CARDIAC CENTER ANNUAL REPORT

January, 2022 - December 31, 2022

Children's Hospital of Philadelphia℠
Cardiac Center

INTRODUCTION

We are again honored to present the Annual Report of the Cardiac Center at Children's Hospital of Philadelphia. With more than 900 employees, we remain one of the largest pediatric cardiac centers in North America with a celebrated history of novel clinical care, ground-breaking scientific discovery, and cutting-edge translational research that daily advances the care of our patients with complex congenital and acquired heart disease.

2022 also marked important progress in the development of the CHOP Cardiovascular Research Institute, under the inaugural direction of Daniel Kelly, MD, to seamlessly enhance and accelerate bench-to-bedside innovation in partnership with the world-renowned University of Pennsylvania Cardiovascular Institute.

In collaboration with the Center for Fetal Diagnosis and Treatment at CHOP, the Cardiac Center remains the highest volume pediatric center in the United States for neonatal cardiac catheter-based and surgical interventions. In parallel, our transition and adult congenital heart disease programs assure continuity of care for our patients as they mature from birth to adulthood.

CHOP has broken ground on plans for a New Patient Tower to be completed in 2028, which will facilitate expansion of our clinical footprint, and growth of our flagship programs including single ventricle care, lymphatics, advanced valve therapies, heart failure, transplantation and mechanical circulatory support. We anticipate the continued growth of our new heart failure/transplant intensive care unit, designed specifically to focus on the unique needs of this population.

As this report also helps to detail, the academic productivity of our faculty and staff is unparalleled internationally and fueled by our relentless drive toward clinical innovation and discovery. We take great pride in the strength and size of our advanced fellowship training programs and platforms for nursing education and advancement.

We hope you will enjoy reading this Annual Report, which provides only a glimpse into the incredible achievements of the CHOP Cardiac Center, and a brief look into our future goals and plans for ongoing expansion. Yet, as impressive as this report is, it cannot fully portray the spectacular clinical care that is provided each and every day in the Cardiac Center and that forms the foundation of our inspiration. Please enjoy.

Joseph Rossano, MD, and Jonathan Chen, MD — Co-Executive Directors, CHOP Cardiac Center

Children's Hospital of Philadelphia℠
Cardiac Center

INTRODUCTION

The CHOP Cardiovascular Institute is Established

The CHOP Cardiac Center was established to integrate the pediatric cardiologic, cardiac surgery and cardiac anesthesia/critical care groups. The CHOP leadership made a strategic decision to invest in the development of a comprehensive research center that spans from fundamental discoveries to their translation and clinical implementation in the Cardiac Center.

To excel the development of a superb cardiovascular research component, the CHOP Cardiovascular Institute (CVI) was established in the spring of 2022, in partnership with the Penn CVI and under the common directorship of Dr. Daniel P. Kelly.

Dr. Kelly is the Willard and Rhoda Ware Professor of Medicine at the University of Pennsylvania Perelman School of Medicine and the Rachel Ash Presidential Professor at Children's Hospital of Philadelphia (CHOP). He trained in Medicine and Cardiology at Barnes Hospital in St. Louis, then joined the faculty of Washington University School of Medicine where he served as Professor of Medicine and Pediatrics, Chief of the Cardiovascular Division, and the founding Director of the Center for Cardiovascular Research. In 2008, Dr. Kelly assumed the role of founding Scientific Director for the Sanford Burnham Prebys Medical Discovery Institute in Florida followed by his recruitment in 2017 to serve as Director of the Penn Cardiovascular Institute.

In 2022, Dr. Kelly assumed the role of founding Director of the CHOP CVI. Channeling the expertise of top basic and translational scientists from Children's Hospital of Philadelphia (CHOP) and Penn, the CHOP CVI will enhance our understanding of pediatric cardiovascular disease and drive scientific discovery and medical breakthroughs that will improve pediatric cardiovascular treatment and care. Given the international stature of the CHOP Cardiac Center in pediatric clinical care, research and training, it is envisioned that this effort will result in the emergence of one of the most significant pediatric cardiovascular research institutions worldwide.

The New Children's Hospital of Philadelphia Cardiovascular Institute (CHOP CVI)

Improving Cardiovascular Health Throughout the Lifespan in Partnership with the Penn CVI

Children's Hospital of Philadelphia℠
Cardiac Center

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CARDIAC CENTER

BY THE NUMBERS

Surgical Volume	
Cardiac Surgeries	964
Open Heart Surgeries	528
Adult Cases – HUP	56
Adult Cases – CHOP	13
Neonatal Cases	134
Heart Transplants	13
VAD Implants	21

Cases By Complexity	
Stat 5	39
Stat 4	56
Stat 3	85
Stat 2	135
Stat 1	319

Interventional Cardiology	
Cardiac Cath Lab (all procedures)	1,462
Cardiac Catheterization (not EP/Lymphatic)	1,093
Interventional	546
Electrophysiology	240
Lymphatic Imaging/Intervention	129

Ambulatory and Imaging	
Outpatient Visits	36,778
Echocardiography Studies	31,660
Fetal Heart Echocardiography Studies	3,473
Fetal Heart Diagnosis of CHD	428
Special Delivery Unit Births	187
Cardiac MRI	1,323
Exercise Studies	1,859

Cardiac Center Admissions	
CICU Admissions	965
CCU/ITCU Admissions	1,608
CICU ADC	31.24
CCU/ITCU ADC	29.79

CHOP Cardiac Center Facilities	
32	Licensed Cardiac Critical Care Beds (additional surge capacity)
29	Licensed Telemetry Beds
10	ITCU
15	Bed Cardiac Prep and Recovery Unit (CPRU)
2	Dedicated Cardiac Operating Suites
3	Cardiac Catheterization Laboratories
1	Hybrid Cath/OR Suite
1	XMRI – adjacent to Cath Lab
13	Satellite OP Cardiology Locations
1	Echocardiography Laboratory (tests done at all locations)
1	Exercise Physiology Laboratory (also satellite at KOP SCC)
1	EKG/Holter Monitor/Heart Station
1	Fetal Heart Program Main Clinic and Bryn Mawr Specialty care center (some screening tests done at Satellite Locations
	Dedicated Bench Research Space and Laboratories

CARDIAC CENTER

EXECUTIVE COMMITTEE

Left to Right

- Deborah Smith, Vice President Operations
- Denise Donaghue, RN, MSN, Vice President/Associate Chief Nursing Officer
- Jonathan Chen, MD, Division Chief, Cardiothoracic Surgery and Co-Executive Director, Cardiac Center
- Joseph Rossano, MD, Division Chief, Cardiology and Co-Executive Director, Cardiac Center
- Mark Schwartz, Senior Director, Cardiac Center Service Line
- Andreas Loepke, MD, Division Chief, Cardiac Anesthesiology
- Sherri Kubis, RN, MSN, Senior Director, Cardiac Center Nursing
- Vivek Allada, MD, Medical Director, OP and Community Cardiology and Associate Chief of Cardiology, Director of Strategic Operations, and Senior Medical Director, Cardiac Center
- Andrew Costarino, MD, Division Chief, Cardiac Critical Care Medicine
- Daniel Kelly, MD, Director of Penn/CHOP Cardiovascular Institute

FLAGSHIP AND FRONTIER PROGRAMS

2022 Cardiac Center Annual Report

FETAL HEART PROGRAM

OVERVIEW

The Fetal Heart Program at CHOP is one of the first programs in the nation dedicated specifically to the evaluation, diagnosis and treatment of heart disease before birth. Now in our 21st year, we perform close to 4,000 fetal echocardiograms annually throughout the Cardiac Center enterprise and treat over 400 unique patients with a variety of forms of prenatal cardiovascular disease each year, making our program one of the largest of its kind in North America. We offer every resource expectant families need — from expert evaluation and diagnosis to innovative strategies of fetal care to planning for delivery and care after birth and beyond.

We believe optimal care includes both state-of-the-art imaging and management of fetal heart conditions as well as attention to family education, distress and trauma associated with fetal heart disease. Our multidisciplinary group includes a team of fetal heart nurse coordinators and a dedicated social worker and psychologist who focus on family education and psychological support. This essential service is just one feature that distinguishes our program from others like it. The Fetal Heart Program is separate from the pediatric ECHO lab and includes dedicated state of the art obstetrical ultrasound equipment with a dedicated and experienced team of fetal cardiovascular sonographers. The CHOP FHP is a sister program to the CHOP Richard D. Wood Jr. Center for Fetal Diagnosis and Treatment, world renowned for innovative fetal surgery and therapy. Patients cared for by the FHP are able to deliver at the Garbose Family Special Delivery Unit at CHOP, the first free-standing children's hospital in the nation to have a dedicated birthing unit solely for mothers carrying a fetus with a birth defect.

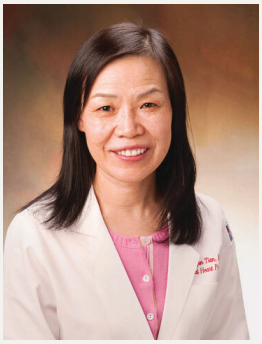
Our breadth of experience, depth of knowledge and commitment to ongoing innovation allow us to offer the utmost care for all types of fetal cardiovascular conditions. From those with simple conditions to the most complex, the Fetal Heart Program offers access to the most compassionate and knowledgeable providers, advanced treatments, and innovative technologies available — with outcomes among the best in the world.

At the Fetal Heart Program, we believe collaboration within a team of providers leads to the best care. Throughout delivery and all types of cardiovascular care, close contact with referring obstetricians and pediatric cardiologists is essential to ensure the highest level of collaborative, multidisciplinary care to our patients.

LEADERSHIP

Jack Rychik, MD
Medical Director

Jill Combs, MSN, RN
Program Manager



Zhiyun Tian, MD, RDCS
Chief, Fetal Cardiovascular Imaging

Amanda Shillingford, MD
Director Fetal Heart Community Outreach

FETAL HEART PROGRAM

FACULTY & TEAM

Stephanie McNelis, BSN, RN
Nurse Clinical Coordinator

Peter (Yajun) Guo, RDCS
Fetal Cardiovascular Sonographer

Elizabeth Coulter, MS, BSN, RN
Nurse Clinical Coordinator

Elizabeth Smith, BSN, RN
Nurse Clinical Coordinator

Fetal Heart Program Attendings:
Jack Rychik, MD, Medical Director
Shivani Bhatt, MD
Meryl Cohen, MD
Michele Cohen, DO
Karl Degenhardt, MD
Stan Ewing, MD
Christine Falkensammer, MD
Elizabeth Goldmuntz, MD
Shobha Natarajan, MD
Chandni Patel, MD
Michael Quartermain, MD
Lindsay Rogers, MD
Jill Savla, MD
Amanda Shillingford, MD
Anita Szwast, MD

Program Manager:
Jill Combs, MSN, RN

Social Worker:
Lucia Figueroa, MSW, LSW

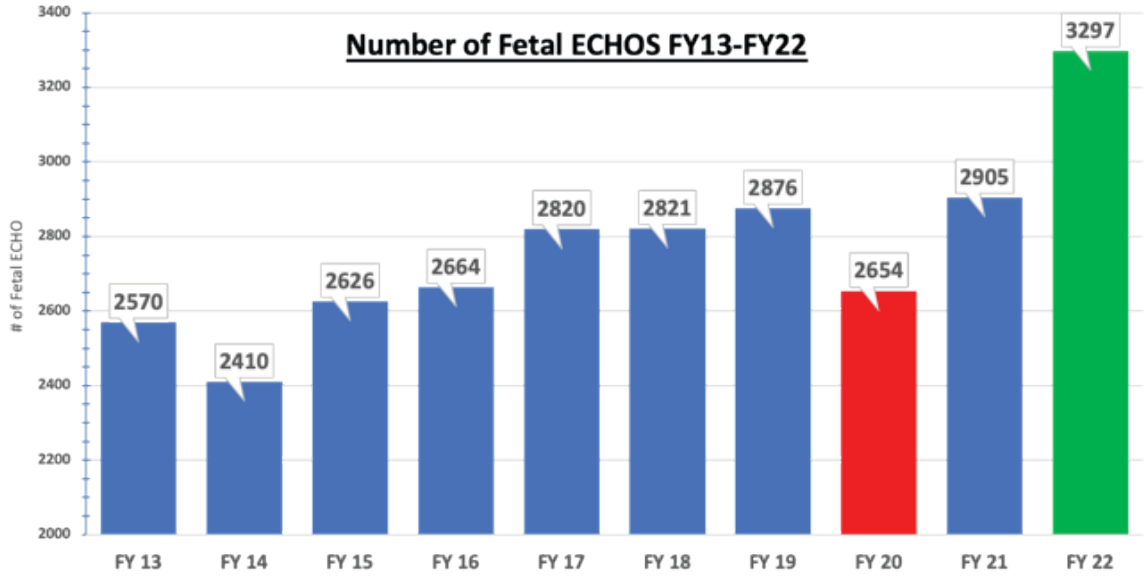
Chief, Fetal Cardiovascular Imaging:
Zhiyun Tian, MD, RDCS

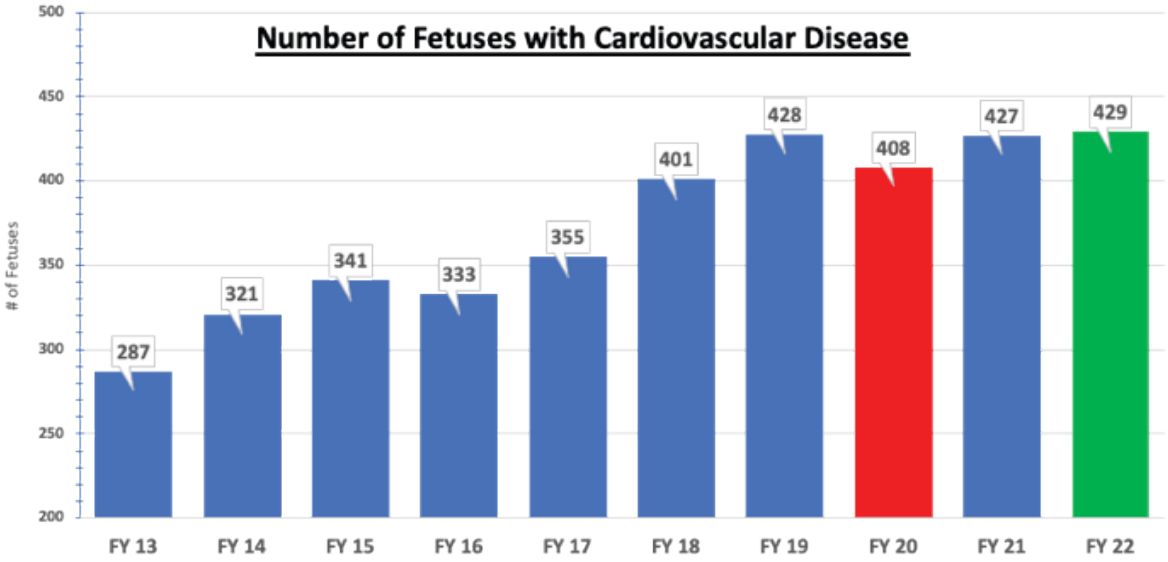
Fetal Cardiovascular Sonographers:
April Hamilton, RDCS
Margaret McCann, RDCS
Debbra Soffer, RDCS

Administrative Assistants:
Cynthia Baker
Lorri Dippel

FETAL HEART PROGRAM

METRICS





FETAL HEART PROGRAM

RESEARCH HIGHLIGHTS

1. Investigation of placental abnormalities in association with congenital heart disease. We are studying placental blood flow in utero in complex CHD such as transposition of the great arteries and hypoplastic left heart syndrome and inspecting their placentas at birth, with a variety of interesting important findings that convey the presence of placental insufficiency in association with complex CHD.
2. Mental health when there is prenatal diagnosis of CHD. We are exploring the relationship between severity of fetal heart disease and various aspects of maternal psychological health at different points of time before birth and right after birth of a fetus with heart disease, this in a very large-scale collaborative study between CHOP Fetal Heart Program and Center for Fetal Diagnosis & Treatment.
3. Exploration of the role of maternal hyperoxygenation in better defining outcomes for complex fetal heart disease. In an effort led by Dr. Anita Szwast, we are investigating whether maternal hyperoxygenation can better predict need for newborn early intervention in conditions such as transposition of the great arteries.

FUTURE DIRECTION:

We are excited about the future of the Fetal Heart Program as the introductory gateway of care and entryway to the Cardiac Center, with plans for:

- New facilities
- Personnel growth
- Expansion of unique programs such as early fetal cardiovascular imaging, maternal hyperoxygenation and placental evaluation and incorporation into management strategies
- Focused attention on prenatal family education and counseling
- Strengthening family psychological support
- Continued improvement of services that offer delivery of premier state-of-the-art diagnostic and management care to the fetus and family with cardiovascular disease

THE JILL AND MARK FISHMAN CENTER FOR LYMPHATIC DISORDERS

INTRODUCTION

The Jill and Mark Fishman Center for Lymphatic Disorders is currently in its eighth year and continues to be under leadership of Yoav Dori, MD. The center continues to thrive and in 2022 we received many referrals to our program from throughout the United States and Internationally. Dr. Dori and Dr. Smith continue to perform Lymphatic procedures regularly in the cardiac catheterization lab as well assisting surgical procedures with Drs Pablo Laje and Katsuhide Maeda. To handle the increasing clinical volume the program has hired additional advanced clinical team members, is recruiting a new program manager, and has continued to collaborate with Interventional Radiology physicians Dr. Abhay Srinvasan, Dr. Fernando Escobar and Dr. Ganesh Krishnamurthy (Dr. Krishnamurthy now has his own lymphatic procedural schedule). In 2023 we hope to recruit and hire a Ph.D Scientist to oversee research operations, offer technical support for research study design, and provide direct supervision for scientific work in the Abramson and animal lab. We also welcomed Drs. Rachel Shustak and Jessica Tang onto the Lymphatic Service attending schedule and Dr. Mudit Gupta as an additional inpatient service support.

The faculty and staff of the program continue to educate teams domestically and internationally and have helped start lymphatic programs in Denmark, Austria, Poland, Italy, Germany, England, Israel, Columbia, Mexico, and Brazil. We have also hosted many domestic and international visitors. In addition, faculty members continue to have a very busy lecture schedule with multiple invited lectures and grand rounds given by all team members, and we are working on formalizing a lymphatic fellowship.

LEADERSHIP

Yoav Dori, MD, Ph.D
Medical Director,
Interventional Cardiology

Christopher L. Smith, MD, PH.D
Interventional Cardiology

Pablo Laje, MD
General/Lymphatic Surgery

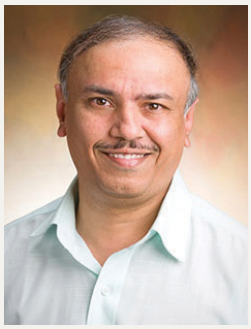
Katsuhide Maeda, MD
Cardiothoracic/Lymphatic Surgery

THE JILL AND MARK FISHMAN CENTER FOR LYMPHATIC DISORDERS

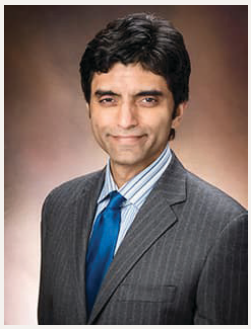
LEADERSHIP (continued)

Erin Pinto, MSN, CCRN, FNP-BC,
Advanced Practice Team Lead

Aaron DeWitt, MD
Cardiac Critical Care



Ganesh Krishnamurthy, MD
Interventional Radiology



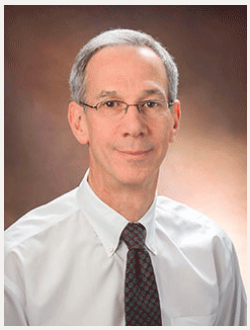
Abhay Srinvasan, MD
Interventional Radiology

Fernando Escobar, MD
Interventional Radiology

Rachel Shustak, MD
Cardiology

David Goldberg, MD
Cardiology

Chitra Ravishankar, MD
Cardiology



Jonathan Rome, MD, FACC
Interventional Cardiology

Danish Vaiyani, MD
CMR Cardiology

Emmanuelle Favilla, MD
Cardiology

David Biko, MD, MBA
CMR Radiologist

THE JILL AND MARK FISHMAN CENTER FOR LYMPHATIC DISORDERS

Lymphatic interventions in patients with primary lymphatic disorders

The program continues to maintain a busy clinical schedule with increasing involvement with the CHOP Comprehensive Vascular Anomalies Program. This work has led to the discovery of multiple genetic causes for lymphatic disorders and the development of new treatment option for patients with primary lymphatic disorders. This year the program also established a research collaboration with the NIH to look at lymphatic disorders in patients with RASopathies and a research collaboration with researchers in Harvard and Columbia University to use artificial intelligence to analyze MR lymphangiograms.

Lymphatic interventions in patients with cardiac related disorders

Great strides have been made this year in the development of treatment strategies for Protein Losing Enteropathy (PLE) and multicompartment lymphatic failure. Results show that with our current treatment strategies we can get a much more sustainable improvement in outcome with prolonged normal and stable albumin levels. The physicians have also performed nearly thirty (30) thoracic duct decompression procedures (the Jack Rome, MD procedure) in patients with multicompartment lymphatic failure and are now looking at our midterm outcomes. The team has also performed this procedure for the first time in Ireland, Slovakia, and Denmark and we have centers from around the world referring patients to our center for consideration for this approach.

Thoracic duct obstruction

In collaboration with Dr. Vibeke Hjortdal from Denmark, two papers have been published about the pressures and pressure generation in the thoracic duct in humans. This has never been described previously. A paper was also recently published about the pressure gradients that develop as a result of various causes of thoracic duct obstruction and have shown that relieving pressure gradients inside the duct can lead to resolution of clinical symptoms.

Involvement with PICS

This year the program established a formal relationship with the Pediatric and Congenital Interventional Cardiovascular Society (PICS). With the help of Dr. Damien Kenny and Dr. Ziyad Hijazi a lymphatic working group has been created and now has a regular lymphatic session in the PICS meetings in the USA and Europe.

THE JILL AND MARK FISHMAN CENTER FOR LYMPHATIC DISORDERS

BUBBA'S STORY

During the pandemic, when now 11-year-old "Bubba" (Jack) was quarantined at home with his large family, including three older sisters, one younger brother and one younger sister, he convinced them all to pass the time with CrossFit. That's Bubba — full of energy and enthusiasm, even during difficult circumstances. So, when Bubba was diagnosed with chylopericardium and his infectious spirit began to waste away, his parents knew something was very wrong and turned to Children's Hospital of Philadelphia (CHOP) for help.

Born with transposition of the great arteries and tricuspid atresia, Bubba had already undergone four open-heart surgeries, including the Fontan procedure at 5 years old. Single-ventricle individuals, like those with Fontan circulation, have elevated central venous pressure, which may put them at higher risk for lymphatic disorders.

After Bubba's fourth open-heart surgery, he developed a pleural effusion, a condition in which excess fluid builds up around the lungs. Bubba was admitted to his local Portland hospital where doctors drained the effusion and discharged him. A few months later, however, during a post-surgical follow-up, an echo revealed a pericardial effusion. This time, the fluid had turned "chylous," and Bubba spent 10 days in the ICU with a chest tube draining fluid from around his heart.

A healthy lymphatic system carries fat, protein and other nutrients throughout the body through lymph vessels. When the lymphatic system isn't working properly, this normal flow can't happen. Chyle, which is made of lymph fluid and fat, can't get into the blood. Instead, it leaks into other parts of the body. Chylopericardium is a rare condition in which lymphatic fluid leaks into the space around the heart. When this fluid builds up, it can compress the heart and lead to poor heart function.

The Jill and Mark Fishman Center for Lymphatic Disorders at CHOP is the world's only center providing highly specialized care for children and adults with lymphatic disorders. Bubba's Portland care team consulted with Aaron G. DeWitt, MD, an attending cardiologist in CHOP's Lymphatic Center. Dr. DeWitt recommended medication management and a low-fat diet. The fluid decreased enough for the chest tube to be removed and for Bubba to return home with his family.

For a while, he remained stable, but soon began to experience weight loss and limited appetite. A heart catheterization procedure showed Bubba's left lung was functioning at approximately 20 percent, with vessels so compressed it was barely getting any oxygenated blood. His care team drained nearly one liter of fluid, only to have it immediately build up again. "We knew that CHOP is the only place in the country to go for lymphatics," says Bubba's dad, John, Lt. Colonel of the 225th Air Defense Squadron. "There aren't any other places that have committed the same amount of time and resources to solve this problem in children."

THE JILL AND MARK FISHMAN CENTER FOR LYMPHATIC DISORDERS

Bubba's family began to work with CHOP's lymphatics team to determine the best course of treatment. In the meantime, Bubba lived in a state of chronic illness, with little energy and no appetite, even for his favorite food, meat subs. "I could only get him to eat a few bites," says Bubba's mom, Cara. "That's how we were living: day by day, bite by bite."

Once Bubba's lymphatic intervention was scheduled, the family encountered many obstacles on Bubba's path to care, including COVID-19 and d-dimer levels (a marker for inflammation) far too high for Bubba to undergo surgery. "It was hard to deal with as a big family," says John, "but CHOP reinvigorated our hope. We knew Bubba could get better."

Finally, Bubba was cleared for surgery and the trip to CHOP was scheduled. Though John and Cara had both attended all four of Bubba's previous surgeries, the last several months of medical trauma had taken a toll on the family, and the couple decided that Cara would take Bubba alone. "I'm used to having John with me," says Cara, "but at that point, I would've walked to Philadelphia to get Bubba help."

Bubba underwent a lymphatic intervention with Yoav Dori, MD, PhD, Director of the Center for Lymphatic Disorders. This procedure included selective embolization to block the leaking lymphatic vessels. It took nearly ten hours, and the care team kept Cara informed with regular updates. Afterwards, Dr. Dori explained the intervention to Cara, drawing the lymphatic system for further illustration. "I asked him to autograph his drawing," laughs Cara. "He's my hero!"

An outpatient surgery nurse, Cara has high expectations of medical care and was impressed by the level of expertise with which the Cardiac Center nurses cared for Bubba. "They thought of things we needed before we knew we needed them," she says. "I felt like I could just be a mom and trust them to manage his care. The CHOP team held our hands through the whole experience. They helped heal our hearts, in so many ways."

Bubba spent nine days in recovery at CHOP; he was visited by Dilly, CHOP's full-time facility dog, and he loved making slime with his favorite child life specialist. When, during rounds, Bubba pulled up a chair so he could listen to the doctors talk about his care, Cara told them, "Guys, Bubba's back."

Follow-up echocardiograms at home in Portland have shown no further issues for Bubba. He's playing sports again, including baseball with his younger brother, and is back to eating his favorite foods. Thrilled that her son is getting back to a healthy weight, Cara says, "Every meal is a joyous occasion!"

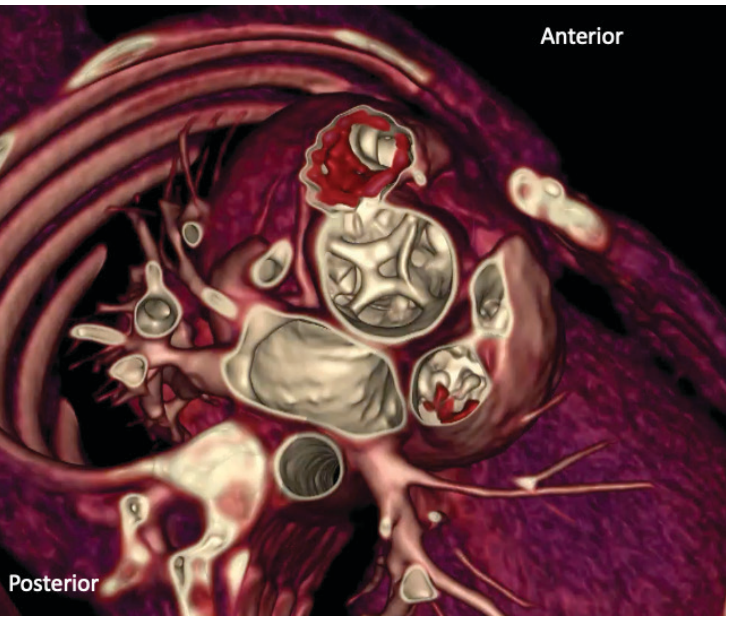
Adds John: "We're just so grateful that Dr. Dori and others saw a need to help kids like Bubba, who have already had so many heart surgeries. This experience affected every part of our lives, but we kept going and we tried to find joy every day. This was one chapter of Bubba's journey. Thanks to CHOP, we got through it, and we came out stronger on the other side."

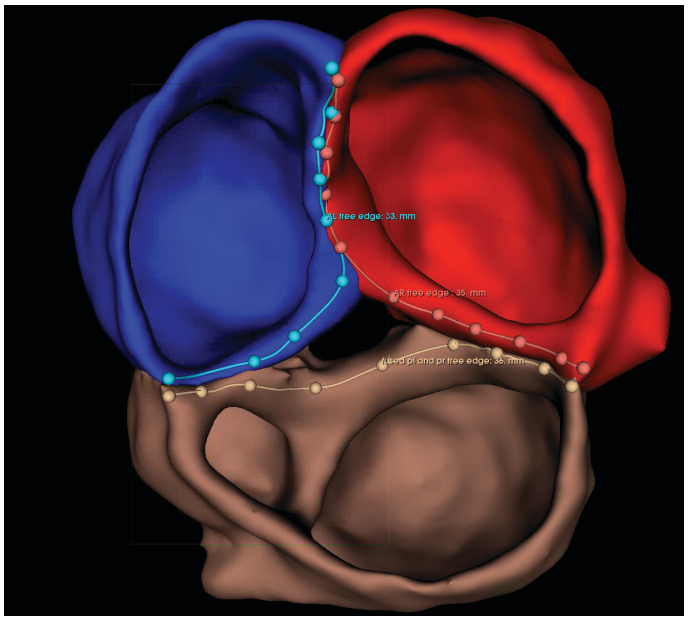
CENTER FOR PEDIATRIC HEART VALVE DISEASE

OVERVIEW

Established in 2020, the Center for Pediatric Heart Valve Disease has continued to grow and revolutionize the diagnosis and treatment of pediatric heart valve disease. Vital to this work has been the ongoing development of novel imaging technology in the three dimensional and virtual reality domains to help create innovative interventional strategies (surgery or catheter-based) for complex valve disorders. The clinical-translational research arm of the program focuses on fundamental mechanistic causes of valve degeneration as well as leverages evolving technology to better assess structural valve (dys)function and thereby potential for surgical repair.

In 2022, our investigators focused their efforts specifically on the creation of new advanced imaging platforms (with a program developed in Dr. Matthew Jolley's laboratory called SlicerHeart, an open source framework for visualization and quantification of cardiac images) to better assess aortic and neo-aortic valve incompetence. With a focus on truncal valve pathology, these techniques have guided several advanced truncal valve repairs using advanced techniques. This work has extended more recently to include atrioventricular valves.





The Pediatric Heart Valve Center was able to create new resources for families whose child has valve disease and are considering operative interventions. The content discusses (a) mechanical valves (b) aortic valve repair options and (c) the Ross procedure, and hopefully answers many of the concerns and/or questions your patients and families may have prior to meeting with our surgical faculty.

Click to view Options for Pediatric Heart Valve Repair on YouTube

CENTER FOR PEDIATRIC HEART VALVE DISEASE

LEADERSHIP

Jonathan Chen, MD
Principal Investigator
Cardiothoracic Surgery

Michael Quartermain, MD
Co-Lead Investigator
Cardiology
Echocardiology

Matthew Gillespie, MD
Co-Lead Investigator
Interventional Cardiology

Sara Baumgarten, BA
Program Manager

FACULTY

Matthew Jolley, MD
Collaborator
Cardiac Anesthesiology
Echocardiography

Lindsay Rogers, MD
Collaborator
Cardiology
Echocardiology

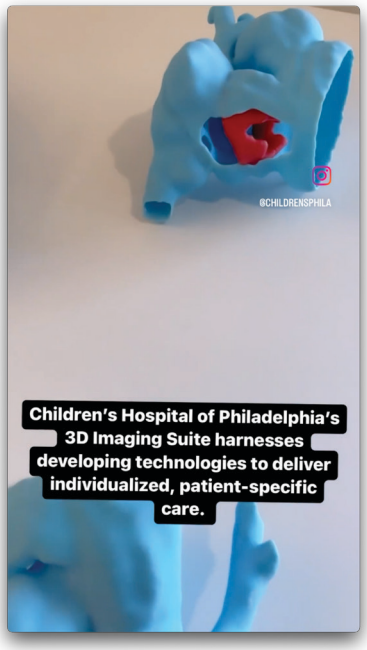
Muhammad Nuri, MD
Collaborator
Cardiothoracic Surgery

Robert Levy, MD
Collaborator
Cardiology/Research

OTHER KEY PERSONNEL

Keith Coleman BSN – Specialty Practice Nurse
Christian Herz – Software Engineer
Patricia Sabin – Jolley Lab Manager
Yan Wang – Project Lead Sonographer
Benjamin Pressly – Lab Tech
Steven Ching – Research Coordinator
Trevor Williams, MD
Jill Savla, MD
Therese Giglia, MD
Danish Vaiyani, MD
Devin Laurence, PhD – Postdoctoral Fellow
Nikia Toomey, PhD, MD
Ben Pressly – Research Tech
Silvani Amin – Research Assistant
Alana Cianciulli – Research Assistant
Hannah Dewey – Research Assistant

CENTER FOR PEDIATRIC HEART VALVE DISEASE

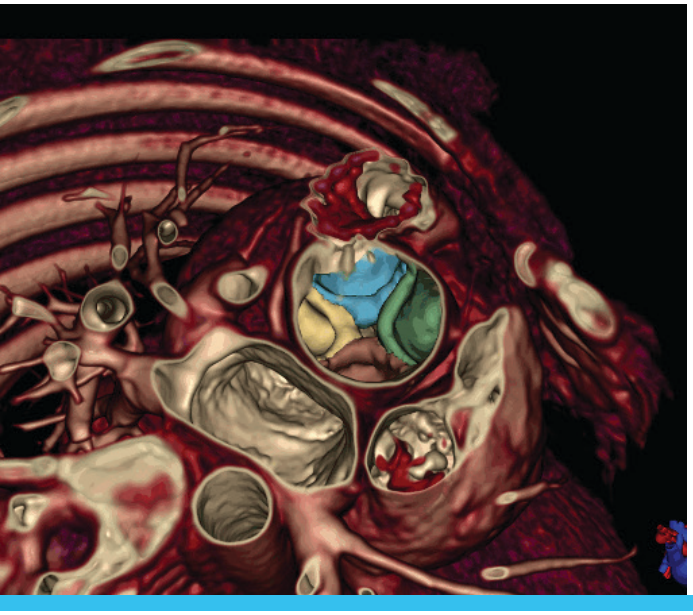


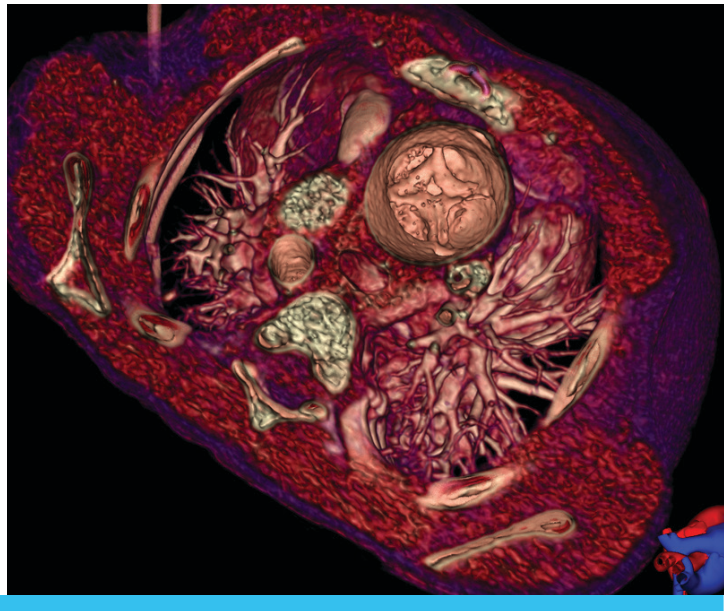
View reel on Instagram

The Valve Center has two primary laboratories for research. Dr. Levy's laboratory continues to examine the mechanism and potential targets for therapy of native and prosthetic valve calcification and degeneration, and had major publications in Science Translational Medicine and Proceedings of the National Academy of Sciences (PNAS). Dr. Jolley was awarded an NIH R01 grant to further evaluate the mechanisms of tricuspid valve insufficiency in children with hypoplastic left heart syndrome. His laboratory in addition is comprised of software engineers and analysts who are continually developing novel imaging techniques to better model structural valve disease and even allow for 'virtual repair' options prior to actual surgical intervention.

2022 VOLUME

2022 Calendar Year Referrals	55
Valve Surgeries	18
CTA	7
MRI	12
TTE/TEE	19
Cardiac Cath	2





CENTER FOR PEDIATRIC HEART VALVE DISEASE

Research Highlights from Dr. Robert Levy

Publication of our NIH and CHOP Frontier Heart Valve Center Serotonin Mitral Valve Program's results in *Science Translational Medicine* (publication listed below). This article was also the subject of an editorial in *Nature Cardiovascular Research* (https://doi.org/10.1038/s44161-023-00226-w).

Publication of our NIH and CHOP Frontier Heart Valve Center Bioprosthetic Heart Valve Program's results with two papers in *Proceedings of the National Academy of Sciences* and a publication in *Biomaterials*.

Primary Research Activities: Dr. Levy's group during 2022 was supported by three NHLBI R01 grants:

Oxidation-mediated structural degeneration of bioprosthetic heart valves (HL143008): This program investigates a novel failure mechanism that affects artificial heart valves, known as bioprostheses. Dr. Levy's group has discovered that oxidation related damage to bioprosthetic valve leaflets associated with protein deposits, occurs commonly and therapeutic strategies to prevent this are being studied.

Serotonin Signaling in Mitral Valve Homeostasis, Maintenance and Restoration (HL131872): Serotonin is a neurotransmitter that has been linked to heart valve disease through either rare forms of cancer or as a side effects of certain drugs. This NIH program investigates the idea that serotonin contributes to the progression of heart valve disease in general, and insights from the results may provide novel therapeutic targets.

Oxidation Resistant ApoA1 Gene Delivery Stents (HL137762): Dr. Levy's lab has been studying administration of gene therapy from stents since 2000, contributing the first paper in the field at that time. This phase of the program studies a novel therapeutic gene that enhances the function of high density lipoprotein (HDL).

Research Highlights from Dr. Matthew Jolley

Williams TR, Cianciulli AR, Wang Y, Lasso A, Pinter C, Pouch AM, **Biko DM**, **Nuri M**, **Quartermain MD**, **Rogers LS**, **Chen JM**, **Jolley MA**. Truncal Valve Repair: 3-Dimensional Imaging and Modeling to Enhance Preoperative Surgical Planning. Circ Cardiovasc Imaging. 2022 Dec;15(12):e014424. doi: 10.1161/CIRCIMAGING.122.014424. Epub 2022 Sep 12. PubMed PMID: 36093770; PubMed Central PMCID: PMC9772078.

Wu W, Ching S, Maas SA, Lasso A, Sabin P, Weiss JA, **Jolley MA**. A Computational Framework for Atrioventricular Valve Modeling Using Open-Source Software. J Biomech Eng. 2022 Oct 1;144(10). doi: 10.1115/1.4054485. PubMed PMID: 35510823; PubMed Central PMCID: PMC9254695.

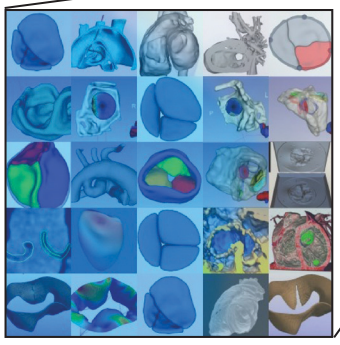
Lasso A, Herz C, Nam H, Cianciulli A, Pieper S, Drouin S, Pinter C, St-Onge S, Vigil C, Ching S, Sunderland K, Fichtinger G, Kikinis R, **Jolley MA**. SlicerHeart: An open-source computing platform for cardiac image analysis and modeling. Front Cardiovasc Med. 2022;9:886549. doi: 10.3389/fcvm.2022.886549. eCollection 2022. Review. PubMed PMID: 36148054; PubMed Central PMCID: PMC9485637.

Nam HH, Herz C, Lasso A, Cianciulli A, Flynn M, Huang J, Wang Z, Paniagua B, Vicory J, Kabir S, Simpson J, Harrild D, Marx G, Cohen MS, Glatz AC, **Jolley MA**. Visualization and Quantification of the Unrepaired Complete Atrioventricular Canal Valve Using Open-Source Software. J Am Soc Echocardiogr. 2022 Sep;35(9):985-996.e11. doi: 10.1016/j.echo.2022.04.015. Epub 2022 May 7. PubMed PMID: 35537615; PubMed Central PMCID: PMC9452462.

CENTER FOR PEDIATRIC HEART VALVE DISEASE

Scientist or artist - why not both? Research Assistant Alana Cianciulli brings an "artist's eye" to her science, which is grounded in her desire to help kids. Her mosaic, titled "The Big Picture of Pediatric Cardiac Research" and built upon her own artwork, is comprised of hundreds of images showcasing the Jolley Lab's research in patient-specific modeling and analysis of abnormal heart structures, demonstrating the integration of Alana's passion for art, science, and medicine.

More information about Alana and this artwork can be found here.



HEART FAILURE/ TRANSPLANT & ACT FRONTIER PROGRAM

OVERVIEW

The Cardiomyopathy, Heart Failure, Heart Transplant, and Ventricular Assist Device Program at CHOP had a very busy year in 2022, continuing in its mission to offer state-of-the art care to an ever-growing population of complex patients with heart failure. The Advanced Cardiac Therapies (ACT) Program, which includes new clinical and research initiatives for patients with heart failure, was funded by the Hospital's Frontier Programs initiative for a 3-year period and provides extensive resources for clinical and research program development. A major component of the ACT Frontier Program is the development of the ACT ICU, a dedicated intensive care unit for children experiencing heart failure and/or needing mechanical circulatory support with ventricular assist devices.

HIGHLIGHTS/ACCOMPLISHMENTS

In 2022, the Heart Transplant Program performed 13 heart transplants in patients with cardiomyopathy and congenital heart disease, including one patient who underwent re-transplantation. The use of ventricular assist devices continues to increase, with 33 devices implanted in 18 patients over the course of the year. These devices included the Impella, CentriMag, Berlin Heart, and HeartMate3, and patients with complex circulations including hybrid and Glenn physiology were successfully supported to transplantation. In November 2022, the ACT ICU opened. This unit is dedicated to the care of children with heart failure of diverse etiologies and includes care for children with ventricular assist devices and after heart transplantation. Patients in the ACT ICU benefit from a dedicated team of physicians and advanced practice providers with interest in the care of this patient population, as well as receiving intensive, in-place rehabilitation from our colleagues in the Physical Medicine and Rehabilitation Department.

HEART FAILURE/ TRANSPLANT & ACT FRONTIER PROGRAM

LEADERSHIP

Kimberly Lin, MD
Cardiomyopathy Program
Medical Director

Matthew O'Connor, MD
Heart Transplant Program
Medical Director

Katsuhide Maeda, MD, PhD
ACT Frontier Program
Principal Investigator

Joseph Rossano, MD
ACT Frontier Program
Principal Investigator

Aaron DeWitt, MD
ACT ICU Medical Director

Jonathan Edwards, MD
ACT Frontier Program
Co-Investigator

Zoltan Arany, MD, PhD
ACT Frontier Program
Co-Investigator

Daniel Kelly, MD, PhD
ACT Frontier Program
Co-Investigator

Farrell Weiss, MSN, CRNP
Clinical Program Manager

Sara Baumgarten, BA
Program Manager

Debra Lefkowitz, PsyD
Psychology

Charisse Rhone
Social Work

HEART FAILURE/ TRANSPLANT & ACT FRONTIER PROGRAM

FACULTY

Cardiology
Joseph W. Rossano, MD
Matthew J. O'Connor, MD
Kimberly Y. Lin, MD
Jonathan B. Edelson, MD
Carol A. Wittlieb-Weber, MD
Jonathan Edwards, MD
Justin Berger, MD PhD
Chitra Ravishankar, MD

Cardiothoracic Surgery
Katsuhide Maeda, MD
Jonathan Chen, MD
Stephanie Fuller, MD
Muhammad Nuri, MD
Constantine Mavroudis, MD
J. William Gaynor, MD

Cardiac Critical Care
Aaron DeWitt, MD
Benjamin W. Kozyak, MD

Physical Medicine and Rehabilitation
Sarah Evans, MD

Nursing/Advanced Practice Providers/ Allied Health Professionals
Lynne Ha, CRNP (Heart Transplant)
Carley Boyle, CRNP (Heart Transplant)
Erin Kramer, CRNP (Cardiomyopathy)
Rachel White, RN (Heart Transplant)
Farrell Weiss, MSN, CRNP
Jessica Eichner, CRNP
Katherine Montgomery, RN (VAD Coordinator)

PM&R Team
Sally Evans
Rachael Prendergast

ACT PT/OT Leads
Amanda Waples
Kristin Caputo
Sarah Stevens

PT/OT Team Members
Rebecca Hoffritz
Emily Roberts
Tabatha Rudzinski
Jordan Porter

Speech Therapy
Amy Colin
Julia Welc
Christina Minkoff

RESEARCH HIGHLIGHTS

The Cardiomyopathy, Heart Failure, Heart Transplant, and Ventricular Assist Device Program continues to be very active academically, with multiple publications and presentations at national and international meetings. In addition, a major component of the ACT-HF Frontier Program is support for research led by Drs. Jonathan Edwards and Zoltan Arany. Their research focuses on novel mechanisms of right ventricular failure in children with single ventricle congenital heart disease, with the objective of identifying novel mechanisms and pharmacological targets for therapy.

KEY 2022 PUBLICATIONS

Thangappan, Karthik., Zafar, Farhan., Lorts, Angela., Adachi, Iki., Rosenthal, David., Rossano, Joseph., Maeda, Katsuhide., Morales, David L S. MILESTONE: More Than 1,200 Children Bridged to Heart Transplantation with Mechanical Circulatory Support. ASAIO Journal. 2022, April. 68(4) P.577-583. DOI: 10.1097/MAT.0000000000001635. PMID: 35349524

Edwards JJ, **Edelson JB**, Mondal A, Katcoff H, Reza N, Griffis H, Burstein DS, **Wittlieb-Weber CA**, **O'Connor MJ**, **Rossano JW**, Ravishankar C, **Mascio C**, Birati EY, **Lin KY**. Impact of Age on Emergency Resource Utilization and Outcomes in Pediatric and Young Adult Patients Supported with a Ventricular Assist Device. ASAIO J. 2022 Aug 1; 68(8):1074-1082. doi: 10.1097/MAT.0000000000001603. Epub 2021 Nov 3. PMID: 34743138; PMCID: PMC9061895

HEART FAILURE/ TRANSPLANT & ACT FRONTIER PROGRAM

Mavroudis CD, **Edelson JB**, **Wittlieb-Weber CA**, **O'Connor MJ**, **Maeda K**. The innominate arteryto-pulmonary artery shunt as ventricular assist device outflow in hybrid stage one procedure with aortic coarctation. JTCVS Tech. 2022 May 14; 14:204-206. doi: 10.1016/j.xjtc.2022.05.005. PMID: 35967216; PMCID: PMC9366619

Burstein DS, **Rossano JW**, Lindenfeld J, Schlendorf KH, Do N, Godown J, **O'Connor MJ**, **Maeda K**, **Edelson JB**, **Lin KY**, Mazurek JA, Scholl SR, Menachem JN. Association of Donors with US Public Health Service Risk Criteria and Outcomes after Adult vs Pediatric Cardiac Transplant. JAMA Cardiol. 2022 Sep 21:e223070. doi: 10.1001/jamacardio.2022.3070. Epub ahead of print. PMID: 36129691; PMCID: PMC9494268

Nandi D, Auerbach SR, Bansal N, Buchholz H, Conway J, Esteso P, Kaufman BD, Lal AK, Law SP, Lorts A, May LJ, Mehegan M, Mokshagundam D, Morales DLS, **O'Connor MJ**, Rosenthal DN, Shezad MF, Simpson KE, Sutcliffe DL, Vanderpluym C, **Wittlieb-Weber CA**, Zafar F, Cripe L, Villa CR. Initial multicenter experience with ventricular assist devices in children and young adults with muscular dystrophy: An ACTION registry analysis. J Heart Lung Transplant. 2022 Sep 20:S1053-2498(22)02117-9. doi: 10.1016/j.healun.2022.09.003. Epub ahead of print. PMID: 36270923

FUTURE DIRECTIONS

In 2023, the Cardiomyopathy, Heart Failure, Heart Transplant, and Ventricular Assist Device Program continues to anticipate high patient volumes and acuity. The ACT ICU has been off to a great start and we are particularly proud of the collaborations with our colleagues in Physical Medicine and Rehabilitation to improve outcomes in our patients supported on ventricular assist devices. In early 2023, we implanted the first Berlin Heart device at CHOP using the new and improved "Active" driving unit as part of a nationwide study through the ACTION (Advanced Cardiac Therapies Improving Outcomes) Network.

HEART FAILURE/ TRANSPLANT & ACT FRONTIER PROGRAM

HEART TRANSPLANT: JAYDEN'S STORY

In the fall of 2021, 11-year-old Jayden started vomiting often — soon it was happening every day, sometimes more than once. "We took him to the E.R., to his primary care doctor," says his older brother Travis, who is Jayden's primary caregiver. "No one could figure out why. They were thinking it was a digestive issue."

It was a tough time. The brothers were still grieving their mother's death from cancer just a few months prior. Jayden's vomiting and stomach pain persisted for weeks. Then his legs began swelling. Jayden's primary care doctor was concerned about the swollen legs and ordered imaging. That's when it was discovered that his heart was enlarged.

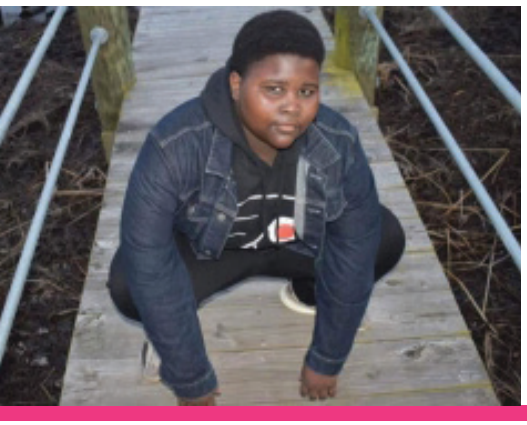
Jayden was diagnosed with cardiomyopathy, a disease of the heart muscle that makes it difficult for the heart to pump blood to the rest of the body. Cardiomyopathy can lead to heart failure. He was admitted to a local children's hospital and put on medications, but he didn't improve.

"The doctors met with us, and they mentioned transplant," says Travis. They suggested transferring Jayden to Children's Hospital of Philadelphia (CHOP), where the experts at the Heart Failure and Transplant Program have extensive experience treating heart failure in children of all ages.

"They've been an amazing team," Travis says of CHOP. "They explained everything about the procedure and what Jayden had to do to be in good enough health for a transplant." Jayden first underwent surgery in December 2021 to implant a left ventricular assist device, which is a pump that does most or all of the work of the heart.

After a few weeks, they received the call: a heart was available. Travis laughs with amazement about Jayden's reaction. "He was acting like he wasn't nervous — like just nonchalant. I asked him, 'How are you not afraid?' If that was me, hearing they're going to take my heart out, I wouldn't be that brave!" Travis thinks Jayden was taking after their late mother. "Mom had brain cancer and three operations, and she was always tough. He gets it from her."

The transplant surgery in February 2022 was successful, and Jayden's recovery has been steady. When it was time to go home, "They were great in training us," Travis says of the CHOP team, "and were always checking in on us." Jayden, now 12, was able to return to school near the end of the spring semester and was recently cleared to play sports. "We're getting back into a routine," Travis reports happily.



FONTAN **FORWARD**

PROGRAM

OVERVIEW

Today it is anticipated most individuals diagnosed with single ventricle malformation will survive surgical reconstruction through a successful Fontan operation. As greater numbers of patients survive, so has the recognition that individuals with Fontan circulation face a variety of challenges. The goal of a normal quality and duration of life will not be reached by all. The hurdles fall into a variety of domains. From a cardiovascular perspective, the Fontan circulation is fundamentally flawed by its inherent nature of creating a state of chronically elevated venous pressure and congestion, accompanied by a relatively low cardiac output. Ventricular dysfunction, atrioventricular valve regurgitation, and arrhythmia may directly impact cardiac performance and can progress with time. Problems are not limited to the cardiovascular system. Fontan circulatory physiology impacts a multitude of biological processes and health parameters outside the heart. The lymphatic circulation is under strain manifesting as variable degrees of protein rich lymph loss and immune system dysregulation.

Organ system dysfunction develops through altered perfusion profiles. Liver fibrosis is ubiquitous and a process of systemic fibrogenesis in response to circulatory stressors may affect other organs as well. Somatic growth and development can be delayed. Behavioral and mental health problems are common, presenting as clinically important levels of anxiety and depression. Most striking is the high variability in prevalence and magnitude of these complications within the population.

The Children's Hospital of Philadelphia has always been and continues to be a leader and pioneer in the care of single ventricle and Fontan patients. To care for and manage the emerging complications in this unique population, we created the first of its kind multidisciplinary model of Fontan care in 2011 and then expanded and rebranded this program in 2019 to the Fontan FORWARD Program. The "Fontan rehabilitation, wellness and resilience development" or FORWARD Program is a unique multidisciplinary clinic combining the expertise of dedicated clinical providers in the realms of cardiology, hepatology, endocrinology, immunology, psychology, exercise physiology, dietary and nutritional science, and social work. The CHOP Cardiac Center FORWARD Program is now a model that many other centers have emulated to provide specialized care specific to the growing number of individuals with Fontan circulation.

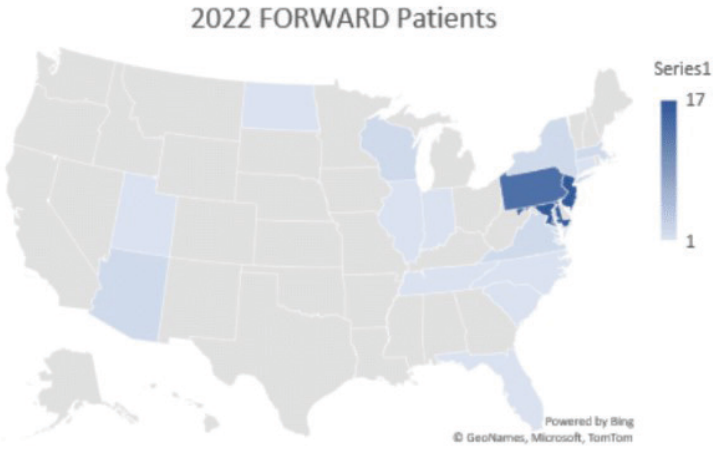
The FORWARD program is led by Dr. Jack Rychik, Medical Director, and Katie Dodds, MSN, Clinical Program Manager and supported by an exceptional team of experts experienced and dedicated to advancing knowledge and providing care to individuals with single ventricle and Fontan circulation.

METRICS

The Program Volume in 2022 included:

Total Multi-Specialty Visits 49
Total Targeted Visits 54

Total Patients 103
Follow Ups 64
New Patients 39



FONTAN **FORWARD**

PROGRAM

LEADERSHIP

Jack Rychik, MD
Medical Director

Katie Dodds, MSN, CRNP
Clinical Program Manager

Dave Goldberg, MD

Nancy Ebaid
Program Coordinator

FACULTY/TEAM

Jack Rychik, MD,
Medical Director
Cardiology

Kathryn M. Dodds, MSN,
Clinical Program Manager
Cardiology

Sara Baumgarten,
Administrative Program Manager
Cardiac Center

David J. Goldberg, MD,
Cardiology

Elizabeth Rand, MD,
Gastroenterology & Hepatology

Edna E. Mancilla, MD,
Endocrinology

Jennifer Heimall, MD,
Immunology

Nicholas Seivert, PhD,
Psychology

Danielle Campbell, MS, RD, LDN,
Clinical Nutrition

Shannon O'Malley, MS,
Exercise Physiologist

Lynn Callaway, MSW, LSW
Social Work

Left to Right:
Jack Rychik, MD
Kathryn Dodds, MSN
Shannon O'Malley, MS
Danielle Campbell, MS, RD, LDN
Elizabeth Rand, MD
Lynn Calloway, MSW, LSW
Edna Mancilla, MD
Nick Seivert, PhD
Jennifer Heimall, MD

Not shown here:
Dave Goldberg, MD
Sara Baumgarten
Nancy Ebaid

FONTAN **FORWARD**

PROGRAM

HIGHLIGHTS/ACCOMPLISHMENTS

Since inception over 11 years ago, the FORWARD clinic has cared for and evaluated over 700 patients with single ventricle Fontan circulation and their families. FORWARD is the first in the nation program dedicated to the multidisciplinary care of patients with Fontan circulation and their families. As such, the FORWARD program has become the model very much emulated by other centers around the world, focused on the unique care needs of these individuals.

Specific accomplishments include:

- Promoting the standard for testing and surveillance evaluations that are uniquely age based for those with Fontan circulation.
- Creating mechanisms for targeted serial follow up surveillance of patients who have undergone initial comprehensive evaluation, thus creating greater opportunities for patients and families to be seen and continue targeted care within the FORWARD clinic service model.
- Increasing surveillance strategies to younger and younger patient populations starting at 2-3 years following Fontan operation [ages 5-6 and above]
- Providing standards and modeling protocols for creation of a nation-wide registry on surveillance of individuals with Fontan circulation through creation and leadership of the "Fontan Outcomes Network."
- Creation of a unique 18-minute patient and family based educational video to introduce the concepts, challenges and hurdles of living with single ventricle and a Fontan circulation.
- Publication of a comprehensive review that shares insights and "pearls of wisdom" into the development of the FORWARD program and its unique care models [Rychik J, Goldberg DJ, Rand E, Mancilla EE, Heimall J, Seivert N, Campbell D, O'Malley S, Dodds KM. A Path FORWARD: Development of a Comprehensive Multidisciplinary Clinic to Create Health and Wellness for the Child and Adolescent with a Fontan Circulation. Pediatr Cardiol. 2022 Aug;43(6):1175-1192]

RESEARCH HIGHLIGHTS

The FORWARD group is actively involved and in the forefront of several research activities in areas that include:

- Understanding the origins of liver fibrosis and other organ fibrogenesis in the Fontan circulation
- Determining the genetic basis to fibrogenesis in the Fontan circulation
- Exploring the pathophysiology of Fontan associated liver disease through study of nearly 200 patients with liver biopsy specimens and cardiac catheterization data and comprehensive characterization of FORWARD surveillance testing
- Identifying optimal tools such as 3D MRI and other techniques to best quantify Fontan-associated liver disease
- Investigating the magnitude of somatic growth limitations and association with Vitamin D deficiency and parathyroid hormone dysregulation in the Fontan circulation
- Exploring relationships between Fontan clinical and emotional wellness such as the role of exercise in both clinical and psychological wellbeing.

FONTAN **FORWARD**

PROGRAM

FUTURE DIRECTION

The FORWARD program continues to innovate and lead the congenital heart community in developing optimal strategies of care and management to allow for creation of a normal quality and duration of life for individuals with Fontan circulation.

Specific areas of future focus include:

- Understanding the relationship between emotional health challenges and physiological limitations of the Fontan circulation
- Targeted therapy of poor growth through careful initiation of individualized strategies of care (eg. nutrition, selective use of growth hormone, etc)
- Evolution and development of detailed database characterization of patients including creation of electronic healthcare record methods for automation and potential ease of data collection.
- Continued leadership and direction of the Fontan Outcomes Network database registry and quality improvement initiative for those with Fontan circulation
- Development of specific age-based video demonstrations of recommended exercise activities for those with Fontan circulation
- Wide-spread utilization of our Fontan circulation educational video and further enhancement of patient and family-based educational programs

DIVISIONS AND CLINICAL PROGRAMS

2022 Cardiac Center Annual Report

DIVISION OF CARDIOTHORACIC SURGERY

INTRODUCTION

The CHOP Division of Cardiothoracic Surgery remains one of the highest volume centers in North America, performing over 500 open cardiac procedures and more than 1000 total cases each year at both CHOP and the Hospital of the University of Pennsylvania (where we perform approximately 60 adult congenital heart disease (ACHD) operations annually). Our cases cover the full spectrum of cardiac surgery, including fetal interventions, neonatal reconstruction, thoracic organ transplantation, mechanical circulatory support, lymphatic procedures, complex aortic arch reconstruction and management of adults with congenital heart disease. The division is consistently the third busiest program in the country by volume, but most notably the highest volume program for neonatal bypass and neonatal total cases.

Our overall STS reported STAT mortality in 2022 was 2.22% for Benchmark Procedures and 2.15% for all STAT Procedures), despite our case mix favoring more complex procedures. Our group continues to explore new surgical solutions to complex problems including lymphatic surgical decompression, complex valve repair, innovative mechanical assist alternatives and two-ventricle conversions. In collaboration with our newest member of the Interventional Cardiology team, Dr. Ryan Callahan, our surgeons are part of a new pulmonary vein disease intervention program, specializing in the development of innovative surgical and transcatheter approaches to this high-risk problem.

Our team includes nine Cardiac Perfusionists who help to drive program initiatives in blood conservation surgery, minimization of cardiopulmonary bypass technology, and advanced short and long-term mechanical circulatory support. Our Chief of Perfusion, Tami Rosenthal, is the current President of the American Society of Extracorporeal Technology (AmSECT). Our team of physician assistants contribute to the pre-operative, intraoperative and postoperative care of our patients, with each focusing their academic work within subspecialty sections of the Cardiac Center.

DIVISION OF CARDIOTHORACIC SURGERY

LEADERSHIP

Jonathan Chen, MD
Chief, CT Surgery Division

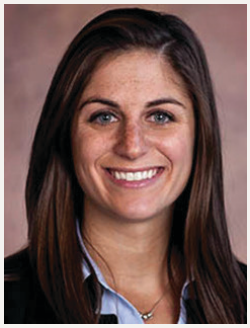
Stephanie Fuller, MD

J. William Gaynor, MD

Katsuhide Maeda, MD, PhD

Constantine D. Mavroudis, MD, MSc, MTR

Muhammed Nuri, MD



Ellen Cannon, MHS, PA
Lead Physician Assistant

Jillian Bacher, RN, BSN
Lead OR Nurse

Nancy Burnham, CRNP, MSN, CCRC
Research Nurse

Debbie McGlinn
Administrative Manager

DIVISION OF CARDIOTHORACIC SURGERY

PHYSICIAN ASSITANT TEAM


Sarah Bond, MS, PA-C


Christy Bosler, MS, PA-C


Laura Murphy, PA-C


Kaitlyn Rubnitz, PA-C


Mikayla Pirrera, PA-C


Melissa Damiano, PA-C


Elizabeth Trovato, MS, PA-C


Christine Welch, PA-C


Kristen Young, PA-C


Taylor Zulli, MS, PA-C

DIVISION OF CARDIOTHORACIC SURGERY

Tami M. Rosenthal, MBA, CCP, LP, FPP
Chief Perfusionist

PERFUSION

The Perfusion team is currently a team of 9 full time and 6 per diem pediatric perfusionists. The Perfusion team supports all cardiac surgery cases in the cardiac OR with cardiopulmonary bypass support and point of care testing. In the CICU and the CCU, the Perfusion team supports all mechanical support and cardiac ECMO patients with initiation of support, in-hospital transport, troubleshooting and clinical education. Members of the Perfusion team are active in professional organizations-The American Society of Extracorporeal Technology, The American Academy of Cardiovascular Perfusion, and the Pennsylvania State Perfusion Society. The team presents current topics in Perfusion at national and international perfusion and cardiac surgery conferences.

PERFUSION TEAM

Justin Farr, CCP, LP

Hannah Tecson, CCP, LP

Richard Melchoir, BS, MPS, CCP, LP, FPP

Brandon Shade, MPS, CCP, LP

Kellie Shiavo, BS, CCP, LP, FPP

Molly Dreher, BSE, BS, CCP, LP

Min-ho Lee, PhD, CCP

Alex Chappell, CCP, LP

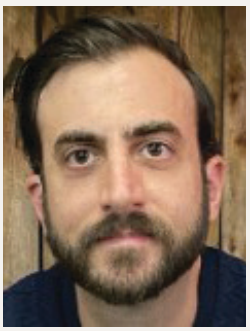
DIVISION OF CARDIOTHORACIC SURGERY

PERFUSION TEAM (continued)

Celia Gagnon, CCP, LP, MLS(ASCP)

Krysta Parker, DBA, MBA, MS, CCP, FPP

John Kernan, CCP



Marc DeCarlo, CCP, LP

DIVISION OF CARDIOTHORACIC SURGERY

OR NURSING

The Cardiothoracic Operating Nursing Team currently consists of fourteen full-time nurses. The nursing team supports all complex cardiac and thoracic surgical procedures on the 6th floor, as well as general and lymphatic cases that require cardiac support and bedside procedures in the CICU. As a team who is on the periphery, a general highlight is to witness a successful and smooth heart transplant for any one of our patients.

The Cardiac OR Team is comprised of nurses who demonstrate a commitment to upholding standards in patient safety by being certified in perioperative nursing (CNOR) and following the Association of perioperative Registered Nurses (AORN) guidelines. Several team members participate in organizational councils and are active members in shared governance committees. We continue to grow our team, as growth within the cardiac center continues.

OR NURSING TEAM


Jessica Bilbow, RN, BSN


Jean Ennis, RN

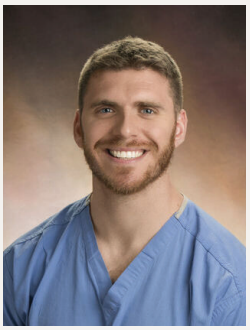

Marie Galvin, RN, BSN


Carly Glover, RN, BSN


Gail Keyser, RN


Sageeb Khan, RN, BSN


Dallas Lupo, RN, BSN


Kevin McLane, RN, BSN

DIVISION OF CARDIOTHORACIC SURGERY

OR NURSING TEAM (continued)


Deborah Slutter, RN


Emily Smith, RN, BSN


Robert Tomlinson, RN


John Vallieres, RN, BSN


Christopher Wainwright, RN

RESEARCH HIGHLIGHTS

The research efforts of the Division are focused in several areas: 1. Long term outcomes after the Norwood procedure and alternative surgical approaches for babies with hypoplastic left heart syndrome and advanced surgical risk. The CHOP cohort is the largest single institution cohort in existence. 2. The Birth Defects Biorepository to facilitate research into the causes and outcomes of babies born with birth defects. 3. The impact of chemical exposures during medical care and childhood on neurodevelopmental outcomes in children with congenital heart disease. 4. Fetal neuroprotection and neuroplasticity. 5. Mitochondrial dysfunction with deep hypothermic circulatory arrest. 6. Genetic modifiers of survival after cardiac surgery in newborns and infants. 7. The development of animal models of lymphatic failure and creation of novel procedures for lymphatic decompression. 8. The development of animal models for single ventricle circulatory collapse and mechanical assistance.

This has been a productive research year for the Division of Cardiothoracic Surgery. Abstracts based on our research efforts were presented at the annual meetings of the American Heart Association, European Association for Cardiothoracic Surgery (EACTS), and the Society of Thoracic Surgeons. Four additional abstracts have been accepted for presentation at the annual meeting of the American Association for Thoracic Surgery. Our abstract describing the impact of cardiopulmonary bypass (CPB) on cerebral mitochondrial function was awarded the Outstanding Research Award for Congenital Heart Surgery at EACTS. We have initiated a project to contact all adult survivors of the Norwood procedure at CHOP; this will be the largest single institution cohort in existence. Dr. Fuller is leading several projects to investigate the outcomes and current status of adults with all forms of CHD.

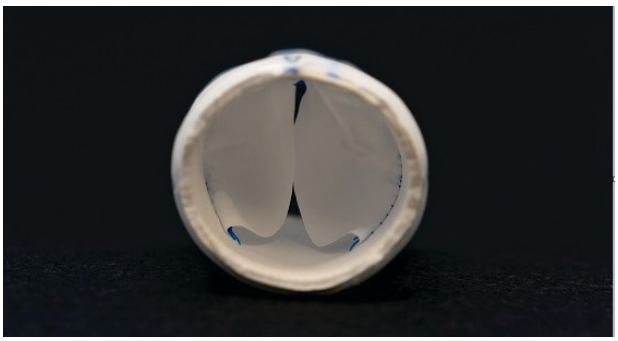
DIVISION OF CARDIOTHORACIC SURGERY

RESEARCH HIGHLIGHTS (continued)

Dr. Mavroudis is continuing to collaborate with Dr. Todd Kilbaugh in Anesthesia and Critical Medicine examining a neonatal model of cardiopulmonary bypass to investigate factors associated with brain injury and to develop novel therapies. Dr. Mavroudis is also the recipient of a two-year research award for his project entitled "The effect of preoperative cyanosis on cerebral mitochondrial function following cardiopulmonary bypass and neuroprotective perfusion strategies in neonatal swine" from The Thoracic Surgery Foundation. Dr. Gaynor is collaborating with The Centers for Disease Control on a project examining exposure to volatile organic compounds in neonates undergoing heart surgery. Dr. Maeda is working with Dr. Yoav Dori to develop novel surgical strategies to effectively treat lymphatic failure and provide relief from its clinical manifestations by promoting sustained decompression of the lymphatic circulation.

Dr. Gaynor continues to serve as Co-PI of the Birth Defects Biorepository (BDB), which is a unique resource focusing on the maternal-fetal relationship with whole genome sequencing of family trios during pregnancy and longitudinally thereafter. The BDB began recruiting subjects in June 2019, and to date has enrolled over 900 babies with birth defects and over 2,400 total subjects (including family members). Whole genome sequencing has been completed in over 1,800 subjects.

Finally an exciting new project is being lead at CHOP by Dr. Maeda. We will be participating in a multi-institutional human trial to evaluate an innovative valved conduit developed by PECA Labs. The MASA Valve is a novel, ePTFE based, bi-leaflet valve for Right Ventricular Outflow Tract (RVOT) Reconstruction. [figures below]



FELLOWS IN THE DIVISION OF CARDIOTHORACIC SURGERY

Garret Coyan, MD received his medical degree from the University of Kansas where he additionally received an MS in clinical/translational research. He then joined the University of Pittsburgh as an integrated cardiothoracic surgery resident and completed a 2-year postdoctoral fellowship in cardiovascular device engineering at the McGowan Institute for Regenerative Medicine. While in residency training, Dr. Coyan authored over 40 publications, submitted 3 U.S. patents and founded 2 medical device companies; he currently serves as the president of the Thoracic Surgery Resident Association (TSRA).

Yasin Essa, MD began his non-ACGME Congenital Cardiac Fellowship in October 2021, having trained in Bad Oeynhausen, Germany, the Mayo Clinic, and Children's National Medical Center in Washington, DC. Dr. Essa is a native of Libya.

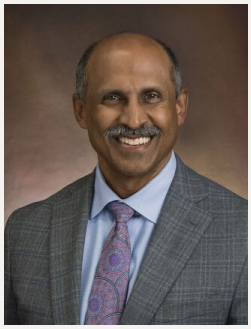
DIVISION OF CARDIOLOGY

OVERVIEW

The Division of Cardiology, founded in 1947 by Rachel Ash, MD who was the first cardiologist at CHOP, is now one of the largest clinical divisions within the Department of Pediatrics with over 80 faculty members. With a long commitment to innovation, the Division is internationally recognized as a premier institution for pediatric cardiac care, research, and education. Over the last two decades, the Division has seen tremendous growth in research, clinical services, training programs, and community outreach. Our specialty programs are described later in this document in more detail.

SENIOR LEADERSHIP

Joseph Rossano, MD
Chief, Division of Cardiology



Vivek Allada, MD
Associate Chief
Community Cardiology
and Outreach

Meryl Cohen, MD
Associate Chief
Education

Chitra Ravishankar, MD
Associate Chief
Inpatient Cardiology

Jonathan Rome, MD
Associate Chief
Clinical Affairs

Jack Rychik, MD
Associate Chief
Academic Affairs

Lawrence Barnes
Senior Administrative Director,
Division of Cardiology

DIVISION OF CARDIOLOGY

HIGHLIGHTS & ACCOMPLISHMENTS

- Dr. Catherine Avitabile was elected as a Member to the Society of Pediatric Research.
- Dr. David Frank was awarded Young Physician Scientist Award by The American Society for Clinical Investigation.
- Dr. Meryl Cohen was appointed Associate Dean of Faculty Development at the University of Pennsylvania.
- Dr. Robert Palermo was awarded Lifesaving and Meritorious Actions by Catasauqua School District for helping a patient newly diagnosed with hypertrophic cardiomyopathy after a cardiac arrest at school.
- Dr. Amy Scholtz was awarded State of Washington Governor's Commendation for creation and operation of Washington State Critical Congenital Heart Disease Newborn Screening Program.
- Dr. Matthew Elias worked as a leader on COVID-19 Vaccinations being safe for children with a history of multisystem inflammatory syndrome (MIS-C).
- Dr. Paul Stephens was awarded the Cardiac Center Distinguished Achievement Award at the 2022 CHOP Cardiology Conference.
- Dr. Jill Hsia received top rated Oral Abstract at Pediatric Cardiac Intensive Care Society Meeting on her study "Risk Factors for Electroencephalographic Seizures in Neonates following Cardiac Surgery."
- Dr. Rachel Shustak was an American Heart Association Young Investigator Finalist.
- Dr. Therese Giglia and her Infant Single Ventricle Monitoring Program was recognized for their efforts improving infant mortality. CHOP Cardiology has the highest interstage volume with the lowest infant mortality.
- Dr. Chitra Ravishankar was awarded the Physician Partnering award from CHOP.
- Dr. Victoria Vetter was the lead study author for a publication in the Journal of the American College of Cardiology focusing which showed that States with laws that require CPR training in schools have higher rates of bystander CPR. The study is the first to compare rates of bystander CPR in states that have and have not enacted CPR education laws. The results hope to encourage more states to pass laws focused on mandatory CPR education laws.
- The Division of Cardiology hosted two visiting professors for a week, who were invited by Dr. Meryl Cohen in 2022. They each spent a week advancing their skills and knowledge with our faculty.
  - Dr. Endale Tefera delivered a lecture on "Global Pediatric Cardiac Care: Sub-Saharan Perspective".
  - Dr. Andrew Cook delivered a lecture on "HIPCT & Congenital Heart Disease to faculty, "Andersonian Morphology 101" to Cardiology Fellows, and "Morphology of Ventricular Septal Defects: Borders and Geography" during Pathology Conference.
- Dr. Maully Shah, her son, and strangers helped rescue an injured hiker in Boston by providing medical care and hours long mountain descend on a stretcher to meet the transport helicopter.

DIVISION OF CARDIOLOGY

NEW RECRUITS

The Division continued to grow substantially with nine new recruits who started in 2022 and several anticipated in 2023.

Started in 2022:

- Marie Carillo, MD – Outpatient, South New Jersey
- Meghan Metcalf, MD – Outpatient, South New Jersey
- Ryan Callahan, MD – Pulmonary Vein Stenosis, Interventional Cardiology
- Andrea Jones, MD – Pulmonary Hypertension
- Yalile Perez, MD – Outpatient, Allentown
- Danish Vaiyani, MD - CMRI
- Jessica Tang, MD – Interventional Cardiology
- Rachel Shustak, MD – Preventive Cardiology, Lymphatics
- James Starc, MD– Outpatient

Starting in 2023:

- Humera Ahmed, MD – Heart Failure/Transplant

The Division of Cardiology continues to grow – now with 86 physicians. in the Division. With clinics at the main campus and at 13 outpatient locations, the Center sees over 35,000 visits annually, performs over 30,000 echocardiography studies, over 1,000 cardiac MRI studies and over 1,400 cardiac catheterizations. Details and more statistics can be found later in this report in each specialty section.

- Continued excellence in clinical, basic, and translational research with over 210 publications (see full list of publications in the research section of this report)

- Preeminent clinical programs including Cardiomyopathy, Heart Failure, and Transplantation which was recently awarded a Frontier Program by CHOP, the third Frontier Program in the Cardiac Center, joining the Jill and Mark Fishman Center for Lymphatic Disorders and the Pediatric Heart Valve Center.

- The Pulmonary Vein Stenosis Program launched in 2022, with Dr. Ryan Callahan as Director for individualized therapies with patients with pulmonary vein stenosis. The program offers innovative interventional techniques and the latest medical therapies to improve the outlook for children with PVS (Pulmonary Vein Stenosis).

- Strong commitment to education with top ranked cardiology training program and advanced fellowship in cardiac catheterization, electrophysiology, advanced imaging including MRI, lymphatic system diagnostic and intervention, and adults with congenital heart disease.

- T32 research training program that has provided excellent training for post-graduate fellows for over 20 years. Currently there are 18 fellows plus 5 advanced 4th year fellows in the program. The fellows participated in numerous research activities including numerous publications in major journals, abstracts and poster sessions including at the AHA (American Heart Association) Scientific Sessions

DIVISION OF CARDIOLOGY

FELLOWSHIP HIGHLIGHTS

Dr. Lindsay Rogers was appointed Director of Pediatric Cardiology Fellowship Program and Dr. Christopher Janson was appointed the Associate Director of Pediatric Cardiology Fellowship Program in 2022.

CURRENT CARDIOLOGY FELLOWS

First Year	Second Year	Third Year	Graduated June 2022	Fourth Year Advanced Fellows
Elizabeth Carter	Anila Chaudhary	Ivor Asztalos	Sheri Balsara	Sheri Balsara
Rodrigo Cardoso Cavalcante	Marc Delaney	Jill Hsia	Ari Gartenberg	Alicia Kamsheh
Ehssan Faraj	Rebecca Moore	Rebecca Josowitz	Alicia Kamsheh	Ari Gartenberg
Avital Ludomirsky	Maria Niccum	Jeremiah Joyce	Mudit Gupta	Kate Restaino
Andrew Freddo	Ilana Schwartz	Jacquelin Morrison	Travus White	Trevor Williams
Emily Olson	Helen Stanley	Scott Weinreb	Trevor Williams	Mudit Gupta

2022 Ann Newman Fellow: Jill Hsia, MD
2022 Ann Newman Lecturer: Roberta Williams, MD

"Building Bridges: Structures to Promote Successful Transition of Patients with Chronic Disease"

OUTPATIENT CARDIOLOGY

OVERVIEW

The Division of Cardiology's Outpatient program represents the Cardiac Center face to the community for patients, families, our referring providers and hospitals. The vision is simply "***best care for all children.***" This vision is achieved by giving the community *access* to the world class *services* provided by clinicians of the Cardiac Center and be an integral part of the CHOP Cardiac Center Regional Network.

LEADERSHIP

Outpatient Leadership Team provides comprehensive oversight for the entire CHOP Cardiology Outpatient regional clinics, labs and programs. This leadership team is charged with overseeing one of the largest outpatient cardiology services in the country and creating a programmatic approach to Outpatient Cardiology similar to other cardiology specialties and includes sections in clinical operations, education, quality/research and wellness.

SENIOR LEADERSHIP

Vivek Allada, MD
Medical Director, Outpatient and Community Cardiology

Matthew Elias, MD
Medical Director, Pennsylvania Cardiology Satellite Operations

Aaron Dorfman, MD
Medical Director, New Jersey Cardiology Satellite Operations

Amy Schultz, MD
Director of Outpatient Cardiology Quality

Carol Wittlieb-Weber, MD
Cardiac Center Physician Wellness Lead

Nursing/Managers

- Lisa Mitchell, RN: Subspecialty Practice Nurse Manager
- Mychele King: Cardiology Physician Practice Manager
- Kristen Smith, MHA, Physician Practice Manager
- Jessica Macker: Practice Manager – Allentown
- Kim Perry: Practice Manager – SPUH
- Leigh Ann Slimm: Practice Manager – Voorhees
- Lauren Zimmerman: Program Manager – CKDP

Cardiology Labs

- Mike McBride: Senior Director Cardiac – EKG, Echo, and Exercise Lab
- Christine Pascua, Program Director – Cardiac Echo Lab
- Michael Convery: Program Manager – Cardiac Echo Lab
- Jill Combs: Program Manager – Fetal Heart Program

Business/Practice Management

- Lawrence Barnes: Senior Administrative Director – Division of Cardiology
- Erin Rissler: Business Manager
- Carl Summers: Senior Business Manager

OUTPATIENT CARDIOLOGY

CHOP OUTPATIENT CARDIOLOGY LOCATIONS:

Main Hospital Clinic
(General Cardiology and Specialty Clinics)
3500 Civic Center Blvd.
12th floor Buerger Building
Philadelphia, PA 19104

SATELLITE LOCATIONS

PENNSYLVANIA:

- Abington Specialty Care Center, 1840 Susquehanna Rd Abington, PA 19001
- Allentown Pediatric Cardiology Practice, 1605 N. Cedar Crest Blvd., Ste 117, 119, Allentown, PA 18104
- Brandywine Valley Specialty Care Center, 819 Baltimore Pike, Glen Mills, PA 19342
- Bryn Mawr Specialty Care Center, 135 S. Bryn Mawr Ave, Suite 240, Bryn Mawr, PA 19010
- Bucks County Specialty Care Center, 500 W. Butler Ave., Chalfont, PA 18914
- Exton Specialty Care Center, 481 John Young Way, Oaklands Corporate Center, Exton, PA 19341
- King of Prussia Specialty Care Center, 550 South Goddard Blvd., King of Prussia, PA 19406
- Lancaster Specialty Care Center, 2106 / 2110 Harrisburg Pike, Lancaster, PA 17601

NEW JERSEY

- Atlantic County Specialty Care Center, 4009 Black Horse Pike, Mays Landing, NJ 08330-3133
- Princeton Specialty Care Center at Plainsboro, 101 Plainsboro Road, Plainsboro, NJ 08536
- St. Peters Hospital Cardiology Practice, 254 Easton Ave., Med Office Bldg, 2nd Fl, New Brunswick, NJ 08903
- Virtua Hospital, 200 Bowman Drive, Health & Wellness Center, 2nd Fl, Ste D260, Voorhees, NJ 08043
- Voorhees Specialty Care Center, 1012 Laurel Oak Rd, Laurel Oak Corporate Center, Voorhees, NJ 08043

OUTPATIENT

CARDIOLOGY

COMMUNITY HOSPITAL OUTREACH PROGRAM:

The Division of Cardiology Faculty also provides consultation services and provide echocardiography services at several community hospitals throughout Pennsylvania and New Jersey. Currently, this includes remote consults in neonatal intensive care units, newborn nurseries, emergency departments and for inpatient infants and children at thirty-three hospitals throughout eastern Pennsylvania and New Jersey:

PENNSYLVANIA:

- Chester County Hospital - 701 E Marshall St, West Chester, PA 19380
- Chestnut Hill Hospital - 8835 Germantown Ave, Philadelphia, PA 19118
- Doylestown Hospital - 595 W State St, Doylestown, PA 18901
- Einstein Montgomery - 559 W Germantown Pike, East Norriton, PA 19403
- Grand View Hospital - 700 Lawn Ave, Sellersville, PA 18960
- Holy Redeemer Hospital - 1648 Huntingdon Pike, Meadowbrook, PA 19046
- King of Prussia Hospital - 550 S Goddard Blvd North Entrance, King of Prussia, PA 19406
- Lancaster General Hospital - 555 N Duke St, Lancaster, PA 17602
- Lancaster Women & Babies Hospital - 690 Good Dr, Lancaster, PA 17601
- Main Line Health Lankenau Medical Center - 100 E Lancaster Ave, Wynnewood, PA 19096
- Main Line Health Bryn Mawr Hospital - 130 S Bryn Mawr Ave, Bryn Mawr, PA 19010
- Main Line Health Paoli Hospital - 255 W Lancaster Ave, Paoli, PA 19301
- Main Line Health Riddle Hospital - 1068 W Baltimore Pike, Media, PA 19063
- Hospital of the University of Pennsylvania - 3400 Spruce Street, Philadelphia, PA 19104
- Pennsylvania Hospital - 800 Spruce St, Philadelphia, PA 19107
- Lehigh Valley Health system, including
  - Lehigh Valley Hospital - Allentown - 1200 S Cedar Crest Blvd, Allentown, PA 18103
  - Muhlenberg
  - Pocono
  - Hazelton
  - Schuylkill
- St Luke's Hospitals (Allentown, Bethlehem, Anderson)
- St. Mary Medical Center – 1201 Langhorne-Newtown Rd, Langhorne, PA 19047

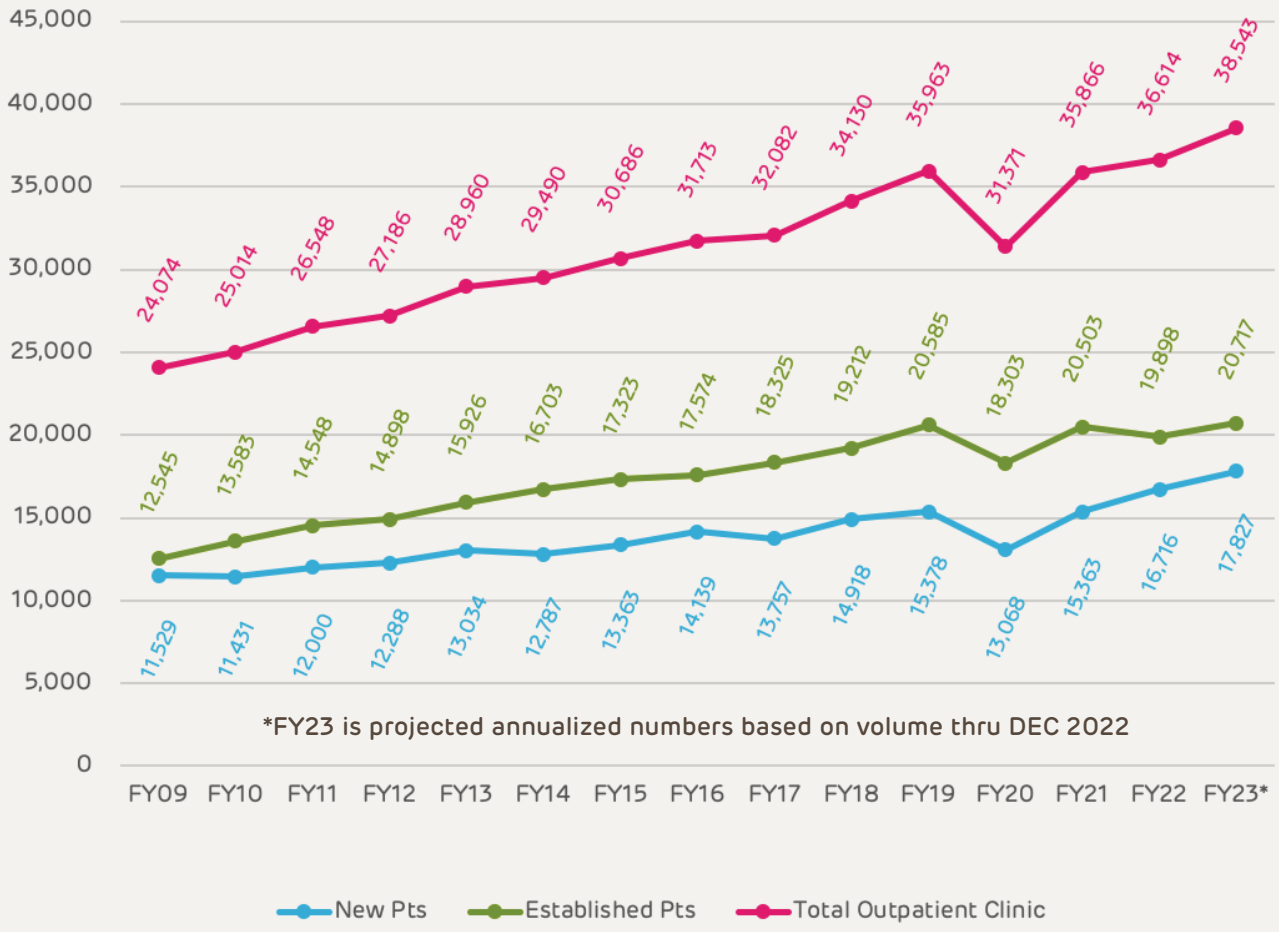
NEW JERSEY:

- AtlantiCare Medical Center, City Campus – 1925 Pacific Ave, Atlantic City, NJ 08401
- AtlantiCare Medical Center, Mainland - 65 W Jimmie Leeds Rd, Pomona, NJ 08240
- Cape Regional Medical Center – 2 Stone Harbor Blvd, Cape May Court House, NJ 08210
- Penn Princeton Medical Center – 1 Plainsboro Rd, Plainsboro, NJ 08536
- St. Peters University Hospital – 254 Easton Ave, New Brunswick, NJ 08901
- Virtua Health System
  - Our Lady of Lourdes Hospital – 1600 Haddon Ave, Camden NJ 08103
  - Voorhees Hospital – 100 Bowman Ave, Voorhees, NJ 08043
  - Marlton Hospital – 90 Brick Road, Marlton NJ 08053
  - Mount Holly Hospital - 175 Madison Avenue, Mount Holly, NJ 08060

OUTPATIENT

CARDIOLOGY

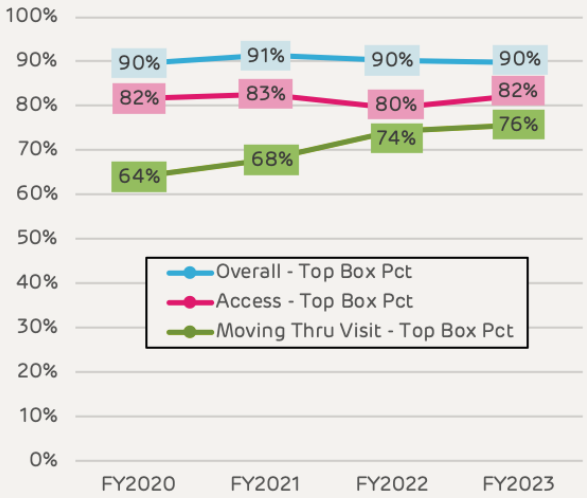
CARDIOLOGY OUTPATIENT VISITS ANNUAL VOLUME TREND



Despite the challenges of COVID (particularly in fiscal year 2020), Cardiology outpatient volume have rebounded and remains robust with 60% growth in Outpatient Visits over 14 years.

OUTPATIENT CARDIOLOGY

PRESS GANEY PATIENT SATISFACTION SCORES: ANNUAL



With increased volume, the Outpatient cardiology team maintains very high patient satisfaction scores:

Press Ganey Survey "TOP BOX Score" definition: Percent of families indicating that the Cardiology service is VERY GOOD (the highest score):

- Outpatient cardiology patient satisfaction continues to be exceptional
- CLINIC FLOW has improved "Moving thru Visit" score

PROGRAM HIGHLIGHTS

- **CHOP-Cardiology - Main Line Health Partnership** A major accomplishment spearheaded by the CHOP Cardiology division, is an agreement to provide CHOP subspecialty services.
  - Our Cardiology group covers the four Main Line Health inpatient hospitals
  - A new CHOP Specialty Care Center anchored, by outpatient cardiology was successfully opened in 2022. This clinic includes general cardiology and some subspecialty services, ECG and transthoracic echocardiograms.
  - The CHOP Fetal Heart program opened the first FHP Annex site at the Bryn Mawr clinic site.
- **CHOP Community Hospital Outreach Program** was successfully rolled out in Jan 2023. This dedicated model provides 24/7/365 coverage of 13 regional hospitals with improved service.
- **CHOP-MAIN clinic move to BUERGER**: We are finalizing plans for the move of Cardiology outpatient clinic from 3rd floor of the Main Hospital to the new 12th floor Buerger building, including a new echo reading site and an expanded exercise and rehabilitation center.
- **Outpatient Cardiology Advanced Practice Nurse Practitioner (APP) program** is being roll out in 2023. The goal for this program is meet the increasing demand for our services and to improve access for new patients. We have started with four APPs (including two new hires: Monica Gianopulos, CRNP and Kaitlin Lewis, CRNP joining two of our current APPS: Rachel Keashen, CRNP and Lou Anne Fromuth, CRNP). This program starts with an extensive training and on-boarding curriculum, and we hope this vision will serve as a template for the future of community-based outpatient cardiology services.

OUTPATIENT CARDIOLOGY

PROGRAM HIGHLIGHTS (continued)

- **King of Prussia Hospital based Cardiology services:** The Outpatient Cardiology group continues to support cardiology services for the new CHOP King of Prussia Hospital. This has included the creation of an on-site Technical Manager and sonographer: Michael Convery, RDCS and support for an inpatient telemetry unit.
- **Process Improvement:** We continue to work on improving the patient-family and provider experience in the outpatient cardiology clinic with a number of initiatives:
  - **Clinic Flow Process Improvement project** – lead by Lisa Mitchell, RN and Amy Schultz, MD
  - **POD RN support model** – lead by Lisa Mitchell, RN and Carol Wittlieb-Weber, MD
- Successful launch of our **Ambulatory Cardiology Conference**, led by Drs. Ramiro Lizano and Amy Schultz.
- **New Hires:** The Outpatient Pediatric Cardiology program continues to expand:

  Physicians
  - Marie Carillo, MD
  - Andrea Jones, MD
  - Meghan Metcalf, MD
  - Yalile Perez, MD
  - Rachel Shustak, MD
  - James Starc, MD
  - Danish Vaiyani, MD

  Advanced Practice Providers
  - Monica Gianopulos, CRNP
  - Kaitlin Lewis, CRNP

  Nurses
  - Natalie Morales-Main POD RN
  - Lauren Blough-Exton POD RN
  - Evie Jarrett-Main POD RN
  - Mallory Lacy-Main POD RN
  - Kaitlyn McAllister-Main POD RN
  - Ashleigh Huber-Allentown Subspecialty Practice Nurse III

  Other Cardiology Staff:
  - Susan White, MSW, BSN, RN

- **Transitions:** *Congratulations!*
  - Aaron Dorfman, MD was named the Medical Director of our Voorhees / South New Jersey practice
  - Eva Guzman promoted to Subspecialty Practice Nurse IV -Clinical Supervisor

The Outpatient Cardiology Team serves our patients and achieves our vision: "Best care for all children".

PUBLICATIONS

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OUTPATIENT CARDIOLOGY

TELEMEDICINE

The Cardiac Center telecardiology program was established in August 2019, with the initial vision funded via a Cardiac Center Innovation grant. The program started with the Infant Staged Monitoring Program patients who are known to be at high risk for interstage morbidity and mortality and account for high use of healthcare resources. Telemedicine eliminates travel time and expenses, avoids wait times, minimizes potential infectious exposures, and can potentially reduce caregiver burden and physical stress for infants related to equipment needs and transport to in-person appointments. Moreover, telemedicine can be deployed quickly and minimizes family disruption, particularly associated with hospitalization. Finally, it creates medical homes that promote continuity as care is received from trusted clinicians with access to the child's electronic medical records. The results from our initial experience with telemedicine in these infants with palliated congenital heart disease demonstrated a significant decrease in median monthly ED visits/patient compared to the pre-telemedicine era and showed that telemedicine for this high-risk cohort was feasible, sustainable, and effective in identifying clinical concerns. It allowed rapid access to expert evaluation with expedited identification of potentially serious issues and resolution of minor problems which previously would have resulted in ED visits and/or hospitalization. There were no deaths recorded during this time. Telemedicine accurately assessed the patient's clinical status with no missed events. These data were presented at the 2020 Scientific Sessions of The American Heart Association and published in 2022. As this has become our standard of practice, with increasing telemedicine visit volume, these results have been maintained.

Under the leadership of Tamar Preminger, MD. The Center continues to grow now completing nearly 10,000 telemedicine visits since its inception with excellent provider and caregiver satisfaction. Our Center involves the talents of multiple integrated team members including cardiologists, nurse practitioners, digital health and quality analytics members.

PROGRAMMATIC HIGHLIGHTS

We continue to expand our efforts and incorporate telemedicine throughout the Cardiac Center with the following notable achievements and unique services offered to our patients and families in 2022:

1. Expansion of Telemedicine in our Infant Staged Monitoring Program:
   A. Clinical Champions: Alyson Stagg CRNP, Therese M. Giglia, MD, Monique Gardner, MD, Bonnie F. Offit, MD, Kate M. Fuller, Shobha S. Natarajan, MD, David A. Hehir, MD, MS, Anita L. Szwast, MD, Jonathan J. Rome, MD, Chitra Ravishankar, MD, Tamar J. Preminger, MD
   B. Use of telemedicine has become standard practice with 1-2 visits per patient/month. We continue to experience excellent results with no missed events, expedited care when indicated and an ongoing decrease in avoidable ED visits. We expanded our remote patient monitoring through the use of Epic Care Companion. These results were presented at CHOP Quality and Safety Day in May 2022 and published in Pediatric Cardiology, 2022 (reference below).

C. Use of Digital Stethoscopes: This past year we introduced digital stethoscopes to our video visits. We have shown this to be feasible in this fragile cohort with high rates of inter-rater reliability and high provider and parental satisfaction. In 12% of visits the digital stethoscope provided additional significant information as compared to our routine telemedicine visits and was truly life-saving in some. These data were presented at SEARCH2022, The National Telehealth Research Symposium in November 2022; manuscript in preparation. We have now completed ~ 150 telecardiology visits with digital stethoscopes.

Most Impactful Cases using digital stethoscopes:

Patient JA: 25 day old male with single ventricle heart disease (tricuspid atresia with normally related great arteries and pulmonary stenosis). He did not require any neonatal intervention. He had an in-person visit several days earlier without concerns. An expedited telecardiology visit was performed due to lower trending saturations by pulse oximetry. During this visit we confirmed lower oxygen saturations correlating the heart rate via auscultation with the digital stethoscope. Cardiac exam via the digital stethoscope also showed a change in his murmur to being higher pitched concerning for a more restrictive VSD. He was admitted directly to the hospital where our concerns were confirmed by transthoracic echocardiography and underwent cardiac surgery for aortopulmonary shunt placement prior to any clinical deterioration.

Patient EB: 5-month-old male with single ventricle heart disease ((d)transposition of the great arteries, very large ventricular septal defect, hypoplastic LVOT (subpulmonic) and diminutive MPA) palliated as neonate with a patent ductus arteriosus (PDA) stent. During a routine scheduled telecardiology visit we noted him to have lower oxygen saturations by pulse oximetry. We correlated the heart rate via auscultation with the digital stethoscope to confirm accuracy. Upon cardiac auscultation we noted diminution in the grade of the murmur. Therefore, we directed him for in person evaluation with urgent readmission; echocardiography confirmed our clinical suspicion. He had expedited surgical intervention with bilateral bidirectional Glenn shunts prior to clinical deterioration. Intraoperative inspection demonstrated a nearly occluded PDA stent.

Expansion of digital stethoscopes can provide high quality telemedicine appointments as well as address our overall goal of increasing access and equity in specialized care. This technology could be adopted on a larger scale and to other cardiac subspecialties. Longer term use of this technology will further establish its role in telecardiology

2. Telemedicine Lipid Program:

A. Clinical champion: Julie Brothers, MD, Tamar Preminger, MD.

B. This program continues to evolve with our initial efforts focused on feasibility, acceptability and health care disparities. It has been successful at the outset with presentations at Quality Improvement Forums and the 2021 Scientific Sessions of the American Heart Association highlighting that Telemedicine in a pediatric lipid clinic is feasible. There was a significant decrease in 48-hour cancellation rates overall, most notably for Non-Hispanic Black patients. No major technical difficulties were encountered. Telemedicine in our pediatric lipid clinic was effective; non-HDL-c levels were significantly decreased in this cohort. Telemedicine was also efficient, allowing for time and travel-related cost savings. Both parents and providers reported high satisfaction with many parents opting for future visits to occur by telemedicine. A manuscript describing this experience is in preparation. We have now conducted ~ 1600 telemedicine lipid visits.

3. **Telemedicine Transition to Adult Congenital Heart Disease Program:**
   A. Clinical Champions: Emily Ruckdeschel, MD, Kate Sullivan CRNP, Tamar Preminger, MD
   B. Advances in the diagnosis and treatment of congenital heart disease have led to dramatic increases in survival to adulthood and a secondary rise in the need to provide age-appropriate care throughout their lives. The transition from pediatric to adult congenital heart disease is known to be associated with a significant attrition rate with secondary significant morbidity and mortality. We developed a telemedicine program for our adolescent patients and their families to prepare them for this transition of care. Annual visits are performed with a multidimensional emphasis on self-management and self-advocacy skills including education regarding their underlying congenital heart disease, long term risks, medications and evolving future issues such as pregnancy, employability, etc. It is critical to streamline and maintain optimal care for our maturing patients and their families during this transition to adult care. This novel program successfully launched in December 2021/January 2022 with rapid expansion over this past year; we project ~ 100 visits to be completed this upcoming year. The implementation of the program and the successful transfer of care to our Adult Congenital Heart Disease Program is being monitored by our Quality Improvement team.

4. **The CHOP Digital Health Team was awarded a Covid 19 telehealth grant (January 2022, $879,000) through the Federal Communications Commission.** These funds will be used to explore uses of novel technologies including within the Cardiac Center. We seek to expand remote patient monitoring and telemedicine services while evaluating the impact of telehealth on disparities in access to care. Our overarching goal is to maximize our ability to provide high quality care for all.

FUTURE DIRECTIONS:

1. Cardiac CATCH Program: under the direction of Emmanuelle Favilla, MD, we are creating a telemedicine program following discharge from our Cardiac Care Unit to optimize continuity of care as patients transition from hospital to home, potentially allow for earlier discharges and reduce readmissions

2. Nenour device/NIH Grant Telehealth Neoneur Device: Demonstrating Clinical Unity in both Hospital and Home, to Improve High Risk Infants Transition to Oral Nutrition and Growth. Under the direction of Barbara Medoff Cooper PhD, RN we are currently investigating a new device to assess feeding patterns and energy expenditures in our infant single ventricle patients to maximize nutrition in this fragile cohort. We anticipate adding this to our telemedicine visit protocol, partnering with a feeding specialist

3. Expansion of our ACHD Transition Program: we anticipate addition of a nurse navigator, remote patient monitoring and QI metrics

4. Further expansion of RPM and technologies within the Cardiac Center including use of digital stethoscopes, home echo devices, etc

Through improved care coordination and management of chronic medical conditions, we anticipate decreased downstream costs and increased care satisfaction. Ultimately, a hybrid model may allow for practice flexibility in optimizing in-person visits (including diagnostic testing) and virtual care that will maintain clinician-family relationships, ensure earlier escalations of care to avoid decompensation, and preserve the medical home while integrating emerging technologies that support detailed home assessments. We anticipate further research exploring and evaluating innovative remote monitoring and diagnostic technologies (e.g., digital stethoscopes, echo, wearable devices, smart phone-enabled devices and apps, artificial intelligence etc.) to optimize decision-making and demonstrate the value of telemedicine to other subspecialties in the Cardiac Center. Our mission is to optimize patient clinical care, safety and education which requires we address health care disparities, complete research to determine the impact of digital technology on our patients, caregivers, healthcare providers and develop standards of digital health for our field.

OUTPATIENT CARDIOLOGY

TELEMEDICINE

PUBLICATIONS:

1. Stagg A, Giglia TM, **Gardner MM**, Offit BF, Fuller KM, Natarajan SS, Hehir DA, Szwast AL, **Rome JJ**, Ravishankar C,Laskin BL, Preminger TJ: Initial Experience with Telemedicine in Infants with Palliated Congenital Heart Disease. Pediatric Cardiology Page: 1-8, September 2022.

2. Preminger TJ: Telemedicine in Pediatric Cardiology: Pros and Cons. Current Opinion in Pediatrics 34(5): 484-490, October 2022.

PRESENTATIONS:

1. Stagg A, Giglia T, Fuller K, Offit B, Natarajan S, Preminger T: Initial Experience with Telemedicine for Interstage Monitoring in Infants with Palliated Congenital Heart Disease. 11th Annual Quality and Safety Day, Children's Hospital of Philadelphia, Philadelphia, PA May 2022

2. Preminger, TJ: "The Pros and Cons of Telemedicine in Pediatric and Congenital Heart Care: What Have we Learned from Covid 19?"; 25th Annual Update on Pediatric and Congenital Cardiovascular Disease Conference, September 2022

3. Nyman A, Shiue M, Karvell R, Partington SL, Preminger TJ, Reda C, Ruckdeschel E, Sullivan K, Tobin L, Vaikunth S, Saef J, **Kim YY**: Adult Congenital Heart Disease and Covid-19: The Patient's Perspective. 25th Annual Update on Pediatric and Congenital Cardiovascular Disease Conference, Huntington Beach, CA September 2022.

4. Shiue M, Nyman A, Karvell R, Partington SL, Preminger TJ, Reda C, Ruckdeschel E, Sullivan K, Tobin L, Vaikunth S, Saef S, **Kim YY**: Pandemic-Associated Patient Experiences and Attitudes Toward Telemedicine in an Adult Congenital Heart Disease Clinic. 25th Annual Update on Pediatric and Congenital Cardiovascular Disease Conference, Huntington Beach, CA September 2022.

5. Stagg A,Giglia TM, Gardener MM, Shustak R, Natarajan SS, Hehir DA, Szwast AL, **Rome JJ**, Ravishankar C, Preminger TJ: Feasibility of Digital Stethoscopes in Telecardiology Visits for Interstage Monitoring in Infants with Palliated Congenital Heart Disease. SEARCH (Society for Education and the Advancement of Research in Connected Health) 2022- The National Telehealth Research Symposium November 2022.

INTERVENTIONAL CARDIOLOGY

INTRODUCTION

The CHOP Interventional Cardiology Section is among the busiest and most forward-thinking congenital interventional programs in the world. The team of seven interventional cardiologists treated over 1400 patients in 2022. In the Cardiac Center's 4 state-of-the-art catheterization labs, they perform the most advanced procedures, including innovative valve and lymphatic interventions that aren't available anywhere else in the world.

INTERVENTIONAL CARDIOLOGY TEAM

Matthew J. Gillespie, MD, FSCAI, FPICS
Medical Director, Interventional Cardiology and Cardiac Catheterization Laboratory

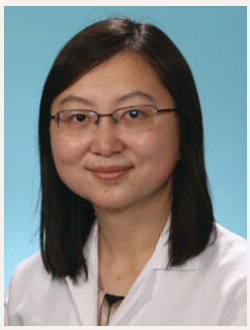
Jonathan J. Rome, MD, F.A.C.C.

Yoav Dori, MD, Ph.D

Michael L. O'Byrne, MD, M.S.C.E

Ryan M. Callahan, MD, FSCAI, FPICS

Christopher L. Smith, MD, Ph.D



Jessica Tang, MD

Lauren Ford, CRNP

Erin Pinto, MSN, RN, CCRN, FNP-BC

Donna Calfin, BSN, MHL, CPN

INTERVENTIONAL CARDIOLOGY

Registered Nurses, cardiovascular technicians, an electrophysiology technician, and an electrophysiology specialist work side by side with physicians in cath, lymphatics, and EP cases. The team is supported by a Lead Materials Management Analyst, perioperative core techs, IS, and biomed. The cath lab more than doubled the number of staff over the past two years to support the 4th lab and the anticipated increase in volumes.

The leadership team onboarded an Educational Nurse Specialist and are continuing to improve the orientation program. In partnership with the physician team and the simulation team, the leadership team has begun building and implementing an ongoing educational plan. Leaders are working on leadership development and professional development for the staff. Cardiovascular techs now can advance from novice to expert with this pathway. Additionally, the techs are now eligible for the PEAK program. Four techs achieved PEAK with the first round of eligibility.

THE TEAM'S RECENT AREAS OF FOCUS INCLUDE:

Advances in Catheter-based Heart Valve Therapies. The CHOP Cath Lab is a center of excellence for advanced Transcatheter Pulmonary Valve Replacement (TPVR) procedures, and among only a few in the world that participated in the groundbreaking Harmony TPV and Alterra Adaptive Pre-stent trials. **Matthew J. Gillespie, MD**, Director of Interventional Cardiology, is leading the expansion of these TPVR technologies both locally and internationally and is also working to introduce new therapeutic options for congenital heart disease patients suffering from atrioventricular valve regurgitation.

Transcatheter thoracic duct decompression. **Jonathan J. Rome, MD** along with Lymphatic specialists **Yoav Dori, MD Ph.D**, and **Christopher L. Smith, MD, Ph.D,** have pioneered a minimally invasive technique in order to decompress the lymphatic system in patients suffering from multicompartment Lymphatic failure after Fontan palliation for complex congenital heart disease. Thus far, nearly 30 patients with end stage heart disease and few or no other treatment options have benefitted from this new therapy. This represents one of the most important, novel advances in interventional cardiology over the last decade. Currently, this procedure is only performed at CHOP.

Stenting of the PDA for patients with ductal-dependent pulmonary blood flow. As one of the busiest PDA stenting programs in the world, under the leadership of Michael **L. O'Byrne, MD, M.S.C.E**, CHOP is a participating center in the **COMPASS** ***(Comparison of Methods of Pulmonary Blood Flow Augmentation: Shunt versus Stent)*** trial. This trial is funded by the NIH/ NHLBI represents the first of its kind randomized multi-center trial comparing a transcatheter to a surgical intervention in congenital heart disease.

Minimally invasive PDA closure in Extremely Low Birth Weight (ELPBW) Infants. The CHOP Cath Lab is a leading center for catheter-based closure of PDA in these fragile infants, and has ongoing research focused on the longer-term outcomes in this population. The CHOP Cath Lab performed more premature PDA closure procedures than any other program in the world in 2022.

Outcomes research/CQI/Registries. The CHOP Cath Lab participates in all of the major data registries, including the IMPACT Registry and C3PO, both of which demonstrate that CHOP is one of the busiest, most effective, and safest congenital interventional programs in North America.

INTERVENTIONAL CARDIOLOGY

Pulmonary Vein Stenosis Program. **Ryan M. Callahan MD**, joined the Interventional Cardiology team at CHOP in 2022, and serves as the Medical Director of the newly formed Pulmonary Vein Stenosis (PVS) Program. Dr. Callahan is recognized as an international leader in the care of these complex patients, and the program provides comprehensive and personalized state-of-the-art care to patients with PVS at CHOP.

State-of-the-Art Patient, Clinician, and Staff Education. **Jessica Tang, MD**, joined the Interventional Cardiology team at CHOP in 2022, and is leading the efforts modernize the teaching in the cathlab to further the educational mission of the Interventional service.

The CHOP Cath Lab is also focused on advancements on multiple other fronts, including:

- minimizing radiation exposure
- novel procedural anticoagulation strategies
- treatment pathways for procedure-associated pulse loss

"The goal of the CHOP Cath Lab is to provide best possible clinical outcomes for our patients, while simultaneously striving to move the field of congenital interventional cardiology forward through research and innovation."

ELECTROPHYSIOLOGY AND HEART RHYTHM PROGRAM

INTERVENTIONAL CARDIOLOGY TEAM

Maully Shah, MBBS, FACC, FHRS, CEPS, CCDS
Medical Director

V. Ramesh Iyer, MD, CEPS, CCDS

Christopher Janson, MD, CEPS, CCDS

Chandra Srinivasan, MD, CEPS, CCDS

Victoria Vetter, MD, MPH

EP PROGRAM STAFF

Electrophysiology Nurses

Karen Smoots, MSN, RN
Dana Sleeman, BSN, RN
Emily Brown, BSN, RN

Electrophysiology Advanced Practice Provider

Tammy Sweeten, MS

EP Lab Specialist

Tammy Sweeten, MS

Administrative Staff

Marva Prince
Amanda Miller

PROGRAM HIGHLIGHTS

The electrophysiology laboratory at CHOP is one of the few state of the art EP labs in the world that is fully equipped with the latest technology to perform catheter ablation of the most complex arrhythmia disorders. With a variety of advanced 3D ultra-high resolution mapping systems available (CARTO® 3 System Version 7 and the CARTO PRIME® Mapping Module, EnSite X EP system, RHYTHMIADx™) and ablation energy sources (radiofrequency, irrigated radiofrequency and cryoablation) and intra-cardiac echocardiography in our EP lab, we are able to select technology that is best suited for an individual patient. We are one of the few pediatric centers in the world to have a dedicated pediatric CIED lead extraction program and have laser technology for lead extraction. We have a robust program for pediatric patients with and at-risk for inherited arrhythmias and sudden cardiac death and provide a thorough evaluation including investigation of the patient's or deceased's medical records, autopsy reports, and genetic testing. In partnership with surgeons, our program offers patients with cardiac channelopathies and life-threatening arrhythmias, cervical sympathectomy procedures which can be lifesaving in some patients.

ELECTROPHYSIOLOGY AND HEART RHYTHM PROGRAM

PROGRAM HIGHLIGHTS (continued)

The EP service continues to perform innovative device procedures which include implantation of Transcatheter Leadless pacemakers. We now perform transcatheter "physiologic" pacing at the site of the Bundle of His or the left bundle branch in select patients that need permanent pacing in order to preserve ventricular function and reverse pacemaker mediated cardiomyopathy.

The EP program has arrhythmia and device clinics at the main hospital as well as satellite clinics in Lancaster, PA, Exton, PA and in Voorhees, N.J. In addition, Dr. Shah travels to Danville, PA to perform catheter ablation procedures at the Geisinger Medical Center. We also conduct combined EP-Cardiomyopathy clinics at the Main Hospital. In addition to having a primary electrophysiology in-patient service on the CCU, we provide consultation for arrhythmia management throughout the hospital including the CICU, PICU, NICU, ER and other in-patient units.

RESEARCH HIGHLIGHTS:

Our electrophysiologists are leaders in multicenter collaborative as well as large clinical database research. Dr. Chandra Srinivasan received funding from the ACC NCDR IMPACT registry for his project on: "Outcomes of Catheter Ablation for Atrial Tachyarrhythmias in Congenital Heart Disease" In addition, Dr. Srinivasan was awarded a grant of $100,000 by the Medtronic Inc. External Research Program for a multicenter study :" Non-traditional ICD Systems in Children and Patients with Congenital Heart Disease" Dr. Maully Shah is the site Principal Investigator for the International LEADR study (https://clinicaltrials.gov/ct2/show/NCT04863664), which is a prospective multicenter clinical trial to investigate a new 4.5 French defibrillation lead. We are the only pediatric EP study site in the world. Our section has presented abstracts at all major national meetings (ACC, AHA, HRS). Below, is a summary of completed studies with current and anticipated publications for 2022/2023:

1. Comparison of Outcomes of Pediatric Catheter Ablation by Anesthesia Strategy: A Report From the NCDR® IMPACT Registry
2. Association Of Center Ablation Volume And Procedural Outcomes In Children: An Analysis Of The NCDR®IMPACT Registry.
3. Comparison of Cryo Vs. Radiofrequency Ablation in Children: An Analysis Of The NCDR®IMPACT Registry
4. Utility of Ivabradine for Postoperative Junctional Ectopic Tachycardia- Multicenter study
5. Contemporary Outcomes in Neonates with Isolated Congenital Complete Heart Block– An Analysis of the PHIS Database
6. Management and outcome of "lone" atrial fibrillation in children and young adults- Multicenter study submitted for NIH funding
7. Risk stratification of sudden cardiac death in Pediatric Hypertrophic Cardiomyopathy- Multicenter study
8. Electrocardiographic signatures for single ventricle failure
9. Cardiac Resynchronization Therapy in Single Ventricle patients
10. Implant characteristics and outcomes of Leadless Pacemakers in Children-Multicenter study
11. Coronary compression by epicardial leads in children and patients with congenital heart disease-Multi center study
12. Implant characteristics and outcomes of physiologic pacing in children- Multicenter study
13. MRI in pediatric and congenital heart disease patients with CIEDs and epicardial or abandoned leads-Multi center study
14. Accuracy And Diagnostic Performance Of The Apple Watch™ Cardiac Features In Pediatric Patients

ELECTROPHYSIOLOGY AND HEART RHYTHM PROGRAM

QA/QI:

Dr. Chandra Srinivasan led the CHOP System wide clinical pathway: "Inpatient Clinical Pathway for Child with Prolonged QTc and Prevention of Torsades de Pointes"

Dr. Ramesh Iyer led the project for weekend reporting of hospital wide ECGs

Scientific Society Clinical Guidelines Document

Dr. Maully Shah led and Co-chaired the first Pediatric specific expert consensus document: *PACES Expert Consensus Statement on the Indications and Management of Cardiovascular Implantable Electronic Devices in Pediatric Patients:*. The document was endorsed by PACES, HRS, ACC, AHA, IHRS, APHRS, AEPC and published in 6 journals.

Education:

In addition to providing didactic and clinical education to categorical fellows, our EP team also trained a 4th year subspecialty fellow in Electrophysiology. Dr. Christopher Janson and Dr. Asztalov designed a rapid ECG reading feedback system for the categorical cardiology fellows. Dr. Christopher Janson was appointed as the associate director for the CHOP Pediatric cardiology fellowship program. Dr. Srinivasan is a Member of PSOM class of 2023 Interview panel.

STATISTICS

Electrophysiology Outpatient Clinic Visits	1436
Device Outpatient clinic visits	406
EP laboratory procedures (ablations, pacemaker, other EP studies)	235
Device implants (Transvenous and epicardial devices)	95
Remote Device Transmissions	1,964
EKG	56,346
Holters	2919
Transtelephonic/MCOT monitoring	602

OTHER ACCOMPLISHMENTS

Dr. Shah is associate editor of the Journal of the American College of Cardiology (EP), and serves on the American College of Cardiology's IMPACT research and publications committee, Heart Rhythm Society's Scientific Clinical Documents and Guidelines committee and on the International Board of Heart Rhythm Examiners' (IBHRE) continuous competency certification and test writing committees. Dr. Shah is a member of the CDC funded Philadelphia County Sudden Death in the Young Advanced Review Team. Dr. Christopher Janson is a member of the research committee, as well as the QI committee of PACES. Dr. Chandra Srinivasan also serves on the PACES QI committee. Dr. Ramesh Iyer's focus is on health care policy. Dr. Victoria Vetter is the Director of Youth Heart Watch at CHOP and affiliate of Project Adam.

YOUTH

HEART WATCH

Youth Heart Watch (YHW), an affiliate of Project ADAM®, is committed to preventing sudden cardiac death in the young through education, research, and advocacy. This is accomplished by the implementation of automatic external defibrillators and CPR training in schools and ECG screening programs in the community. Since January 2022, Youth Heart Watch (YHW) has designated 41 schools as Heart Safe and is currently working with almost 300 additional schools to implement the program, as well as several youth athletic groups. A referral program has officially been rolled out in CHOP cardiac clinics to educate parents on YHW's program and provide a method to submit their child's school contact information for our team; we then communicate with the school and provide information about becoming a Heart Safe School. Additionally, we have again partnered with Philadelphia Parks and Recreation to train 320 Recreation Center staff in CPR and AED use and have trained over 680 students, staff, and community members in CPR and AED use, significantly increasing lay rescuers across the Greater Philadelphia area. In 2022, production of our CPR, AED, and ECG videos concluded. The CPR and AED series currently has >800 views on YouTube and the ECG series has >8,000, totaling over 8,800 views for these new video projects. Regarding funding, Youth Heart Watch was awarded $10,001 from the Philadelphia Eagles to ensure local youth have access to CPR and AED use in the event of a cardiac arrest. YHW was also the beneficiary of a grateful patient family's gift of $50,000. CHOP's Community Impact provided $5,000 through the CHOP Cares Grant to support a CPR and AED Training Equipment Lending Library to loan manikins and AED trainers to the community, free-of-charge, to reduce cost and access barriers for trainings and SCA response practice drills.

Dr. Vetter published Impact of State Laws: CPR Education in High Schools JACC 2022 finding that states with laws requiring CPR training for high school students have higher rates of bystander CPR of out of hospital cardiac arrests than those without laws. The YHW coordinators presented posters at the CHOP Cardiology Conference 2022 on research surrounding AED availability in local public schools and Philadelphia's Parks and Recreation system. We hosted three undergraduate U Penn students through the Penn Undergraduate Research Mentorship program (for the 7th year) assisting with ongoing research studies and independent projects. In partnership with the Daniel E. Rumph II Foundation, the first Heart Health Screening Study event since 2019 was held with 54 participants adding to our total of almost 5000 youth screened.

FACULTY/STAFF

Victoria Vetter, MD, FAAP, FACC

Lindsey Flanagan, MPH

YOUTH

HEART WATCH

ECHOCARDIOGRAPHY LABORATORY

INTRODUCTION

The Cardiac Echo Lab at the Children's Hospital of Philadelphia continues to be one of the largest pediatric echo labs in the United States. As an enterprise, the Cardiac Echo Lab performs over 30,000 exams per year providing services for the Division of Cardiology as well as many other Divisions under the Department of Pediatrics including: Oncology, Pulmonology, Neurology and Nephrology. At the main campus, the echo lab supports both inpatient and outpatient services, providing transthoracic, transesophageal and sedated echo services. The Cardiac Echo Lab also supports echo services across the region as well as in the state of New Jersey.

In January 2022, the Cardiac Echo lab expanded its footprint to provide 24/7 coverage of echo services at the newly opened CHOP King of Prussia Hospital as well as acquiring neonatal echo services within the Main Line Health system (Bryn Mawr, Lankenau, Paoli and Riddle). In October 2022, CHOP also broke ground with an additional specialty care center at the Main Line Bryn Mawr campus and formally announced its partnership to the region. New pediatric echo service affiliations were also created at Princeton Medical Center and St. Mary's Medical Center in Langhorne.

In totality, the Cardiac Echo Enterprise provides service in 14 specialty care centers and 11 affiliated nurseries that send echocardiograms into the central reading system. The Cardiac Echo lab also provides collaborative services for the Hospital of the University of Pennsylvania, supporting inpatient neonatal services as well as outpatient needs for the Philadelphia Adult Congenital Heart Center. The Cardiac Echo Lab is robust with research efforts, many studies originate and are conducted through the Echo Lab though the lab also provides services through the Cardiac Core for the Center for Human Phenomic Science (CHPS).

KEY PERSONNEL

Michael Quartermain, MD
Medical Director

Christine Pascua, RCS, RCCS, B.Sc
Program Manager

Echo Lab Core Directors:

- Center for Human Phenomic Science (CHPS): Laura Mercer-Rosa, MD, MSCE
- Echo Lab Research: Laura Mercer-Rosa, MD, MSCE
- Quality Improvement: Shobha Natarajan, MD
- Education: Lindsay Rogers, MD, Med

Technical Manager, KOPH:

- Mike Convery, RDCS, MBA

Technical Supervisors:

- Valerie Capone, RDCS
- Devon Ash, RDCS
- Melissa Wasserman, RDCS, RCCS

Lead Sonographers

- CHPS Research: Anysia Fedec, RDCS
- Advanced Modality Imaging: Yan Wang, RDCS
- Quality Improvement: Jenna DiFrancesco, RDCS
- Education: Karen Miller, RDCS
- Lancaster Operations: Tiffany Cantler

ECHOCARDIOGRAPHY LABORATORY

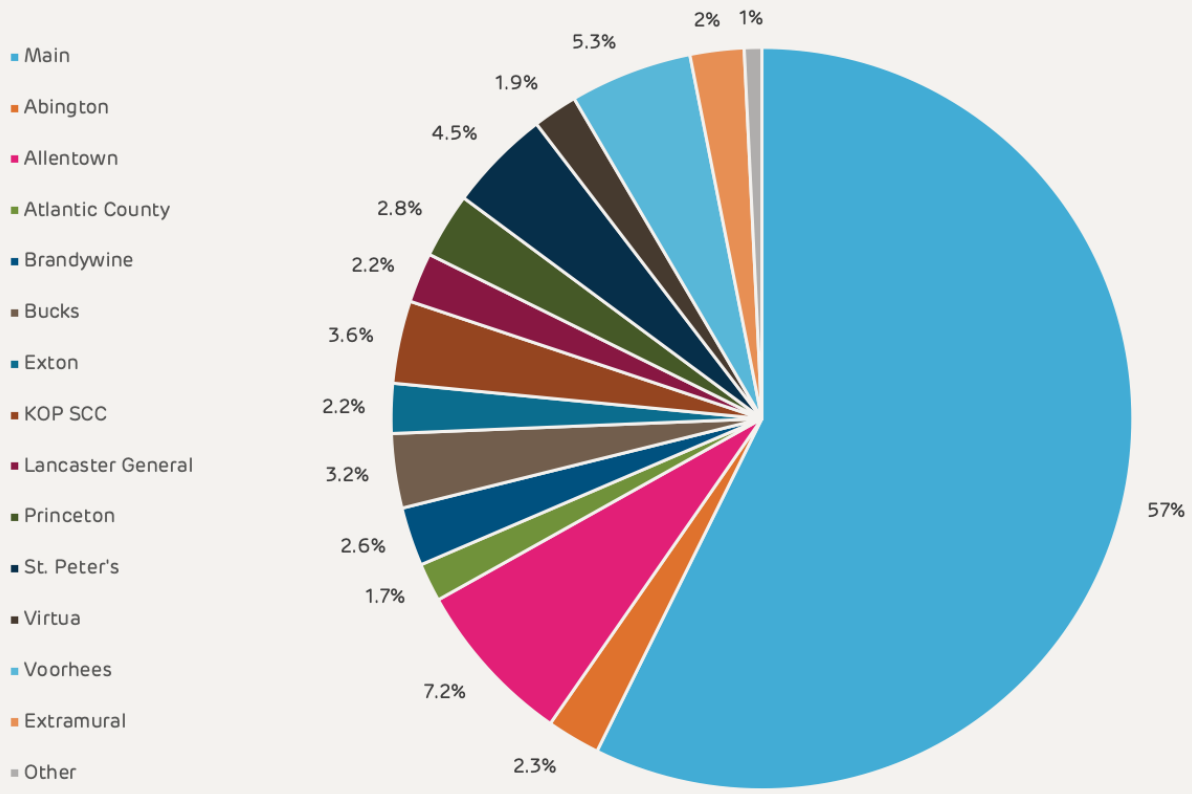
CLINICAL PROGRAMS AND ACTIVITIES

Echocardiograms performed by the echo team provide comprehensive assessment of cardiac anatomy and function to identify cardiac abnormalities, evaluate heart muscle function and surgical repairs.

The Cardiac Echo Lab is also proficient and highly skilled in providing state of the art services in advanced imaging modalities like three-dimensional and strain imaging. Requests for advanced imaging have increased over the past year and intra-operative imaging has become routine in all surgical interventions to improve patient outcomes. Three-dimensional imaging within the catheterization laboratory has also increased this past year and has been an important tool used for novel device programs.

Additionally, advanced vascular evaluation is offered through the Cardiac Echo Lab and includes carotid intima imaging, comprehensive blood pressure assessment, arterial pressure assessment and evaluation of arterial stiffness.

CARDIAC ECHO LAB VOLUME – CALENDAR YEAR 2022 (January 2022-December 2022)



Main: 18,590 Satellites: 12,824 Extramural Studies: 761 Other: 249 Overall Total: 32,424

ECHOCARDIOGRAPHY LABORATORY

RESEARCH ACTIVITIES/HIGHLIGHTS (full publication list included in the Research Section):

The Cardiac Echo Lab Research Unit has made significant progress in 2022 both in terms of prospective research studies and in the development of collaborations with other divisions in the Department of Pediatrics. Of note, the lab has transitioned to have 20 Philips Epiq systems, with all of the systems being fully outfitted with state-of-the-art technology like heart model, 3D automated RV volume and automated strain for all the chambers of the heart. Real time strain measurements for the assessment of ventricular function have directly impacted the Lab's research endeavors and testing the reproducibility of these parameters is part of research protocols. It is part of the Research Unit's mission to support and foster retrospective and prospective studies led by the faculty and sonographers with the ultimate goal to use echocardiography as a tool to inform and improve the outcome of patients with congenital and acquired heart disease. The Research Unit has successfully implemented a Core Lab to augment our collaborative efforts while assuring optimal data quality. We initiated a multicenter collaboration for the NIH-funded ICU-RESUS study, named ICU-RESUS-Echo. Several institutions have signed sub-contracts with CHOP and are now transferring de-identified echocardiograms to our lab for analysis. This data will be used for a future multi-center grant submission in collaboration with the Division of Critical Care Medicine. In addition, we are the Core Lab for a Friedreich Ataxia study in collaboration with Dr. Kimberly Lin. These studies fund sonographer's time for data acquisition.

In 2022, the CHOP Echo Lab was well represented at the Scientific Sessions of the American Society of Echocardiography (ASE). Speakers included Melissa Wasserman, Lindsay Rogers, Laura Mercer-Rosa, and Meryl Cohen. Michael Quartermain presented the annual ASE Year in Review presentation. Several posters were presented, including those by Shobha Natarajan and Meryl Cohen (multi-center collaborative), Ani Banerjee, Laura Mercer-Rosa (in collaborations with fellows Marc Delaney and Andrea Jones, sonographers, Monique Gardner, Shivani Bhatt, Mark Friedberg and Sushma Reddy).
An important metric for the Cardiac Echo Lab Research Unit is the number of publications and grants by the faculty. Several faculty members and Cardiac Echo Lab sonographers remain engaged and collaborative in research projects. A list of publications (not exhaustive) is at the bottom of this report. We also provide a summary of studies with ongoing data collection/analysis with anticipated publications for 2022/2023. Please note that this report does not include prospective studies that are conducted in the Cardiac Echo Lab which are funded through CHPS, now under Laura Mercer-Rosa's leadership. The Cardiac Echo Lab CHPS Core supports a multitude of studies for both transthoracic echo and vascular imaging and assessment. Below is a summary of ongoing research studies and publications by Echo Lab investigators reflecting a collaborative nature among Echo Lab physicians, fellows and sonographers.

Kate Avitabile:

1. Ongoing collaborations with the pediatric surgery group (H. Hedrick) to study the congenital diaphragmatic hernia population
2. Ongoing funding by United therapeutics (with Laura Mercer-Rosa): prospective "Omics" study + RV strain under IRB review in CDH+ TOF + normal controls
3. K23 active enrollment
4. BPD-PH patients discharged on PH drugs-published.

Publications in 2022: (see Cardiac Center Research Section for full Publication List)

Avitabile CM, **McBride MG**, Zhang X, Ampah S, **Goldstein BH**, Alsaied T, Wittekind SG, **Whitehead KK**, Zemel BS, **Paridon SM**. Peak Work Rate Increases With Lower Extremity-Focused Exercise Training in Adolescents With Fontan Circulation. J Am Heart Assoc. 2022 Dec 20;11(24):e027464. doi: 10.1161/JAHA.122.027464. Epub 2022 Dec 14. PMID: 36515264; PMCID: PMC9798796.

Other ongoing Echo-related research work by Kate Avitabile with sonographer involvement (Yan Wang and Devon Ash's efforts are funded by Grant 2021262 from the Doris Duke Charitable Foundation through the COVID-19 Fund to Retain Clinical Scientists collaborative grant program)

1. DeBie FR, **Avitabile CM**, Flohr S, Land S, Mathew L, **Wang Y, Ash D**, Rintoul NE, Hedrick HL. Treprostinil in neonates with congenital diaphragmatic hernia-related pulmonary hypertension. Provisionally accepted pending revision, J Peds
2. **Avitabile CM**, Flohr S, Mathew L, **Wang Y, Ash D**, **Frank DB**, Tingo JE, Rintoul NE, Hedrick HL. Quantitative measures of right ventricular size and function by echocardiogram correlate with cardiac catheterization hemodynamics in congenital diaphragmatic hernia. Under review, J Peds.
3. **Avitabile CM**, Florh S,Mathew L, **Wang Y, Ash D**, Rintoul NE, Hedrick HL. Echocardiographic changes in infants with severe congenital diaphragmatic hernia after fetoscopic endoluminal tracheal occlusion (FETO). Manuscript in progress.
4. **Avitabile CM**, Florh S, Mathew L, **Wang Y, Ash D**, Rintoul NE, Hedrick HL. Impact of ventricular dysfunction on early mortality in congenital diaphragmatic hernia. Manuscript in progress.

Anirban Banerjee: (see Cardiac Center Research Section for full Publication List)

Yubbu P, Kauffman H, Calderon-Anyosa R, Montero AE, Sato T, Matsubara D, **Banerjee A**. Peak apical recoil rate is a simplified index of left ventricular untwist: validation and application for assessment of diastolic function in children. Int J Cardiovasc Imaging. 2022 Mar 15. PMID: 35290534.

Matthew Jolley:

1. Frontier Valve Program: Creating tools for the planning of transcatheter valve interventions
2. R01(PI): Focused on modeling and shape analysis tools for TV and RV applied to HLHS cohort
3. R43 (Co-Investigator): Development of modeling toolkit for self-expanding transcatheter pulmonary valves for TOF (Harmony)
4. PHN Scholars: CAVC modeling tools from 3DE.
5. EP Modeling: Cardiac Center Grant (Janson-PI) to develop tools to put 3DE into CARTO

Publications in 2022: (see Cardiac Center Research Section for full Publication List)

1: **Williams TR**, Cianciulli AR, Wang Y, Lasso A, Pinter C, Pouch AM, **Biko DM**, **Nuri M**, **Quartermain MD**, **Rogers LS**, **Chen JM**, **Jolley MA**. Truncal Valve Repair: 3-Dimensional Imaging and Modeling to Enhance Preoperative Surgical Planning. Circ Cardiovasc Imaging. 2022 Dec;15(12):e014424. doi: 10. 1161/ CIRCIMAGING.122.014424. Epub 2022 Sep 12. PMID: 36093770; PMCID:PMC9772078.

Laura Mercer-Rosa:

1. Prospective cohort of TOF with ongoing analyses: 1) Pre-operative serum biomarkers of myocardial fibrosis predict early post-operative RV dysfunction after TOF repair (Andrea Jones); 2) Right atrial strain reflects diminished diastolic function early after TOF repair; 3) Longitudinal RV remodeling after TOF repair using RV strain (Andrea Jones)
2. Cardiac Center grant: RV remodeling in patients with TOF combining RV strain, biomarkers and diffuse myocardial fibrosis by CMR- enrolling
3. Collaborations: Prospective RV/LV function study in Pediatric Acute respiratory Distress Syndrom (PARDS)- Himebauch- Grants JIPGP/ K23
4. Stress Echo in TOF and Fontans (Shivani Bhatt's work): ongoing analysis of right atrial strain in TOF, and RV strain in Fontans at peak exercise
5. Liquid biopsy of single ventricles- collaboration with Sushma Reddy (Stanford)-funded

6. FA cohort- assessment of LV function (implementing Echolab Core Lab- Kim Lin)
7. ICU-RESUS Study- implemented Echo Core Lab (Robert Sutton, Adam Himebauch)
8. United Therapeutics Grant with Kate Avitabile, funded (detailed above)

Publications in 2022: (see Cardiac Center Research Section for full Publication List)

Mercer-Rosa L, **Fogel MA**, Wei ZA, Trusty PM, Tree M, Tang E, Restrepo M, **Whitehead KK**, Cassedy A, **Paridon SM**, Yoganathan A, Marino BS. Fontan Geometry and Hemodynamics Are Associated With Quality of Life in Adolescents and Young Adults. Ann Thorac Surg. 2022 Sep;114(3):841-847. doi: 10.1016/j.athoracsur.2022.01.017. Epub 2022 Feb 1. PMID: 35120878; PMCID: PMC9528566.

Michael Quartermain:

1. Prospective study of contrast echocardiography
2. Prospective study of point of care ultrasound for imaging of ECMO cannula positioning (Neonatology)

Publications in 2022: (see Cardiac Center Research Section for full Publication List)

Chaszczewski KJ, Linder JR, Campbell MJ, Convery M, Wang Y, **Smith CL**, Kozyak BW, **Quartermain MD**. Novel Utilization of Ultrasound Enhancing Agents in ComplexCongenital Heart Disease Following Superior Cavopulmonary Connection. J Am Soc Echocardiogr. 2023 Jan 13:S0894-7317(23)00016-0. doi: 10.1016/j.echo.2023.01.007. Epub ahead of print. PMID: 36642236.

Meryl Cohen:

Publications in 2022 (see Cardiac Center Research Section for full Publication List)

Cohen MS. Imaging of Left Ventricular Hypoplasia. World J Pediatr Congenit Heart Surg. 2022 Sep;13(5):620-623. doi: 10.1177/21501351221114767. PMID:36053101.

EDUCATIONAL ACTIVITIES

The echocardiography lab continues to provide education to sonographers, nurse practitioners, fellows in cardiology, critical care, emergency medicine, cardiac anesthesia, and cardiac critical care as well as residents and students. There are many ongoing and some new efforts within the educational core of the echo lab for 2022. These are outlined below.

Curriculum Development

In collaboration with Karen Miller, sonographer education lead, we reviewed 2021 experiences of our first-year fellows on their first and second echo rotations and continued to revise the rotation based on feedback. Revisions included a focus on inpatient studies, tailoring second rotation based on first rotation feedback.

We continued the RR2 review sessions on Monday, Wednesday and Friday (9-10am) as well as for the first-year fellows lectures. In this session, the echo faculty review 1-2 studies with a group of fellows and sonographers in the main lab conference area. This session has been well attended and receives positive reviews from fellows.

We continued our TEE educational sessions. This conference is run by our 4th year fellows (overseen by Mike Quartermain and Lindsay Rogers) and occurs every few months to review interesting TEE cases, improving our own practice variation.

As new educational lead sonographer, Karen Miller has given several didactic sessions to both sonographers and fellows on echo related topics. In addition, Karen has given echo education sessions to cardiac nurse practitioners and even started education sessions with CICU front-line providers to improve echo order quality.

Finally, Karen has led the effort to organize a sonographer lecture series, with didactic sessions for sonographers given by sonographers and echo faculty. In addition, she obtained approval for sonographers to receive continuing educational credit for these lectures.

QUALITY IMPROVEMENT INITIATIVES

The CHOP echo lab has a well-developed quality improvement program, currently with 5 active QI imaging projects. The las has set the expectation for both echo attendings and sonographers to be a part of at least 1 Echo Lab QI project and attend quarterly QA reviews. These projects range from standardizing imaging and reporting protocols to reviews of potential diagnostic errors. The most developed program is our pre-operative echo to surgical discrepancy review. All diagnostic discrepancies identified between echo and surgical inspection are reviewed by the group quarterly. This allows for the development of educational activities to improve our imaging capabilities and decrease errors. This work has led to utilization of additional imaging modalities such as epicardial echo imaging. This program is also now part of a multi-institutional study.

In addition to clinical activities, Quality Improvement initiatives have also been impactful to lab operations. Through the ongoing project "Improving Efficiency and Quality of Performing and Reporting on Outpatient Echocardiograms for Routine Visits of Patients with Repaired Congenital Heart Disease", the Echo lab has been successful in implementing standardized imaging and reporting protocols that have been useful in decreasing overall imaging time and improving the patient experience.

QI Projects, Invited Lectures, Abstracts and Publications

Team Lead: Focused Outpatient Echocardiograms in Repaired Congenital Heart Disease

Team Lead: Standardizing Sonographer Workflow in the Outpatient Echo Lab

Team Lead, QI Initiative-Echocardiograms for Patients after Norwood operation in the interstage period

Team Lead, QI Initiative - Inpatient Echocardiograms for Patients with Kawasaki Disease

Director For the Biweekly Neonatal Review: a multi-disciplinary patient review of all postoperative neonates to engage staff in team learning

"Have QI Metrics Made Your Lab Better?" The American Society of Echocardiography, 30th Annual Scientific Sessions, Portland, OR

Chaszczewski KJ, **Quartermain MD**, and Natarajan SS: Implementing a Quality Improvement Tool to Systematically Identify Discrepancies between Pre-operative Echocardiographic Findings and Intraoperative Inspection in Pediatric Patients Undergoing Repair for Congenital Heart Defects. American Society of Echocardiography Annual Scientific Sessions August 2020

ECHOCARDIOGRAPHY LABORATORY

Natarajan SS, Chaszczewski K, Ansah D, Balasubramanian S, Beattie M, Bhat, AH, Brewer C, Campbell MJ, Carney M, Churchill TL, Dhanantwari P, Jone P, Kong G, Kwon EN, Lipinski J, Madan N, Nelson J, Olsen R, Parthiban A, Prospero C, Rajagopal H, Sachdeva R, Sanandajifar H, Sanchez Mejia A, Srivastava S, Stern K, Taylor C, Tierney S, Cohen MS: Rationale and Design of the First Multicenter Pediatric Echocardiography Quality Improvement Collaborative: Decreasing Pre-operative Imaging Discrepancies in Patients prior Congenital Heart Defect Surgery. The American Society of Echocardiography Scientific Sessions 2022.

White BR, Ho DY, **Rogers LS**, Natarajan SS: A Standardized Imaging Protocol Improves Quality and Reduces Practice Variability Echocardiography 36(8): 1515-1523, July 2019.

White BR, Chaszczewski KJ, Lemley B, Natarajan SS, **Rogers LS**: Sustained improvement in fellows' echocardiographic completeness through the coronavirus pandemic with a standardised imaging protocol. Cardiol Young Feb 2022

GOALS AND OUTLOOK FOR FISCAL YEAR 2022

The Cardiac Echo Lab is currently undergoing historical changes with the enterprise effort to build the 'New Patient Tower' in University City. Aligned with the Cardiology outpatient clinic, outpatient echo operations will formally move to Buerger Center for Advanced Pediatric Care, separating inpatient and outpatient services for the first time in its history. In addition to this major shift, the Cardiac Echo Lab will also be implementing Epic Cupid software in 2023 to update the current platform and allow for more workflow optimization. Overall continued growth is expected within the enterprise as we increase services and providers across all areas. The Cardiac Echo lab looks to continue adapting and optimizing to these changes to ensure that we continue to deliver the highest quality exams and service.

CARDIOVASCULAR EXERCISE PHYSIOLOGY LABORATORY

INTRODUCTION

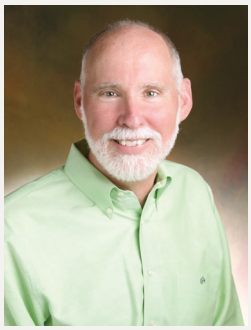
The Cardiovascular Exercise Physiology Laboratory at the Children's Hospital of Philadelphia continues to be one of the most productive clinical pediatric exercise physiology laboratories in the United States. The laboratory serves the exercise physiology testing needs of the Cardiac Center at the Children's Hospital of Philadelphia as well as other Divisions of the Department of Pediatrics including: Pulmonology, Allergy, Oncology, Gastroenterology, Neurology, and Adolescent Medicine. The laboratory also provides both in-patient and out-patient cardiovascular rehabilitation services in conjunction with the Physical Therapy Department for the Cardiac Center and other Divisions of the Department of Pediatrics.

CLINICAL PROGRAMS AND ACTIVITIES

The Cardiovascular Exercise Physiology Laboratory provides comprehensive assessment of exercise performance, risk assessment, and symptoms for a wide range of patients including:

1. Diagnosed congenital or acquired heart disease.
2. Patients with undiagnosed exercise-related symptoms.
3. Patients with known or suspected pulmonary disease affecting exercise performance.
4. Oncology patients who have received or will receive cardio-toxic drugs.
5. Children with undiagnosed musculoskeletal disorders
6. Children with diagnosed or undiagnosed metabolic disorders resulting in exercise related symptoms
7. Children and adolescents with symptoms or concerns about performance in competitive sports.

Testing routinely includes measurements of heart rate, heart rhythm, and blood pressure. Physical working capacity measured by cycle ergometry. Expired gasses using metabolic carts directly measure aerobic capacity. Comprehensive resting and exercise pulmonary functions are routinely obtained. Special protocols using nuclear imaging, stress echocardiography, and pharmacological stress protocols are used when indicated.



Stephen Paridon, MD
Medical Director

KEY PERSONNEL

Attending Physicians:
Julie Brothers, MD
Paul Stephens, Jr., MD
Alexa Hogarty, MD
Matthew Elias, MD
Jonathan Edelson, MD
Emmanuel Favilla, MD

Laboratory Director:
Michael G. McBride, Ph.D.

Laboratory Exercise Physiologists:
Elizabeth Ford, M.Ed.
Shannon O'Malley, M.S.
Andrea Linton, M.S.
Christine Giovinazzo, B.S.

CARDIOVASCULAR EXERCISE PHYSIOLOGY LABORATORY

In addition to exercise testing, the laboratory maintains an active inpatient cardiovascular rehabilitation program. This program is run in conjunction with the Children's Hospital of Philadelphia Physical Therapy Program and serves the needs of both in-patients and out-patients. These patients include many of the sickest children in the institution including children awaiting heart or lung transplantation. Many of these children are on multiple intravenous inotropic medications or have received implantable ventricular assist devices. This Phase I program monitors heart rate, rhythm, blood pressure, and arterial oxygen saturation throughout each hourly exercise session. Non-cardiac in-patients with chronic pulmonary disease are also frequently served by this program. Selected out-patients also use this program. These are frequently children who are too ill or have complicating medical conditions that prohibit enrollment in community based rehabilitation. This is currently the only active pediatric rehabilitation program of its kind in the country.

CARDIOVASCULAR EXERCISE PHYSIOLOGY LABORATORY

EXERCISE LABORATORY VOLUME FOR FISCAL YEAR 2022:

Exercise Testing:

A total of 1974 exercise tests were performed in fiscal year 2022. (see Fig. 1). This number includes the testing done at the Main lab, King of Prussia, and six minute walks. This is a 28% increase in volume over FY 2021.

Cardiovascular Rehabilitation:

A total of 220 rehabilitation sessions were performed in fiscal year 2022. This is a 25% increase compared to fiscal year 2021 (see Fig. 1).

Ambulatory Blood Pressure (ABP):

This is a new program offered for children and adolescents with suspected disease resulting in systemic hypertension or hypotension. While not used frequently, there was a 14% increase in diagnostic testing using this modality during FY21.

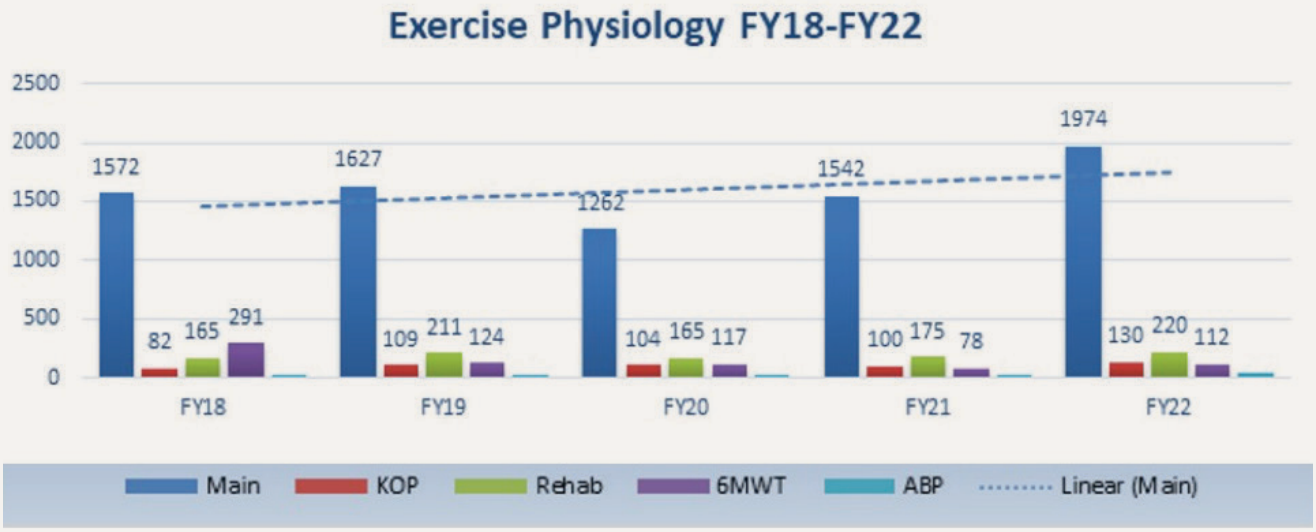


Figure 1.

CARDIOVASCULAR EXERCISE PHYSIOLOGY LABORATORY

RESEARCH ACTIVITIES

The laboratory continues to be productive in research related to cardiovascular exercise physiology. Listed below are the publications and presentations from the laboratory for fiscal year 2022.

Peer Review Publications:

1. Burstein D, **McBride MG**, **Rossano J**, **O'Connor M**, **Lin K**, **Mascio C**, White R, Iacobellis K, Rosenthal T, **Paridon S**. Increasing pump speed during exercise training improves exercise capacity in children with ventricular assist devices. ASAIO Journal 67(4) 449-456 DIO: 10.1097/mat 2021

2. S. Weinreb, K. Dodds, D. Burstein, J. Huang, E. Rand. E. Mancilla, J Jeimall, M. McBride, S. Paridon, D. GoldBerg, J. Rychik. End-Organ Function and Exercise Performance in Patients with Fontan Circulation: What Characterizes the High Performers? J Am Heart Association 9(24) Dec 2020 https://doi.org/10.1161/JAHA.120.016850

3. Varga, C, Kwiatowski, K, Pedro, M, Groepenhoff, H, Gray, C, Pinkerton, K, Wendel, D, McBride, M, Pardion, S. Observation of Aerosol Generation by Human Subjects during Cardiopulmonary Exercise Testing using High Powered Laser technique. J Medical and Biological Engineering 42(pp1-10, 2021, DOI: https://doi.org/10.21203/rs.3.rs-650367/v1

4. Burstein,D, **McBride, MG**, Min, J, Paridon, A, Perelman, S, Huffman, E, O'Malley, S, Del Grosso, J, Groepenhoff, H, Paridon, S, Brothers, J. Normative Values for Cardiopulmonary Exercise Stress Testing Using Ramp Cycle Ergometry in Children and Adolescents. J of Pediatrics 2020 https://doi.org/10.1016/j.jpeds.2020.09.018

5. Goldberg, D, McBride, MG, Paridon, SM. et al. Results from the FUEL Trial. Circulation 2020, 141: 641-651. https://doi.org/10.1161/CIRCULATIONAHA.119.044352

6. McBride, MG, Burstein, D, Edelson, J, Paridon, SM. Cardiopulmonary Rehabilitation in Pediatric Patients with Congenital and Acquired Heart Disease. J of Cardiopulmonary Rehabilitation 2020 40(6): 370-377.

7. Burstein D, Menachem J, Opotowsky A. Exercise Testing for Assessment of Heart Failure in Adults with Congenital Heart Disease. Heart Failure Reviews 2020 25; 647-655.

Reviews and Book Chapters:

1. Stephens Jr. P., **McBride MG**, Opotowsky A, **Paridon SM**: Cardiopulmonary Exercise Testing. Anderson's Pediatric Cardiology 4th Edition. Wernovsky et al (Ed). Elsevier, 2020 CH 23: 379-402.

Educational Activities:

The Exercise Laboratory continues to be an integrated part of the regular cardiology fellowship non-invasive rotation. The yearly didactic lecture series on exercise physiology for the Cardiology and Pulmonary fellows continues.

The laboratory continues to be an extremely popular site for external training for undergraduate students from exercise physiology at regional universities. The laboratory generally averages two externs per year.

CARDIOVASCULAR EXERCISE PHYSIOLOGY LABORATORY

GOALS AND OUTLOOK FOR FISCAL YEAR 2023

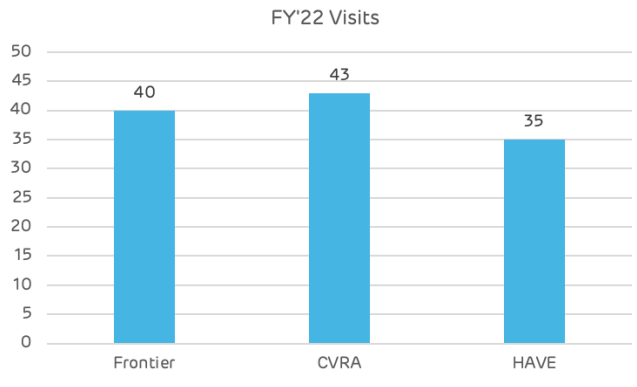
Clinical Program

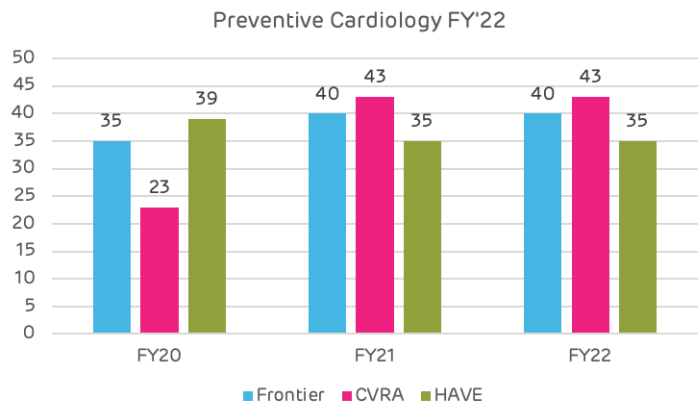
Exercise Testing

Early trends for clinical volume for FY 2023 are unclear in the current COVID era. FY 2020 was the first year in the last 15 years that the number of exercise tests performed in the Laboratory decreased from the previous fiscal year. However, with precautions in place, the Main Lab has nicely rebounded to volumes that approach 95% of the previous fiscal year (FY2019). Our focus this coming year is to expand services into the New Jersey area as a large population of patients requiring exercise testing come from this region. The second major endeavor is the expansion and move to the Buerger Building in the Spring of 2023.

Exercise Counseling

Under the umbrella of the Preventative Cardiovascular Program, staff in the exercise lab routinely attend and provide exercise counselling for patients attending the multi-disciplinary clinics **(Lipid-Heart, Cardiovascular Risk Program, Hypertension, FORWARD/Frontier)**. These clinics are generally held 2 times per month. Our goal is to increase the frequency of visits and utilize telemedicine as a means if tracking patient's wellness and physical activity patterns.
During fiscal year 2022, a cumulative increase of 22% was observed as shown below.





Remote Physical Activity Monitoring

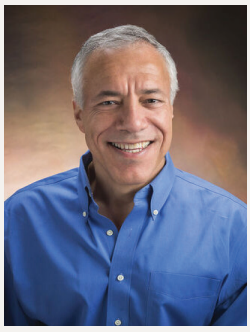
As part of the Cardiac Center Health Initiative we have partnered with the Open Health Network in developing the MyHeartCHOP app to provide remote monitoring in two pilot research studies led by Shana McCormick MD and Kimberly Lin, MD. These studies are designed to assess the effect of home exercise through the use of Fit Bit monitoring and specific individualized exercise regimens in adolescents and young adult with Friedreich's Ataxia and Hypertrophic Cardiomyopathy. This research and recruitment is currently active.

CARDIAC MAGNETIC RESONANCE IMAGING

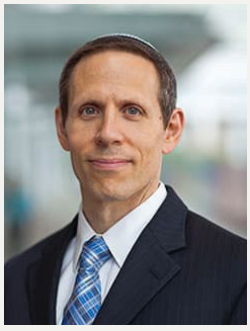
INTRODUCTION AND CLINICAL ACTIVITIES

The Cardiac Magnetic Resonance (CMR) program at CHOP is a state-of-the-art nationally and internationally recognized clinical and research program bringing the highest quality CMR services to patients with congenital and acquired cardiac disease, both pediatric and adult. In calendar year 2022, the program performed 1,322 CMRs, a 3.5% increase over the previous year, despite limitations in cardiac anesthesia manpower. CMRs are offered every day, Monday through Friday as well as one weekend day per month. On Wednesdays, we have the equivalent of 2 full scanners being utilized the entire day. Our primary MRI scanner is a 1.5 Tesla Avanto-FIT system that has been upgraded to the latest hardware and software. For select patients, we offer the higher magnetic field 3 Tesla Skyra system a half day a week to ensure optimal imaging, tailored to each patient's needs. Six CMR physicians, 7 highly trained CMR technologists and two radiology nurses provide the primary services. Recently, Dr Danish Vaiyani joined our group rounding out the 6 physicians.

CARDIAC MRI TEAM

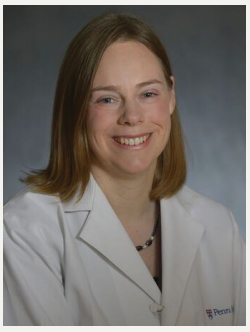


Mark Fogel, MD
Director of Cardiac MR



Matthew Harris, MD

Kevin Whitehead, MD



Sarah Partington, MD

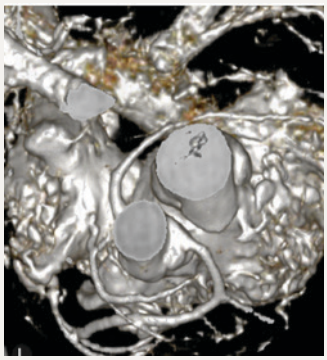
David Biko, MD, MBA

Danish Vaiyani, MD

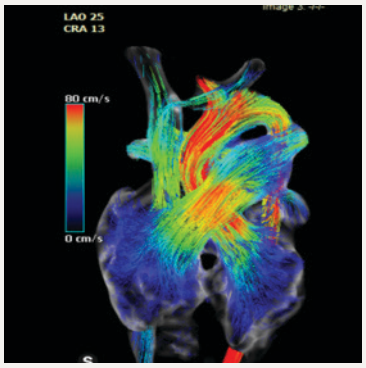
CARDIAC MAGNETIC RESONANCE IMAGING

The section provides not only standard CMR imaging of anatomy, heart function, blood flow and tissue characterization (heart scarring, infarction, edema) from the fetus all the way through and including adulthood, but also brings clinical care that only a few centers worldwide can perform with advanced imaging techniques only a few can provide. Studies such as "XMR," a combination of CMR and cardiac catheterization, are routinely done 2-3 times per week. CMR sometimes replaces cardiac catheterization in these situations. Stress CMR, such as using the drug adenosine or with a supine MRI-compatible bicycle, is used to assess heart blood perfusion or wall motion abnormalities. 3D printing and virtual reality to aid in interventional procedures such as surgery or cardiac catheterization are based in CMR and occur 1-2 times per week. Ferumoxytol, a CMR contrast agent available in only a few centers, is utilized 1-2 times per day to get ultra high quality of small structures such as coronary arteries, newborn pulmonary arteries, small pulmonary veins or to view the beating heart of a patient in four dimensions

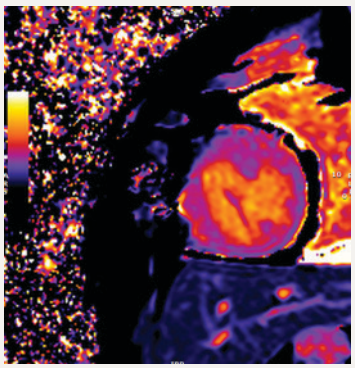
Since 2000, the CMR program has introduced a new service line nearly every year and we have recently introduced compressed sensing which cuts the amount of time to quantify how well the heart pumps from 7-10 minutes to 15 seconds. This also allows the time it takes to image a block of flow in the chest (4D flow imaging) from 7-10 minutes to 3 minutes. The program offers "elastography" which can measure organ stiffness, image the beating heart at many respiratory cycles and a machine learning approach that also accelerates the time it takes image the heart. This year we have introduced machine learning, artificial intelligence analysis of heart function, speeding up time of reporting.



Coronary Arteries in a 2 week old 6 Pound Infant



4D Flow Imaging in a Patient with Pulmonary Hypertension



Heart Scarring in a Single Ventricle Patient after Fontan

CARDIAC MAGNETIC RESONANCE IMAGING

RESEARCH

Our research mission is to support and foster retrospective and prospective studies led by the faculty, fellows and CMR technologists with the ultimate goal to use CMR as a tool to inform and improve the outcome of patients with congenital and acquired heart disease. Besides improving outcome, two major thrusts are understanding the hemodynamics and tissue characteristics that underpin congenital and acquired heart disease along with advancing new techniques in CMR.

The CMR team heads one National Institutes of Health grant (R01 Mark Fogel) using CMR to understand and heart and liver scarring in single ventricles before and after Fontan. The section is involved with 7 other grants also involving CMR including the role of heart function and scarring in Friedrich's Ataxia, heart and liver scarring in teenagers with Fontans and being part of a multicenter registry of CMR in Fontans to name a few. A large tetralogy of Fallot single center tetralogy of Fallot CMR registry was assembled by Dr Fogel to determine CMR predictors of clinical outcomes including global heart function, strain and hemodynamics. The team published 10 manuscripts in prestigious journals such as Journal of the American College of Cardiology: Cardiovascular Imaging, Journal of the American Heart Association, and Annals of Thoracic Surgery to name a few. There are 4 papers submitted and being reviewed. Eight abstracts were presented or accepted for presentation at national meetings such as the American Heart Association, the American College of Cardiology and The Society for Cardiovascular Magnetic Resonance. Staff delivered over mulitiple lectures at national meetings.

CONNECTIVE TISSUE PROGRAM

INTRODUCTION

The combined Cardiology and Genetics Connective Tissue Disease Program is a recognized center of excellence for the diagnosis and treatment for pediatric and young adult patients with underlying disorders of connective tissue that place them at risk for development of aneurysms of the aorta and other vessels. During our second year, we have seen a progressive increase in referrals both locally and regionally. Patients are seen by our Geneticist and Cardiologist together in the same visit using a personalized approach, based upon results of genetic testing and imaging, to create a treatment plan that is unique to each individual.

Cardiovascular imaging can be performed and interpreted on the same day as their visit and, for new patients, genetic counseling and initiation of genetic testing is immediately available. Those with associated medical problems receive referrals to our multidisciplinary team of specialists with expertise caring for these conditions. This team-based approach allows for ease of communication to provide a coordinated approach to care. Our patients are followed closely over time, and we have received very positive feedback from families who appreciate our focus and coordination of their care.

FACULTY LEADERSHIP

Stacey Drant, MD
Pediatric Cardiology
(Director)

Staci Kallish, DO
Medical Genetics

Multiple faculty are also involved from several departments in caring for the program's patients

- Allergy - Dr. Rahul Datta, Dr. Ashley Kazatsky, Dr. Soma Jyonouchi
- Cardiothoracic Surgery - Dr. Jonathan Chen, Dr. Muhammed Nuri, Dr. Stephanie Fuller, Dr. Katsuhide Maeda, Dr. Constantine Mavroudis
- Craniofacial/Plastic Surgery - Dr. Oksana Jackson
- Dietician - Danielle Campbell, RD
- ENT - Dr. Karen Zur
- Gastroenterology/EoE Center - Dr. Terri Brown-Whitehorn, Dr. Jonathan Spergel, Dr. Antonella Cianferoni, Dr. Laura Gober
- Neurology – Dr. Daniel Licht
- Ophthalmology - Dr. William Anninger
- Orthopedics - Dr. John Flynn, Dr. Michael Nance
- Pain management - F. Wickham Kraemer, MD
- Physical Medicine/Rehabilitation - Dr. Sarah (Sally) Evans
- Psychology - Nicholas Seivert
- Pulmonology - Dr. Oscar (Hank) Meyer
- Vascular Surgery - Dr. Alex Fairman, MD (CHOP and Hospital of University of Pennsylvania)

CONNECTIVE TISSUE PROGRAM

PROGRAMMATIC HIGHLIGHTS

1. CHOP sponsored the annual Walk for Victory in June 2022 held at Fairmont Park and Dr. Drant was named as Pediatric Chairperson. We continue to serve as a Referral Center for the National Marfan and Related Disorders Foundation that serves as a vital resource for families affected by these rare disorders to identify centers of excellence to care for their children. Because of the success of the event it will be held again in Philadelphia in 2023.

2. We began enrolling patients in the Lifestyle Medicine Program made available to school age children and teens with connective tissue disorders. Through the program, families learn about the impact of lifestyle choices encompassing diet, physical activity, sleep, social connectedness, and emotional wellbeing on their cardiovascular health. Our health coach then provides guidance and support to empower them to make changes. Lifestyle choices then become an important adjunct to their overall health and emotional wellbeing and the program has been very well received.

3. Drs. Stacey Drant (Cardiology) and Staci Kallish (Genetics) attended the International Symposium on Marfan, Loeys Dietz and Related Conditions meeting in August 2022. This is the only meeting focusing on the field of genetic aortic and vascular conditions in the world and his held every 2-3 years.

4. Dr. Alexander Fairman officially joined the Connective Tissue Disorders program in September 2022. He is a vascular surgeon with expertise and interest in caring for patients with underlying connective tissue disorders involving the vasculature and is already a valued member of the team. CHOP is one of only a few programs in the country with a pediatric vascular surgeon.

RESEARCH HIGHLIGHTS

1. CHOP received IRB approval to begin contributing to the Pediatric Registry for patients with connective tissue disorders (CLARITY). This registry serves as the only venue to share patient information that will allow for sorely needed research to understand these rare diseases and provide evidence-based treatments for children and adults with these debilitating and deadly disorders. The first manuscript has been submitted for publication.

PUBLICATION

1. 1. Mitchell SE, Martin RP, Terry P, Drant SE, Valle D, Dietz H, Sobreira N. Systemic to pulmonary artery aneurysm malformations associated with variants at MCF2L. Am J Med Genet A. 2023 Feb 9. PMID 36760094

PATIENT STORY

KN is now a nearly 3-year-old little girl born with the early onset form of Marfan syndrome. This form of Marfan syndrome is known to severely affect the tricuspid and mitral valves in the heart leading to severe heart failure with an average life expectancy of less than 2 years. Because of her heart failure along with other manifestations of Marfan syndrome, including severely impaired eyesight, she was not able to walk unassisted and interact with us. Through the Valve Center at CHOP, we were able to obtain advanced 3D heart valve imaging that allowed for surgical repair of her heart valves. With this groundbreaking care, her heart failure is significantly improved and now walks over and hangs out with Dr. Drant during her visits. And she is nearing her 3rd birthday!

CORONARY ANOMALY MANAGEMENT PROGRAM (CAMP)

OVERVIEW

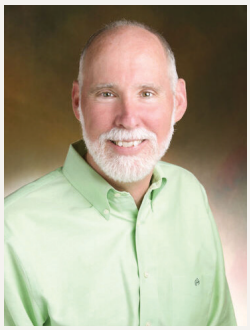
The Coronary Anomaly Management Program is a clinic for children, adolescents, and young adults with coronary artery anomalies. The vast majority of patients seen are those with anomalous aortic origin of the right (AAORCA) or left coronary artery (AAOLCA), but we also see those with rare coronary anomalies as well. Our team consists of Drs. Brothers, Paridon, Harris, Callahan, Maeda, and our Nurse Practitioner, Giordana (Jordy) Martino. The clinic sees patients monthly and together, Drs. Brothers and Paridon saw 37 new patients, 28 follow-up patients, and 12 patients via telemedicine. The team serves as a resource for second opinions from other doctors and patients/families. Together, the CAMP team has provided between 50-75 opinions and record reviews this year. The team in 2023 will be working toward finalizing the treatment and management algorithm for AAOCA patients and looks forward to publishing their experiences to date. Dr Brothers co-founded the Coronary Anomaly Forum that has become a well-attended monthly meeting to present and discuss interesting or challenging coronary patients. In 2022, a European forum was also started. Dr. Brothers also helped organize and spoke at the biennial Coronary Anomaly Symposium, this year in Houston, TX. Drs. Brothers and Paridon have also been involved with a PCORI grant with the coronary anomaly population. Patients continue to be enrolled in the CHSS Anomalous Coronary Artery Registry.

One patient's story exemplifies what the journey can be like for patients with AAOCA. Patient NB came to CAMP clinic in 2016 at age 6 years. He had presented to an ED for headaches and stomachaches after exercising and was referred to Cardiology. At that visit, the symptoms were not felt to be cardiac in origin, but because of a family history of bicuspid aortic valve, he had an echocardiogram performed. This showed both a bicuspid aortic valve and suspicion for AAORCA. He then had a sedated cardiac MRI, which confirmed bicuspid aortic valve with fusion of right and left coronary cusps. He also had an anomalous RCA with suggestion of a 5-7 mm inter-arterial and likely intramural course. He was then referred to CAMP clinic. At the first visit, he underwent an exercise stress test. We then discussed a "road map" for the future. NB has been followed annually and has undergone routine echocardiography which has shown progression of his aortic valve disease to mild aortic stenosis and regurgitation. At age 10 years, he underwent a stress echocardiogram. At now 13 years of age, he is interested in competitive sports, and we had a discussion with shared decision making, encouraging more endurance sports and none that will require heavy weightlifting, due to his valve. He will undergo a bicycle stress MRI summer 2023 before he enters high school. He has remained asymptomatic.

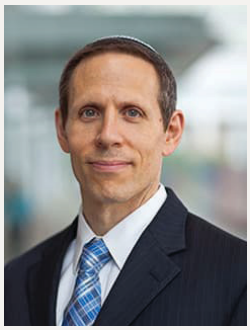
CORONARY ANOMALY MANAGEMENT PROGRAM (CAMP)

CAMP TEAM

Julie Brothers, MD, FAAP



Stephen Paridon, MD



Matthew Harris, MD

Ryan Callahan, MD

Katsuhide Maeda, MD, PhD

Jordy Martino, MSN, CRNP

PREVENTIVE CARDIOVASCULAR PROGRAM

FACULTY

Julie Brothers, MD, FAAP
Co-Medical Director

Shobha Natarajan, MD
Co-Medical Director

Our Preventive Cardiovascular Program, which include Lipid Heart Clinic, Cardiovascular Risk Assessment Clinic (CVRA), and Hypertension Clinic, has continued to expand in 2022, seeing patients in person and via telemedicine at CHOP Main and satellites. We welcomed a dedicated nurse practitioner, Giordana (Jordy) Martino, and Dr. Rachel Shustak, upon her graduation from fellowship and both have been wonderful additions to the program. The different clinics are highlighted below.

LIPID HEART CLINIC

Lipid Heart Clinic (LHC) has continued to see patients at CHOP Main, Brandywine Valley, Voorhees, Lancaster and Allentown. We have added physicians to 2 additional satellites: King of Prussia and Bryn Mawr, both in Pennsylvania. Our providers include at CHOP Main: Drs. Brothers, Bamba, Barsky, Prout, Shustak, and Ms. Martino; King of Prussia: Dr. Shustak; Brandywine Valley and Bryn Mawr: Dr. Brothers; Lancaster: Dr. Elias; Allentown: Dr. Palermo; Exton and Lancaster: Dr. Lizano; and Voorhees: Dr. Lee. The numbers presented are those seen at CHOP Main, Brandywine Valley, and Voorhees (Brothers, Bamba, Prout, Lee, and Barsky). The LHC team saw 993 patients with 375 visits as telemedicine (37.8%). There was a 2% no show rate, 8% 48-hour cancellation rate and 6% 24-hour cancellation rate. Since the COVID-19 pandemic, our clinic has transitioned to telemedicine, and we have continued offering this throughout 2022 and plan to continue in the future. We remain involved with a Quality Improvement project for LHC, looking at parent/patient satisfaction, no show and cancellation rates, and change in non-HDL-cholesterol with telemedicine compared to in person visits. We are working on a manuscript to detail our ongoing experience with telemedicine. We set up a Qlik Sense dashboard so we can continue to track our progress. For this year, our parent/patient satisfaction surveys have a 13.8% completion rate. In 2022, the LHC was involved with a Pediatric Heart Network clinical trial (DO-IT!) and had our final patient visit in January 2022. Dr. Shustak has continued her clinical trial, called SPRINT, enrolling patients through LHC and our other Prevention clinics. Dr. Brothers was the site PI on 2 pharmaceutical trials for treatment of heterozygous and homozygous familial hypercholesterolemia, one of which was completed in 2022, and the other is ending in 2023. Dr. Shustak has continued enrolling with her study "Evaluating the Use of Motivational Text Message and Loss-Frame Financial Incentives to Increase Step Counts in Obese Adolescents with Dyslipidemia." Dr. Justin Berger's paper, entitled "Adherence with lipid

screening guidelines in children with acquired and congenital heart disease: An observational study using data from The Marketscan Commercial and Medicaid Databases" was published in JAHA: Journal of the American Heart Association. Drs. Shustak and Brothers co-authored a book chapter with Dr. Stephen Daniels and was published in "Clinical Lipidology, 3rd edition". Drs. Shustak and Brothers also co-authored a book chapter, "Identification and Management of Children with Dyslipidemia," in the 4th edition of Lifestyle Medicine. As well, Dr. Brothers and her team have given talks around the region regarding treatment and evaluation of pediatric hyperlipidemia.

One patient exemplifies one patient population that we see: those with a genetic dyslipidemia. Patient ES presented to Lipid Heart Clinic after a lipid screening at age 7 years was performed due to family history of hypercholesterolemia. At that time, her LDL-C was 249 mg/dL, with other normal values. Family history was significant for mom with normal cholesterol but elevated lipoprotein (a) and dad with significant hypercholesterolemia. There was a family history of early coronary artery disease in both sides with paternal grandmother and maternal grandfather with heart attacks in their 40s. We recommended repeating the lipid panel and adding a lipoprotein (a) level, which did come back as markedly elevated. We followed her expectantly the next year and when she was 9 years old, due to her risk factors of: elevated LDL-C, elevated lipoprotein (a), and family history of early coronary artery disease, she was started on atorvastatin 10 mg nightly. Two years after starting her statin, it was increased to 20 mg nightly due to LDL-C remaining > 130 mg/dL. On the 20 mg of atorvastatin, her LDL-C had decreased by 30 more points and was at goal. We also recommend screening of siblings, and one of her two brothers had similar lipid values and has also been treated with statin medication.

CARDIOVASCULAR RISK ASSESSMENT CLINIC

The Cardiovascular Risk Assessment Clinic (CVRA) has continued to see patients two times per month. We saw 35 patients total. The physicians for 2022 were Drs. Brothers, Shustak and Palermo. Ms. Giordana Martino has been seeing patients as well. Shannon O'Malley has served as our exercise specialist and Danielle Campbell as our dietitian. We have had many referrals from the LHC as well as from our colleagues in the Healthy Weight Program, with several as pre-bariatric surgery patients. The latter will serve as a patient population we look forward to seeing one year after surgery to assess their vascular improvement after weight loss.

Two siblings exemplify how our Preventive Cardiology clinics work together. Two brothers (AP, SP) were referred from general Cardiology clinic due to recent paternal death at age < 50 years due to atherosclerosis and a history of hypertension, with normal lipid levels. The boys had a normal ECG and echocardiogram already performed. At the CVRA clinic, we noted one brother had elevated BMI (AP) and both boys had mildly elevated systolic blood pressures. We performed vascular testing and AP had elevated pulse wave velocity values. Because the blood pressure had been high in other settings, the family history, and AP with elevated pulse wave velocity, the boys were scheduled to be seen by Nephrology. We also asked them to get fasting lipid panels and lipoprotein (a) levels. While AP had normal lipids and lipoprotein (a), SP had elevated lipoprotein (a) and he will be seen in Lipid Heart Clinic.

PREVENTIVE CARDIOVASCULAR PROGRAM

HYPERTENSION CLINIC

The hypertension clinic (former HAVE clinic) focuses on patients with systemic hypertension related to complex medical conditions including but not restricted to heart defects and transplant, chronic kidney disease and transplant, diabetes, obesity, etc. It is a multidisciplinary clinic staffed by cardiologists (Drs. Natarajan, Palermo and Shustak with our nurse practitioner, Jordy Martino) and nephrologists (Drs. Meyers and Kogon) along with our nutritionist (Danielle Campbell); and exercise physiologist (Shannon O'Malley) who provide important guidance on healthy eating habits and exercise. The Hypertension clinic evaluated 63 patients in 2022 with 24 cancellations and 16 patients who did not arrive in clinic. The team is involved with several research studies, including those sponsored by PCORI, the NIH, and the AHA. There is also a Quality Improvement project, "BP Under Three", with support from the Magic Mila Foundation. In 2022, Drs. Meyers and Natarajan were co-authors on the study, "Left ventricular measurements and strain in pediatric patients evaluated for systemic hypertension and the effect of adequate anti-hypertensive treatment" that was published in Pediatric Cardiology. Dr. Meyers has also co-authored several other publications related to hypertension.

A patient story that exemplifies the Hypertension clinic is pt AM. He is a sweet 8-year-old boy with Williams syndrome which was diagnosed at three months of age when he was evaluated by cardiology for a murmur. He had repair of supravalvar aortic stenosis at The Children's Hospital of Philadelphia by Dr. Spray at 17 months of age. Since that time, he has been followed for his small aorta, renal artery stenosis and mid aortic syndrome. Andrew has had comprehensive testing in the Hypertension clinic and does have significantly thickened carotid artery walls. His pulse wave velocity is normal and although he has no significant LV hypertrophy or residual supravalvar aortic stenosis on his echocardiograms or cardiac magnetic resonance imaging, he does have a diffusely small thoracic and abdominal aorta. Through our multidisciplinary clinic, he has been able to see the nutritionist and exercise physiologist who have made sure that he has a healthy weight and is quite active. Even though AM has systemic hypertension, Dr. Meyers has been able to medically manage him on antihypertensive medication. We have collaborated with our interventional radiology team and have pursued second opinions from other centers of excellence for renal artery stenosis to ensure that AM continues to have the best care. AM is thriving and his family is very grateful for the care that they have received at CHOP's Hypertension clinic.

PULMONARY HYPERTENSION

OVERVIEW

The Children's Hospital of Philadelphia's Pulmonary Hypertension (PH) Program continues to be on of the leading PH Center in North America. The Team cares for pediatric PH patients from neonates to young adults with all forms of PH and right ventricular failure including idiopathic pulmonary arterial hypertension, congenital heart disease-related PH, PH related to developmental lung diseases, chronic thromboembolic PH, sickle cell disease, and others. Members of the PH team provide cardiac care to patients in the Congenital Diaphragmatic Hernia and Bronchopulmonary Dysplasia Programs, which together treat more that 100 new patients per year.

With extensive experience in PH medical therapies, the team offers treatment via continuous prostacylins as well as novel oral therapies. Finally, with colleagues in Interventional Cardiology and Cardiothoracic Surgery, the team continues to pursue breakthrough catheter-based, surgical, and mechanical support strategies as palliations for right ventricular failure or as a bridge to lung transplantation.

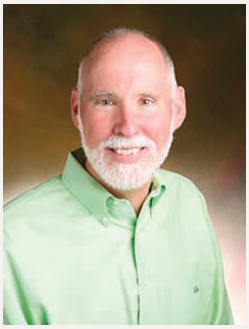
The Program saw close to 1500 encounters in 2022, including close to 1,000 Critical Care encounters. The clinical team also saw 476 OP visits, including 90 new patient visits.

FACULTY

Alex Davidson, MD, FACC
Medical Director

Catherine Avitabile, MD

David Frank, MD, PhD



Stephen Paridon, MD

Chitra Ravishankar, MD

Jennifer Tingo, MD

PULMONARY HYPERTENSION

RESEARCH HIGHLIGHTS

David Frank, MD is currently funded by a NHLBI/NIH K08 Mentored Clinical Scientist Research Career Development Award, a NHLBI/NIH R21 award, and a Doris Duke Charitable Foundation Clinician Scientist Development Award. He is a 2022 American Society for Clinical Investigation Young Scientist Awardee. He has over 40 peer-reviewed publications with a recent paper from his laboratory was recently awarded the Journal Cover of the Year by the journal, Development (CXCL12 defines arterial heterogeneity and promotes distal pulmonary vascular growth, Development. 2022 Nov 1;149(21). PMCID: PMC9687018).

Dr. Avitabile investigates physical activity, skeletal muscle deficits, and home-based exercise training programs in youth with Pulmonary Hypertension through an NIH/NHLBI K23 Mentored Patient Oriented Research Career Development Award. She is also the CHOP site-PI for the North American Pediatric Pulmonary Hypertension Network. In that role, she also serves as a co-investigator and the Actigraphy team lead for an NIH/NHLBI UG3 multi-center randomized clinical trial testing upfront mono- versus dual-therapy for pediatric PH, one of the only clinical trials in the field to date. She collaborates extensively with the CHOP Congenital Diaphragmatic Hernia Frontier program to study the impact of cardiac dysfunction on outcomes in that population and is funded by United Therapeutics to study urinary protein biomarkers in association with RV failure.

CARDIAC CARE UNIT

CARDIAC CARE UNIT (CCU)

The Cardiac inpatient service area includes 40 beds on two vertically integrated units on the 5th and 6th floors and provides intermediate level pediatric cardiac care that includes active telemetry with a high nurse to patient ratio. The inpatient Cardiac service can support care to acutely ill patients on vasoactive or antiarrhythmic infusions, patients with pulmonary hypertension initiating or receiving pulmonary vasodilators, patients with acute and chronic heart failure, patients on non-invasive positive pressure ventilation, and patients with complex lymphatic issues. We also provide care for stable patients with ventricular assist devices, either awaiting transplant or as a bridge to home.

LEADERSHIP AND PERSONNEL

To support our expanded patient numbers and ever-increasing acuity we have hired 4 new Advanced Practice Practitioners (APP) to bring our current number to 14, who along with rotating pediatric residents, provide front line medical team coverage for all patients. The physician coverage team includes 14 general cardiologists (2 new), 7 heart failure/transplant cardiologists, 4 pulmonary hypertension cardiologists, and 5 electrophysiologists. Each physician provides inpatient care for 6-13 weeks/year. The 5th and 6th floor units have a combined total of approximately 150 nurses, 25 senior nurses' aides, 12 telemetry technicians, and 12 inpatient clerks.

Under the leadership of Nurse Managers **Natalie Bernard, RN, BSN** and **Arnetta Woodson, RN, BSN,** along with Medical Directors **Susan Schachtner, MD** and **David Goldberg, MD** and APP team lead Diana Holbein, the cardiac units have continued their strong commitment to patient, and family-centered care including family-centered bedside morning work rounds.

Susan Schachtner, MD
Medical Director

David Goldberg, MD
Medical Director

Natalie Bernard, RN, BSN
Nurse Manager

Arnetta Woodson, RN, BSN
Nurse Manager

Cardiac inpatients are distributed across **four subspecialty cardiac services** providing in-depth, specialized care across a wide array of diagnoses. These subspecialty cardiac services include **general medical/post-surgical, heart failure/ transplant, electrophysiology, and pulmonary hypertension**. A strong partnership exists between nursing, medical provider teams and multidisciplinary support services

CARDIAC CARE UNIT

The Cardiac Care Units and Cardiac Center continue to actively participate in the Pediatric Acute Care Cardiology Collaborative (PAC3), a national learning network created with the aim of improving care for all acute care (non-CICU) pediatric cardiac inpatients. The collaborative is continuing its work on a major project called Hearts to Home with a primary goal of decreasing time to discharge once a patient is medically ready. The CHOP Hearts to Home team consists of advanced practice providers, physicians, nurses, specialist in quality improvement, data analysts and case managers. The project was awarded innovation funding under the direction of Emmanuelle Favilla, MD. Other ongoing work includes a new multicenter project under the PAC3 collaborative umbrella with a focus on reviewing hematochezia and NEC incidence among patients on acute care cardiology units. Ongoing local quality improvement projects include the "Watchers" project, and new Cardiac Critical Assessment Team (CAT) call initiatives, designed to assist with early identification and prevention of hemodynamic instability and to facilitate the smooth transfer of ill patients to the CICU, when indicated. There are additional quality improvement initiatives related to information and education infrastructure, harm prevention, and to the development of educational modules to support cardiac nurses new to the Cardiac Center.

Under the guidance of Natalie Bernard, with support of a Cardiac Center Innovation Grant, the **Cardiac Care Manager Program** was successfully transitioned to the larger hospital wide Care Management Department with two full time care managers supporting patients in the outpatient setting. The program will continue to provide outpatient post-discharge care manager follow-up to families within 24-48 hours of discharge, answering questions, reviewing medications, and providing reinforcement of care and education provided while a patient was hospitalized, in order to decrease readmissions and provide ongoing transitional care.

The **Cardiac Center Education** room continues to teach multiple aspects of home-based complex cardiac care to parents and offers classes on ventricular assist device care, home central line care, feeding tube placement and safety, non-standard formula preparation, medication administration, and cardio-pulmonary resuscitation among others. The education room is staffed by a select group of Cardiac Care Unit bedside nurses who are dedicated to patient safety and education. Parents and families value the education provided during the Education Room classes and the training provides for earlier, safe discharge of complex cardiac patients. Despite challenges maintaining the Education Room open each day, over nearly 550 unique learners were taught over 850 classes in 2022.

The Cardiology inpatient service participates in education of second year pediatric residents, with daily bedside teaching, multiple didactic lectures per week, and code simulations, to approximately 32 unique PL2 residents each year. The Medical Directors and Advance Practice Practitioner team lead work closely with the Pediatric Residency program to ensure excellence in cardiac education for these future intensivists, emergency physicians, neurologists, neonatologists and, of course, future pediatric cardiologists. The Cardiology service is in process of developing a new, revised pediatric education curriculum to ensure education goals are met for board certification.

In addition to the pediatric residents, the Cardiology inpatient service provides a critical opportunity for learning for each of the 6 first year pediatric cardiology fellows. The fellows join the cardiac service for 2 months during their first year, during which they learn management of inpatient cardiac patients from all subspecialists, learn to coordinate multidisciplinary groups and learn to lead/direct inpatient rounds and teams. They are given more responsibility as the year progresses. The fellow participates in education of residents and advance practitioners, as well as bedside nurses, and coordinates admissions and transfers from outside institutions and internal care units.

The Cardiac Care Unit has over 1500 separate cardiac inpatient encounters per year and additional encounters with non- cardiac patients who require telemetry monitoring. Over the past year we have continued to expand telemetry capabilities to cover more service areas within the hospital including coverage at the King of Prussia Middleman Family Pavilion, providing additional safe venues for non-cardiac patients with concern about heart rhythm stability.

CARDIAC PREPARATION & RECOVERY UNIT

The Cardiac Preparation and Recovery Unit (CPRU) supports the Cardiac Operative and Imaging Complex (COIC), which consists of two cardiac operating rooms, three cardiac catheterization labs, a hybrid room that allows for operative, interventional, and complex multidisciplinary procedures, and an MRI dedicated to cardiac imaging. The unit provides spacious private rooms for each family, along with accommodations for overnight observation when needed. Additionally, the unit has a dedicated procedure room that allows patients to have minor procedures with sedation or anesthesia outside of the COIC. The CPRU includes a Cardiac Center reception center with full amenities where families may wait and receive support during their child's catheterization, procedure, or surgery. Care in this recently renovated, state-of-the-art 15-bed unit is provided by an interdisciplinary team of pediatric cardiac interventionalists, electrophysiologists, cardiothoracic surgeons, cardiac anesthesiologists, cardiologists, cardiology fellows, cardiac nurse practitioners, cardiac nurses trained in peri-anesthesia care and child-life therapists. This team is enhanced by a full spectrum of specialized staff from pharmacy, respiratory therapy, child life, social work, case management and psychology with expertise in congenital heart and acquired cardiac diseases. Expert consultation from all of CHOP's clinical and support specialists is just moments away when needed.

CPRU LEADERSHIP

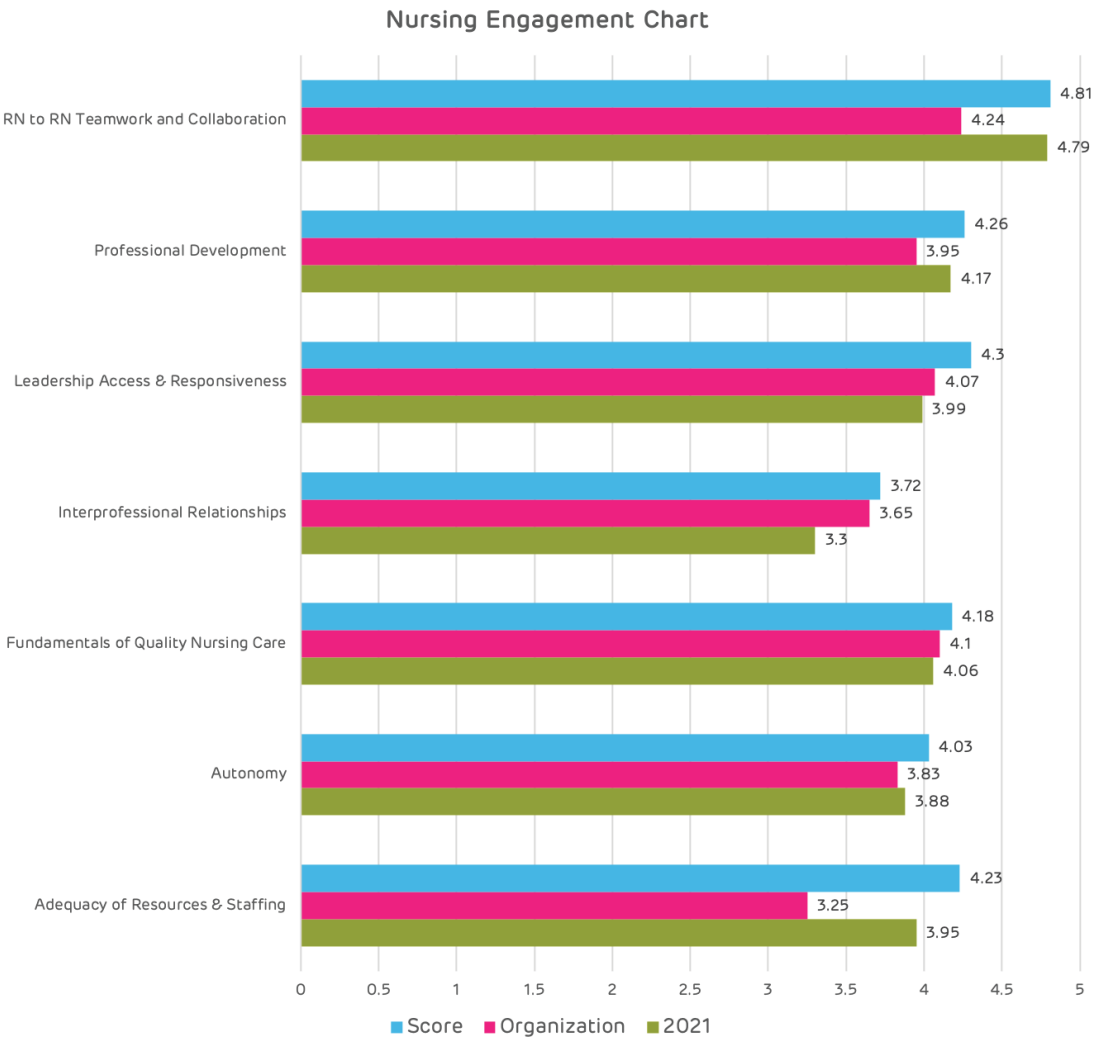
Donna Calfin, RN, MHL, CPN

This interdisciplinary team delivers highly specialized pre- and post-catheterization support, operative and same-day procedural care, as well as infusion therapy, pheresis and initiation/up titration of medical therapies for patients of all ages, from neonates thru adults. Patients treated in the CPRU are those with the most serious cardiac conditions. They include, but are not limited to:

- Patients with congenital (present at birth) or acquired heart disease preparing for surgery or undergoing diagnostic, interventional catheterization, or lymphatic procedures
- Patients with complex, life-threatening arrhythmias (abnormal heart rhythms) undergoing diagnostic catheterization, procedural ablation or pacemaker placement and revisions
- Heart transplant or primary pulmonary hypertension patients requiring medication titration
- Newborns diagnosed with critical congenital heart disease requiring cardiac sedation for echocardiogram or MRI, as well as patients enrolled in our Frontier Program who require specialized echocardiographic assessment of valvar lesions
- Patients requiring a wide range of cardiac procedures, including cardioversion, chest tube placement or an adenosine challenge

CARDIAC PREPARATION & RECOVERY UNIT

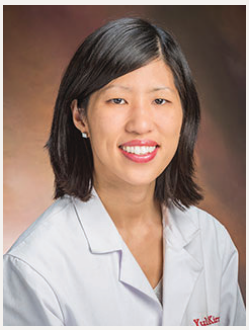
The CPRU follows ASPAN guidelines for recovery of patients receiving and recovering from sedation and cardiac anesthesia. This translates to 1:1 and 2:1 as indicated by the phase of recovery. Nurses and the Nurse Practitioners in the CPRU are highly engaged. They have creatively and proactively supported organizational and Cardiac Center efforts during high census, expanding the footprint to support ongoing patient care needs. The team has led several harm-prevention and quality improvement initiatives including the CPRU Flat-Time Project for catheterization patients. This project directly impacted the care of patients recovering post catheterization to alleviate excessive flat time, improving patient comfort, and the patient family experience. This project was presented at Cardiology 2023. The team was awarded first place for the nursing abstracts and will be presented again at World Congress. The unit leaders continue to expand the cross-training program to promote professional development and growth for nurses. The NPs and CPRU teams have partnered with the Anesthesia Resource Center, increasing day of surgery physical exams to help families and patient flow when having non-COIC procedures. Combined, these measures improve teamwork, patient care, and the patient-family experience resulting in the unit consistently scoring in the top 99th percentile for Press Ganey patient satisfaction scores and scoring above the organization in all categories for Nursing Engagement this year.



ADULT CONGENITAL HEART DEPARTMENT

It is now estimated that 90% of those born with congenital heart disease are expected to reach adulthood. The Philadelphia Adult Congenital Heart Center, a joint program of Children's Hospital of Philadelphia and Penn Medicine, unites expertise from two world-class hospitals to provide state of the art care for this growing population. Our mission is to provide comprehensive, collaborative, patient-centered care to adults affected by congenital heart disease. We strive for clinical excellence through innovative, evidence-based care to enhance the health and quality of life for each patient.

FACULTY



Yuli Kim, MD
Cardiology Medical Director

Sumeet Vaikunth, MD
Cardiology

Emily Ruckdeschel, MD
Cardiology

Sara Partington, MD
Cardiology

Tamar Preminger, MD
Cardiology

Stephanie Fuller, MD
Surgical DIrector

Mohammed Nuri, MD
CT Surgery

Constantine Mavroudis, MD
CT Surgery

Cardiac Surgeons
- Stephanie Fuller, MD
- Muhammad Nuri, MD
- Constantine Mavroudis, MD

Advanced Practice Providers
- Lynda Tobin, CRNP
- Kathleen Sullivan, CRNP

Nursing
- Robert Karvell, RN
- Christian Reda, RN
- Madison Angstadt, RN
- Tyesha Cusack, RN

Social Work
- Dawanna Pratt

Program Manager
- Yaideriah Johnson

ADULT CONGENITAL HEART DEPARTMENT

PROGRAM HIGHLIGHTS

ACHD Social Work

The Adult Congenital Heart Disease program welcomed a social worker to the team in September 2022. Teresa Salinas, LSW collaborates with patients and their families to assess resource needs, coordinate care, and facilitate connection to psychosocial and mental health supports. She aims to address social determinants of health by providing education, supportive counseling, and helpful tools for patients as they navigate adult health care and encounter barriers.

Telemedicine transition pilot program

The transition from pediatric to adult congenital heart disease is known to be associated with a significant attrition rate with significant morbidity and mortality. One of the first of its kind, Dr. Emily Ruckdeschel, Kathleen Sullivan, CRNP and Dr. Tamar Preminger, have started a virtual transition program targeted to adolescents and young adults. Annual visits are performed with a multidimensional emphasis on self-management and self-advocacy skills including education regarding their underlying congenital heart disease, long term risks, medications and evolving future issues such as pregnancy, employability, etc. The implementation of the program and the successful transfer of care to the Adult Congenital Heart Disease Program is being monitored by our Quality Improvement team.

Hearts in Transition

This "buddy program" partnering pediatric patients with volunteers who have successfully transitioned from pediatric to adult care will serve as another resource for our patients to support them through transition. The aim of the program is to provide education, support and resources for patients transitioning from pediatric to adult health care and will officially launch Summer 2023.

PROGRAM STATISTICS

From January to December 2022 there were:

- **3183** total patient visits
- **564** new patient visits (18% of all visits)
- **1842** echocardiograms
- **73** cardiac surgeries
- **151** cardiac catheterizations
- **56** electrophysiology procedures
- **549** CMR Studies (18 and older)

RESEARCH HIGHLIGHTS

MINDS-ACHD

Neurocognitive impairments in ACHD are common, the mechanism of which is incompletely understood. MINDS-ACHD "Multi-Institutional Neurocognitive Discovery Study (MINDS) in Adult Congenital Heart Disease (ACHD)" is the first multi-center neuroimaging study performed to address this issue. Dr. Stephanie Fuller is the site PI for this NHLBI-funded Pediatric Heart Network (PHN) study with CHOP as one of the lead sites for enrollment.

Fontan liver cancer

Fontan associated liver disease (FALD) is a condition affecting single ventricle patients and hepatocellular carcinoma has increasingly become recognized as a morbidity. Dr. Yuli Kim is leading a multicenter study on risk factors for hepatocellular carcinoma in the adult Fontan through the Alliance for Adult Research in Congenital Cardiology and will be presenting the findings at the 2023 American College of Cardiology Scientific Sessions. Data from this effort will form the basis for an international registry of liver cancer to gain insight on this rare complication.

ACHD valve surgery

As lead for a multicenter research initiative on valve surgery in the young, Dr. Stephanie Fuller has started a dual center registry on valve replacement in hundreds of young adults at CHOP and Penn with the intent to collect and report long-term outcomes of these procedures.

INTERSTAGE PROGRAM

INTRODUCTION

CHOP's Infant Single Ventricle Monitoring Program (ISVMP) is one of the nation's highest volume programs with one of the lowest interstage mortalities.

ISVMP was established in the fourth quarter of 2010 to decrease morbidity and mortality during the fragile "interstage" period between discharge after neonatal single- ventricle intervention and second-stage operation at about 4 to 6 months of age. In 2014, at the request of the Cardiac Center, we broadened our enrollment to include all shunt or PDA stent-dependent infants with both single and two-ventricle heart disease. With additional nurse pratitioner support we plan on including all fragile interstage neonates being discharged to home, for example those with pulmonary artery-banded single ventricle heart disease, aortic stenosis with small LV, etc. and to expand our program to beyond the stage I interstage.

For hypoplastic left heart syndrome (HLHS) the "interstage mortality" at the time of ISVMP inception was about 15% nationally. With the institution of the ISVMP at CHOP our interstage mortality for HLHS decreased from 14 % to 4.8%in 2015. Our current "all interstage" mortality is 1% with HLHS interstage mortality at 2%. We have made great strides in the areas of nutrition and communication in HLHS and remain one of the highest volume members and highest performers nationally in the National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC).

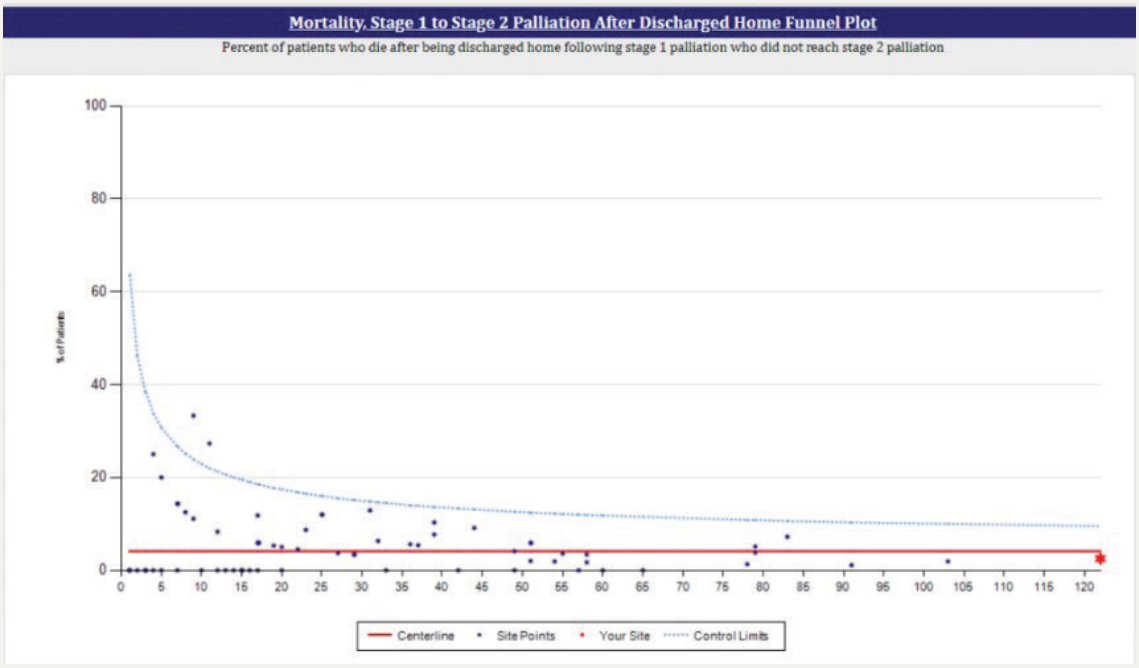
FACULTY

Therese Giglia, MD, FAHA
Medical Director

Alyson Stagg, MSN, CRNP
Program Coordinator

INTERSTAGE PROGRAM

NPC-QIC All-Site Funnel Plot:



*Indicates CHOP's cumulative data from NPC-QIC

STATISTICS

Volume: average 70 patients per year over last 5 years. ~30 Stage I; remainder BTS or PDA stents in other critical heart disease.

PROGRAMMATIC HIGHLIGHTS

- Since the inception of program, we have enrolled 830+ patients
- All Interstage death rate 1%, HLHS interstage death rate 2%
- Monthly telemedicine visits are our standard of care often with digital stethoscopes. 450 telemedicine visits to date since 2019.
- Care Companion Module in EPIC MyCHOP allows families to enter home data directly into the EMR
- Discharge consult on all patients
- Continued enrollment and active participation in NPC-QIC

2022 RESEARCH HIGHLIGHTS

- Publication in *Pediatric Cardiology* on Initial Experience with Telemedicine in Interstage Monitoring. (Stagg, Preminger, et. al.)
- SEARCH abstract presentation on Telecardiology Visits for Interstage Monitoring
- 11 Annual Quality and Safety Day abstract on Telemedicine for Interstage Monitoring
- AHA Young Investigator finalist (Shustak) on Neighborhood Social Vulnerability and Interstage Weight Gain
- Ongoing research includes: COVID-19 and interstage care, BNP in interstage monitoring, disparities in interstage care

CARDIAC KIDS DEVELOPMENTAL FOLLOW-UP PROGRAM

OVERVIEW

TThe Cardiac Kids Developmental Follow-up Program (CKDP) aims to optimize the neurodevelopmental and behavioral outcomes of children with congenital heart disease through equitable clinical care, patient and family education, multidisciplinary collaboration, community outreach, training, and research contributions. The Cardiac Center at The Children's Hospital of Philadelphia has been a pioneer in the important area of developmental care for children with congenital heart disease since the launch of the NeuroCardiac Care Program in 2009. We know that the experiences of our patients can impact their growth and development, even years after cardiac surgery. For that reason, we remain committed to providing a developmental follow-up program to help identify areas of need, and to help our patients and their families access resources within CHOP and the larger community to address any developmental challenges they may face.

OUR TEAM

Alisa A. Burnham, MD
Co-Director

Lyla Hampton, PhD, ABBP-CN
Co-Director

Amanda J. Shillingford, MD
Cardiology Liason

Kate Wallis, MD, MPH
Developmental Pediatrician

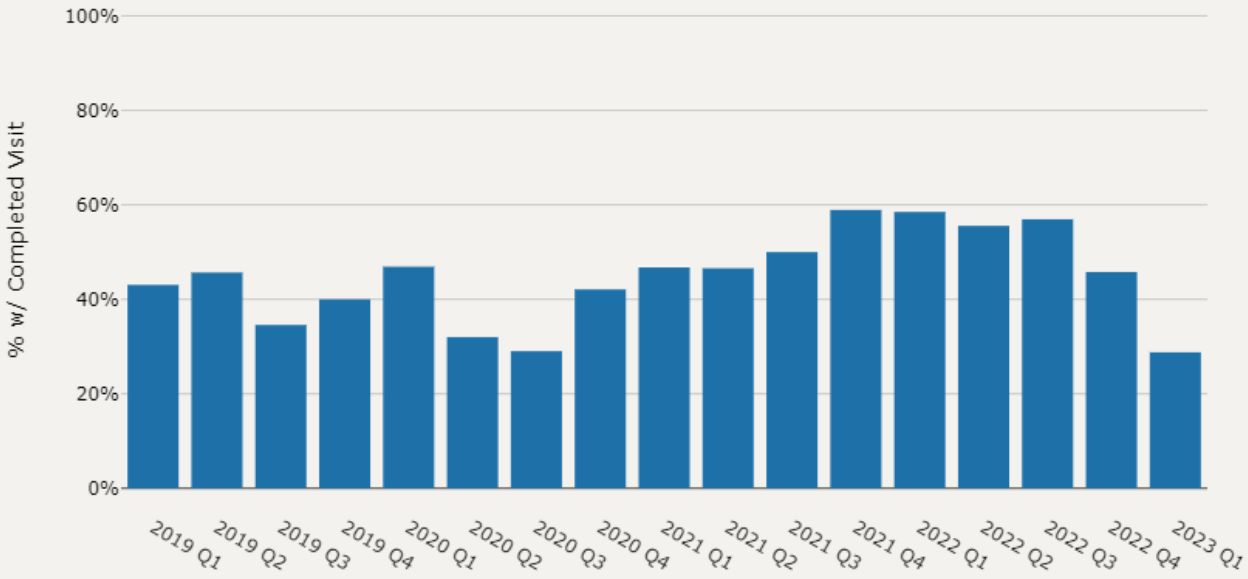
Laura Zimmerman, RN, BSN, CPN
Program Manager

CARDIAC KIDS DEVELOPMENTAL FOLLOW-UP PROGRAM

EVALUATION

The collaborative and multidisciplinary approach of the CKDP allows for care of patients and their families from infancy to school age. Comprehensive evaluation is provided starting at 3 months of age with our pediatrician and occupational, physical, and speech-language therapies. Our psychologists also evaluate developmental and behavioral functioning from early childhood to 5 years of age. Social work and nutrition consultations are available as well. Once children reach school-age and graduate from the CKDP program, there are opportunities for ongoing follow-up with our neuropsychologist to navigate cognitive or behavioral concerns that may present through school age to adolescence. In addition, the CKDP works with a developmental pediatrician who provides ongoing evaluation and treatment of Attention-Deficit/Hyperactivity Disorder (ADHD). Our ability to work with multiple specialties, as well as ancillary support allows us to provide comprehensive care within the patient's visit and reduce burden of multiple appointments and referrals. All clinicians can refer their eligible patients to the CKDP by placing an Epic consult for referral. Any child with CHD who underwent a catheter or surgical based intervention or had prolonged hospital admission prior to 6 months of age is eligible for evaluation. Patient-specific questions can also be routed to the CKDP program manager, Lauren Zimmerman RN via Epic staff message. The CKDP works closely with the Financial Clearance team and families typically opt to bill their insurance for the visits.

Percentage of Qualifying Patients w/ CKDP Visit Prior to 12mo Old

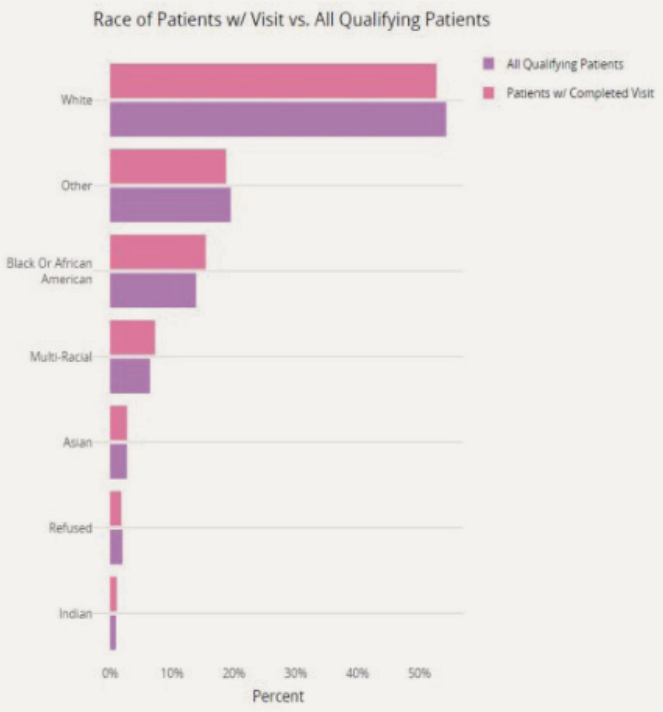


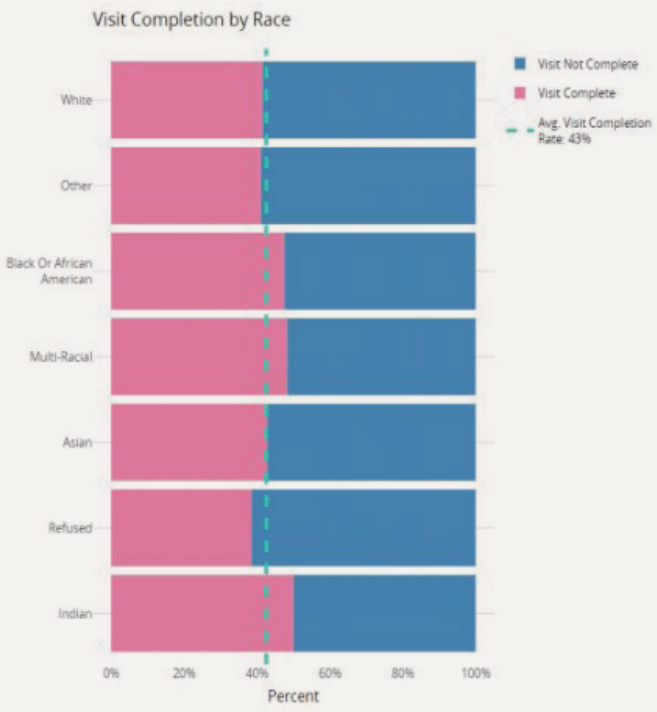
This graph shows the percentage of qualifying patients who completed any recommended CKDP office visit prior to turning 12 months old, therfore indicating capture.

CARDIAC KIDS DEVELOPMENTAL FOLLOW-UP PROGRAM

PROGRAMMATIC DEVELOPMENT

The CKDP program has grown substantially since its conception in 2009. We continue to leverage telehealth for appropriate clinic patients as well as some initial ADHD evaluations. Utilizing the tools available within the CKDP's Healthy Planet build, we have been able to track capture and retention rates. Accountability for equitable services is also shown in some of the demographics data. The included graphs are supplied by the CKDP's Healthy Planet dashboard. The CKDP continues to make progress on our 2022 Innovation Grant, creating updated and curated developmental education that will be widely available for patients and families to supplement the care provided in clinic. In response to family feedback, Cardiology is collaborating with the Hospital School Program in the Patient and Family Services Department, to actively recruit a dedicated Education Coordinator for the cardiac population. This role will support close collaboration between the family, the healthcare team and community schools and serve as a bridge to facilitate necessary resource acquisition in the school setting. The CKDP will be welcoming Colleen Driscoll, Ph.D. this year! Dr. Driscoll is currently a pediatric psychologist and clinical assistant professor at NYU Langone's Hassenfeld Children's Hospital. She earned her doctorate in clinical psychology from Loyola University Chicago and completed a pre-doctoral internship and postdoctoral fellowship at Nemours Children's Hospital, specializing in cardiology, critical care, and early childhood psychology. Dr. Driscoll will be working in both inpatient and outpatient settings, including the CKDP.





These graphs show a demographic breakdown of CKDP patients who completed a visit before 12 months old compared against all qualifying patients under 12 months old. The graph on the left shows the demographic composition of both groups and the graph on the right shows the visit completion ratio for each demographic category.

CARDIAC KIDS DEVELOPMENTAL FOLLOW-UP PROGRAM

RESEARCH/QUALITY IMPROVEMENT

We continue to actively participate in the Cardiac Neurodevelopmental Outcome Collaborative (CNOC) clinical registry, a multicenter, multinational collaborative database resource that is linkable to PC4 and PAC3 data. In addition to recently acquiring personnel resources to facilitate contributions more actively to the CNOC registry, work to streamline data entry utilizing shared Epic flowsheets is underway. Also, ongoing Quality Improvement work is focused on promoting appropriate development following cardiac surgery through education for both caregivers and staff. The CKDP aims to utilize our contribution efforts for future research interests at both the CHOP and larger CNOC levels and welcomes collaboration throughout the enterprise.

CARDIAC ANTICOAGULATION & THROMBOSIS PROGRAM

INTRODUCTION

Children with congenital and acquired heart disease are prone to blood clots that may be life-threatening. The Cardiac Anticoagulation and Thrombosis Program is a one-of-a-kind, multidisciplinary program managed jointly by cardiology and hematology and supported by nursing, and clinical pharmacy to reduce the incidence and complications of thrombosis in cardiac inpatients and to improve outpatient anticoagulation treatment and monitoring.

In July 2013 the Divisions of Cardiology (Dr. Giglia) and Hematology (Dr. Raffini) were awarded a competitive 2-year internal grant (Chair's Initiative) to pilot the program. To our knowledge, our team is the only dedicated, multidisciplinary cardiac thrombosis team in the US, and is now comprised of 2 nurse practitioners, 3 cardiologists, 6 hematologists, and 2 PharmDs. Recently a dedicated CT surgeon joined the team. Our advanced practice providers perform an initial consult on all patients in the cardiac center with clots or in need of anticoagulation and follow them through to discharge. This includes follow-up visits as needed and a discharge visit with a plan that goes into the official discharge summary. Half the year is staffed by cardiology and the other half of the year by hematology. Our outpatient team consists of the nurse practitioners and the cardiology program director who in addition to managing medication adjustments remotely see outpatients in a dedicated outpatient clinic. The entire thrombosis team meets weekly with the individual cardiac center inpatient teams to review inpatients as well as outpatients with questions or of particular concern.

LEADERSHIP

Therese Giglia, MD
Program Director

Leslie Raffini, MD
Hematology Lead

Rachel Keashen, CRNP
Advanced Practice Provider

Jacquelyn Oswald Sager, CRNP
Advanced Practice Provider

TEAM

Cardiologists:
Matthew O'Connor, MD
Chitra Ravishankar, MD

Hematologists:
Bhavya Doshi, MD
Michele Lambert, MD
Ben Samelson-Jones, MD
Hilary Whitworth, MD
Char Witmer, MD

CT Surgery:
Mohammed Nuri, MD

PharmD:
Hailey Collier, PharmD
Alyssa Hager, PharmD

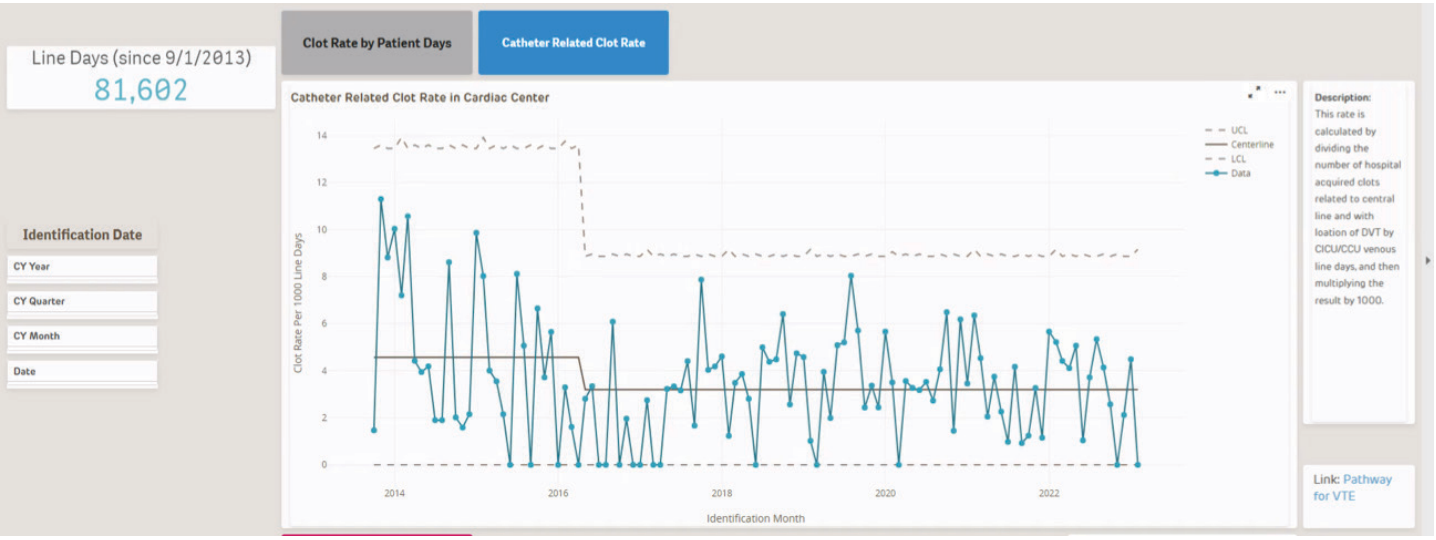
CARDIAC ANTICOAGULATION & THROMBOSIS PROGRAM

STATISTICS

The inpatient team sees 2-5 new consults and 3-8 follow-up visits per week. 200 outpatients on warfarin, enoxaparin or direct oral anticoagulants are currently followed by the outpatient team.

PROGRAMATIC HIGHLIGHTS

- Established a robust REDCap database with QlikView application to track all inpatients with thrombosis and those needing prophylactic anticoagulation
- Established an EPIC flowsheet for tracking outpatient labs and dosages which is maintained by the NPs and is available to all caregivers
- Consulted on nearly 1100 inpatients with thrombosis or on prophylactic anticoagulation since the program inception and currently manage over 200 outpatients on warfarin, enoxaparin, or direct oral anticoagulants
- Built and utilize CICU/CCU Pathway for the Management of Acute Catheter-related Venous Thromboembolism which standardized care https://www.chop.edu/clinical-pathway/venous-thromboembolism-catheter-related-cicu-ccu-clinical-pathway.
- Decreased inpatient thrombosis rate (venous clots per 1000 line days) from 4.6 (initial) to 3.2 (May 2016) with center line shift and have sustained this improvement



RESEARCH HIGHLIGHTS

- We currently are working on a predictive model for first hospital-acquired thrombosis in infants in the Cardiac Center and hope to pilot thromboprophylaxis in identified high-risk infants before launching a multicenter trial
- 6 abstracts at national meetings, 3 papers in preparation

DIVISION OF CARDIAC ANESTHESIOLOGY

OVERVIEW

The Division of Cardiac Anesthesiology is dedicated to the periprocedural care of children with critical congenital heart disease by 1) providing world-class clinical care in an anesthesia care team approach, 2) advancing children's treatment options through cutting edge clinical and basic science research, and 3) training the next generation of Pediatric Cardiac Anesthesiologists. Our interdisciplinary care team, comprised of board-certified anesthesiologists, Cardiac Certified Registered Nurse Anesthetists (CRNAs) and Pediatric Anesthesiology and Pediatric Cardiac Anesthesiology fellows, as well as Cardiac Anesthesiology technicians, is dedicated to treating children with congenital heart disease, complex lymphatic abnormalities, and critical pulmonary hypertension. Last year, we provided more than 3,000 anesthetics in a variety of settings for some of the highest acuity patients in the hospital. Our team takes care of the highest number of neonates with congenital heart disease in the nation, with substantial growth in the past two years. As an integral part of the Cardiac Center, our team's expertise helped facilitate cutting edge procedures and interventions, enabled lifesaving surgeries, and made us the "glue" that holds the Cardiac Center Operational and Imaging Complex (COIC) together. Our Quality/Safety group has made significant contributions to the safety culture in the Cardiac Center. The educational team has been busy in structuring the Cardiac Anesthesiology fellowship to submit an application for the nationally newly developed Pediatric Cardiac Anesthesiology fellowship to the Accreditation Council for Graduate Medical Education (ACGME). Our small and dedicated clinical team works in a high stress/high acuity environment and can only sustainably carry out our mission by working collaboratively and by bestowing the same level of clinical excellence, integrity, compassion, accountability, and respect on our patients and their families as we do on our colleagues. We know that we are at our best when we embrace diversity in people and ideas, when we actively practice inclusion, and when we strive for equity and pride ourselves in being among the best Pediatric Cardiac Anesthesiology teams in the world.

LEADERSHIP

Andreas W. Loepke, MD, PhD, FAAP
Chief, Division of Cardiac Anesthesiology

Lindsey Loveland Baptist, MD, FASA
Associate Chief for Education and Professional Development
Program Director, Advanced Pediatric Cardiac Anesthesiology Fellowship

J. "Nick" Pratap, MB, BChir, MRCPCH, FRCA
Associate Chief for Quality, Safety and Informatics

Rebecca Cardoso, MHA
Administrative Director

DIVISION OF CARDIAC ANESTHESIOLOGY

FACULTY

Eduardo Goenaga Diaz, MD

Matthew Jolley, MD

John McCloskey, MD

Susan Nicolson, MD

Asif Padiyath, MBBS

OTHER KEY STAFF

- Therese Brady, CRNA
- Lisa Jones, CRNA
- Deirdre McFillin, CRNA
- Jamie Sloan, CRNA
- Carolyn Srinivasan, CRNA

NEW RECRUITS

The Division continues to grow substantially with new recruits who started in 2022 and several signed to start in Fiscal Year 2024

Started as of April 2023

- Teresa Murray-Torres, MD
- Rebecca Motykiewicz, CRNA

Starting this coming year

- Jennifer Lynch, MD, PhD
- Manal Mirreh, MD
- Lindsey Weidmann, DO, MS
- Deborah Romeo, MD
- Peter Caruso, CRNA
- Joseph Brunelli, CRNA
- Lapio Tkach, CRNA

LEFT TO RIGHT: Lisa Jones, CRNA, MSN, Hannah Kuhn, CRNA, MSN, Jamie Sloan, CRNA, MSN, Deidre McFillin, CRNA, MSN

LEFT TO RIGHT: Amy O'Donnell, CRNA, MSN (Locums), Lisa Jones, CRNA, MSN, Therese Brady, CRNA, MSN

Carolyn Srinivasan, CRNA, DNP

DIVISION OF CARDIAC ANESTHESIOLOGY

CLINICAL HIGHLIGHT

The Cardiac Anesthesiology team facilitated several cutting-edge procedures and interventions. One of the more memorable events was providing repeated anesthetics for a pair of conjoined twins for several imaging studies and procedures in preparation for their upcoming separation surgery.

SPECIAL PROGRAMS

The Quality and Safety team within the Division of Cardiac Anesthesiology (Nick Pratap, MD; Carolyn Srinivasan, CRNA) has been busy focusing the Division's quality and safety efforts in 2022. Over the course of the year, they were pleased to welcome two new faculty members with Quality & Safety expertise (Eduardo Goenaga Diaz, MD; John McCloskey, MD). To improve quality of patient care and safety, our team implemented a new system for logging critical incidents, which substantially improved timely incident reporting in our busy clinical environment. In our quarterly Morbidity and Mortality conferences, we focus our case selection and our format from individual responsibility to systems issues to identify and implement quality improvement initiatives. Resulting from these efforts, we were able, in partnership with the Cardiac Operative & Imaging Complex (COIC) Safety team, to establish an emergency alert system to rapidly summon assistance to procedural areas, when urgently needed. In partnership with the nursing team, we grew the anesthesia technician team and created a supervisory position for the Anesthesiology Technician team. These measures have created bandwidth for improvements in organization and consistency of equipment and supplies, leading to a safer work environment. The team is collaborating closely with CICU nursing leadership and educators in a joint forum to ensure safer, smoother transitions from the Cardiac OR to the CICU for the Division's highly complex patients. Working with Drs. Loveland Baptist and Loepke, as part of a continuing project to improve culture and wellbeing within the Division, a staff respite space near the COIC was identified and equipped, serving also as a seminar room for Divisional meetings and educational sessions. The Quality and Safety team members have been instrumental in extending laboratory measuring capabilities to the cardiac procedural areas, such as lactate measurement and round-the-clock availability of thromboelastography. In this way, new clinical information is available in a timely and relevant fashion to support clinical decision-making.

The Division of Cardiac Anesthesiology sponsors the advanced pediatric cardiac anesthesiology fellowship, one year of training. The division also supports the three-month rotation in pediatric cardiac anesthesiology for all the pediatric anesthesiology fellows, eleven this year. These two groups of fellows continue to provide a massive amount of outstanding patient care (945 days among them all!), research, and education to others around them. We appreciate all the work that multiple disciplines from across the Cardiac Center do to contribute to the training our fellows receive.

This year was quite remarkable for the advanced fellowship as the American College of Graduate Medical Education (ACGME) approved a program allowing for accreditation of the fellowship. The past year has been spent writing, editing, collating and preparing a greater than 100-page application document to submit to the ACGME. The application is all encompassing and through the work of dedicated faculty and staff we submitted ours for approval. We anticipate our application will be reviewed in April and hope to be granted accreditation. If so, this will make CHOP Cardiac Anesthesiology Division's advanced pediatric cardiac anesthesiology fellowship among the first in the country to be accredited and continues to emphasize the commitment to education. Additionally, if accreditation of our program is approved our current fellows will have the distinction of graduating from an accredited training program.

DIVISION OF CARDIAC ANESTHESIOLOGY

We are incredibly fortunate to have two advanced fellows who will graduate in July 2023. One of them has chosen to stay here in our division at CHOP. Our second fellow has accepted a position at another top tier children's hospital to practice pediatric cardiac anesthesiology and will continue to demonstrate the outstanding education and experience our fellows obtain while at CHOP. We have one fellow who will begin in August 2024, and an additional fellow already committed for 2025. Both commitments are notable because of the incredibly challenging national landscape for not only Pediatric Cardiac Anesthesiology, but also the pipeline from which most of our faculty derive, pediatric anesthesiology. Nationally in the 2022 pediatric anesthesiology fellowship match, only 165 of 266 fellowship positions were filled, or 62% of positions. This continues a trend of downward election of pediatric anesthesiology training we have seen in the past several years. We anticipate this may well further diminish the number of physicians who choose to pursue the advanced training to join our specialty. We are thrilled to have a fellow committed for each of the upcoming academic years.

RESEARCH HIGHLIGHTS (All research publications will be in a combined section at the end)

Dr. Matt Jolley leads a cutting-edge research laboratory focusing on using novel 3D imaging and modeling to inform patient-specific planning of cardiac surgery and interventions in children. In 2022 the Jolley lab released SlicerHeart, an open-source pediatric cardiac imaging-focused image processing framework, which has now been downloaded over fifty-thousand times. In addition, they continued their work to support the Pediatric Valve Center with patient-specific heart valve modeling prior to surgical repair. They were also awarded the Additional Ventures Expansion award and CHOP Cardiac Center Innovation award in 2022. The Jolley lab grew to over 12 members including three post-doctoral fellows in computational physics, biomechanics, and image processing, with resulting publications in Circulation Imaging, the Journal of Biomechanical Engineering, and the Journal of the American Society of Echocardiography.

Dr. Loepke works with Drs. Bill Gaynor, Allan Simpao, Aaron DeWitt and the Cardiac Surgery research team to examine the effects of the sometimes substantial exposures to anesthetics and sedatives during cardiac procedures and in the intensive care unit on long-term neurodevelopmental outcomes.

CURRENT FELLOWS

- Kirsten Groody, MD
- Jennifer Lynch, MD, PhD

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

OVERVIEW

The Cardiac Center's Division of Cardiac Critical Care led by Dr. Andrew Costarino, MD, MSCE, oversees management of the infants and children with congenital and acquired heart disease admitted to the Cardiac Center's pediatric Cardiac Intensive Care Unit (CICU).

Our team experienced no attrition in 2022 and were able to successfully recruit three new faculty members. Dr. Jamie Weller joined in August 2022 after completing her Pediatric Cardiology and Pediatric Critical Care Fellowships at the University of Texas Southwestern. Dr. Elizabeth Herrup joined the division in September 2022. She had trained at CHOP as an advanced fellow in Cardiac Critical Care from 2018-2019 and was most recently working as an Assistant Professor at UPMC Children's Hospital of Pittsburgh. In November, we were joined by Dr. Renee Willett, who comes to us from Children's National Hospital in Washington DC, where she was an Assistant Professor and Attending Physician in the CICU. She has completed her Pediatric Cardiology fellowship at Boston Children's and Critical Care Medicine fellowship at Johns Hopkins in Biltmore.

Continued clinical growth of the Cardiac Center resulted in expansion of the CICU and attending physician care team model. In October, the CICU attending team implemented a 4th care team to facilitate patient flow, bed management, triage, transport intake, admissions, CPR outside of the CICU, and procedural and sedation needs. Attending physician coverage was also expanded into the evening hours and early night, with a second attending now available in the CICU from 3:00-11:00pm every weekday. This expanded attending physician coverage model supported the need for the CICU to surge to 36 beds effective March 2023. Further, a nested sub-unit was created within the structure of the CICU to further advance and streamline the care of children with heart failure and help with deployment of advanced therapies. This unit, Advanced Cardiac Therapies Unit (ACT-ICU) is headed by Dr Aaron Dewitt as its medical director.

The heart of the Cardiac Critical Care Division's Educational effort is the advanced fellowship (PGY 7 level) under the Direction of Dr. Jodi Chen. In addition, the Division trains categorical physician trainees in Critical Care Medicine fellowship and Pediatric Cardiology fellowships (24 months of trainee rotations in the CICU for each program). The Division sponsors and or supports several other education initiatives including a one-month elective for Pediatric residents, an annual multi-institutional "boot camp" for advanced fellows in Cardiac Critical Care, a simulation program for inpatient cardiac center physician and nursing staff and participates in training programs for advance practice nurse students at the University of Pennsylvania, Drexel University and others.

LIST OF CURRENT FACULTY

- Geoffrey Bird, MD, MSIS, FAAP
- Marissa Brunetti, MD
- Jodi Chen, MD, MS
- Andrew Costarino Jr., MD, MSCE
- Aaron Dewitt, MD
- Thomas Dietzman, MD
- Monique Gardner, MD
- Michael Goldsmith, MD
- David Hehir, MD, MS
- Elizabeth Herrup, MD
- Benjamin Kozyak, MD
- Felina Mille, MD
- Maryam Naim, MD, MSCE
- J. "Nick" Pratap, MB BChir, MRCPCH, FRCA
- Amy Romer, MD
- Venkat Shankar, MBBS, MBA
- Jamie Weller, MD
- Renee Willett, MD
- Mahsun Yuerek, MD

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

LEADERSHIP

Andrew Costarino, MD, MSCE
Division Chief
Cardiac Critical Care Medicine

David Hehir, MD, MS
Associate Chief, Quality Impovement
Cardiac Critical Care Medicine
Safety Officer, The Cardiac Center

Maryam Naim, MD, MSCE
Associate Chief, Research
Cardiac Critical Care Medicine

Venkat Shankar, MBBS, MBA
Associate Chief, Clinical Operations
Cardiac Critical Care Medicine
Medical Director, Cardiac Intensive Care Unit

Aaron Dewitt, MD
Medical Director, Advanced Cardiac Therapeutics (ACT) Intensive Care Unit

Jodi Chen, MD
Program Director, Cardiac Critical Care Medicine Fellowship

Rebecca Cardoso, MHA
Administrative Director

NEW RECRUITS

The Division continues to grow substantially with new recruits who started this year and several signed to start in Fiscal Year 2024.

Started as of December 2022

- Elizabeth Herrup, MD
- Jamie Weller, MD
- Renee Willett, MD

Starting this coming year

- Pilar Anton-Martin, MD, PhD
- J. Wesley Diddle, MD

Current Fellows (2022-2023)

- Sheri Balsara
- Suneet Bhansali
- Julie Weld

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

QUALITY & SAFETY PROGRAM

CICU Faculty play key roles in the Quality and Safety programs of the Cardiac Center and Hospital. CICU faculty lead efforts focused on harm prevention areas, including sustained improvement in CLABSI rates, cardiac arrest prevention, and improving outcomes associated with Vascular Access. In addition, team members are leading specific rapid-cycle QI projects resulting in significant improvements in care delivery including: improving efficiency and accuracy of TPN ordering; reducing time to ECPR; improving compliance with daily rounding checklists; and implementation of a high risk situational awareness huddle for patients at risk of cardiac arrest.

A highlight of the year for the Quality and Safety team has been the development and implementation of a Cardiac Center CAT team (critical assessment team) to respond to patient deterioration outside the ICU, with the goal of reducing codes outside the ICU.

The efforts of the CICU faculty members in Quality and Safety have translated to significant academic output, including presentations at national meetings, a number of abstract presentations, and publications. In addition, we continue to support the further education of our team members, with attendance at QI courses, human factors courses, and QI workshops.

The CICU team has continued to demonstrate sustained improvement in CLABSI rates (1.6 events per 1000 line days) meeting its target rate for the year. In addition, our cardiac arrest and failure to rescue rates remain lower than those of peer institutions, by PC4 metrics.

RESEARCH HIGHLIGHTS

In 2022, Dr. Maryam Naim was appointed as the Associate Chief for Research for Cardiac Critical Care Medicine. In this newly created role, Maryam will continue to expand on the Division's research efforts and implement a robust structure for supporting current and future investigators.

RESEARCH AWARDS

Dr. Ben Kozyak was awarded the Cardiac Center Innovation Grant for Fontan pump development. Dr. Monique Gardner was awarded the Big Hearts Little Hearts grant for her work with CICU biomarkers. Dr. Monique Gardner also received the Best Pediatric science poster/podium presentation at Resuscitation Science Symposium for "Early Post-Cardiac Arrest Blood Pressure Thresholds are Associated with Outcomes: A Secondary Analysis of the ICU-Resuscitation Trial". Dr. Jill Hsia mentored by Dr. Maryam Naim received the Top Abstract Award at the Pediatric Cardiac Intensive Care Society Meeting and the Outstanding Investigator Award at Cardiology 2023 for "Risk Factors for Electroencephalographic Seizures in Neonates Following Surgery with Cardiopulmonary Bypass."

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4. Ruiz, Victor M; Goldsmith, Michael P; Shi, Lingyun; Simpao, Allan F; Gálvez, Jorge A; Naim, Maryam Y; Nadkarni, Vinay; Gaynor, J William; Tsui, Fuchiang Rich; Early prediction of clinical deterioration using data-driven machine-learning modeling of electronic health records. The Journal of Thoracic and Cardiovascular Surgery,164,1,211-222. e3,2022

5. Gardner, Monique M; Faerber, Jennifer; Glatz, Andrew C; Preminger, Tamar J; Avitabile, Catherine M; Shankar, Somya; Shustak, Rachel J; Weber, David R; Schachtner, Susan; Ravishankar, Chitra; Relationship Between Serum Brain-Type Natriuretic Peptide and Biomarkers of Growth in Infants With Shunt-Dependent Single Cardiac Ventricle,The American Journal of Cardiology,171,146-150, 2022

6. Gardner, Monique; Chen, Feng; Koterba, Natalka; Reddy, Isabel; Thompson, Jill; Mai, Anh; McGowan, Francis; Gaynor, William; Lacey, Simon; Yehya, Nadir; 390: Preoperative Biomarkers Associated with Poor Outcome After Neonatal Cardiac Surgery. Critical Care Medicine,50,1,183,2022

7. Gardner, Monique M; Kirschen, Matthew P; Wong, Hector R; McKeone, Daniel J; Halstead, E Scott; Thompson, Jill M; Himebauch, Adam S; Topjian, Alexis A; Yehya, Nadir; Biomarkers associated with mortality in pediatric patients with cardiac arrest and acute respiratory distress syndrome. Resuscitation, 170,184-193,2022

8. Kozyak, Benjamin W; Fraga, María V; Juliano, Courtney E; Bhombal, Shazia; Munson, David A; Brandsma, Erik; Stoller, Jason Z; Jain, Ankit; Kesman, Russell; Meshkati, Malorie; Real-Time Ultrasound Guidance for Umbilical Venous Cannulation in Neonates With Congenital Heart Disease,Pediatric Critical Care Medicine,23,5,e257-e266,2022

9. Walter, Jennifer K; Hill, Douglas; Drust, William A; Lisanti, Amy; DeWitt, Aaron; Seelhorst, Amanda; Hasiuk, Ma Luisa; Arnold, Robert; Feudtner, Chris; Intervention Codesign in the Pediatric Cardiac Intensive Care Unit to Improve Family Meetings. Journal of Pain and Symptom Management,2022

10. Gardner, Monique M; Keim, Garrett; Hsia, Jill; Mai, Anh D; William Gaynor, J; Glatz, Andrew C; Yehya, Nadir; Characterization of "ICU-30": A Binary Composite Outcome for Neonates With Critical Congenital Heart Disease, Journal of the American Heart Association,11,12,e025494,2022

11. Naim, Maryam; Griffis, Heather; Al-Araji, Rabab; Chan, Paul; Berg, Robert; Bradley, Richard; Burke, Rita; Markenson, David; McNally, Bryan; Nadkarni, Vinay; OR24 Impact of the Coronavirus 2019 Pandemic on Pediatric Out of Hospital Cardiac Arrest Outcomes During 2020. Resuscitation, 175, S23, 2022.

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

12. Myke Federman, Chella Palmer, Robert A Berg, Deborah Franzon, Kathryn Graham, Leanna Lyn Huard, Theresa Kirkpatrick, Vinay M Nadkarni, Laura A Maitoza, Ryan W Morgan, Matthew Sharron, Heather Wolfe, Robert M Sutton, Maryam Y Naim: Survival with Favorable neurological outcome and quality of CPR following in-hospital cardiac arrest in children with cardiac disease compared to non-cardiac disease. Poster presentation at the American Heart Association Scientific Sessions 2022.

13. Rachel J Shustak, Jing Huang, Vicky Tam, Alyson Stagg, Therese M Giglia, Chitra Ravishankar, Laura Mercer-Rosa, James P Guevara, Monique M Gardne Neighborhood social vulnerability and interstage weight gain: Evaluating the role of a home monitoring program Oral Abstract presentation at the American Heart Association Scientific Sessions 2022.

14. Marissa A. Brunetti, Heather M. Griffis, Michael L. O'Byrne, Andrew C. Glatz, Jing Huang, Kurt R. Schumacher, David K. Bailly, Yuliya Domnina, Javier J. Lasa, Michael Alice Moga, Hayden Zaccagni, Janet M. Simsic, J. William Gaynor Racial and ethnic variation in ECMO use, failure to rescue, & mortality in pediatric cardiac ICU patients: A multicenter cohort study from the pediatric cardiac critical care consortium registry. Poster presentation at the American Heart Association Scientific Sessions 2022

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

OVERVIEW

The CICU is a 32-bed intensive care unit providing care for patients with congenital and acquired heart conditions, largely requiring surgical or medical intervention, often within the neonatal period. The CICU at CHOP is one of the largest in the world, supported by a highly trained interprofessional team dedicated to the healing and well-being of this specialized patient population. State of the art medical technology such as Ventricular Assist Devices (VADs), ECMO, dialysis, and open-heart transplants are readily cared for in the CICU. This education rich and collaborative environment leads with evidence-based practice and innovation to promote the best possible patient outcomes. CICU staff includes over 150 extensively trained nurses that support 1:1 or 1:2 nurse to patient ratios. As co-managers, Amanda Seelhorst and Jamie Fitzgerald lead a dedicated team of advanced practice clinical, safety, and education nurse leaders in supporting the clinical care and unit operations.

ACCOMPLISHMENTS

- Demonstrated the ability to support surged patients to census of 34 and support growing capacity and as well as active planning for further expansion to meet projected growth in the upcoming year.
- 98% of nurses hold a BSN or higher-level degree and 29% are certified in critical care.
- CICU Nursing and Medical Teams collaborated with NICU, dialysis and nephrology to implement a new form of continuous renal replacement therapy (Aquadex) previously only performed in the NICU. This collaborative approach to meet patient specific needs and nimble training timeline for RNs was shared at Cardiology 2023 and AKI & CRRT 2023.
- Recent harm prevention efforts have yielded reduction in preventable harm including ZERO harm in February and three harm-free stretches of greater than 30 days.
- Notable Milestones this year:
    1. 84 days CLABSI free
    2. 100+ days PIVIE free
    3. 162 days CAUTI free
    4. 110 days HAPI free

LEADERSHIP

Amanda Seelhorst, MSN, RN
Nurse Manager, CICU

Jamie Fitzgerald MBA, RN, CPHQ
Nurse Manager, CICU

DIVISION OF CARDIAC CRITICAL CARE MEDICINE

CARDIAC ADVANCED PRACTICE PROVIDERS

INTRODUCTION

Advanced Practice Providers (APP) provide expert care to infants, children, adolescents, and young adults with both acquired and congenital heart disease. APPs in the Cardiac Center work in many areas of the center, such as, CICU, CCU, CPRU/Cardiac Intake Center, CTOR, Consultation and Cardiology Outpatient services.

Advanced Practice Providers consist of Certified Nurse Practitioners and Physician Assistants who provide 24/7 care in our CICU and CCU and our Outpatient APPs provide both inpatient/outpatient care to our patients and families. There are a total of 67 APPs and 5 CRNA's.

Our recruitment efforts in FY22-23 were strong, despite a diminished pipeline of candidates. We successfully hired and on boarded: 16 Nurse Practitioners and 2 Physician Assistants. We added General Cardiology to our APP Team coverage area. Hired two Nurse Practitioners. We also transferred one of our experienced Cardiac Center NP to the Voorhees Cardiology team.

Fun Fact: Since August 2019, I have hired 14 of our own Cardiac Center Nurses; 7 CICU, 4 CCU and 3 Outpatient Cardiology.

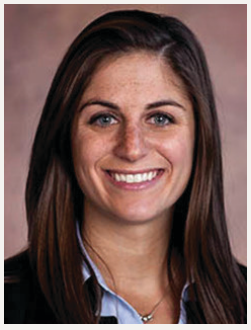
LEADERSHIP

Keri Lombardi, MSN, APRN-BC, MJ, MBA
Advanced Practice Program Manager

Jenna Heichel, MSN, BSN, CRNP
CICU Team Lead

Erin Pinto, MSN, RN, CCRN, FNP-BC
Outpatient Team Lead

Diana Holbein, CRNP
CCU Team Lead



Ellen Cannon, MHS, PA
CT Surgery Team Lead

Sharna Basu, MSN, RN, CRNP
CPRU/Intake Team Lead

CARDIAC ADVANCED PRACTICE PROVIDERS

During the challenges this past year with a pandemic ever present, the APP team has achieved many professional accomplishments:

APP DISTRIBUTION

52 Nurse Practitioners | 15 Physician Assistants

Our APP teams continue to seek out professional opportunities and had many accomplishments. Our APP Advancement Program acknowledges the hard work and dedication that our APPs have. There are two opportunities: Clinical Expert (3 years or greater APP experience) and Master Clinician (5 years or greater experience).

	# In Advancement Program	#Eligible for Advancement Program	% of APP Eligible in Program
CICU	7	7	100%
CT Surgery	7	7	100%
CPRU/Intake	3	4	75%
CCU	2	3	67%
Outpatient Subspecialty	3	9	33%

APP PROFESSIONAL ADVANCEMENT AWARDS

Jenna Heichel nominated as the APP Leader for 2022

Clinical Expert

Sharna Basu
Christy Bosler
Ellen Cannon
*Jessica Eichner
Lisa Gervasi
Diana Holbein
Rachel Keashen
*Emily Schwartz
Farzana Shah
Elizabeth Trovato
*Meghan Yowell
Stephanie Neubert
Alex Tabone
Laura Murphy
Sara Bond
Christine Welch
Taylor Zulli

Clinical Master

Leigh DiFusco
Katie Dodds
Jenna Heichel
Erin Pinto

FY23 Clinical Expert Applicants

Stephanie Braun

FY23 Master Clinician Applicants

Megan Yowell
Jessica Eichner
Emily Schwartz

CARDIAC ADVANCED PRACTICE PROVIDERS

PROFESSIONAL

Jenna Heichel: CICU

- Pediatric Cardiac Intensive Care Society (PCICS) Board Member
- Cardiac Center Education Officer
- APP CICU Curriculum Course, Faculty

Jessica Eichner: CICU

- Patient & Family Experience Leader
- ACT Team Lead (Frontier Program) in the CICU
- Vital Talk, Faculty

Alex Tabone: CICU

- Cardiac Arrest & Debrief Committee, Co-lead

Emily Schwartz: CICU

- Cardiac Center Quality, Safety and Value Advisor
- EPIC Physician Builder and Physician Builder Analytics Accreditation
- CICU EPIC Clinical Champion
- Hospital Wide Cognitive System Analysis Participation
- CHOP Data Team Driven Micro sessions

Jarae Payne: CICU

- Diversity, Inclusion & Equity CICU: Subcommittee-Co-lead
- PCICS: Diversity, Equity and Inclusion Committee

Megan Yowell: CICU

- CICU Procedural Specialist
- Outreach: Camp Heartbeat Nurse 2012-current

Emily Stevenson: CICU

- Outreach: Camp Braveheart-Camp Twin Lakes: Rutledge, GA 2018-current

Farrell Weiss: ACT Frontier Program

- Clinical Program Manager, Heart Failure Frontier Program

Diana Holbein: CCU

- Adjunct Faculty Position: Drexel University College of Nursing & Health Professions; Philadelphia, PA. (2019-2022). Clinical adjunct faculty member overseeing nurse practitioner students in pediatric acute care nurse practitioner program. Includes review of clinical experiences and SOAP note writing, evaluations, and in class presentation as needed.

Meghan Long: CCU

- Editorial Board: Pediatric Nursing Editorial Board Member. 2016-current.

Rachel Keashen: Voorhees Cardiology

- APP Immersion Experience-Steering Committee Member
- APP Mentorship
- APP Multicultural Mentorship Program
- Cardiac Center Quality Improvement & Safety Core/Advisory Council & Steering Committee
- Cardiac Center VAD Work Group
- APP Advancement Model-Steering Committee Member
- Cardiac Center Diversity Council/Steering Committee
- Pediatric Immersion Experience/Steering Committee
- Representative at the Voorhees Satellite Cardiology office for patients/families at the division level council

Sarah Bond: CT Surgery

- APP CHOP Conference Planning Committee

Taylor Zulli: CT Surgery

- Integrative Medicine Fellowship

Kaitlyn Rubnitz: CT Surgery

- APP Wellness Committee

Kirsten Young: CT Surgery

- APP Wellness Committee

Sharna Basu: CPRU/Intake

- APP Multicultural Mentorship Program, Preceptor
- APP Wellness Committee

Farzana Shah: CPRU/Intake

- APP Multicultural Mentorship Program Preceptor
- Outreach Mission: Quito Ecuador with Novick Cardiac Alliance to provide free cardiac care for children and to initiate a cardiac program with the local staff:

SELECT PUBLICATIONS (See Cardiac Center Research Section for the full Publication List)

Justice L, Florez, AR, Diller C, Moellinger, A, Ellis M, Riley C, **Heichel J**, Williams B, Dykton Tl, Foerster LA, Callow L. (2022). Development and implementation of a paediatric cardiac intensive care advanced practice provider curriculum. Cardiol Young. 2022 Aug 5:1-8. Doi 10.1017/S1047951122002542.

Mejia, EJ, O'Connor, MJ, Samelson-Jones, B, Mavroudis, CD, Giglia, TM, **Keashen, R**, et al (2022). Successful treatment of intracardiac thrombosis in the presence of fulminant myocarditis requiring ECMO associated with COVID-19. Journal of Heart and Lung Transplantation. Article in Press.

Stagg, A., Giglia, T.M., Gardner, M.M., Offit, B.F., Fuller, K.M., Natarajan, S.S., Hehir, D.A., Szwast, A.L., Rome, J.J., Ravishankar, C., Laskin, B.L., & Preminger, T.J. (2022, September 1). Initial Experience with Telemedicine for Interstage Monitoring in Infants with Palliated Congenital Heart Disease. Pediatric Cardiology, 44(1), 196-203. https://doi.org/10.1007/s00246-022-02993-y

McSweeney, J., Colglazier E., Becerra, J., Leary, B., Miller-Reed, K., **Walker, S.**, Tillman, K., Magness, M.,Ogawa, M., Bannon, M., Kivett, T., Olson Jackson, E., Davis, A., Shepard, C., Richards, S., Whalen, E., Engstrand, S., DiPasquale, Z., Connor, J. Failure to Tolerate Continuous Subcutaneous Treprostinil in Pediatric Pulmonary Hypertension Patients. In Press.

Smith CL, Liu M, Saravanan M, Dewitt AG, **Biko DM**, **Pinto, EM**, Escobar FA, Krishnamurthy G, Brownell JN, Mamula P, Glatz AC, **Gillespie MJ**, **O'Byrne ML**, Ravishankar C, **Rome JJ**, **Dori Y**. Liver lymphatic anatomy and role in systemic lymphatic disease. Eur Radiol. 2022 Jan;32(1):112-121. doi: 10.1007/s00330-021-08098-z. Epub 2021 Jun 24.

Khan S, **Smith CL**, **Pinto,EM**, Taha DK, Gibbs KA, Rosenblatt SA, **Dori Y**.J Effect of positive pressure ventilation on lymphatic flow in pediatric patients. Perinatol. 2022 Nov 25. doi: 10.1038/s41372-022-01563-7

Yekeler E, Krishnamurthy G, **Smith CL**, Escobar FA, **Pinto EM**, Rapp JB, Otero HJ, White AM, **Dori Y**, **Biko DM**. Dynamic contrast-enhanced MR lymphangiography: feasibility of using ferumoxytol in patients with chronic kidney disease. Eur Radiol. 2022 Apr;32(4):2564-2571. doi: 10.1007/s00330-021-08448-x. Epub 2022 Jan 10.

POSTERS

Boyle, C. (2023). "Helping Transplant Patients Thrive: A Multidisciplinary Approach". Cardiology 2023.

Heichel, Jenna, Pileggi, Michelle, Cohen, Meryl. (2022). CHOP Nursing Orientation Curriculum.

Stagg, A, Giglia, TM, Gardner, MM, Shustak, RJ, Natarajan, SS, Hehir, DA, Szwast, A, Rome, JJ, Ravishankar, C, Preminger, TJ. Feasibility of Using Digital Stethoscopes in Telemedicine for Interstage Monitoring in Infants with Palliated Congenital Heart Disease. Search conference (November 2022)

Shustak RJ, **Huang J**, Tam V, **Stagg A**, Giglia TM, Ravishankar C, **Mercer-Rosa L**, Guevara JP, **Gardner MM**. (2022) "Neighborhood Social Vulnerability and Interstage Weight Gain: Evaluating the Role of a Home Monitoring Program." American Heart Association Scientific Sessions, Oral Abstract Young Hearts Early Career Investigator Competition, Chicago, Illinois.

Eichner, Jessica. (2022). At the Heart of the Matter-Building Peer Directed Patient Centered Communication Skills for Cardiac Advanced Practice Providers. PCICS: Miami, FL.

Schwartz, Emily. (2022). Clinical Informatics in Acute Care. CHOP APP Conference, 2022.

Schwartz, Emily. (2022). Think Twice: Optimizing Red Blood Cell Transfusion Practices: Using the Electronic Medical Record. PCICS: Miami, FL.

Tabone, Alex. (2022). The Utilization of Angiotensin II in Calcium Channel Blocker and Angiotensin Receptor Blocker Overdose: A Cast Study. PCICS, Miami, FL.

Yowell, Meghan, Eichner, Jessica, Schwartz, Emily, Maeda, Katz, Gardner, Monique, Edelson, Jonathan. (2022). Unique Ventricular Assist Device Cannulation Strategy for a Complex Single Ventricle Patient. PCICS: Miami, FL.

CARDIAC ADVANCED PRACTICE PROVIDERS

PRESENTATIONS

Biroc, Lauren. (2022). “Current Treatment Options for Patients with Lymphatic Dysfunction.” CHOP APP Conference.

Gervasi, Lisa. (2023). Reducing post cardiac catheterization flat times in pediatric patients. Cardiology 2023: Puerto Rico. Oral Abstract.

Ha, Lynne. (2023). Case-based discussions of CHD and management challenges. Supporting the failing Glenn. Cardiology 2023: Puerto Rico.

Ha, Lynne. (2023). Cardiac Medications Review: Vasoactive Medications, Sedation/Pain Management, Anticoagulation, Arrhythmia Management, Pulmonary Hypertension Management. Cardiology 2023: Puerto Rico.

Keashen, R. and Sweigart, A. (2022). Anticoagulation and Heart Failure. Presented for the Cardiac Center 4th year seminar. Lecture series for Heart Failure at The Children’s Hospital of Philadelphia.

Lombardi, Kerri. (2022). Utilization of Advanced Practice Providers in the Cardiac Care Unit. Cardiology 2022: Huntingdon Beach, CA.

Payne, Jarae. (2023). Cardiac Medications Review: Vasoactive Medications, Sedation/Pain Management, Anticoagulation, Arrhythmia Management, Pulmonary Hypertension Management. Cardiology 2023: Puerto Rico.

Payne, Jarae (2023). Case-based discussions of CHD and management challenges. Cardiology 2023: Puerto Rico.

Pinto, Erin. (2023). Building a Lymphatic Program: The Team Approach. Cardiology 2023; Puerto Rico.

Pinto, Erin (2022). Cardiac Surgery and Anethesia lecture for Rigshospitlet in Copenhagen, Denmark

Pinto, Erin (2022). ”Lymphatic Dysfunction in Pediatric Patients.” Rigshospitlet in Copenhagen, Denmark
Pinto, Erin (2022). “Lymphatic Dysfunction in Pediatric Patients. “ Lighthouse Lymphedema Conference, Atlanta, GA.

Pinto, Erin (2023). “Building a Lymphatics Program: A Team Approach. Cardiology 2023, Puerto Rico.

Pinto, Erin. (2023). “Lymphatic Imaging, Interventions and Care of the Lymphatic Patient” Cardiac Days: CHOP-CCU and CICU.
Stegman
n, Teresa. (2022). “Nursing Empowerment and Pediatric Cardiac ICU Outcomes” & “Strategies to Decrease Infections in the Pediatric Cardiac ICU.” La Cardio Hospital in Columbia.

Stegmann, Teresa. (2022). Virtual platform with La Cardio Hospital in Columbia: 6 day virtual sessions with the CICU nurses incorporating CHOP CICU in the sessions.

Tabone, Alex, (2022). Clinical Case Scenarios: Lessons Learned from Challenging Cases for Nursing and Advanced Practice Providers. “Angiotensin II in Calcium Channel Blocker and Angiotensin Receptor Blocker Overdose.” Cardiology 2022.

Walker, Stephen. (2022). Panel member at PHA International Conference and Scientific Sessions. Journeys Luncheon.

Yowell, Meghan (2022). Clinical Case Scenarios: Lessons Learned from Challenging Cases for Nursing and Advanced Practice Providers. “Care of the Lymphatic Patient in the Cardiac ICU” Cardiology 2022.

Yowell, Meghan. (2022). Preoperative ICU management of Tetralogy of Fallot and the Spelling “Tet”. CHOP Cardiac Center recorded lecture series.

GRANTS & RESEARCH

Walker, Stephen. (2022). CHOP Investigator for a retrospective descriptive study performed at 11 participating sites in the United States and Canada for patients younger than 21 years of age diagnosed with PH who failed treatment to tolerate SubQ Treprostinil between 1/1/2009-12/31/2019. All data summarized using descriptive statistics.

CARDIAC NURSING

INTRODUCTION

Sherri Kubis, MSN, RN, CCRN, Director of Cardiac Nursing, leads a team of over 350 nurses and 50 interdisciplinary specialists who partner with surgeons, physicians, and many others to ensure that all Cardiac Center patients and their families receive the safest, highest-quality care. This team continually strives for the highest quality of care and develops evidence-based standards of care for children with heart disease.

The entire nursing leadership team consists of eight managers overseeing unit staff and operations. Additionally, a team of specially trained Safety Quality Specialists, Certified Nurse Specialists and Education Nurse Specialists support clinical practice, harm and safety prevention and educational needs for all Cardiac Center nursing and advanced practice staff. They have established highly successful onboarding programs to maintain appropriate staffing levels across all specialized areas. Through strong retention and wellness efforts they are maintaining a 13.6% average turnover rate which is much lower than the national average of 18-20%. Multiple Cardiac Center nurses, advanced practice providers and perfusionists had work accepted for publication or presentation at national and international forums this year as they continually work to advance evidence based practice in the pediatric cardiac field.

Sherri Kubis, MSN, RN, CCRN
Senior Director, Cardiac Nursing Center

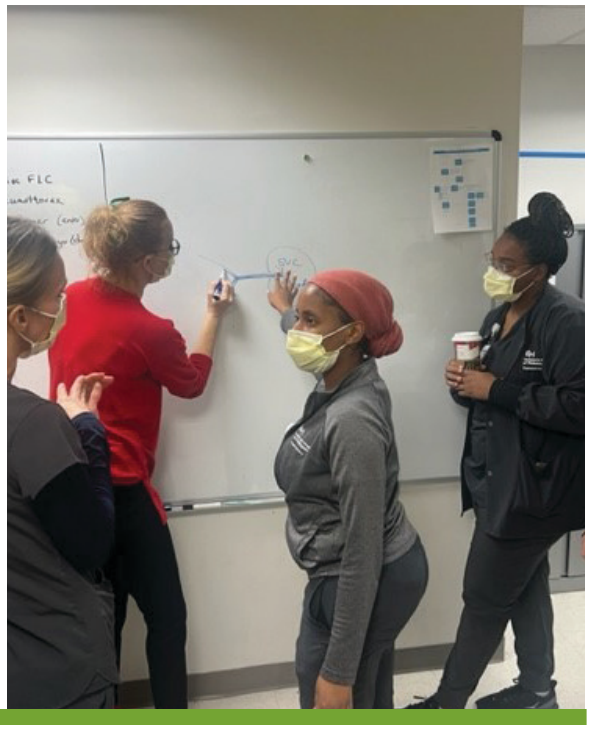
CARDIAC NURSING

The Cardiac Center nursing team's recent notable achievements include:

- Implementation of a robust simulation program that provides regular opportunities for staff to participate in individual and interdisciplinary group learning multiple times each week. The learning center is embedded near inpatient units and procedural areas for easy access around schedules or when staff are able to step away for a session. The learning environment is equipped with high fidelity simulation equipment within a replica patient room set up.

- Implemented a targeted educational curriculum to expand cardiac competency for experienced nurses within the Infant Transitional Care Unit. This program built upon their existing knowledge and skill set to increase their expertise specifically for complex cardiac patients newly cared for on this unit. The program consisted of didactic learning and hands-on learning with multiple interdisciplinary simulations and hands-on training sessions in addition to an immersive rotation caring for patients in other cardiac units.

- The cardiac nursing team has a robust internal safety program designed to help prevent common health care associated infections or preventable injuries. This program includes daily rounding by highly trained nurses who assess all patients with high-risk devices and therapies in place. This year they continued to see marked improvements in key outcomes such as central line associated infections, peripheral IV infiltrates, and skin injury prevention.



PSYCHOSOCIAL SERVICES

PSYCHOLOGY

OVERVIEW

The Cardiac Center currently has two pediatric psychologists (with a third starting in May, 2023) who specialize in providing assessment, intervention, and consultation services to children with congenital and acquired heart disease and their families. We provide services to children who need help adjusting to a diagnosis, adhering to treatment, or may be experiencing symptoms of anxiety, depression, or traumatic stress related to their illness and associated hospitalization, treatments, and surgical interventions. Psychology services are available to all patients followed by the Division of Cardiology, though each of our providers are also embedded into subspecialty programs. As a group, our psychologists are committed to promoting the psychological well-being of patients and their families through clinical care, active engagement in program development and collaborative research, and training of medical residents and fellows as well as future psychologists at the pre- and post-doctoral level.

Debra Lefkowitz, PsyD specializes in providing services to patients undergoing heart transplantation or ventricular assist device (VAD) implantation and their families. Families typically meet her for the first time during the pre-transplant evaluation process, and she provides consultation and inpatient and outpatient intervention pre and post-transplant or VAD implantation. Her focus is on optimizing child and family long-term health and well-being, which includes increasing transplant readiness, adhering to the post-transplant medical regimen, and navigating the many transitions post-transplant, including school, adolescence, and to adult transplant care.

Dr. Lefkowitz is an Associate Professor of Psychology in the Department of Psychiatry at the University of Pennsylvania. In 2022, she collaborated on 5 peer-reviewed publications and gave multiple lectures at national and international psychology and transplant conferences on topics related to pediatric transplant ethics, increasing multidisciplinary team engagement in transplant rounds, and pediatric pre-transplant evaluations. She currently is leading an international group of transplant professionals to develop a consensus paper on best practices in the pediatric pre-transplant and VAD psychosocial evaluation.

Nick Seivert, PhD works with youth of all ages and their families with a special focus on school-age and adolescent patients. His clinical interests include child and parent adjustment to illness as well as children with comorbid medical and psychiatric disorders. Dr. Seivert provides both inpatient and outpatient services as well as consultation to patients, families, and the medical team in the Fontan Rehabilitation, Wellness, Activity and Resilience Development (FORWARD) Program and the Lifestyle Medicine Program.

Dr. Seivert is an Assistant Professor of Psychology in the Department of Psychiatry at the University of Pennsylvania. In 2022, he published two papers and presented four posters at psychology and cardiology conferences. He also participated in the Family Starting Early with Psychosocial Support (StEPS) Program in the Cardiac Center, provided lectures to the Pediatric Cardiology Fellows on mental health in congenital heart disease, and engaged in a number of ongoing program development projects in the Cardiac Center.

PSYCHOSOCIAL SERVICES

CHILD LIFE

OVERVIEW

Child Life and Creative Arts Therapy services are active parts of the Cardiac Center psychosocial team in the inpatient, outpatient and procedural areas of the Center. Individualized care and support to meet each patient and families' needs for coping is provided by Certified Child Life Specialists, a Child Activity Coordinator, Board-Certified Music Therapists and Registered Board-Certified Art Therapists. Team members provide age-appropriate preparation, education, therapeutic and development play, and the therapeutic use of art and music by specially trained therapists to help support clinical goals. The Child Life team welcomed two new staff members in 2022 and are eager for a third child life specialist to join the team in May 2023. The current inpatient child life specialist team who also cover patients at pre-surgical appointments in the Intake Center are Elizabeth Becraft and Sammi Bachrach; Kaylee O'Brien will be joining in the spring 2023. The inpatient Child Activity Coordinator is Brittany Wickham. The child life specialist covering the CPRU, Cath Lab, Intake Center and Outpatient consults is Megan Fogerty. The Music Therapists for the Cardiac Center are Lydia Westle and Patrick Lipawen. The Art Therapist is Jonathan Jenkins.

HIGHLIGHTS AND ACCOMPLISHMENTS

The Child Life team has continued to provide individualized preparation, support and play to patients and families at the bedside and in the playrooms throughout this past year. The team has continued to celebrate the individual patient milestones in partnership with the family; create unique and memorable keepsake items with the patients and families; find opportunities for connectiveness for patients and families as healthcare experiences can separate friends and families; along with time for play to meet the large variety of therapeutic and developmental needs of our patient population. The child life specialists continued to have increased involvement with procedural preparation and support, including chest tube pulls, dressing changes, surgery preparation, and cardiac catheterizations. Our music and art therapists offer unique interventions, helping patients and families bond through memory making experiences like the creation of special art-based keepsakes, songwriting, and music recording projects. We continue to appreciate the close partnership with the medical and psychosocial teams to provide comprehensive, therapeutic support for patients and families to support the patients and families coping with the healthcare experience.

There were several programming highlights for 2022. In the spring of 2022, we were excited to welcome back group programming opportunities in the playroom and teen activity center in the Cardiac Center. Routine art therapy and music therapy groups resumed for the patients and families. In addition, the child life team often partners with our Facility Dog, Dilly, and his handler, child life specialist Lizzy Olsen, to support individual patients with their therapeutic coping goals.

PSYCHOSOCIAL SERVICES

CREATIVE ARTS

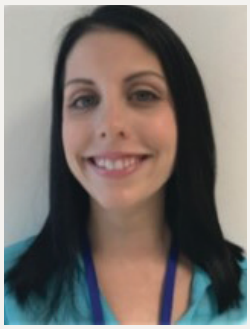
OVERVIEW

After a long pause on offering Creative Arts Therapy Groups for the Cardiac Unit due to the Covid-19 pandemic, we received clearance to restart groups on the unit!

Our team of Music and Art Therapists in the Cardiac Center offer unique interventions, helping patients and families bond through memory making experiences like the creation of special art-based keepsakes, songwriting, and music recording projects to name a few.

TEAM

Jonathan Jenkins, MA, ATR-BC, LPC
Registered Board-Certified Art Therapist



Lydia Westle, MMT, MT-BC
Board-Certified Music Therapist

Patrick Lipawen, MA, MT-BC
Board-Certified Music Therapist

PSYCHOSOCIAL SERVICES

SOCIAL WORK

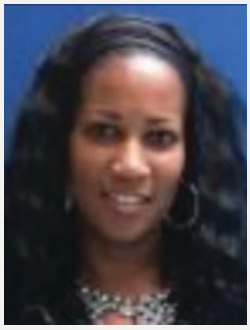
OVERVIEW

Throughout the past year, the Social Work Team within the Cardiac Center has continued to support the patients and families of the Cardiac Center throughout the ongoing COVID pandemic and all of the additional layers of stress and demands in addition to those experienced due those raising a child with a Cardiac diagnosis. Such things as travel and visitation restrictions, job loss and financial instability, illnesses of other family members including parents at times, were and remain areas for which our Social Team is helpful and supportive to our patients and families. Social Workers provide information, support and counseling to patients and their families regarding adjustment to illness, crisis management, and assistance with ongoing healthcare communication and decision making. In addition, Social Workers are able to guide and connect families with community resources, such as lodging, transportation assistance, behavioral health and financial resources such as Foundations or special funds for families as appropriate. Social workers are integral members of our interdisciplinary teams that help care for the patient and family Families with a child diagnosed with a heart defect or disease can be emotionally, physically, and financially draining. Social Work services are available at CHOP 24-hours seven days a week to care for our patient & families' needs.

TEAM

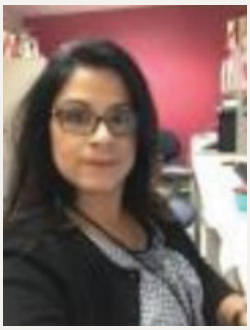
Gino Poliziani
CICU

Melissa Greberman
CICU



Charisse Rhone
Transplant & Heart Failure

Taylor Goldberg
CCU & Lymphatics



Lucia Figueroa
Fetal Heart

Susan White
Outpatient & CPRU

Lynn Callaway
Single Ventricle & Cardiac Kids

EDUCATION

EDUCATION LEADERS

Jenna Heichel MSN, BSN, CRNP

Meryl Cohen, MD, MSEd

The program is supported by Christa Piccininni.

CARDIAC CENTER GRAND ROUNDS

The Cardiac Center Grand Rounds is an education series offered for all colleagues and disciplines across the Cardiac Center. It has been reinstated on a quarterly basis with the future goal of 2023 to be provided on a monthly basis. The series will be held in Hope Auditorium with a virtual option to view from home. Our next upcoming presentation will be provided by Ryan Callahan on March 20th, presenting on strategies for pulmonary vein stenosis. Other upcoming speakers include Maully Shah on diversity and inclusion, and Dan Penny, Division Chief of Pediatric Cardiology at Texas Children's Hospital.

EXPANDED ACCESS TO LITERATURE

Historically at CHOP, open access to journal articles and current literature has been limited to our physician colleagues and those with active IRBs. With the help and support of our medical librarians and the CCEC, we have expanded access of all colleagues to ClinicalKey Flex as well as other medical journals. This provides full-text access to 650+ Elsevier medical journals and 950+ medical books. Colleagues can utilize this clinical search engine through the search functions on the CHOP library portal.

CARDIAC CENTER EDUCATION DAYS

Didactic and simulation content has been developed for all nurses on orientation across the Cardiac Center. The 8-week curriculum is offered quarterly and includes multidisciplinary presentations, case scenarios and hands-on simulation opportunities. The Cardiac Center Education Days are coordinated by our Education Nurse Specialists (ENS), who also obtain pre- and post knowledge assessments and tailor the content for future improvements. With the addition of several ENS team members, education has been tailored to the needs within each specialized practice area. Future goal is to develop curriculum for nurses off orientation for ongoing learning and professional growth!

APRN EDUCATION CURRICULUM

A monthly education series has been developed for Cardiac Center APRNs and house physicians. The series is offered virtually and includes a variety of topics such as mechanical assist support, congenital heart defects, cardiac associated genetic syndromes, etc. The lectures are recorded and available for asynchronous learning as well as teaching new APPs who are joining the team. Future direction includes lectures focused on echocardiogram and electrocardiogram diagnostics based on specific cardiac lesions to strengthen these skills for our APP group.

EDUCATION

RECORDED LECTURE SERIES

We have coordinated two separate lecture series on Hypoplastic Left Heart Syndrome and Tetralogy of Fallot. Each series includes 10-15 brief recorded lectures presented by experts across the Cardiac Center. The lectures are designed for asynchronous learning for all colleagues. These series can be viewed on the Cardiac Center Library. Our next recorded lecture series will be on Transposition of the Great Arteries.

CARDIAC CENTER LIBRARY

The digital Cardiac Center Library is a compilation of educational materials including articles, PowerPoint lectures, and recorded presentations designed for shared learning. The library has moved to a new platform, LibGuides, with improved search functions and navigation. We now have a medical librarian to research and catalog the materials. New content on the library includes the recorded lecture series, Paul Weinberg's pathology lectures, virtual CHD links, and the Mullins and Mayer Atlas. To share your own contributions, please email Bri Johnson (johnsonbk@chop.edu).

https://chop.libguides.com/cardiaclibrary

INFORMATICS AND INFORMATION SERVICES

Cardiac Center Informatics and Information Services is a joint group of Cardiac Center clinicians, dedicated Cardiac Information Services analysts, and Data and Analytics engineers who work to support our clinical, research, analytics, and reporting initiatives. This group develops, optimizes, and advocates for Cardiac Center specific Epic content, Cardiac Center Clinical Applications, and communication technology. The Clinical Informatics and Cardiac Center IS group works alongside the data and analytics team to optimize data capture and reporting work in the Cardiac Center.

Michael Goldsmith, MD
Cardiac Center Information Technology & Information Systems Officer

Over the past year, the CC Informatics/IS group facilitated implementation of several impactful CHOP-wide projects including Electronic Consents and Clinical Communications go live (conversion to Epic Secure Chat). Locally, upgrades of the EKG reading application, GE Muse, have dramatically improved clinician's ability to read and evaluate EKGs. The upgrade, from older GE Muse to modern GE Muse NX allows clinicians to seamlessly read and review EKGs within Epic, eliminating the need to open GE Muse separately. Additionally, GE Muse NX allows clinicians to pull EKG data directly into Epic notes. This is the first of several strategic updates over the next 1-2 years of our Cardiac Imaging/ Testing Applications which will allow clinicians to pull data directly from application into Epic, which will reduce clicks, and improve note accuracy.

The clinical informatics team, led by Epic physician builders Emily Schwartz, NP, Robert Palermo, MD, and Epic Nursing Clinical Champion Jessica Kane, BSN, RN, CPN continue to provide clinical oversight for Epic in the Cardiac Center, facilitating builds and updates. The team regularly meets to review Epic requests from Cardiac Center clinicians and stakeholders, ensuring all builds and updates add value to the electronic medical record.

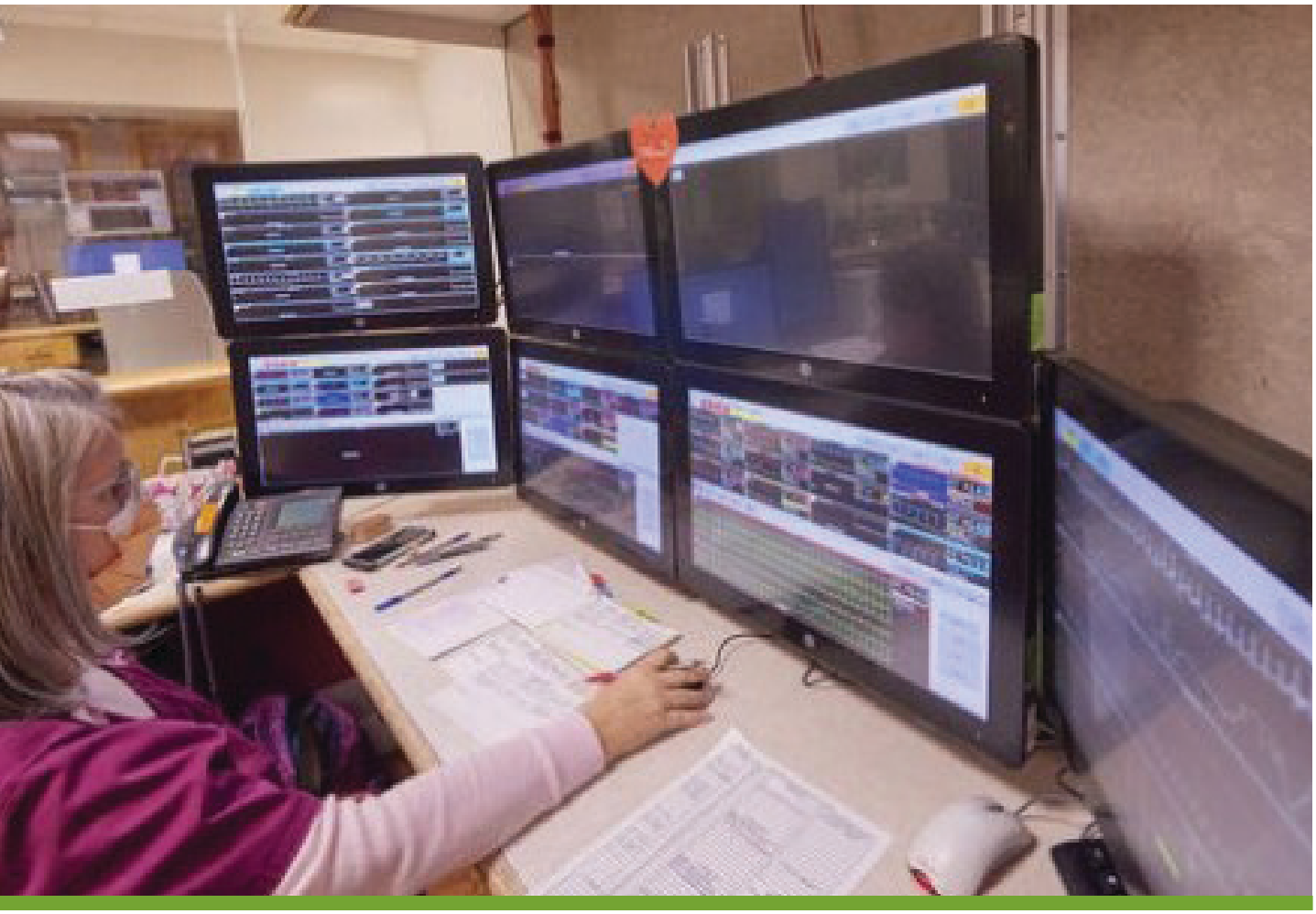
There are several new faces joining the CC-Informatics/IS Team. Karen Keough brings 14 years of Epic building experience to the Cardiac Center in her role as a Principal IS Systems Analyst. In this role, she oversees builds and improvements to Cardiac Center Epic. Working with Dr. David Goldberg, Karen developed a smart, Epic-based, Fontan survey form, replacing older paper forms. The information is discretely captured and stored in Epic eliminating the need to keep and track separate documents for each patient. Robert Palermo, MD has shared: "Karen has been an excellent addition to the team. She is easy to get in contact with and quickly completes requests. Karen is very knowledgeable about Epic and will often recommend further changes than the original request if these will improve the workflow." We are additionally pleased to welcome Terry Hutchinson, BC-RN, MSN, CCRN into her new role as Nursing Informaticist-Principal, bringing years of experience from t he CHOP CICU. She joins Mary Beth Bartko, RN, MSN as our other dedicated Cardiac Center Nursing Informaticist. Surbhi Gupta has joined a team as a program coordinator to support the informatics and information services.

This past year marked the first of a significant 2-year update to Epic in the Cardiac Center, with the implementation of Epic Cupid. Epic Cupid is a dedicated module for Cardiac-specific testing/intervention such as Echo, Cath, and Exercise Lab. This upgrade will modernize many current systems in place, improve data capture, and study reporting in Epic. There is much work to be done in 2023 on this and many other CC-Informatics/IS projects, we look forward to their results.

INFORMATICS AND INFORMATION SERVICES

SELECT CARDIAC CENTER INFORMATICS PROJECTS

- Merge of Syngo Echo and Syngo Cath databases
- Upgrade of EKG reading system GE Muse NX Upgrade
- Cardiac Center Epic Dashboard
- ACT ICU Informatics Development
  - Acute Heart Failure Order Set
  - Developed VAD Timeline
  - Developed VAD rounding notes - highlights Epic build for ACT ICU
- CICU Attending Note Bloat Project
- CICU Epic Safety Checklist
- Exparel BPA Creation
- Cardiac CAT Program Clinical Communication Group and Note



DATA & ANALYTICS

OVERVIEW

The Cardiac Center Product Team consists of Data Analytics and Engineering resources along with a team of Data Specialists who are all focused on the practical implementation of data solutions related to cardiac data management, collection, quality assurance, insights, and governance. The Product Team targets five key program areas:

1. Providing data solutions that meet the needs of our data consumer community.
2. Assessing, measuring, publishing, and communicating outcomes and clinical quality indicators, both internally and externally.
3. Implementation of data management best practices aimed at improving data timeliness, reliability, validity, and completeness in new and existing data collection efforts.
4. Development and maintenance of a data dictionary that serves as the identification of cardiac center data and source of truth for clinical data elements.
5. Participation in various, well-respected clinical data registries (STS, CCAS, ACC-NCDR, PC4, PAC3, CNOC, Perfusion PediPerform, Fontan Forward and CCRC) which serve as expert consensus on common data definitions and data standards.

LEADERSHIP

Andrea Kennedy
Manager Data Analytics

Douglas Ryba
Analytics Lead

Kelly Veneziale
Clinical Data Specialist Lead

Data Team

- Robert Olsen, Sr. Data Analyst
- Kyle Winser, Sr. Data Analyst
- Benjamin Parrish, Data Analyst
- Nina Griffonetti, Sr. Data Engineer

Patient Reported Outcomes Program

- Eurrai Booth, Sr. Quality and Outcomes Specialist

Data Specialist Team

- Alison Hill, Clinical Data Specialist
- Brittany McClelland, Sr. Clinical Data Specialist
- Karen Murphy, Sr. Clinical Data Specialist
- Ashley Paulson, Clinical Data Specialist
- Judah Siomos, Sr. Clinical Data Specialist
- Melissa Wiggins, Sr. Clinical Data Specialist

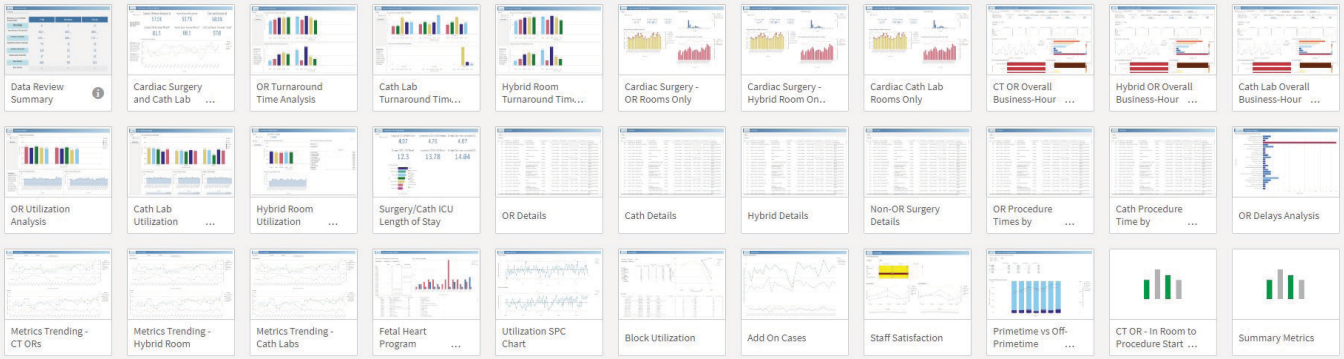
DATA & ANALYTICS

HIGHLIGHTS AND ACCOMPLISHMENTS

- Developed numerous Cardiac-specific data sets for the trusted data layer, including cardiac arrest, cardiac unit encounters, cardiac registry patients, cardiac surgery, and cardiac ECMO which helps drive fundamental projects such as Cardiac Center Overview, Patient Reported Outcomes (PRO), and Quality Improvement.
- Implementation of registry automation which decreases data entry burden allowing clinicians to focus on direct patient care.
- Established several dashboards for key Cardiac Center initiatives, such as identifying patients at risk for Hospital Acquired Infections, helping nursing team make decisions regarding vascular access, Patient Reported Outcomes (PRO) and management of ECG operations.
- The data team contributed to projects that resulted in over $650,000 dollars in cost savings/cost avoidance.
- Incorporated real-time EHR data into a dynamic application that allows Cardiac Center operations to effectively manage Anesthesia resources.
- Engineered the VIS (Vasoactive Inotropic Score) Score outside of the HER for clinical and research initiatives. This score represents a key numerical representation of patient acuity for prognostic use.

MAJOR PROJECTS

- Partnered with Patient Family Experience Improvement efforts by utilizing Press Ganey data to provision a dashboard to track patient and family feedback in real time.
- Supported Diversity, Equity, and Inclusion efforts by incorporating Social Vulnerability Index data.



WELLNESS

TEAM


Carol Wittlieb-Weber, MD


Ashley Phillips, RN


Mayam Naim, MD


Lindsay Loveland Baptist, MD


Constantine Mavroudis, MD


Sarah Bakke, CRNP

The Cardiac Center Well-being Committee formed in the fall of 2021 and includes Carol Wittlieb-Weber, MD (Cardiac Center Physician Well-being Lead, Cardiology Well-being Lead), Ashley Phillips, RN (Cardiac Center Nursing Well-being Lead), Maryam Naim, MD (Cardiac ICU Well-being Lead), Lindsey Loveland Baptist, MD (Cardiac Anesthesia Well-being Lead), and Constantine Mavroudis, MD (Cardiothoracic Surgery Well-being Lead). The Well-being Committee expanded in this academic year with two new additions to the group, Sarah Bakke, CRNP (APP well-being representative) and Christa Piccininni (program coordinator). Over the last year, the Well-being Committee has worked to increase visibility of provider well-being efforts in line with prioritization of provider well-being across the Cardiac Center. Resources have been focused on several Cardiac Center wide initiatives that hope to strengthen our culture of wellness. The Well-being Committee received two Cardiac Center Academic Enrichment Awards (a total of $100,000 in grant funding) to support their work. The 'recognition' program, led by Ashley Phillips, RN has the mission to recognize all members of the Cardiac Center on their respective (recognition) days in order to share gratitude for each individual's contribution. Currently, 24 different departments/disciplines are recognized that are active throughout the Cardiac Center.

WELLNESS

Carol Wittlieb-Weber, MD, led the first Cardiac Center fitness initiative called “CHOP Cardiac Center Hearts on the Move”. Through this initiative, 90 members of the Cardiac Center completed one of the races included in Philadelphia Marathon Weekend thanks to the support from the Exercise Lab team and funding from a Cardiac Center Academic Enrichment Award. The data collected from this initiative will be submitted for presentation at the American Conference on Physician Health in the fall of 2023. Given the success of this program, “CHOP Cardiac Center Hearts on the Move” will return for Philadelphia Marathon Weekend 2023!

Lindsey Loveland Baptist, MD and Constantine Mavroudis, MD were awarded an Academic Enrichment Award for their initiative, "Academic Enrichment through Asynchronous Coaching: An in-app, Mobile based Approach to Burnout Mitigation using Targeted Education, Training and Data Feedback” which will be in partnership with Arena Strive. We are excited to see the results of this novel work.

Maryam Naim, MD led efforts in the CICU focused on recruitment to keep pace with the growth of the CICU and evolving coverage models. The CICU successfully recruited 5 new attendings in the last academic year, an effort that will both support future growth but also, will support retention of existing faculty.

The Cardiac Center Well-being Committee continues to support the Physician Women of the Cardiac Center (PWOC) group which includes over 60 female physicians from Cardiology, CICU, Cardiac Anesthesia, and Cardiothoracic Surgery including our female fellows in training. Over the last year, the Well-being committee sponsored several female faculty members to attend Harvard’s ‘Career Advancement and Leadership Skills for Women in Healthcare’ course and guest speaker Dr. Beth Cabrera, who spoke about ‘Women, Work, and Well-being’ in celebration of National Women Physician Day. Members of PWOC have worked with the CME and Physician Affairs offices to ensure equal representation of CHOP female faculty at CHOP sponsored conferences, with new policies put in place to ensure this mission.

The Cardiac Center Well-being committee remains committed to continuing to serve cardiac patients and families by ensuring that their medical providers are optimally supported to provide high quality care in a healthy and sustainable way.

PATIENT/FAMILY EXPERIENCE

OVERVIEW

Sara Baumgarten and Jessica Eichner have been leading the Patient and Family Experience work in the Cardiac Center. They strive to provide an experience where the patients and families feel welcomed, cared for, have timely access to care, their needs are prioritized, receive top notch hospitality & service, and know their opinions matter. Their yearly goals align with the hospital strategic pillars to improve access and improve the care experience.

The Patient and Family Experience Steering Committee has grown by leaps and bounds! We currently have close to 20 active members and want to welcome anyone who has a passion for this work. Because of all the hard work, dedication, and commitment to this committee we were able to complete all of initiatives below.

The Patient and Family Experience Steering Committee has grown by leaps and bounds! We currently have close to 20 active members and want to welcome anyone who has a passion for this work. Because of all the hard work, dedication, and commitment to this committee we were able to complete all of initiatives below. The program is supported by Christa Piccininni.

- **FAC members at Cardiology Conference** – At the recent Cardiology Conference in Huntington Beach, CA a few members for our Cardiac Center Family Advisory Council were able to attend the conference and create meaningful content for families back home. This allowed patients and families to see new and innovative research across Pediatric Cardiology.
- **Diverse and Inclusive Family Council** – This year the Cardiac Center Family Advisory Council welcomed their first father and first Spanish speaking family!
- **Welcome Guide Additions** – The Jill and Mark Fishman Lymphatics Welcome Guide will be published by the end of this fiscal year! This includes specific information related to the Lymphatics Program. The Cardiothoracic Surgery Welcome Guide additions will also be published soon to allow patients and families prepare for their upcoming surgery and procedures.
- **Ollie's Branch** – A foundation that brings mental health services to heart warriors and their families at no cost to them will be partnering with the Cardiac Center with a launch date of May 1st 2023!
- **Farmers Fridge** – A self service meal vending machine was recently installed on the bridge between the CCU and CICU. This fridge offers patients, families, and staff the opportunity to have a quick and healthy meal without traveling too far from the bedside.
- **Bereavement Program** – The Cardiac Center Bereavement program has formally begun, led by Maryam Naim with the first initiatives of connecting with families and supporting staff in the works.
- **VitalTalk Communication and Training** - The first 'Delivering Serious News' sessions specifically for advanced practice providers in the Cardiac Center were held to help prepare them for responding to emotion and improving communication with families during challenging conversations. More to come in the next year!
- **Cardiac Patient and Family Dashboard** – With the help of Doug Ryba and Andrea Kennedy, we were able to publish a 'Cardiac Center Patient and Family Dashboard.' This allows us to view Press Ganey data at a higher level and break down the scores and easily manage trends over time.

LEADERSHIP

Sara Baumgarten, BA

Jessica Eichner, MSN, BSN, CRNP

PATIENT/FAMILY EXPERIENCE

Over the next year we hope to make updates to the inpatient family lounges, create inpatient orientation videos for both nurses and patients/families, publish the welcome guide in Spanish, and make sure our patients and families feel welcome in our new outpatient Burger space.

PATIENT/FAMILY EXPERIENCE

QUALITY IMPROVEMENT & SAFETY

FACULTY

Cardiac Center QI Core Team

- Shobha Natarajan, MD
- David Hehir, MD
- Katie Kennedy, Senior Enterprise Improvement Advisor
- Andrea Kennedy, Cardiac Center Data Manager
- Susan Ferry, Cardiac Center QI Manager
- Kyle Winser, Data Programmer/Analyst
- Jacqueline Zedalis, QI Improvement Advisor
- Emily Schwartz, MSN, CRNP, Quality, Safety and Value Advisor
- Robert Olsen, Data Programmer/Analyst
- Leanne Cimato, BSN, RN, Manager, Enterprise Quality Improvement
- Torrin Davis, Enterprise Improvement Advisor

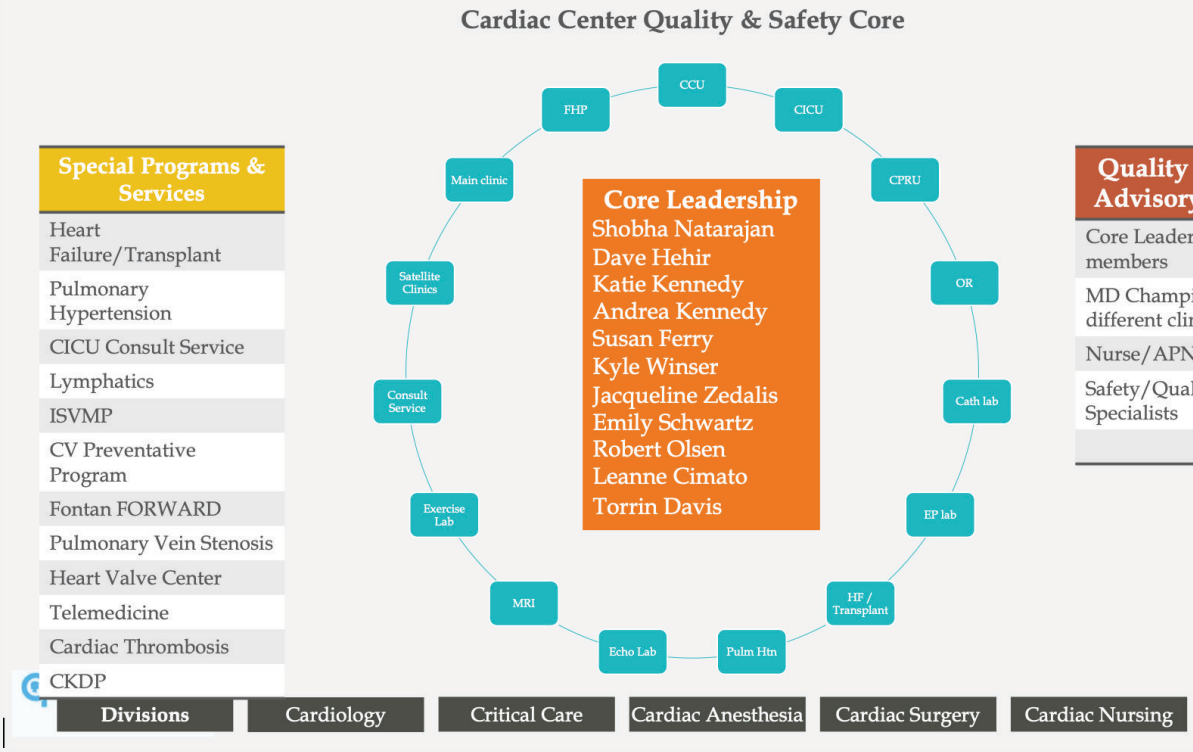
Shobha Natarajan, MD
Director, Cardiac Center QI

David Hehir, MD
Associate Director, Cardiac Center QI and Safety Officer

Under the joint leadership of Drs. Natarajan and Hehir, the Cardiac Center QI and Safety Core continued its vision to engage, train, and promote leaders in improvement science and patient safety while upholding a culture of collaboration and transparency with our patients, families, and colleagues, to deliver safe, effective and equitable care. The Quality Improvement and Safety Leadership Core leveraged collaborations to bring a broader range of expertise to support bedside initiatives. Projects aligned grass roots clinical needs with Cardiac Center strategic priorities. New areas of focus will include work to measurably improve patient outcomes, promote patient and staff safety, improve the efficiency of care, and prevent harm.

QUALITY IMPROVEMENT & SAFETY

CARDIAC CENTER QI AND SAFETY CORE ORGANIZATIONAL STRUCTURE

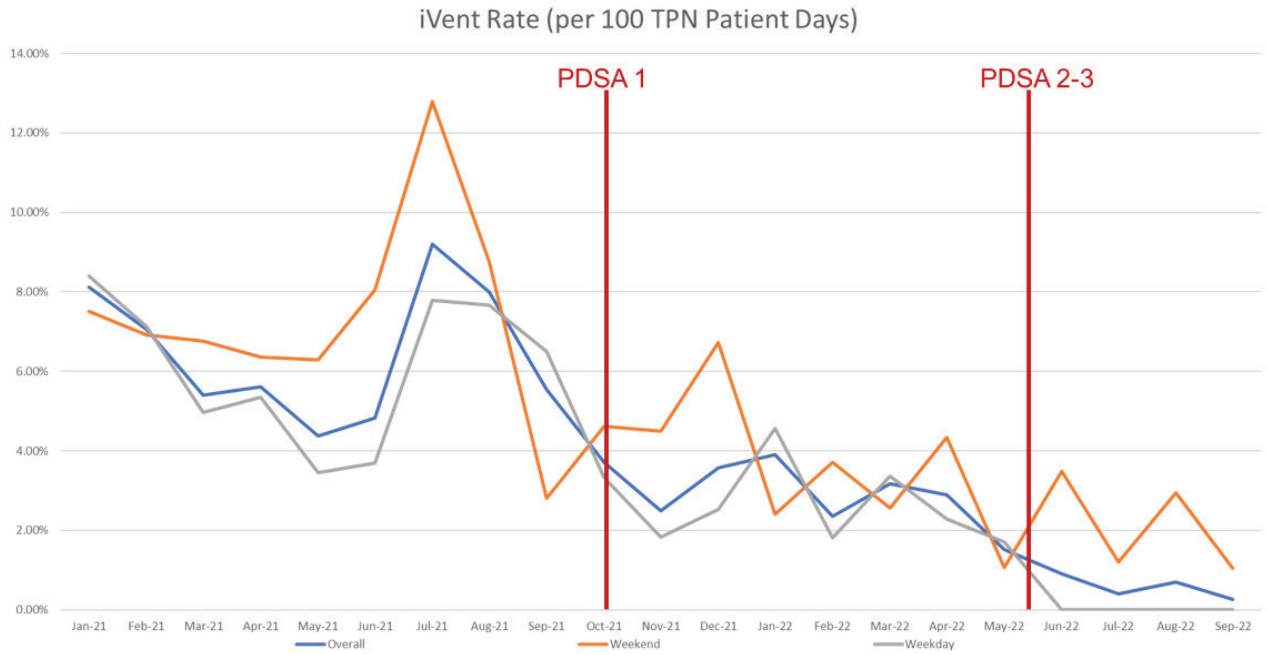


PAST YEAR ACCOMPLISHMENTS

The QI/Safety Core provided leadership for ongoing work in areas of programmatic focus, including harm prevention with a focus on sustained improvement in CLABSI rates, cardiac arrest prevention, and improving outcomes associated with Vascular Access. In addition, the core will provide support for new several projects, including: 1) The bedside driven *Improving Consistency and Efficiency of Parenteral Orders*, 2) *Processing and Stocking of C-MAC Blades in the Cardiac OR*, 3) *Reducing Time to ECPR*, and 4) *Standardizing Sonographer Workflow in the Outpatient ECHO Lab*. Projects in progress include, 1) Remote Telemetry Monitoring, and 2) Decreasing Post-operative Complications after Cardiac Surgery to Improve Patient Outcomes.

QUALITY IMPROVEMENT & SAFETY

Improving Consistency and Efficiency of Parenteral Orders had a goal of decreasing errors related to TPN administration. The project identified the many challenges of providing adequate nutrition for critically ill patients and implemented a series of improvements. The team created a concise summary for each patient for how to navigate the weekend care needs for the patient and sent them to the team via secure EPIC chat to provide clarity and continuity. They created pocket guide education on TPN ordering. The team implemented a new process of RD pending orders in EPIC for CICU patients requiring TPN to improve timeliness and communication of TPN recommendations while allowing our talented RDs to work at the top of their scope of practice. The impact has been a dramatic decrease in iVent (TPN error reports) rate by September of 2022.



Processing and Stocking of C-MAC Blades in the Cardiac OR was a project designed to prevent shortage of critical supplies used at the bedside for intubation of critically ill patients. This team created a daily report for situational awareness for the team when blades were not in the expected location as a preliminary step in identifying factors contributing to the problem. Blades were barcoded and could be scanned by the cardiac anesthesia technician and nursing teams. Central processing recorded serial numbers and partnered with the cardiac team to locate and track blades. The process was centralized with other blades in the hospital for improved enterprise-wide management. Additional work will be continued by the Anesthesia Task Force.

Reducing Time to ECPR mapped the key drivers to achieving more timely activation of ECPR cannulation. CICU faculty gave approval for activation after a first dose of Epinephrine. A checklist was created to aid in this intervention. Simulations of ECPR activation process were simulated in the Summer and Fall of 2022 and continue to be held bi-monthly. The team also created an ECPR activation checklists to help medical teams prepare the room at patient for ECPR activation. Due to a limited number of ECPR activations since starting the project, the goal to reduce time to activation from 45 minutes to 40.5 (10%) decrease has not yet been achieved. No additional PDSA cycles are planned at this time. We will continue to monitor the data and asses the need for additional interventions for the next 6 months.

The Standardizing Sonographer Workflow in the Outpatient ECHO Lab aimed to reduce the time sonographers spent on measurements, submitting their preliminary report and cleaning the room in preparation for the next patient, which we identified as the reporting time. Our primary PDSA cycle altered the sonographer workflow to clean the room after completing the preliminary report. The PDSA cycle resulted in a reduction in post-echo reporting time from a median of 18 minutes to a median of 16.5 minutes as of December 2022. Following the relocation of the Echo lab to Buerger Building in Spring 2023, the team hopes to focus efforts on reducing variation in how sonographers measure various echo parameters and reducing time from rooming the patient in the Echo lab to the start of the study (pre-echo time).

PLANS FOR THE COMING YEAR

Proposals (both grassroots and Cardiac Center strategic priorities): We just completed a review of QI proposals and selected formal CHQA support for "Reducing Unnecessary Blood Orders in the CHOP Cardiac Catheterization Lab". "Reducing no show rates in patients with critical cardiac disease" is also receiving support pending a few questions. Other proposals will have QI consultations or referred to the harm prevention team and to the Cardiac Center operations team. We continue to have annual submissions of proposals and encourage fellow-led work.

Cardiac Center Pathways and guidelines: Comprehensively review, edit, and discard these documents as appropriate in conjunction with the hospital-wide Pathways team.

Harm prevention efforts: Utilize various forums, including Morbidity, Mortality and Improvement conference, Neonatal Review, unit-based Clinical Quality Improvement conference and Root Cause Analyses to systematically review both positive aspects of care and how we can improve systems in collaborative, non-hierarchical ways. Keep Patients Safe is also an anonymous, online survey used to bring inadvertent safety events to light.

Learning opportunities in improvement science: CHOP Improvement Leadership course, CHIPS Certificate course or master's program provide excellent education on and research opportunities for quality improvement. We will continue to have quarterly Cardiac Center QI/Safety newsletters to keep our colleagues and staff up to date on the activities of the QI/Safety Core. We will have our annual QI/Safety Forum to showcase the work to the Cardiac Center. The leadership has reached out to the nurse practitioners in the Cardiac Center to develop a QI/Safety curriculum for their group. Lastly, to provide incentives for our colleagues to actively participate in and lead quality and safety efforts, we have an umbrella MOC application for the Cardiac Center for folks to obtain MOC credit, integrated QI as part of the annual incentive plan, encourage abstracts and publications using the SQUIRE guidelines, and encourage fellows to be involved in QI as one of their career goals.

CARDIAC CENTER

OPERATIONS TEAM

In 2022, the Cardiac Center operational leadership in conjunction with CCEC built upon the existing organizational structure to develop the Executive Operations Committee. This small team of operational and administrative leaders from across the cardiac center was developed to execute upon the cardiac center strategic plan, updated in 2022, to drive work to attain our goals for growth and development over the next 5 to 10 years.

TEAM

Mark Schwartz, MBA, M.Ed.
Senior Director, Cardiac Center Administration and Service Line

Vivek Allada, MD
Director, Cardiac Center Strategic Operations

Sherri Kubis, RN, MSN
Senior Director of Cardiac Nursing

Lawrence Barnes, MBA
Senior Director Physician Practice Operations and Outreach, Pediatric Cardiology

Victoria Otarola
Senior Director, Anesthesiology and Critical Care Medicine

Rebecca Cardoso, MHA
Administrative Director, Cardiac Anesthesiology & Cardiac Critical Care Medicine

Heather Meldrum, RN, BSN
Cardiac Center Procedure, Care Coordination and Flow Manager

Jenny Osborne, RN, MSN
Clinical Operations Manager, Cardiac Center

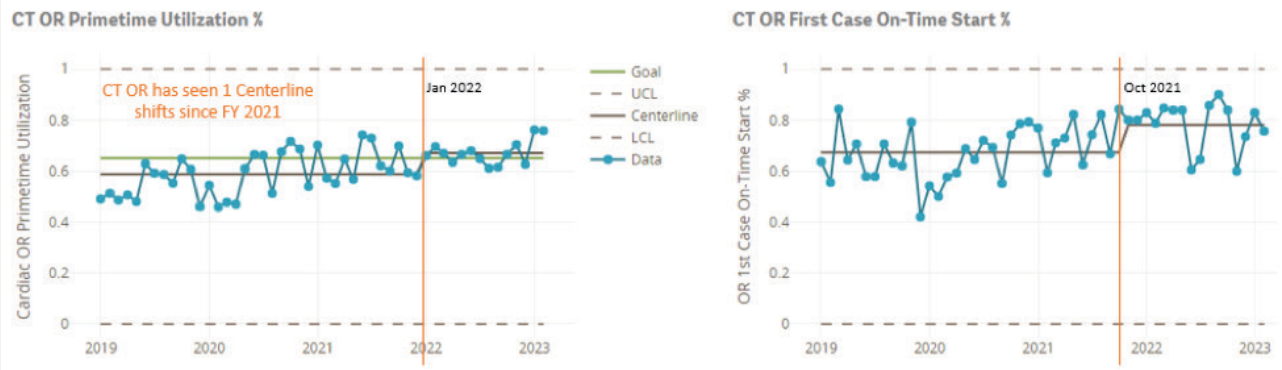
CARDIAC CENTER

OPERATIONS TEAM

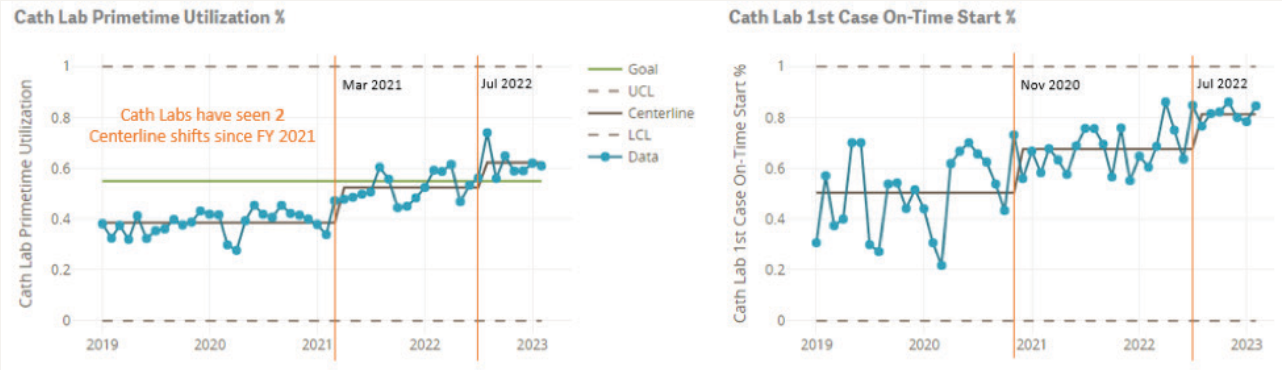
During the year, several successful initiatives were developed and operationalized including:

1. Electronic daily procedural schedule
2. Continued improvement in procedural volume, utilization and on time starts (reference graphs below)
3. Consistent block utilization and release processes
4. Expanded cardiac flow facilitator role and team to optimize patient flow through the center and procedural utilization
5. Streamlined Peri-Op cardiac anesthesia review and scheduling processes with additional optimization plans still underway
6. Creation of new Echo orders to capture our advanced imaging needs for TEE or TTE in the COIC
7. Additional CMR coverage on weekends to increase volume and reduce backlog
8. Expansion of available data analytics/dashboards to support operations across the Center, including an executive dashboard

CT OR Primetime Utilization and First Case On-Time Starts



Cath Lab Primetime Utilization and First Case On-Time Starts



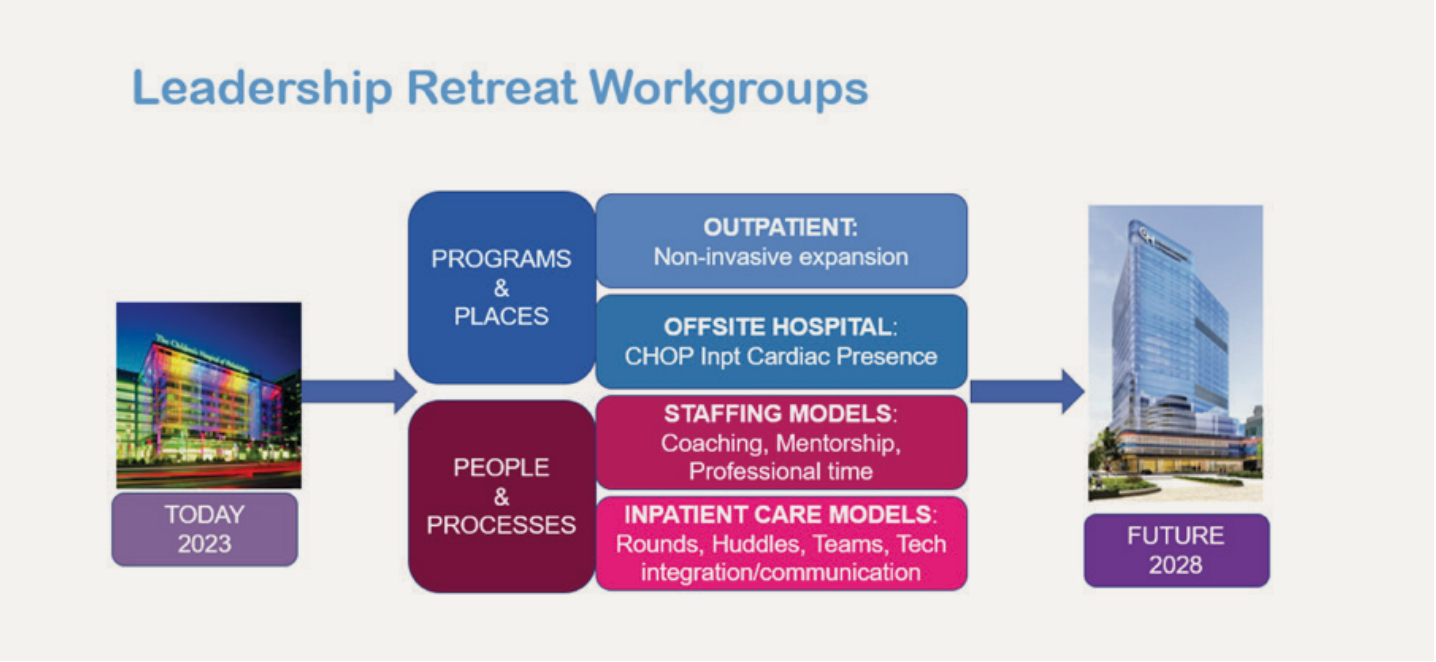
CARDIAC CENTER

OPERATIONS TEAM

The **November 2022, Cardiac Center Leadership Retreat** provided an opportunity to bring many of our leaders across the cardiac center together in one room to discuss opportunities for growth and engagement over the next 6 years in preparation for our expansion to the New Patient Tower.

From these discussions, **4 key areas** were highlighted for expanded focus and multidisciplinary discussion to strategize for optimization and expansion:

1. **Outpatient:** Non-invasive Outpatient expansion
2. **Offsite Hospital:** CHOP Inpatient Cardiac Presence
3. **Staffing Models:** Coaching mentorship and professional time
4. **Inpatient Care Models:** Rounding, huddles, teams, technology integration and communication



These themes identified by our CC members at the retreat, will become the focus of multidisciplinary workgroups to expand the discussions at the retreat and develop a cardiac center road map moving forward.

Looking ahead, calendar year 2023 will continue focus on expansion and efficiency for inpatient and procedural areas with key focus on team development and engagement.

NURSE NAVIGATOR/ REFERRAL

CARDIAC CENTER REFERRAL AND NURSE NAVIGATOR TEAM

The Cardiac Center's Referral Team is dedicated to helping all referring physicians, and new patients and their families, connect with the Cardiac Center at CHOP. The current team consists of a Cardiac Center Access Coordinator, Kelly Thomas, and five nurse navigators: Bethany Seidel, Hollis McLaughlin, Kristen Skrobanek, MarlaJan Wexler-Gormley and Shaylyn Leahy. The referral team welcomed a new manager this year in June as Katelyn Zeoli BSN returned to CHOP Cardiac Center in her new role as manager of the referral program.

Patients are referred to the Cardiac Center from all over the region, country and internationally. This year alone the team communicated with referring providers from 46 of our 50 states in the US with most of the key referral sources being the private pediatric cardiologists throughout New Jersey and Pennsylvania. We also receive regular referrals from regional hospitals from our primary, secondary, and tertiary markets such as Geisinger Medical Center. In addition, many of our programs continue to have an international reach, and this year there have been well over 100 international referrals to the Cardiac Center. The team also works closely with the International Medicine staff to navigate the complexities of coming to CHOP from outside of the U.S.

Families and patients throughout the country are helped by our referral team directly with getting the services and information they need. This includes working very closely with our flagship programs such as the Jill and Mark Fishman Center for Lymphatic Imaging and Intervention and the Center for Pediatric Heart Valve Disease, The team acts as the intermediary between the referral community and the expert clinicians of specialty programs at CHOP. Some of the highest programmatic referrals include Lymphatics, Electrophysiology and Heart Failure.

The referral process often starts with a simple phone call or email. The referral team then uses their clinical knowledge to connect with the family or provider directly to gather all appropriate information needed to triage the request or have the patient clinically reviewed. The referral team continues to communicate with referring providers through all stages of services being provided at CHOP to ensure an open and direct line of communication with the Cardiac Center. This includes working closely with the Cardiac Center Complex Procedure Scheduling staff to facilitate the scheduling process when procedures and testing are clinically indicated. Referrals for cardiac procedures include Cardiac MRI's, interventional and diagnostic cardiac catheterizations as well as surgical procedures. The team also sends updates to referring physicians weekly and ensures discharge summaries are provided timely. The cardiac center referral team is happy to remain a resource to referring cardiologists and families for all information related to services in the Cardiac Center. For second opinions, more information, or to make a referral contact 267-426-9600 or CHOPCardiacReferral@chop.edu

Katelyn Zeoli, BSN
Manager, Cardiac Center Referrals

MARKETING/

PUBLIC RELATIONS

MARKETING PRIORITIES AND ACTIVITY

2022 marketing efforts focused on

- Promoting the Cardiac Center's ongoing thought leadership in through research and conferences
- Supporting an excellent patient family experience through improved, family-centric communications and informational content
- Building/maintaining awareness of key services and network locations

ACTIVITY HIGHLIGHTS

- Heart Month Campaign
- Philly Spin-In (May)
- Launched New Patient Family Welcome Guide
- Piloted new patient email journey campaign
- Event presence and support:
  - Cardiology 2022 (Aug)
  - PCICS
- New physician intros
- Patient stories
- Launched new chop.edu sites for
  - Advanced Cardiac Therapies for Heart Failure Patients
  - Pulmonary Vein Stenosis Program
  - Sports Cardiology Clinic
  - TRACK Program
- Consumer ad campaigns (national and regional)
- Expanded NJ referral materials
- Supporting launch of Bryn Mawr SCC with Cardiology and CHOP's first Fetal Heart Program Annex
- Direct to referrer outreach on Doximity
  - Cardiology 2022 Conference
  - First Annual Middle East Fetal-Neonatal Cardiovascular Conference
  - Advanced Cardiac Therapies for Heart Patients
  - Fetal Heart Program – Bryn Mawr

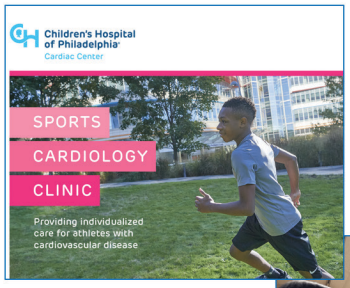
2022 BY THE NUMBERS

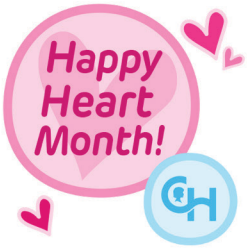
Media Relations

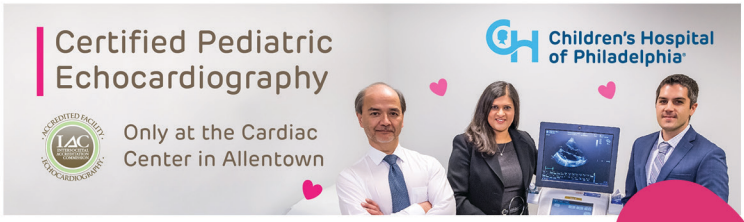
- 1,900 Cardiac Center media mentions
- 2022 Heart Month Radio Media Tour with Dr. Chen
  - 16 interviews, with a Projected Audience of over 21 million
- Top stories
  - Russell's Story – one of first Harmony Valve recipients, interview by Ivanhoe Productions, his story was shared via multiple syndicated news outlets across the country
  - AHA study led by Dr. Anirban Banerjee re: long term cardiac outcomes in children diagnosed with MIS-C – multiple media interviews and placements
  - Announcement of new CHOP Cardiovascular Research Institute
  - Coverage for Dr. Vetter's JACC study on bystander CPR rates in states in high school mandates for CPR training
  - Philly Spin-In 2022 – interview with patient families and cardiac center staff
- Newsletter and Emails
  - Reaching **2,000 families**
  - Reach **5,000 potential referrers**
- Cardiac Center Social Media
  - Facebook: 40,000+ followers
  - Twitter: 2,400+ followers
- Website Traffic
  - **715,735 users**
  - **828,438 sessions**
  - **1,239,342 page views**

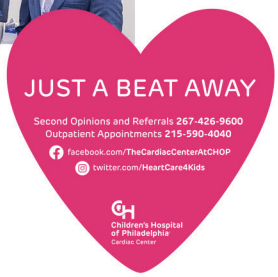
MARKETING/

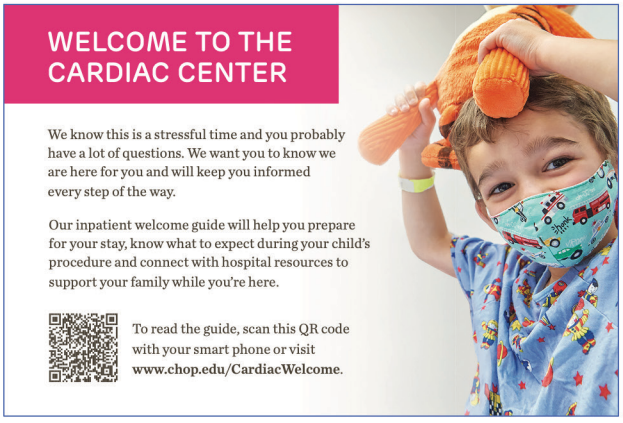
PUBLIC RELATIONS

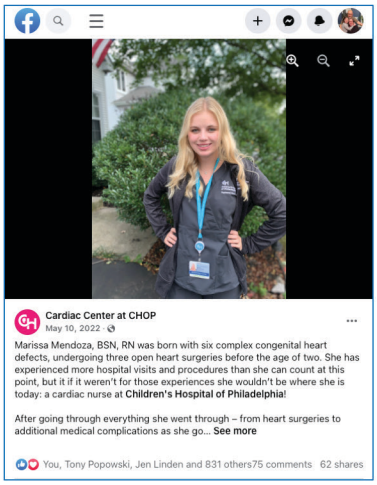












MARKETING/

PUBLIC RELATIONS

LOOKING AHEAD - 2023

- Launch of Valve Center Educational Videos
- Welcome Guide Updates
- Expanded Email Journeys
- CVI communications integration (Penn, RI and CC Clinical Marketing)
- Cardiac Transition support materials
- Expansion of Sports and PVS promotion

MEDIA HIGHLIGHTS FROM 2022

- https://www.today.com/health/health/nurse-congential-heart-defect-rcna16824
- https://www.inquirer.com/health/coronavirus/mis-c-heart-inflammation-covid-chop-20220125.html
- https://www.medpagetoday.com/infectiousdisease/covid19/96744
- https://www.beckershospitalreview.com/cardiology/children-s-hospital-of-philadelphia-launches-cardiovascular-research-institute.html
- https://www.nbcphiladelphia.com/news/health/pedal-power-to-benefit-childrens-hospital-of-philadelphias-cardiac-center/3234362/
- https://www.medscape.com/viewarticle/974649
- https://www.wafb.com/2022/06/27/first-world-harmony-heart-valve/
- https://www.bostonglobe.com/2022/07/08/metro/when-boston-hiker-took-treacherous-fall-mount-monadnock-group-strangers-sprang-into-action-help/

PHILANTHROPY

OVERVIEW OF THE FOUNDATION/CARDIAC PARTNERSHIP

The CHOP Foundation continues to grow both in size and fundraising capacity with increasing success. Fundraising for the Cardiac Center is multi-faceted and requires a truly collaborative approach. We work closely with and engage cardiac leadership and faculty/staff to understand and advocate for the needs within clinical care, patient experience, research, and training and education, and to connect us with grateful patient families. Our progress is built on trust, a mutual ambition to advance the Cardiac Center's goals through external partners, new foundation infrastructure and collaboration and prioritization of multiple fundraising streams. We are excited about what we have built over the last year and what it will produce for the Cardiac Center moving forward.

FOUNDATION TEAM DEDICATED TO THE CARDIAC CENTER

The CHOP Foundation has grown rapidly over the past year to accommodate the growing volume and sophistication of our donors. We have multiple teams dedicated to fundraising for the Cardiac Center. These teams work in tandem to drive revenue from a variety of charitable sources to support the strategic goals and priorities of the Cardiac Center. Below are some of the Cardiac Center's main foundation partners.

Individual Giving

Geminesse Johnson – Director of Development, Major Gifts (joined March 2023)
Hannah Rawdin – Major Gift Officer (joined August 2022)
Jennifer Mathews-Daniel - Associate Director, Major Gifts
Allison Karp – Annual Giving Officer, Cardiac Center
Susan Wallach - Senior Director of Principal Gifts Fundraising

Events and Community Fundraising

Amanda Higgins – Peer to Peer Fundraising (Spin-In)
Jenny Bundy – Assoc. Director Community Fundraising

Institutional and Event Fundraising

Kate Maloney-Gross - Sr. Associate Director Foundation Relations

Summary of Fundraising Performance FY 22 (July 2021- June 2022):

Total Dollars Raised for the Cardiac Center Fiscal Year 22 to March 2023		
Foundation	Total Dollars Raised	Total Number of Donors
Principal Giving	$4,024,800.00	7
Major Gifts	$418,583.65	15
Planned Gifts	$8,678.54	3
Annual Giving	$398,991.38	823
Events	$1,571,687.17	16,081
Corporate and Foundation Relations	$1,336,152.26	9
Retail Cause Marketing	$1,492,011.02	78
Grand Total	$9,250,904.02	17,016

PHILANTHROPY

PHILLY SPIN IN

Each year the CHOP Philly Spin In continues to grow and raise the bar year after year, and our most recent Spin In has been the biggest yet- breaking our previous records for number of teams, participants, and funds raised.

Funds raised from Philly-Spin In support the Cardiac Center Innovation Fund, a fund dedicated to funding various grant proposals from staff each year. Since its inception the event has fundraised over 4.1 million dollars to support more than 21 projects including clinical and bench research, education, and patient family experience projects.

New this year, we introduced the inaugural Philly Spin-In: Heart of Gold Award which recognizes five CHOP Cardiac Center staff and faculty for their compassion in their field.

2022 – Raised $824,000
2023 – Raised **$1,143,362** from **8,665** unique donors (**60%** who were new donors to CHOP) and had over **200 teams** participate. Of note, we had **$67,000 in 9 gifts of $5,000+** including a $25,000 gift from one family.

BOARD OF VISITORS

The Cardiac Board of Visitors meets twice annually, and have met three times during FY22 through March 2023. Meetings highlight the cutting-edge work and possible areas of philanthropic need within the Cardiac Center. A few recent presentations include:

- Dr. Daniel Kelly, – Announcing the new Cardiovascular Institute
- Charisse Rhone and Lucia Figueroa – Hope for Families Fund
- Dr. Matthew Jolley & Matthew O'Connor- Exploring Cardiac Frontier Programs
- Sara Baumgarten & Jessica Eichner - Enhancing the Patient Family Experience
- Dr. Constantine Mavroudis & Dr. Laura M. Mercer-Rosa - A Window into Pediatric Subspecialty Training

As a result of these focused presentations, many board members felt inspired to give - investing over $170,000 in some of the areas above.

Additionally, the Board of Visitors played an integral role in overall philanthropic support of the Philly Spin-In two years in a row by raising a collective matching gift. In 2022, the BoV raised $70,000 as a matching gift campaign. This year, board members Kati Penney, Rich Seidel, Peter Kyriakodis and Bruce Hertzfeld made contributions totaling $50,000 inspiring many other to join the effort.

KEY TAKEAWAYS AND LESSONS LEARNED

Spin In continues to be an integral asset to CC fundraising strategy, as both a rising annual revenue stream and pillar of culture that galvanizes both staff/faculty, as well as our patient and family community. Thank you for your participation and support of this critical event.

Major Gifts vary on an annual basis. FY22 in particular was a "building year" for what ultimately led to two substantial gifts resulting in $8M in additional revenue to the Cardiac Center, including a new endowed chair in Cardiology. With this understanding, it's essential to take a diversified approach to our fundraising efforts. With our new team structure, we intend to further build and employ the strengths of this team-based approach, focusing on building a higher volume for Annual Gifts, leveraging the Spin In for new corporate partnerships, and utilizing the strengths of a full time Major Gift Officer and Director of Development to build a more consistent Major Gift stream.

PHILANTHROPY

PHILLY SPIN IN

On Sunday, March 12th over 2,000 people rode for the big and little hearts at CHOP at our 7th annual Philly Spin-In. Close to 200 teams consisting of grateful patients families, CHOP staff and corporate partners raised a recording breaking $1.1 million dollars to support the Cardiac Center Innovation Awards. Since inception this event has raised more than $4.4 million dollars for the Cardiac Center at CHOP.

PHILANTHROPY

INNOVATION GRANTS

2022 INNOVATION GRANTS

Matthew Jolley, MD, Lindsay Rogers, MD, Michael Quartermain, MD, David Biko, MD, Kevine Whitehead, MD

Clinical Research

Proposal: Quantitative 3D Analysis to Inform Systemic Semilunar Valve (SSV) Repair in Children

Description: Create and apply semi-automatic multimodality 3D image derived modeling tools for the visualization, quantification and planning of surgical repair in pediatric systemic semilunar valves

David Frank, MD, Jonathan Rome, MD, Katsuhide Maeda, MD, Ph.D.

Bench Research

Proposal: Leveraging an Omics Approach for Discover of Molecular Mechanisms and Therapies for Pulmonary Vein Stenosis

Description: Expand knowledge of PVS by identifying molecular mechanisms orchestrating disease mechanisms early in the disease rather than end-stage seen in humans and provide novel therapies for PVS treatment

Constantine Mavroudis, MD, William Gaynor, MD, Daniel Licht, MD, Todd Kilbaugh, MD

Bench Research

Proposal: Mitochondrial Targeted Diagnostics and Therapeutics in a Swine Model of Cardiac Surgery and Deep Hypothermic Circulatory Arrest

Description: Determine mitochondrial injury impacting neurological harm and assess effect of cyclosporin-A to reverse symptoms

Ben Kozyak, MD, Katsuhide Maeda, MD, Ph.D., Jordan Raney, MD

Translational Research

Proposal: Development of a Pulsatile Cavopulmonary Conduit using Architected Materials and Soft Robotics

Description: Improve Fontan Circulation through creation of an electromagnetic robotic system

Betsy Goldmunts, MD, Mark Fogel, MD, Walter Wichtesey, Ph.D

Bench Research

Proposal: Machine Learning of Advanced Imaging-Derived Phenotypes and Genomics for Clinical Outcomes Research in Congenital Heart Disease

Description: Develop Automated Techniques for extraction of image derived phenotypes (IDPs) in CHD patients using machine learning. Identify associations between myocardial disease IDPs, genetic variants and outcomes

Lyla Hampton, Ph.D. Alison Burnham, MD, Amanda Shillingford, MD

Improving Clinical Care/Outcomes

Proposal: Promoting Engagement, Advocacy, and Access to Developmental Care for Families of Children with Congenital Heart Disease

Description: Expand Neurodevelopment program including further development of educational content, and family learning programs using technological advances

INNOVATION GRANTS

2023 INNOVATION GRANTS

Jennifer Lynch, MD

Clinical Research

Proposal: Development and use of novel neuromonitoring devices during neonatal cardiac surgery

Description: Our unique, multidisciplinary team is suited to solve the problem of how to improve neuromonitoring during pediatric cardiac surgery.

Matt Jolley and Matt Gillespie, MD

Clinical Research

Proposal: Optimization of Patient Candidacy and Device Selection for TPVR into Native Outflow Tracts

Description: We will address this critical need by developing and applying a image-derived, mechanics-based modeling workflow to insert a TCPV into patient specific pulmonary artery models.

Monique Gardner, MD

Clinical Research

Proposal: Advanced Cardiac Therapies ICU - Biorespository for Heart

Description: We propose collecting pre- and post-operative bio-samples (blood, urine, respiratory) from patients cared for in the ACT ICU who are listed for OHT and/or scheduled for VAD. From these, we will perform multi-omic molecular phenotyping to gain insight into novel, predictive biomarkers that may also reveal mechanistic mediators that can be targeted in future interventional trials.

Meg Cates DNP, RN, CCRN

Programmatic

Proposal: Cardiac Center Acute Renal Replacement Therapy Core Team

Description: CC ARRT will reduce barriers to initation and maintenance of Acute RRt, support clinical decision-making, improve operational infrastructure to support timely and consistence Acute RRt delivery.

Laura Mercer-Rosa, MD

Programmatic

Proposal: Implementation of the Cardiac Center Biorepository: Across the Lifespan of Children with Heart Disease

Description: This biorepository for the Cardiac Center will advance translational research, foster successful collaborations, facilitate external funding and support research training for fellows and jr faculty.

Emmanuelle Favilla, MD

Programmatic

Proposal: PAC3 Hearts to Home - Discharge Optimization

Description: Improve discharge efficiency for patients once they are medically ready to leave the hospital

CARDIOVASCULAR INSTITUTE

CHOP CARDIOVASCULAR INSTITUTE

Pediatric cardiology and cardiac surgery at CHOP are well-known as leaders in the care of children with congenital forms of heart and vascular disease, and in the development of breakthrough therapeutics and diagnostics. The CHOP Cardiac Center was established to further integrate the pediatric cardiologic, cardiac surgery and cardiac anesthesia/critical care groups. CHOP leadership made a strategic decision to invest in the development of a comprehensive research center that spans from fundamental discoveries to their translation and clinical implementation in the Cardiac Center. To excel the development of a superb cardiovascular research enterprise at CHOP, the CHOP CVI was established in the spring of 2022 in partnership with the Penn CVI, under the common leadership provided by Dr. Daniel Kelly. An overview of the early-stage progress and long-term plans for the CHOP CVI is provided here, with emphasis on linkage to the CHOP Cardiac Center.

CHOP CVI MISSION STATEMENT

Channeling the expertise of top basic and translational scientists from Children's Hospital of Philadelphia (CHOP) and Penn, the CHOP CVI will enhance our understanding of pediatric cardiovascular disease and drive scientific discovery and medical breakthroughs that will improve pediatric cardiovascular treatment and care. The objectives of the CVI are:

- **Fundamental discovery** to elucidate the pathophysiology of pediatric heart and vasculature.
- **Translation** to rapidly move discovery to new paradigms in pediatric patient cardiovascular care.
- **Train the next generation** of pediatric cardiovascular scientists.

PROGRESS UPDATE KEYED TO 5-YEAR PLAN GOALS

1. Strategic planning workshops with potential stakeholders. A series of workshops were held in May/June 2022 by Dr. Kelly so that CHOP faculty with research interests in the cardiovascular disease arena could share their interests and learn more about the emerging CHOP CVI. Many Cardiac Center faculty attended. This process allowed the Director to become acquainted with the faculty and vice versa. In addition, the meetings helped guide the strategic plan for the emerging CVI as well as to identify potential members.

2. Establish CHOP CVI membership. To date, 28 faculty have become members of the CHOP CVI, many of whom are within the Cardiac Center. The faculty membership list and research interests are currently being populated on the CHOP CVI website (https://www.research.chop.edu/chop-cardiovascular-institute).

3. Recruit new faculty into the CHOP CVI. A 3-pronged plan to recruit new scientists into the CVI has been established. The first and highest priority involves recruiting a mid-senior level scientist to lead the development of the first CHOP CVI Scientific Program. This new Program will complement and dovetail with the discovery science Programs established in the Penn CVI (Figure 1). Once the Program Director is recruited, 2-3 additional junior faculty recruits, with thematic interests consistent with the new Program, will follow. Potential thematic research areas for the new Program include regenerative medicine, genetics and gene editing, cardiac development, and bioengineering as applied to pediatric heart and vascular disease. Five prioritized candidates have been identified by the Search Committee and will be making visits to CHOP-Penn from February to May, 2023. A second recruitment effort will be focused on fostering the development of physician-scientist fellows within the Cardiac Center towards establishing independent research programs in the CVI. Lastly, the CHOP CVI will engage in collaborative recruiting with other CHOP Research Centers/Institutes and various schools and departments across the University of Pennsylvania campus (e.g. School of Engineering, School of Nursing, School of Medicine Basic Science Departments).

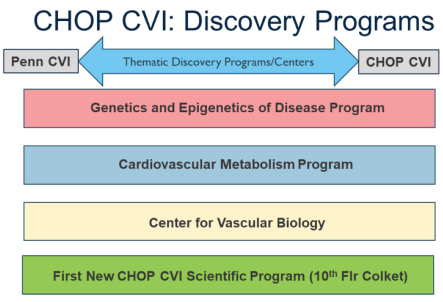


Figure 1. Plans to establish a new CHOP CVI Discovery Program in partnership with the Penn CVI.

4. Develop a centralized "through the door" CVI/Cardiac Center (CC) Biobank. A plan to develop a comprehensive biorepository with clinical data, blood samples and in some cases tissue samples is being developed with Drs. William Gaynor and Laura Mercer-Rosa. The plan will be to capture Cardiac Center patients from many sources including the fetal program, outpatient visits, and ICUs. Clinical data and tissue will be collected with a common consent and SOP. Data acquisition, blood and tissue retrieval, storage, and informatics capabilities will be provided by the emerging CHOP institution-wide biobank (Figure 2). The CVI/CC Biobank will be built upon the current infrastructure of the Birth Defect Biorepository (BDB). This new Biobank will provide efficiency for existing investigator-initiated protocols and will help spawn new studies of longitudinal nature. Studies across the lifespan will also be possible in the future by linking the CHOP and Penn biobanks. The final proposal and budget for the emerging Biobank will be presented to the Cardiac Center Executive Committee in the next several months.

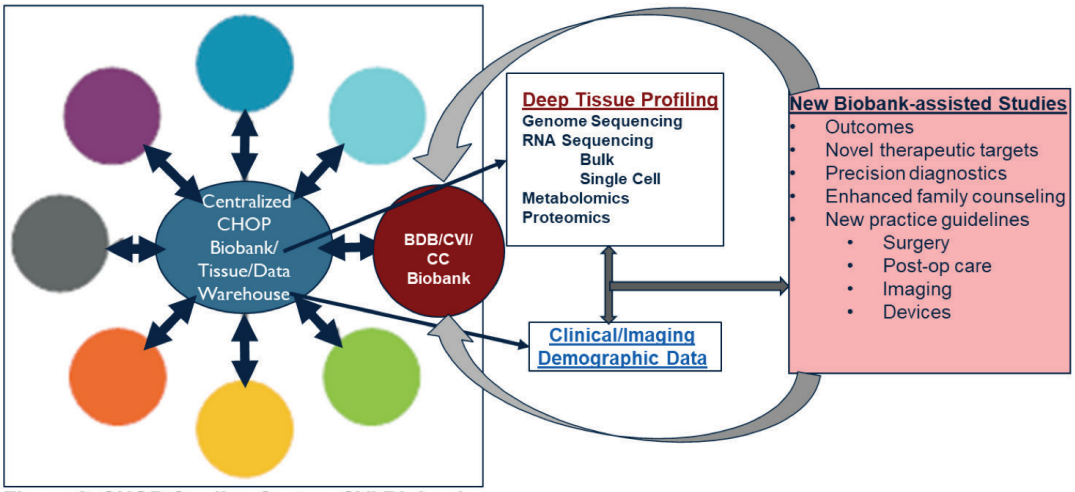


Figure 2. CHOP Cardiac Center- CVI Biobank.

5. Develop a strategic plan for Cardiac Center clinical research. The Cardiac Center has a very robust clinical trial platform with statistical and trial design support by its Research Core. With the launch of the CHOP CVI, an opportunity exists to establish meaningful collaborative bridges between the new Cardiac Center researchers, the newly recruited CVI Scientific Discovery Program faculty and the CVI/Cardiac Center Biobank. In addition, there is great opportunity to expand clinical research activities in the Cardiac Center in conjunction with the existing Cardiac Center Frontier Programs. A sub-committee of the Cardiac Center Executive Committee comprised of Drs. Kelly, Chen, and Rossano has been assembled to develop a strategic plan for Cardiac Center clinical research activities, including recruitment of a Director of Clinical Research in the Cardiac Center.

6. Penn-CHOP CVI education and mentoring. Research seminars focused on cardiovascular research hosted by CHOP and Penn CVI are being linked and announcements placed on the corresponding websites. Mentoring Committees for young Cardiac Center faculty with research programs are being established.

7. Fundraising. Dr Kelly in partnership with Drs. Chen and Rossano are working with the CHOP Development team to establish priorities for fundraising to support research initiatives, with emphasis on clinical research. Dr. Kelly presented his vision for the CHOP CVI at the October 2022 Cardiac Center Board of Visitors meeting. Dr Kelly is also presenting the plans for the new CHOP CVI to the Research and Innovation Committee of the CHOP Board of Trustees on March 15, 2023.

CLINICAL RESEARCH HIGHLIGHTS

INTRODUCTION

In 2022, CHOP Cardiac Center clinical researchers continued to be immensely productive, receiving prestigious grants and wards, presenting at national and international scientific meetings, and publishing high-impact manuscripts.

THE CARDIAC CENTER CLINICAL RESEARCH CORE

Under the direction of Michael O'Byrne MD MSCE, Heather Griffis PhD, and Jing Huang PhD, the Research Core supports much of the clinical research efforts in the CHOP Cardiac Center. In 2022, the Research Core has supported 32 distinct research projects, providing data science, statistical and epidemiological support to investigators in all of the divisions and sections of the Cardiac Center. The Research Core also serves as the Scientific Review Committee for protocols and reviews of applications for the intramural Cardiac Center Grant Program.

NOTABLE AWARD AND GRANT RECIPIENTS

In addition to ongoing federal, foundation, and industry support for clinical research, CHOP Center Researchers have obtained a number of foundation-level research grants supporting clinical research.

CHOP Cardiac Research teams were awarded two Additional Ventures Single Ventricle Research Fund Awards in 2022: Matthew Jolley (Cardiology and Cardiac Anesthesiology) and Limeng Pei (Pathology) and Jack Rychik (Cardiology). Dr. Jolley's award supports a project using computational modeling of the atrioventricular valve in common atrioventricular canal defects. This is in addition to a previous Additional Ventures award using novel techniques to evaluate the tricuspid valve in hypoplastic left heart syndrome. Dr. Pei and Rychik's project aims to develop a mechanistic understanding of Fontan-associated liver disease.

J. William Gaynor (Cardiac Surgery) was awarded a Congenital Heart Disease Coalition Grant to support ongoing research to define health status and quality of life for patients with hypoplastic left heart syndrome surviving into adulthood and support the infrastructure undergirding this long-term follow-up.

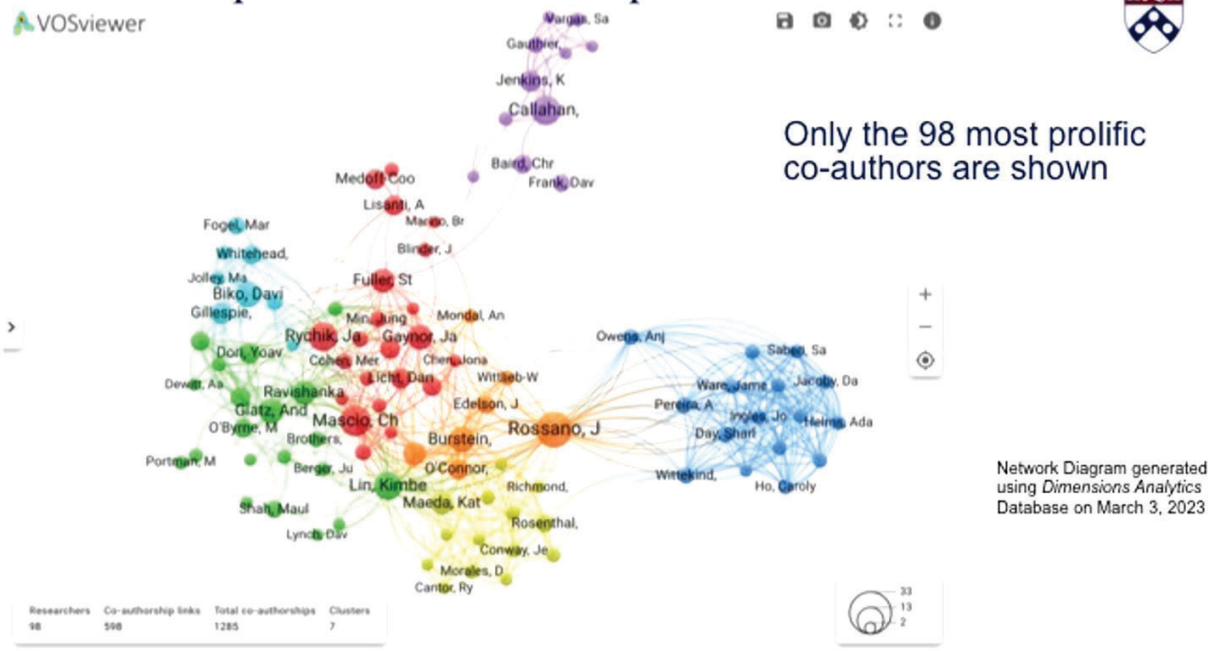
Shivani Bhatt (Cardiology) was awarded a McCabe Pilot Grant award to support a study applying novel measures of right ventricular function on stress echocardiograms to patients with pulmonary hypertension.

PRESENTATIONS AT SCIENTIFIC MEETINGS

Although COVID travel restrictions limited many scientific meetings to virtual formats over the last two years, relaxed travel restrictions in 2022 allowed CHOP clinical researchers to attend conferences in person. Many were prominently featured at the American Heart Association Scientific Sessions along with numerous subspecialty meetings.

At the **American Heart Association Scientific Sessions** (11/2022) CHOP Cardiac Center faculty and trainees were prominently involved. Rachel Shustak (attending physician) was one of the Young Hearts Young Investigator finalist, and Radhika Rastogi (CHOP pediatric resident and rising CHOP pediatric cardiology fellow) received the Young Hearts Travel award for high scoring abstract. In total cardiac center faculty, presented six invited lectures along with 25 abstracts from CHOP Cardiac Center authors including 3 moderated posters and 3 rapid-fire abstract presentations.

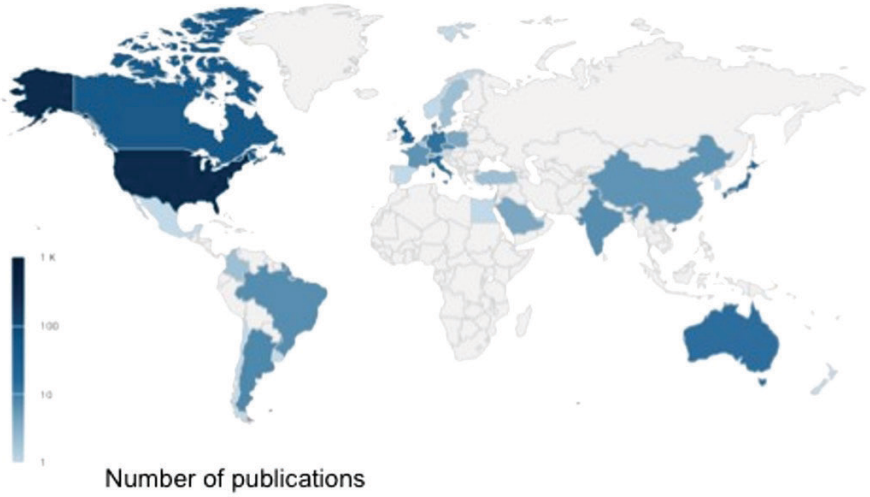
Co-authorship Network for 265 publications in 2021



Network Diagram generated using *Dimensions Analytics* Database on March 3, 2023

Countries of collaborators in 265 publications for 2021

Cardiac Center's global collaborations spanned over 330 institutions in 34 countries



Map generated using *Dimensions Analytics* Database on March 3, 2023

CLINICAL RESEARCH HIGHLIGHTS

PUBLICATIONS IN MEDICAL JOURNALS

CHOP Cardiac Center faculty authored over 213 manuscripts in 2022. Of these, 50 were published in high impact (impact factor >6) journals. These included clinical trials of pharmacological agents, reports leveraging national databases and multi-institutional collaboratives to identify opportunities to improve quality of care, and invited commentaries and national guidelines. Cardiac Center faculty and trainees are listed in pink font.

1. Amdani S, Marino BS, Rossano J, Lopez R, Schold JD, Tang WHW. **Burden of Pediatric Heart Failure in the United States**. J Am Coll Cardiol. 2022, May 17; 79(19):1917-1928. doi: 10.1016/j.jacc.2022.03.336. PMID: 35550689

2. Avitabile CM, McBride MG, Zhang X, Ampah S, Goldstein BH, Alsaied T, Wittekind SG, Whitehead KK, Zemel BS, Paridon SM. **Peak Work Rate Increases With Lower Extremity-Focused Exercise Training in Adolescents With Fontan Circulation**. J Am Heart Assoc. 2022, Dec 20; 11(24):e027464. doi: 10.1161/JAHA.122.027464. PMID: 36515264

3. Balaji S, Atkins DL, Berger S, Etheridge SP, Shah MJ; Pediatric and Congenital Electrophysiology Society (PACES). **The Case for Home AED in Children, Adolescents, and Young Adults Not Meeting Criteria for ICD**. JACC Clin Electrophysiol. 2022 Sep; 8(9):1165-1172. doi: 10.1016/j.jacep.2022.07.020. PMID: 36137726

4. Berger JH, Faerber JA, Chen F, Lin KY, Brothers JA, O'Byrne ML. **Adherence With Lipid Screening Guidelines in Children With Acquired and Congenital Heart Disease: An Observational Study Using Data From The MarketScan Commercial and Medicaid Databases.** J Am Heart Assoc. 2022, Apr. 11(7):e024197. doi: 10.1161/JAHA.121.024197. PMID: 35301862

5. Beroukhim RS, Ghelani S, Ashwath R, Balasubramanian S, Biko DM, Buddhe S, Campbell MJ, Cross R, Festa P, Griffin L, Grotenhuis H, Hasbani K, Hashemi S, Hegde S, Hussain T, Jain S, Kiaffas M, Kutty S, Lam CZ, Liberato G, Merlocco A, Misra N, Mowers KL, Muniz JC, Nutting A, Parra DA, Patel JK, Perez-Atayde AR, Prasad D, Rosental CF, Shah A, Samyn MM, Sleeper LA, Slesnick T, Valsangiacomo E, Geva T. **Accuracy of Cardiac Magnetic Resonance Imaging in Diagnosing Pediatric Cardiac Masses: A Multicenter Study.** JACC Cardiovasc Imaging. 2022, Aug. 15(8):1391-1405. doi: 10.1016/j.jcmg.2021.07.010. PMID: 34419404

6. Burstein DS, Rossano JW, Lindenfeld J, Schlendorf KH, Do N, Godown J, O'Connor MJ, Maeda K, Edelson JB, Lin KY, Mazurek JA, Scholl SR, Menachem JN. Association of donors with US public health service risk criteria and outcomes after adult vs pediatric cardiac transplant. JAMA Cardiol. 2022, Sep. 21: 7(11): 1121-1127. doi: 10.1001/jamacardio.2022.3070. PMID: 36129691; PMCID: PMC9494268

7. Burstein D, Kimmel S, Putt M, Rossano J, VanderPluym C, Ankola A, Lorts A, Maeda K, O'Connor M, Edelson J, Lin K, Buchholz H, Conway J. Cost-effectiveness of bivalirudin in pediatric ventricular assist devices. J Heart Lung Transplant. 2022, Oct. 42(3):390-397. doi: 10.1016/j.healun.2022.10.006. PMID: 36333207

8. Byrne AB, Brouillard P, Sutton DL, Kazenwadel J, Montazaribarforoushi S, Secker GA, Oszmiana A, Babic M, Betterman KL, Brautigan PJ, White M, Piltz SG, Thomas PQ, Hahn CN, Rath M, Felbor U, Korenke G, Smith CL, Wood KH, Sheppard SE, Adams DM, Kariminejad A, Helaers R, Boon LM, Revencu N, Moore L, Barnett C, Haan E, Arts P, Vikkula M, Scott HS, Harvey NL. Pathogenic variants in MDFIC cause recessive central conducting lymphatic anomaly with lymphedema. Science Translational Medicine. 2022, Mar. 14(634). 10.1126/scitranslmed.abm4869. PMID: 35235341

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CARDIOLOGY

RESEARCH LABORATORY

LEADERSHIP AND KEY STAFF MEMBERS

Robert J. Levy, MD

Robert J. Levy, MD
Section Head for Research in the Division of Cardiology, and William J. Rashkind Endowed Chair in Pediatric Cardiology at CHOP, Professor of Pediatrics and Professor of Systems Pharmacology, Perelman School of Medicine, University of Pennsylvania (PSOM)

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Stanley J. Stachelek, PhD
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RESEARCH HIGHLIGHTS

Publication of our NIH and CHOP Frontier Heart Valve Center Serotonin Mitral Valve Program's results in Science Translational Medicine (publication listed below). This article was also the subject of an editorial in Nature Cardiovascular Research (https://doi.org/10.1038/s44161-023-00226-w).

Publication of our NIH and CHOP Frontier Heart Valve Center Bioprosthetic Heart Valve Program's results with two papers in Proceedings of the National Academy of Sciences and a publication in Biomaterials.

Primary Research Activities: Dr. Levy's group during 2022 was supported by three NHLBI R01 grants:
Oxidation-mediated structural degeneration of bioprosthetic heart valves (HL143008): This program investigates a novel failure mechanism that affects artificial heart valves, known as bioprostheses. Dr. Levy's group has discovered that oxidation related damage to bioprosthetic valve leaflets associated with protein deposits, occurs commonly and therapeutic strategies to prevent this are being studied.

Serotonin Signaling in Mitral Valve Homeostasis, Maintenance and Restoration (HL131872): Serotonin is a neurotransmitter that has been linked to heart valve disease through either rare forms of cancer or as a side effects of certain drugs. This NIH program investigates the idea that serotonin contributes to the progression of heart valve disease in general, and insights from the results may provide novel therapeutic targets.

Oxidation Resistant ApoA1 Gene Delivery Stents (HL137762): Dr. Levy's lab has been studying administration of gene therapy from stents since 2000, contributing the first paper in the field at that time. This phase of the program studies a novel therapeutic gene that enhances the function of high density lipoprotein (HDL).

Programmatic Efforts—FDA Pediatric Medical Device Consortium (P50 FD006427)

Dr. Levy is the Principal Investigator of the Pennsylvania Pediatric Medical Device Consortium (PPDC), now in its 10th year. The PPDC is one of 5 FDA funded pediatric medical device consortiums in the US. The consortium has assisted more than 300 pediatric device projects. The current phase of the program is carried out in partnership with the McGowan Institute for Regenerative Medicine at the University of Pittsburgh.

Research Training (T32-HL007915)

Dr. Levy is the founding director of the Division of Cardiology's NHLBI Research Training Program, now in its 24th year. This program has trained an outstanding cohort of basic and clinical researchers, many of whom have continued as Cardiac Center faculty. Thus far, all cardiology fellows who have trained in this program and applied for NIH career development awards (K-awards) have been funded.

Research Track Faculty were also productive and supported by extramural grants:

Ivan Alferiev, PhD, Research Associate Professor

- Norepinephrine transporter-targeted pharmacotherapy of aggressive neuroblastoma. Alex's Lemonade Stand Foundation (ALSF); 10/2019 - 05/2023; PI: Chorny. Role: Co-I.
- Increasing biocompatibility of stents via CD47 surface functionalization: mechanistic and preclinical studies; NIH/NIBIB R01EB023921; 09/2017 - 05/2023; PI: Stachelek; role: Co-I
- Macromolecular prodrug-based therapy for indolent neuroblastoma; CURE Childhood Cancer; CHOP FP39254; 07/2022 - 06/2023; PI: Chorny. Role: Co-I.
- Multimeric prodrugs for pulmonary hypertension therapy; NIH/NHLBI; R21HL159562; 09/2021 - 08/2023; PI: Chorny. Role: Co-I.
- Local control of endochondral ossification by retinoid-loaded nanoparticles, NIH/NIAMS/ R01AR072713, 9/2018-8/2023; MPI: Iwamoto MPI; role: Co-I.
- Overcoming drug resistance to treat high-risk neuroblastomas, US Department of Defense/CDMRP; W81XWH-21-1-0536; 09/2021-09/2024; PI: G Brodeur. Role: Co-I
- Prodrugs targeting norepinephrine transporter for dual-selective therapy of refractory neuroblastoma, NIH/NCI/R01CA251883, 7/2020-6/2025; PI: Chorny. Role: Co-I.

Michael Chorny, PhD, was promoted to Research Professor in the summer of 2022.

- Norepinephrine transporter-targeted pharmacotherapy of aggressive neuroblastoma. Alex's Lemonade Stand Foundation (ALSF); 10/2019 - 05/2023; PI: Chorny; Role: PI.
- Macromolecular prodrug-based therapy for indolent neuroblastoma, CURE Childhood Cancer, 7/2022-6/2023 PI: Chorny; Role: PI
- Multimeric prodrugs for pulmonary hypertension therapy, NIH/NHLBI R21HL159562, 9/2021-8/2023; PI: Chorny; Role: Contact PI
- Local control of endochondral ossification by retinoid-loaded nanoparticles, NIH/NIAMS R01AR072713, 9/2018-8/2023; MPI: Iwamoto MPI; role: co-PI
- Overcoming drug resistance to treat high-risk neuroblastomas, US Department of Defense/CDMRP W81XWH-21-1-0536; 09/2021-09/2024; PI: G Brodeur. Role: Co-I
- Prodrugs targeting norepinephrine transporter for dual-selective therapy of refractory neuroblastoma, NIH/NCI R01CA251883, 7/2020-6/2025; PI: Chorny; Role: PI.

Ilia Fishbein, MD, PhD, Research Associate Professor

- Oxidation Resistant ApoA1 Gene Delivery Stents, NIH/NHLBI R01HL137762, 7/2017-6/2023; MPI: RJ Levy; Role: Co-PI, NCE.
- Serotonin Signaling in Mitral Valve Homeostasis, Maintenance and Restoration; NIH/NHLBI R01HL131872; 03/01/21 - 02/28/25; MPI: RJ Levy; Role: Co-I.
- Increasing biocompatibility of stents via CD47 surface functionalization: Mechanistic and Preclinical Studies; NIH/NIBIB R01EB023921; MPI: Stachelek; Role: Co-PI. Renewal pending.

Stanley J. Stachelek, PhD, Research Associate Professor

- The role of CD47 interactions with Complement factor H related protein 5 in Lupus Nephritis; CHOP Academic Enrichment Fund; 07/01/22 - 06/30/23; PI: Stachelek; Role: PI.
- Medical Device Consortium at the Children's Hospital of Philadelphia; FDA P50FD006427; 06/01/20 - 08/31/23; MPI: RJ Levy; Role: Co-I.
- Serotonin Signaling in Mitral Valve Homeostasis, Maintenance and Restoration; NIH/NHLBI R01HL131872; 03/01/21 - 02/28/25; MPI: RJ Levy; Role: Co-I.
- Increasing biocompatibility of stents via CD47 surface functionalization: Mechanistic and Preclinical Studies; NIH/NIBIB R01EB023921; MPI: Stachelek; Role: Contact PI. Renewal pending.

CHOP Research Initiatives

In 2020 a Frontier Program was awarded by CHOP leadership for the establishment of a Pediatric Heart Valve Center, directed by Dr. Jonathan Chen, Co-executive Director of the Cardiac Center and Chief of Cardiothoracic Surgery. Dr. Levy is a member of the team that successfully competed for this award, and he directs the basic and translational science studies that take place in this center.

FUTURE DIRECTIONS

Dr. Robert Levy has submitted (January 2023) the programmatic renewal of the Cardiology NHLBI Research Training Grant for program years 26-30. NIH review will take place in June 2023.

Dr. Levy has submitted two new R01 applications that will be reviewed by the NIH in March 2023. One of these proposals is concerned with oxidative damage to heterograft biomaterials, and the other addresses the unique pathophysiology of metabolic syndrome in the presence of heart valve disease and bioprosthetic valve replacement.

The FDA PPDC program renewal (Robert J Levy, MD, Program Director) will be submitted March 30, 2023, for years 11-15, with novel directions concerned with patient matched pediatric medical devices based on 3D printing strategies, and the use of real world evidence for evaluation and labeling of pediatric medical devices. The FDA will review this proposal in June 2023.

LIST OF PUBLICATIONS, 2022-JANUARY, 2023. (Faculty member; *Lab postdoc*)

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CARDIOLOGY CONFERENCE

26TH ANNUAL UPDATE IN PEDIATRIC & CONGENITAL CARDIOVASCULAR DISEASE - CARDIOLOGY 2023 HELD IN RIO GRANDE PUERTO RICO

The premier annual educational event in the field, our 26th annual update on pediatric and congenital cardiovascular disease, was held in beautiful Rio Grande, Puerto Rico February 23-26, 2023. Over 400 participants – cardiologists, surgeons, nurses, perfusionists and allied providers from around the world - gathered for a 4-day conference focused on the "The Circulation: What Makes the Blood Go Round in Pediatric & Congenital Heart Disease." From the basic principles of William Harvey to the iconoclastic innovations of Francis Fontan and other pioneers, the concepts of the human circulation are fundamental to our practice. The conference covered topics ranging from the left and right ventricle and their roles in the circulation, the pulmonary circulation, myocardial conditions, heart failure, mechanical support, the Fontan circulation, and a host of other relevant topics. A unique session focused on topics specific to congenital heart care in Latin America was of great interest. Breakout sessions specific to nursing education were very well attended. A highlight of the conference was the initiation of the inaugural Thomas L. Spray named lectureship, personally attend by Tom Spray himself and delivered by one of his earliest trainees, James O'Brien of Children's Mercy Kansas City.

Once again, our educational event demonstrates the inspiring multidisciplinary collaborative effort so necessary for success in our field of work. Our annual update in pediatric & congenital cardiovascular disease conference continues to grow as a highly popular event with new centers from around the country regularly joining the multicenter effort, which highlights every aspect of our field. Our objectives are to offer the ultimate opportunities for state-of-the-art learning, sharing and exchange of knowledge, networking, and professional socializing. This year we were able to offer an experience in a unique setting on the island of Puerto Rico. We look forward as we continue to expand our endeavor with plans to hold our next meeting, the 27th annual update on pediatric & congenital cardiovascular disease in Scottsdale, Arizona February 14-18, 2024.





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