

# 2021 CARDIAC OUTCOMES REPORT

Inova L.J. Murphy Children's Hospital



## CONTENTS

- |           |  |           |   |
|-----------|--|-----------|---|
| <b>1</b>  | A Message from Our Hospital Service Line Leaders       | <b>19</b> | Aortopathy Program                      |
| <b>2</b>  | Moving Inova Children's Heart Center to the Next Level | <b>20</b> | Single Ventricle Interstage Program     |
| <b>4</b>  | Cardiac Surgery  | <b>21</b> | Neurodevelopmental Care                 |
| <b>6</b>  | Interventional Cardiology                              | <b>22</b> | Pediatric Cardiac Anesthesia            |
| <b>8</b>  | Electrophysiology                                      | <b>23</b> | Nursing                                 |
| <b>10</b> | Adult Congenital Heart Disease                         | <b>24</b> | Child Life                              |
| <b>11</b> | Fetal Cardiology                                       | <b>25</b> | International Care                      |
| <b>13</b> | Noninvasive Cardiology                                 | <b>26</b> | Cardiac Parent Advisory Council         |
| <b>14</b> | Exercise Stress Lab                                    | <b>27</b> | Research                                |
| <b>15</b> | Ambulatory Cardiology                                  | <b>28</b> | Publications                            |
| <b>16</b> | Advanced Multimodal Imaging                            | <b>29</b> | Meet Our Team                           |
| <b>17</b> | Quality Initiatives Program                            | <b>31</b> | Giving to Inova Children's Heart Center |
| <b>18</b> | Intensive Care   | <b>32</b> | Inova in the Community                  |



## A MESSAGE FROM OUR HOSPITAL SERVICE LINE LEADERS

Dear Colleagues:

Although 2020 brought us many challenges, we experienced joy as recipients of a surprising and transformational gift to Inova Children's from a beloved community pediatrician and member of our medical staff, Laurence J. Murphy, MD. In recognition of Dr. Murphy's generous gift, Inova Children's has renamed the children's hospital building to **Inova L.J. Murphy Children's Hospital**.

From the new Inova L.J. Murphy Children's Hospital, we are pleased to share our 2021 Inova Children's Heart Center outcomes report with the community. These outcomes are the result of the combined efforts of our team members, who have come together with a single purpose in mind: caring for children with complex heart conditions.

This report focuses on data reported through 2020; however, we must acknowledge that 2020 brought on unique challenges to not only Inova Children's Heart Center, but to the entire health system, community and nation.

While it seemed COVID-19 put a pause on many aspects of our daily lives – school, travel, even trips to the grocery store – we know that congenital heart disease doesn't stop for COVID-19. Over the course of the year, our teams continued to focus on providing world-class healthcare, every time, every touch, to children and adults with congenital heart disease. In addition to caring for patients with complex cardiac disease, Inova Children's Heart Center's leaders stepped up in the face of the pandemic.

At Inova Fairfax Hospital, the pediatric and adult extracorporeal membrane oxygenation (ECMO) programs supported children and adults with COVID-19 and multisystem inflammatory syndrome in children (MIS-C) in need of mechanical circulatory support. The program contributed to the development of guidelines for the utilization of ECMO in COVID-19 patients and was seen as a national leader in the field. In caring for children with COVID-19 and MIS-C, our pediatric cardiologists have developed clinical guidelines and research pathways to support the ongoing care of children and to understand the long-term effects of the disease on a child's heart.

Our team members stepped outside their comfort zones in 2020. During the peak of the pandemic, physicians, nurses and other allied health professionals expanded their scope to meet the patient care needs of the community. Inova L.J. Murphy Children's Hospital began to care for adults, and providers also supported adult populations within the COVID-19-dedicated units across Inova Fairfax Medical Campus. Team members supported the pandemic efforts in every imaginable way, from stepping up as respiratory therapy extenders, to staffing COVID-19 testing sites, to simply decorating windows in support of our staff. No matter the request, the teams stepped up without hesitation.

As a leadership team, we are proud to share with you the outcomes associated with care that Inova Children's Heart Center provides to children with congenital heart disease. Beyond these outcomes, we are amazed with the way this team supported so many patient care populations, and each other, throughout 2020.



**Steven Narang, MD, MHCM**  
*Interim President  
Inova Pediatric Service Line*



**Joanna Fazio**  
*Vice President & Administrator  
Inova Pediatric Service Line*



**Ashley Virts, RN, MSN-FNP**  
*Vice President, Nursing  
Inova Pediatric Service Line*

## MOVING INOVA CHILDREN'S HEART CENTER TO THE NEXT LEVEL

Every year, our pediatric heart surgeons perform more than 200 cardiac surgeries, and our interventional cardiologists and electrophysiologists perform procedures on more than 600 patients. In addition, our multidisciplinary team of experienced cardiologists, surgeons, intensivists, anesthesiologists, nurse practitioners and nurses provide care to patients – from fragile newborns facing complex, challenging health problems, to adults with complex congenital heart disease.

Our 2021 outcomes report reflects these efforts. It demonstrates the many ways we provide consistently high performance in outcomes, access, value and experience for children with cardiac disease and their families.



### 2020 Highlights

- Continued **increase** in **cardiac surgical procedures** and **fetal referrals** throughout Virginia and Maryland
- Continued **growth** of the **adult congenital heart disease (ACHD) program** in partnership with Inova Heart and Vascular Institute
- Ongoing **growth** in the **pediatric electrophysiology (EP) program** and our ACHD EP program
- Continued **growth** of our **aortopathy program** bridging pediatric and adult cardiac specialties
- Creation of a **dedicated inpatient echocardiography reading team** with continued quality improvement projects
- Expansion of our **inherited arrhythmia clinic** with dedicated genetics counselors and state-of-the-art clinical and research genomics
- **Participation** in **national research studies** and registries across the spectrum of cardiac care
- Participation in national **COVID-19-related research** trials
- **Collaboration with primary care specialists** in Virginia regarding sports participation for children after COVID-19
- **Caring for children with MIS-C** with advanced immunomodulators, monoclonal antibodies, antivirals and ECMO support if needed



Inova L.J. Murphy Children’s Hospital was front and center in the fight against the COVID-19 pandemic. The presentation of children with MIS-C brought together specialists in cardiology, infectious disease, critical care, emergency medicine and primary care to care for these children. Our proximity to the National Institutes of Health and the U.S. Food and Drug Administration facilitated our ability to be involved in research trials and be up to date on the latest treatment strategies as we learned about the potential acute and late myocardial manifestations of this disease.

Our goal is to achieve the best possible outcome for every patient and provide long-term support for every family. Thank you for helping us advance exceptional heart care in our community and provide groundbreaking, lifesaving services to children throughout our region.



**Mitchell Cohen, MD, FACC, FHRS**  
*Chief, Pediatric Cardiology*  
*Co-Director of Inova Children’s Heart Center*

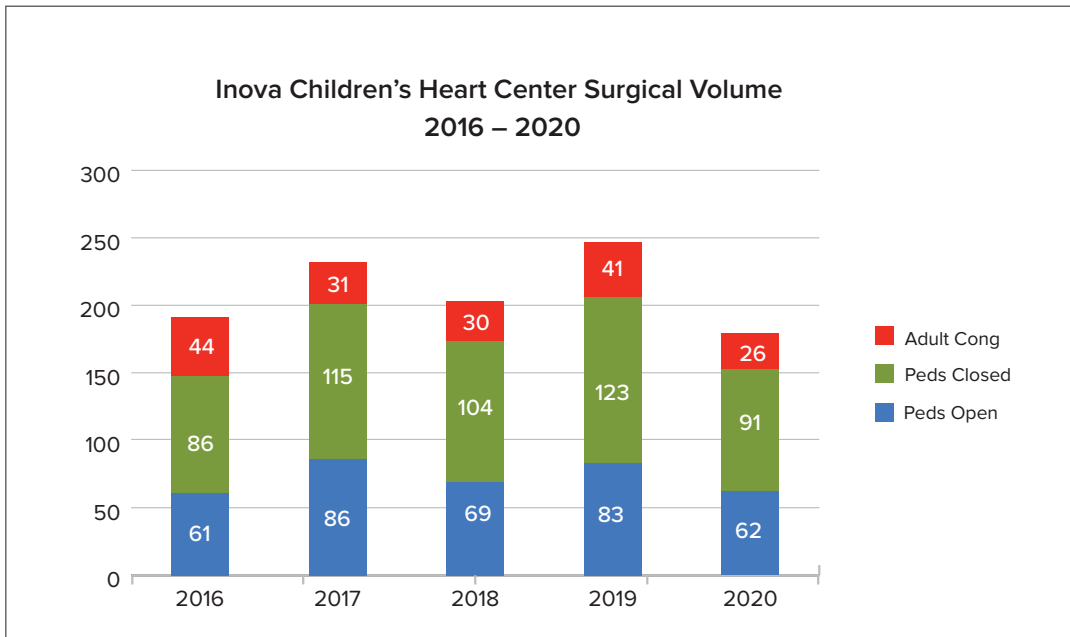
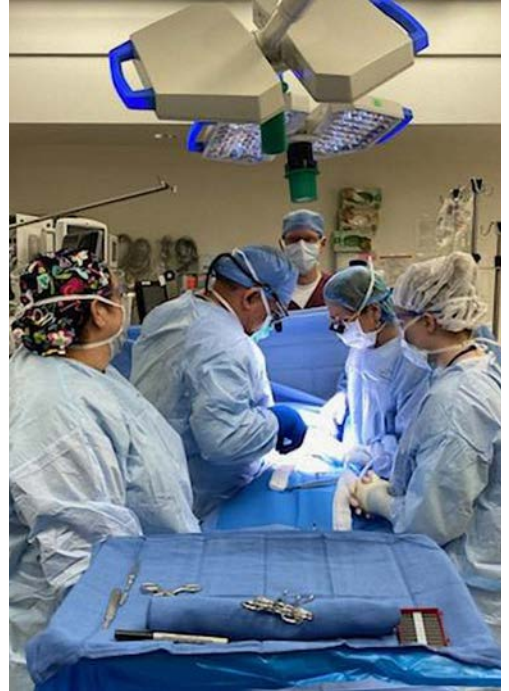


**Lucas Collazo, MD**  
*Chief, Pediatric Cardiac Surgery*  
*Co-Director of Inova Children’s Heart Center*

# CARDIAC SURGERY

Our cardiac surgery program provides patients with a continuum of care that spans a lifetime. We perform a wide spectrum of surgeries for congenital heart defects in neonates, infants, children, teenagers and adults. Our goal is to deliver innovative surgical care in a compassionate, family-centric environment.

- Our surgical team includes: two full-time pediatric cardiac surgeons experienced in all aspects of pediatric and congenital cardiac surgery, dedicated physician assistants, surgical nurse practitioner navigators, and dedicated operating room (OR) staff including nurse first assistants, nurse anesthetists, perfusionists and OR nurses.
- Following surgery, cardiac-focused intensivists and nurse practitioners care for patients in the pediatric cardiovascular intensive care unit (PCICU).
- As patients move toward discharge, the surgical team; cardiologists; case managers; occupational, speech and physical therapists; child life specialists; and dietitians coordinate and guide care.



### Complete Case Mix: 2018 – 2020

Peds Case Mix	2018	2019	2020
Case Type	Volume	Volume	Volume
ASD	3	10	3
VSD	17	8	10
TOF	6	6	6
ASO	1	5	2
AVC (complete, partial)	8	6	6
PAPVR	4	3	0
TAPVR	2	3	2
COA (nonpump)	8	5	8
COA/hypoarch	2	9	5
Glenn/Fontan	5	5	8
Systemic pulmonary shunt	1	4	3
Pacer/ICD	12	13	12
PVR/conduit/RVOT procedure	15	15	6
AVR/supra-sub AS	3	3	0
MV repair/replacement	5	3	4
Tricuspid valve	0	0	1
ECMO cannulation	8	14	6
ECMO procedure	7	13	11
PDA	12	5	7
Norwood/STAT 5	0	1	1
Thoracic procedure	14	7	3
Anomalous coronary surgery	0	3	4
Other STAT categories	7	6	8
Other cardiac nonpump	33	59	37
<b>Total</b>	<b>173</b>	<b>206</b>	<b>153</b>

### Neonatal (<30 days) Case Load: 2018 – 2020

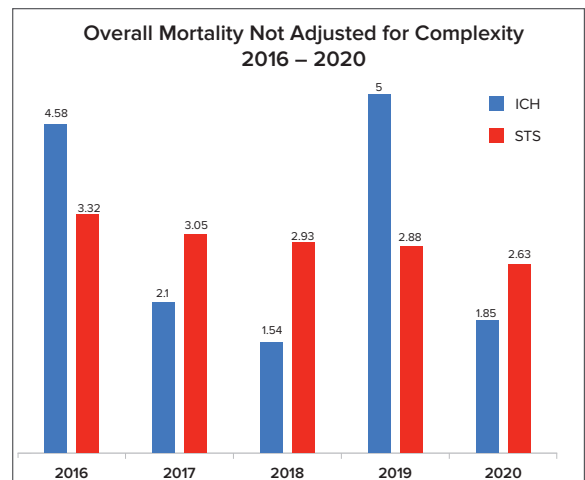
Neonatal Patients	2018	2019	2020
Complex cardiac repair	15	35	22
PDA ligation – premature infant	12	4	5
<b>Total</b>	<b>27</b>	<b>39</b>	<b>27</b>

### ACHD (>18 years) Case Load: 2018 – 2020

Adult Congenital Case Mix	2018	2019	2020
Case Type	Volume	Volume	Volume
ASD	3	3	3
AVR/ASAA/sub AS	6	7	4
MVR	2	1	2
PVR	3	3	4
PAPVR	1	4	3
VSD	2	0	0
AVC-partial/transitional	0	2	0
Anomalous coronary surgery	3	6	4
Other	10	15	6
<b>Total</b>	<b>30</b>	<b>41</b>	<b>26</b>

We participate in the Society of Thoracic Surgeons’ congenital heart surgery national database (STS) to ensure the highest quality care with results comparable to the country’s leading pediatric heart centers. The ability to benchmark our performance is a powerful tool that drives our improvement efforts. In addition, we believe that transparency with families and healthcare providers is critical. For this reason, we publicly report our outcomes.

### Mortality data comparison to other congenital cardiac programs participating in the STS’s national database.



## INTERVENTIONAL CARDIOLOGY

Our program offers a wide array of diagnostic and interventional procedures in dedicated pediatric cardiac catheterization labs. We use catheters, balloons and coils – designed uniquely for children and infants – to open, dilate or close blood vessels and heart valves. In 2019, our interventional team performed the first-ever patent ductus arteriosus (PDA) closure of a micropreemie (800 grams) using the new Amplatzer Piccolo™ device in our region.

Minimally invasive procedures include:

- Closing a PDA
- Closing an atrial or ventricular septal defect
- Dilating an aortic or pulmonary valve
- Dilating a coarctation of the aorta
- Replacing a transcatheter pulmonary valve (Melody and Edwards valves)
- Coiling abnormal vessels in the heart or lungs
- Performing a balloon atrial septostomy
- Conducting diagnostic cardiac catheterization
- Performing hybrid therapies

To ensure we provide high-quality care and outcomes, we participate in the IMPACT database. In addition, we have installed state-of-the-art Phillips imaging equipment, which delivers the clearest pictures with the lowest radiation possible.



## Cardiac Catheterizations in Children in the First Year of Life: 2019 – 2020

	2019		2020	
	< 1 month	1 to 12 months	< 1 month	1 to 12 months
Diagnostic	9	16	4	15
PDA closure	4	8		3
PS balloon	5		3	
Recoarctation balloon		4		10
Coartation balloon + PTA innominate vein				1
Coartation balloon + coil RIMA				1
Coartation balloon + coil collaterals + balloon LPA				1
AS balloon		1	1	
Coil collaterals		1		1
Coil coronary fistula				1
Coil collaterals + balloon subclavian art		1		
Balloon PS + LPA + RPA		1		
Balloon/stent LPA + RPA		1		
Balloon/stent pulmonary vein				1
Perf & balloon PS + stent DA			1	
Balloon LPA + RPA	1			
Balloon RPA + supra-valv PA		1		
Balloon PS + LPA			1	
Balloon RPA				2
Balloon central shunt		1		

## Cardiac Catheterization Procedures: 2020

Age	Diagnostic	Interventional	Total
< 1 year	27	16	43
1 – 18 years	24	33	57
≥ 18 years	45	111	156
<b>Total</b>	<b>96</b>	<b>160</b>	<b>256</b>

## ELECTROPHYSIOLOGY

Our EP program offers a full complement of diagnostic and treatment options for children with known or suspected heart rhythm problems. As the largest outpatient program in Northern Virginia, we perform more than 15,000 electrocardiograms and administer 1,000 ambulatory monitors annually.

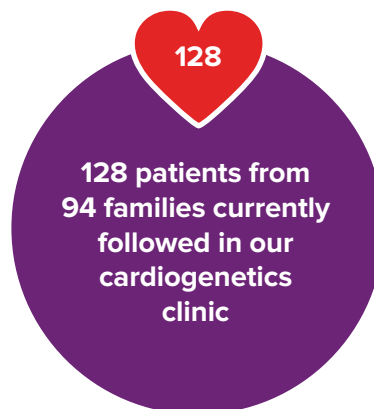
Comprehensive services include:

- **Cardiac implantable electronic devices.** We monitor patients with pacemakers and defibrillators via in-office checks and convenient home-based monitoring. We use the latest Bluetooth technology to follow children with implantable loop recorders. Our cardiac implantable device program now follows more than 150 children through remote technology, which has been crucial during the current pandemic.
- **Inherited arrhythmia clinic.** Our inherited arrhythmia clinic, now entering its third year, bridges the adult and pediatric arms of cardiogenetics at Inova. With a multidisciplinary team of adult and pediatric cardiologists and genetic counselors, we are able to evaluate, manage and follow children, parents, siblings and extended family members with inherited life-threatening and rare arrhythmias, as well as cardiomyopathies. In 2019, we evaluated 47 patients with either a suspected channelopathy or nonsyndromic cardiomyopathy. With state-of-the-art whole genome and targeted sequencing, we achieved a yield of 78 percent with a pathogenic mutation. By identifying this mutation, we were able to screen more than 50 additional first-degree relatives within the virtually linked pediatric and adult cardiogenetics comprehensive clinic. We also followed identified a rare severe form of long QT syndrome characterized in a child with bilateral sensorineural hearing loss, profound QT prolongation and homozygous recessive KCNQ1.



### New Evaluations at the Inherited Arrhythmia Clinic

	2019	2020
Long QT syndrome	28	6
Hypertrophic cardiomyopathy	6	1
CPVT	1	-
LLRC	1	-
Brugada	1	-
Gene negative	10	-
RBM20	-	1
Titin	-	4



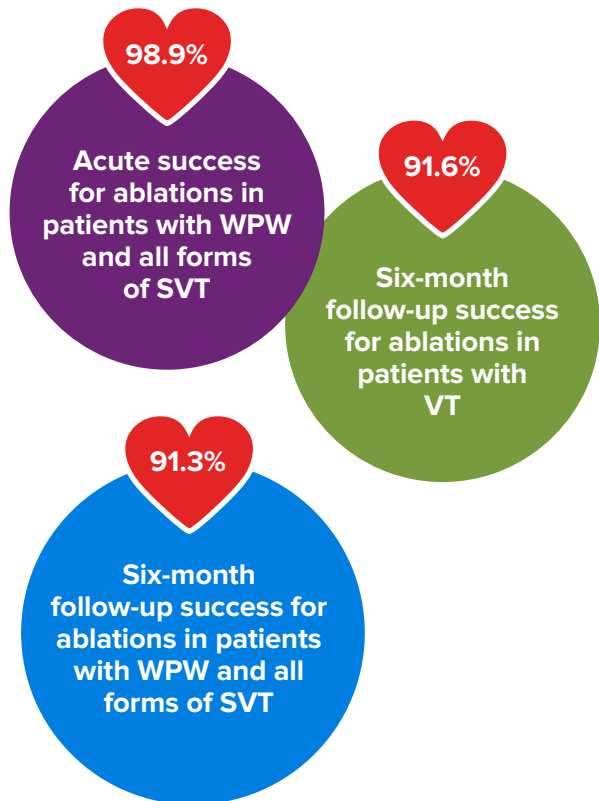
- **EP procedures.** We use the latest technology including radiofrequency energy, cryoablation and irrigated radiofrequency to treat supra-ventricular and ventricular arrhythmias. With 3D mapping, we can locate arrhythmias with minimal fluoroscopy exposure. In addition, advanced automation, impedance field flexibility and magnetic field precision significantly shorten procedure time. The latest contact-force catheters are critical in ablating patients with complex congenital heart disease to optimize effective lesions.

We have seen tremendous growth in our ACHD EP program. Our ability to partner with adult cardiologists and adult electrophysiologists has allowed us to manage these patients jointly, planning for catheter ablations with both pediatric and adult EP presence. This joint relationship has significantly improved outcomes for these very complex patients.

- **Sudden cardiac death prevention program.** We promote community awareness to identify children at risk of sudden life-threatening events. In partnership with local fire and rescue services, we promote automated external defibrillator usage in the community and CPR training for high school students. We are continuing to engage with adult cardiologists in Loudoun County, VA, to educate the community about secondary prevention measures from a Good Samaritan vantage point.

### Electrophysiology Procedures: 2019 – 2020

	2019	2020
EP study only	29	34
EP study and ablation (total)	110	104
EP study and ablation (SVT-peds)	86	78
EP study and ablation (VT-peds)	6	6
EP study and ablation (SVT-ACHD)	11	13
EP study and ablation (VT-ACHD)	7	7
Pacemaker implant	16	15
CRT implant	2	1
ICD implant	6	10
Lead extraction	1	1
Implantable loop recorder	23	37
<b>Total Case Volume</b>	<b>187</b>	<b>202</b>



## ADULT CONGENITAL HEART DISEASE

Thanks to advances in pediatric cardiac care, there is a growing population of adults with congenital heart disease who previously might not have survived childhood. Established in 1994 as a partnership between Inova Children's and Inova Heart and Vascular Institute (IHVI), Inova's ACHD program was one of the first such programs in the country. Today, the ACHD program provides complete continuity of care for patients with a variety of congenital heart defects, including those complicated by heart rhythm problems, heart failure and pulmonary hypertension. The program currently has five board-certified specialists in adult congenital heart disease. The ACHD program also partners with Inova Women's Hospital to achieve the safest delivery plans possible for mothers with congenital heart defects and their babies.

The ACHD clinic is located in the advanced heart and lung disease specialty clinic on the Inova Fairfax Medical Campus. This provides patients seamless access to the collective expertise of Inova's highly skilled pediatric and adult specialists in a single location, to improve outcomes and enhance quality of life.

Areas of specialization cover the full range of IHVI's advanced cardiac therapies including:

- **Adult congenital cardiac catheterization.**

Cardiac surgeons and interventional cardiologists perform structural heart procedures such as transcatheter aortic valve replacement (TAVR) and catheter-based pulmonary valve replacement.

- **Adult congenital EP.** All patients with arrhythmias are followed by both an electrophysiologist and ACHD specialists. In the past two years, we performed more than 100 EP procedures (ablations and devices) in ACHD patients, including catheter ablations in complex congenital heart disease patients such as those with a Fontan procedure or tetralogy of Fallot, as well as following atrial switch Mustard patients. We also place biventricular pacemakers to resynchronize the heart and improve myocardial dysfunction as well as ICDs for those ACHD patients at risk of life-threatening arrhythmias.
- **Proactive evaluation of tetralogy patients.** We evaluate patients for potential arrhythmias prior to catheter-based or surgical pulmonary valve implantation.
- **Maternal-fetal medicine.** Inova's high-risk obstetric specialists partner with the ACHD team in the management of women with congenital heart disease during pregnancy. They also care for women carrying a baby with suspected congenital heart disease who may need specialized pediatric cardiac care after birth.



## FETAL CARDIOLOGY



1,400

In 2020, our eight fetal cardiologists performed almost 1,400 fetal echocardiograms.

The Fetal Care Center at Inova L.J. Murphy Children’s Hospital provides a supportive team approach with prenatal consultation and pediatric care planning for pregnant women suspected of, or at risk of, carrying a fetus with a congenital heart defect.

Resources include expert evaluation and diagnosis by a board-certified pediatric cardiologist, a coordinated delivery plan, and care for newborns after birth in our neonatal intensive care unit (NICU) and PCICU. **Expectant mothers deliver their babies on site at Inova Women’s Hospital, allowing mother and baby to remain in the same facility, close together.** Delivery at Inova also ensures continuity of care by the same team that cared for the baby in utero. Our patients benefit from the combined expertise of pediatric cardiologists, cardiac surgeons, cardiac anesthesiologists, nurses and a genetic counselor working hand in hand with maternal-fetal medicine specialists and obstetricians to provide comprehensive care. We also participate in multicenter trials for fetal cardiac research.



One call provides access to diagnosis, neonatal care and pediatric subspecialty care. Families also receive the emotional, educational and logistical support services they need during this critical time.

Members of our fetal heart program are involved in the development of quality improvement metrics through the American College of Cardiology. They are also active in the Fetal Heart Society. Our leaders sit on the quality improvement committee of the American College of Cardiology.

As always, we strive to partner with maternal-fetal medicine physicians in the community to assure consistent approaches to diagnostic evaluations, necessary follow-ups and delivery care plans. We believe that an open dialogue with maternal-fetal medicine specialists is the key to a successful fetal program.

**New  
Facility  
Coming  
Soon**

We are excited to announce the opening of our new Fetal Care Center, expected in fall of 2021, which will allow us to provide a customized, supportive environment for our expecting moms. This dedicated space will be utilized for multispecialty care meetings and will be outfitted with a state-of-the-art exam room for fetal echocardiograms and other procedures.

- ✓ **Mom and Baby in One Place**
- ✓ **Cardiac Surgery**
- ✓ **Excellent Clinical Care**
- ✓ **Fetal Cardiology**
- ✓ **Genetic Counseling**
- ✓ **Maternal-Fetal Medicine**
- ✓ **Neonatology**
- ✓ **Patient Navigation**
- ✓ **Quality Outcomes and Clinical Research**

## NONINVASIVE CARDIOLOGY

Inova Children's Heart Center offers state-of-the-art cardiac imaging to diagnose the unique medical and surgical needs of newborns, children and adults in a safe, family-friendly environment.

Our advanced procedures include:

- Fetal echocardiography to detect heart problems before birth, allowing for faster medical or surgical intervention once the baby is born
- 3D and intracardiac echocardiography for better visualization of the heart chambers and valves
- Transesophageal echocardiography (heart scan with endoscopy) to guide and facilitate surgical and catheter-based procedures



Our team of experienced, certified pediatric cardiac sonographers work with a specialized team of seven pediatric cardiologists who have specific expertise in pediatric cardiac imaging to produce comprehensive, high-quality images of the heart.

We have a quality improvement program to monitor and improve the standard of our imaging. This includes reviewing the correlation between pre-operative imaging and surgical findings and reviewing image quality, study completeness and report completeness. Our pediatric echocardiography lab is accredited by the Intersocietal Accreditation Commission (IAC).





Exercise testing is an important diagnostic tool for children with congenital or acquired heart disease. It allows us to measure pulmonary function, rate of perceived exertion, subjective exercise intensity and workload resistance. On average, our outpatient clinicians perform more than 400 ambulatory treadmill stress tests annually. We use exercise stress testing to assess the response to various antiarrhythmic drugs and cardiotoxic medications. Metabolic exercise stress tests have proven to be valuable for ACHD follow up, as well as for patients about to undergo cardiovascular surgery.

**On average, our outpatient clinicians perform more than 400 ambulatory treadmill stress tests annually.**





## AMBULATORY CARDIOLOGY

Our ambulatory cardiology program makes it easy for patients to receive the care they need close to home.

- Our cardiologists practice in ambulatory settings throughout Maryland and Virginia, and our team cares for infants at NICUs across the region.
- Expanded telemedicine capabilities improve access for patients who live in remote areas. Cardiologists can review clinical information, such as electrocardiograms, echocardiograms and remote rhythm monitors to develop an individualized care plan. This has been especially valuable during the COVID-19 pandemic.
- Our EP program offers convenient home-based monitoring of patients with pacemakers, minimizing travel and missed work and school days.
- Many of our clinics offer exercise stress tests, as well as Holter monitoring and implantable loop recorders for evaluation of arrhythmias.
- In the last year, our cardiologists provided monthly Zoom series lectures on multiple topics including updates on COVID-19, MIS-C and sports participation after COVID-19 recovery. Our cardiologists are involved with the Virginia chapter of the American Academy of Pediatrics.

As our ambulatory program grows, we use the American College of Cardiology's Adult Congenital and Pediatric Cardiology Quality Metrics for chest pain, Kawasaki disease, infection prevention and more.



**In 2020, our ambulatory cardiology team evaluated almost 16,500 patients.**

Inova is committed to partnering with our patients' primary care physicians throughout Maryland and Virginia. We pride ourselves on maintaining continuity with the pediatrician or family practitioner on heart center outcomes, to provide consistent care even after discharge.

## ADVANCED MULTIMODAL IMAGING



Inova Children's Heart Center offers state-of-the-art imaging technology, including cardiac MRI and CT imaging. Inova Fairfax MRI Center was the first location in the United States to offer comprehensive cardiac MRI with 4D flow imaging, a novel technique to evaluate flow dynamics in the heart and surrounding vasculature. It reduces scan time, so children do not need to hold their breath. It also may avoid the need for anesthesia in younger children.

**In 2018, a new GE Revolution CT scanner was installed on the Inova Fairfax Medical Campus.** It allows for lower-dose imaging techniques for our pediatric patients, without anesthesia, as well as whole-heart imaging in a single beat. Although MRI is our technique of choice for congenital heart patients, CT is a valuable tool in certain circumstances.

In 2021, cardiac stress MRI will be added to the list of many services provided for our pediatric cardiac patients.

All pediatric cardiac studies are performed and interpreted by fellowship-trained cardiac imagers and presented at our weekly multidisciplinary conference to allow a comprehensive review of the imaging.

## QUALITY INITIATIVES PROGRAM

The best programs constantly reassess themselves to maintain excellence, to identify opportunities to improve and to develop more robust safety measures. In the last decade, Inova Children's and Inova Health System have taken a proactive approach to improving quality outcomes through more reliable and consistent measures. We have seen dramatic reductions in hospital acquired infections, reduced length of stay, and improvement in the overall patients' and family experience.

We use data to not only provide the highest quality and safest care possible, but to exceed national benchmarks and be fully transparent with our clinical outcomes. In 2018, our heart center, under the leadership of Alan Benheim, MD, and Allison Barberio, MHSA, CPHQ, established a methodical approach to critically reviewing our outcomes with all cardiac admissions.

With support from Inova's quality department, a multidisciplinary team meets monthly. The group includes pediatric cardiologists, pediatric cardiac surgeons, pediatric cardiac intensivists, neonatologists, nurses, nurse practitioners, physician assistants and numerous other specialists involved in the care of these challenging patients. This extends to care on the cardiac ward, NICU, OR, cath lab and other hospital units. Even when analyzing cases with good outcomes, the group has found opportunities to improve our care, add safety measures for future cases and strengthen procedures.

Each case that comes to the team for review is not only assessed in the context of that particular patient but also also in light of a critical review of the latest scientific evidence and global children's hospital practices to include the best principles from around the world. The group has also identified opportunities to proactively prepare our team to anticipate the needs of patients having innovative new procedures and techniques in order to maintain consistent care models.



**We use data to not only provide the highest quality and safest care possible, but to exceed national benchmarks and be fully transparent with our clinical outcomes.**



## INTENSIVE CARE

Inova L.J. Murphy Children's Hospital offers a full range of pediatric cardiac critical care services, all housed in a family-centered, comprehensive care environment. The service is staffed around the clock by board-certified pediatric intensivists specially trained to care for critically ill children with heart disease. The PCICU team includes physicians, advanced practice nurses, pediatric critical care nurses, pediatric pharmacists, respiratory therapists, and occupational and physical therapists who work together to provide optimal care for each precious pediatric patient and young adult we serve. Family support through these stressful times is provided by child life specialists, pastoral care and certified social workers.

The PCICU has eight dedicated ICU beds for the care of critically ill cardiac patients with an additional four beds for intermediate level care. Beginning in 2020, pediatric cardiac surgical patients were admitted to the PCICU from admission through discharge, remaining in one physical location with one dedicated team providing comprehensive care through all phases of treatment (pre-operative, postoperative and progression toward discharge home).

Supportive treatments include:

- Comprehensive hemodynamic monitoring
- Continuous renal replacement therapy
- Inhaled nitric oxide
- ECMO

Our outcomes meet or exceed national benchmarks (STS, VPS); however, the real strength of Inova Children's lies in our commitment to patients and families. Our multidisciplinary team continually strives to provide the highest quality care and best possible outcomes through open and effective communication among all clinicians each and every day, and **parents are key members of the care team at all times.**

In response to the pandemic, we have also enhanced our teleICU capabilities to assess patients as a team remotely including:

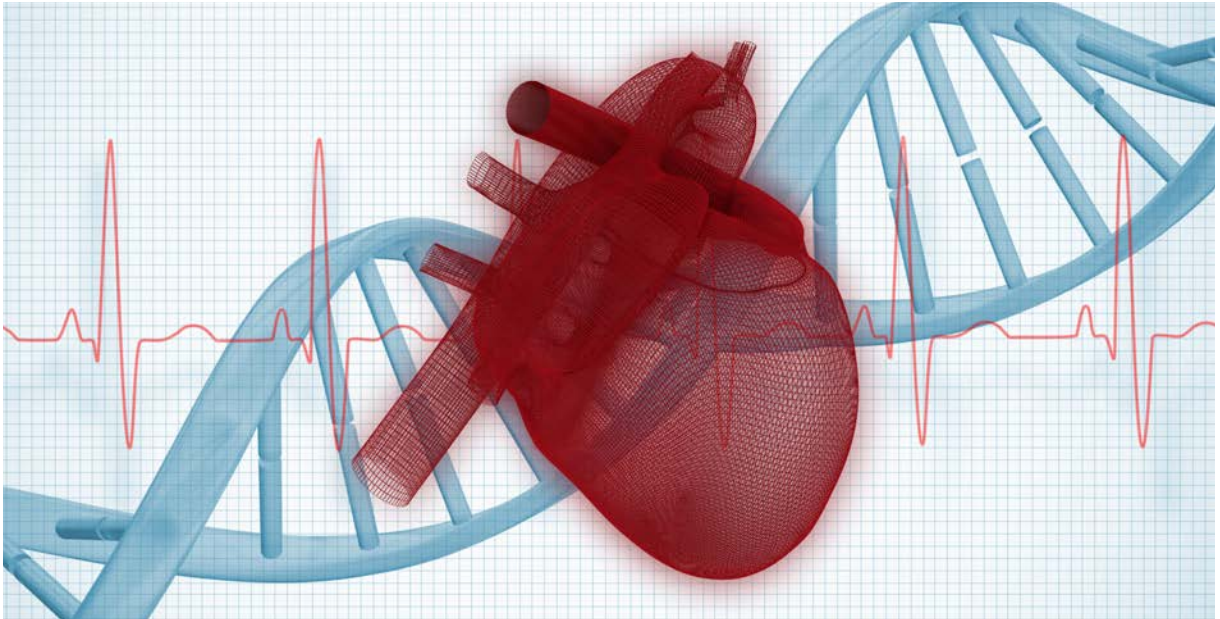
- 1) Multidisciplinary rounds each day that includes more than 10 healthcare providers and parents.
- 2) Weekly joint cardiology/cardiac surgical conference to bring upwards of 30 cardiologists, cardiac surgeons, intensivists, fetal experts and numerous other healthcare providers together to develop a comprehensive care plan for newly diagnosed and established patients who are being considered for cardiac surgical or catheter based interventions. In addition, broad medical input and consensus building is sought for any critically ill patients currently in the PCICU.
- 3) Collaboration with other pediatric cardiac centers around the country when previous or future care will be managed jointly between the two centers.



200

**In 2020, our PCICU team provided diagnostic evaluation and intensive care to almost 200 critically ill infants, children, adolescents and young adults with congenital and acquired critical cardiac disease.**

## AORTOPATHY PROGRAM



In 2018, our cardiovascular genomics clinic added a program for patients with aortopathy and/or connective tissue disorders and their families. The aortopathy program provides expert medical management, integrated care and advanced genetic services for an array of conditions, including bicuspid aortic valve, Marfan syndrome, Loeys-Dietz syndrome, familial aneurysms/dissections, aortic and arterial aneurysms, Ehlers-Danlos syndrome (vascular type), and other genetic syndromes associated with aortic aneurysms. Our team of pediatric and adult cardiology and cardiac surgery specialists uses evidence-based medical surveillance and genetic screening to guide medication management, lifestyle modifications, and both catheter-based and surgical interventions. If needed, the cardiovascular genomics clinic provides multi-disciplinary care coordination with experts in vascular and nonvascular specialties. Resources include personalized education and psychosocial support and documentation. In 2020, our aortopathy team presented at two national meetings.



**The aortopathy program provides expert medical management, integrated care and advanced genetic services for an array of conditions.**

## SINGLE VENTRICLE INTERSTAGE PROGRAM

The single ventricle interstage program provides comprehensive care and support for families of infants with complex conditions, such as hypoplastic left heart syndrome and shunt-dependent circulation, that require intervention in stages. The program bridges the gap between a child's first and second heart procedures.

Our multidisciplinary team includes two cardiologists, physician assistants, a nurse navigator, clinic nurses, speech therapists and dietitians. Because clear communication and care transition from hospital to home improve outcomes and survival, families receive extensive education to help them care for their children upon discharge, as well as home monitoring equipment, including a digital tablet, to enter and track vital signs and progress.

Patients are seen at regular intervals in our single ventricle clinic. They also follow up with their primary cardiologist. In addition, our clinical nurse navigator checks in with parents every week by phone and reviews the telehealth data. Between appointments, parents have access to a dedicated phone line, where a clinical staff member is available to coordinate care, troubleshoot problems and discuss concerns. To provide the highest quality care, we are part of the National Pediatric Cardiology Quality Collaborative.



## NEURODEVELOPMENTAL CARE

Children with complex congenital cardiac disease are at increased risk for neurodevelopmental delays and disabilities. In 2012, the American Heart Association identified those infants at greatest risk and recommended early screening and intervention to help them achieve their highest neurodevelopmental potential.

Inova Children's Heart Center partners with our pediatric rehabilitation specialists to provide this service to our at-risk population. The follow-along clinic provides developmental evaluation for infants and children who have experienced:

- Regional cerebral perfusion techniques (used for certain complex neonatal surgical procedures)
- ECMO support
- Cardiac arrest

Our pediatric rehabilitation specialists (physical, occupational and speech-language therapists) use a standardized developmental assessment tool to determine:

- Mental abilities
- Motor skills
- Problems of weakness or tone (via neurologic screening)
- Speech skills

Recommendations are provided for:

- Home activities to promote an infant's developmental potential
- Referral to community-based resource centers as appropriate

The clinic team works with the patients, families and primary care providers to ensure they can manage any neurodevelopmental concerns, even after they leave the hospital.



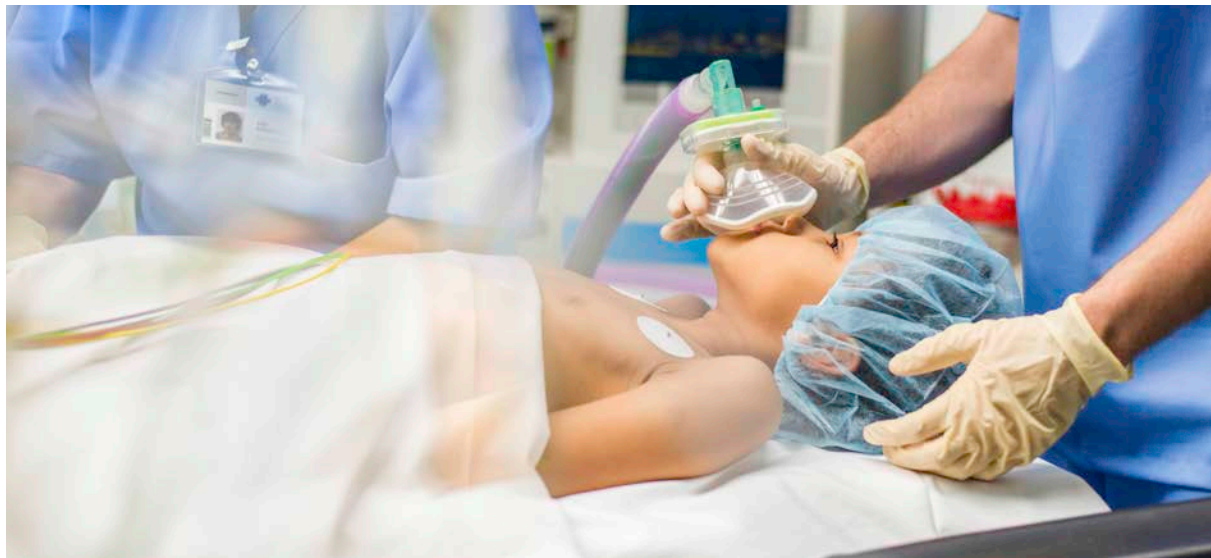
**In 2019, Inova L.J. Murphy Children's Hospital joined the prestigious Cardiac Neurodevelopmental Outcome Collaborative (CNOC).**

A multicenter, multidisciplinary group of healthcare professionals, CNOC is dedicated to working together and partnering with families to optimize neurodevelopmental outcomes for children and adolescents with congenital heart disease through clinical, quality and research initiatives, to maximize quality across the lifespan.



**Cardiac Neurodevelopmental Outcome Collaborative**

## PEDIATRIC CARDIAC ANESTHESIA



At Inova L.J. Murphy Children's Hospital, patients with congenital heart disease are cared for by a dedicated team of pediatric cardiac anesthesiologists who understand children's unique physiology and needs. Our team of board-certified pediatric anesthesiologists and experienced certified registered nurse anesthetists provides comprehensive care for patients anywhere anesthesia or sedation is required, including:

- Cardiac OR
- Catheterization lab
- NICU
- Radiology and MRI
- Pediatric sedation
- General OR

Patients with congenital heart disease often require sedation and anesthesia for multiple procedures, and our anesthesiologists work in collaboration with the entire cardiac team to ensure the safest outcomes.



Benjamin Cramer, MD  
*Pediatric Cardiac Anesthesiology*



## NURSING

Inova L.J. Murphy Children's Hospital is a 226-bed pediatric quaternary care center. The eight-bed PCICU is housed within the larger, state-of-the-art PICU. A 22-bed pediatric specialty care unit (PSCU) is located next to the PCICU and PICU.

The PCICU provides the highest level of care for a culturally diverse population of young patients and their families and serves as a referral unit within the hospital. The unit's scope of service ranges from birth to 21, with the majority of patients younger than five years old. Admission diagnoses include postoperative cardiac surgery, ECMO, high-frequency oscillation ventilation, continuous renal replacement therapy, vasoactive drip management and management of other life-threatening conditions, including heart failure and arrhythmias.

The PCICU is committed to a team approach with joint accountability among staff, leadership and key stakeholders. Effective communication is critical to providing high-quality care and outcomes for patients in a family-centered environment. The unit approaches staffing from a healthy work environment perspective, matching nurse skill with the needs of all cardiac patients. Continuing education is provided to the cardiac nursing team, and staff are assigned to patients within their experience and expertise, with advanced support nurses caring for the most complicated cases.

The PSCU has the ability to provide 24-hour telemetry by a centralized monitoring station with staff specializing in identification of arrhythmias.

Inova L.J. Murphy Children's Hospital is committed to reducing hospital-acquired infections (HAI). The hospital has participated in the Solutions for Patient Safety (SPS) network since 2014, working to hardwire central line-associated bloodstream infections (CLABSI) bundle compliance and proactively address HAI reduction. Our active and comprehensive plan continues to evolve with dynamic team engagement.

The hospital's CLABSI rate is within the top 10 percent of the SPS network.



## CHILD LIFE

At Inova Children's, we believe that meeting the psychosocial needs of children and their families is an essential component of exceptional comprehensive care. Our certified child life specialists partner with physicians, nurses and the entire team to craft an experience that is not only comfortable and soothing, but also promotes healthy coping and healing strategies.

For children scheduled for cardiac surgery, Inova's child life team provides:

- A pre-op tour that includes a hands-on, developmentally appropriate description of what to expect
- Support during pre-op bloodwork, echocardiograms and other tests, as needed
- Hands-on preparation and support through admission and each step of the surgical process

In addition, Inova's child life specialists support children who come to the hospital for outpatient cardiac procedures.



## INTERNATIONAL CARE

40

In 2020, our cardiac surgeons traveled to Macedonia and Lebanon, where they operated on nearly 40 children with congenital heart disease and helped train local surgeons.



In addition, our cardiologists participated in international missions to Haiti, Ghana and the Dominican Republic.



Marcelo Cardarelli, MD, teaching in Lebanon.

Marcelo Cardarelli, MD, in Macedonia.

## CARDIAC PARENT ADVISORY COUNCIL

The Cardiac Parent Advisory Council (CPAC) was formed in 2018. Led by Jamie Gentile, MPH, CCLS, Director of Child Life Services, CPAC includes parents who have had a recent experience at Inova Children's Heart Center, as well as physicians, nurses, child life specialists and hospital leaders. Parents are key members of the care team, and we are most successful when we leverage their knowledge and listen to their perspectives. Now 20 parent members strong and growing, CPAC provides a wealth of insight that has strengthened the cardiac program, especially around patient education, program development and quality/safety initiatives.



## RESEARCH



Inova L.J. Murphy Children's Hospital is actively involved with clinical research in fetal cardiology, congenital heart disease, ACHD and complex hereditary arrhythmias. With the support of two generous external grants, Inova provides sponsored continuing medical education lectures from visiting professors throughout the year. Currently, our heart program is involved in research to improve understanding of the functional genomic abnormalities associated with hereditary arrhythmias such as long QT syndrome, catecholaminergic polymorphic ventricular tachycardia, arrhythmogenic right ventricular dysplasia and Brugada syndrome. By partnering with our adult cardiogenetics program, we can better understand the unique genetic and genomic factors within families and apply our collaborative findings these innovative discoveries to improve health.

Our research team has also partnered with our adult colleagues at IHVI on various COVID-19 trials and will continue to identify appropriate clinical trials for pediatric patients as they become available. Our primary cardiologists have also been working closely with the local Virginia State Chapter of the American Board of Pediatrics to help with the recommendations and messaging regarding sports participation after recovery from COVID-19 for our teenagers.

## PUBLICATIONS (RECENT)

**Miller RL, Diamonstein CJ, Benheim A.** The importance of genetics and genetic counselors in the evaluation of patients with bicuspid aortic valve and aortopathy. *Curr Opin Cardiol.* 2019 Jan;34(1):35-40.

**Karr S.** Avoiding physician burnout through physical, emotional and spiritual energy. *Curr Opin Cardiol.* 2019 Jan;34(1):94-97.

**Chambers Gurson S.** Advances in fetal echocardiography: myocardial deformation analysis, cardiac MRI and three-dimensional printing. *Curr Opin Cardiol.* 2019 Jan;34(1).

Balaji S, DiLorenzo MP, Fish FA, Etheridge SP, Aziz PF, Russell MW, **Cohen MI**, et al. Risk factors for lethal arrhythmic events in children and adolescents with hypertrophic cardiomyopathy and an implantable cardioverter defibrillator: An international multi-center study. *Heart Rhythm.* 2019 Apr 23.

**Cohen MI.** Frequent premature ventricular beats in healthy children: when to ignore and when to treat? *Curr Opin Cardiol.* 2019 Jan;34(1):65-72.

Cohen E, **Cohen MI.** COVID-19 will forever change the landscape of telemedicine. *Curr Opin Cardiol.* 2021 Jan;36(1):110-115.

Dzelebdzic S, **Tawfik SS, Collazo LR,** Shorofsky M, **Benheim AE,** Ansong AK, Karr SS. Diagnosis and management of fontan failure secondary to aortopulmonary artery fistula. *Journal Of Structural Heart Disease,* April 2019, Volume 5, Issue 2:38-42.

**Cohen MI,** Cohen J, Stollar L, Collazo L. Ivabradine as a stabilizing anti-arrhythmic agent for chaotic atrial tachycardia. *Cardiol Young.* 2020 Jun;30(6):899-902

Firan A, Dangol A, Collazo L, **Cohen MI:** An unusual presentation of a large cardiac mass. *Cardiol Young.* 2019 Dec;29(12):1549-1551.

Escudero CA, Ceresnak S, Collins KK, **Cohen MI,** Cannon BC, Anne Dubin AM, Tanel RE, Zimmerman F, Etheridge SP, Jansen CP. Loss of ventricular pre-excitation during non-invasive testing: A multicenter study of children with Wolff-Parkinson-White Syndrome. *Heart Rhythm.* 2020 Oct;17(10):1729-1737.

**Lizano-Santamaria R, Cohen M, Atkins M, Collazo** Left ventricular aneurysm in a child after recovering from dilated cardiomyopathy. *World J Pediatr Congenit Heart Surg.* 2020 Jul;11(4):515-517.

## MEET OUR TEAM

### Cardiology

*Mitchell Cohen, MD*  
*Chief, Pediatric Cardiology*

Hasan Abdallah, MD  
Alan Benheim, MD  
Patrick Callahan, MD  
Sarah Chambers Gurson, MD  
Jared Hershenson, MD  
Sharon Karr, MD  
William Kirby, MD  
Jennifer Lindsey, MD  
Ramiro Lizano, MD  
Keyur Mehta, MD  
Jennifer O'Neil, MD  
Kinjal Parikh, MD  
Jin Park, MD  
Jaheedah Roane, MD  
Harish Rudra, DO  
Shripriya Sahay, NP  
Sherif Tawfik, MD  
Kalpana Thammineni, MD  
Christina Thurber, PA

### Cardiac Surgery

*Lucas Collazo, MD*  
*Chief, Cardiac Surgery*

Glenn Bailey, PA  
Marcelo Cardarelli, MD  
Mechelle Fleischer, PA  
Kathryn Jolda, NP

### Adult Congenital Heart Disease

*Mitchell Cohen, MD*  
Lucas Collazo, MD  
Shashank Desai, MD  
Rui Guan, RN  
Pradeep Nayak, MD  
Carolyn Rosner, CRNP  
Sherif Tawfik, MD  
Mark Tannenbaum, MD  
Karl D. Young, PA

### Cardiovascular Anesthesiology

Benjamin Cramer, MD  
Joyce Hairston, MD  
Danica Han, MD  
James Konigsberg, MD  
Jennifer Maher, MD  
Tiffany Minehart, MD  
Tana Tyler, MD

### Electrophysiology

Mitchell Cohen, MD  
Christina Thurber, PA

### Inherited Cardiac Conditions Clinic

Mitchell Cohen, MD  
*Co-Director, Pediatrics*

Palak Shah, MD  
*Co-Director, Adult (IHVI)*

Rebecca Miller, MS, CGC  
*Head Genetics Counselor*

Ryan Hartman, MS, CGC  
*Genetics Counselor*

Alan Benheim, MD

### Interventional Cardiology

Sherif Tawfik, MD

### Noninvasive Imaging

Sarah Chambers Gurson, MD  
*Medical Director*

Hassan Abdallah, MD  
Melany Atkins, MD (MRI/CT)  
Alan Benheim, MD  
Patrick Callahan, MD  
Jared Hershenson, MD  
Edmund Hong, MD (MRI/CT)  
Sharon Karr, MD  
William Kirby, MD  
Kunal Kothari, MD (MRI/CT)  
Jennifer Lindsey, MD  
Ramiro Lizano, MD

Keyur Mehta, MD  
Jennifer O'Neil, MD  
Kinjal Parikh, MD  
Jin Park, MD  
Harish Rudra, DO  
Kalpana Thammineni, MD

### Intensive Care

Keith Kocis, MD  
*Medical Director, PCICU*

Kathleen Donnelly, MD  
*Interim Medical Director, PICU*

Swati Agarwal, MD  
Cynthia Gibson, MD  
Peter Grundl, MD  
Jeremy Lamkin, MD  
William Stotz, MD  
Mahsheed Taeb, MD  
Megan Tzeng, MD

### Nursing Leadership

Ashley Virts, *Vice President Nursing, Inova Pediatric Service Line*

Lynda Mullinix, MSN, RN  
*Senior Director, Nursing Services*

Gail Green, MSN, RN  
*Clinical Director, PICU/CICU*

Amber Fuller, MSN, RN  
*Clinical Director, NICU*

Paula Thomspson, MSN, RN  
*Clinical Director, NICU*

### Advanced Nurse Practitioners

Fiona Baus, CRNP  
Maria Liz Bullock, CRNP  
Kelly Feran, CRNP  
Lauren Hancock, CRNP  
Louis Seay, CRNP  
Lauren Stollar, CRNP  
Joyce Vamja, CRNP

## MEET OUR TEAM, cont.

### Fetal Care Team

Margot Ahronovich, MD  
*Medical Director*

Sarah Chambers Gurson, MD  
*Director, Fetal Cardiology*

Patrick Callahan, MD

Erin Caufield, BSN

Melissa Eatherly, FNP-BC

Jared Hershenson, MD

Sharon Karr, MD

Jennifer Lindsey, MD

Jennifer O'Neil, MD

Jin Park, MD

Harish Rudra, DO

### Multimodal Imaging

Melany Atkins, MD

Edmund Hong, MD

Kunal Kothari, MD

### ECHO Reading team

Sarah Chambers Gurson, MD  
*Director, Pediatric  
Echocardiography Lab*

Patrick Callahan, MD

Sharon Karr, MD

Jennifer Lindsey, MD

Jennifer O'Neil, MD

Harish Rudra, DO

### Cardiac Research

Suchitra Hourigan, MD  
*Vice Chair, Research*

Marcelo Cardarelli, MD

Erica Christian, MS

Mitchell Cohen, MD

Lucas Collazo, MD

### Single Ventricle Care Team

Harish Rudra, DO

*Medical Director*

Glenn Bailey, PA

Marcelo Cardarelli, MD

Lucas Collazo, MD

Mechelle Fleischer, PA

Kimberly Hill, CCC, SLP

*Speech Therapist*

Kristine Lewis, RN

*Coordinator*

Jamie MacIntosh, RN

Karyn Theis, RD

*Nutrition Specialist*

### Child Life Services

Jamie Gentile, MPH, CCLS  
*Director of Child Life*

Nicole Johnson, MA, CCLS  
*Child Life Specialist*

### Administration

Steve Narang, MD, MHCM

*President, Inova Fairfax Medical  
Campus*

*Interim President, Inova Pediatric  
Service Line*

Christopher O'Connor, MD  
*President, Heart and Vascular  
Service Line*

Cynthia Gibson, MD  
*Interim Chair, Pediatrics,  
Inova Fairfax Medical Campus*

Joanna Fazio  
*Vice President and Administrator,  
Inova Pediatric Service Line*

Megan Hindenburg  
*Program Coordinator*



## GIVING TO INOVA CHILDREN'S HEART CENTER

Inova Children's Heart Center is nationally recognized and one of the largest, most successful programs in the Washington, DC region. With more than 28 dedicated pediatric cardiologists and advanced practitioners, our program provides a continuum of care from the fetus to young adult, all within the same family-centered children's hospital.

Philanthropy has empowered the program to grow with an increase in cardiac surgical procedures, advancements in our fetal heart program, the creation of a dedicated electrophysiology program and ongoing growth of our adult congenital heart program in collaboration with IHVI. Inova relies on community support to provide excellent care close to home.



If you would like to support Inova Children's Heart Center, contact Kirstin McArthur, Philanthropy Director, at 703.776.6081 or [kirstin.mcarthur@inova.org](mailto:kirstin.mcarthur@inova.org).



The **14th Annual Inova Children's Hospital StarKid 5K and Family Fun Run** transitioned to a virtual format in 2020 due to COVID-19, but that did not stop the fun! More than 1,300 participants of all ages ran around the DMV and beyond, raising nearly \$125,000 to support patients and healthcare workers at Inova Children's Hospital and through our Emergency Preparedness Fund. Stay tuned for information on our 2021 StarKid event.

More than 1,000 people from our community showed up in a big way for **2020 Inova Honors**, our virtual celebration of our 19,000 frontline heroes. The event was chaired by Inova grateful patient and Washington Football Team Quarterback Alex Smith and his wife Elizabeth. Because of the generous support of philanthropists, Inova leaders, the business community and our own team members, Inova Health Foundation raised an unbelievable \$1.15 million! This incredible support will provide cornerstone funding for well-being and resilience initiatives to help Inova team members persevere as we continue to care for patients with COVID-19.







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