International Journal of Contemporary Pediatrics
Kebede AF. Int J Contemp Pediatr. 2026 Jul;13(7):1284-1293
https://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20261846

Review Article

The next era in pediatric cardiology: from lesion-based repair to precision, prediction and lifelong care

Abenezer Feleke Kebede*

Department of Pediatrics, NYC Health and Hospitals/Lincoln, Bronx, New York, USA

Received: 20 May 2026
Accepted: 04 June 2026

***Correspondence:**
Abenezer Feleke Kebede,
E-mail: abnzrflk@gmail.com

ABSTRACT

Pediatric cardiology is evolving from a disease-oriented model to a more precision-oriented, predictive, long-term follow-up-oriented and practically implementable discipline across care settings. With congenital heart disease (CHD) present in approximately 1% of live births, an increasing number of children and adults are living with heart defects that have been completely repaired, incompletely repaired, palliated, or medically managed. This review follows the child's heart from fetal diagnosis and newborn detection through precise diagnosis, intervention, prediction of late outcomes, neurodevelopmental monitoring, transition to adult CHD care and prevention of acquired cardiovascular disease. New strategies, including updated algorithms for critical congenital heart disease screening, fetal cardiac programs and selected interventions, exome/genome sequencing, 3D surgical planning, catheter-based PDA closure in infants weighing ≥700 g, ductal stenting versus shunting, AI-assisted ECG and imaging analysis, wearables for heart failure monitoring, neurodevelopmental guidance, transition programs and global surgical quality registries, will only have value when matched to a specific patient, setting, threshold, owner, action and limitation.

Keywords: Pediatric cardiology, Congenital heart disease, Precision medicine, Fetal cardiology, Artificial intelligence, Lifelong care

INTRODUCTION

The field of Pediatric Cardiology exists at the crossroads of Fragility and Possibility. We are able to make a diagnosis and treat a fetus with a developing left-sided obstructive lesion, a newborn with a patent ductus arteriosus maintaining systemic perfusion, an infant after a staged palliation, and an adolescent with repaired congenital heart disease (CHD) progressing into adulthood. A future facing tool for the next era of Pediatric Cardiology would allow for delivery of care at a location other than a tertiary referral center, decrease the use of prostaglandin, change the time of transfer, allow for a genetic evaluation, change the design of a procedure based on a complete and accurate understanding of the child's anatomy, allow for monitoring of the child between clinic visits, increase the number of neurodevelopmental referrals and/or interventions, increase home monitoring with resultant decrease in up-stream escalation of care, and/or increase transition of care to adult healthcare providers as well as increase amount of cardiovascular prevention in children with high risk anatomy. Historically, pediatric cardiology has been focused on a lesion-centric model. This model includes defining the defect in a child's heart, fixing the heart by either repairing or palliating the heart and then managing any residual disease. However, the next era of management of pediatric and CHD is going to be a trajectory-centric model of care. This model will allow for the prediction of when a child at risk will deteriorate, definition of a child's anatomy and biology precisely, intervention with the best anatomy-specific tools

available, long monitoring of a child's heart health (beyond the confines of the clinic), protection of the brain of a very physically and developmentally challenged patient, safe transition of the young adult with CHD to adult cardiovascular care and finally, most importantly, the prevention of acquired cardiovascular disease in patients with CHD. CHD affects approximately 9 per 1000 live births globally and nearly 1% of births in the United States; about one-quarter of affected infants have the critical CHD requiring the surgery or a catheter-based intervention in the first year of life.[1-3] In 2021, more than 4.18 million children under five were living with CHD globally, with the highest mortality in low and low-middle Socio-Demographic Index regions.[4] We review the pathway of the cardiac child from fetal life through to their cardiovascular health in the adult years in four main future directions for the field: precision, prediction, lifelong care and equity.

Table 1: Next-era pediatric cardiology framework.

Domain	Clinical shift	Patient example	What changes in care	Maturity
Precision	Lesion label → anatomy, physiology, genotype, intervention target	Neonate with CHD and extracardiac anomalies	ECHO plus genetic testing, extracardiac screening, operative-risk counseling	Already here/emerging
Prediction	Clinic snapshots → risk anticipation	Single-ventricle infant between operations	Saturation, weight, feeding, and home-monitoring triggers	Already here/emerging
Lifelong care	Childhood repair → lifelong circulation	Adolescent with repaired tetralogy or Fontan physiology	Transition plan, ACHD referral, arrhythmia/HF surveillance	Already here
Equity	Tertiary innovation → population benefit	Newborn in rural/low-resource setting	Screening, telecardiology, transport, registry-linked referral	Already here/emerging

NEWBORN DETECTION AND SAFETY-NET CARDIOLOGY

A pulse oximeter in the nursery can begin the next era of pediatric health care when that simple screen becomes a thoughtful decision rather than a routine check off. A 2-day-old newborn who has a saturation of 91-93% who is tachypneic and has poor feedings but no loud murmur is an example of an infant that would be considered to be in either a transitional or an occult critical CHD state. Safety pathway for this type of infant would include: preductal and postductal pulse oximetry; assessment of perfusion; examination of femoral pulse; four extremity blood pressures if there is a concern for systemic obstruction; echocardiography access; consideration of prostaglandin; and transfer planning to a cardiac center for stabilization as needed.

Currently the AAP-endorsed critical congenital heart disease (CCHD) screening algorithm for all newborns is provided below. A newborn would be considered to have passed if saturation readings are at least 95% in both the right hand and foot with a difference of 3% or less between the two extremities. A failed screen would be a reading less than 90%. Intermediate values are to be retaken and the infant evaluated as necessary. Pulse-oximetry screening for CCHD has been shown to decrease early infant deaths from this condition by about one-third. These findings provide the beginning for a potential population-based pediatric cardiology intervention using low-cost, bedside screening for a large group of cardiac conditions with key intervention being treatment.[5-7]

Newborn screening for CHD can only potentially save children with CHD where all of the following components of the screening algorithm function as a single integrated safety system: the sat level used as a threshold for abnormal, a complete and correct assessment of perfusion, timely access to diagnostic echocardiography, availability of PGE for suspected ductal-dependent CHD, and planning and execution of transfer to a receiving center for stabilization.

FETAL CARDIOLOGY AND PLANNED PERINATAL PHYSIOLOGY

Fetal cardiology allows us to see the fetal circulation prior to birth. However, the most important thing is how we use this information after the birth of the fetus. A 30-week fetus with severe ductal-dependent congenital heart disease does not need a name of the lesion. Information about the lesion is only important if it changes the delivery site, changes the delivery team and significantly changes the stabilization and CICU course of the newborn. The mechanism by which severe CHD affects

the neonate is generally determined by fetal and transitional physiology. In severe aortic stenosis, the afterload against which the left ventricle must contract can increase to the point that it may progress toward hypoplastic left heart syndrome. Other lesions such as PA/IVS or critical pulmonary stenosis cause increased right ventricular afterload with restriction to growth of right-sided structures. Lesions of HLHS with a restrictive or intact atrial septum cause severe pulmonary venous hypertension. D-TGA with a restrictive or intact atrial septum causes severe hypoxemia in the neonate very early in life due to lack of adequate mixing at the atrial level.[8,9] Fetal markers that could potentially indicate the need for intervention for severe aortic stenosis include a narrow aortic valve jet velocity (≥2 m/s), retrograde flow in the aortic arch, left-to-right shunting across the atrial septum, monophasic or decreased mitral inflow, new onset of mitral regurgitation, and abnormal pulmonary venous doppler.[8] Fetal aortic valvuloplasty has been reported in 389 fetuses from 10 cohorts with a technical success of 84% and biventricular conversion in 33% of cases with a mortality of 20%.[10] High-yield takeaway: fetal cardiology is not prenatal labeling; it is planned perinatal physiology, with intervention reserved for selected progressive lesions.

GENOMICS AND SYNDROMIC PRECISION

An echocardiogram gives a good sense of the shape of the heart and genomics can explain the shape of the heart and provide insight into other potential risks, many of which are outside of the heart. We can also find out whether or not other family members of a child in front of us harbor risk for other than the condition in the child in front of us. A child with conotruncal cardiac malformations presents an interesting case. This child is also hypocalcemic with renal anomalies and is dysmorphic. This child has arrhythmias and decreased ventricular function. This child is very ill for unknown reasons. We have the option of stopping with an assessment of the heart of the child in front of us and then management of that heart in isolation or proceed to the biology of that child's heart and all of the issues that go along with that. We can provide surveillance and counseling to the family and we can discuss recurrence risk in subsequent children of this family. Already there are several genetic tests for certain forms of heart disease. There are emerging applications for CICU exome and genome sequencing. However, universal sequencing of all patients in the intensive care unit for which there is no counseling infrastructure in place is not indicated.

Chromosomal microarray (CMA) has become a standard diagnostic tool for identifying copy-number variants and aneuploidies in children with CHD who have signs or symptoms of extracardiac anomalies. An increasing number of CHD have a monogenic basis, including certain types of cardiomyopathy and channelopathies. These conditions can be part of a larger syndrome of aortopathies, pulmonary vascular diseases and developmental disorders and are best diagnosed with exome or genome sequencing. Several studies have demonstrated the diagnostic yields of exome or genome sequencing in critically ill children in the CICU with undiagnosed heart disease that approach 44% in neonates, making it a very practical tool in the pediatric cardiac critical care diagnostic armamentarium today. However, results from exome or genome sequencing are not always diagnostic and results that identify variants of uncertain significance require the involvement of a geneticist.[11-14] High-yield takeaway: genomic testing is only valuable if it will change the amount of monitoring of a child and/or the family with which a child has been tested will need to be counseled, if other family members will need to be tested, if pre- and postoperative management of a child will be different, etc.

IMAGING, THREE-DIMENSIONAL MODELING AND ANATOMY BEFORE INTERVENTION

Advancements in pediatric heart imaging have come a long way from the two-dimensional images of cardiac structures. The ability to potentially use heart images to aid in the actual operation for children with complex heart defects is rapidly evolving. The question remains for children with complex cardiac anatomy, such as a child with a double-outlet right ventricle with an anomalous return of the pulmonary veins, a vascular ring, a failed repaired tetralogy of Fallot with right ventricular outflow tract dysfunction or a failing Fontan, is whether 2D imaging is sufficient for management or if spatial modeling would be of great benefit. As echocardiography, MRI and CT scans are integral parts of pediatric cardiac imaging, 3D printing and virtual and augmented reality are emerging technologies that are increasingly being offered to aid in the preoperative planning of children with complex cardiac anomalies. Advanced imaging would be of value only if it alters the pediatric cardiac teams' plan of care for simple heart defects. In an international study, 3D printed models changed the preoperative planning for 19 of 40 complex CHD cases.[15] In a systematic review and meta-analysis of 75 complex CHD cases, 51.8% of the cases studied used preoperative 3D-printed models for patient-specific spatial modeling for planned intervention(s) and the surgical decision changed in 35 (51.8%) of the cases.[15-17]

Pediatric cardiologists should consider using advanced imaging for selected complex lesions where understanding the spatial relationships of the cardiac structures in 3D can change timing of intervention, intervention from catheterization to surgery, type of ventricular repair, i.e., univentricular versus biventricular, type of RVOT valve intervention, pulmonary artery and pulmonary vein reconstruction, preoperative counseling of the child and the family and risk of the intervention.

High-yield takeaway: advanced imaging and 3D/virtual modeling should be used in pediatric cardiology for situations in which spatial anatomy can make a concrete change in a decision regarding a surgical, catheterization, surveillance or counseling situation.

PRECISION INTERVENTION AND LESS INVASIVE PATHWAYS

The future of Interventional Cardiology for Children is not about making a smaller incision. It's about matching the lesion with the child's anatomy, the child's size, the appropriate device, the best access route, the child's ventricular physiology and the child's growth over the years with the least amount of harm as possible. Whether it's a premature infant with a hemodynamically significant PDA, a neonate with ductal-dependent pulmonary blood flow or a 15-year-old patient after tetralogy of Fallot repair with severe pulmonary regurgitation and right ventricular dilatation, the decision between cath and operation is not as clear cut. In fact, the main question will be which intervention is best to perform taking into account the child's size, anatomy, immediate risk to the child and risk for future reintervention. Evidence is emerging about the use of selected transcatheter PDA closures and about the use of selected transcatheter pulmonary valve replacements (TPVR). The decision between stenting of the ductus and creation of a shunt will also need to be addressed.

The Amplatzer Piccolo Occluder was FDA approved for PDA closure in infants greater than or equal to 700 grams in 2019. The COMPASS trial is a multicenter non-inferiority randomized controlled trial comparing stenting of the ductal artery versus surgical creation of a systemic-to-pulmonary artery shunt in neonates with ductal-dependent pulmonary circulation. The study plans to enroll 236 subjects from 27 centers across North America. For RVOT lesions, there are established roles for balloon-expandable pulmonary valves in selected cases (i.e. larger stented conduits or failing bioprostheses). There are also emerging roles for self-expanding pulmonary valves, particularly in younger patients with larger native RVOTs. A growing number of interventional devices are also amenable to serial dilations to increase valve size over time.[18-20] The crucial first step to achieving Precision Intervention for a given child is to develop a clear and shared description of the specific nature of their heart condition, their current size and anticipated growth over time, details about the major access vessels and key intervening structures above and below the area to be intervened and all of the potential settings in which the intervention could be carried out (e.g. catheterization laboratory vs. operating room) and subsequent follow-up and surveillance will be carried out (e.g. imaging studies). In addition, the team must develop a shared understanding of potential complications that could occur and strategies to manage them, as well as anticipated next steps if intervention is not successful.

ARTIFICIAL INTELLIGENCE, PREDICTIVE ANALYTICS AND DIGITAL DECISION SUPPORT

AI has the potential to be a very powerful yet silent tool in the armory of pediatric cardiology, and indeed pediatricians in general. However, it is crucial that this emerging technology is utilised merely as an adjunct to the clinical workflow of the pediatric cardiologist and cardiothoracic surgeon, and must not become an autonomous decision-maker controlling the circulation of a child with heart disease. With reference to the 14-year-old patient with a history of repaired CHD who is exercising less and trying to stop activity early and whose clinic ECG looks non-urgent while AI has picked up on ventricular dysfunction, the crucial decision point is whether AI-ECG will detect ventricular dysfunction before the child's symptoms deteriorate further, thus triggering an earlier echocardiogram or CMR. In the scenario of the postoperative CICU patient with variable heart rate, oxygen saturation, blood pressure, lactate and ventilator settings, the utility of prediction would be to prompt review of this child's bedside data to make a potential escalation in care or seek the expertise of a pediatric cardiologist.

AI for pediatric and adult patients with CHD: A 2025 multicenter deep learning study for prediction of left ventricular systolic dysfunction using AI-assisted ECG in pediatric and adult patients with CHD was published recently.[21] An example for a machine-learning deterioration prediction in the workflow of the postoperative CICU is given by CORTEX, a CHD traffic light system.[22] Also, there is recent meta-analysis and several reviews on the topic of fetal AI and CMR AI.[23,24] The images (ECG signals, etc.) have to be of sufficient quality, the training dataset has to be of sufficient size and quality and most importantly they have to be verified by an expert. AI-assisted auscultation can differentiate between pathologic murmur and innocent murmur, but cannot rule out CHD without murmur.

High-yield takeaway: AI belongs in pediatric cardiology only when pediatric-validated, clinician-verified, workflow-defined and tied to concrete action.

WEARABLES, HOME MONITORING AND DIGITAL PHYSIOLOGY

As children with heart disease are increasingly being discharged and managed at home, monitoring of some of their vital signs can help detect early signs of deterioration allowing for timely intervention to alter their course. For the single-ventricle infant after the first stage of surgery and before the Glenn surgery, some of the key vital signs that the family would be monitoring and possibly calling the team for would be: falling oxygen saturation; poor weight gain; decreased oral intake; increased work of breathing. The team would be monitoring these "signals for the single-ventricle infant" in a more structured fashion than the other "signals for the child with heart disease at home" but the family would be monitoring them. In contrast, an adolescent with cardiomyopathy; Fontan circulation; at risk for heart failure would have rhythm; heart rate; activity; respiratory rate; blood pressure; and any symptoms that they are experiencing monitored as well as: exercise decline.

Home monitoring of the interstage single-ventricle patient typically involves review of home monitoring data for the interstage single-ventricle patient including daily measurement of oxygen saturation, weight and intake of food/enteral nutrition. Various programs exist for home monitoring of single-ventricle patients in the interstage period. For example, the WeRoaM study is currently recruiting 100 children (8-18 years) at risk for pediatric heart failure using wearable textile heart rate/rhythm monitoring, respiratory rate monitoring, activity monitoring, home blood pressure monitoring and oxygen saturation monitoring. A small pilot study of 5 adolescents (12-17 years) at risk for pediatric heart failure used a pediatric heart-failure wearable for monitoring and proved the concept of use; however, the study identified several challenges including those related to incompletely captured data and failures of the wearable monitors.[25-27]

A few important metrics can be monitored and translate into very important action steps for a child's health when there is specified responsibility: someone reviews the information; a threshold for action and a list of subsequent steps for a child.

THE HEART-BRAIN-DEVELOPMENT AXIS

In order to take care of future generations of children with heart disease, not only are they going to need their heart to be fixed, but they are going to need their brain development to be supported as well while growing up and developing in childhood. A child of school age who had a heart surgery as a neonate for heart disease, who now has a speech delay, a feeding aversion, is clumsy, has attention problems, has problems with his or her executive functioning, behavior, school this is not a problem for the school and for the child's primary care physician alone. This child is a survivor of CHD and cardiology needs to follow this child's cognition, language, motor skills, behavior, feeding, growth and school. A fork in the road for cardiology: do we celebrate the survival of children and adults with heart disease or do we follow their cognition, language, motor skills, behavior, feeding, growth and school as children grow and develop through childhood.

In 2024, the AHA published a scientific statement on the outcomes of children with complex congenital heart disease.[28] Specifically, they noted that children with complex CHD have a nearly 25% increased risk of suboptimal school performance with a 50% increased risk for receiving special education services when compared to their peers. Thus, even one normal infant assessment is not sufficient for the long-term follow up of children with CHD, and multiple assessments are needed to identify any change or new findings in neurodevelopmental outcomes.[29] The Cardiac Neurodevelopmental Outcome Collaborative defined and operationalized cardiac neurodevelopment across various domains including motor, language, cognitive, social-emotional, and psychological that affect development throughout the life span of individuals with CHD.[30]

High-yield takeaway: The neurodevelopment of children with CHD is a core survivorship outcome. Every high-risk child with CHD needs surveillance for neurodevelopmental outcomes, a clinician responsible for their neurodevelopmental follow-up and referral when indicated.

TRANSITION, ACHD AND LIFELONG CONGENITAL CARE

Repaired congenital heart disease is not a closed chapter in a child's medical history but rather a circulation of care that can be handed from pediatric to adult congenital heart disease (ACHD) care without losing the patient in the transfer. For the 17-year-old with repaired tetralogy of Fallot, Fontan type circulation, repaired coarctation of the aorta, arterial switch operation or repaired atrioventricular canal, the pediatrician's question at the final pediatric visit should be whether to continue to follow this young adult with routine echo follow-up or to begin to transition this patient to ACHD care with a discussion of lesion, surgeries, residual risks, current medications, red flags, self-management and ACHD destination. Transition readiness is here but reliable systems to support this transfer are uneven.[31-35]

The adolescent with moderate to complex CHD should have a complete transfer of care by the time they leave the pediatric cardiology clinic. This would include: a summary of the lesions of CHD and surgeries that the patient has had; Knowledge of the patient's current anatomy and physiology; a plan for any remaining lesions or heart problems; an assessment of risk for arrhythmias and heart failure; a list of all current medications; information about activity limitations; information regarding endocarditis (as appropriate); information regarding reproductive health; red flags for emergency care; information regarding the patient's insurance and appointment systems; and information and confirmation of the ACHD team(s) that will be taking care of the patient. The patient with less complex CHD should have similar information regarding their diagnosis, current medications, activity limitations and warning symptoms for clinical deterioration and should have knowledge of when to schedule their next cardiology appointment. The pediatrician's greatest limitation to transfer of care is the loss to follow-up of their patients, due to a variety of reasons. These reasons include: Geography; Insurance; Neurocognitive limitations; Mental health needs; Language; and fragmented medical records.

Transition is a fixable and structured clinical intervention. High-yield topics for review before transfer of a patient with moderate to complex CHD are: The lesion(s) left behind and planned management of these; The current anatomy and/or physiology of the patient; The

patient/family's self-management skills regarding the CHD.

PREVENTIVE AND ACQUIRED PEDIATRIC CARDIOLOGY

The pediatric cardiologist of the future is not only going to fix the heart of the child born with heart defects, they will also try to prevent the cardiovascular disease of that child as an adult. A 10-year-old with high LDL cholesterol and a family history of early heart attacks; a teenager with obesity and high blood pressure; a child with dilated coronary arteries from previous Kawasaki disease; a child who has survived cancer and been treated with anthracyclines; a child from a country where rheumatic heart disease is common – all of these children can be monitored for cardiovascular risk by their pediatrician and referred to a pediatric cardiologist when indicated. But then the pediatric cardiologist has a lifelong prevention job to do with each of these children.

Screening for Hypertension: Children with hypertension should be treated to reduce blood pressure to less than the 90th percentile or less than 130/80 mm Hg in children ≥13 years. Children with hypertension should be treated with a healthy diet such as the DASH diet and regular physical activity of moderate to vigorous intensity for at least 3-5 days per week with at least 30 minutes of physical activity per day for children ≥5 years.[36] Screening for Hyperlipidemia:

The NHLBI recommends screening all children for hyperlipidemia at 9-11 years and again at 17-21 years. Children with average LDL-C ≥250 mg/dl should be referred to a lipid specialist for evaluation and treatment. Children as young as 10 years old with LDL-C≥190 mg/dl on average after 6 months of attempted lifestyle modification or dietary changes should be considered for statin therapy for primary prevention of cardiovascular disease.[37]

After Kawasaki disease, children are considered to be of high risk for cardiovascular complications if they are ≤6 months old or have a LAD/RCA Z-score of ≥2.5.[38] The emerging field of cardio-oncology is dedicated to the management of children with heart disease during cancer treatment and long after treatment has ended.

RHD is a major public health problem found in children and adolescents in low- and middle-income countries as well as in disadvantaged populations worldwide.[39,40] The Pediatric Heart Network's CAMP (cardiomyopathy in children and adolescents with myocarditis or pericarditis) study is a prospective multicenter study that follows children 0-21 years old with myocarditis or pericarditis to better define outcomes for these children.[41]

High-yield takeaway: the next era includes prevention because BP, LDL-C, BMI, coronary Z-score, myocarditis recovery, cardiomyopathy risk, anthracycline exposure, and rheumatic fever history are childhood measurements that shape adult cardiovascular health.

EQUITY, TELECARDIOLOGY, REGISTRIES AND GLOBAL IMPLEMENTATION

What is the value of having the ability to three dimensionally map the ventricle of a heart, yet being unable to bring essential tools of care to a newborn in need, such as pulse oximetry, echocardiography, prostaglandin, transport, catheterization, surgery and follow up? This is not yet an equitable future. A baby is found in a rural nursery with a pediatric cardiologist not on-site. The baby's oxygen saturation is on the border and the femoral pulse is weak. Can the risk be managed with local observation or will the baby have to be transferred to a regional center that can perform telecardiology, have access to echocardiography, be able to stock and give prostaglandin, be able to transport the baby and have a receiving center. This is what we call equity and this is how we test precision and prediction of tools of care.

There are more than 4.18 million children under 5 years of age living with CHD worldwide. Low and low-middle Socio-Demographic Index countries bear the highest prevalence and mortality of CHD. A global initiative IQIC was conceptualized in 2008 with 56 active centers in 24 countries utilizing data for congenital heart surgery quality improvement benchmarking.[42]

In the US and Canada, STS publicly reports data on congenital heart surgery outcomes. ECHSA compares risk factors affecting surgical and late outcomes of congenital heart disease and risk factors in individual centers. WDPCHS is currently a global registry of surgical outcomes in pediatric and congenital surgery without geographical restrictions.[43-46] In the Philippines, Health technology assessment council recently positively recommended financing of newborn pulse oximetry for CCHD screening in 2025. Thus, what used to be a tertiary center tool for detection of CCHD is now a national financing decision for its detection.

Technology can mask failures in processes and systems by hiding them. While telecardiology for example can be a powerful tool for rural clinics and hospitals, it will not perform surgery when there is no pathway for it to be done. People are needed to review the information that is generated by new technologies such as AI.

Genomics testing of all kinds will not be of any use unless it is coupled with counseling of the patient and their family. Monitoring of patients in a wearable or remote fashion requires a team of health care providers who are taking responsibility for the patient's care. High-yield takeaway: screen, refer, stabilize, transport, treat, follow, measure outcomes and feed into registry for quality improvement tracking.

Table 2: What is already being done to make the next era real.

Domain	Where/who/when	What is being done	Patient/system	Clinical bridge
Newborn detection	United states, AAP/CDC, 2011-2025	RUSP adoption, state implementation, updated CCHD algorithm	Newborn nurseries	Low-cost detection before discharge
Public-health financing	Philippines HTA council, 2025	Pulse-oximetry financing recommendation	National newborn screening	Detection as public-health benefit
Fetal/perinatal care	Specialized fetal programs	Fetal ECHO, delivery planning, selected fetal intervention	High-risk fetuses/newborns	Postnatal rescue → planned physiology
Neonatal intervention	PHN COMPASS	Ductal stent versus surgical shunt	Neonates <30 days with ductal-dependent pulmonary flow	Evidence-based palliation
Premature PDA	FDA/device pathway, 2019	Piccolo approval for PDA closure ≥700 g	Premature infants	NICU-CATH structural intervention
Genomics	Pediatric CICU ES/GS studies	Sequencing in critically ill cardiac patients	Complex cardiac phenotypes	Anatomy plus biology
AI prediction	Multicenter AI-ECG and CORTEX	Ventricular dysfunction/deterioration prediction	CHD and postoperative patients	Low-cost surveillance signal
Wearables	WeRoaM/action-linked work	Pediatric HF wearable monitoring	Children at HF risk	Home physiology → risk prediction
Neurodevelopment	AHA 2024, CNOC	Risk stratification and evaluation pathways	Children with CHD	Brain as survivorship outcome
Transition	ACHD guideline, WE BEAT CHD, SV-ONE	Adult congenital guidance and adolescent/lifespan programs	Adolescents/young adults	Lifelong continuity
Global QI	IQIC, WDPCHS, STS, ECHSA	Registries, benchmarks, public reporting	Surgical programs	Outcome measurement and QI

Table 3: Monday-morning actions for pediatric readers.

Setting	Trigger	Action	Owner
Newborn nursery	Failed/borderline CCHD screen, poor feeding, shock, weak pulses	Confirm sats, assess perfusion, four-extremity BP when relevant, urgent ECHO/transfer, prostaglandin if ductal-dependent physiology suspected	Nursery clinician, neonatologist, cardiologist
Fetal clinic	Ductal-dependent lesion, HLHS, D-TGA restrictive septum	Define delivery site, prostaglandin, immediate ECHO, CATH/surgery backup	MFM, fetal cardiologist, neonatologist
CICU/NICU	CHD plus extracardiac anomalies or unexplained cardiomyopathy/arrhythmia	CMA or ES/GS with genetic counseling	Cardiologist, intensivist, geneticist
Surgical/CATH planning	Complex anatomy before intervention	MRI/CT/3D model only if it changes approach	Cardiologist, imager, surgeon, interventionalist
Intervention	PDA, ductal-dependent flow, RVOT dysfunction	Define lesion, size, anatomy, access, device, surveillance target	Interventional cardiologist, surgeon, CICU

Continued.

Setting	Trigger	Action	Owner
AI/digital workflow	Abnormal AI-ECG, ECHO, murmur or ICU alert	Human verification, repeat testing, imaging, referral, escalation	Cardiologist, EP, ICU team
Home/interstage	Saturation, weight, feeding, rhythm, activity concern	Defined escalation pathway, not passive data collection	Cardiology team, nurse coordinator, family
Primary care	CHD survivor with school/speech/motor/attention concerns	Developmental screening and formal referral	Pediatrician, cardiology, developmental team
Adolescence	Repaired CHD nearing transfer	Lesion summary, medication ownership, red flags, ACHD appointment	Pediatric cardiologist, transition team
Preventive visit	High BP, LDL, obesity, Kawasaki history, anthracycline exposure	Quantify risk, apply thresholds, refer or monitor	Pediatrician, cardiology, oncology survivorship
Rural/low-resource care	Suspected CHD without local cardiologist	Telecardiology, prostaglandin, transfer route, registry feedback	Public-health/referral network

CONCLUSION

As pediatric cardiac providers we are envisioning the future of pediatric cardiology not just in bringing cutting edge technology to the bedside but rather to how that technology can enhance our ability to better understand and manage our patients and their families in more than one way. This review lays out the future of fetal cardiology, allowing for earlier diagnosis of risk in fetuses prior to birth and also in the immediate moments of birth via CCHD screening at birth allowing for safe discharge practices. Furthermore, genomics helps us better understand why a child's heart has a particular set of anatomy that could suggest a particular syndrome or heritable condition allowing for precision in our diagnostic approach as well as therapeutic approach. Also, in the future as imaging technology advances, it will allow for increasingly complex procedural decisions as well as open up more options for non-surgical approaches to treating heart disease such as transcatheter and hybrid therapies as well as novel applications for existing technologies by use of AI and wearables extended far beyond the walls of the clinical space on a daily basis.

Additionally, the pediatric cardiac community is now more aware of the critical role of neurodevelopmental outcomes in children with heart disease in a new definition of survival and thus will play an increased role in the long-term management of children with heart disease as we continue to evolve transition planning to adult congenital care for children with repaired heart disease. There are also a host of reasons for heart disease in children that are preventable and which we can treat as well.

The measurement of currently established inequity in registry measurement will become a critical metric to monitor in the future. To truly matter in the pediatric cardiology arena of the future each of these new technologies will need to have the patient, an owner, a threshold for intervention, an action to take, a limitation to acknowledge, and an implementation plan and that implementation plan will be particularly important outside of major pediatric cardiac centers. Precision must remain practical; prediction must be held accountable and most importantly children and their families must have the potential for and receipt of this precision in their care.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

REFERENCES

1. Van der Linde D, Konings EEM, Slager MA, Witsenburg M, Helbing WA, Takkenberg JJM, et al. Birth prevalence of congenital heart disease worldwide: a systematic review and meta-analysis. J Am Coll Cardiol. 2011;58(21):2241-7.
2. Centers for Disease Control and Prevention. Data and statistics: congenital heart defects. Atlanta (GA): CDC. 2025. Available at: https://www.cdc.gov/heart-defects/data/index.html. Accessed on 29 April 2026.
3. Centers for Disease Control and Prevention. About congenital heart defects. Available at: https://www.cdc.gov/heart-defects/about/index.html. Accessed on 29 April 2026.
4. Xu J, Li Q, Deng L, Xiong J, Cheng Z, Ye C. Global, regional, and national epidemiology of congenital heart disease in children from 1990 to 2021. Front Cardiovasc Med. 2025;12:1522644.
5. Oster ME, Pinto NM, Pramanik AK, Markowsky A, Schwartz BN, Kemper AR, et al. Newborn screening for critical congenital heart disease: a new algorithm and other updated recommendations. Pediatrics. 2025;155(1):e2024069667.
6. Centers for Disease Control and Prevention. Clinical screening and diagnosis for critical congenital heart defects. Atlanta (GA): Centers for Disease Control

and Prevention. 2026. Available at: https://www.cdc.gov/heart-defects/hcp/screening/index.html. Accessed 29 April 2026.
7. Abouk R, Grosse SD, Ailes EC, Oster ME. Association of US state implementation of newborn screening policies for critical congenital heart disease with early infant cardiac deaths. JAMA. 2017;318(21):2111-8.
8. Aypar E. Fetal cardiac interventions: a review of the current literature. J Updates Cardiovasc Med. 2025;13(1):1-7.
9. Freud LR, McElhinney DB, Marshall AC, Marx GR, Friedman KG, Del Nido PJ, et al. Fetal aortic valvuloplasty for evolving hypoplastic left heart syndrome: postnatal outcomes of the first 100 patients. Circulation. 2014;130(8):638-45.
10. Mendel B, Kohar K, Amirah S, Vidya AP. The outcomes of fetal aortic valvuloplasty in critical aortic stenosis: systematic review and meta-analysis. Int J Cardiol. 2023;382:25-30.
11. Geng J, Picker J, Zheng Z, Zhang X, Wang J, Hisama F, et al. Chromosome microarray testing for patients with congenital heart defects reveals novel disease-causing loci and high diagnostic yield. BMC Genomics. 2014;15:1127.
12. Onorato AC, Gosselin R, Chaudhari BP, Alvarado C, White P, Garg V, et al. Diagnostic yield of exome and genome sequencing for critically ill pediatric cardiac patients. Transl Pediatr. 2026;15(2):44.
13. Pidaparti M, Geddes GC, Durbin MD. Clinical genetic and genomic testing in congenital heart disease and cardiomyopathy. J Clin Med. 2024;13(9):2544.
14. Landstrom AP, Kim JJ, Gelb BD, Helm BM, Kannankeril PJ, Semsarian C, et al. Genetic testing for heritable cardiovascular diseases in pediatric patients: a scientific statement from the American Heart Association. Circ Genom Precis Med. 2021;14(5):e000086.
15. Valverde I, Gomez G, Gonzalez A, Suarez-Mejias C, Adsuar A, Coserria JF, et al. Three-dimensional printed models for surgical planning of complex congenital heart defects: an international multicentre study. Eur J Cardiothorac Surg. 2017;52(6):1139-48.
16. Yahiro DS, Cruz MP, Ribeiro BFC, Teixeira LM, Oliveira MFRM, Souza ALAAG, et al. Impact of 3D printing on cardiac surgery in congenital heart diseases: a systematic review and meta-analysis. Arq Bras Cardiol. 2024;121(12):e20240430.
17. Batteux C, Haidar MA, Bonnet D. 3D-printed models for surgical planning in complex congenital heart diseases: a systematic review. Front Pediatr. 2019;7:23.
18. Sathanandam SK, Gutfinger D, O'Brien L, Forbes TJ, Gillespie MJ, Berman DP, et al. Amplatzer Piccolo Occluder clinical trial for percutaneous closure of the patent ductus arteriosus in patients ≥700 grams. Catheter Cardiovasc Interv. 2020;96(6):1266-76.
19. Petit CJ, Romano JC, Zampi JD, Pasquali SK, McCracken CE, Chanani NK, et al. Rationale and design of the randomized COmparison of Methods for Pulmonary blood flow Augmentation: Shunt versus Stent (COMPASS) trial: A Pediatric Heart Network study. Catheter Cardiovasc Interv. 2024;104(4):637-47.
20. American College of Cardiology. Past, present, and future of transcatheter pulmonary valves. 2025. Available at: https://www.acc.org/latest-in-cardiology/articles/2025/05/05/17/03/past-present-and-future-of-transcatheter-pulmonary-valves. Accessed on 29 April 2026.
21. Mayourian J, Asztalos IB, El-Bokl A, Lukyanenko P, Kobayashi RL, La Cava WG, et al. Electrocardiogram-based deep learning to predict left ventricular systolic dysfunction in paediatric and adult congenital heart disease in the USA: a multicentre modelling study. Lancet Digit Health. 2025;7(4):e264-74.
22. Garcia-Canadilla P, Isabel-Roquero A, Aurensanz-Clemente E, Valls-Esteve A, Miguel FA, Ormazabal D, et al. Machine learning-based systems for the anticipation of adverse events after pediatric cardiac surgery. Front Pediatr. 2022;10:930913.
23. Liastuti LD, Nursakina Y. Diagnostic accuracy of artificial intelligence models in detecting congenital heart disease in the second-trimester fetus through prenatal cardiac screening: a systematic review and meta-analysis. Front Cardiovasc Med. 2025;12:1473544.
24. Gearhart A, Anjewierden S, Buddhe S, Tandon A. Review of the current state of artificial intelligence in pediatric cardiovascular magnetic resonance imaging. Children. 2025;12(4):416.
25. Rudd NA, Ghanayem NS, Hill GD, Jacobs JP, Jacobs ML, Lofland GK, et al. Interstage home monitoring for infants with single ventricle heart disease: education and management: a scientific statement from the American Heart Association. J Am Heart Assoc. 2020;9(16):e014548.
26. ClinicalTrials.gov. WeRoaM: Wearable Remote Monitoring in Heart Failure. NCT06969560. Available at: https://clinicaltrials.gov/study/NCT06969560. Accessed on 29 April 2026.
27. Peng DM, Edelson JB, Gureddygari HR, Duganiero T, Lynch A, McQueen M, et al. Capturing physiological data in children with heart failure using wearable digital technology: lessons from pilot project. CJC Pediatr Congenit Heart Dis. 2025;4(4):226-30.
28. Sood E, Newburger JW, Anixt JS, Cassidy AR, Jackson JL, Jonas RA, et al. Neurodevelopmental outcomes for individuals with congenital heart disease: updates in neuroprotection, risk-stratification, evaluation, and management: a

scientific statement from the American Heart Association. Circulation. 2024;149(13):e997-1022.
29. Marino BS, Lipkin PH, Newburger JW, Peacock G, Gerdes M, Gaynor JW, et al. Neurodevelopmental outcomes in children with congenital heart disease: evaluation and management. Circulation. 2012;126(9):1143-72.
30. Ware J, Butcher JL, Latal B, Sadhwani A, Rollins CK, Brosig Soto CL, et al. Neurodevelopmental evaluation strategies for children with congenital heart disease aged birth through 5 years: recommendations from the Cardiac Neurodevelopmental Outcome Collaborative. Cardiol Young. 2020;30(11):1609-22.
31. Centers for Disease Control and Prevention. Transitioning from pediatric to adult health care. 2026. Available at: https://www.cdc.gov/heart-defects/living-with/transitioning-from-pediatric-to-adult-medical-care.html. Accessed on 29 April 2026.
32. Pediatric Heart Network. WE BEAT CHD. Available at: https://www.pediatricheartnetwork.org/studies/we-beat-chd/. Accessed on 29 April 2026.
33. Moons P, Bratt EL, De Backer J, Goossens E, Hornung T, Tutarel O, et al. Transition to adulthood and transfer to adult care of adolescents with congenital heart disease: a global consensus statement. Eur Heart J. 2021;42:4213-23.
34. Gurvitz M, Krieger EV, Fuller S, Davis LL, Kittleson MM, Aboulhosn JA, et al. 2025 ACC/AHA/HRS/ISACHD/SCAI guideline for the management of adults with congenital heart disease. Circulation. 2025;153(8):e115-251.
35. Single Ventricle Outcomes Network. SV-ONE network. Available at: https://www.svone.org. Accessed on 29 April 2026.
36. Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, et al. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. Pediatrics. 2017;140(3):e20171904.
37. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents. Summary report. Pediatrics. 2011;128(5):S213-56.
38. Jone PN, Tremoulet A, Choueiter N, Romero Domínguez S, Harahsheh AS, Mitani Y, et al. Update on diagnosis and management of Kawasaki disease: a scientific statement from the American Heart Association. Circulation. 2024;150:e481-500.
39. Ehrhardt MJ, Leerink JM, Mulder RL, Visscher H, Kremer LCM, Van der Pal HJH, et al. Systematic review and updated recommendations for cardiomyopathy surveillance for survivors of childhood, adolescent, and young adult cancer. Lancet Oncol. 2023;24(3):e108-20.
40. WHO. Rheumatic heart disease. Available at: https://www.who.int/news-room/fact-sheets/detail/rheumatic-heart-disease. Accessed on 29 April 2026.
41. Pediatric Heart Network. CAMP study. Available at: https://www.pediatricheartnetwork.org/studies/. Accessed on 29 April 2026.
42. International Quality Improvement Collaborative for Congenital Heart Disease. IQIC program. Available at: https://iqic.chboston.org. Accessed on 29 April 2026.
43. Society of Thoracic Surgeons. Congenital Heart Surgery Public Reporting. Available at: https://publicreporting.sts.org/chsd. Accessed on 29 April 2026.
44. European Congenital Heart Surgeons Association. Congenital Database history. Available at: https://www.echsa.org/congenital-database-history. Accessed on 29 April 2026.
45. Health Technology Assessment Council, Philippines. Newborn pulse oximetry as a screening test for critical congenital heart disease among asymptomatic, apparently healthy newborns. 2025. Available at: https://hta.dost.gov.ph. Accessed on 29 April 2026.
46. World Society for Pediatric and Congenital Heart Surgery. World Database for Pediatric and Congenital Heart Surgery. Available at: https://wspchs.org/world-database-for-pediatric-and-congenital-heart-surgery/. Accessed on 29 April 2026.

Cite this article as: Kebede AF. The next era in pediatric cardiology: from lesion-based repair to precision, prediction and lifelong care. Int J Contemp Pediatr 2026;13:1284-93.