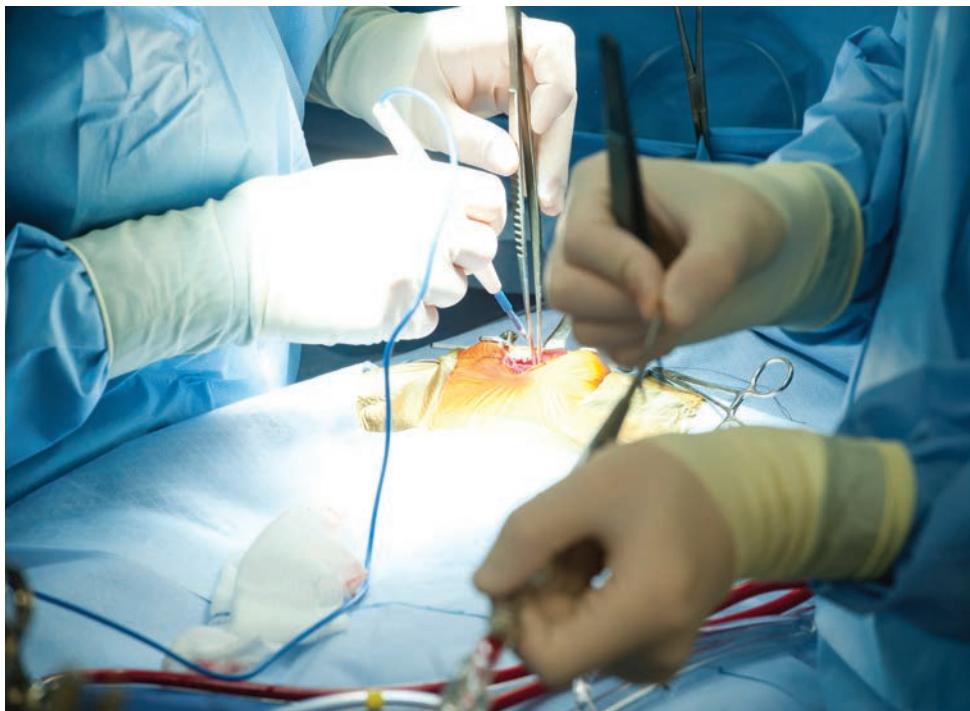
2.7%

Valve Repair

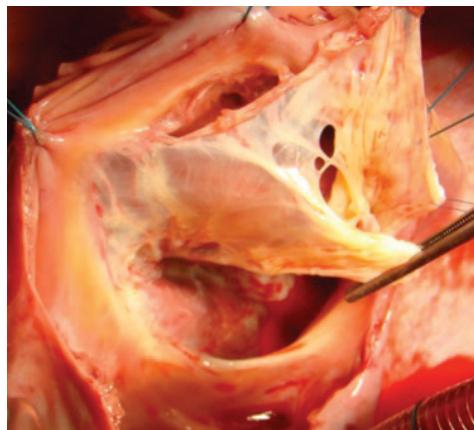
A valve repair is more complicated surgery than a valve replace, but the advantage is that patients retain their own valve. And in young patients, the repaired valve grows with the child as he or she gets older.

Pediatric and congenital heart surgeons at NewYork-Presbyterian Hospital have published extensively on pediatric heart valve surgery and have pioneered many of the valvuloplasty techniques used today to repair conditions such as:

- Ebstein's anomaly
- aortic valve disease
- congenital mitral valve disease



Our pediatric heart surgeons have **pioneered many of the innovative surgical techniques** used today to treat heart valve disease in children



Cone repair for Ebstein's malformation

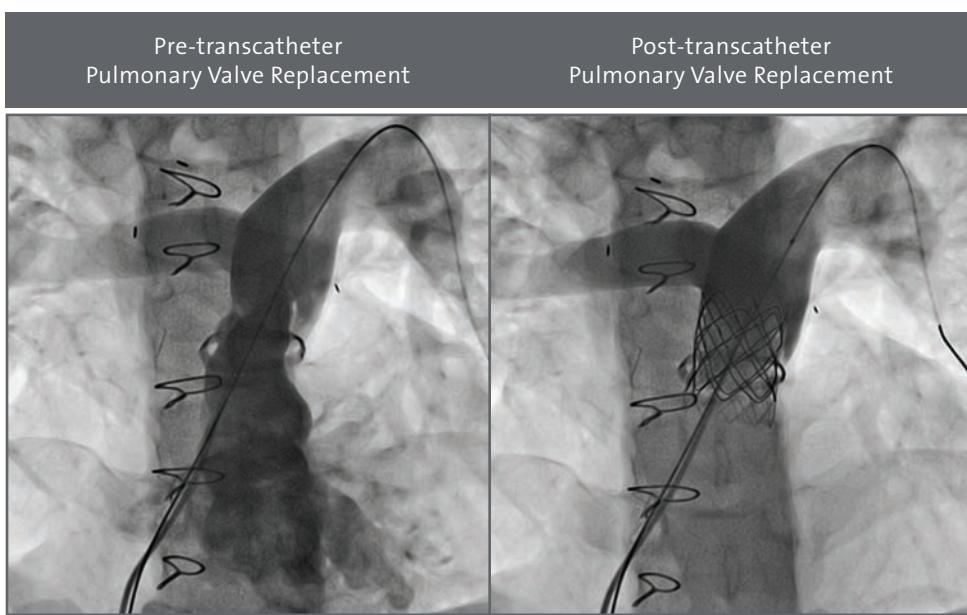
Transcatheter Pulmonary Valve Replacement

In 2007, interventional cardiologists at NewYork-Presbyterian Morgan Stanley Children's Hospital performed the first catheterization-based pulmonary valve replacement in the state of New York, as part of the first FDA trial in the United States involving transcatheter valve placement for congenital heart disease (CHD). Until that time, replacing a faulty pulmonary valve could be done only with open-heart surgery.

This transcatheter valve procedure has evolved into a viable alternative to surgical valve replacement, allowing us to replace the patient's pulmonary valve by passing the device (valve with stent frame) within a small-diameter tube (called a sheath), through a vein in the leg, and up into the heart. The goal of this procedure is to replace the pulmonary valve non-surgically, and decrease the number of open-heart surgeries a patient with congenital heart disease may need over a lifetime.

Over the last decade, our interventional cardiologists have performed more than 140 of these procedures in children and adults with CHD. NewYork-Presbyterian is the primary referral hospital for transcatheter pulmonary valve replacement in the greater New York City area, with procedures being performed on both the Columbia and Weill Cornell campuses. New York-Presbyterian Hospital and its interventional cardiology team are internationally recognized for their expertise and as a center of excellence for this procedure.

We have the largest
transcatheter valve program
for congenital heart disease
in New York State



**Total Transcatheter Pulmonary Valve Replacement Volume = 48
2013-2016**

Our interventional cardiologists currently perform more than 20 transcatheter pulmonary valve replacements each year.

Pediatric Transplant & Mechanical Assist Devices

Having performed more than 500 pediatric heart transplants since 1984, we are one of the largest pediatric heart transplant programs in the United States, ranking in the nation's top five centers for pediatric heart transplant for the last decade. We perform more than 25 pediatric and adult congenital heart transplants each year – typically more than any other hospital in the country – many on children who could not be helped at other institutions.



In 1984, surgeons at NewYork-Presbyterian Morgan Stanley Children's Hospital performed the **world's first successful pediatric heart transplant**

Adult Congenital Heart Surgery

As more patients survive open heart repairs as children, they often require additional procedures such as valve surgeries or Fontan conversions in adulthood. In fact, it is expected that by the year 2020, more adults than children will need open heart procedures to correct congenital heart defects.

Under the direction of Marlon S. Rosenbaum, MD at NewYork-Presbyterian's Schneeweiss Adult Congenital Heart Center and Harsimran Singh, MD at the Cornell Center for Adult Congenital Heart Disease at Weill Cornell Medicine, we offer personalized, lifelong care for adult patients with congenital heart disease.

NewYork-Presbyterian provides a full range of inpatient and outpatient clinical services and diagnostics including cardiac catheterization and surgical repair, with particular expertise in minimally invasive treatment strategies and hybrid procedures. Our world-renowned surgeons perform sometimes lengthy and complex adult surgeries. Interventional cardiologists offer non-surgical and minimally invasive solutions for repair of congenital cardiac defects. Patients are cared for by a team with specialized expertise in adult congenital heart disease including clinical consultants in adult & pediatric cardiology, heart failure, pulmonary hypertension, high-risk obstetrics, neurology, and pulmonary medicine. Specialists in congenital electrophysiology with state-of-the-art arrhythmia mapping systems offer potential curative therapies for life-threatening arrhythmias.



Meet Our Team

Surgeons



Emile A. Bacha, MD

Chief, Cardiac, Thoracic and Vascular Surgery
NewYork-Presbyterian/Columbia University Medical Center
Director, Congenital and Pediatric Cardiac Surgery
NewYork-Presbyterian
Co-Director
NewYork-Presbyterian Congenital Heart Center
Calvin F. Barber Professor of Surgery
Vagelos College of Physicians and Surgeons
Columbia University
Adjunct Professor of Surgery
Weill Cornell Medicine



David Kalfa, MD, PhD

Assistant Professor of Surgery
Vagelos College of Physicians and Surgeons
Columbia University
Adjunct Assistant Professor of Surgery
Weill Cornell Medicine



Paul J. Chai, MD

Director, Pediatric Heart Transplantation and Mechanical Assist Device Services
NewYork-Presbyterian Morgan Stanley Children's Hospital
Site Director, Pediatric and Congenital Cardiac Surgery
NewYork-Presbyterian Komansky Children's Hospital
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Columbia University
Adjunct Associate Professor of Surgery
Weill Cornell Medicine



Damien J. LaPar, MD, MSc

Assistant Professor of Surgery
Vagelos College of Physicians and Surgeons
Columbia University
Adjunct Assistant Professor of Clinical Cardiothoracic Surgery
Weill Cornell Medicine

Meet Our Team

Cardiologists



Julie A. Vincent, MD, FACC, FSCAI, FAAP

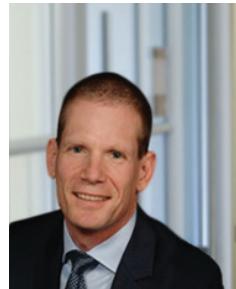
Alexandra and Steven Cohen Chief of Pediatric Cardiology
NewYork-Presbyterian/Columbia University Medical Center

Samberg Scholar in Children's Health
NewYork-Presbyterian Morgan Stanley Children's Hospital

Co-Director
NewYork-Presbyterian Congenital Heart Center

Welton M. Gersony Professor of Pediatric Cardiology
Vagelos College of Physicians and Surgeons
Columbia University

Adjunct Professor of Pediatrics
Weill Cornell Medicine



Ralf J. Holzer, MD, MSc, FACC, FSCAI

Chief, Pediatric Cardiology
NewYork-Presbyterian/Weill Cornell Medical Center
Director, Pediatric Cardiac Catheterization
NewYork-Presbyterian Komansky Children's Hospital

Co-Director
NewYork-Presbyterian Congenital Heart Center
David Wallace-Star Professor of Pediatric Cardiology
Weill Cornell Medicine



Marlon S. Rosenbaum, MD

Director, Schneeweiss Adult Congenital Heart Center
NewYork-Presbyterian/Columbia University Medical Center

Associate Clinical Professor of Medicine and Pediatrics
Vagelos College of Physicians and Surgeons
Columbia University



Harsimran Sachdeva Singh, MD , MSc

Director, Adult Congenital Heart Disease Interventional Cardiology
NewYork-Presbyterian Hospital
David S. Blumenthal Assistant Professor of Medicine
Assistant Professor of Medicine in Pediatrics
Weill Cornell Medicine



Erika S. Berman Rosenzweig, MD

Associate Chief, Pediatric Cardiology
Director, Pediatric Pulmonary Hypertension Center
NewYork-Presbyterian Morgan Stanley Children's Hospital

Associate Professor of Pediatrics (in Medicine)
Vagelos College of Physicians and Surgeons
Columbia University

Cardiac Neonatal-Perinatal Medicine



Ganga Krishnamurthy, MBBS, DCH

Director, Neonatal Cardiac Intensive Care
NewYork-Presbyterian Morgan Stanley
Children's Hospital

*Garrett Isaac Neubauer Assistant
Professor of Pediatrics*
Vagelos College of Physicians and Surgeons
Columbia University

Cardiac Intensive Care



Arthur J. Smerling, MD

*Medical Director Pediatric Cardiac ICU and
Respiratory Therapy*

NewYork-Presbyterian Morgan Stanley
Children's Hospital

*Associate Professor of Pediatrics and
Anesthesiology*
Vagelos College of Physicians and Surgeons
Columbia University

Perioperative Cardiac Services



Eva Cheung, MD

Director, Perioperative Cardiac Services
NewYork-Presbyterian Morgan Stanley Children's
Hospital

Assistant Professor of Pediatrics
Vagelos College of Physicians and Surgeons
Columbia University

Fetal Cardiology



Stéphanie Levasseur, MD

Director, Fetal Cardiology
NewYork-Presbyterian Morgan Stanley
Children's Hospital

Assistant Professor of Pediatrics
Vagelos College of Physicians and Surgeons
Columbia University



Sheila J. Carroll, MD

Director, Fetal Cardiology
NewYork-Presbyterian Komansky
Children's Hospital

Associate Professor of Pediatrics
Weill Cornell Medicine



NewYork-Presbyterian Morgan Stanley Children's Hospital and
NewYork-Presbyterian Komansky Children's Hospital
have built a national reputation for outstanding care devoted to children.



NewYork-Presbyterian KIDS

Locations

Morgan Stanley Children's Hospital at
NewYork-Presbyterian/Columbia University
Medical Center
3959 Broadway
New York, NY 10032

Pediatric Cardiac Surgery **212-305-2688**
Pediatric Cardiology **212-305-4622**

Komansky Children's Hospital at
NewYork-Presbyterian/Weill Cornell Medical Center
525 East 68th Street
New York, NY 10065

Pediatric Cardiac Surgery & Cardiology **212-746-3561**

Physician-to-Physician Transfer: **1-800-NYP-STAT (1-800-697-7828)**
For more information visit: nyp.org/pediatrics

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